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Advanced Energy Systems Division

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(March 1978 Through March 1982)

R. Unterzuber
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G. M. Kubancsek

Prepared For
THE UNITED STATES DEPARTMENT OF ENERGY
COMMERCIAL SPENT FUEL MANAGEMENT PROGRAM OFFICE
AT THE PACIFIC NORTHWEST LABORATORY
UNDER CONTRACT B-D3339-A-G

September 1982

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ABSTRACT

From March 1978 through March 1982, spent fuel dry storage tests were conducted at the Engine Maintenance, Assembly and Disassembly (E-MAD) facility on the Nevada Test Site to confirm that commercial reactor spent fuel could be encapsulated and passively stored in one or more interim dry storage cell concepts. These tests were:

- Electrically Heated Drywell
- Isolated and Adjacent Drywell
- Concrete Silo
- Fuel Assembly Internal Temperature Measurement
- Air-Cooled Vault

This document presents the test data and results as well as results from supporting test operations (spent fuel calorimetry and canister gas sampling).

Near-surface instrumented drywells were tested using an encapsulated electric heater and encapsulated spent fuel assemblies. The Electrically Heated Drywell Tests were run at electric power outputs of 1.0, 2.0, and 3.0 kW. Testing shows the peak measured canister and liner temperatures to be 276 and 232°F for 1.0 kW, 506 and 458°F for 2.0 kW and 785 and 747°F for 3.0 kW. Isolated and Adjacent Drywell Tests were conducted using pressurized water reactor spent fuel assemblies with decay heat levels at emplacement of about 1.0, 1.25, and 0.63 kW. Testing shows the peak measured canister and liner temperatures to be 254 and 203°F for 1.0 kW, 323 and 262°F for 1.25 kW and 199 and 158°F for 0.63 kW. The Concrete Silo Test placed an encapsulated spent fuel assembly with a decay heat level of about 1.0 kW at emplacement in an instrumented above-surface storage cell. Canister and liner temperatures reached peak values of 202 and 141°F, respectively. The Fuel Assembly Internal Temperature Measurement Test placed pressurized water reactor spent fuel assemblies with decay heat levels of about 0.85 and 1.4 kW in a test fixture with internal fuel assembly temperature instrumentation to measure fuel assembly thermal response to various temperature profiles (imposed by external electric heaters) for air, helium and vacuum atmospheres. The peak recorded internal temperature (measured inside the center instrumentation tube) was 680°F which corresponded to a peak canister temperature of 595°F. The Air-Cooled Vault Tests included flow rate, vault outlet temperature and canister temperature measurements during the temporary storage of 13 encapsulated pressurized water reactor spent fuel assemblies in an underground vault. Canister temperatures reached peak values of 149 and 181°F for forced cooling and natural circulation cooling respectively.

In all the above tests (except the Air-Cooled Vault), computer models evaluated thermal response. The computer predictions of the transient and steady-state temperatures are presented and compared with the actual test data. The predictions showed reasonable agreement with test data.

Predictions of peak fuel clad temperatures were made for each spent fuel test using the rela-

tionships developed from Fuel Assembly Internal Temperature Measurement Test data. These predictions (including maximum prediction errors and uncertainties) showed peak fuel clad temperatures as follows: 452, 364 and 291°F for the drywell stored spent fuel assemblies with 1.25, 1.0 and 0.63 kW decay heat levels at emplacement, respectively; 334°F for the concrete silo stored fuel assembly; and 532°F for the air-cooled vault stored fuel assembly. These values were well below a fuel assembly storage temperature limit of 715°F.

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LIST OF ACRONYMS

AESD	Advanced Energy Systems Division
ARD	Advanced Reactors Division
BCL	Battelle Columbus Laboratory
BWR	Boiling Water Reactor
CMB	Crane Maintenance Balcony
CSA	Cell Service Area
CWSFP	Commercial Waste and Spent Fuel Packaging Program
EIV	Engine Installation Vehicle
E-MAD	Engine Maintenance, Assembly and Disassembly
EPC	East Process Cell
ETSMB	Engine Transport System Maintenance Building
F/A	Fuel Assembly
FMHS	Floor-Mounted Handling System
HEDL	Hanford Engineering Development Laboratory
HEPA	High Efficiency Particulate Air
HCMTS	Hot Cell Mobile Table Subsystem
HHTT	Hot Hold Transfer Tunnel
HVAC	Heating, Ventilating and Air Conditioning
MCC	Manned Control Car
MCR	Master Control Room
MWD/MTU	Megawatt Days per Metric Ton Uranium
NERVA	Nuclear Engine Rocket Vehicle Application
ORNL	Oak Ridge National Laboratory
PNL	Pacific Northwest Laboratory
PWR	Pressurized Water Reactor
RTS	Railroad Transport System
SFT-C	Spent Fuel Test at Climax
SFHPP	Spent Fuel Handling and Packaging Program
TC	Temperature Control
T/C	Thermocouple
TIG	Tungsten Inert Gas-Cooled
TVCC	Television Control Center
WMHS	Wall-Mounted Handling System
WPC	West Process Cell

1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This report was prepared in response to a request by Pacific Northwest Laboratory to consolidate previous dry storage test reports (References 2 through 9) and to report any additional test data.* These tests were performed at the Engine Maintenance, Assembly and Disassembly (E-MAD) facility at the Nevada Test Site as part of the Department of Energy's Spent Fuel Handling and Packaging Program (SFHPP) 1978 Demonstration, and Commercial Waste and Spent Fuel Packaging (CWSFP) Programs. The objective of these programs was to develop and test the capability of satisfactorily encapsulating typical spent fuel assemblies from commercial nuclear power plants and to establish the suitability of one or more surface and near-surface concepts for the interim dry storage of the encapsulated fuel assemblies. E-MAD was selected because of its extensive existing capabilities for handling highly radioactive components and desirable site characteristics for the proposed storage concepts.

The E-MAD facility is operated for the Department of Energy Nevada Operations Office by the Advanced Energy Systems Division (AESD) of the Westinghouse Electric Corporation. All testing at E-MAD was conducted by Westinghouse AESD personnel. In addition, test hardware for the 1978 Demonstration was designed, analyzed, built and installed by Westinghouse AESD with the exception of the concrete silos (designed by Kaiser Engineers for Rockwell Hanford operations). Onsite construction activities were performed by Reynolds Electric and Engineering Company with architect-engineering services provided by Holmes & Narver Inc. Additional canister and auxilliary hardware for the CWSFP Program was designed and built by Westinghouse in support of the Spent Fuel Test at Climax (SFT-C) Program.

This report provides test descriptions, results and conclusions for the Electrically Heated Drywell Test, Spent Fuel Drywell Test, Concrete Silo Test, Fuel Assembly Internal Measurement Test and Air-Cooled Vault Test conducted at E-MAD from March, 1978 through March, 1982. The report is organized to present the testing in the following order:

- Drywell Testing - including objectives, hardware, operations, results, analyses, extrapolations and applicability
- Concrete Silo Testing - including objectives, hardware, operations, results, analyses, extrapolations and applicability
- Fuel Assembly Internal Temperature Measurement Testing - including objectives, hardware, operations, results, analyses and applicability
- Air-Cooled Vault Testing - including objectives, hardware, operations, results,

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*Editor's note: The configurations, operations and test data presented herein have been ammended and/or augmented from those previously reported to present accurate information.

extrapolations and applicability

Additional supplementary information included to more completely describe the tests and data is presented in the following order:

- E-MAD Facility and Equipment Descriptions
- Construction, Installation, and Spent Fuel Handling Operations
- Test Data
- Test Data Illustrations
- Spent Fuel Assembly Calorimetry Operations and Results
- Spent Fuel Canister Gas Sampling Operations and Results
- Test Data and Peak Fuel Clad Predictions Uncertainty Analyses

1.2 SUMMARY

The tests conducted during the SFHPP and CWSFP Programs are summarized in bar chart form in Figure 1.2-1. The following is a summary description of each of the tests performed.

ELECTRICALLY HEATED DRYWELL TEST

The Electrically Heated Drywell Test primary objective was to confirm, by electric heater simulation, that commercial reactor spent fuel assembly storage in Nevada Test Site soil for an extended period of time would not result in exceeding design temperature limits. The Electrically Heated Drywell testing began in March, 1978, and operated at various power levels for nearly three years. The test arrangement consisted of an extensively instrumented carbon steel drywell liner, a stainless steel canister containing an assembly of electric heaters in an air atmosphere, and a concrete-filled shield plug to support the canister from the top liner. Details of the test hardware are included in Section 3.2 and Appendix B. The drywell liner is grouted into a hole in the soil. An array of thermocouple wells measured ground temperature response to the electric heat source. Throughout the test, readings from the thermocouples, heater input voltage and current, and atmospheric conditions were recorded. The test objectives, operations and results are described in Sections 3.1 through 3.4. The test data can be found in Appendix C.

A finite difference computer model was developed in conjunction with the Electrically Heated Drywell Test to predict canister, drywell and soil temperatures. Results from the computer model were compared to the test temperature data and are presented in Section 3.5. Sections 3.6 and 3.7 discuss temperature extrapolations and the applicability of test results.

SPENT FUEL DRYWELL TEST

The Spent Fuel Drywell Test primary objective was to confirm, by actual testing, that commercial reactor spent fuel could be passively stored in near-surface drywells at the Nevada Test Site. The Isolated Drywell Test Phase I began on

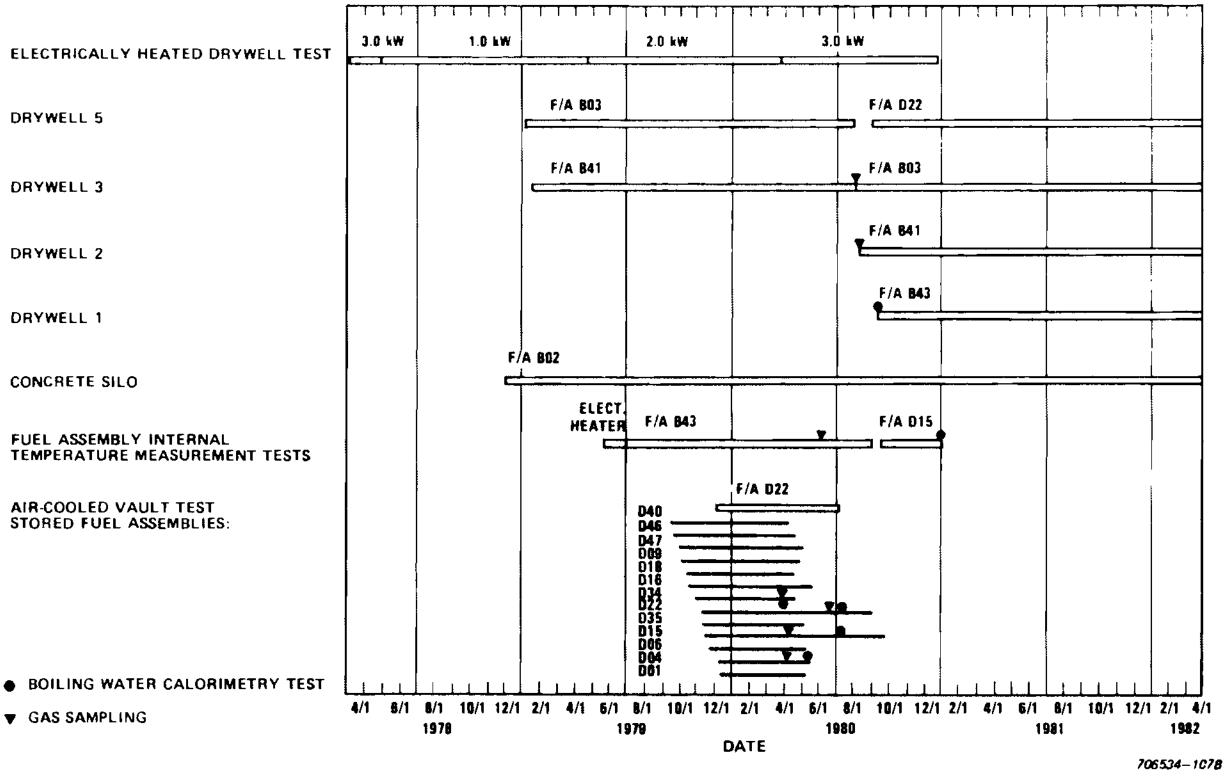


Figure 1.2-1. Summary of E-MAD Testing, March, 1978 through March, 1982

January 12, 1979 when a pressurized water reactor (PWR) spent fuel assembly with a decay heat level of about 1.0 kW was placed into a drywell storage cell. The Isolated Drywell Test Phase II began on September 4, 1980, when a 1.25 kW spent fuel assembly was stored. The Adjacent Drywell Test began on September 15, 1980. This test consisted of placing three nearly identical PWR spent fuel assemblies, each with a decay heat level of about 0.63 kW, into three in-line drywells spaced 25 feet apart. The test hardware for each drywell consisted of an instrumented carbon steel liner, an instrumented stainless steel canister (containing the PWR spent fuel assembly) and a concrete-filled shield plug to support the canister from the liner top. Details of the test hardware are included in Section 3.2 and Appendix B. The drywell liner was grouted into a hole in the soil. Thermocouple wells measured ground temperature response to the spent fuel decay heat. Throughout the test period, temperature readings from thermocouples on the canister, liner, and in the soil were recorded. The test objectives, operations and results are discussed in Sections 3.1 through 3.4. The test data are presented in Appendix D.

The finite difference computer model, developed for the Electrically Heated Drywell Test, was modified to match the fueled drywell configuration and predicted transient and steady-state canister, drywell and soil temperatures. These results are presented in Section 3.5 while Sections 3.6 and 3.7 examine the temperature extrapolations and the applicability of test results.

CONCRETE SILO TEST

The Concrete Silo Test primary objective was to confirm, by actual testing, that commercial reactor spent fuel could be passively stored in an above-ground concrete silo at the Nevada Test Site. The Concrete Silo Test began on December 7, 1978 when a PWR spent fuel assembly with a decay heat level of about 1.05 kW was placed into a concrete silo and transferred to a storage pad next to the E-MAD facility. The test hardware consisted of an instrumented carbon steel liner, an instrumented stainless steel canister (containing the spent PWR fuel assembly), a concrete-filled shield plug to support the canister from the liner top and the instrumented reinforced concrete around the liner. Details of the test hardware are included in Section 4.2 and Appendix B. Throughout the test period, temperature readings from thermocouples on the canister, liner and in the concrete were recorded. The test objectives, operations and results are described in Sections 4.1 through 4.4. The test data are presented in Appendix E.

A finite difference computer model predicted concrete silo and canister temperatures. Comparisons of the analytical predictions with the test data are presented in Section 4.5. Sections 4.6 and 4.7 discuss temperature extrapolations and the applicability of the test results.

FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST

The primary objective of the Fuel Assembly Internal Temperature Measurement Test was to provide spent fuel assembly internal temperature data under simulated dry storage cell conditions to verify that spent fuel assemblies with a decay heat level of about 1.0 kW could be stored in drywells and concrete silos at the Nevada Test Site without exceeding design temperature limits. Phase I began in May, 1979 and was run with an electrical heater assembly inside the canister. Phase II began on July 18, 1979 when an actual PWR spent fuel assembly with a decay heat level of about 0.85 kW was placed in the test stand. In Phase III, begun in September, 1979, a second PWR spent fuel assembly with a decay heat level of about 1.4 kW was used. The test arrangement consisted of an instrumented stainless steel canister, a stainless steel canister lid containing instrumentation tubes to measure internal fuel assembly temperatures, a stand to support a carbon steel liner representative of the storage cell liner, and an evacuation and backfill system. Details of the test hardware are included in Section 5.2 and Appendix B. The test objectives, operations and results are described in Sections 5.1 through 5.4.

Phase I provided canister temperature profiles for heater power levels between 0.5 and 3 kW. Phase II tests, run with air, helium and in a vacuum, measured the internal fuel assembly temperature distributions as a function of canister temperature profile and atmosphere. Phase III test, also run with air, helium and in a vacuum, provided additional fuel assembly temperature response data to the different media and canister temperature profiles for a higher decay heat level fuel assembly. Test data can be found in Appendix F.

Several computer models developed by Oak Ridge National Laboratory and Pacific Northwest Laboratory were used to calculate fuel cladding and canister temperatures under test conditions. Results from these computer model predictions were compared to the test temperature data and are discussed in Section 5.5. Section 5.6 presents the applicability of the test data.

AIR-COOLED VAULT TEST

The primary objective of the Air-Cooled Vault Test was to provide temperature and flow data under normal operating and simulated accident conditions to verify that spent fuel assemblies with a decay heat level of 2.0 kW could be stored temporarily or for long periods in the E-MAD Lag Storage Pit (an air-cooled vault). The Lag Storage Pit stored 13 PWR spent fuel assemblies with decay heat levels up to 2.0 kW. Fuel assembly storage began September 21, 1979. Air flow and temperature measurement tests under normal and accident conditions were conducted several times with a different number of assemblies in the vault. Canister temperature measurements were taken between December 1979 and June 1980 for one canister.

The test arrangement consisted of stainless steel canisters (each containing a PWR spent fuel assembly) and concrete-filled shield plugs to support the canisters from the concrete vault covers. The concrete lined Lag Storage Pit consisted of three individual vaults each with three inlets from a common inlet header and three outlet pipes for air flow. Eight canisters were installed in one vault (one canister instrumented) and five in another. Outlet pipe air flow and temperature readings were taken for various flow conditions (forced flow, partial flow blockage and natural circulation flow) in two separate tests. Throughout much of the test period, temperature readings from thermocouples on the canister and in the outlet pipes were recorded. The test objectives, operations and results are described in Sections 6.1 through 6.4. Sections 6.5 and 6.6 discuss temperature extrapolations and the applicability of test results. Test data are provided in Appendix G.

1.3 CONCLUSIONS

The following conclusions can be drawn from the results of each of these tests:

ELECTRICALLY HEATED DRYWELL

1. The peak measured canister and liner temperatures for an air filled canister and a 1.0, 2.0 and 3.0 kW constant power level applied to an isolated near-surface drywell installed in soil typical of the Nevada Test Site were as follows:

Power Level (kW)	Peak Canister Temp (°F)	Peak Liner Temp (°F)
1.0	276	232
2.0	506	458
3.0	785	747

2. The maximum spent fuel decay heat level which can be stored

in an air filled canister in an isolated drywell configuration in Nevada Test Site soil is between 2.0 and 3.0 kW based on a fuel assembly storage temperature limit of 715°F.

3. Day/night variations in ambient air temperature have little effect on the peak canister temperatures which occur 10 feet below the ground surface.

4. The proportion of heat transferred to the atmosphere through the drywell itself and through the surrounding soil becomes greater as the power level in a drywell increases as evidenced by:

   - Peak canister temperatures occurred at lower depths as the power level was increased from 1.0 to 2.0 kW and from 2.0 to 3.0 kW

   - Temperatures along the entire canister decreased during 3.0 kW operation by about 40°F in nearly direct response to the seasonal atmospheric temperature decrease from October to December, 1980 (about 40°F) whereas previous canister response to seasonal atmospheric temperature changes had a definite time lag similar to that of the soil at the same elevation

5. For soils typical of the Nevada Test Site, near-surface drywell thermal response characteristics are affected by the heat-source-induced changes in soil thermal conductivity (specifically from the surrounding soil drying out). To accurately model drywell thermal response, the proper relationship between soil thermal conductivity, temperature and time are needed. This relationship, a function of soil moisture content and the effects of moisture transport mechanisms, would yield time and temperature dependent properties of heat capacity and thermal conductivity.

FUELED DRYWELLS

1. The peak measured canister and liner temperatures for encapsulated PWR spent fuel assemblies with helium backfill stored in an isolated drywell configuration in soil typical of the Nevada Test Site were as follows:

Fuel Assembly Decay Heat at Emplacement (kW)	Peak Canister Temp (°F)	Peak Liner Temp (°F)
1.25	323	262
1.00	254	203
0.63	199	158

2. Predictions using the relationships developed from the Fuel Assembly Internal Temperature Measurement Tests show the peak fuel clad temperatures (including prediction error and uncertainties) were as follows:

Fuel Assembly Decay Heat at Emplacement (kW)	Estimated Peak Fuel Clad Temp (°F)
1.25	452
1.00	364
0.63	287

3. For decay heat levels of about 1.0 kW, the peak drywell canister and liner temperatures and the time to reach the peaks are influenced by the seasonal ambient air temperature variations, by the decrease in decay

heat level, and by thermal property changes in the soil.

4. Day/night variations in ambient air temperature had little or no effect on peak canister temperatures.

5. A 50 foot spacing between adjacent drywells in Nevada Test Site alluvial soil is judged to thermally isolate spent fuel assemblies with decay heat levels of about 1.0 kW.

6. A 25 foot spacing between linearly arrayed adjacent drywells in Nevada Test Site alluvial soil is judged to produce virtually no thermal interaction between drywells containing spent fuel assemblies with decay heat levels of about 0.5 kW.

7. The peak canister and liner temperatures reached by an unused drywell were about 10°F less than those for a drywell which had contained the same decay heat level fuel assembly (about 0.5 kW) for some period of time (about 30 months). This is attributed to the decrease in soil thermal conductivity caused by the heat-source-induced moisture loss with time in the surrounding soil.

8. For soils typical of the Nevada Test Site, near-surface drywell thermal response characteristics are affected by the heat-source-induced changes in thermal properties of the surrounding soil. To accurately model drywell thermal response, the proper relationship between soil thermal properties (heat capacity and thermal conductivity), temperature and time are needed.

CONCRETE SILO

1. The peak measured canister temperature for an encapsulated PWR spent fuel assembly with helium backfill and an initial decay heat level of 1.05 kW stored in a concrete silo configuration at the Nevada Test Site was 202°F. The peak liner temperature was 141°F.

2. Predictions using the relationships developed from the Fuel Assembly Internal Temperature Measurement Tests show the peak fuel clad temperature (including prediction error and uncertainties) was 334°F.

3. Seasonal variations in ambient air temperatures and solar radiation have a noticeable effect on the canister temperature. The peak canister temperature is about 115°F above the average monthly ambient temperature (yearly range is 37 to 83°F).

4. Day/night variations in ambient air temperature are essentially damped out within the outer 15 inches of concrete.

FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TESTS

1. Both helium and air are acceptable canister backfill media for spent fuel decay heat levels near 1.4 kW based on measured peak center thermowell to canister temperature differentials.

2. The helium backfill is a noticeably better radial heat conductor than air and produced the smallest center thermowell to canister temperature differentials.

3. The air backfill is a better axial heat convector and produced canister and thermowell temperature profiles skewed towards the upper end (fuel temperatures at the upper end exceeded those for the vacuum backfill).

4. As canister temperatures increased, the peak center thermowell to canister differentials decreased as did the effects of axial heat convection for the air backfill.

5. The 15 axial thermowell tubes provided in the test assembly to measure temperatures inside the spent fuel assembly reduced fuel assembly upper end temperatures (by creating additional axial heat conduction paths) which would not occur in the actual storage cells.

6. The peak fuel clad temperature for a 1.0 kW decay heat level spent fuel assembly stored in an air filled canister in an isolated drywell at the Nevada Test Site would be about 400°F based on a 275°F peak canister temperature measured for the Electrically Heated Drywell Test.

7. The peak center thermowell temperatures measured for fuel assembly B43 for a uniform canister temperature of 500°F were about 550°F for a helium backfill and 575°F for an air backfill.

8. The peak fuel clad temperature for a 1.4 kW decay heat level spent fuel assembly stored in an air filled canister in an isolated drywell at the Nevada Test Site would be about 525°F based on a 348°F peak canister temperature interpolated from the Electrically Heated Drywell Test.

9. The peak fuel clad temperature for the 1.6 kW decay heat level spent fuel assemblies stored in helium filled canisters in drywells at the Spent Fuel Test at Climax was about 460°F based on a measured 289°F peak canister temperature.

10. The peak center thermowell temperature measured for fuel assembly D15 for a uniform canister temperature of 600°F was 680°F for a helium backfill.

AIR-COOLED VAULT TESTS

1. The peak measured canister temperature for an air filled canister containing a PWR spent fuel assembly with a decay heat level of about 1.8 kW in the E-MAD Lag Storage Pit was 181°F for natural convection cooling. The peak measured canister temperature for forced cooling was 149°F.

2. Predictions using the relationships developed from the Fuel Assembly Internal Temperature Measurement Tests show the peak fuel clad temperatures (including prediction error and uncertainties) were 532°F for natural convection cooling and 516°F for forced cooling.

3. Canister temperatures in the E-MAD Lag Storage Pit were affected by changes in the total decay heat of fuel assemblies in the pit, by changes in Hot Bay ambient air temperature, by pit cooling flow conditions, and by removal of adjacent canisters.

2.0 OVERVIEW

2.1 PROGRAM BACKGROUND

The E-MAD facility at the Nevada Test Site was chosen as the location for the SFHPP 1978 Demonstration because of its extensive existing capabilities for handling highly radioactive components and because of the desirable site characteristics for the proposed storage concepts. The E-MAD facility is described in Appendix A and in more detail in Reference 1. Near-surface and above-surface storage concepts were chosen for testing. The near-surface storage concept or drywell consisted of a steel liner grouted into a shallow hole drilled in the alluvial soil at the E-MAD facility. A sealed canister containing the fuel assembly in a helium atmosphere is suspended from a shield plug which, in turn, is supported on an internal ledge in the liner. The above-ground storage concept, or concrete silo, had a steel liner (identical to that used in the drywell) encased in a 252 inch high, 104 inch diameter reinforced concrete silo with the canister/shield plug package supported in the liner in the same manner as in the drywell. In these storage systems, the decay heat of the fuel assembly is passively transmitted to the storage cell and then dissipated to the environment. The drywell and concrete silo storage cells were constructed in an area immediately adjacent to the E-MAD facility.

An overriding requirement from the start of the SFHPP 1978 Demonstration Program was that the spent fuel storage system and associated activities not result in undue risk to the public, property, environment, or site employees. To ensure meeting this requirement, the leak-tight integrity of the fuel cladding and the canister was maintained. Because high temperature can affect the long-term integrity of both of these barriers to fission product release, thermal considerations were an important concern in the storage cell design. Preliminary analyses performed by the Hanford Engineering Development Laboratory established 715°F (380°C) as the fuel cladding temperature limit below which fuel cladding integrity would be maintained in an inert (helium) environment for long storage times (100 years). Scoping thermal analyses of the storage cell concepts indicated that cladding temperatures reached in the concrete silo would be well below the limit, but that those reached in the drywell could approach the limit. Therefore, a series of tests was conducted to verify that fuel cladding temperatures would remain below the established limit and to obtain data for use in qualifying the thermal design model.

The two verification tests were defined to provide temperature measurements from the canister out into the soil and inside a canister containing a spent fuel assembly. The first test, the Electrically Heated Drywell Test, used an in-ground electrically heated drywell configuration to measure the spatial temperature distributions on the canister surface, the drywell liner surface, and in the surrounding grout and soil. The canister temperature profile (approximating that for an actual drywell) would then be input to the Fuel Assembly Internal Temperature Measurement Test to determine peak fuel cladding temperatures. This test used a canister containing a spent fuel assembly and internal temperature instrumentation to determine fuel cladding thermal response to an imposed canister axial temperature profile from thermocouples inserted into fuel assembly guide tubes. The canister is installed in a drywell liner with electrical band heaters along the liner axial length. The Fuel Assembly Internal Temperature Measurement Test apparatus is located in a large hot cell (West Process Cell) inside the E-MAD facility. A test within the E-MAD facility hot cells was used to determine canister interior temperatures rather than using internal canister instrumentation wells in the actual storage canisters. It was felt that adding multiple thin-wall internal canister instrumentation tubes would decrease the canister reliability in providing a leak-tight radioactive containment boundary. These two tests would provide canister and spent fuel temperature data for storage of the original SFHPP 1978 Demonstration spent fuel assemblies at E-MAD.

In addition to the above mentioned verification tests, soil properties testing was done to measure thermal properties from soil core samples. These measurements were made on reconstituted soil samples under laboratory conditions and the results are discussed in Section 3.5.1.1.

The storage cell experiments consisted of encapsulating spent fuel assemblies and placing them in storage with thermocouple instrumentation on the exterior of the fuel storage canister and throughout the storage cell. The fuel assemblies selected had a burnup of approximately 25,000 megawatt days per metric ton uranium (MWD/MTU) and were approximately three years out of the reactor with a thermal power level of approximately 1.25 kW. Fuel encapsulations were performed at E-MAD during December 1978 and January 1979. An encapsulated PWR fuel assembly was placed in a concrete silo on December 7, 1978, and two other encapsulated PWR fuel assemblies were placed in drywells on January 12 and 24, 1979. The fourth PWR fuel assembly was placed in the Fuel Assembly Internal Temperature Measurement Test on July 18, 1979.

Results from the Electrically Heated Drywell Test presented in Reference 2 and Section 3.4 confirmed that fuel cladding temperatures for the spent fuel assemblies selected for testing would remain below established limits. Results from the Fuel Assembly Internal Temperature Measurement Test, presented in Reference 3 and Section 5.4, provided additional confirmation that fuel cladding temperatures were well below the limits. The Concrete Silo Test is described and results are presented in Reference 4 and Section 4.4. The results from the Phase I Isolated Drywell Test (1.0 kW spent fuel assembly) are presented in Reference 5 and Section 3.4.

Following completion of the SFHPP testing in FY 1979, further testing was initiated as part of the CWSFP Program. The objective of the CWSFP Program tests at the Nevada Test Site was to further evaluate E-MAD drywell performance. This included additional testing using the Electrically Heated Drywell Test, all four drywells, and the Fuel Assembly Internal Temperature Measurement Test assembly.

The Spent Fuel Test at Climax (SFT-C) used the E-MAD facility for encapsulation and temporary storage of 13 PWR spent fuel assemblies. The SFT-C Program, a test of retrievable geologic storage of spent fuel assemblies in a granite mine at the Nevada Test Site, provided the additional spent fuel assemblies for further Isolated Drywell, Fuel Assembly Internal Temperature Measurement, and Air-Cooled Vault Tests. Of the thirteen assemblies acquired for the SFT-C Program, eleven were installed in the SFT-C test array and two were retained at E-MAD awaiting a series of fuel assembly exchanges to be performed periodically during testing. These two fuel assemblies were chosen for testing as part of the CWSFP Program tests at E-MAD.

As part of the CWSFP Program, additional testing at a 2.0 kW level (and later a 3.0 kW level) was defined for the Electrically Heated Drywell Test. Since the results of the SFHPP 1978 Demonstration showed that peak canister temperature and associated fuel cladding temperatures for a 1.0 kW spent fuel decay heat level were well below the design limit, this test was used to evaluate drywell response to higher power levels. This additional testing provided canister temperature data that was used with the Fuel Assembly Internal Temperature Measurement Test and thermal models to determine the maximum decay heat level a drywell storage cell could accomodate in Nevada Test Site soil.

Several additional tests were identified for the E-MAD drywells. To complete the original testing, an Adjacent Drywell Test was performed. This used three SFHPP 1978 Demonstration PWR spent fuel assemblies placed in adjacent drywells spaced 25 feet apart. This test provided additional data which could be used in evaluating drywell arrays and compared to computer code predictions. The data evaluation would provide confirmed heat transfer correlations of interactions between adjacent drywells and could be used to determine optimum drywell spacing in Nevada Test Site soil. A higher decay heat level (approximately 1.25 kW) spent fuel assembly was installed in the fourth drywell to evaluate isolated drywell response to higher power levels. This test was identified as the Phase II Isolated Drywell Test.

To supplement the drywell testing (electrical and spent fuel), additional Fuel Assembly Internal Temperature Measurement Tests were planned. The results of the initial test showed that peak fuel clad temperatures for the storage cell tests were well below the design limit. Fuel assembly internal temperatures for higher decay heat level fuel assemblies were then studied. This testing provided fuel temperature data in conjunction with the 2.0 kW Electrically Heated Drywell Test data and the Phase II Isolated Drywell Test data to further define the thermal response of drywell storage cells.

The results from the CWSFP Program testing are presented in References 2 and 6 and Section 3.4 for the 2.0 and 3.0 kW Electrically Heated Drywell Tests, respectively, Reference 7 and Section 3.4 for the Phase II Isolated Drywell Test where an approximately 1.25 kW spent fuel assembly was tested, in Reference 8 and Section 3.4 for the Adjacent Drywell Test where three approximately 0.63 kW spent fuel assemblies were tested and in Reference

9 and Section 5.4 for the Fuel Assembly Internal Temperature Measurement Test where an approximately 1.4 kW spent fuel assembly was tested.

2.2 E-MAD STORAGE AREA AND TEST ARRANGEMENT

The E-MAD facility, shown in Figure 2.2-1 was originally constructed for use in the nuclear rocket development program. As such, a Cold Bay was provided for the assembly of rocket engines to be tested, a large Hot Bay for the disassembly of the highly radioactive nuclear reactors following test runs, and a railroad system for transporting the test engines between E-MAD and the remotely located engine test stands. The major features of the E-MAD building are indicated in Figure A-3. E-MAD was readily adapted to perform the remote encapsulation and handling functions required for the SFHPP Demonstration. The Cold Bay is used for the assembly and checkout of equipment for later remote operations in the Hot Bay. The Hot Bay is used for the receipt and unloading of spent fuel shipping casks; the remote handling of spent fuel assemblies, fuel canisters, and equipment for encapsulation; and the lag storage of up to 24 fuel assemblies in an air-cooled vault. The existing railroad system and equipment are used in transporting encapsulated fuel assemblies from the Hot Bay to the outside drywells.

A number of modifications were made inside the E-MAD facility to accomodate the SFHPP Demonstration. Major modifications in the Hot Bay

Figure 2.2-1. E-MAD Facility

involved construction of a weld pit, a transfer pit, a survey pit, a shipping cask work platform, and a lag storage pit or air-cooled vault. A significant modification was the lag storage pit used to store spent fuel assemblies in canisters prior to final closure welding and during the interval before storage emplacement. The lag storage pit is discussed in detail in Section 6.0. The other modifications are described in Appendix A.

Additional modifications were made on the west side of the E-MAD building to provide the site for the Electrically Heated Drywell Test and for the encapsulated fuel tests (Drywells and Concrete Silos). Figure 2.2-2 shows the storage area relative to the entire E-MAD facility and the specific arrangement of the test hardware for all the tests.

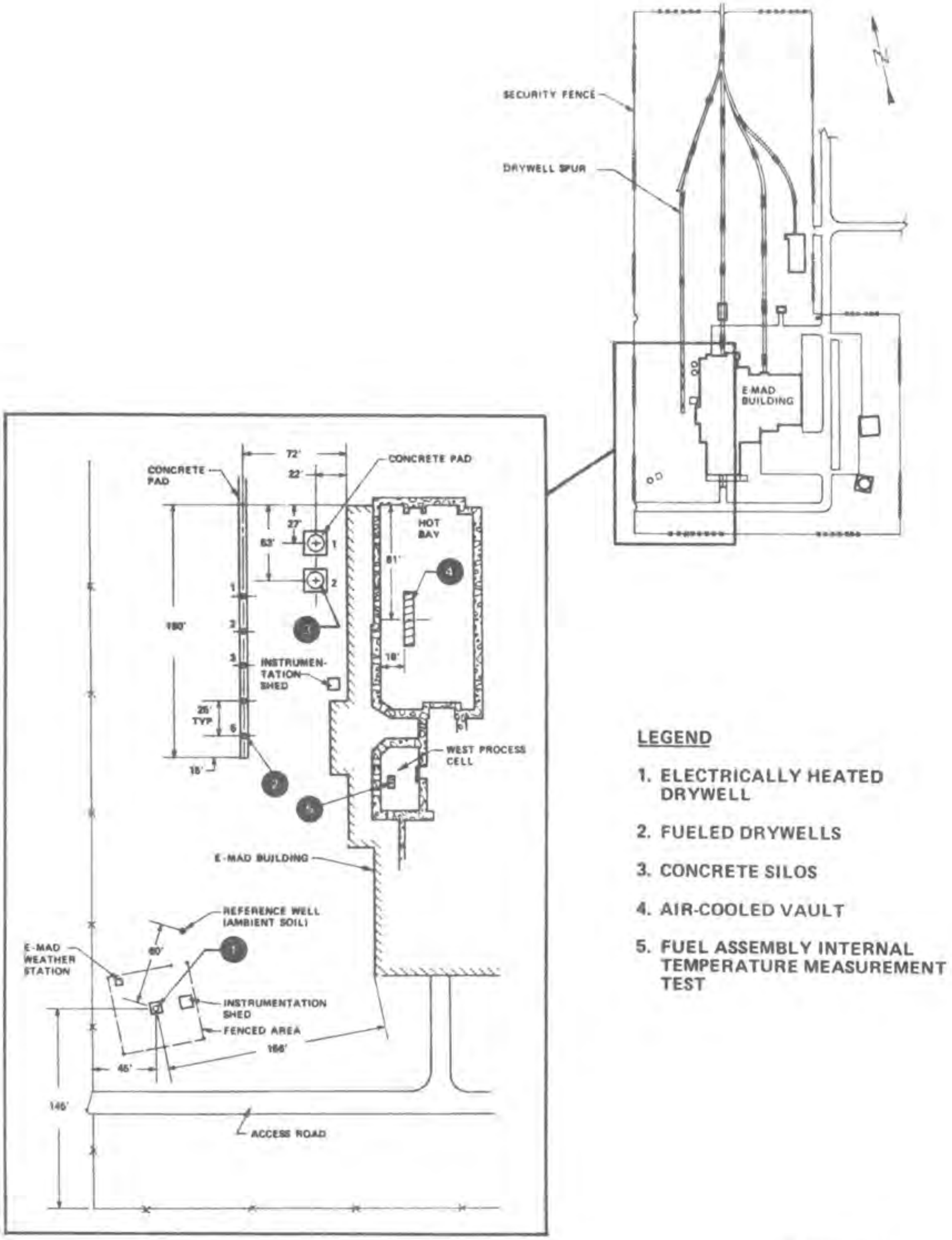
The Electrically Heated Drywell Test was located in the southwest corner of the E-MAD facility fenced area. A 60 foot square leveled fenced area was prepared. The drywell liner was installed in a 7 foot square by 15 inch deep concrete pad. Five soil instrumentation wells and one soil Reference Well were grouted into the soil near the drywell. The E-MAD weather station and an environmentally controlled instrumentation shed were also installed within the fenced area.

Two concrete silos and associated support pads were constructed adjacent to the west side of the E-MAD building. The silo site was chosen for compacted soil properties to support the heavy loads of the concrete silo, mobile transporter and crane during emplacement. The reinforced concrete pad is 16 feet by 16 feet by 9 feet deep. A second environmentally controlled instrumentation shed was installed near the concrete silos.

Four drywells were constructed west of the E-MAD building. This site was chosen since it was fairly level and would allow rail spur installation with a minimum of modifications. Because the existing railroad equipment was to be used to move a fuel canister from the Hot Bay to the drywells, the drywells were embedded in reinforced concrete and centered between the rails of a new rail spur which tied into the existing trackage north of the E-MAD building as shown in Figure 2.2-2. An additional switch located 100 feet south of the north fence was used to start a new rail spur for the drywell storage site. The three northernmost drywells on the new spur are spaced 25 feet apart while the southern-most drywell is 50 feet from the adjacent drywell. The 7 foot wide by 28 inch deep by 235 foot long concrete pad provides: 1)a level surface to facilitate canister emplacement with the transfer shield, 2)support for the rail equipment during emplacement, and 3)shielding in the immediate area. Four soil instrumentation wells were grouted into the soil adjacent to each drywell.

Details of storage area construction and hardware installation are provided in Appendix B.

Two other spent fuel tests were performed inside the E-MAD building. The Air-Cooled Vault Tests used the lag storage pit in the Hot Bay. The Fuel Assembly Internal Temperature Measurement Test used a special test stand and equipment located in and around the West Process Cell.



LEGEND

1. ELECTRICALLY HEATED DRYWELL
2. FUELED DRYWELLS
3. CONCRETE SILOS
4. AIR-COOLED VAULT
5. FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST

706534-110A

Figure 2.2-2. Arrangement of E-MAD Spent Fuel Storage and Related Tests

2.3 SPENT FUEL ASSEMBLIES

Seventeen PWR spent fuel assemblies were either stored or tested at E-MAD during the period covered by this report. These assemblies were acquired by the Department of Energy from the Florida Power and Light Turkey Point Unit Number 3. Four assemblies (serial numbers B02, B03, B41 and B43) were shipped to E-MAD for the SFHPP 1978 Demonstration Program. Fuel assembly B02 was installed in Concrete Silo No. 2 for the Concrete Silo Test, fuel assemblies B03 and B41 were installed in Drywells 5 and 3 respectively for the Phase I Isolated Drywell Test and fuel assembly B43 was used for the Phase II Fuel Assembly Internal Temperature Measurement Test. Fuel assemblies B03, B41 and B43 were later installed in Drywells 3, 2 and 1 respectively for the Adjacent Drywell Test.

The 13 PWR spent fuel assemblies acquired for the SFT-C Program (serial numbers D01, D04, D06, D09, D15, D16, D18, D22, D34, D35, D40, D46 and D47) were encapsulated and stored in the E-MAD lag storage pit prior to transport and installation in the SFT-C test array. Two of these assemblies, D22 and D15, were used in the Phase II Isolated Drywell Test and the Phase II Fuel Assembly Internal Temperature Measurement Test, respectively, prior to being transported to the SFT-C test site. While in the lag storage pit, the canister containing fuel assembly D22 was instrumented for the Air-Cooled Vault Tests.

A representative Turkey Point PWR fuel assembly is illustrated in Figures 2.3-1 and 2.3-2. Table 2.3-1 provides fabrication statistics for Turkey Point fuel assemblies. The fuel assembly is 161.3

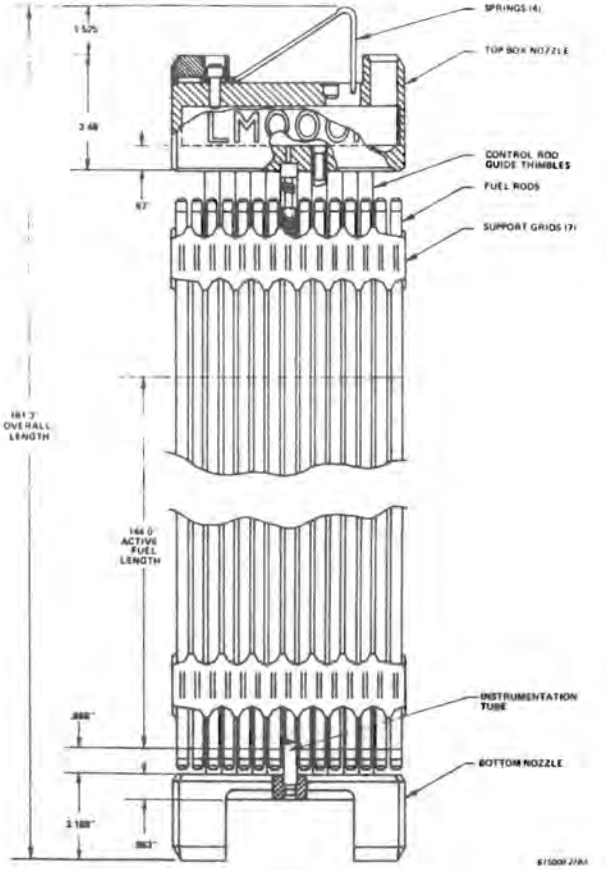


Figure 2.3-1. PWR Fuel Assembly Configuration

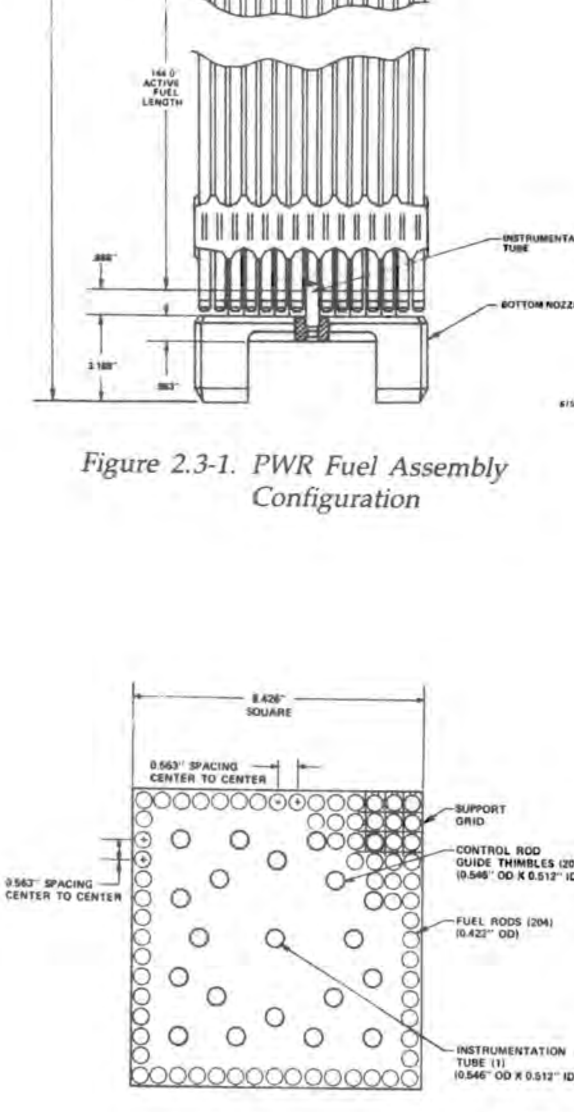


Figure 2.3-2. PWR Fuel Assembly Cross Section

inches long (prior to irradiation) with a square cross section having a maximum distance across flats of 8.426 inches (including grids). The overall length is made up of top nozzle, the fuel rods, and the bottom nozzle. The fuel rods consist of a 15 by 15 array of 0.422 inch diameter Zircaloy cladding around uranium oxide pellets. The fuel rods are arranged in a square pattern with 0.563 inches between centers. The active fuel length is nominally 144 inches. The fuel rods are laterally constrained by a series of seven grids located along the length of the rods. The PWR fuel assembly is supported by the bottom nozzle when in the vertical position. The bottom nozzle has four square feet located at the corners of the assembly. When installed in any of the test canisters, the fuel assembly bottom nozzle plate is seated on the horizontal cruciform plate at the bottom of the canister (see Figure 3.2-18).

The fuel assembly configuration in Figure 2.3-1 is accurate for the four B serial number fuel assemblies. The D serial number fuel assemblies are of a slightly different design with some of the dimensions for the top nozzle, bottom nozzle and overall length being different. These differences are noted below:

	B Assemblies	D Assemblies
Overall Length	161.29 in.	161.45 in.
Height of Top Nozzle	3.48 in.	3.495 in.
Height of Bottom Nozzle	3.188 in.	2.738 in.
Bottom Nozzle Support Plate Thickness	0.953 in.	0.755 in.

Of these differences, only the bottom nozzle support plate thickness is significant since it affects the elevation of the active fuel bottom in the canister.

Fuel assembly operating data pertinent to fuel assemblies tested at E-MAD are provided in Table 2.3-2. This data was used to generate decay heat level predictions using the ORIGEN 2 computer code (Reference 10). Decay heat level predictions for the fuel assemblies are provided in Figures 2.3-3, 2.3-4, 2.3-5 and 2.3-6. Figure 2.3-3 shows the decay heat level predictions for all four B serial number assemblies calculated using the burnup for B02, B03 and B41. Also shown is the Boiling Water Calorimeter data for fuel assembly B43 measured on September 10, 1980. Figures 2.3-4, 2.3-5 and 2.3-6 show the decay heat level predictions for each group of D serial number assemblies with different predicted burnups. Each figure shows a Boiling Water Calorimeter data point for one of the assemblies in that group. Further information on the Boiling Water Calorimeter and data shown on these figures is contained in Appendix L.

Specific data concerning some of the spent fuel assemblies were collected during nondestructive

TABLE 2.3-1
FABRICATION STATISTICS FOR TURKEY POINT FUEL ASSEMBLIES

Vendor	Westinghouse Electric Corp.
Type (Rod Array)	15 x 15
Assembly Parameters	
Transverse Dimension	8.426 in.
Assembly Weight	1439 lb.*
Assembly Length	161.3 in.*
Control Rod Guide Thimble Tubes	
Number	20
Upper OD	0.546 in.
Wall Thickness	0.017 in.
Material	Zr-4
Instrument Tubes	
Number	1
OD	0.546 in.
Wall Thickness	0.017 in.
Material	Zr-4
Spacer Grids	
Number	7
Material	Inconel 718
Spring Material	Inconel 718
Fuel Rods	
Number	204
Length	152.0 in.*
OD	0.422 in.
Wall Thickness	0.0243 in.
Material	Zr-4
Fuel Length	144.0 in.*
Top Nozzle Material	304 SS
Bottom Nozzle Material	304 SS
Plenum Springs	
Working Length	6.80 in.
Material	Inconel 718
Fuel Pellet	
Material	UO_2
Enrichment	2.559 Weight % U^{235}
Density	92% Theoretical

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* See Table 2.3-3 for measurements taken on spent fuel assemblies

examination at Battelle Columbus Laboratory (BCL) prior to their shipment to E-MAD. Five of the B serial number assemblies (including B17 - not part of E-MAD tests) and three of the D serial number assemblies (D01, D04 and D06) were examined at BCL. The results are reported in References 11 and 12, respectively.

To allow temperature measurements in fuel assembly center instrumentation tube using the Fuel Assembly

TABLE 2.3-2
FUEL ASSEMBLY OPERATING DATA

B Assemblies	
Date Irradiation Began	January 12, 1972
Date Reactor Shutdown	October 25, 1975
Total Effective Full Power Days	825 Days
Initial Uranium Loading per Assembly	448 kg
Calculated Burnup	
B02, B03, B41	25,665 MWD/MTU
B43	25,595 MWD/MTU

D Assemblies	
Date Irradiation Began	December 12, 1974
Date Reactor Shutdown	November 19, 1977
Total Effective Full Power Days	851 Days
Initial Uranium Loading per Assembly	457 kg
Calculated Burnup	
D09, D16, D18, D34	27,863 MWD/MTU
D01, D04, D06, D15, D35, D40, D46, D47	28,430 MWD/MTU
D22	26,485 MWD/MTU

Internal Temperature Measurement Test closure lid, a clearance hole had to be made through the fuel assembly top nozzle. This was accomplished prior to fuel shipment to E-MAD from BCL. A 3 inch diameter hole was cut into the fuel assembly top nozzle plate and a steel plug with a clearance hole in the center was installed in the hole in the nozzle plate for fuel assemblies B43 and D15. This hole provided the necessary access for closure lid central thermowell insertion.

TABLE 2.3-3
NONDESTRUCTIVE EXAMINATION DATA FOR B AND D SERIES FUEL ASSEMBLIES

	B Assemblies		D Assemblies	
Measured Weight (lb.)	B02	1465	D01	1462
	B03	1450	D04	1457
	B41	1452	D06	1459
	B43	1448		
Measured Irradiated Length Between Top and Bottom Nozzles (in.)	153.360 (ave)		153.660 (ave)	
Measured Irradiated Fuel Rod Lengths (in.)	152.539 (ave)		152.561 (ave)	
Measured Irradiated Active Fuel Length (in.)	144.532 (ave)		N/A	
Measured Irradiated Fuel Rod Weights (lb.)	6.75 (ave)		6.82 (ave)	

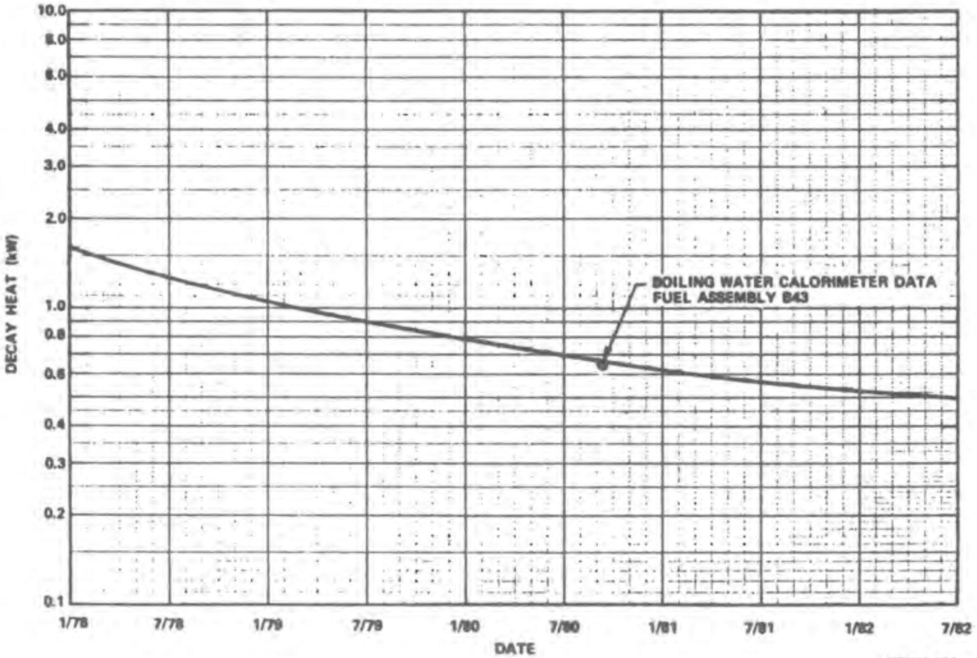

Figure 2.3-3. *Predicted Decay Heat Curve for Fuel Assemblies B02, B03, B41 and B43*

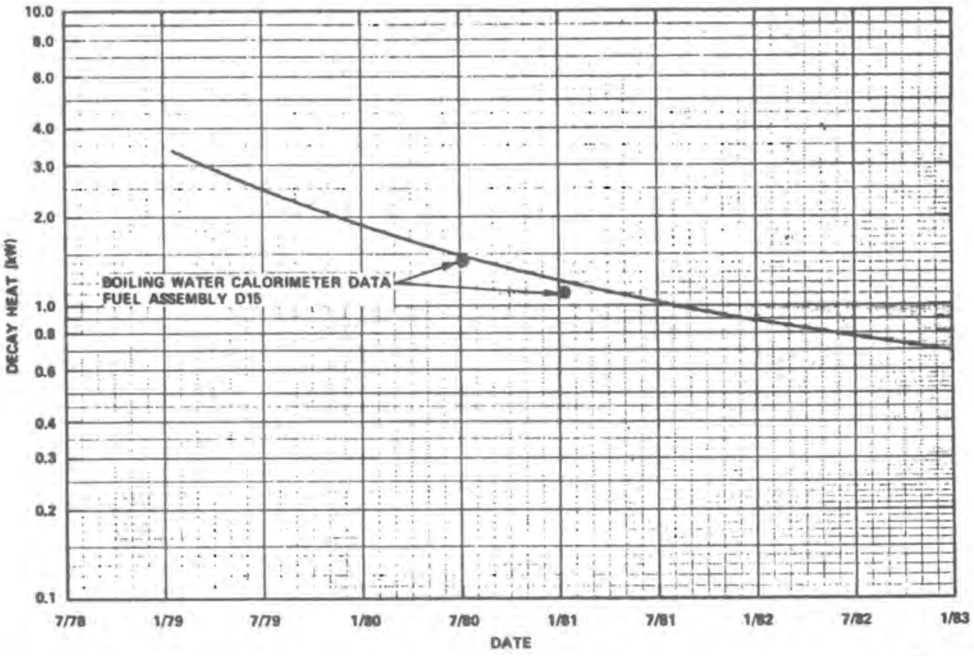

Figure 2.3-4. *Predicted Decay Heat Curve for Fuel Assemblies D01, D04, D06, D15, D35, D40, D46 and D47*

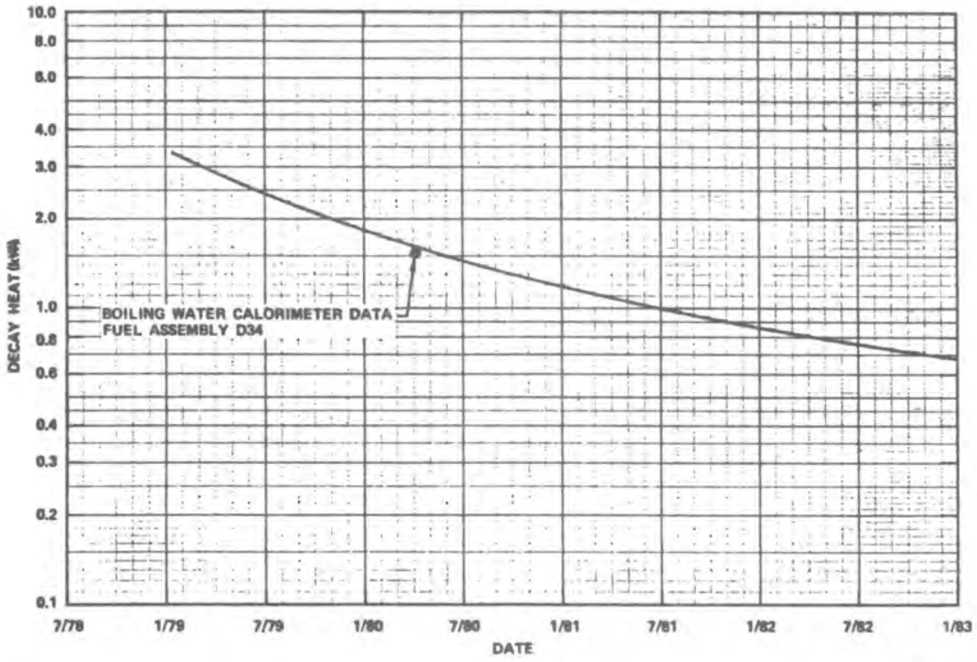

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Figure 2.3-5. Predicted Decay Heat Curve for Fuel Assemblies D09, D16, D18 and D34

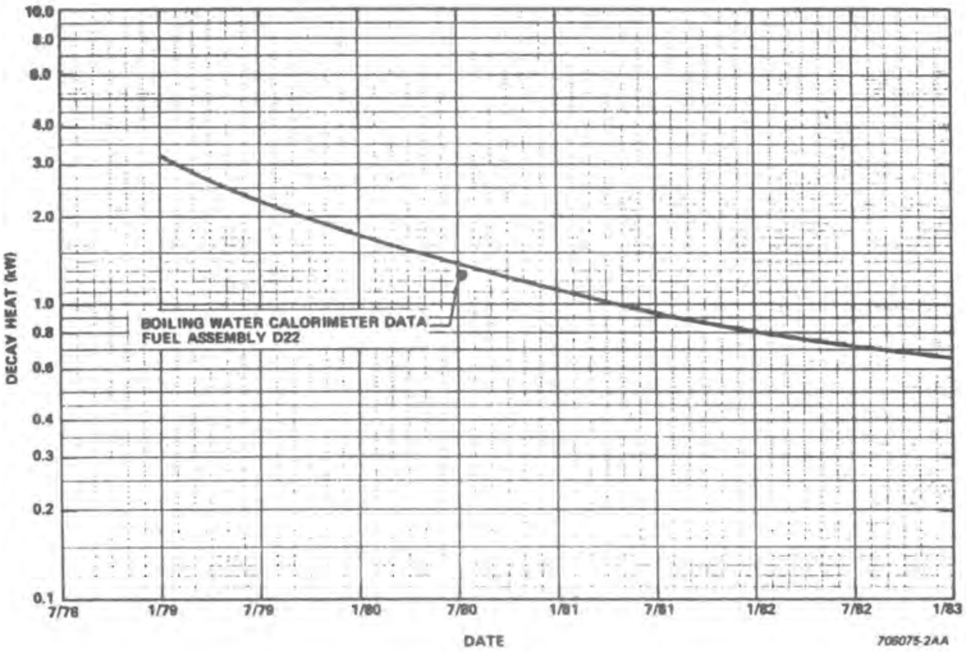


Figure 2.3-6. Predicted Decay Heat Curve for Fuel Assembly D22

3.0 DRYWELL TESTING

The following section describes the drywell testing performed at E-MAD during the period March, 1978 through March, 1982. Included are the test objectives, hardware descriptions, test operations, test results, and thermal analyses for both the Electrically Heated Drywell and Fueled Drywell Tests.

3.1 TEST OBJECTIVES

3.1.1 ELECTRICALLY HEATED DRYWELL TEST

The goals of the Electrically Heated Drywell Test (as defined for the SFHPP 1978 Demonstration) were:

- Objective 1 - To provide data in the form of prototypic drywell canister temperatures which could be used, in conjunction with the Fuel Assembly Internal Temperature Measurement Test, to verify that spent fuel assemblies with a decay heat level of about 1.0 kW could be stored in Nevada Test Site soil without exceeding design temperature limits
- Objective 2 - To checkout instrumentation, construction and installation methods for drywells prior to installing actual drywells for spent fuel storage
- Objective 3 - To provide storage cell thermal response data so that thermal properties and boundary conditions could be accurately determined to calibrate and verify a drywell thermal model

The engineering approach applied to ensure that the Electrically Heated Drywell Test met the above stated objectives included an extensively instrumented drywell and soil test arrangement and a multi-phase confirmation test program. Confirmation Phase I was designed to generate data to support the spent fuel encapsulation in late 1978 (Objectives 1 and 2 above) and Confirmation Phase II was designed to collect test data to support the verification of a drywell thermal model (Objective 3 above). Additional test phases, identified following Confirmation Phase II completion, were designed to generate data to satisfy Objectives 1 and 3 at higher decay heat levels of 2.0 and 3.0 kW.

The Electrically Heated Drywell Test Confirmation Phase I data generation and evaluation would be directed towards providing a basic understanding of the drywell storage cell thermal response. Test Phase I, performed at a nominal constant power level of 1.0 kW (preceeded by an accelerated heatup at 3.0 kW), was intended to verify that the original drywell thermal analyses were sufficiently conservative to negate any concern about spent fuel temperatures. Data evaluation would concentrate on steady-state canister midplane (i.e., hottest) temperatures, on near-field (drywell liner and canister only) temperatures, and on checking out installation and construction methods.

Recognizing that the Electrically Heated Drywell Test is strictly a thermal test and, as such, a tool for thermal model verification, the Confirmation Phase II period of steady-state operation at 1.0 kW would be extended and would include an evaluation of test data directed towards reducing certainties and conservatisms in the drywell thermal model. Test data evaluation was specifically identified for: soil and grout thermal properties, far-field effects, axial temperature effects, seasonal and day/night temperature variations, canister and liner end effects, and transient and steady-state temperature trends. Data evaluation would provide an understanding of the various heat transfer mechanisms present in the test arrangement.

The results of the SFHPP 1978 Demonstration (Test Phases I and II) showed that peak canister temperature and associated fuel cladding temperatures for a 1.0 kW spent fuel decay heat level were well below the design limit. Therefore, for Test Phase III, the power level was raised and drywell response evaluated at 2.0 kW by the Electrically Heated Drywell Test. This additional test was designed to provide canister temperature data which could be used, in conjunction with the Fuel Assembly Internal Temperature Measurement Test and fuel assembly canister thermal models, to determine the maximum decay heat level a drywell storage cell in Nevada Test Site soil could accommodate. The results of Phase III testing showed that peak canister temperature and associated fuel cladding temperature for a 2.0 kW spent fuel decay heat level were still substantially below their design limits. It was decided to extend the Electrically Heated Drywell Test to Phase IV at a power level of 3.0 kW. This extension would provide test data to meet the CWSFP Program objective for the Electrically Heated Drywell Test.

3.1.2 FUELED DRYWELL TEST

The objectives of the spent fuel Drywell Test (as defined for the SFHPP 1978 Demonstration) were:

- Objective 1 - To verify that spent fuel assemblies can be safely stored in Nevada Test Site soil
- Objective 2 - To determine storage cell thermal properties and interface and boundary conditions to calibrate and verify thermal models
- Objective 3 - To determine thermal interactions of adjacent drywells

The test objectives would be met by a combination of actual test results and calibrated computer model predictions. Encapsulated spent fuel assemblies would be installed into drywells and the thermal response of the canisters, drywell liners, and surrounding soil would be recorded. In addition, a computer model of the drywell would be compared with the test results and would be used to evaluate drywell performance beyond the test limits.

The maximum canister temperature level attained would be compared with the Fuel Assembly Internal Temperature Measurement Test measured temperatures and existing fuel assembly and canister thermal models to evaluate drywell performance. Acceptable drywell storage capabilities were verified if fuel cladding temperatures were less than the 715°F criteria.

Transient test results would be compared to computer code predictions using the decay heat versus time predicted for the actual spent fuel assembly as input. Computer model thermal property and heat transfer correlation revisions would be made as necessary to update the model for good model/test agreement. This agreement would qualify the computer model for use in the evaluation of various decay heat level fuel assembly storage and conceptual drywell spacing variations.

Due to delays in completion of the Fuel Assembly Internal Temperature Measurement Test and in procurement of boiling water reactor (BWR) spent fuel assemblies, the Drywell Test was limited to two drywells rather than the four originally planned. Two drywells were chosen to provide data for two thermally isolated drywells. The computer model to be used would be limited to a single thermally isolated drywell for comparison with results of the two isolated drywells. This first portion of the Isolated Drywell Tests had a heat decay level of approximately 1.0 kW.

A higher decay heat level (approximately 1.25 kW) spent fuel assembly was installed in the fourth drywell to evaluate isolated drywell response to higher power levels. This additional portion of the Drywell Test was termed the Phase II Isolated Drywell Test.

As part of the CWSFP Program, several additional objectives were identified. To complete the originally planned testing, an Adjacent Drywell Test (Phase III) was identified to use three of the SFHPP 1978 Demonstration PWR spent fuel assemblies placed in adjacent drywells spaced 25 feet apart. This test was to provide additional data to be used in evaluating drywell arrays and in comparing computer code predictions for drywell arrays.

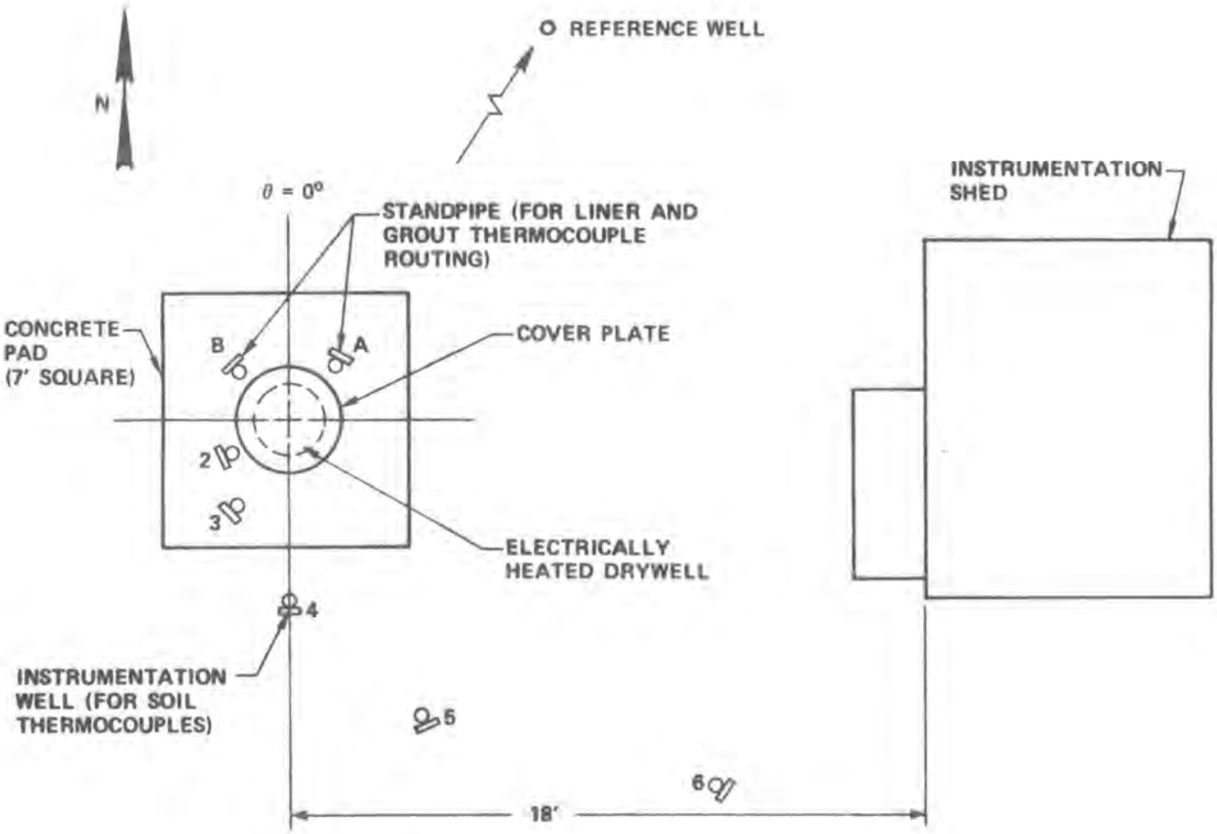
3.2 HARDWARE DESCRIPTIONS

This section describes in detail the hardware for the Electrically Heated Drywell Test and the Fueled Drywell Tests. The descriptions focus on the specific test articles, instrumentation, and overall arrangement of the test hardware to allow independent modeling of the test configurations. Details of the construction and installation operations used to assemble the test hardware including identification of hardware not essential to modeling the test arrangement (conduit and pipes for routing instrumentation, positioning of auxiliary test equipment, etc) is included in Appendix B. The overall arrangement of the drywells in relation to the E-MAD building and other tests is shown in Figure 2.2-2.

3.2.1 ELECTRICALLY HEATED DRYWELL TEST

3.2.1.1 GENERAL ARRANGEMENT

The Electrically Heated Drywell Test general arrangement is shown in Figure 3.2-1. The test hardware consists of: 1) a drywell liner grouted into a 26 inch diameter hole drilled approximately 19 feet deep, 2) a test canister assembly consisting of a canister body, a closure lid, and a concrete-filled shield plug to support the test canister from the top of the liner, 3) an electric heater assembly containing four tubular heater elements, 4) an array of soil instrumentation wells to measure ground temperature response, 5) an electric power supply control panel



INSTRUMENTATION WELL LOCATIONS:

WELL	RADIUS	ORIENTATION (CW)
2	21.0"	240°
3	33.0"	210°
4	60.0"	180°
5	108.0"	155°
6	189.0"	130°
REFERENCE	720.0"	30°

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Figure 3.2-1. Electrically Heated Drywell General Arrangement

for heater power control, and 6) a data acquisition system to record thermocouple data. Figure 3.2-2 provides a detailed illustration of the Electrically Heated Drywell Test drywell and installed hardware. Figure 3.2-3 shows the relative dimensions and elevations of the installed hardware. A map of thermocouple locations and identification of the data acquisition system channel number to which each thermocouple is attached is provided in Figure 3.2-4. A description of the Electrically Heated Drywell Test construction and hardware installation has been provided in Appendix B.

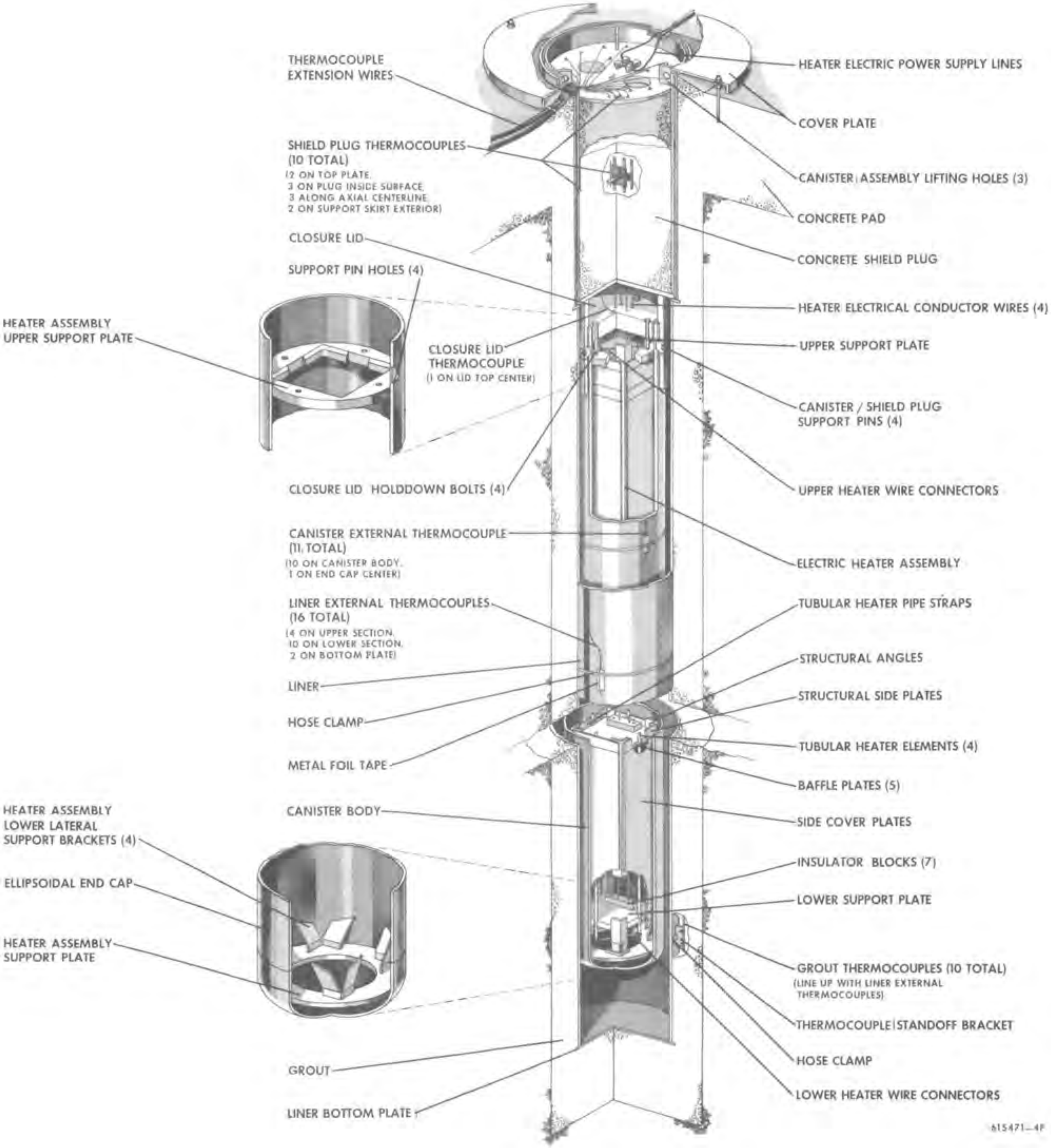

Figure 3.2-2. Electrically Heated Drywell Test Configuration

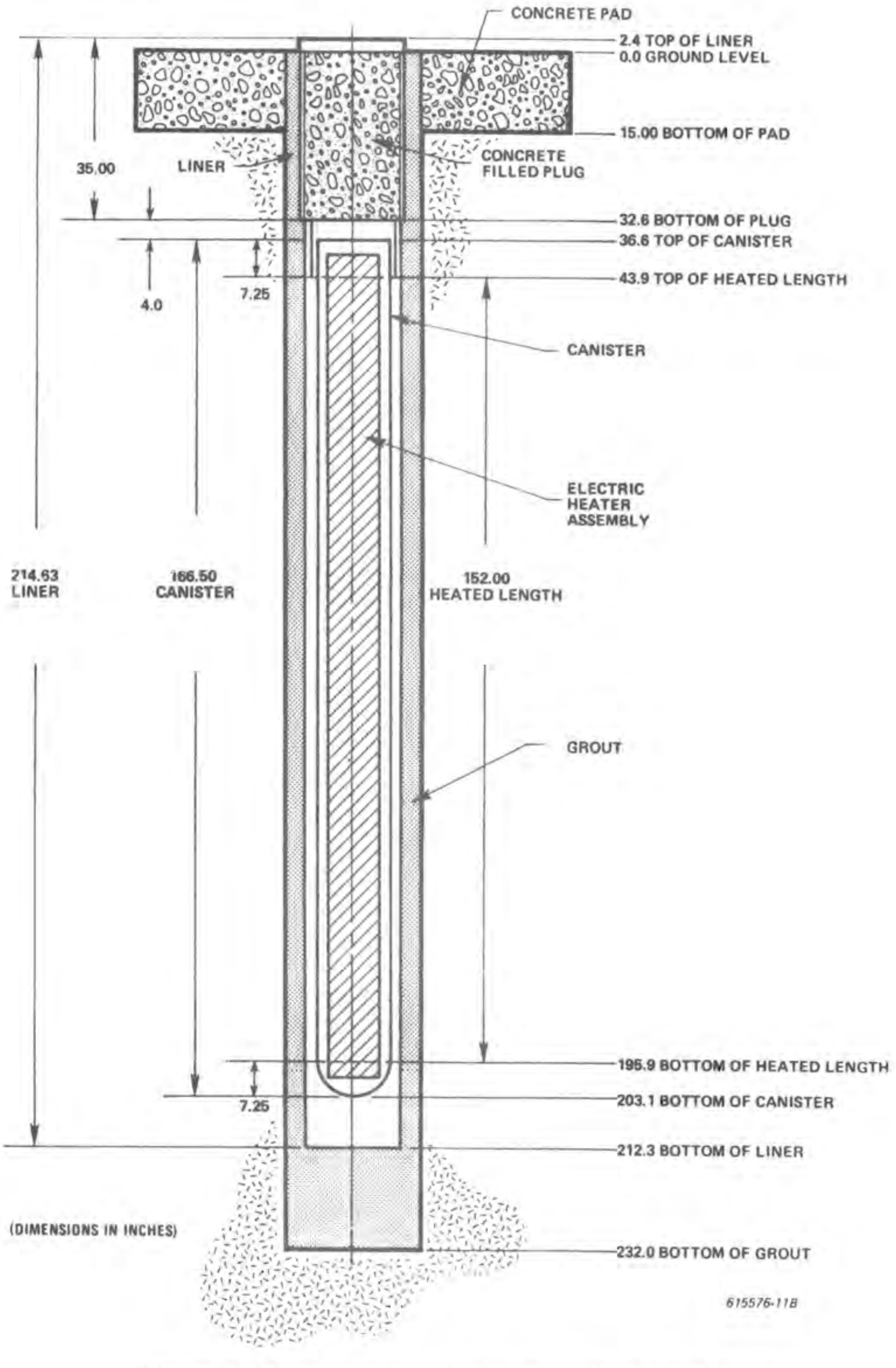

Figure 3.2-3. Electrically Heated Drywell Test Schematic

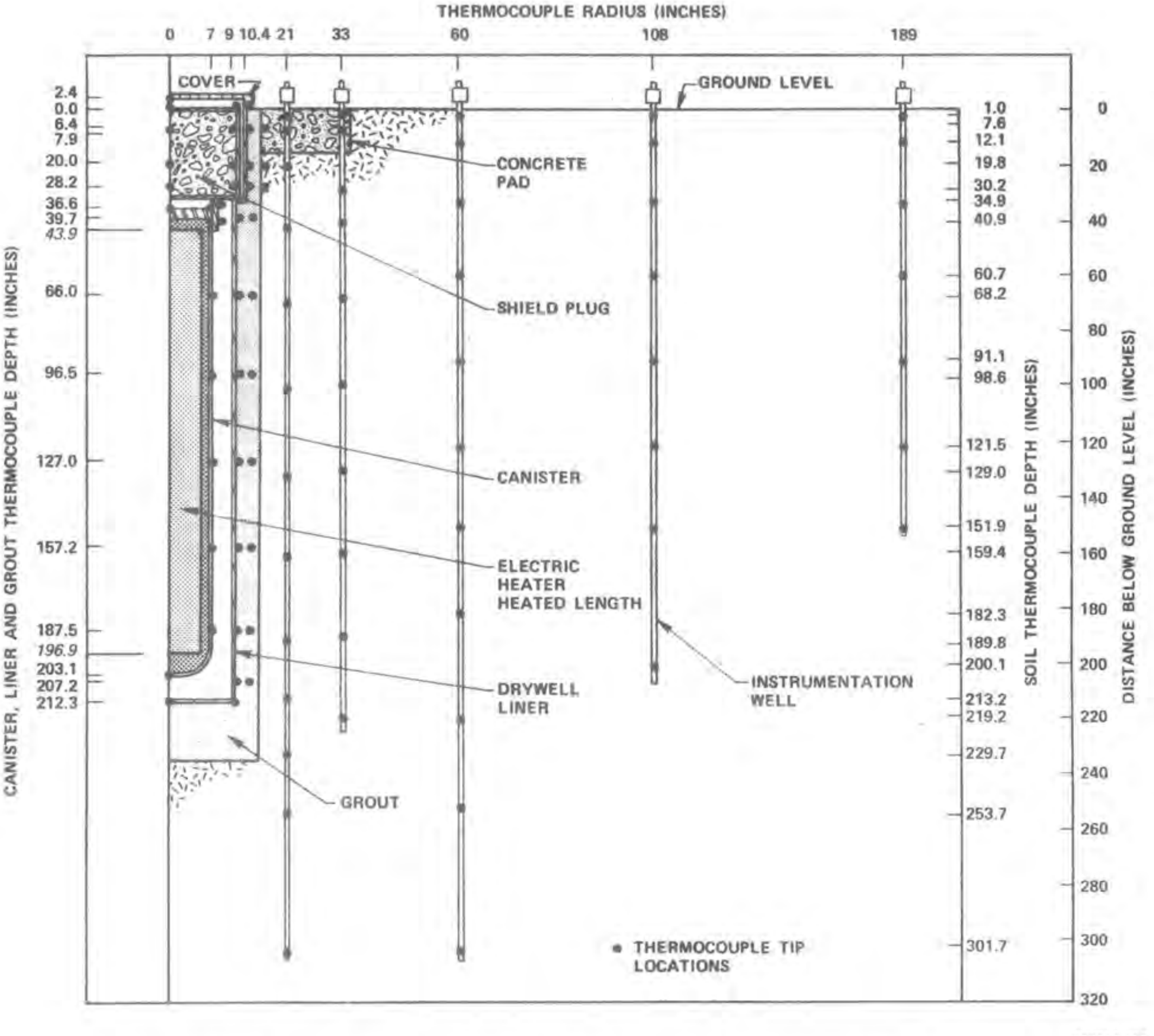

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Figure 3.2-4. Electrically Heated Drywell Test Thermocouple Locations

3.2.1.2 DRYWELL LINER

The liner lower section consists of a 15 foot long section of 18 inch diameter by 0.25 inch thick pipe. The liner upper section is manufactured from a 3 foot long, 0.25 inch thick plate which was rolled to form a cylinder having a 20.25 inch nominal inside diameter. The upper and lower sections of the liner are positioned concentrically to one another and welded to opposite sides of a 21 inch outside diameter, 17.5 inch inside diameter, 0.375 inch thick ring. This ring forms the ledge on which the 20 inch diameter shield plug (connected to the canister assembly) is supported. A 20 inch diameter, 0.375 inch thick plate is welded to the bottom of the lower portion of the liner to seal the lower end. The liner material is carbon steel.

LINER INSTRUMENTATION

There are 26 thermocouples secured to the liner. Sixteen thermocouples are attached directly to the liner exterior surface while ten are positioned in the grouted region surrounding the liner after installation. Liner thermocouple installation photographs are shown in Figures 3.2-5 and 3.2-6.

Eleven of the sixteen thermocouples which are attached directly to the liner exterior surface are arranged in an axial column at spacings varying from 8.8 inches below the top of the liner to the liner bottom plate. The positions are tabulated in Table C-1. At one axial elevation (98.7 inches from the top of the liner), there are three additional thermocouples oriented at 90, 180 and 270° from the thermocouple column to form a circumferential array around the outside diameter of the liner. This array corresponds to a similar circumferential array on the canister assembly. There is an additional thermocouple at the center of the bottom plate and one near the top of the liner. The thermocouple tip of the top-most thermocouple is offset at 30° from the axial column to avoid interference

Figure 3.2-5. Thermocouples Installed on Liner

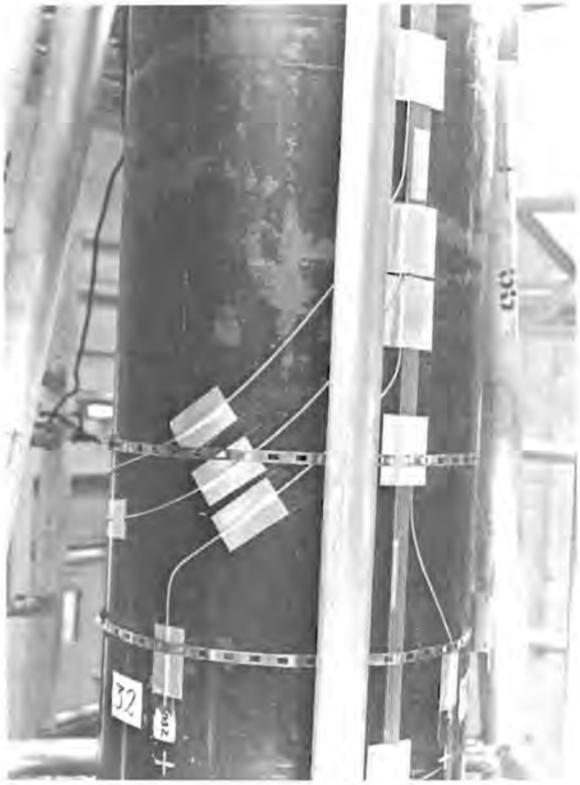

Figure 3.2-6. Thermocouple Bead Routing on Liner

with the orientation and handling features present on the liner upper surface.

Of the sixteen thermocouples attached directly to the liner outside surface, four are on the upper portion, ten are on the lower portion, and two are on the liner bottom plate. All sixteen are secured to the outside of the liner using metal foil tape and large diameter stainless steel hose clamps. The thermocouples were taped to the exterior surface of the liner ensuring contact with the liner. The thermocouple tip extends approximately 0.5 inches below the tape (i.e., the tape is not in direct contact with the thermocouple tip). The thermocouple at the center of the liner bottom plate is tack-welded to the bottom plate by a small sheet metal dimpled bracket.

Ten thermocouples are attached to the liner exterior with the bottom 6 to 12 inches supported by a bracket which places the thermocouple tip about 1.8 inches away from the liner surface. This standoff distance places the thermocouple tip in the approximate center of the ring of grout between the liner and the drilled emplacement hole. Each standoff bracket consists of a 0.25 inch thick by 3 inch long PVC plate strapped to the liner using large diameter hose clamps and epoxied into position on the liner exterior. The thermocouple sheathing is bent away from the liner and wire wrapped in two places to the 0.25 inch by 3 inch long face of the standoff bracket. The axial elevations of the thermocouple tips correspond to the thermocouple tips secured directly to the liner exterior surface.

LINER INSTALLATION

The fully-instrumented liner assembly was grouted into a 26 inch diameter 19 foot deep hole drilled into E-MAD soil. A photograph of the liner and its installation is shown in Figure B-5. An 84 inch square by 15 inch thick concrete pad is provided at the top of the electrically heated drywell. This pad simulated that which would exist at the top of an actual storage cell. The pad construction is shown in Figure B-4. After the liner was positioned into the emplacement hole, the annulus was filled with high conductivity Luminite grout. The grout consisted of two parts soil removed from the emplacement hole to one part Luminite. Figure 3.2-7 provides a photograph of the installed liner and the cracks which formed when the power level was decreased. Details of liner installation operations are contained in Section B.1.1.

3.2.1.3 CANISTER ASSEMBLY

The canister assembly consists of the following components: canister body, closure lid, and shield plug. The canister assembly is shown in Figure 3.2-8 during a trial fitup with the liner. The following describes each of these components.

CANISTER BODY

The canister body for the Electrically Heated Drywell Test consists of a 160 inch long section of 14 inch diameter, 0.375 inch thick 304 stainless steel pipe welded to a standard 14 inch diameter, 6.5 inch high ellipsoidal end cap. Welded into the end cap is a 13.25 inch outside diameter, 8.5 inch inside

Figure 3.2-7. Cracks in Grout Around Liner, Formed When Power Was Reduced From 3 kW to 1 kW

diameter, 0.5 inch thick 304 stainless steel ring. Welded to this ring are 4 sheet metal brackets which form the corners of an 8.26 inch square which mate with the lower end of the electric heater assembly. The brackets also serve as funnels to guide and center the heater assembly (which sits on the ring welded into the ellipsoidal end cap). These features are shown in Figure 3.2-2.

Welded into the canister body 4.5 inches below the canister top surface is a 13.25 diameter, 1.0 inch thick 304 stainless steel plate containing an 8.5 inch square chamfered opening. This plate and opening provides centering and support for the upper end of the electric heater assembly. The outside upper surface of the canister body contains four blind holes equally spaced around the pipe circumference for the attachment of the shield plug (described later).

This canister body simulates the actual storage canister in terms of material, size and shape. These were judged to be the most important parameters since they provide for proper thermal simulation of the conductivity, thermal diffusivity, and total radiating area of an actual canister. The major difference between the test canister and an actual storage canister is found in the canister internal features. An actual storage canister contains an internal cage formed by four structural angles tied together laterally by rectangular plates at six elevations. This internal cage provides support

Figure 3.2-8. Electrically Heated Drywell Test Canister Assembly Prior to Fitup with Liner

along the entire length of an encapsulated pressurized water reactor spent fuel assembly. Thermally, it acts as a thermal radiation barrier at the corners of the fuel assembly. Although the test canister body does not contain this cage, its presence is simulated by the electric heater assembly which uses four structural angles along its entire length.

An actual storage canister differs from the test canister in the following additional areas:

- Different bottom support for a fuel assembly
- No top support plate
- Instrumentation tubes on the exterior of the canister body
- Helium rather than air in canister

The mechanical differences are judged to have a negligible effect on the thermal results. The air backfill media is judged to have some effect in that the air conductivity and density differences produce a canister temperature profile differing in shape from a helium filled canister temperature profile.

CANISTER INSTRUMENTATION

There are eleven thermocouples attached to the canister body exterior surface. These thermocouples are attached at various angular orientations and at six different elevations, including one on the bottom center of the ellipsoidal cap. The thermocouple attachment method is the same as used for the liner (see the Liner Instrumentation section). The thermocouple locations are tabulated in Table C-1.

CLOSURE LID

The test canister closure lid is a 13.25 inch diameter, 2.5 inch thick 304 stainless steel plate. It contains four through-holes which accept 0.5 inch diameter bolts which thread into the upper support plate of the canister body. Four small spacers extend from the bottom surface of the lid to control the axial positioning when installed in the canister body. After assembly, the annular gap between the closure lid and the canister body was filled and sealed with adhesive cement to better simulate a sealed canister containing fuel.

There are four additional holes in the closure lid through which the electric heater assembly conductor wires are routed. These holes are lined with a stack of high temperature interlocking ceramic tubes cemented in place. These ceramic insulators protect the conductor wires from inadvertently grounding to the closure lid.

CLOSURE LID INSTRUMENTATION

There is one thermocouple attached to the top center of the canister closure lid. This thermocouple is attached by a small sheet metal dimpled bracket which is tack-welded to the top surface of the closure lid. The thermocouple tip is inserted through the dimple on the bracket and held in contact with the closure lid top surface. A second thermocouple is supported from the shield plug and contacts the closure lid near the outside diameter of the lid. This thermocouple is attached to the underside of the shield plug bottom plate by a tack-welded sheet metal bracket and extends at a 45° angle from the shield plug plate.

SHIELD PLUG

The test shield plug simulates the concrete-filled shield plug design used in actual spent fuel storage. The canister assembly is supported from this plug which, in its installed condition, rests on the ledge in the top of the drywell liner.

The shield plug consists of a 34 inch long section of 20 inch diameter, 0.25 inch thick carbon steel pipe which has a circular plate welded to both ends. The top plate is a 19.5 inch diameter, 0.25 inch thick carbon steel plate positioned about 2 inches below the top surface of the pipe. This 2 inch indentation provides space for the bundling and connection of instrumentation and power leads from the canister assembly. The top plate contains two 4 inch diameter holes for the installation of concrete and three lifting brackets for handling the entire assembled canister assembly. These features are shown in Figure 3.2-9.

Figure 3.2-9. Top View of Electrically Heated Drywell Test Canister Assembly Shield Plug Fitup Inside Liner

The shield plug bottom plate is a 20 inch diameter, 0.5 inch thick carbon steel plate which is welded to the face of the 20 inch pipe. Extending from and welded to the bottom plate is an 11 inch long "skirt" of 16 inch diameter, 1.031 inch thick carbon steel pipe. The inside diameter of this skirt is machined to closely fit the outside of the canister body. There are four threaded holes in this skirt which line up with the four blind holes machined into the top portion of the canister body. These threaded holes accept large diameter threaded pins. It is through these pins that the canister is supported from the shield plug.

Fifteen 0.375 inch outside diameter, 0.035 inch thick carbon steel tubes extend from the top to the bottom shield plug plates. Thirteen tubes are spaced on a 16.5 inch diameter circle and provide a routing path for the 11 canister thermocouple leads and for two shield plug skirt thermocouple leads. The canister thermocouple leads run along the canister exterior surface, past the shield plug skirt into these tubes, and exit the top surface for routing to the data acquisition system.

Two additional tubes are located on a 10 inch diameter circle and provide for routing of canister and closure lid upper surface thermocouples. One provides a routing path for the thermocouple leads for the thermocouple attached to the top center of the closure lid. The other provides a routing path for a spring loaded thermocouple which contacts the outer rim of the canister body after it is installed inside of the shield plug skirt. There are an additional four 0.5 inch outside diameter by 0.035 inch thick carbon steel tubes extending from the top to the bottom shield plug plates. These four tubes are arranged in a close rectangular pattern (1.76 inches by 1.5 inches) and provide for routing the four conductor wires from the heater assembly. The shield plug instrumentation and conductor wire tubes are shown in Figure 3.2-9. Figure 3.2-10 provides a photograph of the completed Electrically Heated Drywell Test assembly.

SHIELD PLUG INSTRUMENTATION

In addition to two thermocouples attached to the outside surface of the shield plug skirt, eight additional thermocouples are attached to the shield plug. Two of these are attached to the top plate of the shield plug using the small dimpled sheet metal brackets described earlier. One of these thermocouples is at the center of the top plate, the other at the outside edge. Three thermocouples are located in the internal cavity of the plug slightly offset from the axial centerline at a radius of 0.7 inches. These thermocouples are supported from small gusseted brackets attached to the two innermost 0.5 inch diameter by 0.035 inch thick tubes described earlier. These thermocouples were installed prior to the pouring of concrete into the shield plug cavity. The remaining three thermocouples are installed along the inside wall of the shield plug body at the same axial elevation as those along the axial centerline of the plug. These thermocouples are inserted into holes in small pins which are threaded through the shield plug wall.

3.2.1.4 ELECTRIC HEATER ASSEMBLY

The electric heater assembly consists of four tubular heater elements mounted in an 8.42 inch square steel frame. The frame outer dimensions and the heater power profile approximate those of a pressurized water reactor fuel assembly. Details of the heater assembly are shown in Figure 3.2-11.

The electric heater assembly frame consists of four 1.5 inch by 1.5 inch by 160 inches long by 0.12 inches thick 304 stainless steel

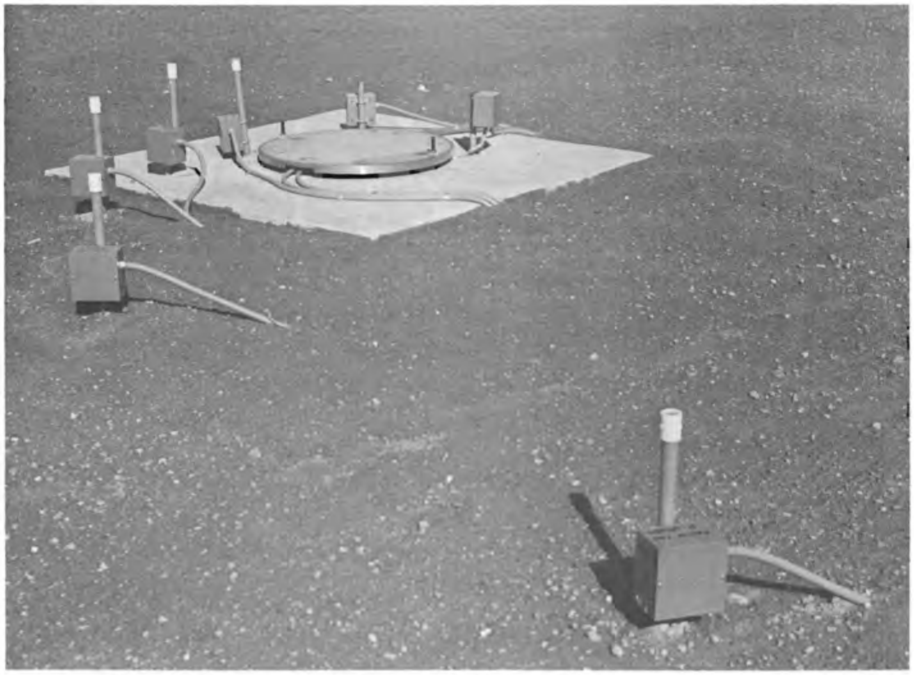

Figure 3.2-10. Electrically Heated Drywell Test Installation Completed With Drywell Cover in Place

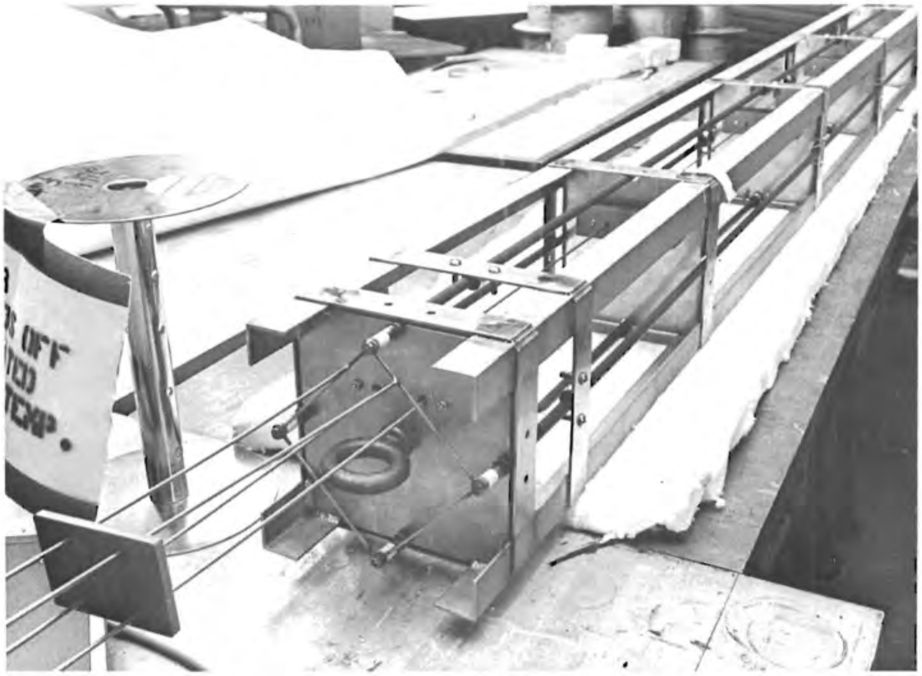

Figure 3.2-11. Electric Heater Assembly

angles which are tied together by a series of four stainless steel plates welded to the angles at nine elevations. These structural side plates are 1.5 inches high by 0.109 inches thick. Inside the angles, five baffle plates (7.92 inch square, 0.048 inch thick 304 stainless steel) and a top and bottom plate (7.92 inch square, 1.25 inch thick and 0.75 inch thick, respectively, 304 stainless steel) are welded at various elevations. These plates are provided to reduce convection currents within the heat assembly (simulating the fuel assembly grids). Outside the angles, cover plates of 0.05 inch thick 304 stainless steel are welded to the angles between the structural side plates to enclose all but the top and bottom 2.5 inches of the frame.

Four tubular heaters are secured inside the heater frame by screw-mounted pipe straps on the middle seven structural side plates. Each heater is located at the center of one side of the heater frame. Clearance holes are provided in the internal baffle plates and the top and bottom plates for the heaters. The tubular heaters are 0.43 inches in diameter by 156 inches long with a 0.049 inch thick incoloy sheath. The heaters have a precision-wound nickel chromium wire heating element rated at 4 kW heat output at 240 volts. The heaters have 2 inches of unheated section at each end and have threaded stud terminals at each end for electrical connections. A locator ring is welded to the heater sheath about 0.5 inches from one end. The heaters are capable of operating at about 1600°F at rated power.

The tubular heaters are interconnected at the top and bottom by a series of four 0.125 inch diameter 304 stainless steel wire assemblies. Each assembly has a 0.06 inch thick steel washer welded to both ends which fits over the heater stud terminal. Two wire assemblies at the lower heater end have 210 inch long wires which extend through the interior of the heater assembly to approximately 50 inches above the heater frame. Two wire assemblies at the top of the heaters have 54 inch long wires which extend approximately the same distance above the heater frame. All wire assemblies are secured to the heater stud terminals between the two hex nuts provided and then brazed to the nuts. The two heater conductor wires which extend through the heater interior pass through all seven interior plates. Clearance holes are provided in each plate and insulator blocks of marimet (through which the conductor wires pass) are bolted to each of the plates. The four conductor wires are arranged in a rectangular pattern and pass through ceramic insulators in the closure lid and through tubes in the shield plug.

Prior to the completion of heater assembly fabrication, the heater subassembly was heated to approximately 4 kW. This power output was maintained for 48 hours to allow heater off-gassing and to verify proper heater operation. The photograph of the heater assembly shown in Figure 3.2-11 was taken prior to this heater "burn-in" period. After "burn-in", the insulating blocks were tightened and the heater cover plates installed. Prior to installing the assembly into the test canister, a stack of high temperature interlocking ceramic tubes was assembled on each of the conductor wires and cemented together. This insulation between the conductor wires and the shield plug tubes prevented inadvertent grounding of the wires.

3.2.1.5 INSTRUMENTATION WELLS

The soil surrounding the electrically heated drywell was instrumented with 49 thermocouples divided and grouped into five wells. The instrumentation wells are oriented in a spiral pattern around the drywell so as not to affect the soil thermal conductivity between the electrically heated drywell and instrumentation well and thus not affect soil thermal response readings. The spatial location is defined by a radius and angle with respect to the drywell axial north-south centerline (defined as 0°) as shown in Figure 3.2-1.

Each instrumentation well consists of a 1 inch diameter schedule 80 PVC pipe grouted into a 3 inch diameter hole drilled into E-MAD soil. A typical instrumentation well is illustrated in Figure 3.2-12. The sheathed thermocouples for each well were attached to the outside surface of the PVC pipe at various axial locations. The thermocouples were attached using wire ties and epoxy cement. Table C-1 provides the location data for the thermocouple array on the instrumentation wells.

Figures B-6 and B-7 show photographs of instrumentation well installation. The top of each instrumentation well extended above ground level where an enclosure box was provided to attach the flexible conduit routed to the instrumentation shed. The enclosure boxes and flexible conduit were used to route the thermocouple leads after installation of the well and conduit.

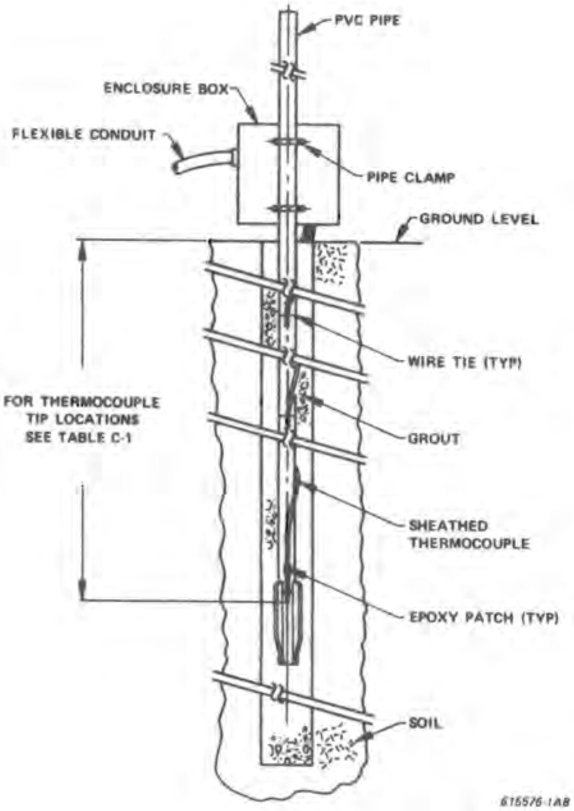

Figure 3.2-12. Electrically Heated Drywell Test Instrumentation Well Configuration

Details of the instrumentation well installation operations are contained in Section B.1.1.

A sixth well was spaced 60 feet from the center of the liner and designated as a Reference Well to provide soil temperatures unaffected by the test heat source. The Reference Well consists of a 1 inch diameter schedule 80 PVC pipe with sheathed thermocouples attached using wire ties only. The Reference Well is grouted into a 3 inch diameter hole, similar to the instrumentation wells, and is completely buried. The Reference Well thermocouples are routed through a buried pipe to the instrumentation shed. Details of Reference Well installation operations are contained in Section B.1.1.

3.2.1.6 HEATER POWER CONTROL

Power to the four tubular heaters in the electric heater assembly is controlled by a variable voltage power transformer located in an instrumentation shed. The environmentally-controlled instrumentation shed is located 18 feet from the electrically heated drywell as shown in Figure 3.2-1. The transformer is mounted on the cover of a waterproof, dustproof electrical enclosure. The transformer accepts a 120 volt AC input and has an adjustable output capability of 0 to 140 volts, and is rated for 7 kW.

Mounted to the controller electrical enclosure are two meters to determine transformer power output. A 0 to 150 volt AC voltmeter and a 0 to 50 amp ammeter are mounted above the transformer on the electrical enclosure cover. A digital voltmeter, located in the instrumentation shed and attached to the top of the heater conductor wires provides more accurate voltage readings. Adjustments to the test power level are made based on the current measurement of the controller meter and the voltage measurement of the digital voltmeter.

Also mounted to the controller electrical enclosure is a powerline monitor chart recorder. The recorder continuously monitors the input voltage for fluctuations, and the strip chart recording provides a permanent record of applied voltage. The electrical wiring from the heater power control to the electric heater assembly is enclosed in underground flexible conduit for protection.

3.2.1.7 DATA ACQUISITION SYSTEM

The data acquisition system for the Electrically Heated Drywell Test consists of the array of thermocouples, two remote signal conditioning/multiplexing units, and the E-MAD data logger. The thermocouples are attached to the test hardware as described earlier in this section of the report. The thermocouple leads are routed through flexible conduit to the multiplexer units located in the instrumentation shed. Multiplexer signal cables are routed through an underground pipe to the data logger (see Section A.5.5).

THERMOCOUPLES

All thermocouples used in the Electrically Heated Drywell Test described in the previous sections consist of a Type K, chromel-alumel thermocouple with an ungrounded junction enclosed in a 0.125 inch diameter 304 stainless steel sheath. Two 24 gage, Type K extension wires are brazed to the thermocouple wires and are enclosed in a 0.187 inch diameter by 0.028 inch thick by 2.75 inch long stainless steel transition boot. The transition boot is crimped onto the end of the thermocouple cable sheath and filled with epoxy.

3.2.2 FUELED DRYWELL TEST

3.2.2.1 GENERAL ARRANGEMENT

The Drywell Test hardware arrangement is shown in Figures 3.2-13, 3.2-14 and 3.2-15. The test hardware consists of: 1) a drywell liner grouted into a 26 inch diameter hole drilled 23 feet deep, 2) a canister assembly, consisting of a canister body, a closure lid

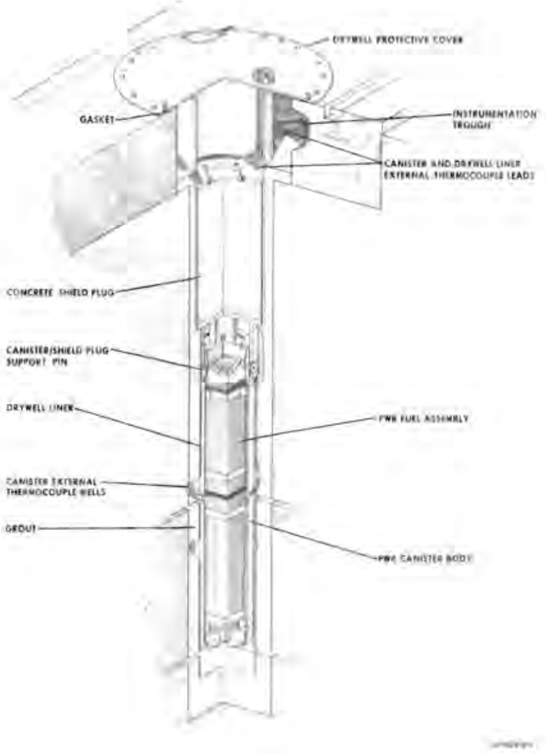

Figure 3.2-13. SFHPP Fueled Drywell Configuration

and a concrete-filled shield plug, which supports the canister from the liner, 3) a PWR spent fuel assembly, 4) an array of soil instrumentation wells to measure ground temperature response, and 5) a data acquisition system to record thermocouple data. A description of the Drywell Test storage area construction and hardware installation have been included in Appendix B.

3.2.2.2 DRYWELL LINER

The drywell liner is illustrated in Figure 3.2-16. The liner lower section consists of a 17 foot long section of 18 inch diameter by 0.375 inch thick pipe. The liner upper section is manufactured from a 51.5 inch long, 22 inch diameter, 0.75 inch thick pipe. The upper and lower sections of the liner are positioned concentrically to one another and welded to opposite sides of a 22 inch outside diameter, 17.25 inch inside diameter, 0.5 inch thick ring. This ring forms the ledge which supports the 20 inch diameter shield plug (connected to the canister assembly). A 20 inch diameter, 0.5 inch thick plate is welded to the bottom of the liner lower portion sealing the lower end. Four 1 inch diameter holes spaced 90° apart are located 1.5 inches below the top of the liner for handling and installation. The liner material is carbon steel. The assembled liner is shown in Figure 3.2-17.

LINER INSTRUMENTATION

Nine tubes, with a 0.156 inch outside diameter and 0.086 inch inside diameter are attached to the outside of the liner and serve as thermocouple wells. The nine tubes extend from about 17 inches below the liner top to about 2 inches from the liner bottom. The tubes are clamped to the liner by ten large hose clamps. The tubes are secured to the liner near the top and bottom and at two intermediate points by 0.03 inch thick brackets spot welded to the liner as shown in Figure 3.2-16.

The thermocouple tubes are oriented around the liner in three groups as shown in Figures 3.2-15 and 3.2-16. The first two groups each contain three tubes that are spaced 30° apart. The middle tubes of these groups are 180° apart. The third group has three tubes banded together. The middle tube of this group is spaced 90° from the middle tubes of the other groups. The six

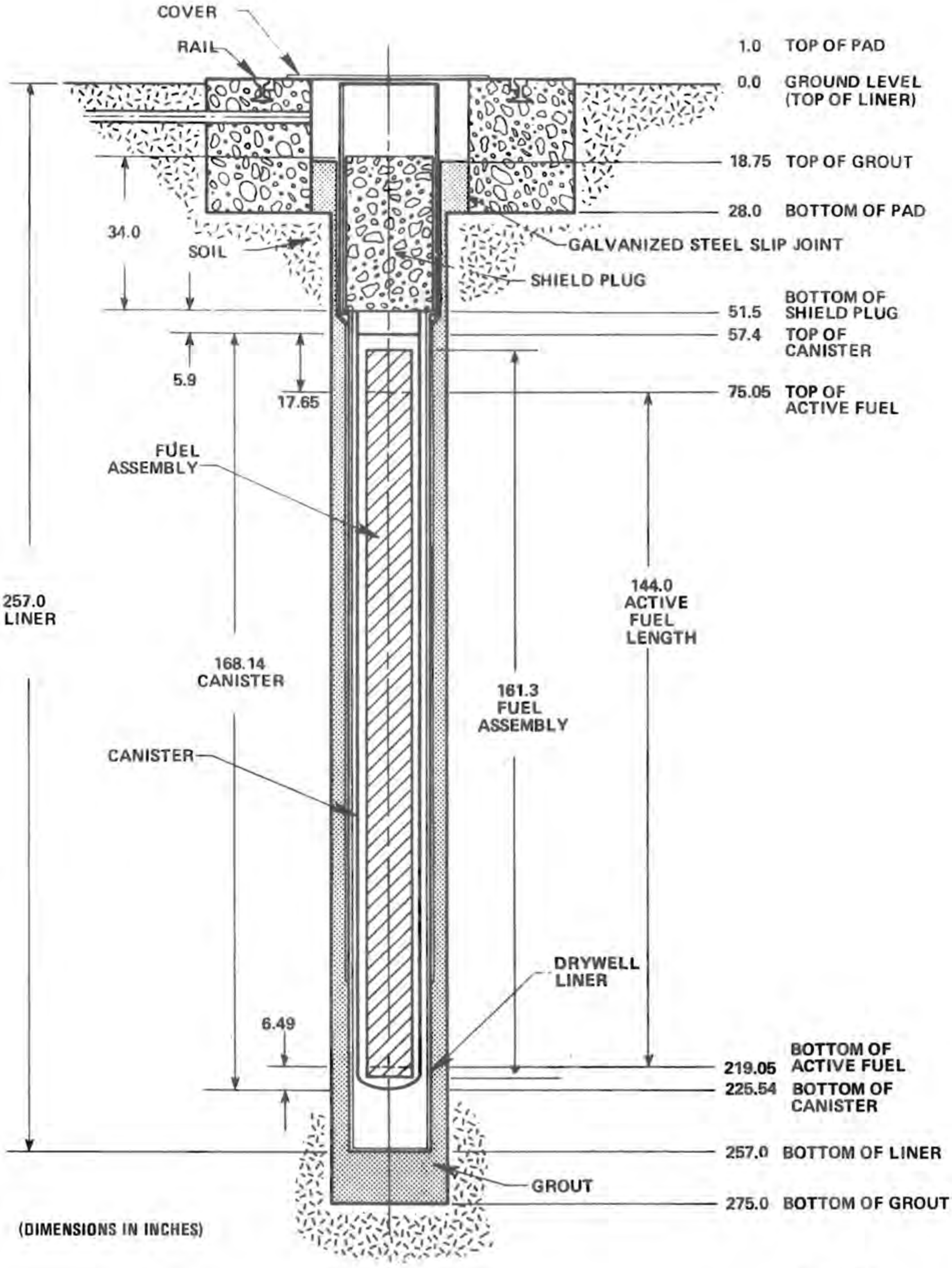

Figure 3.2-14. Fueled Drywell Schematic

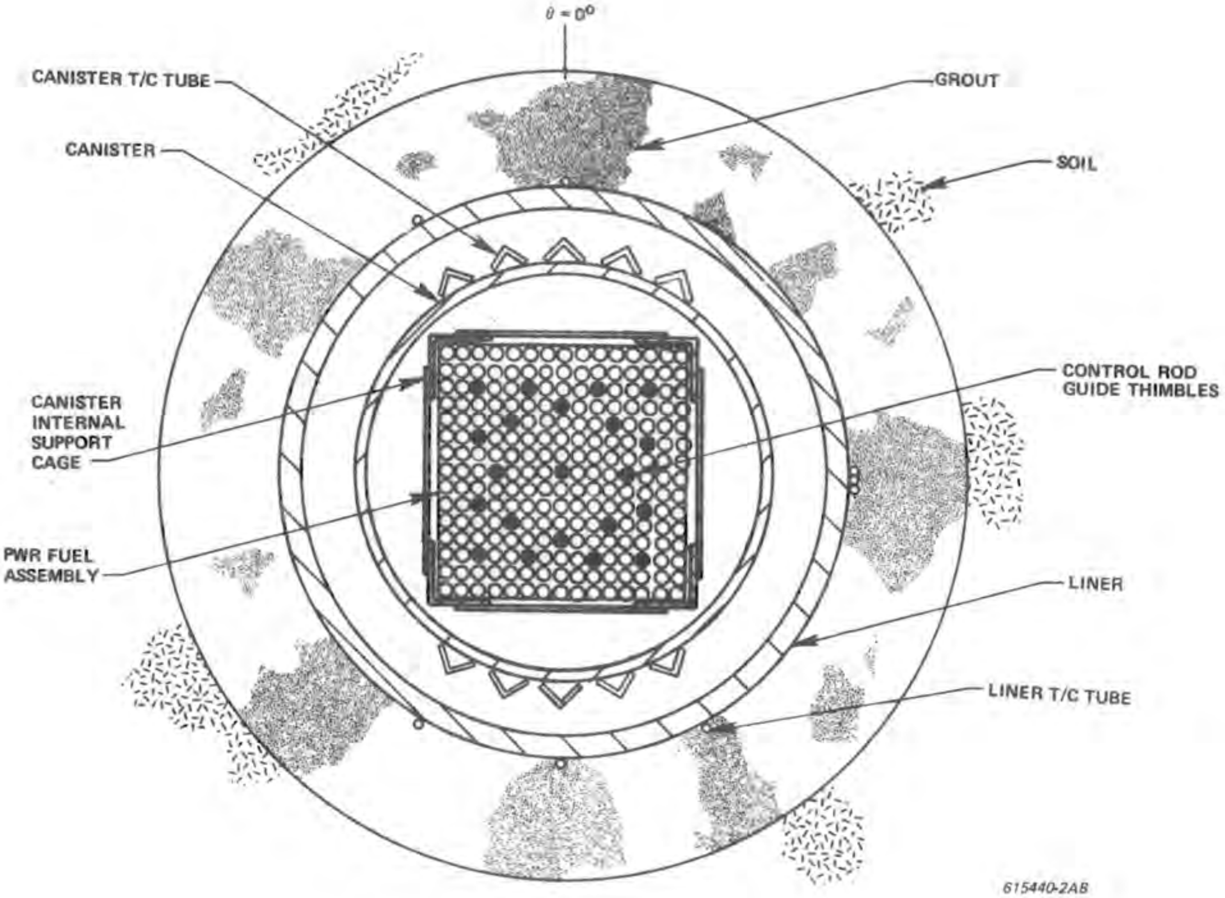

Figure 3.2-15. Drywell Section View

thermocouple tubes spaced 30° apart match six of the ten thermocouple tubes on the installed canister. The third group of thermocouple tubes provides additional circumferential temperature reading positions. The tubes allow thermocouple installation to any elevation. The ends of the tubes are swaged and tack-welded to prevent grout from entering during liner installation.

The installed elevation of the thermocouples in the tubes is controlled by the thermocouple length. The thermocouples are inserted until the transition boot between thermocouple and extension lead contacts the tube top thus controlling the position of the thermocouple tip. One thermocouple is positioned at the middle of the fuel assembly active fuel length, another about one foot above the bottom of the active fuel and the other about one foot below the top of the active fuel. These positions line up with positions on the canister. Tables D1-1, D2-1, D3-1, D5-1 and D5-8 provide depth and position data for the installed

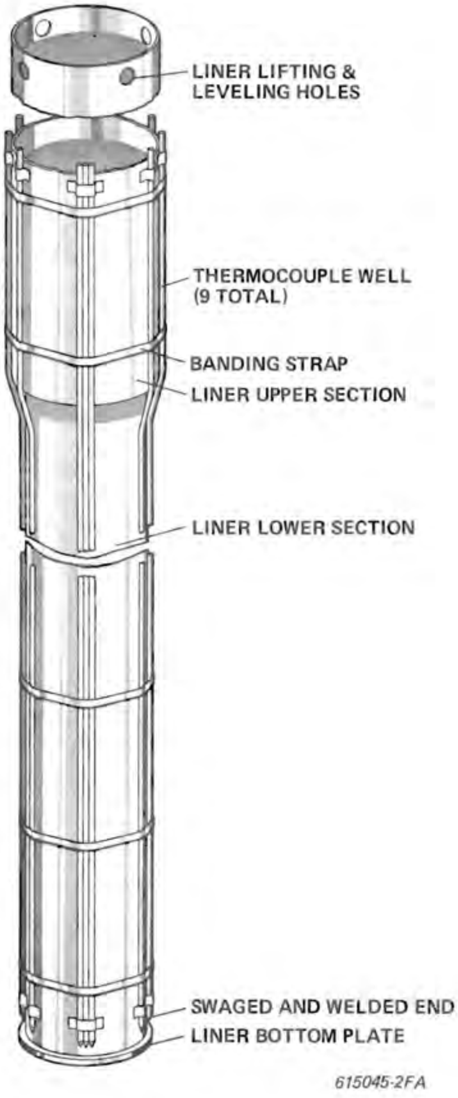

Figure 3.2-16. Drywell Liner Showing Instrumentation Configuration

liner thermocouples for Drywells 1, 2, 3 and 5.

LINER INSTALLATION

The liner assembly was positioned and leveled inside of a 26 inch diameter, 23 foot deep hole drilled into E-MAD soil. The liner is shown during installation in Figure B-14. An 84 inch wide by 28 inch deep concrete pad with standard gauge rails was provided at the top of the drywells. The pad has an 18.75 inch deep by 37.25 inch diameter annulus around the liner upper section in which a portable lead shield adapter is installed (see Figure A-24).

Figure 3.2-17. Drywell Liner Prior to Shipment

The pad provided a reference datum to aid in drilling and liner installation operations. After the liner was positioned into the emplacement hole, the annulus was filled with Luminite grout to the top of the instrumentation tubes. The grout consisted of two parts soil, removed from the emplacement hole, to one part Luminite. Details of liner installation operations are contained in Section B.1.1.

3.2.2.3 CANISTER ASSEMBLY

The canister assembly consists of a canister body, a closure lid and a shield plug. The canister assembly in a drywell is illustrated in Figure 3.2-13. The canister described below was designed to accommodate one PWR spent fuel assembly. The canister assembly used in Phase II Isolated Drywell Test was actually part of the Spent Fuel Test at Climax. The encapsulated fuel assembly was being temporarily stored at E-MAD and thus was available for the Phase II test. The minor differences are noted below.

CANISTER BODY

The canister body is illustrated in Figure 3.2-18. The main body of a PWR canister is a standard 14 inch diameter, 0.375 inch thick, 304 stainless steel pipe (304L for Phase II) 154 inches long. Welded to the bottom of this pipe is a standard 14 inch diameter, 6.5 inch high ellipsoidal end cap. This end cap has welded into it a cruciform formed of a 0.75 inch thick 304 stainless steel plate with four 0.25 inch thick 304 stainless steel vertical gussets welded to the underside. This cruciform supports the bottom of the PWR fuel assembly.

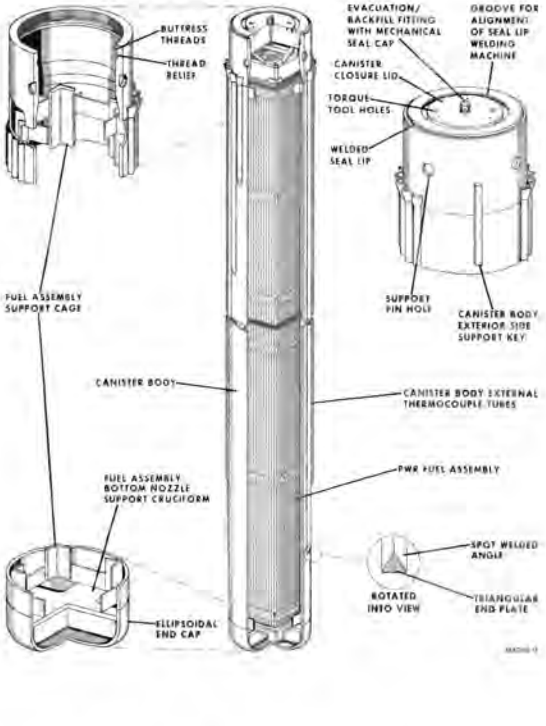

Figure 3.2-18. Canister Configuration

The top of the PWR canister body consists of a section of 14 inch diameter, 0.937 inch thick, 304 stainless steel pipe approximately 9 inches long. This section is welded to the 0.375 inch thick main body pipe and contains machined threads which mate with the closure lid. The outside upper surface of the canister body contains four blind holes equally spaced around the pipe circumference for shield plug attachment. Two 0.75 inch square bars (keys) are welded to the outside of the canister body to support the canister during remote operations and to position the shield plug so that the instrumentation tubes on both components are properly aligned.

Welded to the inside is a fuel assembly support cage formed of standard 2 inch by 2 inch by 0.18 inch thick 304 stainless steel angles tied together on four sides at six elevations by 7.12 inch long by 2 inch high by 0.18 inch thick plates. At the cage top, eight additional straps are welded between the canister body pipe and the top cage straps to provide centering and support.

CANISTER INSTRUMENTATION

The canister has ten thermocouple "tubes" (six for Phase II) for insertion of thermocouples after emplacement in a drywell. The thermocouple "tubes" consist of

0.75 inch by 0.75 inch angles, intermittently welded to the outside of the canister body. A funnel is formed at the top of each tube by a 1.25 inch by 1.25 inch angle, cut to match the smaller angle and welded to the top of the tube (see Figure 3.2-18). The funnel is provided to compensate for potential radial and azimuthal mismatch between shield plug and canister body instrumentation tubes and thereby ensure proper thermocouple installation. A triangular plate is welded to the bottom of each tube. Contact with this plate is intended to cause the tip of the thermocouple to be diverted toward and eventually touch the canister body.

For Phases I and III, five thermocouple tubes are located on opposite sides of the canister. The five tubes in each group are spaced 15° apart and extend down the canister to lengths approximately matching the PWR fuel assembly active fuel middle, 2.5 feet above and below the active fuel middle and 1 foot from each end of the active fuel. Each different tube length is matched by a tube of the same length 180° away.

In Phase II, three thermocouple tubes are located on opposite sides of the canister. The tubes extend down the canister to lengths approximately matching the PWR fuel assembly active fuel middle, and 1 foot from each end of the active fuel.

The thermocouples are installed through tubes in the shield plug until they contact the bottom of each instrumentation tube. When installed, the thermocouples measure temperatures at five different elevations on both sides of the canister to determine the axial canister temperature profile. The uppermost, middle and lowermost thermocouples are located at the same elevations as those in the drywell liner. Tables D1-1, D2-1, D3-1, D5-1 and D5-8 identify the thermocouples installed in the canisters for Drywells 1, 2, 3 and 5.

CLOSURE LID

The canister closure lid is illustrated in Figure 3.2-19. The closure lid is a flat disc, 3.5 inches thick and 12.5 inches in diameter made of 304 stainless steel. This disc has approximately 1 inch of buttress threads machined near the top which mate with threads machined into the thicker section of pipe at the top of the canister body. The top outside surface of the closure lid has a seal lip for remote seal welding of the canister after fuel assembly installation. Features include a machined groove for alignment of the seal welding machine with the machined seal lip, provisions for the lifting and torquing tool, and a fitting with a mechanically sealed cap through which helium is introduced into the canister. The bottom 1 inch of the closure lid serves as a lead-in for the lid installation.

The seal lip on the canister closure lid is welded to the canister body to complete the containment boundary. The gas fitting on the top of the closure lid provides access to evacuate the canister and backfill with helium. The helium provides an indicator for initial leak checking of the closure lid seal weld and the gas fitting mechanical seal, to stabilize the fuel assembly in an inert atmosphere, and to enhance conductive heat transfer to the canister.

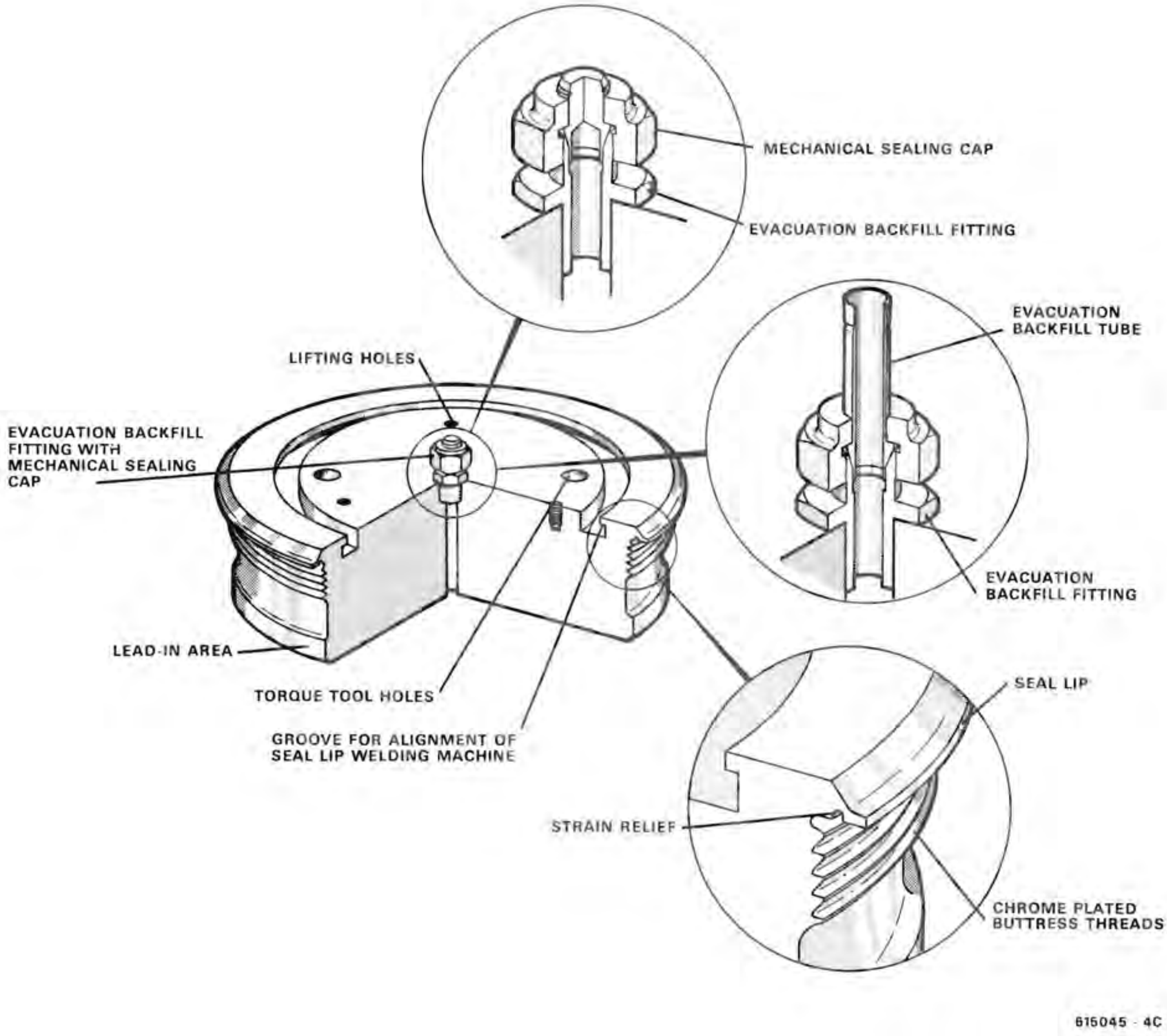

Figure 3.2-19. Canister Closure Lid Configuration

SHIELD PLUG

The canister is attached to a shield plug before emplacement into storage. The shield plug, shown in Figure 3.2-20, is a 20 inch diameter, 0.25 inch thick carbon steel pipe approximately 34 inches long with a 1.5 inch thick plate welded to the top and a 1 inch thick plate welded to the bottom. The volume between the two end plates is filled with concrete for shielding. Extending from the bottom plate of the assembly is a 16 inch diameter, 1.031 inch thick, carbon steel pipe approximately 13.5 inches long. This pipe extension contains four tapped and spot-faced holes 90° apart to accept the canister support pins which secure the canister to the shield plug. The shield

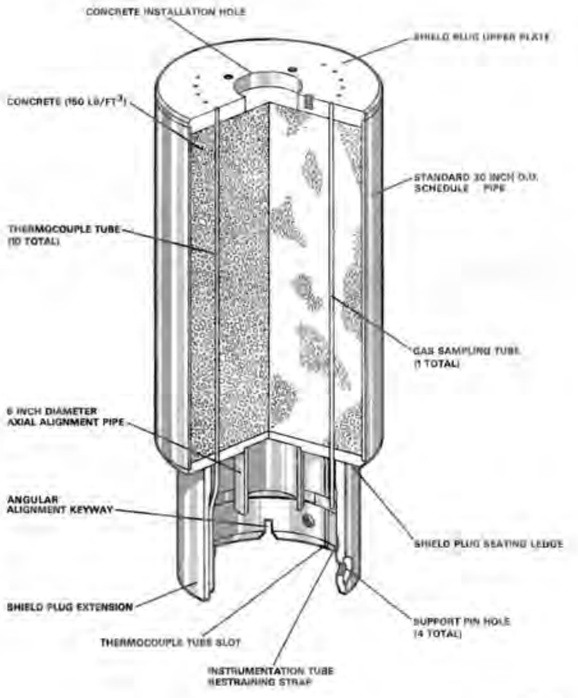

Figure 3.2-20. Shield Plug Configuration

plug is lowered over the canister (which fits inside of the 16 inch diameter extension) and the support pins are threaded into the shield plug extension. The pins protrude from the inside of the extension into four flatbottomed holes in the canister upper portion.

The shield plug has eleven 0.086 inch inside diameter tubes extending from the upper plate, through the lower plate down to the bottom of the shield plug extension; ten for routing thermocouples into the canister tubes and one for sampling the atmosphere above the closure lid. The tubes are routed through slots in the bottom portion of the extension so there is no interfere with the canister body. The tubes are secured to the extension by spot welded straps. The shield plug has two sets of five tubes with 15° spacing between tubes. These tubes match the thermocouple tubes on the canister by an alignment keyway in the shield plug extension and a bar (key) on the outside of the canister.

CANISTER ASSEMBLY EMPLACEMENT

The encapsulated fueled canister assemblies are installed into the drywell using a railcar-mounted transfer shield and a drywell shield adapter described in Appendix A. The Engine Installation Vehicle, Manned Control Car and L-3 locomotive, previously used as part of the Nuclear Engine for Rocket Vehicle Application (NERVA) Program, transport the canister to the drywell. The drywells are centered between rails and the concrete shield pad above each drywell which is level to facilitate transfer shield and drywell alignment. Horizontal alignment of the transfer shield with the drywell is accomplished by aligning a pointer on the transfer shield with targets inscribed on the top of the drywell concrete pad. Details of spent fuel encapsulation, canister transfer to the drywell, and emplacement in the drywell have been included in Appendix B.

3.2.2.4 STORAGE AREA

The storage area for the Drywell Test is located on the west side of the E-MAD building within the security fence surrounding the E-MAD complex. Early in the SFHPP 1978 Demonstration, it was decided that canister emplacement into the drywells would use existing rail equipment at E-MAD. The area west of the E-MAD building was chosen as the storage site since it was fairly level and would allow rail spur installation with a minimum of site modifications.

The drywells are centered between rail tracks embedded in a reinforced concrete pad as illustrated in Figure 3.2-13. The pad is 84 inches wide by 28 inches deep by 235 feet long. The pad provides: 1) a level surface to facilitate emplacement of the canister with the transfer shield, 2) support for the rail equipment during emplacement, and 3) shielding in the immediate area around the drywell.

Four drywell liners were installed for the SFHPP 1978 Demonstration using the three northernmost and the southernmost concrete pad holes for alignment and spacing. The spacing between the three northernmost drywells (25 feet) was chosen to provide test data for what had been predicted to be thermally interacting drywells whereas the southernmost drywell was placed 50 feet from an adjacent drywell to thermally isolate it from the others.

Each drywell has a cover plate which is bolted to the top of the concrete pad. The drywell cover plate is 46 inches in diameter by 0.25 inches thick and is made of carbon steel. Four lifting eyes are welded to the top of the cover plate for handling. A 41 inch outside diameter by 39 inch inside diameter by 0.25 inch thick neoprene gasket is cemented to the underside of the cover plate to seal the plate against the concrete pad. The cover plate has sixteen 0.625 inch diameter clearance holes for the 0.5 inch diameter by 1.25 inch long hex head bolts used to secure the cover plate to the concrete pad. Four bolts on each cover plate have a hole through the hex head which allows security wires to be placed through two pair of adjacent bolts on each drywell after the canister has been installed. The cover plate is shown in Figure 3.2-21.

Figure 3.2-21. Drywell Cover Plate Showing Neoprene Gasket

3.2.2.5 INSTRUMENTATION WELLS

The soil surrounding each drywell was instrumented with a total of 12 thermocouples divided and grouped into four instrumentation wells. These instrumentation wells were similar to those for the Electrically Heated Drywell Test (see Figure 3.2-12). The orientation of the instrumentation wells is shown in Figure 3.2-22 for all four drywells. Each instrumentation well consists of a 19 foot long, 1 inch diameter, schedule 80 PVC pipe grouted into a 3 inch diameter hole drilled into the soil. The sheathed thermocouples for each instrumentation well were attached

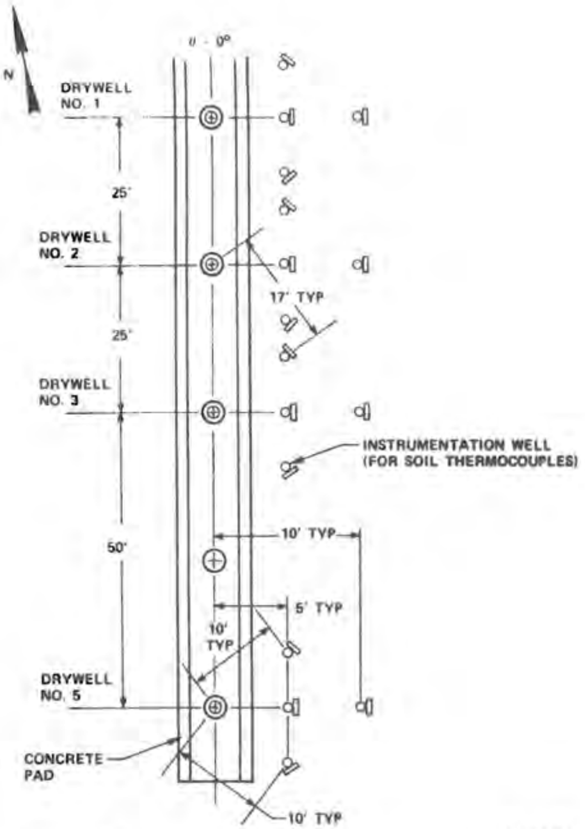

Figure 3.2-22. Drywell and Soil Instrumentation Well Arrangement

to the outside surface of the PVC pipe at three axial locations. The thermocouples were attached using wire ties and epoxy patches spaced 12 inches apart. Tables D1-1, D2-1, D3-1 and D5-1 provide the location data for the attached thermocouples on the instrumentation wells.

The top of each instrumentation well extended above ground level where an enclosure box was provided to attach a flexible conduit which was routed to a storage area electrical enclosure. The electrical enclosures were attached to underground pipe which connected the enclosures to the instrumentation shed. The well enclosure boxes and flexible conduit were used to route the thermocouple leads after installation of the well and conduit. Figures B-15 and B-16 show instrumentation well installation activities.

3.2.2.6 DATA ACQUISITION SYSTEM

The data acquisition system for the Drywell Test consists of the array of thermocouples, a remote signal conditioning/multiplexing unit and the E-MAD data logger. The thermocouples are attached to the test hardware as described earlier in this section of the report. The thermocouple leads are routed to sealed electrical enclosures and to the multiplexer unit located in the instrumentation shed. Multiplexer signal cables are routed through an underground pipe to the data logger (see Section A.5.5).

THERMOCOUPLES

Each thermocouple used in the Drywell Tests consists of a Type K, chromel-alumel thermocouple with ungrounded junction enclosed in a 304 stainless steel sheath. The canister and liner thermocouples have a 0.062 inch diameter sheath and the instrumentation well thermocouples have a 0.125 inch diameter sheath. Two 24 gauge Type K extension wires are brazed to the thermocouple wires and are enclosed in a 0.187 inch diameter by 0.025 inch thick by 2.75 inch long stainless steel transition boot. The transition boot is crimped onto the end of the thermocouple cable sheath and filled with epoxy. Heat shrink tubing is installed on the instrumentation well thermocouples transition boot and a length of the extension wires to provide additional moisture protection for the portion installed underground. Appendix D provides the identification and location data for all the thermocouples installed in and around Drywells 1, 2, 3 and 5. Figure 3.2-23 shows the typical drywell thermocouple elevations.

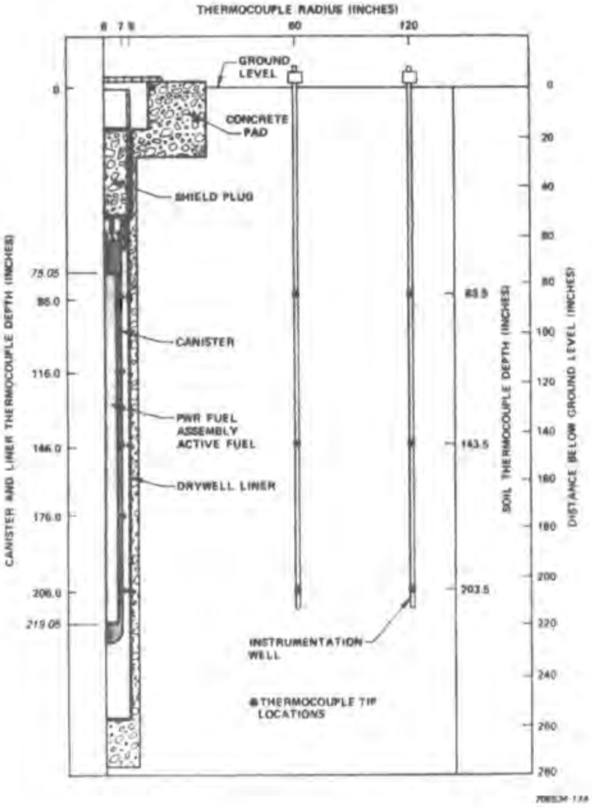

Figure 3.2-23. Typical Drywell Thermocouple Locations

Instrumentation for the Phase II Isolated Drywell Test was the same as that used for the Phase I test except some of the Phase I test thermocouples could not be used for Phase II. These included the four thermocouples which had been installed on the Phase I canister for which there were no Phase II canister instrumentation tubes and four thermocouples on the liner which had been affected during removal for canister assembly changeout (Phase I to Phase II). The four canister thermocouples which could not be installed (T/C's 870, 871, 881 and 882) were coiled in the annulus around the top of the drywell liner and their data were not included for the Phase II test. Four of the liner thermocouples (T/C's 866, 867, 877 and 888) were broken during their removal. For three of the four, the thermocouple broke near the top of the liner tube; therefore, no replacement could be made. The fourth liner thermocouple (T/C 866) broke about 78 inches below ground level. A replacement was installed to provide an additional data point at that elevation. The degradation of the thermocouple sheaths and the corrosion of the liner instrumentation tubes caused by moisture in the drywell concrete pad annulus (discovered after the Phase I test - see Section 3.3.2) was the hypothesized reason for thermocouple breakage. Thermocouple 828 failed prior to the Adjacent Drywell Test. Since no replacement thermocouple was available, no data readings from this thermocouple were taken. Table D5-8 identifies the specific thermocouples used for the Phase II test and describes their locations.

3.3 OPERATIONS

3.3.1 ELECTRICALLY HEATED DRYWELL TEST

The Confirmation Phase I test sequence, with a March, 1978 start up date, consisted of a low power level heatup rate phase to verify heater operation and instrumentation; an accelerated heatup phase at 3.0 kW heater output level to raise the test hardware and surrounding soil temperature to at or above the thermal stabilization point; and operation at a constant 1.0 kW heater output level until thermal stabilization was achieved.

The Confirmation Phase II test consisted of an extended period of 1.0 kW heater output level. In April, 1979, Phase III testing was initiated, as part of the CWSFP Program, by increasing heater power level to 2.0 kW. The Phase III testing was completed in April, 1980. Phase IV extended the testing to a 3.0 kW heater power level and recorded data for a nine month period.

Phases I, II, III and IV of the Electrically Heated Drywell Test are described in detail in the following sections.

CONSTRUCTION AND ASSEMBLY

The Electrically Heated Drywell Test area construction was completed in early 1978. This area, relative to the E-MAD site, is illustrated in Figure B-1 of Appendix B. The construction activities, beginning with site grading and pad forming, and continuing through liner, thermocouple, and test assembly installation, are shown in Figures B-3 through B-9 in Appendix B.

INITIAL PREPARATION AND HEATUP CHECK

Prior to Electrically Heated Drywell Test startup, the entire array of test thermocouples was checked to ensure proper operation. The heater and control panel were calibrated so that the power level (wattage) at the heaters could be approximated by the voltage setting of the control panel. The data logger was also tested to verify proper operation. A data logger scan and printout of all thermocouples was made just prior to starting the heatup check.

The heatup check began on March 6, 1978, at a power level of 0.5 kW for about 19 hours, and verified that the system was operating properly. Thermocouple data were taken at one hour intervals by the data logger and compared to the ambient data. The input power applied to the heaters was checked and recorded.

ACCELERATED HEATUP (3.0 kW POWER OPERATION)

On March 7, 1978, at 11:00 a.m., the power level was raised from 0.5 to 3.0 kW. As expected, the canister and liner began to heat up rapidly. On the first day of 3.0 kW power operation, thermocouple readings were recorded at one hour intervals. Readings were then recorded at 4 hour intervals until the tenth day. After 10 days thermocouple readings were recorded at 12 hour intervals.

1.0 kW POWER OPERATION

On May 1, 1978, at 11:00 a.m., test power was reduced to 1.0 kW and maintained at this power level for a 12 month period. To record the transient temperatures more closely, thermocouple readings for the first two weeks were taken every four hours. The thermocouple readings after the first two weeks were recorded twice a day at 4:00 a.m. and 4:00 p.m.

2.0 kW POWER OPERATION

On April 26, 1979, at 12:00 noon, test power increased from 1.0 to 2.0 kW. For the following seven days, thermocouple readings were taken every four hours. After this initial period, thermocouple readings were recorded three times a day at midnight, 8:00 a.m. and 4:00 p.m.

3.0 kW POWER OPERATION

On April 1, 1980, at 12:00 noon, heater power was increased from 2.0 to 3.0 kW. For the first seven days of increased power operation, thermocouple readings were taken every four hours. After this initial period, thermocouple readings were recorded three times a day at midnight, 8:00 a.m. and 4:00 p.m. Following one month's operation, thermocouple readings were recorded once a day at 4:00 p.m. until December 30, 1980 when power operation was terminated.

HEATER POWER VARIATIONS

Throughout the Electrically Heated Drywell Test, measurements of input voltage to the heater power controller and power applied to the test heater were made. The strip chart recorder mounted to the power controller cabinet recorded input voltage variations. The power applied to the heater was checked and recorded each weekday at 8:30 a.m. and 3:30 p.m. Power levels were determined from the current measured by the power controller ammeter and from the voltage measured at the top of the heater conductor wires. Frequent voltage adjustments compensated for minor input powerline changes and heater resistance changes with temperature.

3.3.2 FUELED DRYWELLS

CONSTRUCTION

The drywell storage area construction (shown in Figures B-11 through B-13) was completed in September, 1978. Four drywell liners were installed in positions 1, 2, 3, and 5 (drywell positions numbered from north to south, see Figure B-10). The positions chosen were based on the preliminary thermal analyses to provide one thermally isolated drywell and three adjacent drywells providing test data on drywell thermal interactions.

Instrumentation well installation was completed in October, 1978. Sixteen instrumentation wells were installed with four wells near each of the four installed drywell liners (Figures B-14 through B-16). The 19 canister and liner thermocouples and the instrumentation well thermocouples for each drywell were coiled and placed in the adjacent electrical enclosures.

ENCAPSULATION AND ASSEMBLY

The Drywell Test spent fuel assemblies were encapsulated prior to emplacement in a drywell. The following presents a brief summary of these activities. Further details are found in Appendix B. The operations began with preparing the spent fuel shipping cask for fuel assembly unloading. Next, by remote operations, a fuel handling tool was inserted in the cask and the handling tool and fuel were lifted out. Each fuel assembly was visually examined by a remotely held TV camera and then placed in a canister located in the Hot Bay weld pit. The canister closure lid was installed and seal welded to the canister. The weld was made remotely and the completed weld visually inspected using a wall-mounted periscope. The canister was then evacuated and backfilled with helium. A sample was drawn from the vacuum chamber into a helium leak detector in the operator gallery and examined for helium. The canister and shield plug were then moved to the survey pit where swipes are made of the canister surface using the master-slave manipulators. Prior to transferring the canister to the drywell, the canister was moved to a transfer pit where a special lifting bail was installed on the shield plug. The canister and shield plug were then moved to a drywell in the storage site. To complete the drywell operations, the thermocouples were inserted through the shield plug and liner, the instrumentation connections made at the multiplexer unit, and the drywell cover secured.

ISOLATED DRYWELL TEST - PHASE I (FUEL ASSEMBLIES B03 AND B41)

The first canister assembly containing fuel assembly B03 was installed in Drywell 5 on January 12, 1979. The second canister assembly containing fuel assembly B41 was installed in Drywell 3 on January 24, 1979. Thermocouples for both drywells were attached to the multiplexer and a set of reference temperature readings taken prior to thermocouple insertion.

During thermocouple installation activities for both drywells, it was noted that some of the pad concrete in the area of the drywell cover gasket had cracked or was broken and that a good seal between the gasket and concrete would not occur. The pad top was repaired using epoxy grout which provided a 53 inch square by 1 inch high raised area on the pad top. Drywell 5 concrete pad repairs were completed on January 22, 1979, and Drywell 3 concrete pad repairs were completed on February 12, 1979.

Temperature data monitoring from the two drywells began from their dates of emplacement. For each drywell, data logger printouts were made every hour for the first day, every four hours for the next six days and twice a day, at 4:00 a.m. and 4:00 p.m., thereafter until May, 1979. In May, 1979, the printouts were made at 8:00 a.m. and 4:00 p.m. and continued at these times throughout the Phase I test period.

DRYWELL REARRANGEMENT

After the initial phase of Drywell Testing, a second and third phase of isolated drywell tests were planned. Phase II would use a higher decay heat level fuel assembly and Phase III an adjacent drywell test using three PWR fuel assemblies from the SFHPP 1978 Demonstration. To accommodate these two tests, the two fueled drywells (3 and 5) were rearranged so that the canister assembly in Drywell 3 would be placed in Drywell 2, and the canister assembly in Drywell 5 would be placed in Drywell 3. Moving both canister assemblies was considered necessary (rather than moving the canister in Drywell 5 to Drywell 2) to maintain the canister and fuel assembly temperatures for the Hanford Engineering Development Laboratory Materials Interaction Test experiment in fuel assembly B03 by keeping the canister in a previously heated drywell. Removing the canister from Drywell 5 left this drywell available for the higher power level isolated drywell test.

Drywell rearrangement activities started on August 4, 1980 when the canister with fuel assembly B03 was removed from Drywell 5 and transported to the Hot Bay by the rail-mounted transfer shield, Engine Installation Vehicle, Manned Control Car and L-3 locomotive. The canister containing fuel assembly B41 was moved from Drywell 3 to Drywell 2 prior to emplacing the canister containing fuel assembly B03 in Drywell 3. On August 5, the canister containing fuel assembly B41 was also moved to the Hot Bay. While in the Hot Bay, each canister assembly was placed in the weld pit, the shield plug removed and a gas sample taken to determine if any fuel rods had failed during storage. Further description of the gas sampling is provided in Appendix L. No evidence of fuel rod failure was found.

To remove the canister assemblies, the drywell liner thermocouples had to be removed. Problems were encountered in removing the Drywell 5 thermocouples and four liner thermocouples broke off. Subsequent drywell rearrangement operations used lead bricks as spacers beneath the drywell adapter to preclude liner thermocouple removal.

Each drywell was inspected both before and after the canister was removed. Once the drywell covers were removed, it was noted that much of the epoxy grout placed above the concrete pad had cracked and that there was a lack of adhesion to the concrete as shown in the photograph in Figure 3.3-1. In addition, both of the drywell cover gaskets were uneven and not flat enough to seal. The cover plate and gasket for Drywell 3 are shown in Figure 3.3-2. The annulus around each liner contained quite a bit of sand and small concrete chunks as shown in the photograph in Figure 3.3-3 for Drywell 3. After each canister was removed

Figure 3.3-1. Drywell 5 at End of Isolated Drywell Test Phase I With Cover Plate and Canister Removed

Figure 3.3-2. Drywell 3 Cover Plate Removed After Isolated Drywell Test Phase I

Figure 3.3-3. Drywell 3 Concrete Pad Annulus After Isolated Drywell Test Phase I

from its drywell, a visual inspection showed several inches of water at the bottom of both liners. Both liners also had surface rust and evidence of water having entered the liner lower section. Prior to replacing each drywell cover, the liner was dried out. To prevent water from getting inside the liner for the Adjacent Drywell Test and to investigate how the water got into the drywells, a series of moisture collection tests and drywell cover insulating and venting tests were planned. As part of these tests, a thin cover plate was installed on the top of the liner to catch the moisture which condensed on the bottom of the cover. These tests are judged to have had little or no effect on the drywell data taken during the tests since they only affected heat transfer through the drywell cover plate.

ISOLATED DRYWELL TEST - PHASE II (FUEL ASSEMBLY D22)

Fuel assembly D22 was received at E-MAD on November 12, 1979. The fuel assembly was visually examined, placed in an SFT-C canister body and a canister lid installed but not welded. A standard drywell shield plug was installed and the canister assembly was placed in the lag storage pit inside the E-MAD Hot Bay for temporary storage. While in storage in the lag storage pit, two thermocouples were installed through the shield plug into the center canister thermocouple tubes. These monitored and tested the thermal response of the lag storage pit to varying decay heat loads and pit cooling conditions. Results are described in Section 6.0.

Following the completion of canister transport activities for the eleven canisters shipped to the SFT-C site, the canister containing fuel assembly D22 was retrieved from the lag storage pit and the shield plug and lid were removed. Fuel assembly D22 was removed from the canister and placed in the Boiling Water Calorimeter in the E-MAD Hot Bay for a decay heat level measurement on July 9, 1980. After the calorimetry was completed, the fuel assembly was reinstalled in the canister body, the lid and shield plug installed and replaced in the lag storage pit. On August 7, 1980, the canister assembly was seal welded, helium backfilled and leak checked and returned to the lag storage pit to await transfer to Drywell 5.

Following the drywell rearrangement activities, the canister assembly containing fuel assembly D22 was transported to and installed in Drywell 5 on September 4, 1980 at

4:00 p.m., 31 days after the canister assembly containing fuel assembly B03 had been removed. To complete drywell canister operations, the drywell shield adapter and the shield plug lifting bail were removed, the thermocouples inserted through the shield plug into the canister instrumentation tubes and into the liner instrumentation tubes, the thin liner cover installed and the drywell cover secured in place.

Temperatures from Drywell 5 with fuel assembly D22 were monitored from the time of emplacement (September 4, 1980). Data logger printouts were made every hour for the first day, every four hours for the next 18 days and twice a day thereafter at 4:00 a.m. and 4:00 p.m.

ADJACENT DRYWELL TEST - PHASE III (FUEL ASSEMBLIES B03, B41 AND B43)

Fuel assemblies B03, B41 and B43, used in the Adjacent Drywell Test, were previously used for SFHPP 1978 Demonstration spent fuel tests. Fuel assemblies B03 and B41 were part of the Isolated Drywell Test (Phase I). Fuel assembly B43 was previously installed in the test stand for the Fuel Assembly Internal Temperature Measurement Test.

Fuel assembly B43 was received at E-MAD on February 6, 1979, visually examined, placed in a canister body and a canister lid installed but not welded (see Appendix B for a complete description of standard encapsulation procedures). A standard drywell shield plug was installed and the canister assembly was placed in the transfer pit inside the E-MAD Hot Bay for temporary storage. On July 18, 1979, the canister assembly was removed from the transfer pit; the shield plug and lid were removed; and fuel assembly B43 was removed and installed in the Fuel Assembly Internal Temperature Measurement Test stand. Following test stand lid installation and placement of the stand in the E-MAD West Process Cell, testing began on July 23. The tests consisted of a series of air, vacuum and helium backfill tests with various heater imposed canister temperature profiles. Test-ing was concluded on July 2, 1980.

Following test completion and return to the E-MAD Hot Bay the fuel assembly was removed and placed in the Boiling Water Calorimeter for a decay heat level measurement. This occurred on September 10, 1980. The fuel assembly was subsequently installed in a canister body, and a lid installed and seal welded. Following the helium backfill and leak check operations, a drywell shield plug was installed and the canister assembly was returned to the transfer pit to await transfer to Drywell 1.

Phase III began with the canister containing fuel assembly B03 being transported to and installed in Drywell 3 at 7:00 p.m. on August 4, 1980. The canister containing fuel assembly B41 was installed in Drywell 2 at 4:00 p.m. on August 4, 1980 but was removed for about six hours for gas sampling on August 5, 1980. The canister containing fuel assembly B43 was transported to Drywell 1 and installation completed at 1:00 p.m. on September 15, 1980. To complete drywell canister operations for each drywell, the drywell shield adapter and the shield plug lifting bail were removed, the thermocouples installed, the thin liner cover installed and the drywell cover secured in place.

Thermocouple installation for the three drywells differed slightly. In Drywells 1 and 2, the thermocouples were installed through the shield plug into the canister instrumentation tubes and into the liner instrumentation tubes. In Drywell 3, the thermocouples were installed through the shield plug into the canister instrumentation tubes only. Thermocouples had not been removed because of the problems experienced removing Drywell 5 thermocouples during canister rearrangement operations. As a result of thermocouples having been installed beyond the end of the canister instrumentation tubes in Drywells 5 and 3 for the Isolated Drywell Test, the instrumentation tubes on the canisters containing fuel assemblies B03 and B41 had been measured while the canisters were in the E-MAD Hot Bay. The thermocouple lengths for these canisters were marked and the thermocouples were installed so that their tips were approximately 0.25 inches above the bottom of each instrumentation tube. The instrumentation tube ends had been sealed on the canister containing fuel assembly B43 prior to fuel assembly encapsulation; and therefore thermocouples for Drywell 1 were installed until they contacted the bottom of the tubes. A sealing compound was installed around the thermocouple at the top of each liner thermocouple tube for all three drywells to prevent entry of water.

Since Drywells 1 and 2 had not been previously used for drywell testing, the thermocouple leads for each drywell and the four adjacent instrumentation wells had to be routed to the multiplexer unit in the instrumentation shed. During routing of the Drywell 1 thermocouple leads, it was found that they would not reach the multiplexer unit. All the leads were then connected to a terminal strip with compensated thermocouple terminal lugs (chromel and alumel) and placed in a waterproof, dustproof junction box mounted on the outside wall of the instrumentation shed. Chromel and alumel extension leads connected the junction box terminal strip and the multiplexer unit. It should also be noted that two sets of instrumentation well thermocouples for Drywell 2 (798 to 801 and 809 to 811) were not connected to the multiplexer unit until September 18.

Temperature data from two of the three drywells were monitored from canister emplacement. For Drywell 3, data logger printouts started on August 4, 1980 and continued for every four hours for the first eight days, and then twice daily at 4:00 a.m. and 4:00 p.m. until September 15, 1980. For Drywell 2, data logger printouts started on August 7, 1980 at 2:00 p.m. and continued for every four hours for the next seven days, and then twice daily at 4:00 a.m. and 4:00 p.m. until September 15. On September 15, 1980, following Drywell 1 canister emplacement marking the official Adjacent Drywell Test start, data logger printouts for all three drywells were made at four hour intervals for two weeks and twice daily thereafter at 4:00 a.m. and 4:00 p.m.

3.3.3 AMBIENT TEMPERATURE MEASUREMENTS

In addition to Electrically Heated Drywell Test and Drywell Test near-field soil temperature measurements, ambient air temperatures and ambient soil temperatures were recorded. A weather station installed near the Electrically

Heated Drywell Test provided a continuous record of atmospheric conditions at E-MAD.

Thermocouple readings from the Reference Well located about 60 feet from the Electrically Heated Drywell Test drywell provided a record of the axial soil temperature variations from atmospheric temperature changes during the test period.

3.4 RESULTS

3.4.1 ELECTRICALLY HEATED DRYWELL TEST

INITIAL HEATUP CHECK

A printout of the thermocouple readings at the start (March 6, 1978 at 3:51 p.m.) and end of the heatup check period (March 7 at 10:57 a.m.) are provided in Appendix C, Table C-2. The second set of readings represents the initial conditions for the Electrically Heated Drywell Tests.

ACCELERATED HEATUP (3.0 kW POWER OPERATION)

Thermocouple readings at 24 hour intervals for the first five days of 3.0 kW operation (March 8, 9, 10, 11 and 12), on March 15, on April 1 and on April 15 are shown in Appendix C, Tables C-3 through C-6. Data are also shown for the end of 3.0 kW operation in Table C-7.

Thermal data for canister, liner and soil at 21, 33 and 60 inch radii are shown in Figure 3.4-1. Figure H-1 shows the temperature distribution within the soil using isotherms (constant temperature lines) interpolated from thermocouple data at the end of 3.0 kW operation. One day of 3.0 kW operation resulted in the canister maximum temperature (located about midway down the heated length) rising from 117 to 310°F. The canister maximum temperature gradually rose from 310 to 515°F after 55 days of 3.0 kW operation. At this time, the liner maximum temperature had risen to 450°F (50°F above the predicted 1.0 kW liner thermal stabilization temperature), so the test power level was reduced to 1.0 kW. The corresponding inground soil thermocouple at the 21 inch radial position and same depth was at 270°F.

Thermal model studies indicated that only one month of operation at 3.0 kW would be necessary to reach a liner temperature of 400°F. The moisture that had accumulated around the test area from concrete pad construction, grout installation and rain apparently largely affected the test transient behavior. Heavy rain fell during Electrically Heated Drywell Test liner installation. The combination of rain in the hole and water in the grout surrounding the liner caused the soil to have a high moisture content. During the 3.0 kW power operation phase, the temperatures measured by the thermocouples in the grout and at a 21 inch radius in the soil rose to 200°F (the approximate boiling point of water at E-MAD). The temperatures remained at this value for 16 days and then steadily rose. The constant temperature period was caused by water vaporization. Once the soil was free of excess water, the thermocouple readings rose above 200°F.

1.0 kW POWER OPERATION

Thermocouple readings at the start of 1.0 kW power operation, for the

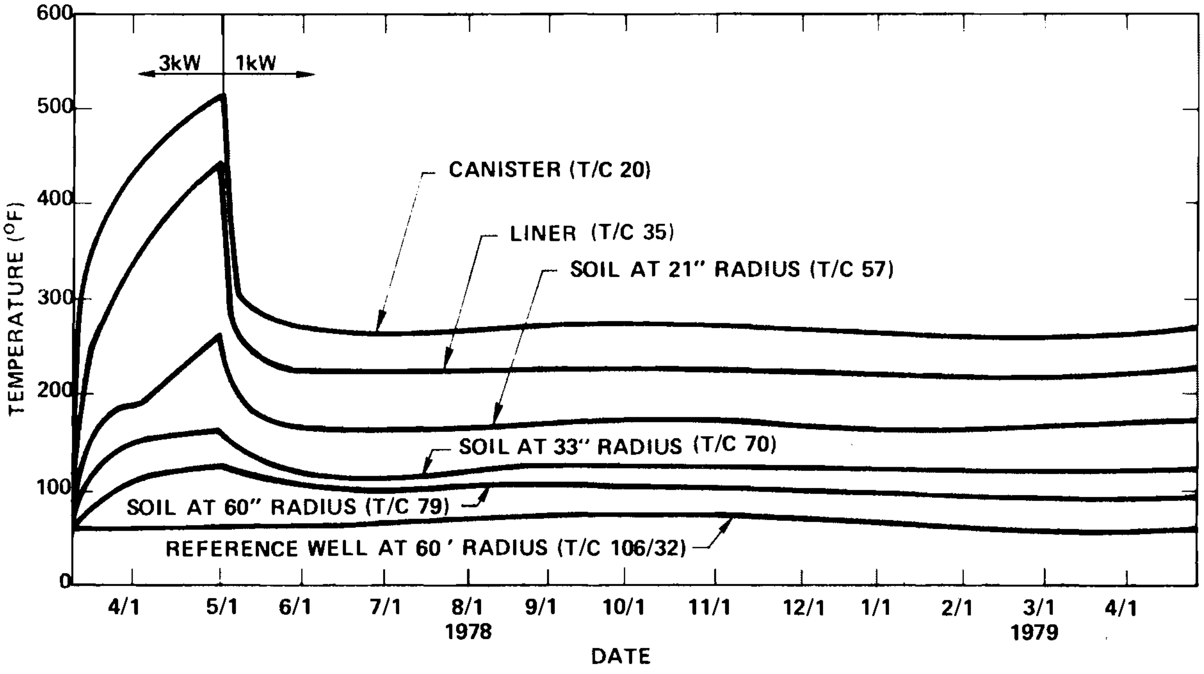

Figure 3.4-1. Peak Temperature Distributions for Initial Electrically Heated Drywell Test Phases

first five days, after two weeks of 1.0 kW power operation, and at one month intervals during 1.0 kW power operation are provided in Appendix C, Tables C-7 to C-16.

On February 6, 1979 at 4:00 p.m., data channels were rearranged eliminating the second multiplexer unit. Four redundant canister and three redundant liner thermocouples were disconnected and the Reference Well thermocouples connected to their channels on the remaining multiplexer. Figure C-2 shows the revised thermocouple identifications.

Thermal results for 1.0 kW operation are shown in Figures 3.4-1, 3.4-2 and 3.4-3. Figure 3.4-1

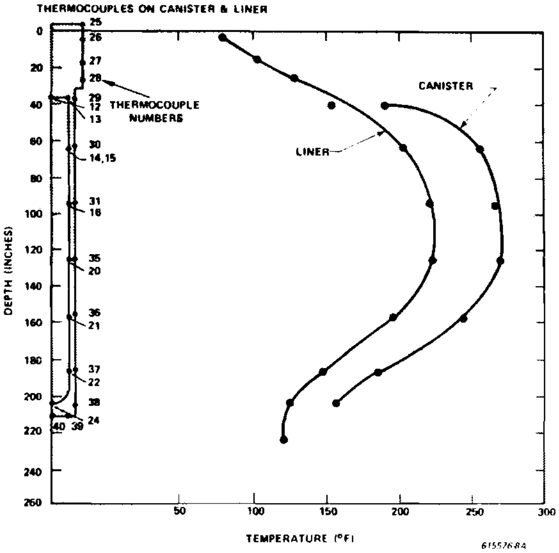

Figure 3.4-2. Canister and Liner Axial Temperature Profiles at 1 kW Power Level Thermal Stabilization, April 1, 1979

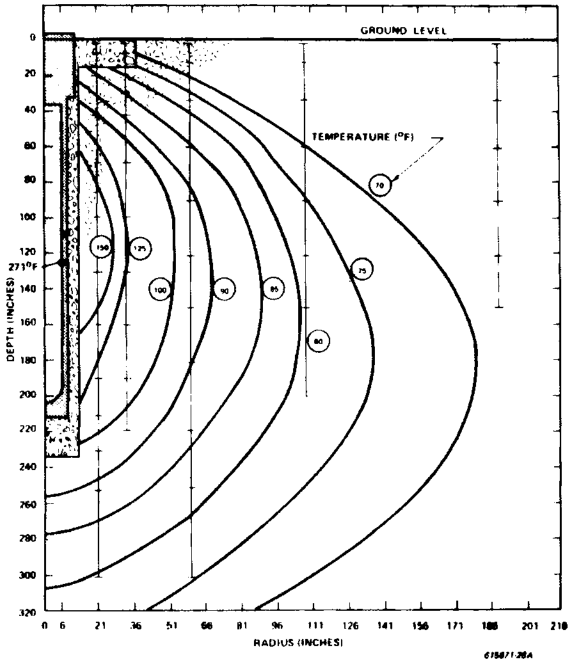

Figure 3.4-3. Soil Isotherms at 1 kW Power Level Thermal Stabilization, April 1, 1979

presents the temperature distributions representing the peak temperatures recorded for the canister, liner and soil at a depth of about 127 inches. Included is the Reference Well temperature plot for comparison with seasonal temperature variations at the same depth. Figure 3.4-2 shows the canister and liner axial temperature profiles on April 1, 1979 after 8045 hours of 1.0 kW power operation. Figure 3.4-3 shows the temperature distribution within the soil using isotherms (constant temperature lines) interpolated from the thermocouple data on April 1, 1979. The data shown in Figures 3.4-2 and 3.4-3 are representative of thermal stabilization conditions.

When test power was reduced from 3.0 to 1.0 kW, the canister and liner temperatures rapidly dropped as shown in Figure 3.4-1. This indicated that for a 1.0 kW heat source, the test had been heated to above the thermal stabilization temperature. About 25 days after the power was reduced to 1.0 kW, a steady-state canister peak temperature of 276°F and a liner peak temperature of 232°F were achieved. These peak temperatures were measured halfway down the canister heated length (about 127 inches below ground level) and represent the thermal stabilization temperatures. Throughout the 1.0 kW operational period, peak measured canister temperatures varied from 276 to 261°F and peak liner temperatures varied from 232 to 214°F due to seasonal temperature effects.

When the test power level was reduced from 3.0 to 1.0 kW on May 1, 1978, shrinkage cracks between the drywell grout and the concrete pad appeared. These cracks are shown in Figure 3.2-7. These cracks are assumed to have occurred due to the rapid decrease in liner temperature.

2.0 kW POWER OPERATION

Thermocouple readings at the start of 2.0 kW power operation and for the first five days are provided in Appendix C, Tables C-16 to C-18, respectively. In addition, thermocouple readings on May 15, 1979, at one month intervals, and on March 15, 1980 are included in Tables C-19 to C-25. The data on March 15, 1980 presents the peak temperatures recorded during 2.0 kW power operation. The data on April 1, 1980 were taken just prior to raising the test power level to 3.0 kW.

The 2.0 kW power operation test thermal results are shown in

Figures 3.4-4, 3.4-5 and 3.4-6. Figure 3.4-4 shows the peak temperature distribution (at about 127 inches deep) for the canister, liner and soil for the entire test period. Also shown are the Reference Well temperatures recorded for the same depth. Figure 3.4-5 shows the canister and liner axial temperature profiles on March 15, 1980 after 7780 hours of 2.0 kW operation. Figure 3.4-6 presents the soil temperature distribution on April 1, 1980 using isotherms interpolated from the thermocouple data.

Canister and liner temperatures rapidly rose in the first two days followed by a steady increase to thermal stabilization. The peak canister temperature rose from 271 to 365°F after 48 hours and reached a maximum of 506°F in December, 1979. The peak liner temperature rose from 227 to 294°F after 48 hours and reached its maximum of 458°F in December, 1979. These peak readings were measured about 127 inches below ground level. The canister and liner temperatures reached thermal stabilization (neglecting variations due to

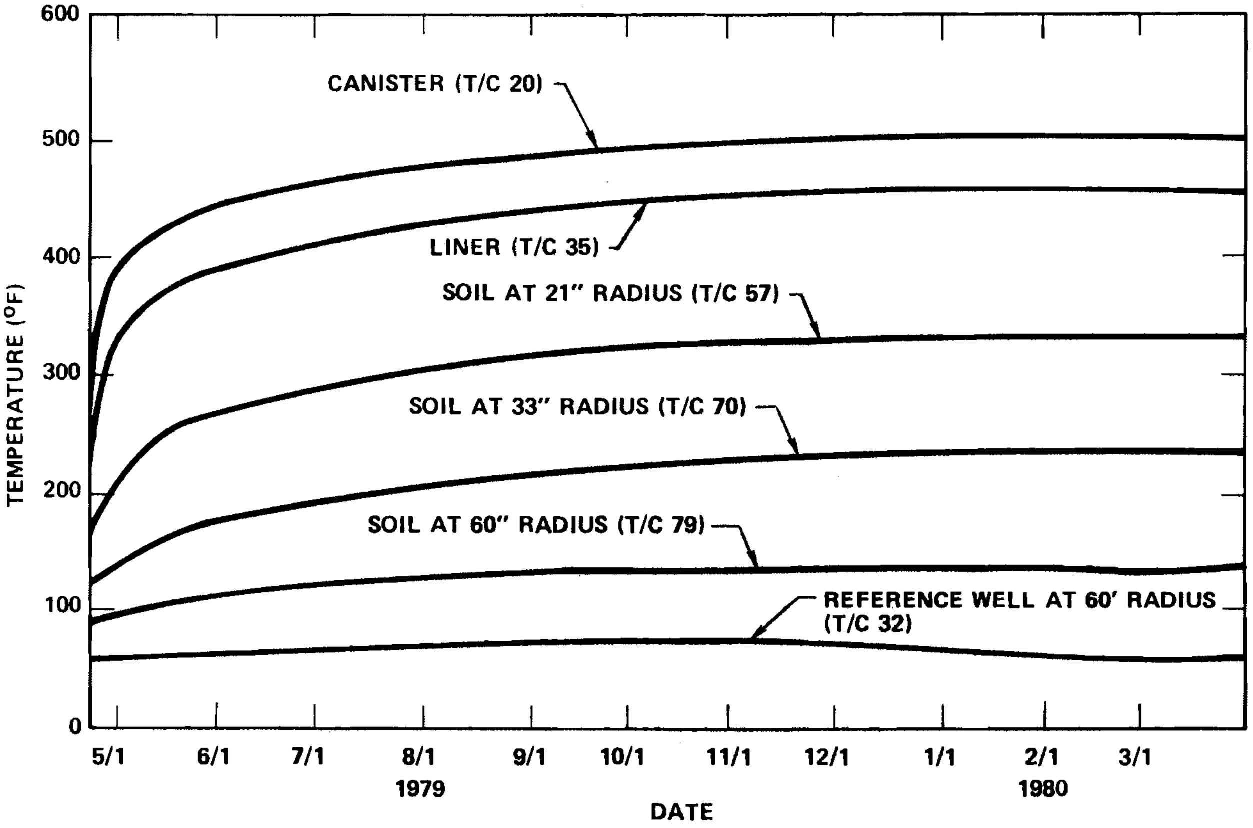

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Figure 3.4-4. Peak Temperature Distributions for 2 kW Electrically Heated Drywell Test Phase

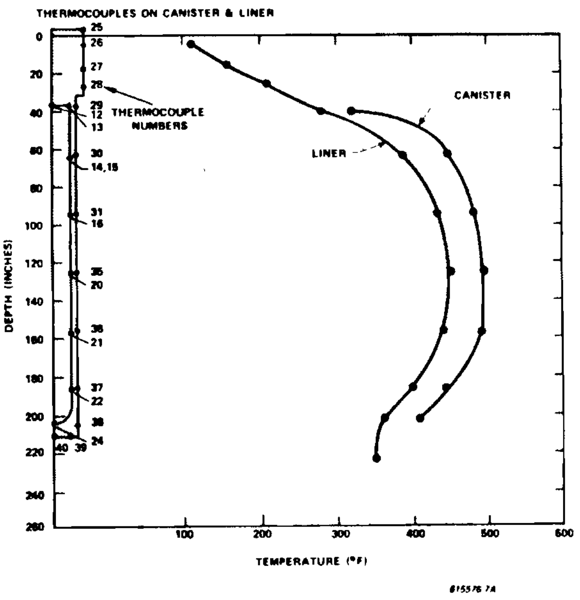

Figure 3.4-5. Canister and Liner Axial Temperature Profiles at 2 kW Power Level Thermal Stabilization, March 15, 1980

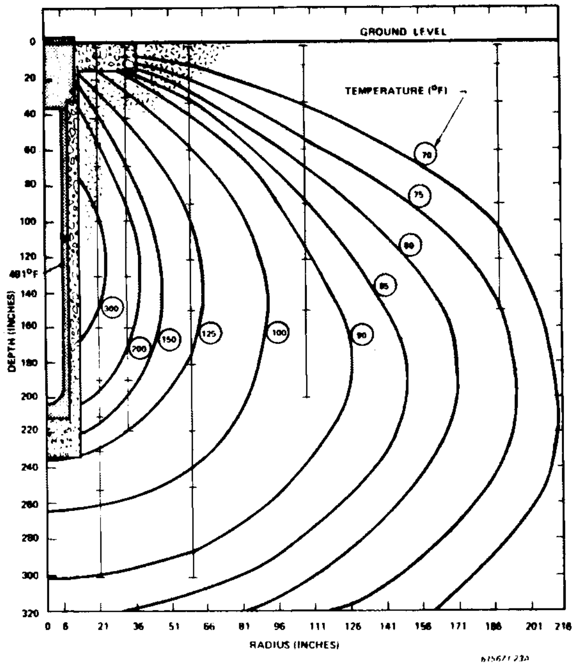

Figure 3.4-6. Soil Isotherms at 2 kW Power Level Thermal Stabilization, April 1, 1980

seasonal temperature effects) in six months. Peak temperatures at thermal stabilization were 500°F for the canister and 450°F for the liner. The soil temperatures below the level of peak readings (unaffected by seasonal variations) continued to slowly rise until reaching stabilization in March of 1980 (approximately 11 months into the test period).

Figures H-2 and H-3 show canister and liner axial temperature profile changes during 2.0 kW operation. The profiles shown are for July 1, 1979, September 1, 1979 and March 15, 1980; the March 15, 1980 profiles represent the peak temperature profiles during 2.0 kW operation. Each set of profiles shows drywell temperature progression with time and the shape change in the axial profile. The canister and liner lower end temperatures increased at a faster rate than the canister midplane until the entire drywell reached thermal stabilization.

3.0 kW POWER OPERATION

Thermocouple readings at the start of 3.0 kW power operation and for the first five days are provided in Appendix C, Tables C-25 to C-27. In addition, thermocouple readings on April 15, 1980, at about one month intervals through December 30, 1980, and on October 8, 1980 are provided in Tables C-28 and C-33, respectively. The readings on December 30, 1980, were taken the day before the 3.0 kW power operation was terminated.

The 3.0 kW test thermal results are shown in Figures 3.4-7, 3.4-8 and 3.4-9. Figure 3.4-7 shows the peak temperature distributions for the canister, liner and soil over the

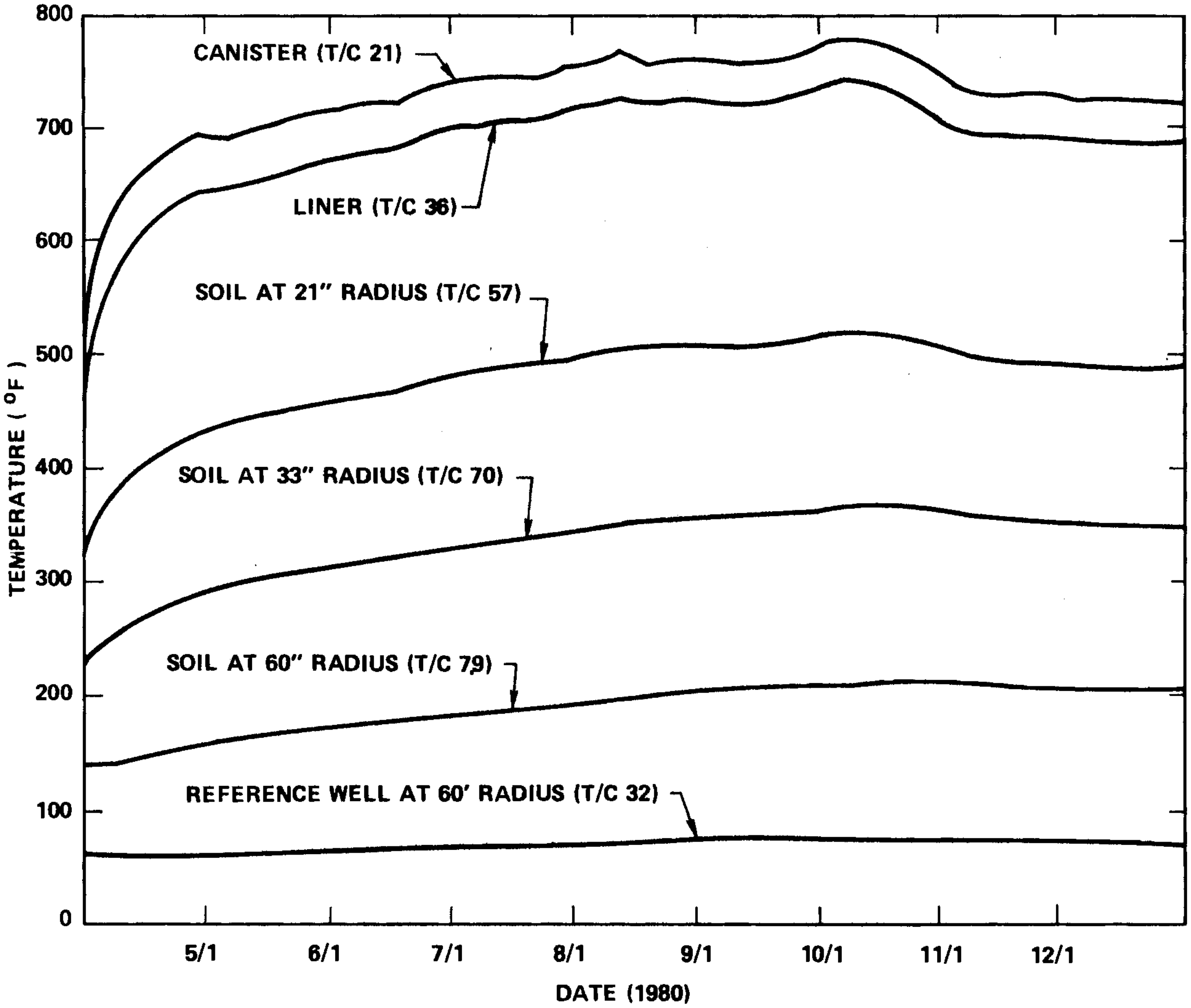

Figure 3.4-7. Peak Temperature Distributions for 3 kW Electrically Heated Drywell Test Phase

entire test period. The soil temperatures were measured at a depth of about 127 inches and the canister and liner temperatures were measured about 30 inches lower. Also shown are the Reference Well temperatures recorded for the 127 inch depth. Figure 3.4-8 shows the canister and liner axial temperature profiles on October 8, 1980 after 4564 hours of 3.0 kW operation when peak canister and liner temperatures occurred. Figure 3.4-9 shows the soil temperature distribution on October 8, 1980, using isotherms interpolated from the thermocouple data.

Canister and liner temperatures rapidly rose in the first two days followed by a fairly steady increase to thermal stabilization.

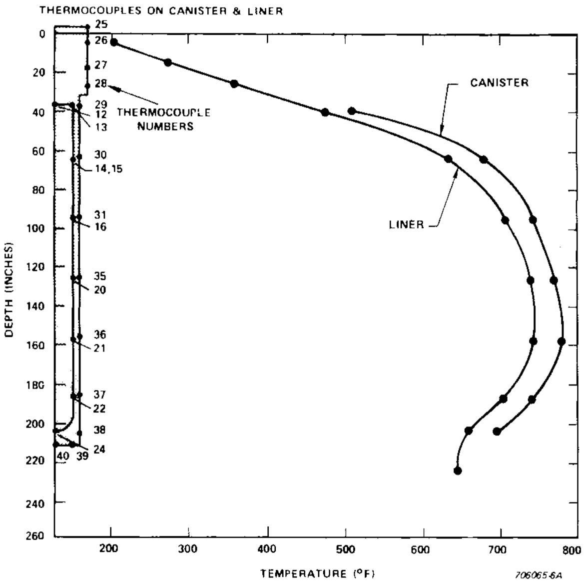

Figure 3.4-8. Canister and Liner Axial Temperature Profiles at 3 kW Power Level Thermal Stabilization, October 8, 1980

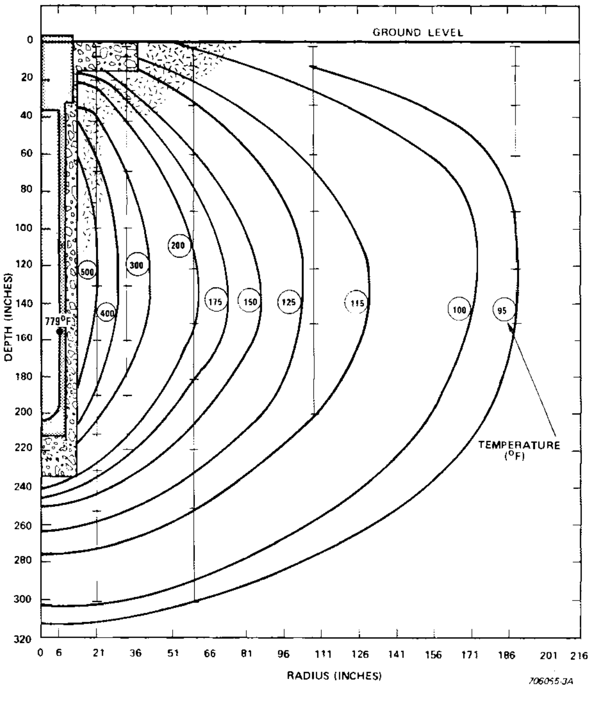

Figure 3.4-9. Soil Isotherms at 3 kW Power Level Thermal Stabilization, October 8, 1980

The peak canister temperature rose from 490 to 579°F after 48 hours and reached a maximum of 785°F in October, 1980. The peak liner temperature rose from 447 to 522°F after 48 hours and reached a maximum of 747°F in October, 1980.

The canister and liner temperatures reached thermal stabilization in about six months. However, the effect of seasonal temperature variations (specially those experienced during October, 1980) on canister and liner temperatures could not be fully examined due to the nine month test time period. The soil temperatures below the level of peak readings continued to slowly rise until reaching stabilization in late December, 1980.

The drywell transient response in Figure 3.4-7 was as expected except during October, 1980. The temperatures steadily increased to a peak value during the first five months of 3.0 kW operation in response to the higher power level. They slightly decreased during the last two months in response to the seasonal decrease in atmospheric temperatures. The unexpected canister, liner and nearby soil temperature increase and decrease during October resulted from an increased power level to the heater and the response to unusual atmospheric temperatures. The air temperatures at E-MAD were higher than normal during the last half of September and the first ten days of October (see Table 3.4-1). Average air temperatures were above 80°F (normal averages are 70°F) with daily highs in the 90's and in some cases above 100°F. From October 13 to 16, the average air temperatures dropped to near 50°F and then returned to normal. In addition, it was noted that a heater power measurement of 3242 watts was recorded at 8:30 a.m. on October 14 following a three day weekend. The heater power output was subsequently adjusted back to 3000 watts.

These canister, liner and nearby soil temperature changes in October can be explained by heat transfer mechanisms. The slow rise in canister and liner temperatures during the second half of September and the fairly uniform decrease during the second half of October indicate a slightly delayed response to the average atmospheric temperature. Along the entire length of the canister and liner, temperatures changed due to axial heat transfer by conduction in the canister and liner walls and by air convection within the canister and between the canister and liner. The peak canister, liner and soil temperature increase at the 21 and 33 inch radii can be attributed to the higher heater output. This heat, transferred to the canister and liner, was then transmitted radially by conduction into the soil. This resulted in higher canister, liner and near-drywell soil temperatures. The soil temperatures began to decrease after the heater power level was reset at 3000 watts. The peak recorded temperatures (785°F for the canister and 747°F for the liner) occurring on October 12 were also affected by the higher heater output. Values for peak canister and liner temperatures were 778 and 742°F, respectively prior to October 12 and 777 and 741°F, respectively on October 14.

Figures H-4 and H-5 show canister and liner axial temperature profile changes during 3.0 kW operation for April 1, April 15, August 1 and October 8, 1980. The profiles for April 1 represent the canister and liner temperatures just prior to 3.0 kW operation startup. The profiles for October 8 represent the peak temperature profiles throughout the 3.0 kW operation period (except for those on October 12 which were affected by higher heater output as noted). Each set of profiles shows the drywell temperature progression with time and the shape change in the axial profile. Both figures show after two weeks of 3.0 kW operation, the temperature profiles progressed about half-way to their final values. After four months of 3.0 kW operation, each profile was 95 percent of the peak profile reached two months later. In addition, as the operating period continued, the temperature increase for the canister and liner lower half became larger than the increase for the top half. The canister temperature increase from April 1 to October 8 at the heater top was 240°F compared to 280°F at the heater axial midplane and 290°F 40 inches lower. For the liner, the comparable temperature increases were 250, 294 and 303°F for the heater top, heater axial midplane and 40 inches below the midplane, respectively.

HEATER POWER VARIATIONS

The heater power adjustments maintained the nominal power level variations to within two percent during normal working hours. However, during non-working hours, input voltage variations caused heater power levels to exceed two percent from April through September. The air conditioning systems shutdown throughout the Nevada Test Site after the final daily heater power check was suspected to have increased the line voltage. This increase raised the heater power level to five percent above the recorded power levels and the average power level by three percent over the five summer months.

COMPARISON OF ELECTRICALLY HEATED DRYWELL TEST PHASES

A comparison of the results from the Electrically Heated Drywell Test 1.0, 2.0 and 3.0 kW operation phases are presented in Figures 3.4-10 through 3.4-13 at comparable periods. Figure 3.4-10 compares canister axial temperatures for approximately 4565 hours of operation at each power level. Figure 3.4-11 compares these test data normalized to heater axial midplane temperature. Figures 3.4-12 and 3.4-13 compare the 100 and 200°F isotherms, respectively for all three power levels.

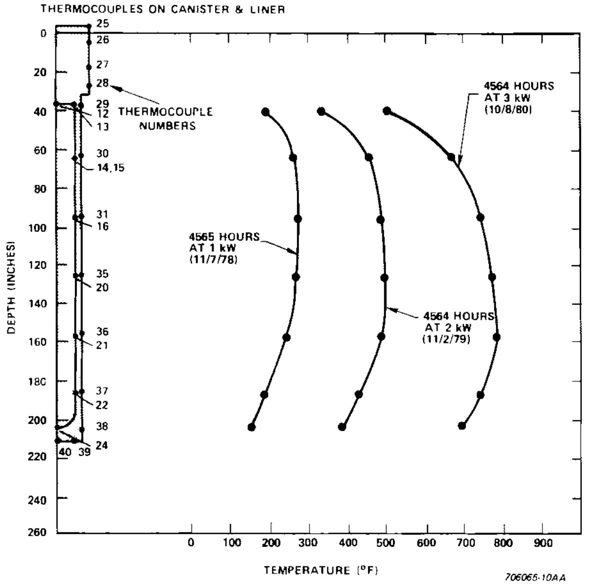

Figure 3.4-10. Canister Axial Temperature Comparison for 1 kW, 2 kW and 3 kW Operation

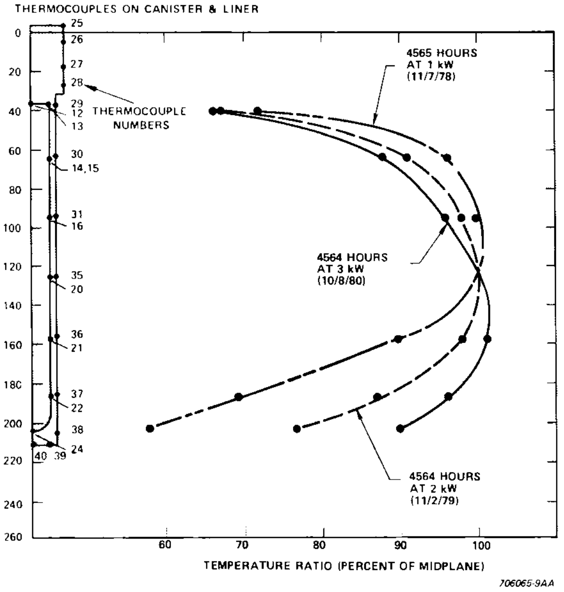

Figure 3.4-11. Normalized Canister Axial Temperature Comparison for 1 kW, 2 kW and 3 kW Operation

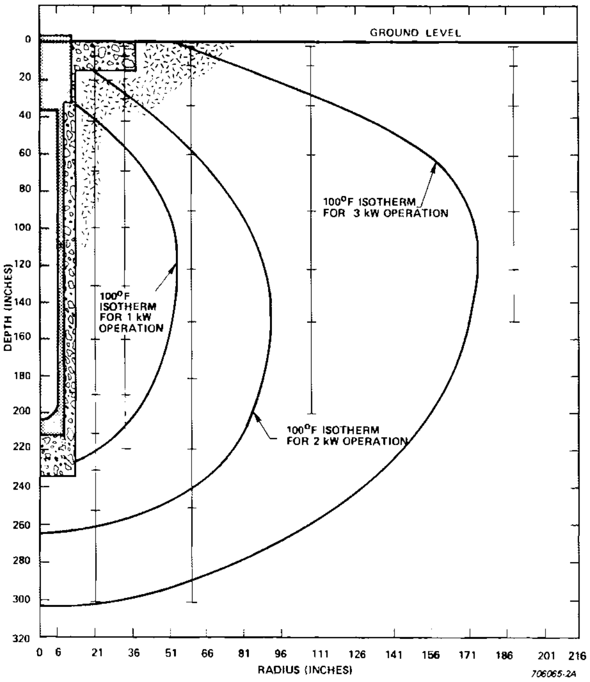

Figure 3.4-12. Comparison of 100°F Isotherms for 1 kW, 2 kW and 3 kW Operation

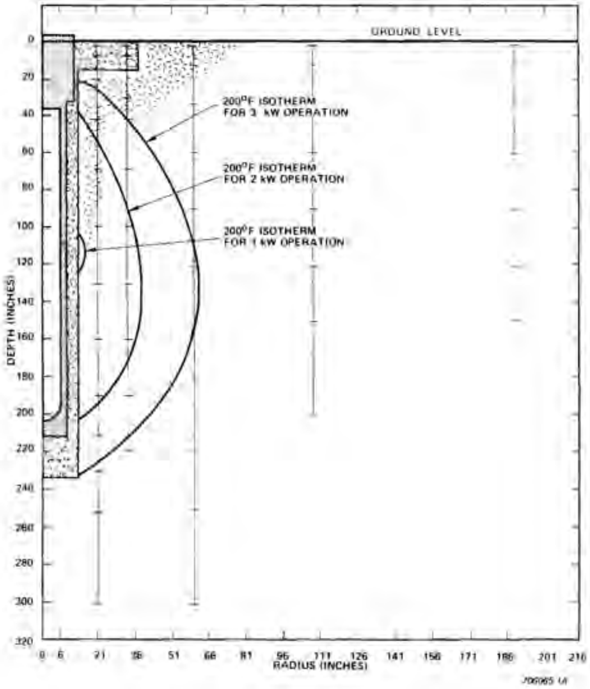

Figure 3.4-13. Comparison of 200°F Isotherms for 1 kW, 2 kW and 3 kW Operation

The canister axial temperature profiles show a different shape for all three power levels. The locations of peak and minimum canister temperatures were reversed for the 3.0 kW power level as compared to the 1.0 kW power level. The axial profile for the 2.0 kW power level is much flatter over the canister's heated length. The differences in axial profiles can be explained by the heat transfer mechanisms involved inside the canister and soil. These heat transfer mechanisms (convection, conduction and radiation) can also be related to the temperatures of the canister and soil surrounding the drywell.

As previously noted, the 1.0 kW power level axial profile shows the effect of free convection in the air inside the canister (skewed canister temperature profile towards the top). The 2.0 kW power level axial profile increases from radiation heat transfer to the liner at higher canister temperatures (flatter temperature profile). For the 2.0 kW power level, the soil heating may have caused a greater canister temperature rise below the canister midplane elevation than above (due to soil thermal conductivity decrease). Comparing the 3.0 kW power level canister axial profile with the 2.0 kW profile shows a continuation of the canister profile change noted from 1.0 to 2.0 kW. For the higher canister temperatures (over 700°F), it is expected that radiation heat transfer from heater to canister and canister to liner would dominate the free air convection effects. This effect might be expected to flatten the profile even further than that for the 2.0 kW power level; however, as noted in Figures 3.4-10 and 3.4-11, the 3.0 kW power level canister axial profile is skewed toward the canister bottom end. This skewed shape is more directly related to the decreasing soil thermal conductivity caused by heating of the soil.

As shown in Figures 3.4-12 and 3.4-13, more soil is heated above 100°F for the 3.0 kW power level than for the 2.0 kW power level. In addition, a larger soil volume is heated above 200°F for the 3.0 kW power level. The soil thermal conductivity versus temperature relationship, shown in Figure 3.5-8 from laboratory measurements at four separate soil depth ranges, shows a large change at 200°F (the approximate boiling point of water at E-MAD). As discussed previously, some decrease in soil moisture content and resulting decrease in soil thermal conductivity does occur as the soil is heated. The increased volume of heated soil around the drywell lower portion results in a higher resistance to heat flow from the canister lower half. This causes canister lower end temperatures to rise as shown in Figures 3.4-10 and 3.4-11. In addition, the increased thermal resistance to radial heat flow also causes a higher canister heat flux on the top end due to heat flow to the ambient air. The Electrically Heated Drywell Test recorded data may have been influenced by two events occurring during construction and hardware setup. Due to an operations delay, the liner emplacement hole remained open for several days before liner installation, and some portions collapsed which resulted in redrilling the hole. As a result, the amount of grout needed was roughly double the original estimate. The collapsing occurred on the north side of the hole. The grout and soil temperature measurements were taken on the south side where the final configuration fairly accurately matches that described. In addition, most of the excess grout is located near the bottom of the hole. Since it is estimated that over 90 percent of the heat is dissipated at the ground surface, the extra grout should have had only a small effect on the test thermal response.

The second event was water in the liner. During canister assembly installation, approximately two inches of water was inadvertently left in the liner bottom. Test assembly operations were nearly complete when this was discovered, so after an engineering evaluation it was decided to let the water remain and evaporate during the test. Considering the canister temperature levels, the length of the test, and the low desert air humidity, it is assumed that prior to thermal stabilization no water remained. It was judged that the water in the liner has had little or no effect on the steady-state temperatures since the model predictions correlated with the test results.

3.4.2 FUELED DRYWELLS

ISOLATED DRYWELL TEST - PHASE I

This section presents the Phase I test results for the isolated drywells (Drywell 5 with fuel assembly B03 and Drywell 3 with fuel assembly B41) from drywell and soil thermocouples. Thermocouple readings for each drywell are provided for the start of testing, for the first five days, and at two week intervals throughout Phase I (January 12, 1979 through August 4, 1980). Drywell 5 thermocouple readings are provided in Tables D5-2 through D5-7 and Drywell 3 thermocouple readings are provided in Tables D3-2 through D3-7.

The peak measured temperatures for Drywell 5 are presented as canister, liner, and soil temperature distributions throughout the test period in Figure 3.4-14 and as canister and liner axial temperature profiles in Figure 3.4-15. Figures 3.4-16 and 3.4-17 present the peak measured temperatures for Drywell 3. The peak temperatures occurred several inches below the canister midplane during August, 1979. For Drywell 5, the peak canister temperature was 253°F, and the peak liner temperature 203°F. For Drywell 3, the peak canister temperature was 254°F, and the peak liner temperature 198°F. After the peak temperatures occurred, all temperatures decreased and began a

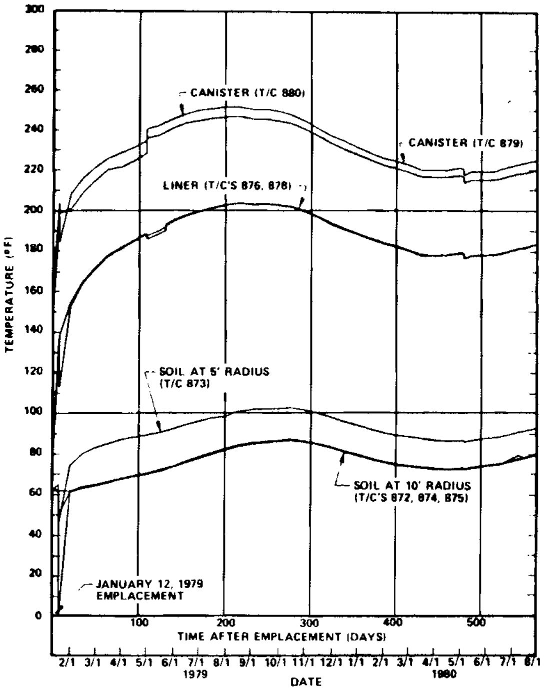

Figure 3.4-14. Drywell 5 (F/A B03) Peak Canister, Liner and Soil Temperature Distributions at About 145 Inches Below Ground Level, January 12, 1979 to August 4, 1980

cycling pattern in response to seasonal atmospheric temperature changes.

Figures I-1 to I-6 show additional plots of temperature data measured for both drywells during the drywell testing. Figures I-1, I-2, and I-3 show sets of canister, liner, and soil temperature data for the top, middle, and bottom thermocouple levels, respectively for Drywell 5. Figures I-4, I-5, and I-6 show the same data for Drywell 3. These data plots were generated by a computer code providing straight lines between data points at two week intervals.

Axial heat convection effects inside the canister were evident in

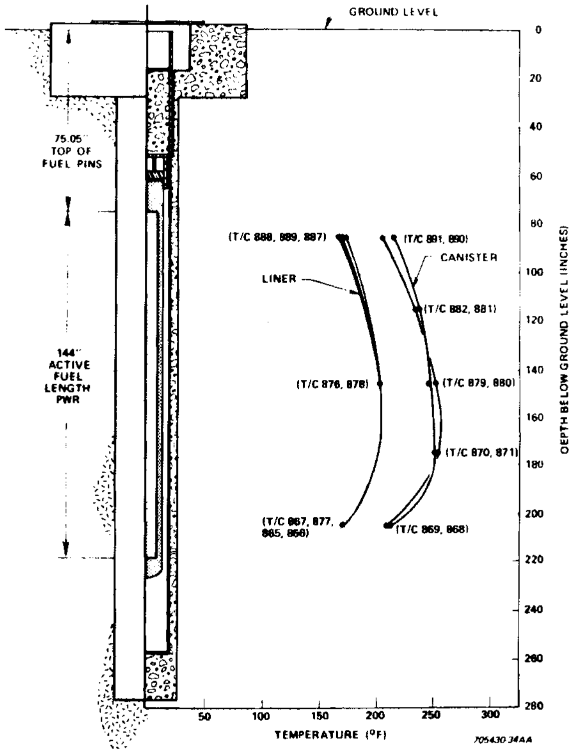

Figure 3.4-15. Drywell 5 (F/A B03) Peak Canister and Liner Axial Temperature Profiles, August 15, 1979

Drywells 5 and 3. Convection effects within an air filled canister were evident in the Electrically Heated Drywell Test data as discussed in Section 3.4.1. Convection currents cause canister temperature variations at one elevation to occur more rapidly due to temperature changes at other elevations than would be possible by conduction heat transfer alone. Thus, canister temperatures at two different elevations are more closely in phase than soil temperatures at the same elevations. The same phenomenon is apparent in data from Drywells 5 and 3. Canister temperature data from three elevations on Drywell 5 in Figure

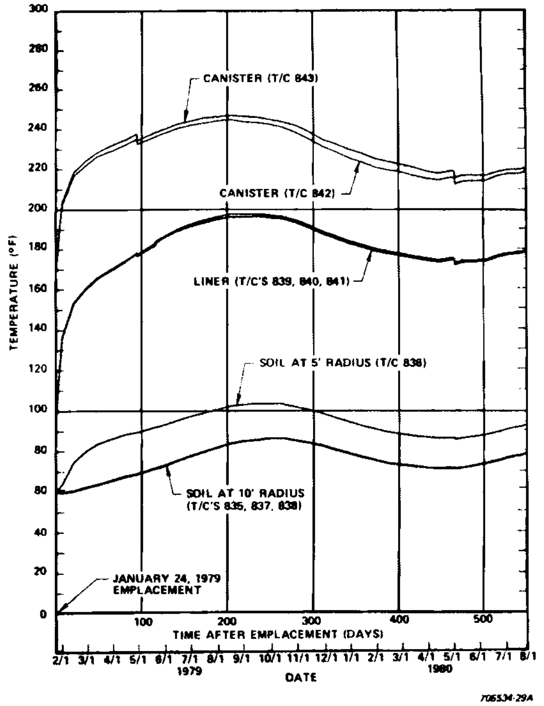

Figure 3.4-16. Drywell 3 (F/A B41) Peak Canister, Liner, and Soil Temperature Distributions at About 145 Inches Below Ground Level, January 24, 1979 to August 4, 1980

3.4-18 were compared with soil temperature data at a 10 foot radius in Figure 3.4-19 for the same elevations. The canister temperatures all peak within a period of approximately 30 days, while the soil temperature peaks are distributed over a period of 60 to 70 days.

The thermal data from Drywells 5 and 3 showed that the day/night atmospheric temperature changes had little or no effect on the drywell temperatures. Comparing the canister, liner, and soil temperatures at the 5 foot and 10 foot radius of the uppermost thermocouple elevation showed a maximum 0.5°F difference between early morning and mid-afternoon data recordings.

For the test period after April, 1979, the temperature versus time

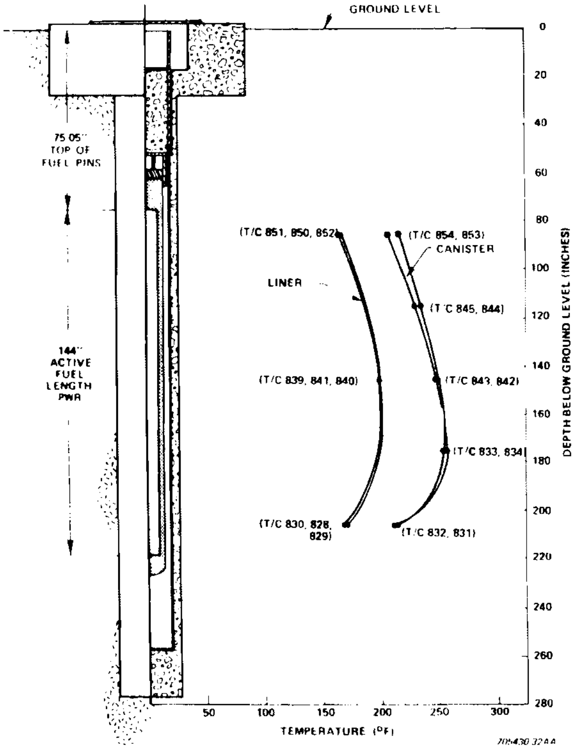

Figure 3.4-17. Drywell 3 (F/A B41) Peak Canister and Liner Axial Temperature Profiles, August 15, 1979

curves show small (10°F or less) circumferential temperature variations at all instrument elevations. In addition, comparing four Drywell 5 liner thermocouples at an elevation 205 inches below ground level shows a variation of less than 2°F until March 1, 1980 when a thermocouple (867) varied between 3 and 6°F. This indicates that uniform soil properties exist circumferentially; and there are no thermal effects of one drywell on another.

The following operations and activities pertinent to the Phase I Isolated Drywell Test and the recorded data should be noted.

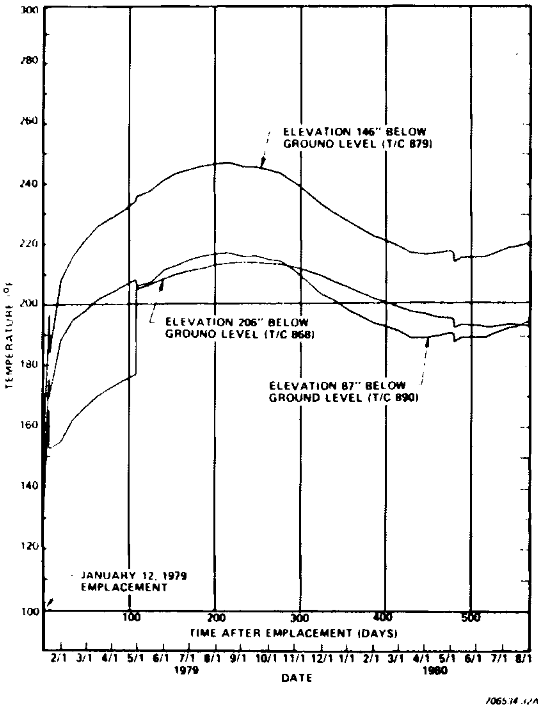

Figure 3.4-18. Drywell 5 (F/A B03) Canister Temperature Distributions, January 12, 1979 to August 4, 1980

During thermocouple routing from the electrical enclosure to Drywell 5, liner thermocouple 877 broke. A replacement was installed, a Type K thermocouple connector joining it to the existing wire leading to the instrumentation shed. This connection was made in the electrical enclosure. Later evaluations determined this replacement thermocouple was 60 inches longer than the original thermocouple.

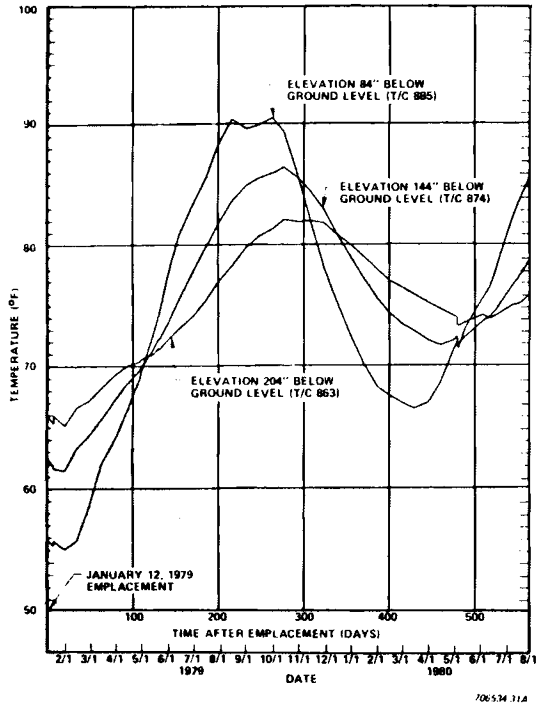

Figure 3.4-19. Drywell 5 (F/A B03) Soil Temperature Distributions, January 12, 1979 to August 4, 1980

Two liner thermocouples failed during the Phase I Isolated Drywell Test. Data readings from Drywell 3 liner thermocouple 829 greatly differed from the similar position thermocouples (876 and 878, see Figure I-6) soon after thermocouple installation (no irregularity in reading had been noted during initial temperature readouts). Following an integrity check, this thermocouple was removed and replaced on March 16, 1979. A Type K thermocouple connector joined the replacement thermocouple with the extension wire connected to the data logger system multiplexer. On February 15, 1980, Drywell 3 liner thermocouple 828 stopped providing data. After an integrity check, this thermocouple was disconnected. Since no replacement thermocouple was available, no further data readings were taken.

Initially, Drywell 5 canister thermocouples were installed with the transition boots about 6 inches above the shield plug. Later on

January 19, 1979, these thermocouples were inserted further so the transition boots contacted the shield plug. The results of this readjustment can be seen as abrupt temperature changes on Figures 3.4-14, I-1, I-2, and I-3. Later, an engineering evaluation of the canister thermocouple tube/thermocouple interface was conducted since the transition boots should have been about 6 inches above the shield plug top. The evaluation showed that the ten canister thermocouples could pass between the canister and thermocouple tube angle and plate, and may be measuring air temperatures between the canister and liner. It was determined that the thermocouples be raised with the transition boots 5.5 inches above the shield plug top. This was accomplished on April 30, 1979. The test data results shown in the Drywell 5 and Drywell 3 temperature distribution figures indicate that all 20 canister thermocouple temperatures were affected by this action. This indicates the thermocouples were originally outside the canister tubes.

Inadvertantly the nine liner thermocouples for each drywell were also raised by 5.5 inches on April 30. Evaluating the liner temperature versus time curves shortly thereafter revealed the change in thermocouple position. The liner thermocouples were properly reinserted on May 22, 1979. The change in temperature readings on these two dates is evident for all liner thermocouples on Figure 3.4-14, 3.4-16 and I-1 through I-6.

It should also be noted that temperature readings for ten Drywell 5 thermocouples varied widely between January 19 and February 1, 1979 as shown on Figures 3.4-14, I-1, I-2, and I-3. An adjustment made to the thermocouple reference board on January 27, 1979 corrected the variations.

The overall effects of the water discovered in Drywells 5 and 3 during canister rearrangement operations have not been completely evaluated. However, based on thermal data results from the two isolated drywells and the amount of water present, water should have had little effect on drywell temperatures. Water vapor in the annulus would increase the heat transfer between canister and liner causing the canister temperatures to be slightly lower than if the drywells were dry. Since the majority of heat flow resistance from the fuel assembly to the surrounding atmosphere is due to the low soil thermal conductivity, the effect of water vapor inside the drywell should be minor. Water in the liner thermocouple tubes could have affected the temperature readings and caused thermocouple 828 to fail. Examining the overall temperature versus time curves for both sets of drywell liner thermocouples shows that no liner temperature reading exceeded 200°F, which is the approximate boiling point of water at E-MAD. In addition, the liner temperature transient curves do not show any unexpected changes caused by water in the tubes. Therefore, the water was not expected to have influenced the temperature data presented in this report.

ISOLATED DRYWELL TEST - PHASE II

This section presents the thermal test results for the Phase II Isolated Drywell Test (Drywell 5 with fuel assembly D22). Thermocouple readings from Drywell 5 are provided in Appendix D for one hour after emplacement, for the first five days, and at two week intervals throughout the Phase II test (September 4, 1980 through March 31, 1982) in Tables D5-9 through D5-14.

The peak measured temperatures for Drywell 5 are presented as canister, liner, and soil temperature distributions throughout the Phase II test period in Figure 3.4-20 and as canister and liner axial temperature profiles in Figure 3.4-21. Following canister emplacement, canister and liner temperatures rose rapidly. The peak temperatures occurred during October, 1980 (about six weeks after canister emplacement). The peak canister temperature was 323°F, and the peak liner temperature was 262°F. After the peak temperatures occurred, all temperatures decreased in response to seasonal atmospheric temperature and decay heat changes. Thereafter, the temperatures show seasonal cycles superimposed on decreasing mean temperatures resulting from the decreasing decay heat level.

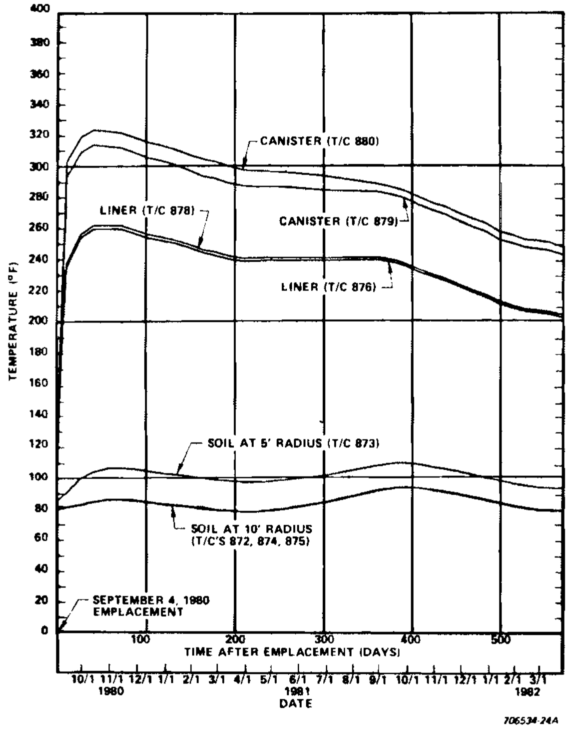

Figure 3.4-20. *Drywell 5 (F/A D22) Peak Canister, Liner and Soil Temperature Distributions at About 145 Inches Below Ground Level, September 4, 1980 to March 31, 1982*

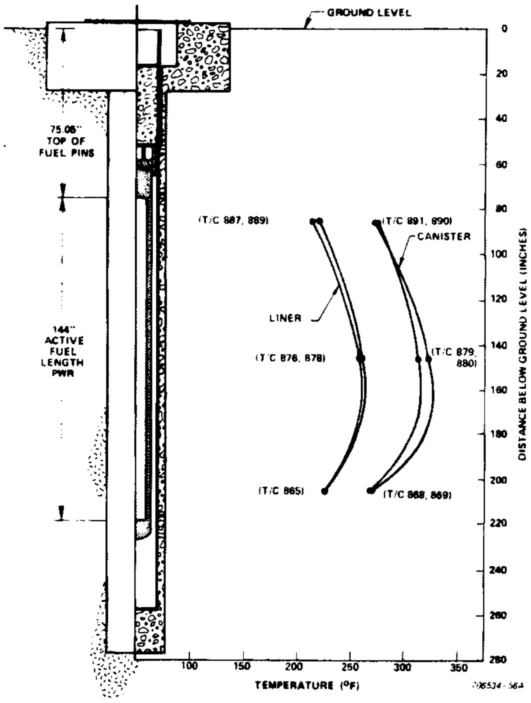

Figure 3.4-21. *Drywell 5 (F/A D22) Peak Canister and Liner Axial Temperature Profiles, October 15, 1980*

Figures I-1, I-2 and I-3 show sets of canister, liner, and soil temperature data for the top, middle, and lower thermocouple levels, respectively for Phase I and II. These data plots were generated by a computer code providing straight lines between data points for data at two week intervals.

Some of the Drywell 5 test thermocouples could not be used for Phase

II. Four canister thermocouples could not be installed (T/C's 870, 871, 881 and 882) since there were no Phase II canister instrumentation tubes and were coiled in the annulus around the drywell liner top. Four liner thermocouples (T/C's 866, 867, 877 and 888) were broken during removal for canister rearrangement. For three, the thermocouple broke near the liner tube top; therefore, no replacement could be made. The fourth liner thermocouple (T/C 866) broke about 78 inches below ground level. A replacement provided an additional data point. The thermocouple sheath degradation and the liner instrumentation tube corrosion caused by water in the drywell annulus was the hypothesized reason for thermocouple breakage.

The Phase II Isolated Drywell Test data exhibit the same basic thermal response characteristics as the Phase I test data. Figures 3.4-22, 3.4-23 and 3.4-24 compare Drywell 5 thermal response in both test phases. Figure 3.4-22 shows the peak canister, liner and soil temperatures, the ambient soil temperatures at the elevation of peak drywell temperatures, and the predicted spent fuel assembly decay heat curves over the 39 months of Isolated Drywell Testing (Phases I and II). Figure 3.4-23 compares the peak canister and liner axial temperature profiles for Phase I and Phase II. Figure 3.4-24 shows the canister axial temperature profiles for both test phases with similar fuel assembly decay heat levels.

The major difference between the Phase I and Phase II thermal response is the rapid temperature rise of the canister, liner and soil for the Phase II test. This is because the soil and grout surrounding Drywell 5 had been heated and dried out. Although the drywell had been empty for 31 days, the soil at the 5 foot radius was still above 80°F when testing began. This initial heat would be expected to shorten the soil heatup period. The soil dryness resulted in a decrease in thermal conductivity and an increase in soil thermal resistance causing the canister and liner temperatures to rise much faster than in Phase I.

The change in soil thermal conductivity from Phase I to Phase II is also evident in comparing the axial temperature profiles of Figures 3.4-23 and 3.4-24. The canister temperature difference at the active fuel midplane level from the peak temperature profiles in Figure 3.4-23 is 69°F for a predicted decay heat level difference of 0.47 kW. In Figure 3.4-24, for a predicted decay heat level difference of only 0.06 kW, the same canister temperature difference is 33°F. A much smaller canister temperature difference would be expected for the 0.06 kW decay heat difference; however, the in soil thermal conductivity decrease resulted in a higher Phase II canister temperature.

Another difference in the drywell thermal response was the higher peak temperatures reached. For the Phase II test, peak canister and liner temperatures reached 323 and 262°F, respectively. For the Phase I test, the peak canister and liner temperatures were 254 and 203°F, respectively. The higher temperatures can be related to the higher decay heat level of the Phase II fuel assembly. Figure 3.4-22 includes a decay heat curve for both fuel assemblies. The above

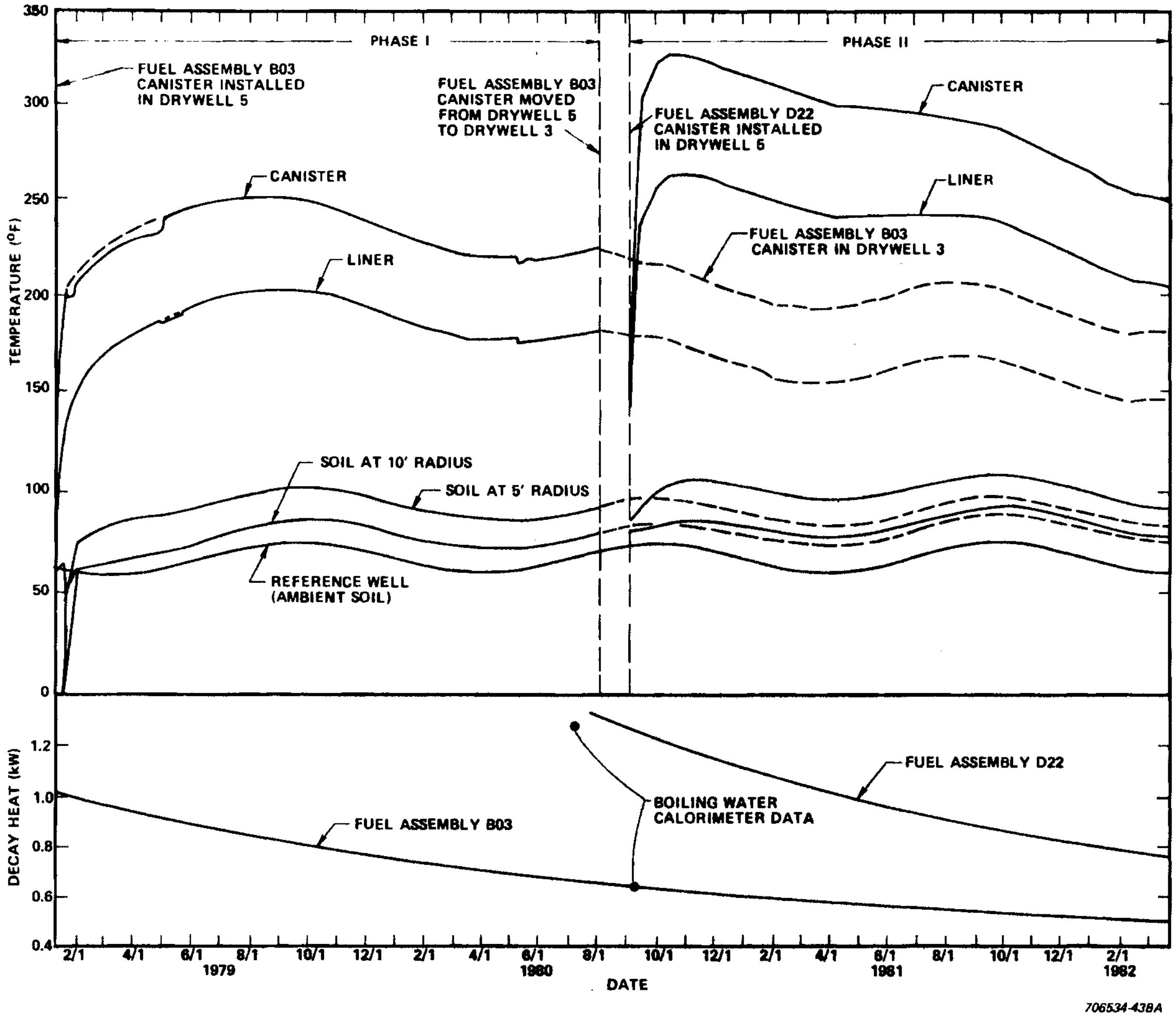

Figure 3.4-22. Isolated Drywell Test Phases I and II Temperature and Decay Heat Distributions

peak temperatures correspond approximate decay heat levels of 1.2 and 0.83 kW for the fuel assemblies at the time peak temperatures occurred.

The Phase II test data again showed that the day/night atmospheric temperature changes had little or no effect on drywell temperatures. Comparing the temperatures of the canister, liner, and soil at the 5 foot and 10 foot radius at the uppermost thermocouple elevation showed less than 0.5°F difference between early morning and mid-afternoon data recordings. Ambient air temperatures varied by as much as 30°F at these two times.

The Phase II canister and drywell response to seasonal ambient temperature changes can be seen in Figure 3.4-22. The peak temperatures were reached in mid-to-late October for the canister, liner and

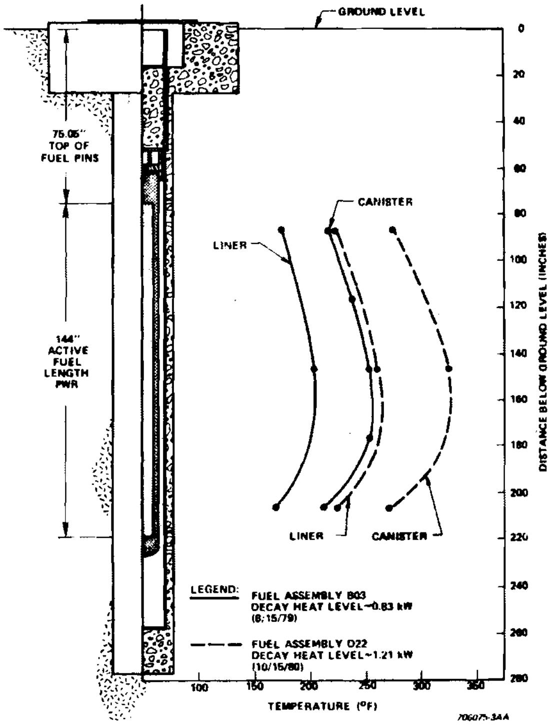

Figure 3.4-23. Drywell 5 Peak Canister and Liner Axial Temperature Profile Comparison for Phases I and II

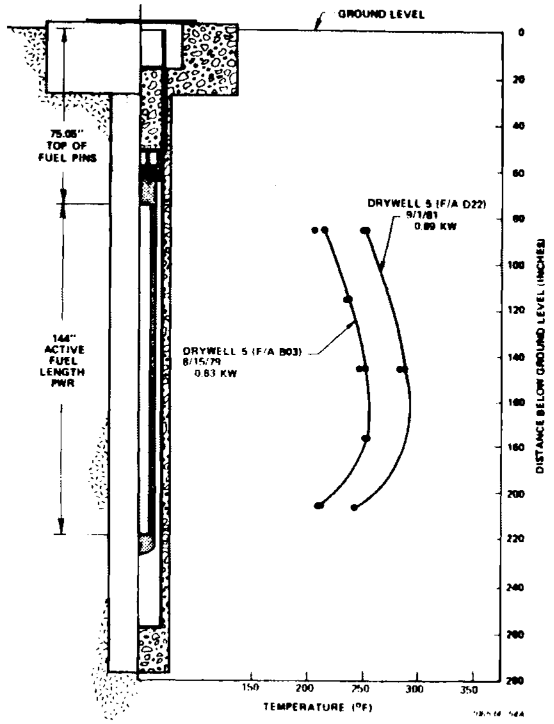

Figure 3.4-24. Drywell 5 Axial Temperature Profile Comparison for Phases I and II for Similar Decay Heat Levels

soil. The temperatures then decreased cyclicly as did the ambient soil temperatures. The same response was experienced during the Phase I test.

The 19 month duration of the Phase II test shows only three peaks and three valleys in the seasonal temperature response. These peaks and valleys tend to occur in a yearly cycle with each showing a temperature decrease corresponding to the decay heat decrease. In Figure 3.4-22, the Phase I test data have been supplemented with data from Drywell 3 to give more than three years of isolated drywell thermal response for fuel assembly B03. The canister, liner and soil peak temperatures during Phase II occurred after the peak ambient soil temperatures. This was caused by the heatup transient starting on September 4. If canister emplacement had occurred earlier, the peak temperatures may have occurred sooner and been slightly higher.

The Drywell 5 response to seasonal ambient air temperature variations showed the axial heat transfer effects within the canister, liner and soil. The conduction path through the steel canister and liner and the convection paths within the canister and between the canister and liner, allow for more rapid axial heat transfer than through the soil. This was again demonstrated by the Phase II data showing a slightly faster axial temperature response in the canister and liner than in the soil. Peak temperatures at the lowest elevation thermocouples on the canister and liner occurred about 30 days after those at the top elevation. Soil peak temperatures at the same approximate elevations occurred about 45 days apart.

The Phase II test data showed small circumferential temperature variations at all three instrumentation elevations indicating fairly uniform soil properties. However, due to the breaking of four thermocouples, circumferential temperature comparisons were not as conclusive as for Phase I. Liner temperatures at two elevations were compared for thermocouples located 90 and 120° apart. These showed variations between 1.7 and 7.3°F. Canister temperatures at all three instrumentation elevations were compared for thermocouples located 180° apart. These showed variations between 3.3 and 4.8°F at the top, 9.4°F at the middle and -0.4 to +0.4°F at the bottom. Soil temperature variations measured in the same region as the liner temperatures showed differences of less than 1.4°F at all elevations. Based on the thermocouple accuracy and positional accuracy, these differences were negligible.

ADJACENT DRYWELL TEST - PHASE III

This section presents the test results for the three adjacent drywells (Drywell 3 with fuel assembly B03, Drywell 2 with fuel assembly B41, and Drywell 1 with fuel assembly B43) during the Phase III test (August 4, 1980 to March 31, 1982). Thermocouple readings for each drywell are provided at (or near) canister emplacement, for the first five days, and at two week intervals in Tables D3-8 through D3-13 for Drywell 3, Tables D2-2 through D2-7 for Drywell 2 and Tables D1-2 through D1-7 for Drywell 1.

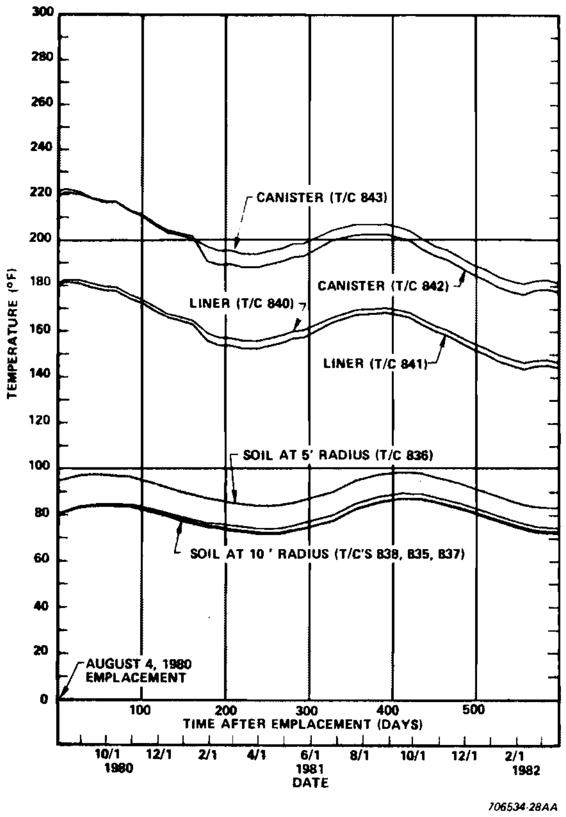

Figure 3.4-25. Drywell 3 (F/A B03) Peak Canister, Liner and Soil Temperature Distributions at About 145 Inches Below Ground Level, August 4, 1980 to March 31, 1982

Thermal test results are shown in Figures 3.4-25 through 3.4-30. The measured temperatures for Drywells 3, 2 and 1 at the 145 inch depth below ground level are presented as canister, liner and soil temperature distributions in Figures 3.4-25, 3.4-27 and 3.4-29, respectively. Peak canister and liner axial temperature profiles on September 1, 1981 are presented in Figures 3.4-26, 3.4-28 and 3.4-30 for Drywells 3, 2 and 1, respectively.

The temperature distributions are shown from canister emplacement until March 31, 1982. For Drywells 1 and 2, the temperatures presented at the 145 inch depth represent the peak values recorded. For Drywell 3, peak canister temperatures were recorded 30 inches below those shown on Figure 3.4-25 and were between 6 and 10°F higher. Additional

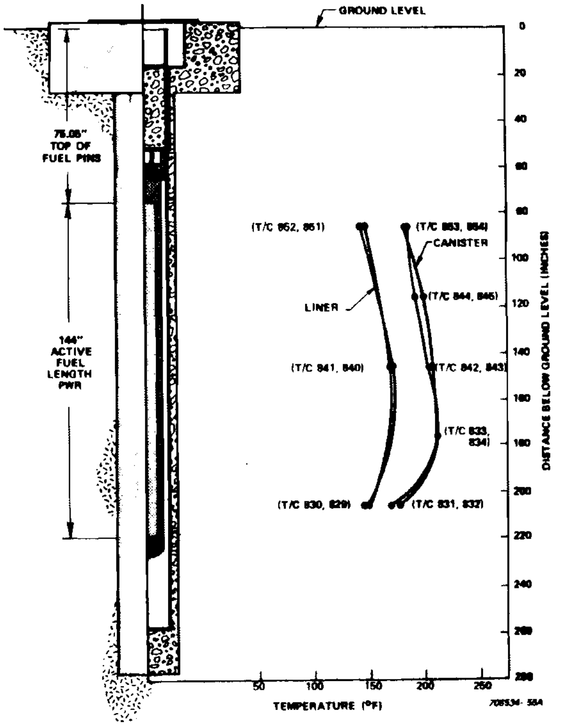

Figure 3.4-26. Drywell 3 (F/A B03) Peak Canister and Liner Axial Temperature Profiles, September 1, 1981

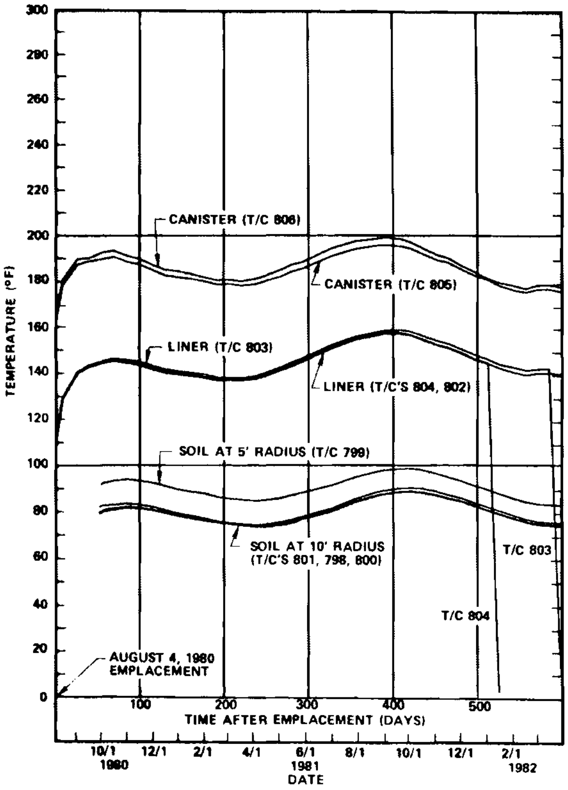

Figure 3.4-27. Drywell 2 (F/A B41) Peak Canister, Liner and Soil Temperature Distributions at About 145 Inches Below Ground Level, August 4, 1980 to March 31, 1982

canister, liner and soil temperature distribution figures are provided in Appendix I. Figures I-4 and I-5 present Drywell 3 temperatures at 85 and 205 inches deep, respectively. Figures I-7, I-8, I-9 and I-10 present Drywell 2 and Drywell 1 temperatures at the same depths. It should be noted that all temperature distribution plots were generated by a computer code providing straight lines between data points.

Drywells 1 and 2 had a similar thermal response. For each drywell, the temperatures rose to an initial peak value and then decreased in response to the decreasing decay heat level and the seasonal change in ambient atmospheric and soil temperatures. Peak temperatures for Drywell 1 (188°F for the canister and 141°F for the liner) occurred about 30 days after canister emplacement, around November 15, 1980. Peak temperatures for Drywell 2 (193°F for the canister and 146°F for the liner) occurred about 70 days after canister emplacement, around October 15, 1980. The temperatures for both drywells converged during December, 1980 and remained within 2 to 5°F throughout the test.

For Drywells 1 and 2, the late summer canister emplacement caused the peak temperatures to be less than expected. Canister temperatures (197°F for Drywell 1 and 199°F for Drywell 2) and liner temperatures (157°F for Drywell 1 and

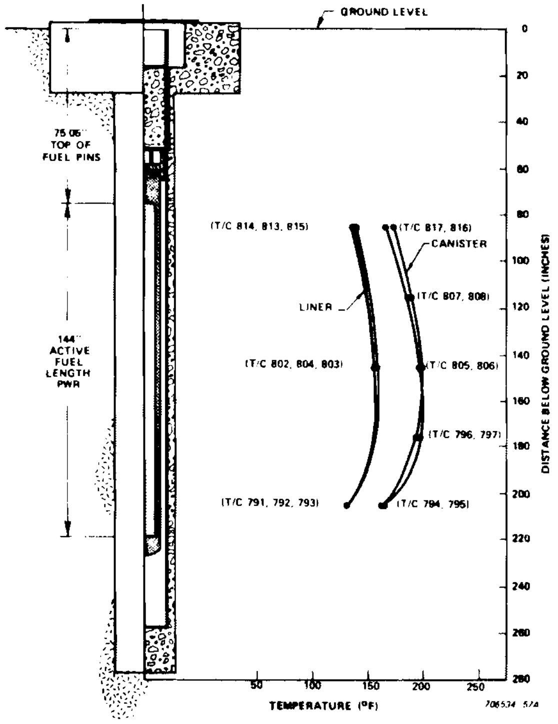

Figure 3.4-28. Drywell 2 (F/A B41) Peak Canister and Liner Axial Temperature Profiles, September 1, 1981

158°F for Drywell 2) recorded in September, 1981 were higher than the peaks reached in 1980. The decay heat level is estimated to have decreased from 0.63 kW in August, 1980 to 0.54 kW in September, 1981 for the fuel assemblies. Peak 1980 temperatures should have been 20°F higher than those in 1981 as evidenced by the data from Drywell 3. Therefore, the initial peaks reached in 1980 were less than those which would have occurred if the canisters had been installed earlier in the year.

The thermal response of Drywell 3 continued to follow the seasonal cycles superimposed on a decreasing mean temperature as during Phase I. Following canister rearrangement, Drywell 3 canister and liner temperature readings showed a small

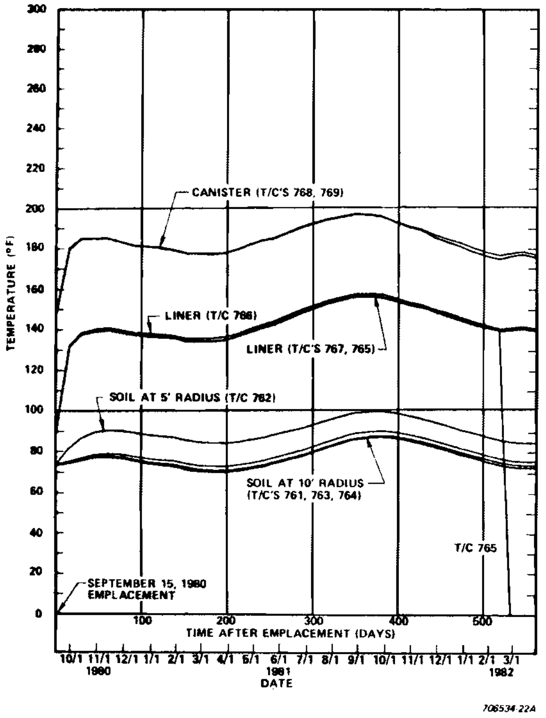

Figure 3.4-29. Drywell 1 (F/A B43) Peak Canister, Liner and Soil Temperature Distributions at About 145 Inches Below Ground Level, September 15, 1980 to March 31, 1982

change. This could be attributed to slight differences in thermocouple position in the canister instrumentation tubes and canister position in the drywell. The peak temperatures for the Drywell 3 canister and liner during the Adjacent Drywell Test were 229 and 183°F, respectively, which occurred on August 22, 1980. The peak readings on September 1, 1981 were 211°F for the canister and 170°F for the liner.

Some comments concerning Phase III thermocouples and data readings should be made. Shortly after canister thermocouple installation in Drywell 3, thermocouple 843 failed. On August 6, 1980, a replacement thermocouple was installed in the same manner as the replacement for

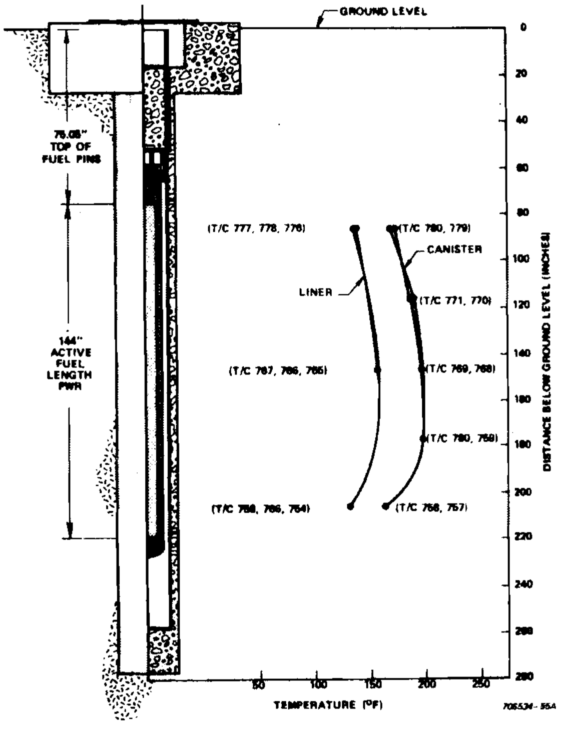

Figure 3.4-30. Drywell 1 (F/A B43) Peak Canister and Liner Axial Temperature Profiles, September 1, 1981

thermocouple 879. Later it was found that liner thermocouples 839 and 850 had failed (on August 14, 1980 and January 23, 1981, respectively, see Figures I-4 and I-5). Since no replacements were available, these thermocouples were disconnected and no further readings taken. Data for soil thermocouple 824 was inadvertently lost during October, November, and December of 1980 (as shown in Figure I-6).

For Drywell 2, four liner thermocouples failed during Phase III. Thermocouples 804 and 803 failed on January 4, 1982 and March 20, 1982 as shown in Figure 3.4-27. Thermocouples 792 and 791 failed on December 3, 1981 and February 24, 1982 as shown in Figure I-8. Data for thermocouples 792 and 791 show a marked divergence for some time before failure (between September 4 and December 3, 1981 for T/C 792 and between January 1 and February 24, 1982 for T/C 791). Some data for T/C 803 also showed a marked divergence between January 8 and March 30, 1982; however, the diverging data occurred intermittently. Two other items relative to Drywell 2 data should be noted. First, soil thermocouples 798 to 801 and 809 to 812 were not hooked up until September 18, 1980 which accounts for no data shown on Figures 3.4-27 and I-7. Also, the recorded data from thermocouples 800 to 809 from August 7, 1980 to May 19, 1981, was determined to be 12.4°F too high when the scanner was calibrated on May 19, 1981. The data shown in Drywell 2 figures and in Appendix D has been adjusted by the 12.4°F error in data recording to present accurate temperatures.

For Drywell 1, two liner thermocouples failed during Phase III. Thermocouple 765 failed on February 26, 1982 (see Figure 3.4-29). Thermocouple 755 failed on November 28, 1981; however, the data for this thermocouple shows a divergence from the other two liner thermocouples after October 15, 1981 (see Figure I-10).

Thermocouple failure was attributed to sheath degradation caused by water entering the liner and shield plug thermocouple tubes during Phase I.

A comparison of test data from Drywells 3, 2 and 1 was made to evaluate the drywell thermal response and to determine the extent of thermal interactions between adjacent drywells. The difference in thermal response is illustrated in canister test data comparisons.

The extent of thermal interaction between drywells is shown in soil test data comparisons.

Figure 3.4-31 compares all three drywell axial temperature profiles for the canisters and liners on September 1, 1981. Data from Drywells 1 and 2 showed little temperature difference at the three liner and five canister thermocouple elevations. Data from Drywell 3 showed the same shape profiles as those for Drywells 1 and 2 but with temperature readings uniformly about 10°F higher. This difference is attributed to the soil dryout experienced by Drywell 3.

Figure 3.4-32 compares canister temperatures at the spent fuel midplane elevation throughout the test period. As previously noted, Drywells 1 and 2 responded in the same manner as had isolated Drywells 5 and 3 where an initial heatup transient was followed by a cycling trend caused by seasonal ambient air temperature changes. Drywell 3 continued the cyclic transient. During the test period, two peaks and two valleys occurred for Drywell 3 in response to seasonal ambient air temperature changes superimposed on the decreasing mean temperature.

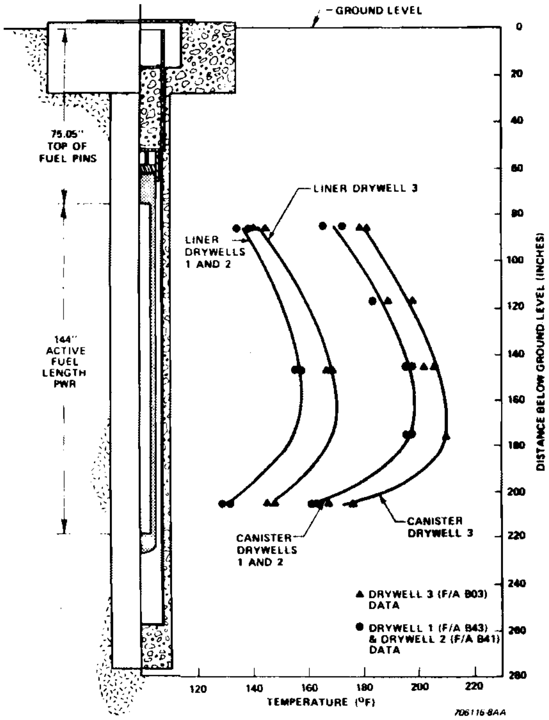

Figure 3.4-31. Comparison of Canister and Liner Axial Temperature Profiles, Drywells 1, 2 and 3, September 1, 1981

Figure 3.4-32 also shows the effects of soil thermal conductivity change on Drywells 1 and 2. Following the initial heatup transient for Drywells 1 and 2, the difference between canister temperatures (Drywell 3 versus Drywells 1 and 2) decreased fairly steadily to a minimum of 10°F in March, 1982. This is attributable to the decreasing thermal conductivity for the soil around Drywells 1 and 2. The thermal conductivity decrease has been explained as the effect of soil moisture content change due to the drywell heat source.

Figures 3.4-33 to 3.4-36 show the soil temperature distribution comparison for all three drywells at a 10 and 5 foot radius. These curves show a very limited extent of thermal interaction between drywells. An initial comparison of thermocouple readings on opposite sides of all three drywell canisters and liners (all thermocouples running along the rail spur centerline) showed no evidence of thermal interaction. For many of the comparisons, larger temperature readings occurred on either side of the canister or liner for differing thermocouple elevations. A comparison of soil temperature readings was therefore used to investigate thermal interaction between drywells.

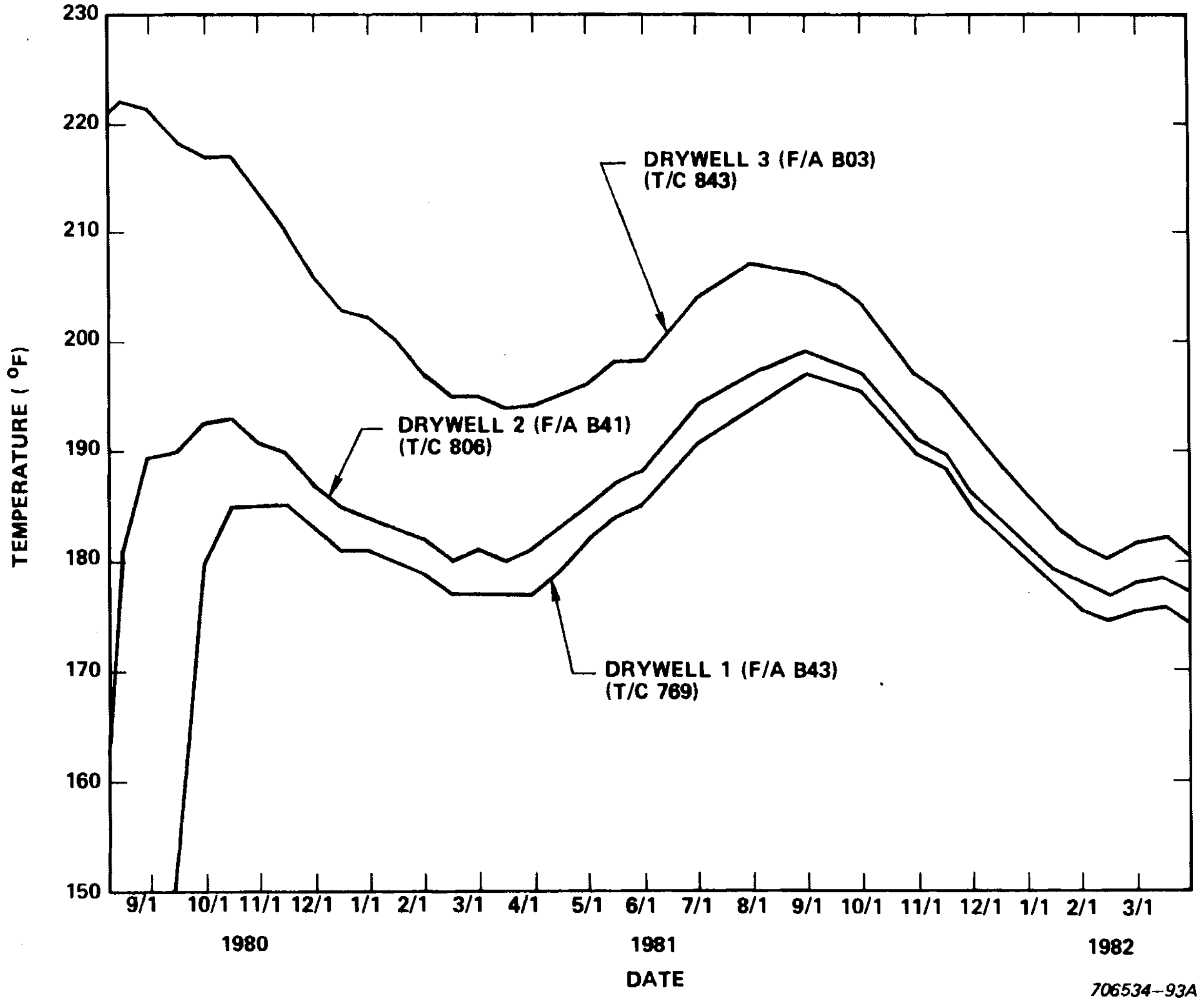

Figure 3.4-32. Comparison of Drywell Thermal Response - Canister Temperatures at 146 Inches Below Ground Level, August 4, 1980 to March 31, 1982

The temperature data distributions at the 143.5 inch depth for all three thermowells at a 10 foot radius are shown in Figures 3.4-33, 3.4-34 and 3.4-35, respectively. Each data set varies slightly from the adjacent drywell. For each drywell, the nearest adjacent drywell thermowell is 17.6 feet away. In Figure 3.4-35, the Drywell 1 soil temperatures show the influence of the Drywell 2 heat source. Following Drywell 1 canister assembly emplacement, the difference between the southern thermowell (closest to Drywell 2) and the other two increased until the difference was 3°F. The other two thermowells (east and north side of Drywell 1) showed nearly similar readings with the eastern thermowell slightly higher.

In Figure 3.4-34, the Drywell 2 soil temperatures showed the influence of both the Drywell 1 and Drywell 3 heat sources. During the early test period, the southern

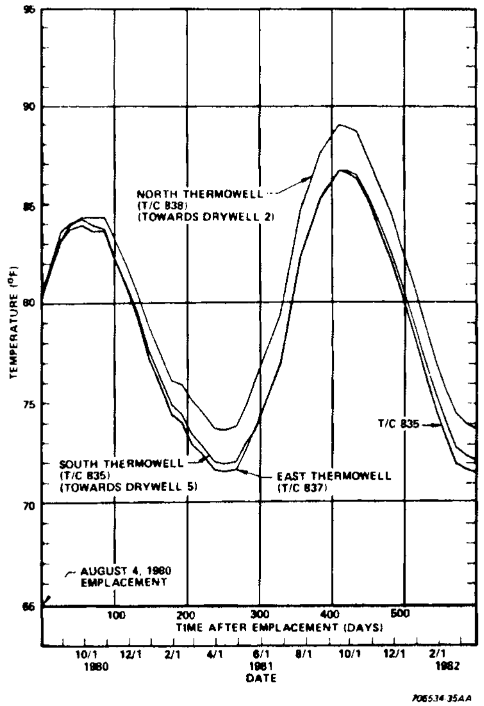

Figure 3.4-33. Drywell 3 (F/A B03) Soil Temperature Distribution Comparison at a 10 Foot Radius, August 4, 1980 to March 31, 1982

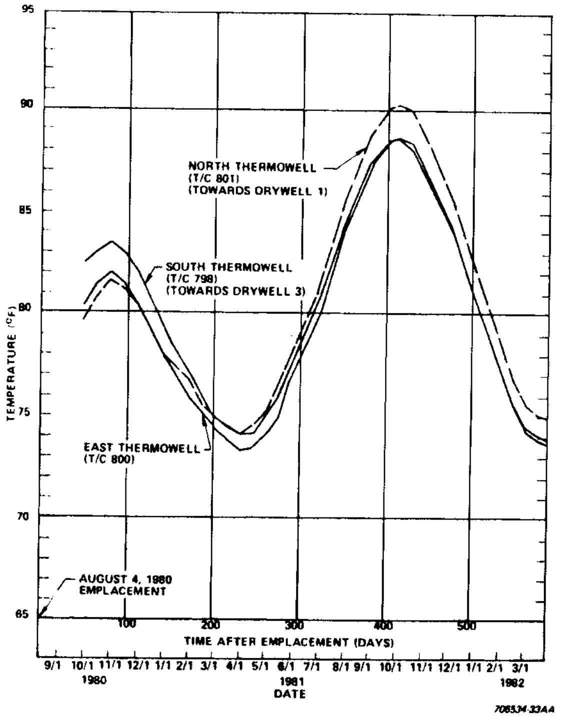

Figure 3.4-34. Drywell 2 (F/A B41) Soil Temperature Distribution Comparison at a 10 Foot Radius, October 1, 1980 to March 31, 1982

thermowell (closest to Drywell 3) showed the highest temperature with the eastern slightly higher than the northern. This is due to the soil nearest to Drywell 3 being heated prior to the test. As the test continued, the northern thermowell (closest to Drywell 1) temperature readings became the highest with the eastern the lowest. The Drywell 1 heat source and a slight difference in thermal conductivity for soil on either side of Drywell 2 caused this effect. The prolonged Drywell 3 heat source caused the overall soil thermal conductivity between Drywell 3 and Drywell 2 to be lower than that between Drywell 1 and Drywell 2. With comparable heat sources on both sides of Drywell 2, the northern side soil (with slightly higher thermal conductivity) conducted more heat from the adjacent northern drywell.

In Figure 3.4-33, the Drywell 3 soil temperature distributions at the 143.5 inch depth are shown for all three thermowells at a 10 foot radius. This figure, like Figure 3.4-35, shows the effect of the heat source from Drywell 2. For the period prior to about October 15, 1981, all three thermowells had similar temperature readings. Following October 15, the northern thermowell (closest to Drywell 2) showed an increasingly higher temperature than the other two. The

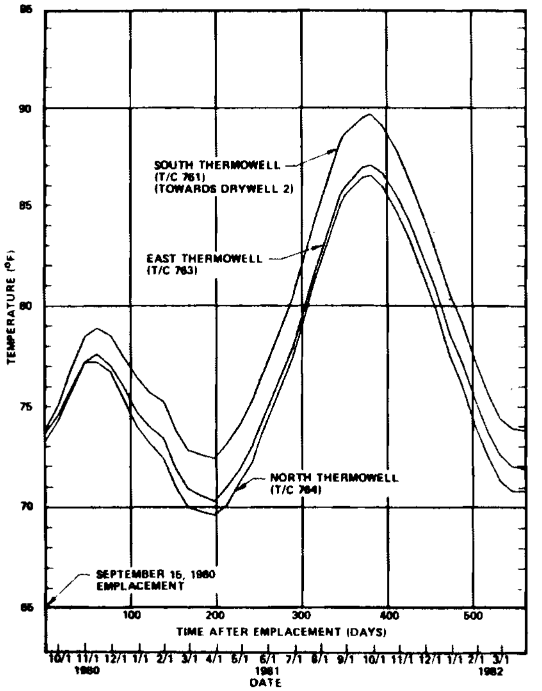

Figure 3.4-35. Drywell 1 (F/A B43) Soil Temperature Distribution Comparison at a 10 Foot Radius, September 15, 1980 to March 31, 1982

difference in temperature reached a maximum of 3°F.

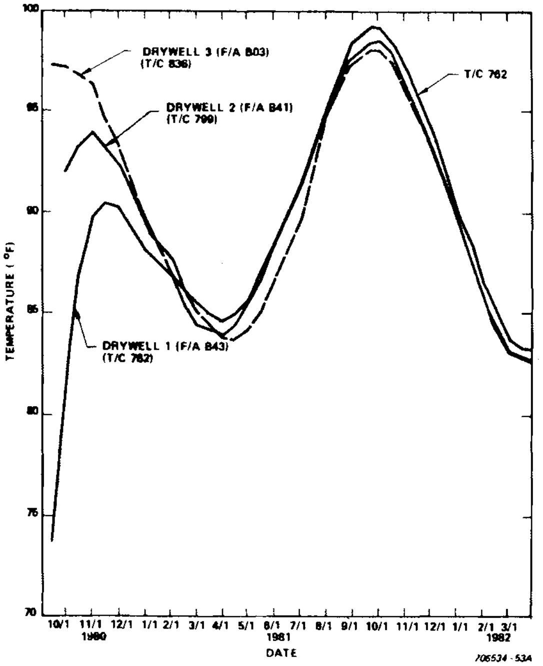

Figure 3.4-36. Drywell 3, 2 and 1 Soil Temperature Distribution Comparison at a 5 Foot Radius, September 15, 1980 to March 31, 1982

Figure 3.4-36 shows the soil temperature distributions for the 5 foot radius thermowell for all three drywells. The temperatures shown are the peak values recorded at the 143.5 inch depth. Comparing the thermal response of these three thermowells shows the effects of the canister emplacement time and the relative soil thermal conductivity. During the early test period, the Drywell 3 thermowell showed the highest and Drywell 1 thermowell the lowest temperatures. The peak temperatures reached by the three thermowells during 1980 occurred at different times reflecting the different canister emplacement dates (Drywell 3 peak occurred earlier than Drywell 2 with the Drywell 1 peak occurring last). As the test period progressed, the temperatures of the thermowells for Drywells 1 and 2 converged and for most of the 1981 test period all three thermowells were within 2°F. After April 1, 1981, Drywell 3 thermowell temperatures became the lowest. The lowest Drywell 3 temperature occurred after those for Drywells 1 and 2. This slight difference is attributable to the difference in soil thermal conductivity.

The conclusions reached by comparing the thermal response of the three adjacent drywells are: 1) virtually no thermal interaction between adjacent drywell canisters occurred, and 2) the small differences noted for the thermal response of the soil surrounding the three drywells were due to soil moisture level changes and the adjacent drywell heat source. The soil temperature differences are relatively small (a maximum of 3°F) compared to the temperature measurements accuracy (+2°F). However, it is expected that these trends are fairly accurate (temperature readings relative to one another) even if the absolute temperature values recorded are slightly inaccurate.

3.4.3 AMBIENT TEMPERATURE MEASUREMENTS

Ambient temperature data were recorded by the E-MAD weather station (atmospheric temperatures) and the Reference Well (soil temperatures) during the E-MAD drywell testing period. Table 3.4-1 presents the ambient air temperatures during 1978 to 1982. Reference Well temperature readings are included with the Electrically Heated Drywell Test data in Appendix C.

Figures 3.4-37 and 3.4-38 illustrate Reference Well recorded soil temperature variations. Figure 3.4-37 shows soil axial temperature profiles at two month intervals during 1980. Figure 3.4-38 shows soil temperature distributions for depths of 6 inches (thermocouple 101), 18 inches (thermcouple 102) and 192 inches (thermocouple 107) for slightly more than one year. The 6 inch deep soil thermocouple readings reflect insolation and higher daytime air temperatures in Figure 3.4-37 (readings taken at 4:00 p.m.) and in Figure 3.4-38 (both day and night temperatures). The 18 inch depth soil thermocouple readings show little effect from solar insolation and day/night air temperature variations. The deeper thermocouple readings show small soil temperature variations at the depths of peak temperature levels (12°F at 127 inches deep and 7°F at 192 inches deep).

3.5 DRYWELL THERMAL ANALYSIS

ANALYSIS PURPOSE AND METHOD

The purpose of the drywell thermal analysis is to develop thermal models for the electrically heated and fueled drywell configurations and to demonstrate the models satisfactorily predict soil and drywell temperatures. After comparing model predictions with test data, the passive heat dissipation process, soil properties, and the effects of power level and seasonal ambient variations should be sufficiently understood that the model can be applied with confidence.

Drywell test predictions and data analyses were performed using the TAP-A digital computer program, Reference 13. TAP-A was developed at AESD and has been used extensively there and at the Westinghouse Advanced Reactors Division during the past ten years. It is a finite difference program calculating steady-state and transient temperature distributions in a configuration of solid materials using the radiation, convection, and conduction heat transfer modes. To apply the program, a two or three-dimensional configuration is divided into elements called nodes. The nodes, connected to each other by heat transfer links having lengths and cross-sectional areas, can have time and temperature dependent thermal properties (density, heat capacity, and conductivity) as well as time dependent heat generation rates. Outer surfaces are assigned time dependent

TABLE 3.4-1
E-MAD AMBIENT AIR TEMPERATURES DURING TEST PERIOD

Period Ending	Average* Temp (°F)	Period Ending	AVerage* Temp (°F)	Period Ending	Average* Temp (°F)	Period Ending	Average* Temp (°F)	Period Ending	Average* Temp (°F)
1/15/78		1/15/79	36.9	1/15/80	41.7	1/15/81	50.3	1/15/82	40.2
1/31	43**	1/31	37.3	1/31	37.0	1/31	44.2	1/31	45.2
2/15		2/15	45.4	2/15	41.1	2/15	46.1	2/15	41.8
2/28	46**	2/28	47.9	2/29	54.0	2/28	49.5	2/28	58.0
3/15		3/15	56.1	3/15	51.9	3/15	45.7	3/15	52.0
3/31	50**	3/31	48.1	3/31	52.3	3/31	50.1	3/31	46.7
4/15		4/15	59.2	4/15	61.0	4/15	60.8		
4/30	59**	4/30	64.2	4/30	66.5	4/30	71.2		
5/15		5/15	65.6	5/15	65.6	5/15	68.9		
5/31	66**	5/31	77.1	5/31	68.1	5/31	68.5		
6/15		6/15	78.6	6/15	74.5	6/15	82.0		
6/30	78.2	6/30	79.0	6/30	86.0	6/30	89.1		
7/15	83.3	7/15	82.5	7/15	86.1	7/15	87.5		
7/31	90.6	7/31	83.5	7/31	94.8	7/31	85.8		
8/15	90.1	8/15	78.1	8/15	92.7	8/15	87.3		
8/31	78.8	8/31	74.9	8/31	81.5	8/31	87.2		
9/15	75.0	9/15	82.5	9/15	79.7	9/15	80.5		
9/30	77.9	9/30	76.3	9/30	81.5	9/30	77.2		
10/15	76.9	10/15	71.9	10/15	80.5	10/15	60.4		
10/31	64.5	10/31	57.4	10/31	62.1	10/31	61.9		
11/15	55.1	11/15	50.5	11/15	63.3	11/15	62.6		
11/30	48.6	11/30	43.6	11/30	52.4	11/30	49.7		
12/15	36.9	12/15	47.7	12/15	52.8	12/15	51.6		
12/31	38.6	12/31	42.3	12/31	57.8	12/31	46.1		

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*Determined by averaging daily temperature extremes over two week periods (Data from E-MAD weather station)

**Extreme temperatures averaged for each month over period 1956 to 1966 (Data collected by Air Resources Laboratory at weather station near E-MAD)

temperatures or convective heat transfer coefficients that vary with time or with a surface-to-ambient temperature differential.

3.5.1 THERMAL MODEL DESCRIPTIONS

3.5.1.1 ELECTRICALLY HEATED DRYWELL TEST

MODEL SIZE AND BOUNDARY CONDITIONS

The TAP-A nodal model of the Electrically Heated Drywell Test is depicted in Figures 3.5-1 and 3.5-2 and the nodes representing each test component are identified in Table 3.5-1. The model is two dimensional in the r and z directions (radius and depth, respectively) with no variations circumferentially. The outer radius extends to 60 feet (corresponding to the Reference Well location) and has an adiabatic boundary condition. The model radius is arbitrary and it could be given any value greater than the radius at which the radial temperature gradients are expected to be zero (20 feet based on Electrically Heated Drywell Test results). The model lower boundary is set at a depth of 1000 feet approximately corresponding to the E-MAD water table

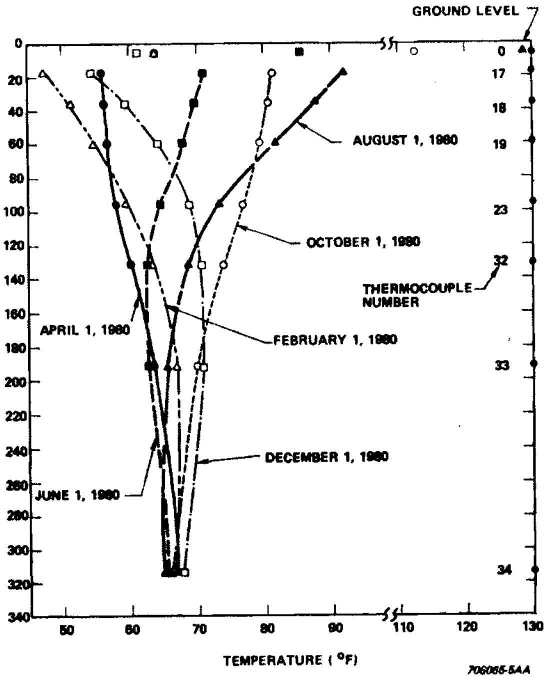

Figure 3.4-37. Reference Well Axial Temperature Profiles At Two Month Intervals During 1980

depth. A constant 65°F boundary condition is applied at that boundary simulating the water table's constant temperature heat source and sink effect.

ELECTRICALLY HEATED DRYWELL TEST CANISTER HEAT FLUX DISTRIBUTION

A comparison of measured temperatures with TAP-A model calculations shows the model with a uniform heat generation rate consistently overpredicts soil temperatures at depths at the canister middle and lower end and underpredicts soil temperatures at levels near the canister upper end.

This discrepancy could be caused by insufficient heat flow from the upper end of the canister model. To evaluate canister heat flow, the actual canister heat flux distribution was calculated using temperature data from the pairs of adjacent canister and liner thermocouples identified in Table 3.5-2.

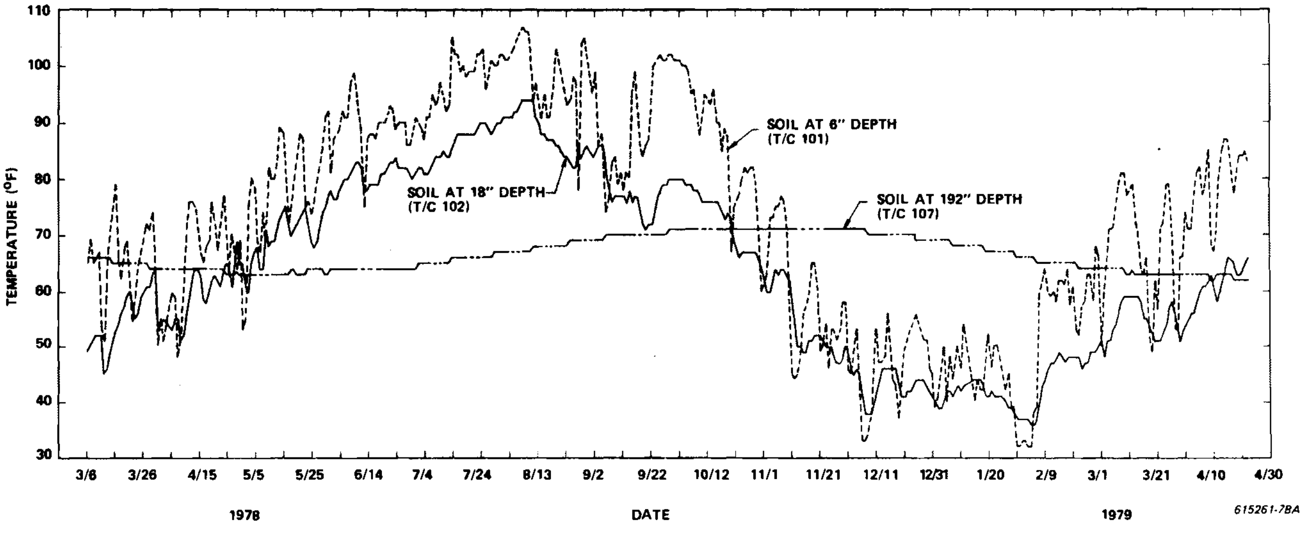

Figure 3.4-38. Reference Well Temperature Distributions as a Function of Time

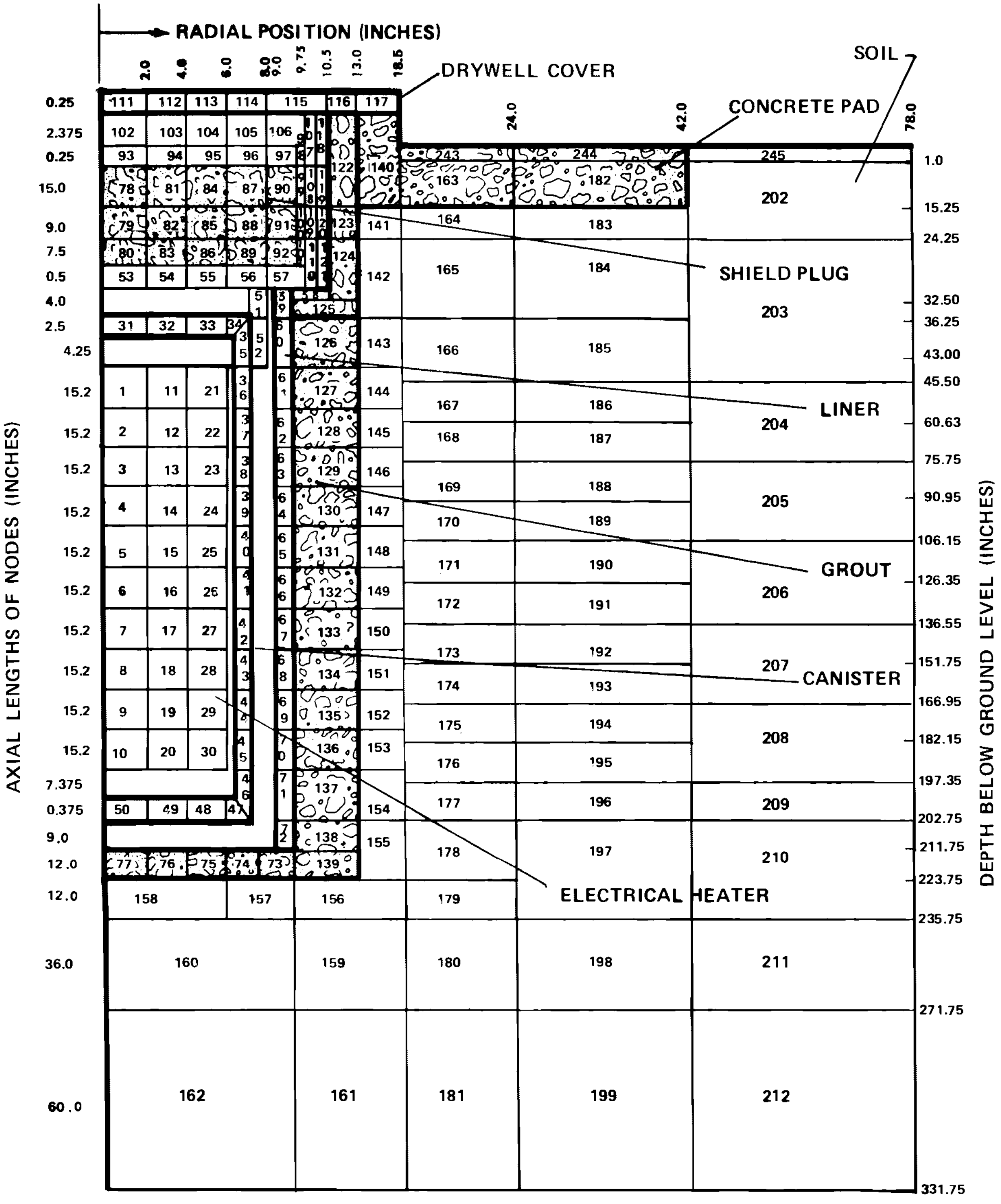

Figure 3.5-1. Near-Field Electrically Heated Drywell Test Thermal Model Node Locations

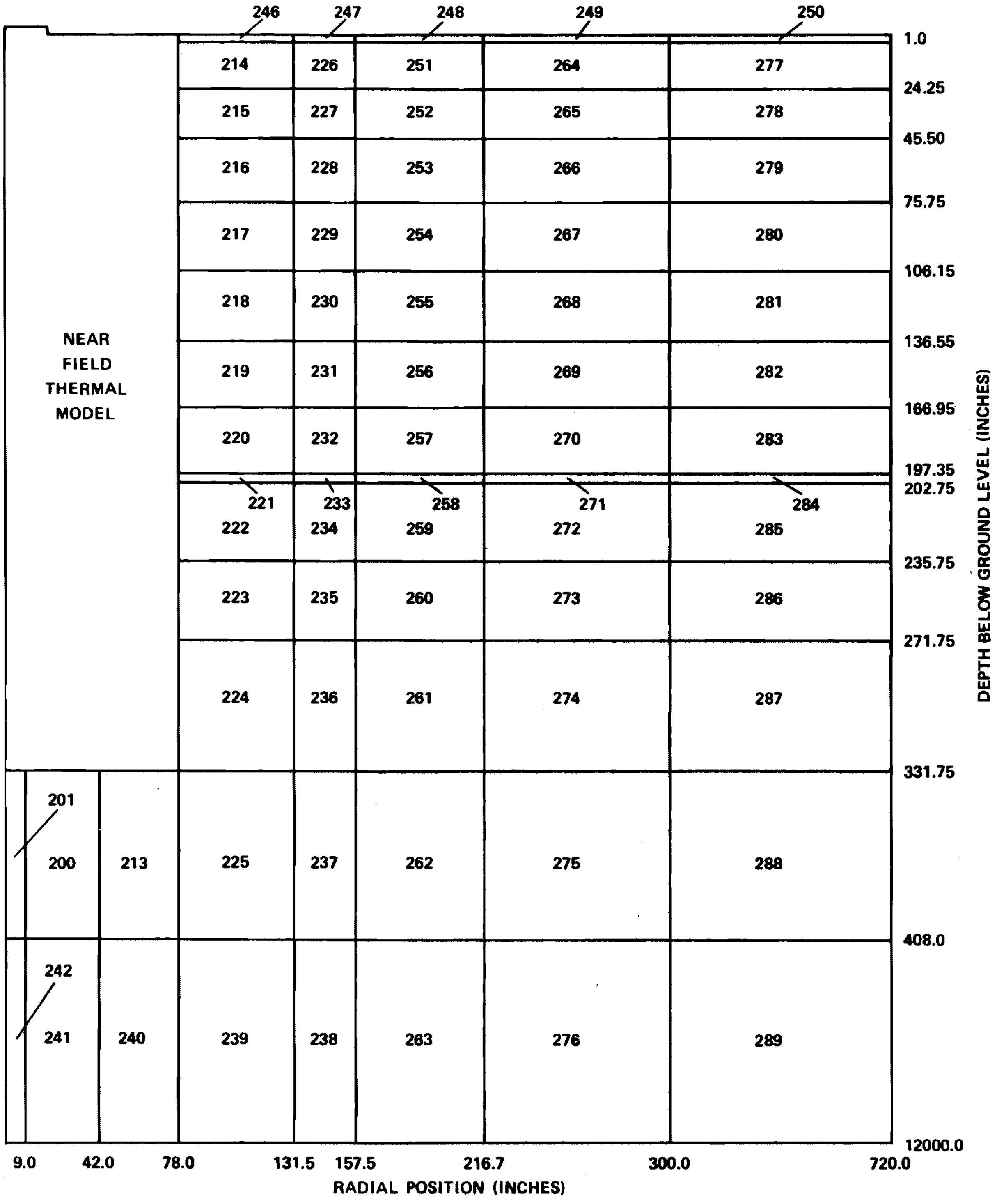

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Figure 3.5-2. Far-Field Electrically Heated Drywell Test Thermal Model Node Locations

TABLE 3.5-1
TAP-A ELECTRICALLY HEATED DRYWELL TEST MODEL NODE DESCRIPTION

Nodes	Test Components
1-30	Heater Assembly
31-50	Canister
51-52	Shield Plug Skirt
53-57	Shield Plug Bottom Plate
58-72	Liner Lower Section
73-77	Grout at Bottom of Liner
78-92	Concrete in Shield Plug
93-97	Shield Plug Top Plate
98-101	Shield Plug Body Pipe
102-110	Air Gap Around Shield Plug
111-117	Drywell Cover
118-121	Liner Upper Section
122-139	Grout Between Liner and Soil
140	Concrete Pad
141-162	Soil
163	Concrete Pad
164-181	Soil
182	Concrete Pad
183-242	Soil
243-244	Concrete Pad
245-289	Soil

Assuming the canister and liner are positioned concentrically and that temperatures and heat flow do not vary circumferentially, the local canister heat flux at a particular elevation can be expressed in terms of the canister and liner temperatures at that location as follows:

$$\phi = \frac{Ke}{2b}\left(1 + \frac{r_L}{r_c}\right)(T_c - T_L) + F\sigma(T_c^{\,4} - T_L^{\,4})$$

where

ϕ - heat flux, Btu/hr-ft^2
b - radial clearance between liner and canister, ft
Ke - effective thermal conductivity of the gas in the clearance region (considering both conduction and free convection), Btu/hr-ft-°F
r_c - canister outer radius, ft
r_L - liner inner radius, ft
F - shape factor
σ - Stefan-Boltzman constant, 0.1714×10^{-8} Btu/hr- ft^2-°R^4
T_c - canister temperature, °R
T_L - liner temperature, °R

TABLE 3.5-2
CANISTER AND LINER THERMOCOUPLES USED IN CANISTER HEAT FLUX CALCULATIONS

Thermocouple Pair	Elevation* (in.)	Canister T/C No.	Angle** (Deg.)	Liner T/C No.	Angle** (Deg.)
1	29.5	14	0	030	0
2	29.5	15	135	030	0
3	60.0	16	0	031	0
4	60.0	17	90	032	90
5	60.0	18	180	033	180
6	60.0	19	270	034	270
7	90.4	20	0	035	0
8	120.8	21	180	036	0
9	151.2	22	180	037	0
10	151.2	23	315	037	0

---

*Measured from top of canister

**See Figure 3.2-1 for 0° position

The first term on the right hand side of this equation describes heat transfer between the canister and liner by the combined effects of conduction and free convection. The effective thermal conductivity, Ke, calculated using the method discussed in Reference 14 (p. 331, 332), is typically greater than the thermal conductivity of air (evaluated at 1/2 (T_C + T_L)) by a factor of 2 to 3. Radiation, the dominant heat transfer mode between the canister and liner, is accounted for by the second term.

The analysis procedure consisted of first determining local heat flux values at the five thermocouple elevations. The resulting heat flux profile was integrated over the canister length and the estimated drywell power level was compared with the known actual power level. Their ratio (actual/estimate) was always less than 1.0 (typically 0.55 to 0.65), attributed primarily to the shape factor value of 1.0 used in the radiation calculations. This ratio was then applied as a multiplier on the heat flux estimates at the five thermocouple elevations. While the need for the multiplier stems primarily from the radiation calculational method, it was applied to both the radiation and the convection/conduction term to simplify the calculations. This approach resulted in variations between test data and predicted local heat fluxes of less than 8 percent at 1.0 kW and less than 4 percent at the 2.0 and 3.0 kW power levels. The heat flux profiles derived in this manner are shown in Figure 3.5-3.

The main difference between these profiles and the uniform flux distribution is that a peak heat flux peak now occurs at the canister

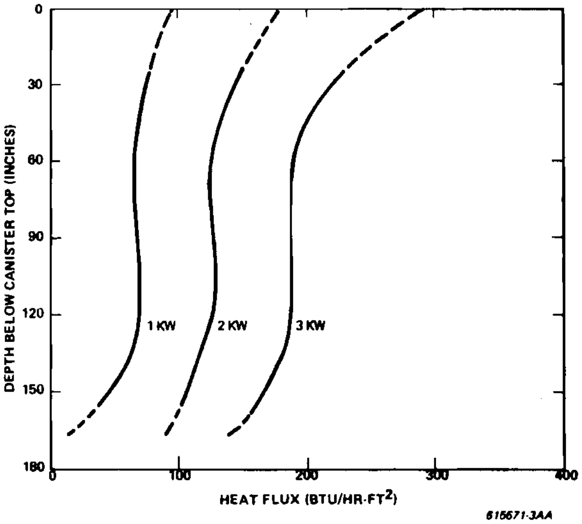


Figure 3.5-3. Canister Axial Heat Flux Distributions Derived from Electrically Heated Drywell Test Canister and Liner Temperature Data

upper end. A flux peak there could be due to natural circulation effects within the canister. The canister heat flux distributions of Figure 3.5-3 improve canister and soil temperature predictions as shown in Figures 3.5-4 and 3.5-5. It is therefore apparent that the canister heat flux distribution has an appreciable influence on drywell and soil temperature predictions and that the canister model should include the appropriate heat flux distribution.

ELECTRICALLY HEATED DRYWELL TEST ELECTRIC HEATER POWER VARIATIONS

As previously noted, voltage variations at the electric heater terminals occurred during the warm months of the year apparently in response to the cycling air conditioning load. The heater controller setting was checked and adjusted (if necessary) during the warm daytime hours but not after working hours and resulted in a

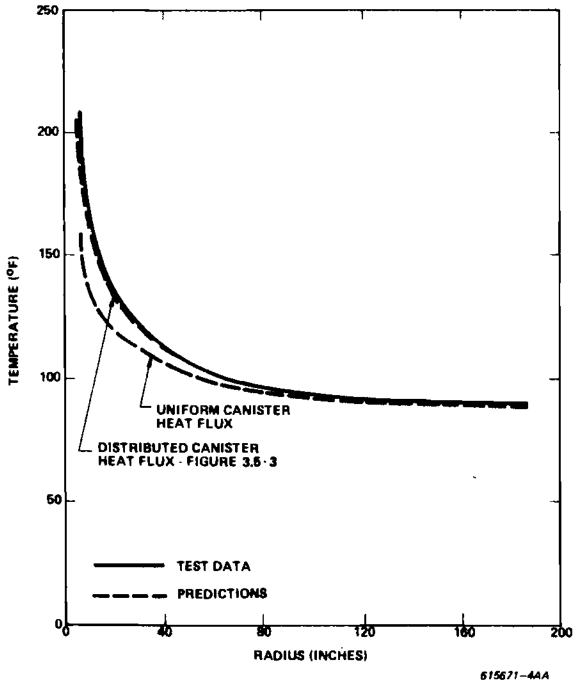


Figure 3.5-4. Test Data and Predictions Comparison of Radial Temperature Profile at 40 Inch Depth Showing Canister Heat Flux Modeling Effects, 1 kW Operation, September 1, 1978

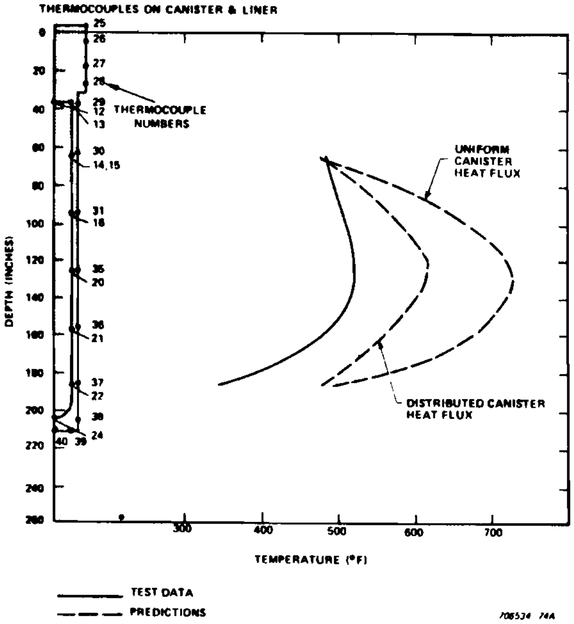


Figure 3.5-5. Test Data and Predictions Comparison of Axial Canister Temperature Profile Showing Canister Heat Flux Modeling Effects, End of Accelerated Heatup, May 1, 1978

higher voltage across the terminals at night. Heater controller input voltage data records were analyzed to determine the overall effect on heater power level. The analysis for the 1.0 and 2.0 kW periods indicated that the integrated power output by the heater was about 3 percent higher during the April to September period but virtually equal during the remaining months of the year. This variable power effect was included in the thermal model accurately represent actual test conditions.

HEAT TRANSFER MECHANISMS

Heat transfer between the electric heater assembly (nodes 1 to 30) and the canister is modeled by conduction. Heat transfer from the heater to canister actually occurs by convection and radiation (primarily by radiation at high temperatures). Since TAP-A has no mass flow capability and therefore cannot model convection effects, a simplifying assumption was made to calculate canister temperatures. An arbitrary conductivity value was chosen to represent the radiation, convection, and conduction heat transfer. A temperature dependent conductivity, calculated over the anticipated range of canister temperatures using a 1000°F peak heater temperature, is used in the model. To compensate for convection effects inside the canister, the present model includes a nonuniform axial heat generation rate for the heater assembly as previously described. The heater assembly heat capacity which is small compared to that for other system components (canister, liner, grout, etc.), is modeled accurately to produce fairly accurate transient predictions for the entire drywell system.

Heat transfer from the canister to the liner and shield plug occurs by radiation, conduction and free convection and the thermal model includes all three modes. Convection and conduction were treated using the effective thermal conductivity approach with appropriate conductivity values in the r and z directions. The radiation calculation for canister to liner heat transfer uses the shape factor expression for concentric gray cylinders as follows:

$$F_{12} = \frac{1}{\frac{1}{\varepsilon_1} + \frac{A_1}{A_2}\left(\frac{1}{\varepsilon_2} - 1\right)}$$

where

ε = emissivity
A = surface area
1 = canister outer surface
2 = liner inner surface

Emissivity values for the canister (0.45) and liner (0.60) were obtained from References 15 (p. 475) and 16 (p. 15 - 21), respectively, for Type 304 stainless steel (canister) and hot-rolled iron (liner).

Heat transfer from the shield plug sides to the upper liner occurs primarily by radiation and free convection. Heat transfer from the shield plug upper surface to the drywell cover plate occurs by convection. For modeling purposes, conduction through an air-filled space is assumed in each direction. This approach is used since TAP-A has no mass flow capabilities. This simplifying assumption is judged to be acceptable since, due to the relatively small shield plug heat transfer rates, even large modeling inaccuracies in these regions would have little effect on canister temperature predictions.

Heat transfer through the steel, concrete, grout and soil is modeled by conduction. Heat transfer through porous materials such as concrete, grout and soil can occur by a combination of conduction, radiation and convection. Conduction occurs at points of granular contact, radiation occurs across the voids between grains and convection occurs throughout the medium on both the microscopic and macroscopic scales. However, in compacted sandy soils with fines, conduction is the dominant mechanism and in this analysis, heat transfer in all solid materials, including soil, is based upon that mode.

The interface between two solid materials in contact produces a heat flow resistance across that boundary. Since the extent of actual contact is not known, intimate contact is assumed between the various material pairs (liner and grout, grout and soil, concrete and soil) and all contact resistances are assigned zero values.

GROUND-TO-AMBIENT HEAT TRANSFER

The previous Electrically Heated Drywell Test analyses, reported in References 2 and 6, considered solar effects at ground level as well as convection to and from the ambient air. Further work has confirmed, however, that the ground level model can be simplified, with satisfactory results, by equating air and surface temperatures and ignoring the solar effects. This approach has been applied throughout the drywell analyses presented in this report. The air temperatures used are the monthly temperature averages taken from E-MAD site weather data provided in Table 3.4-1. The model predicts seasonal soil temperature variations with good accuracy confirming this approach.

MATERIAL PROPERTIES

The various materials used in the Electrically Heated Drywell Test and the thermal properties input to the thermal model are identified in Table 3.5-3. Thermal conductivities of the grout and soil were determined experimentally since they are specific to the E-MAD area. The thermal conductivity of grout (a two-to-one mixture by weight of soil and cement) was measured as a function of temperature in laboratory tests performed by Holmes and Narver, Inc. Grout samples were poured during drywell installation for use in the laboratory tests. The results are shown in Figure 3.5-6.

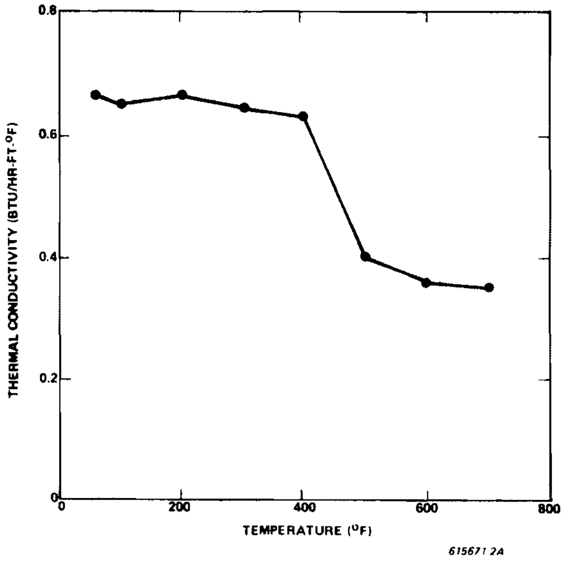


Figure 3.5-6. Laboratory Measured Grout Thermal Conductivity

TABLE 3.5-3
MATERIAL THERMAL PROPERTIES USED IN DRYWELL ANALYSIS

Material	Density (lb/ft^3)	Heat Capacity (Btu/lb-°F)	Thermal Conductivity (Btu/hr-ft-°F)	Source
Concrete	142.0	0.2	1.05	Ref. 17, pp. 4-9, 4-97
Stainless Steel	490.0	0.11	10.0	Ref. 18, p. 533
Carbon Steel	490.0	0.11	23.0	Ref. 18, p. 533
Grout	117.0	0.2*	See Fig. 3.5-6	
Soil	105.0	0.25**	See Fig. 3.5-9	

---

*Value based on dry soil, dry concrete heat capacity values

**Dry soil plus 5 percent moisture assumed

Since soil thermal conductivity is an important parameter in the analysis of drywell thermal performance, the conductivity value or relationship used must be selected carefully. To illustrate its influence, steady-state predictions of temperature versus radius at canister mid-plane are plotted in Figure 3.5-7 for three typical values of soil conductivity with all other parameters held constant. These conductivity values obtained from Reference 19 apply to a variety of soils with a range of moisture contents and densities. Generally, low conductivities are associated with dry, lightweight soils while moist, high density soils exhibit higher conductivities. It is apparent from Figure 3.5-7 that the drywell temperature field in general and the canister temperature in particular are sensitive to soil conductivity variations.

For the Electrically Heated Drywell Test, E-MAD soil density and thermal conductivity were measured by Holmes and Narver, Inc. in laboratory tests using borehole samples. The samples were taken at four depths (5, 10, 15 and 20 feet) and their moisture contents, densities and compositions determined. At a later date, the dried samples were recombined with the correct moisture (typically 5.0 to 5.2 percent by weight at each level) and compacted to the correct density to form cylinders (2.8 inch diameter by 5.6 inch length) on which conductivity tests were performed. The tests employed the transient line source method described in References 20 and 21. By placing the samples in an electrically heated furnace, the thermal conductivity versus temperature measurements were obtained (tabulated in Table 3.5-4 and graphed in Figure 3.5-8).

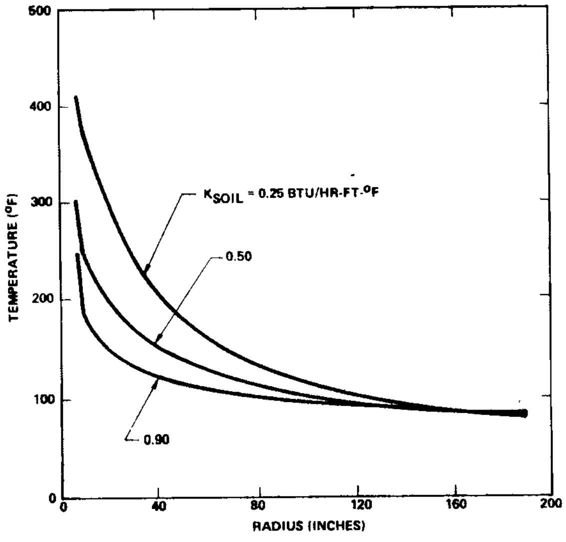


Figure 3.5-7. Radial Temperature Profile Predictions at Canister Midplane as a Function of Soil Thermal Conductivity, 1 kW Operation, September 1, 1978

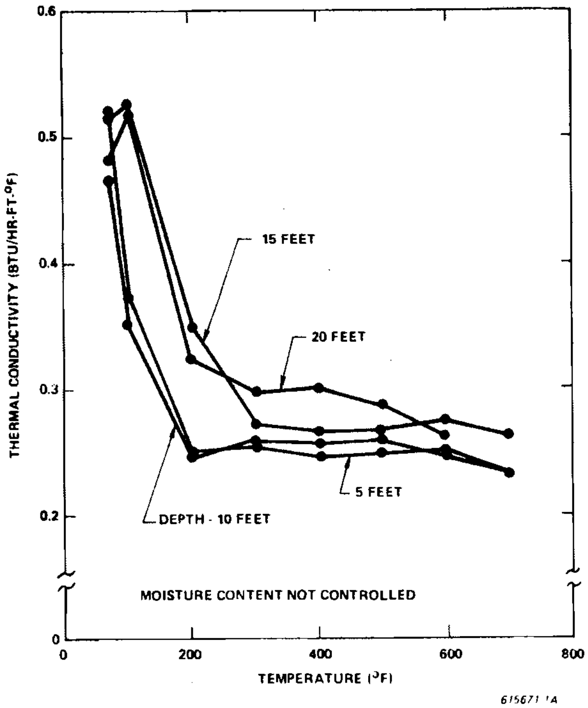


Figure 3.5-8. Laboratory Measured E-MAD Soil Thermal Conductivity

As noted above, the soil samples contained 5 percent moisture at the test start. However, nearly 20 hours elapsed between tests at each temperature and since the furnace was not air-tight, it is virtually certain the samples quickly lost their initial moisture. Above 200°F, all moisture would have vaporized and the data obtained apply to dry soil conditions. However, during the tests below 200°F, the samples could have contained some moisture but at levels less than the original moisture content due to evaporation during the stabilization period. Therefore, the measured thermal conductivities at 70 and 100°F are expected to be lower than conductivities at the same temperature with 5 percent moisture.

Predicted drywell temperatures were significantly higher than the test data when the E-MAD soil sample thermal conductivity data were used as input to the model. An assessment of the potential thermal conductivity discrepancy in the temperature range of 70 to 200°F was done by comparing the E-MAD soil data with published soil data and conductivity correlations. A correlation described in Reference 22 developed for sandy soils comparable to that at E-MAD was used. The E-MAD samples contained approximately 70 percent sand (SiO_2). Although the correlation assumed the other main soil component is clay (E-MAD samples showed no clay), the correlation has been used in this study primarily to illustrate the influence of moisture on soil thermal conductivity. Figure 3.5-9 compares the correlation conductivity predictions with E-MAD soil test data. The correlation as published in Reference 22 only covers a temperature

TABLE 3.5-4
MEASURED THERMAL CONDUCTIVITY OF SOIL INSIDE E-MAD FACILITY COMPOUND

Temperature (°F)	Depth (Feet) 5	10	15	20
70	0.466*	0.520	0.513	0.479
100	0.374	0.350	0.525	0.517
200	0.248	0.246	0.349	0.321
300	0.253	0.257	0.269	0.295
400	0.243	0.255	0.265	0.298
500	0.247	0.258	0.266	0.287
600	0.250	0.244	0.274	0.261
700	0.231	0.231	0.262	0.343**

---

*Thermal conductivity measured in Btu/hr-ft-°F

**Reading was judged erroneous due to problem with potentiometer

range of 40 to 100°F. For a fixed moisture content, the correlation shows a weak dependency on temperature; and therefore, the correlation can probably be safely extrapolated between 100 and 200°F, as done in Figure 3.5-9.

Several observations can be made concerning Figure 3.5-9. First, the low moisture predictions are similar to the high temperature (above 200°F) conductivities measured for the E-MAD soil samples. Since the samples tested were dry above 200°F, the reasonable agreement at high temperatures supports the use of this correlation for the high sand content soil at E-MAD. Second, the correlation predicts low temperature conductivities of about 0.85 Btu/hr-ft-°F for moisture levels of 5 percent as compared with 0.5 Btu/hr-ft-°F measurements from the E-MAD soil samples. Third, the measured E-MAD soil conductivity continued to fall between 70 and 200°F instead of following the slight rising trend predicted by the correlation. These three observations support the contention that the E-MAD test samples, after being mixed and molded with the correct moisture content, lost moisture by evaporation even before the room temperature tests were performed.

A time and temperature dependent soil thermal conductivity was developed which conservatively represents the soil drying out near the drywell. All soil nodes in the model are assigned unique thermal conductivities dependent on their temperature history. The soil in

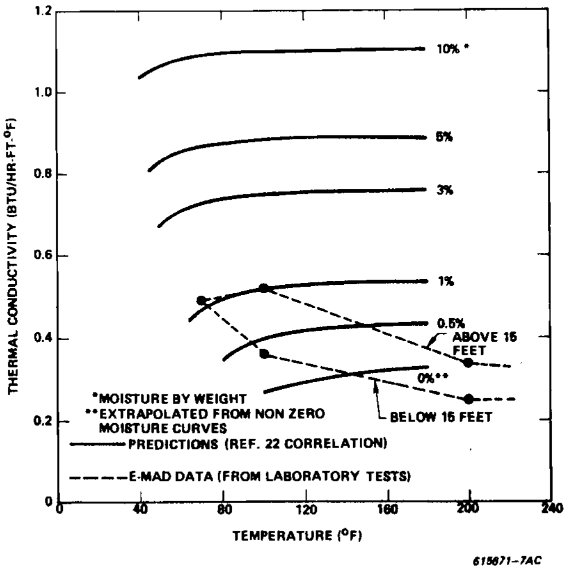


Figure 3.5-9. E-MAD Soil Thermal Conductivity Test Data and Predictions

the model is assumed to begin at 5 percent moisture level with a corresponding thermal conductivity of 0.85 Btu/hr-ft-°F. When the soil reaches 100°F, drying out begins, and the thermal conductivity decreases with time, following the normalized curve shown in Figure 3.5-10. This relationship was developed from Phase I Isolated Drywell Test results. During most of the Phase I test, the temperature difference between the liner and soil at a 5 foot radius remained constant whereas the fuel assembly decay heat decreased nearly 40 percent. Assuming the rate of soil thermal conductivity decrease with time matched that of the decay heat (resulting in no change in the noted temperature difference), the normalized curve in Figure 3.5-10 was developed from the decay heat curve for fuel assembly B03 (see Figure 2.3-3). If the soil reaches 200°F, the soil is assumed to be totally

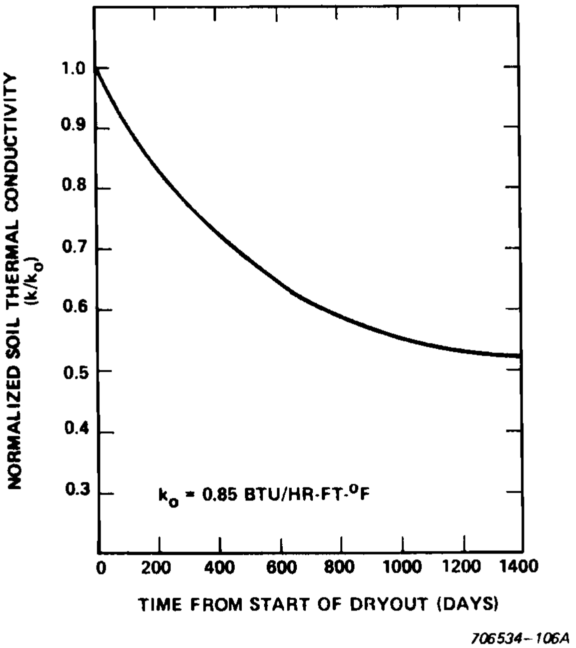


Figure 3.5-10. Soil Thermal Conductivity Dryout Model Derived From Drywell Data

dry and is given a thermal conductivity of 0.25 Btu/hr-ft-°F. A drywell soil thermal conductivity parameter study was done and is described in Section 3.5.3.

3.5.1.2 FUELED DRYWELLS

MODEL SIZE AND BOUNDARY CONDITIONS

The TAP-A nodal model applied to the Fueled Drywell Test is depicted in Figures 3.5-11 and 3.5-12, and the nodes representing each test component are identified in Table 3.5-5. The model is two-dimensional in the r and z directions (radius and depth, respectively) with no variations circumferentially. With several minor exceptions, it is identical to the Electrically Heated Drywell Test thermal model described in Section 3.5.1.1. The exceptions pertain to

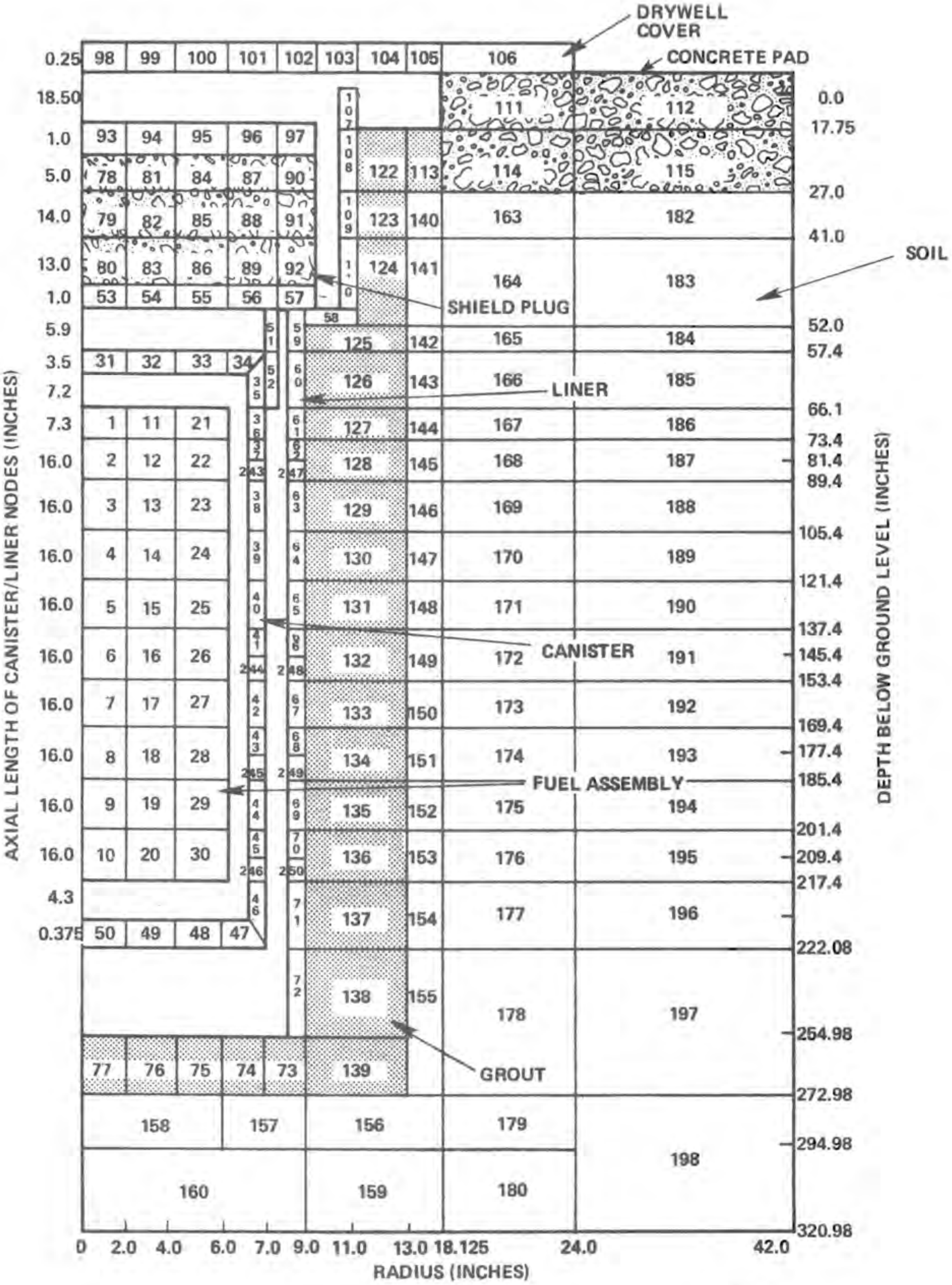


Figure 3.5-11. Near-Field Isolated Drywell Thermal Model

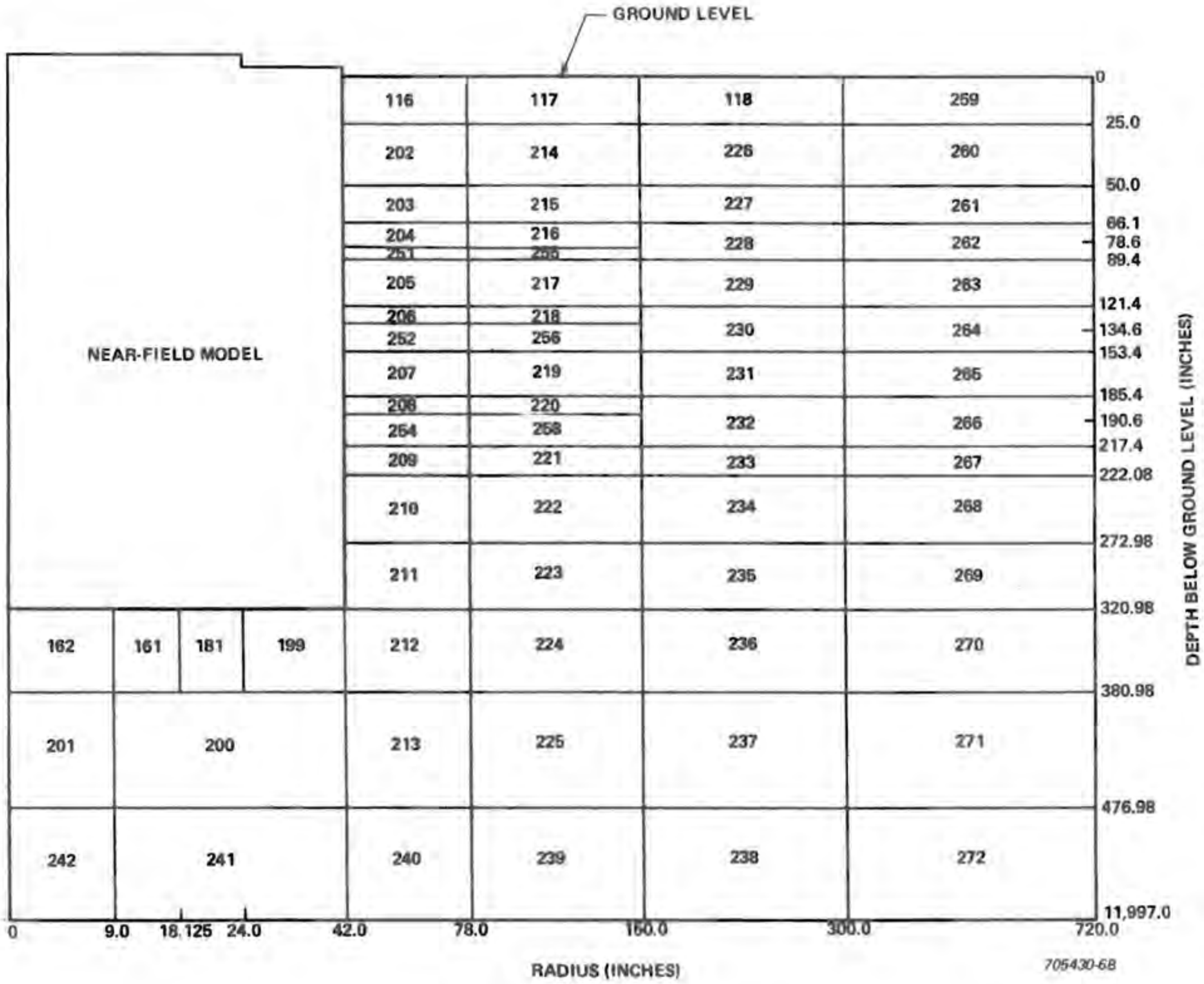


Figure 3.5-12. Far-Field Isolated Drywell Thermal Model

the depth of the shield plug top plate relative to the ground level (18.5 inches below ground level in the fueled drywells versus at ground level in the Electrically Heated Drywell Test) and to the slight rearrangement of nodes to calculate temperatures at drywell thermocouple locations. The rearrangement resulted in several nodes being eliminated explaining the reduction in node number from 289 for the Electrically Heated Drywell Test to 272.

The fueled drywells were treated as thermally isolated. This assumption is based upon Electrically Heated Drywell Test results where ambient soil temperatures existed at all radii beyond 20 feet, even while operating at 2 kW. This assumption is further verified by the similarity in soil temperature data from instrumentation wells E and H for Drywell 3 and from instrumentation wells A and D for Drywell 5 (see Figure D-1). The drywell thermal model extends to a

TABLE 3.5-5
TAP-A DRYWELL MODEL NODE DESCRIPTION

Nodes	Test Components
1-30	Fuel Assembly
31-50	Canister
51-52	Shield Plug Skirt
53-57	Shield Plug Bottom Plate
58-72	Liner Lower Section
73-77	Grout at Bottom of Liner
78-92	Concrete in Shield Plug
93-97	Shield Plug Top Plate
98-106	Drywell Cover Plate
107-110	Liner Upper Section
111-112	Concrete Pad
113	Grout
114-115	Concrete Pad
116-118	Soil
122-139	Grout Between Liner and Soil
140-242	Soil
243-246	Canister
247-250	Liner Lower Section
251-272	Soil

radius of 60 feet, which is given an adiabatic boundary condition. The model lower boundary is located at a depth of 1000 feet where a constant 65°F boundary condition is applied.

FUEL ASSEMBLY HEAT GENERATION RATE

The fueled drywell analysis applies the transient spent fuel decay heat curves shown in Figure 2.3-3 for fuel assemblies B03, B41 and B43 and Figure 2.3-6 for fuel assembly D22. All heat is assumed to be produced in the fuel zone (Nodes 1 to 30). The volumetric heat generation rate is distributed uniformly over the entire fuel zone creating a cosine shaped heat flux distribution at the canister wall similar to that deduced from canister and liner temperature data.

HEAT TRANSFER MECHANISMS

The Fueled Drywell heat transfer is modeled in the same way as in the Electrically Heated Drywell Test (see Section 3.5.1.1). However, the effective heat transfer properties of the fuel zone are different. This effective conductivity versus temperature was calculated to produce reasonable fuel assembly temperatures in the 300 to 800°F range (see Figure 4.5-2). This was necessary for proper drywell transient response. The fuel assembly heat capacity is modeled accurately to produce a proper transient response. The model was supplied with an accurate estimate of the fuel assembly mass of 1450 pounds and a specific heat capacity of 0.066 Btu/lb-°F representing, in proper proportions, the heat capacities of the Zircaloy clad, the UO_2 fuel and the stainless steel nozzle plates.

MATERIAL PROPERTIES

Thermal properties used in the analysis of the fueled drywells are identical to those applied in the Electrically Heated Drywell Test identified in Table 3.5-3.

For the fueled drywells, soil temperatures were never greater than about 160°F. Therefore, the soil was considered to never totally dry out and the dry soil thermal conductivity of 0.25 Btu/hr-ft-°F had little or no effect. The normalized soil thermal conductivity versus time relationship in Figure 3.5-10 represented the dryout of any soil exceeding 100°F. A soil conductivity parameter study discussed in Section 3.5.3 shows that the percentage of moisture initially in the soil was between 2 and 5 percent (soil thermal conductivities of 0.60 and 0.85 Btu/hr-ft-°F, respectively).

3.5.2 COMPARISON OF MODEL PREDICTIONS WITH TEST DATA

With proper input, the drywell thermal models should produce accurate temperature predictions for the canister, liner, and near-field soil zone. Accurate canister temperatures are important as input to independent fuel assembly studies while accurate soil temperatures are important for drywell array and thermal interaction analyses. The most important model evaluation criteria is that it must correctly predict temperature trends and relationships over a range of power levels and as the seasons vary. Satisfying this third criteria will demonstrate that the thermal model correctly simulates the appropriate heat transfer mechanisms and maintains the proper relationships as system forcing functions and boundary conditions change. When this criteria is satisfied, small differences between predicted and measured temperatures should not be of concern. In most cases, the differences can be recognized and explained based upon inaccuracies in model input, actual test configuration uncertainties and/or heat transfer mechanism uncertainties.

ELECTRICALLY HEATED DRYWELL TEST MODEL/DATA COMPARISONS

Predicted axial temperature profiles for the Electrically Heated Drywell Test canister and liner are compared with test data in Figures 3.5-13 to 3.5-16. These figures show the comparison at the end of the 3 kW accelerated heatup period on May 1, 1978, during 1 kW operation on September 1, 1978, during 2 kW operation on September 1, 1979, and during 3 kW operation on October 1, 1980. In each figure, the peak predicted canister temper-

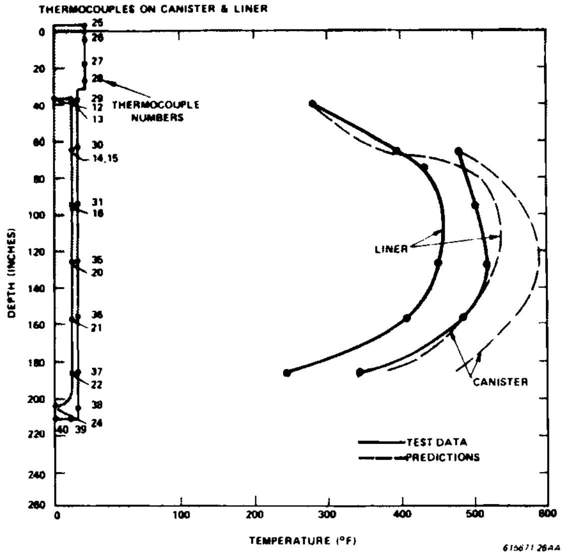


Figure 3.5-13. *Electrically Heated Drywell Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles at End of 3 kW (Accelerated Heatup) Operation, May 1, 1978*

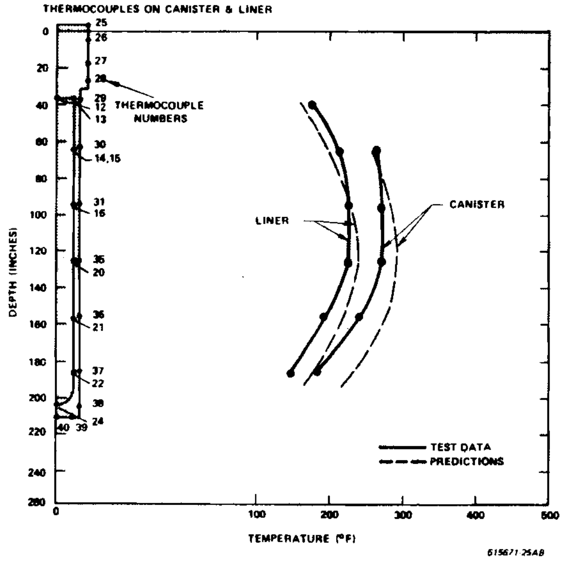


Figure 3.5-14. *Electrically Heated Drywell Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles for 1 kW Operation, September 1, 1978*

ature is conservative when compared to the test data.

Generally, the predicted relationship between canister and liner temperatures agree well with the data. However, the predicted axial profiles themselves vary in shape from those of the data in every case. For the two comparisons at a 3 kW power level, the model significantly overpredicts the canister and liner temperatures. These discrepancies are attributed to the

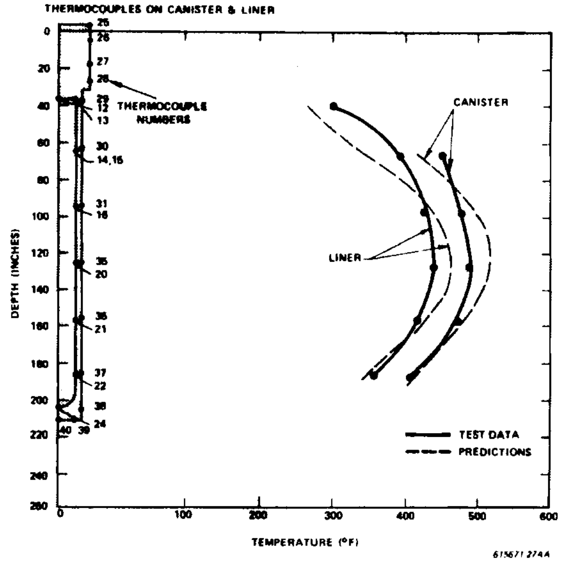


Figure 3.5-15. *Electrically Heated Drywell Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles for 2 kW Operation, September 1, 1979*

differences in axial heat transfer within the canister and in soil thermal conductivity differences between the drywell and model. The differences and their effects on all predictions are discussed later in this section.

Canister and soil temperature data at about 11 feet deep are compared with predictions in Figures 3.5-17 to 3.5-19. Figure 3.5-17 compares canister and soil at a 3 foot radius for the accelerated heatup and 1 kW power operation phases. For most of these periods, the predicted canister temperatures are conservative. The model prediction for the initial drywell heatup exceeds the recorded temperatures by about 80°F. Following the rapid cooldown from a 3 to 1 kW power level, the predicted relationships between canister and soil at a 3 foot radius is similar to that of the data. Figures 3.5-18 and 3.5-19 compare canister and 3 foot radius soil for power operation at 2 and 3 kW, respectively. For both of these test phases, the canister

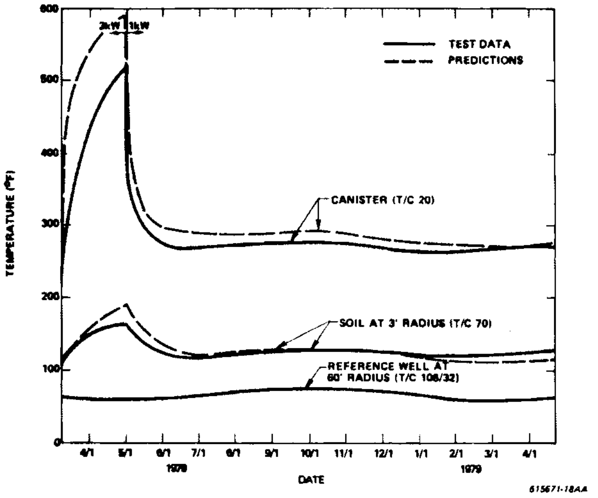


Figure 3.5-17. *Electrically Heated Drywell Test Data and Predictions Comparison for the 11 Foot Depth During 1 kW Operation*

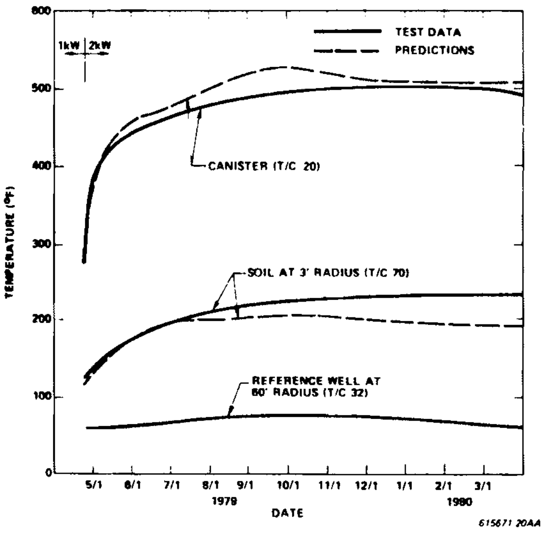


Figure 3.5-18. *Electrically Heated Drywell Test Data and Predictions Comparison for the 11 Foot Depth During 2 kW Operation*

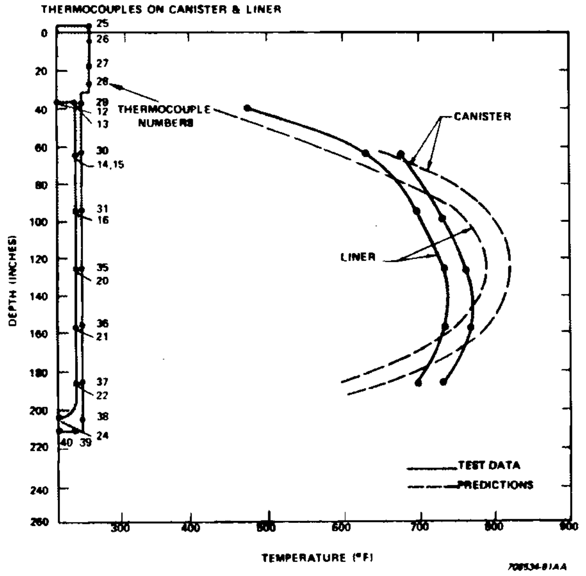


Figure 3.5-16. *Electrically Heated Drywell Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles for 3 kW Operation, October 1, 1980*

predictions were conservative (by as much as 60°F at 3 kW); however, the soil predictions were nonconservative. The difference between the predicted canister and soil temperatures was greater than that for the actual drywell. The discrepancies between the predictions and data at the 11 foot depth can again be attributed to differences between modeled and actual soil thermal conductivities.

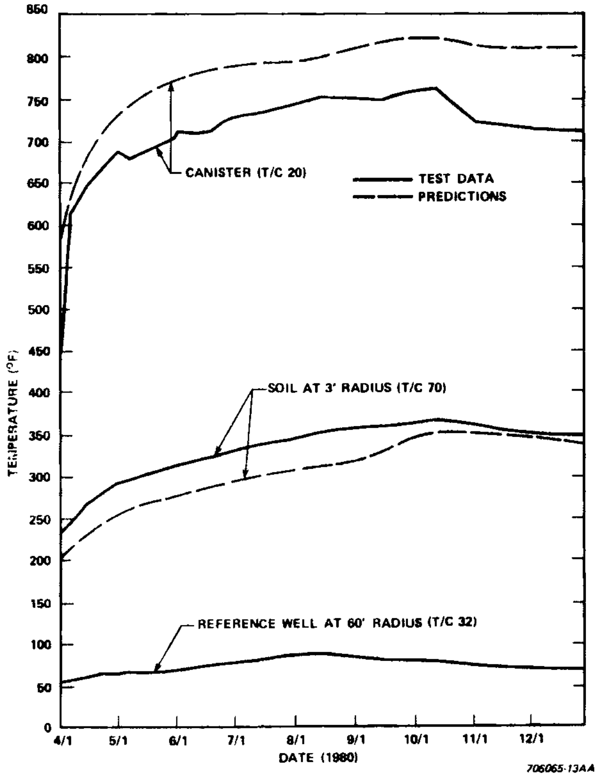


Figure 3.5-19. Electrically Heated Drywell Test Data and Predictions Comparison for the 11 Foot Depth During 3 kW Operation

Axial temperature profile comparisons for the grout and for soil at 21 and 60 inch radii are shown in Figures 3.5-20 to 3.5-23. These comparisons are for the same times as those for the canister and liner axial profile comparisons (Figures 3.5-13 to 3.5-16). These four figures show a similar overprediction of peak temperatures close to the drywell. For several comparisons, the soil temperatures were underpredicted in the region of drywell heated length and overpredicted in the region beneath the drywell.

CONCLUSIONS FROM ELECTRICALLY HEATED DRYWELL TEST MODEL/DATA COMPARISON

The Electrically Heated Drywell Test thermal model described in

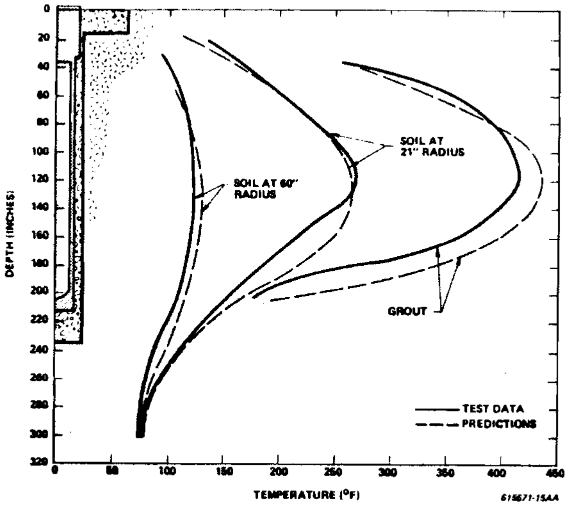


Figure 3.5-20. Electrically Heated Drywell Test Data and Predictions Comparison of Grout and Soil Axial Temperature Profiles at End of 3 kW (Accelerated Heatup) Operation, May 1, 1978

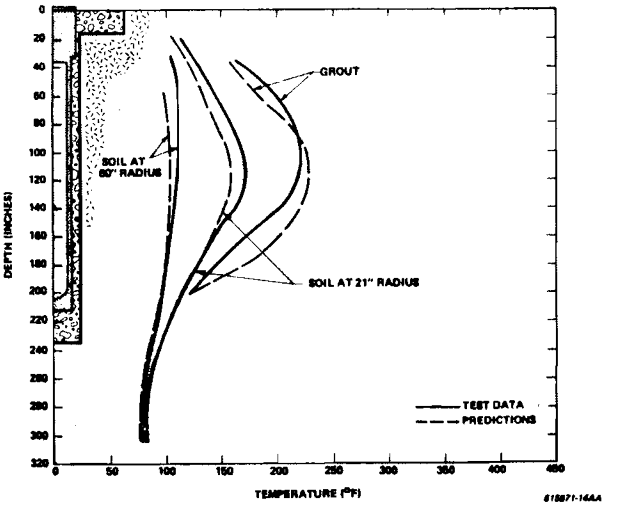


Figure 3.5-21. Electrically Heated Drywell Test Data and Predictions Comparison of Grout and Soil Axial Temperature Profiles for 1 kW Operation, September 1, 1978

this report does a fairly good job of predicting conservative peak canister temperatures for the air filled canister. The relationship predicted between canister and liner temperatures shows reasonable agreement with the test data showing satisfactory simultation.

However, the accuracy of canister and liner temperature predictions was found to be influenced by the modeling of heat transfer mechanisms inside the drywell and out in the soil. The two areas where model refinement is needed are the free convection and radiation effects inside the canister and between canister and liner, and the effects of in-situ soil thermal conductivity changes with temperature. Test data and prediction evaluations show canister and liner temperature predictions both above and below the midplane level are sensitive to these effects and the skewed canister heat flux and the soil thermal conductivity change with time included in the model do not provide accurate representations of these effects.

Free convection effects of air inside the test canister were assumed to have caused a nonuniform axial heat flux profile peaking near the canister upper end. Due to computer code limitations, free convection effects were modeled by imposing a skewed axial heat generation rate rather than using mass flow dependent temperature calculations between heater and canister. In addition, the tendency of radiation to be the dominant heat transfer mechanism at higher temperatures was not included in the model. A more accurate modeling method should be developed to include both free convection and radiation effects over the entire range of heater power output and canister temperatures. In this way, model prediction agreement with test data for the entire drywell could be improved.

The relationship of soil conductivity to temperature and time in the thermal model had a significant effect on drywell and soil temperature prediction agreement with test data. The soil conductivity values in the model were based on correlations from literature for comparable soils and from an analytical evaluation of soil temperature data rather than the soil properties test data conducted at E-MAD. Model analyses using the measured thermal conductivity data grossly overpredict test canister temperatures (see Section 3.5.3). Moisture variations in the soil samples tested and in the soil itself are judged to cause the differences in soil thermal conductivity.

The relationship between soil thermal conductivity, temperature, and time appears to be a function of the instantaneous moisture content of the soil. An adequate model should incorporate experimental and theoretical relationships for soil thermal conductivity as a function of temperature and moisture content. Additional investigations are needed to properly evaluate the transport mechanisms involved in drying the soil at various depths. These mechanisms would include the flow and possible recondensation of vapor in the soil and the flow of liquid toward a heated zone.

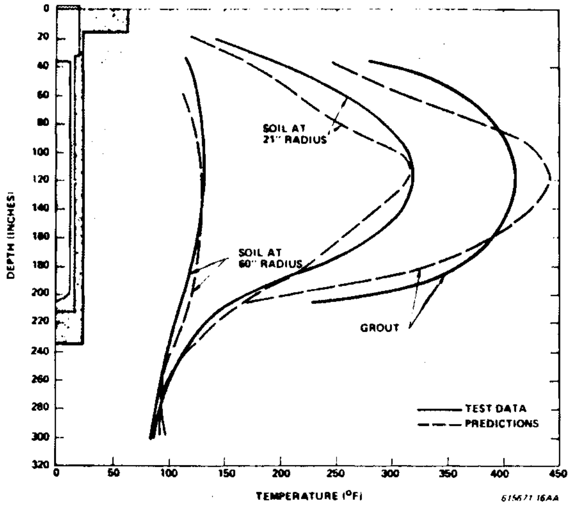


Figure 3.5-22. Electrically Heated Drywell Test Data and Predictions Comparison of Grout and Soil Axial Temperature Profiles for 2 kW Operation, September 1, 1979

FUELED DRYWELL MODEL/DATA COMPARISONS

Predicted canister and liner axial temperature profiles for Drywells 5 and 3 at various times during testing are compared with test data in Figures 3.5-24 to 3.5-28. For Drywell 5, the comparisons are made on August 15, 1979, October 15, 1980 and September 1, 1981 (Figures 3.5-24 to 3.5-26). For Drywell 3, the comparisons are made on September 2, 1980 and September 1, 1981 (Figures 3.5-27 and 3.5-28). These dates correspond to the times when peak canister temperatures occurred during each year. For both drywells, the predicted axial temperature profiles were lower than those from the test data. The predicted profiles also diverged from the data at lower depths. The divergence can be attributed to the choice of the initial soil thermal conductivity. The soil temperatures did not exceed 200°F in the analysis and very little soil exceeded 100°F. Therefore, the temperature and time dependent soil conductivity model did not affect the predicted temperatures while the initial soil thermal conductivity (based on an assumed 5 percent moisture level) greatly influenced the predictions. The effect of different soil thermal conductivities on model predictions is further discussed in Section 3.5.3.

Canister, liner and soil temperature data at a depth of about 145 inches are compared with prediction in Figures 3.5-29 and 3.5-30 for Drywells 5 and 3 over the entire test period. The initial soil moisture level is assumed to be 5 percent for both drywells. The thermal model underpredicts the canister and liner temperatures except during periods of rapidly using temperatures when the predicted temperatures rise more rapidly and tend to overshoot the measured values. This discrepancy

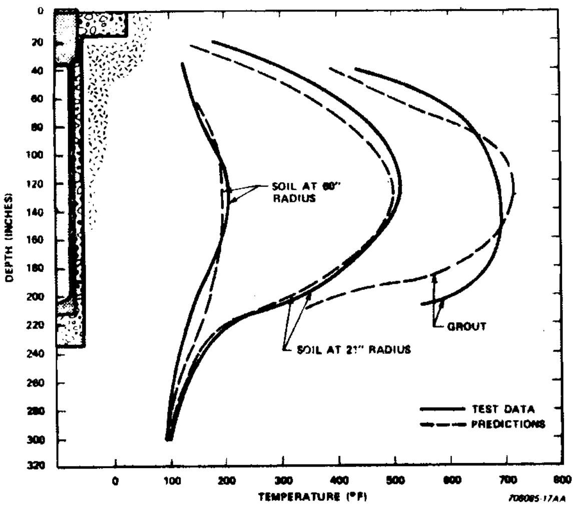


Figure 3.5-23. Electrically Heated Drywell Test Data and Predictions Comparison of Grout and Soil Axial Temperature Profiles for 3 kW Operation, October 1, 1980

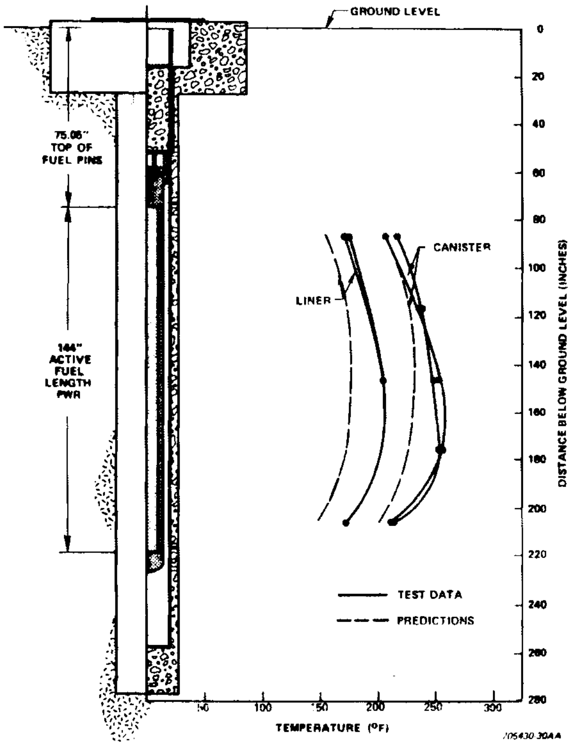


Figure 3.5-24. Drywell 5 (F/A B03) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, August 15, 1979

may be due to heat capacity prediction innaccuracy (most likely caused by soil and grout moisture levels) and the inability of the thermal model to accurately treat moisture evaporation. For both drywells, the predicted response to seasonal temperature changes tends to lag that shown by the data for canister, liner and soil at a 5 foot radius. This may be due to use of average monthly temperatures for ambient air in the model.

CONCLUSIONS FROM FUELED DRYWELL MODEL/DATA COMPARISON

In general, the predicted temperatures for Drywells 5 and 3 are fairly good except that they are nonconservative (except for the peak temperature for fuel assembly D22 in Drywell 5). The prediction accuracy for the fueled drywell model described in this report was also influenced by the modeling of the heat transfer mechanisms inside the drywell and the soil thermal conductivity changes with temperature.

The model tends to overpredict the temperature differental between canister and liner. This is attributed to inaccuracies input to the radiation and conduction/convection models. The accuracy of the "effective conductivity" type of correlation is typically no better than about ± 20 percent while emissivities and reflectivities of surfaces are known with less accuracy. With relatively thin canister walls providing a poor path

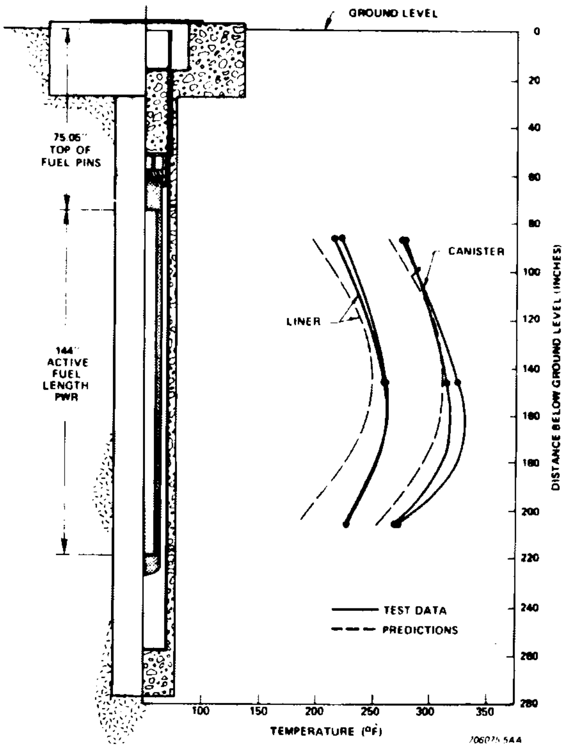


Figure 3.5-25. Drywell 5 (F/A D22) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, October 15, 1980

for axial heat conduction and with a uniform heat generation rate, the canister temperature is constrained to follow the liner temperature profile. This is, in turn, determined by the response of the grout and surrounding soil to the imposed heat flux. The discrepancy in shape and absolute value of the liner temperature distribution is due to an incomplete understanding of the soil response to applied heat, in particular, the effect on moisture content on thermal conductivity.

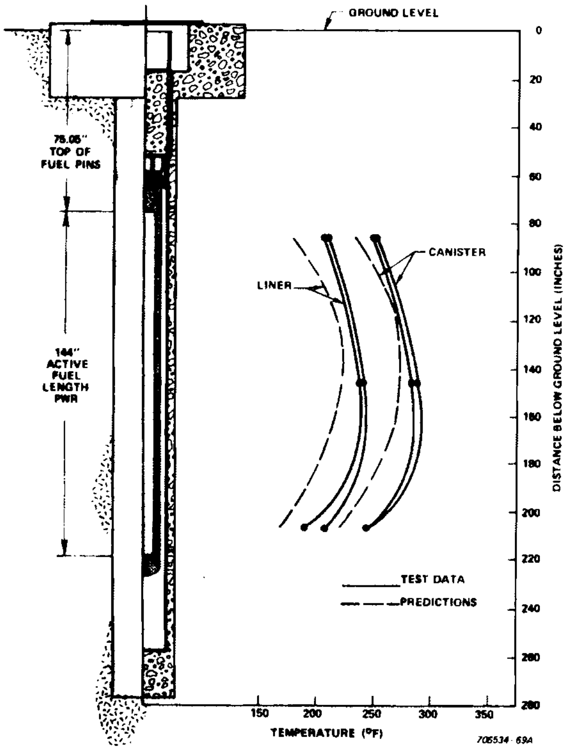


Figure 3.5-26. Drywell 5 (F/A D22) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, September 1, 1981

The discrepancies in the axial temperature profiles indicate that further refinement in the soil thermal conductivity model is required. Because of the reasonably good agreement near the canister top and underprediction near the canister bottom, it appears that the thermal conductivity model does not accurately reflect the soil thermal conductivity.

It can be concluded from these results that the E-MAD soil thermal conductivity has not been accurately modeled by a simple function of temperature and time. In order to model soil properties accurately, a knowledge of soil properties as a function of moisture content is necessary. An understanding of the transport mechanisms involved for water vapor released and liquid water in the soil is needed. It is expected that the actual equilibrium moisture content reached at any temperature represents a

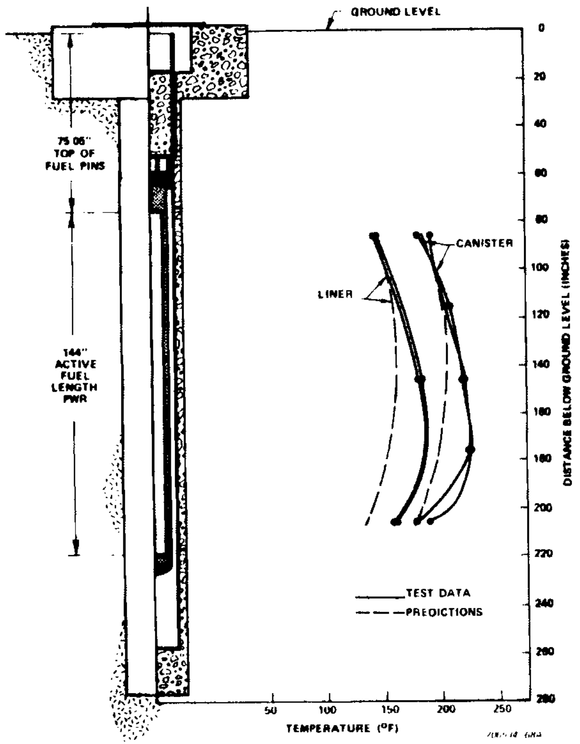


Figure 3.5-27. Drywell 3 (F/A B03) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, September 2, 1980

balance between vapor transport to the surface and replenishment by liquid water from the surrounding soil. Once the moisture transport mechanisms are investigated, it may be possible to accurately represent the soil thermal conductivity as a function of temperature and soil type, introducing a first order lag representing the transport mechanism. The time constant for the lag is expected to be a function of temperature level and depth below the ground surface, as well as the soil type.

3.5.3 EFFECT OF VARIABLES ON DRYWELL TEMPERATURES

Parameter studies were conducted using both drywell models to investigate the effects of variables on predicted drywell temperatures.

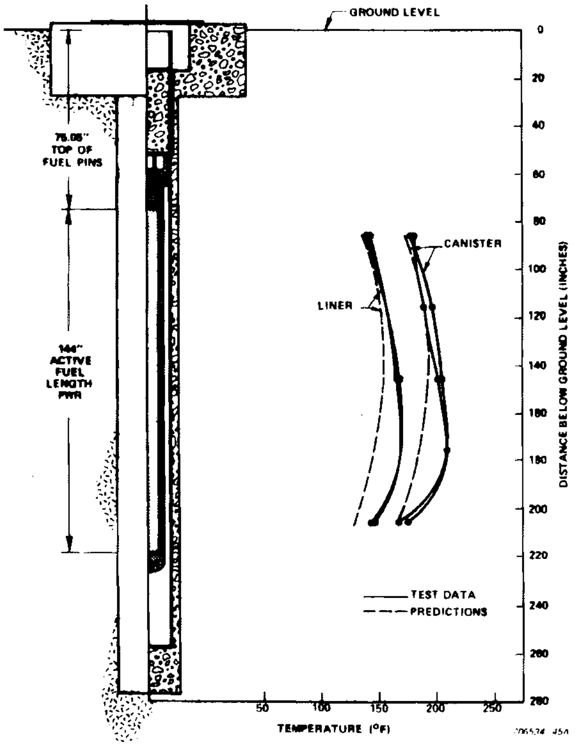


Figure 3.5-28. Drywell 3 (F/A B03) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, September 1, 1981

Specific parameters investigated include soil thermal conductivity, power levels for the heat source and the seasonal ambient air temperature changes. Each parameter was varied or maintained constant while other parameters were varied to determine overall impact each had on drywell temperatures.

SOIL THERMAL CONDUCTIVITY

Early in drywell analysis, it was recognized that soil conductivity had a large effect on temperature predictions. The soil thermal conductivity data generated from soil sample testing (shown in Table 3.4-4) indicated a significant difference between dry soil (above 200°F) and soil with moisture. Figures 3.5-31 and 3.5-32 show canister temperature predictions

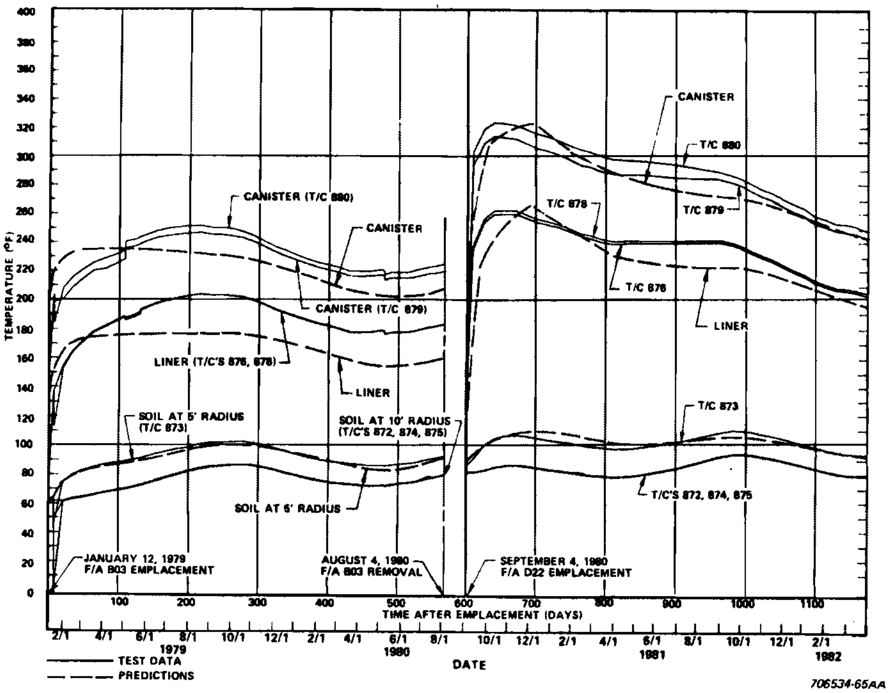


Figure 3.5-29. Drywell 5 (F/A B03 and D22) Test Data and Predictions Comparison at About 145 Inches Below Ground Level, January 12, 1979 to March 31, 1982

for wet and dry soil thermal conductivities using the Electrically Heated Drywell Test model. The two figures compare predictions for both conductivities with test data at about 11 feet deep for the accelerated heatup and 1 kW operation phase, and the 3 kW operation phase. The dry soil is assumed to have a constant thermal conductivity of 0.25 Btu/hr-ft-°F and wet soil is assumed to have a 5 percent moisture level with a thermal conductivity of 0.85 Btu/hr-ft-°F. Throughout each transient period, the dry soil predictions are excessively conservative. The wet soil predictions are slightly nonconservative during 1 kW operation and very nonconservative during 3 kW operation.

To further refine thermal model predictions, a parameter study using various combinations of wet and dry soil thermal conductivities was conducted. Two thermal conductivities were chosen for each soil type. For the wet soil, thermal conductivities of 1.1 and and 0.85 Btu/hr-ft-°F were chosen, which represent 10 and 5 percent moisture in the soil, respectively (see Figure 3.5-9). For the dry soil, thermal conductivities of 0.4 and 0.25 Btu/hr-ft-°F were chosen based on results of the E-MAD soil properties tests at different soil depths (see Figure 3.5-8). Figure 3.5-33 compares predictions for the four combinations of wet and dry soil thermal conductivities with test data using the Electrically Heated Drywell Test model. The comparisons are shown during the

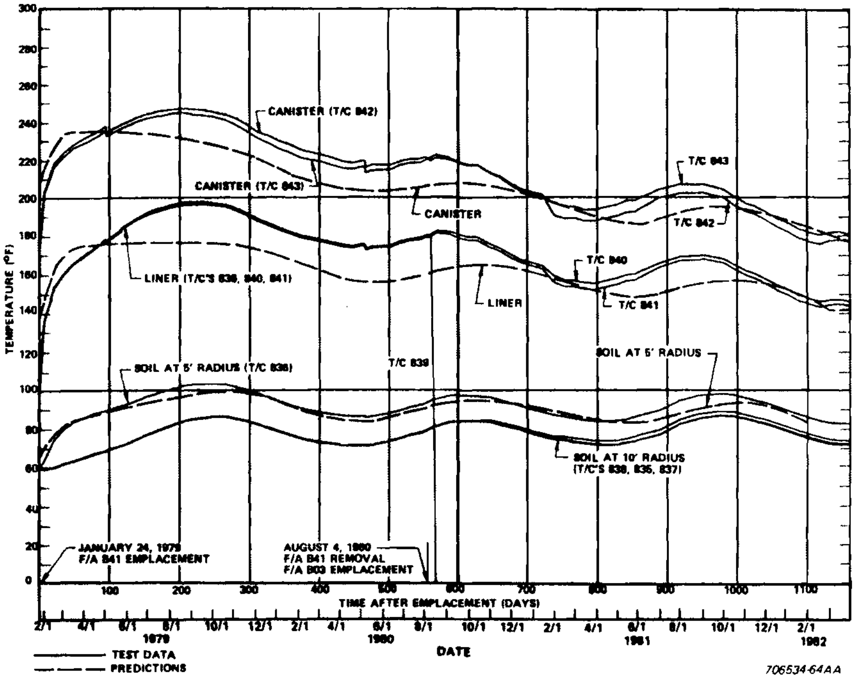


Figure 3.5-30. Drywell 3 (F/A B41 and B03) Test Data and Predictions Comparison at About 145 Inches Below Ground Level, January 24, 1979 to March 31, 1982

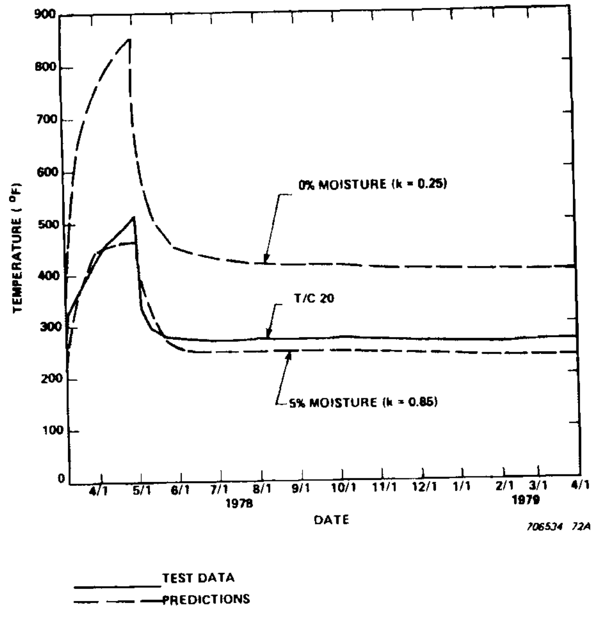


Figure 3.5-31. Electrically Heated Drywell Test Comparison of Canister Temperature Predictions for Constant Wet and Dry Soil During 1 kW Operation

period June through December for 1 kW operation (lower curves) and for 3 kW operation (upper curves). From these results, Case C with conductivities of 0.25 and 0.85 Btu/hr-ft-°F for dry and wet soil provided more conservative predictions than the other cases and these values were therefore used in both models.

As a result of previous model/test data comparisons, the effect of soil dryout due to the drywell heat source was included in the two models. Because TAP-A has no mass flow capability, the effect of moisture evaporation on soil thermal conductivity is represented by a time and temperature dependent thermal conductivity model. Each TAP-A soil node in the thermal model is given a unique thermal conductivity dependent on its temperature history. The soil nodes begin with a given moisture level and are assigned a corresponding wet soil thermal conductivity (Kwet). If a soil node reaches 100°F, the soil starts drying out and the soil thermal conductivity decreases with time from Kwet following the normalized curve in Figure 3.5-10. If a soil node exceeds 200°F, the soil becomes totally dry and is assigned a corresponding dry soil conductivity (Kdry). The effect of this model is shown in Figure 3.5-34 which compares canister and liner temperature predictions from the fueled drywell model for constant and time dependent soil thermal conductivities with Drywell 3 test data. The divergence between the constant and time dependent conductivities is evident from the figure. The time dependent conductivity model tends to predict temperatures closer to the data.

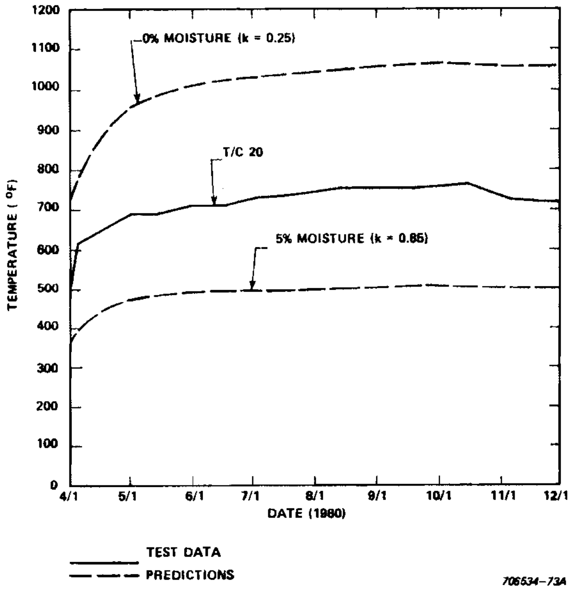
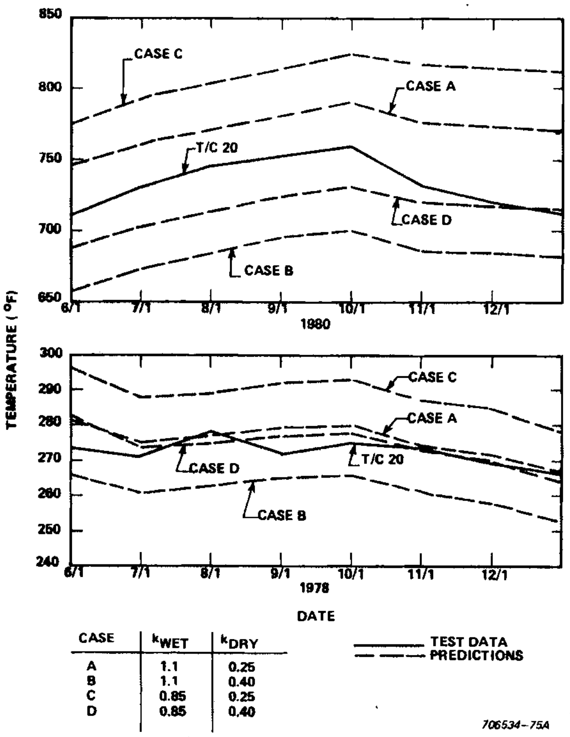


Figure 3.5-32. *Electrically Heated Drywell Test Comparison of Canister Temperature Predictions for Constant Wet and Dry Soil During 3 kW Operation*

The predictions using a constant soil thermal conductivity are shown in Figure 3.5-35. This figure compares canister temperature predictions for dry soil and for soils with 2 and 5 percent moisture with Drywell 3 test data. As with the Electrically Heated Drywell Test model predictions, the use of totally dry soil results in temperatures with excessive conservatism. For Drywell 3, the test data is bounded by the predictions using constant 2 and 5 percent moisture levels for the soil. Further comparison of canister and liner temperature predictions using thermal



CASE	k_{WET}	k_{DRY}
A	1.1	0.25
B	1.1	0.40
C	0.85	0.25
D	0.85	0.40

Figure 3.5-33. *Electrically Heated Drywell Test Comparison of Canister Temperature Predictions for Varied Soil Thermal Conductivity During 3 kW Operation (Top Curve) and 1 kW Operation (Bottom Curve)*

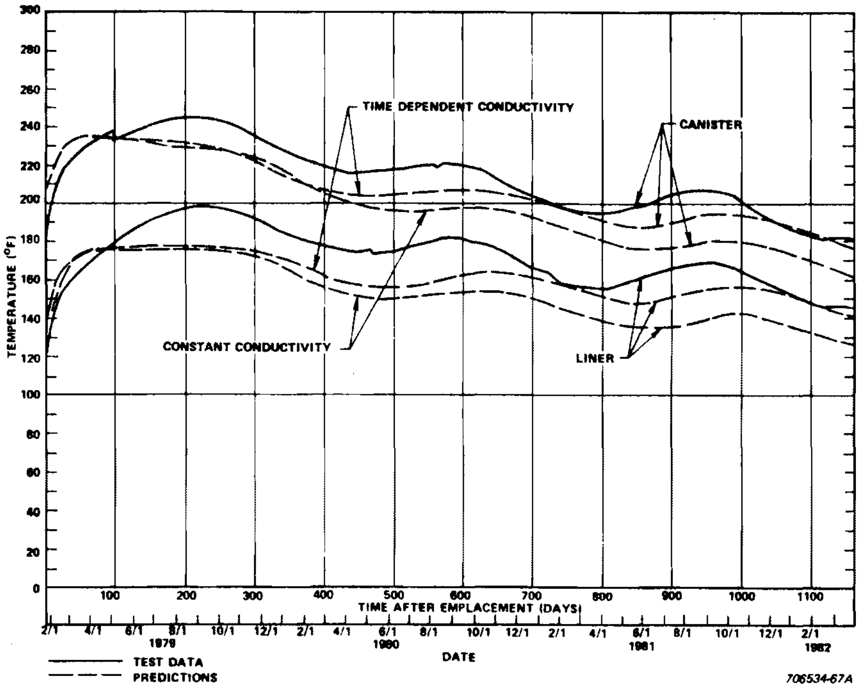


Figure 3.5-34. Drywell 3 (F/A B41 and B03) Comparison of Canister and Liner Temperature Predictions for Constant Soil Thermal Conductivity and Time Dependent Soil Thermal Conductivity

conductivities for 2 and 5 percent soil moisture content with time and temperature dependent soil thermal conductivity model are shown in Figures 3.5-36 and 3.5-37 for Drywells 5 and 3, respectively.

POWER LEVEL VARIATIONS

The effect of power level variations on canister temperature predictions can be seen in Figure 3.5-38. Canister temperature predictions for power levels of 1 and 2 kW are compared using the fueled drywell thermal model for constant power and the decay heat curve for spent fuel assemblies (see Section 2.3). The decay heat curve predictions show temperatures peak very early in the transient, whereas the constant power level cases do not reach a peak over the duration of the transient. All curves exhibit seasonal temperature variations. The 2 and 1 kW decay heat curve predictions converge towards the end of the transient as do the decay heat levels. All the predictions use an initial 2 percent soil moisture level thermal conductivity of 0.6 Btu/hr-ft-°F and a dry soil thermal conductivity of 0.25 Btu/hr-ft-°F with time and temperature dependence.

AMBIENT AIR TEMPERATURE CHANGES

Variation in seasonal ambient air temperatures affects drywell canister and liner temperature response. This effect is shown in Figure 3.5-39 which compares canister and liner temperature predictions for a constant ambient air temperature of 68°F to test

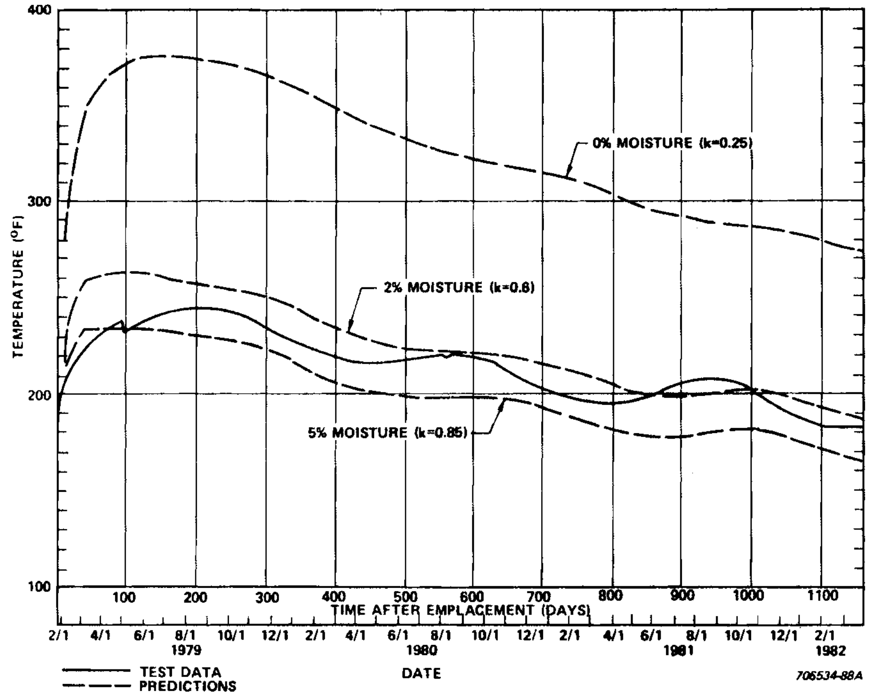


Figure 3.5-35. Drywell 3 (F/A B41 and B03) Comparison of Canister Temperature Predictions for Constant Wet and Dry Soil

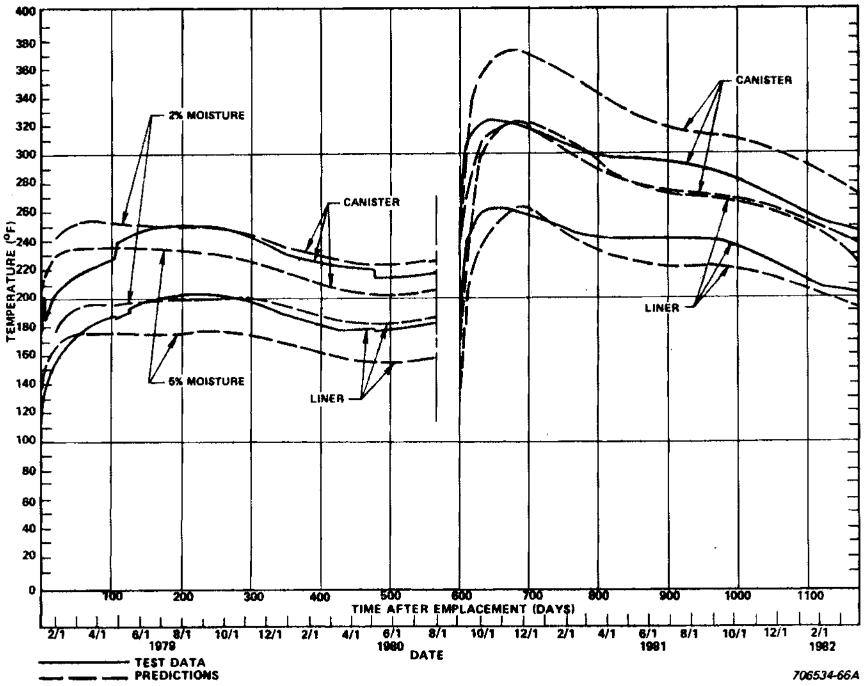


Figure 3.5-36. Drywell 5 (F/A B03 and D22) Comparison of Canister and Liner Temperature Predictions for 2 and 5 Percent Soil Moisture Content

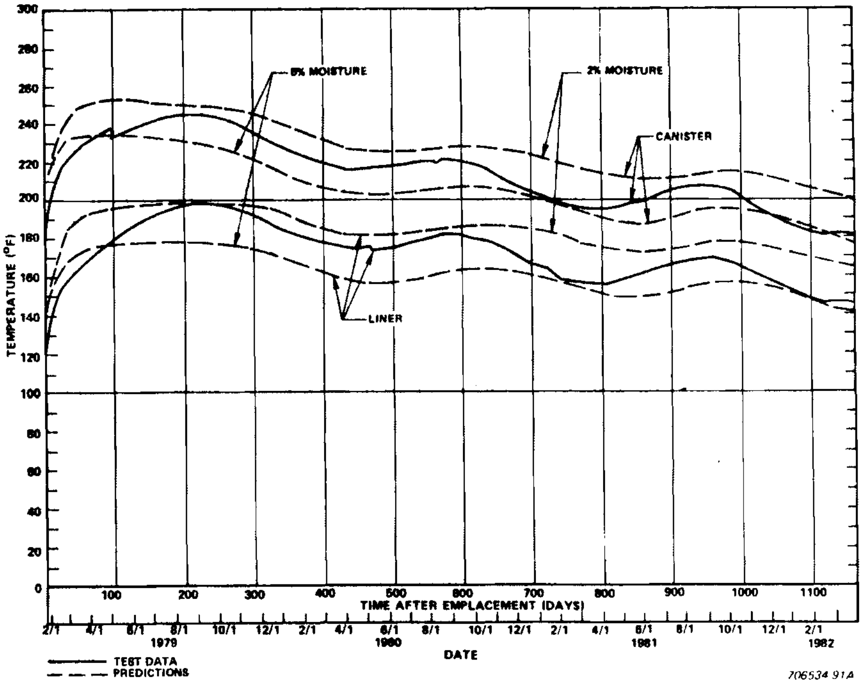


Figure 3.5-37. Drywell 3 (F/A B41 and B03) Comparison of Canister and Liner Temperature Predictions for 2 and 5 Percent Soil Moisture Content

data from Drywell 3. The temperature predictions follow a sloping path which is dependent only on the decay heat curve.

3.6 DRYWELL TEMPERATURE EXTRAPOLATIONS

The peak fuel clad temperatures have been predicted from the test data for all four fueled drywells using the relationships developed from Fuel Assembly Internal Temperature Measurement Test data. Figures 3.6-1, 3.6-2, 3.6-3, and 3.6-4 show the peak measured canister temperatures and the estimated peak fuel clad temperatures for Drywells 5, 3, 2, and 1, respectively.

The peak fuel clad temperature estimates were calculated using the method described in Section 5.6.1. The peak measured canister temperatures and the predicted fuel assembly decay heat levels (from Figures 2.3-3 and 2.3-6) were used to calculate the peak fuel clad to canister temperature difference from the relationship developed from the helium backfill Fuel Assembly Internal Temperature Measurement Test data (see Section 5.6.1). This difference was then added to the peak measured canister temperature to develop the peak fuel clad temperatures.

Figure 3.6-1 shows the estimated peak fuel clad temperatures for Drywell 5 from January 12, 1979, to March 31, 1982. The estimated peak fuel clad temperatures for fuel assembly B03 range from 321°F at emplacement, to a 352°F maximum and down to 309°F prior to assembly

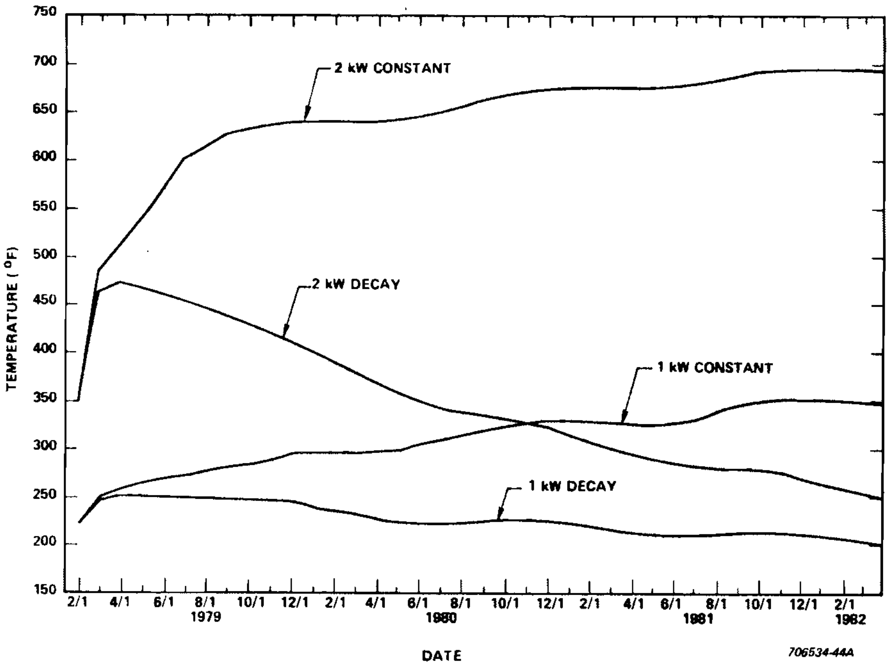


Figure 3.5-38. Comparison of Drywell Canister Temperature Predictions for Various Power Level Conditions at About 145 Inches Below Ground Level

movement to Drywell 3. The estimated peak fuel clad temperatures for fuel assembly D22 range from 392°F at emplacement, to a 437°F maximum and then decrease to 336°F on March 31, 1982. Figure 3.6-2 shows the estimated peak fuel clad temperatures for Drywell 3 from January 24, 1979 to March 31, 1982. The estimated peak fuel clad temperatures for fuel assembly B41 range from 319°F at emplacement, to a maximum of 353°F and down to 309°F prior to assembly movement to Drywell 2. Fuel assembly B03 temperatures continued to show the cycling response to seasonal ambient air temperature variations ranging from 307°F at emplacement in Drywell 3 to 258°F on March 31, 1982.

Figures 3.6-3 and 3.6-4 show the estimated peak fuel clad temperatures for Drywells 2 and 1. These two figures show similar temperature response with little differences. For fuel assembly B41 in Drywell 2, the temperatures ranged from 262°F at emplacement to a maximum of 278°F, to 254°F on March 31, 1982. For fuel assembly B43 in Drywell 1, the temperatures ranged from 250°F at emplacement (about 38 days later than Drywell 2), to a maximum of 274°F, to 253°F on March 31, 1982.

The errors in these peak fuel clad temperature predictions was determined from the temperature measurement uncertainties and calculational method inaccuracies (see Appendix M, Section M.3). The following are the estimated maximum errors in

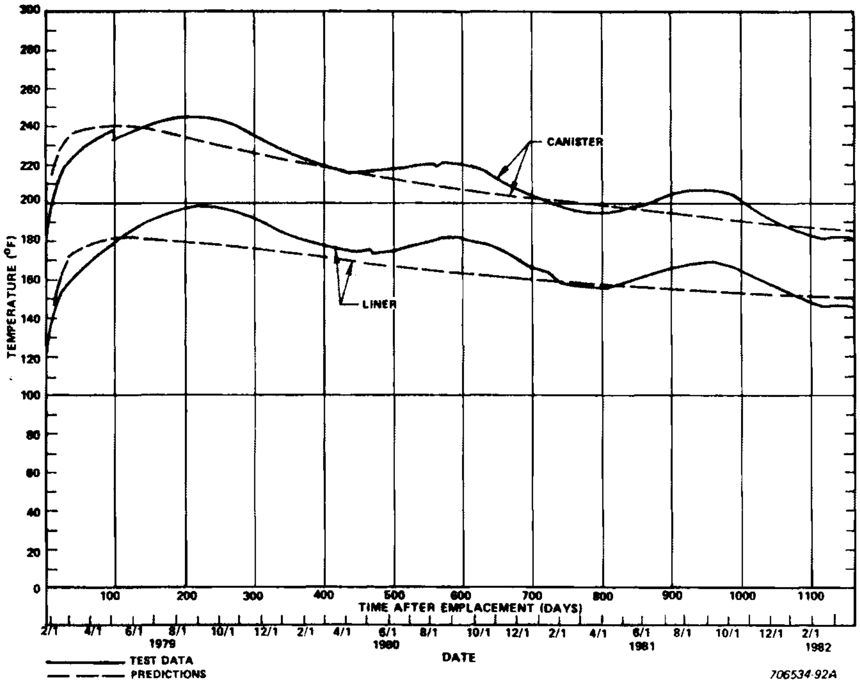


Figure 3.5-39. Drywell 3 (F/A B41 and B03) Comparison of Canister and Liner Temperature Distributions with Predictions for Constant Ambient Air Temperature of 70°F

the peak fuel clad temperatures noted above:

Drywell	Fuel Assembly	Maximum Errors (°F)
5	B03	-5.7 to +9.3
5	D22	-5.7 to +14.0
3	B41	-5.7 to +11.3
3	B03	-5.7 to +10.0
2	B41	-5.7 to +12.4
1	B43	-5.7 to +13.6

3.7 APPLICABILITY OF TEST RESULTS

APPLICATION

The results from the Electrically Heated Drywell Tests and Fueled Drywell Tests conducted at E-MAD can be applied to drywell storage cells of similar configuration and soil thermal properties. The thermal response of the air filled electrically heated canister to the various constant power levels tested can be considered indicative of air filled canisters in comparable drywells. The thermal response of the helium filled spent fuel canisters to various decay heat levels can be considered indicative of helium filled canisters in comparable drywells. The overall drywell response to the various heat sources is specifically configuration and soil material property related. Drywell liner and soil temperatures reported herein have been influenced by the configuration of the drywell (concrete pad

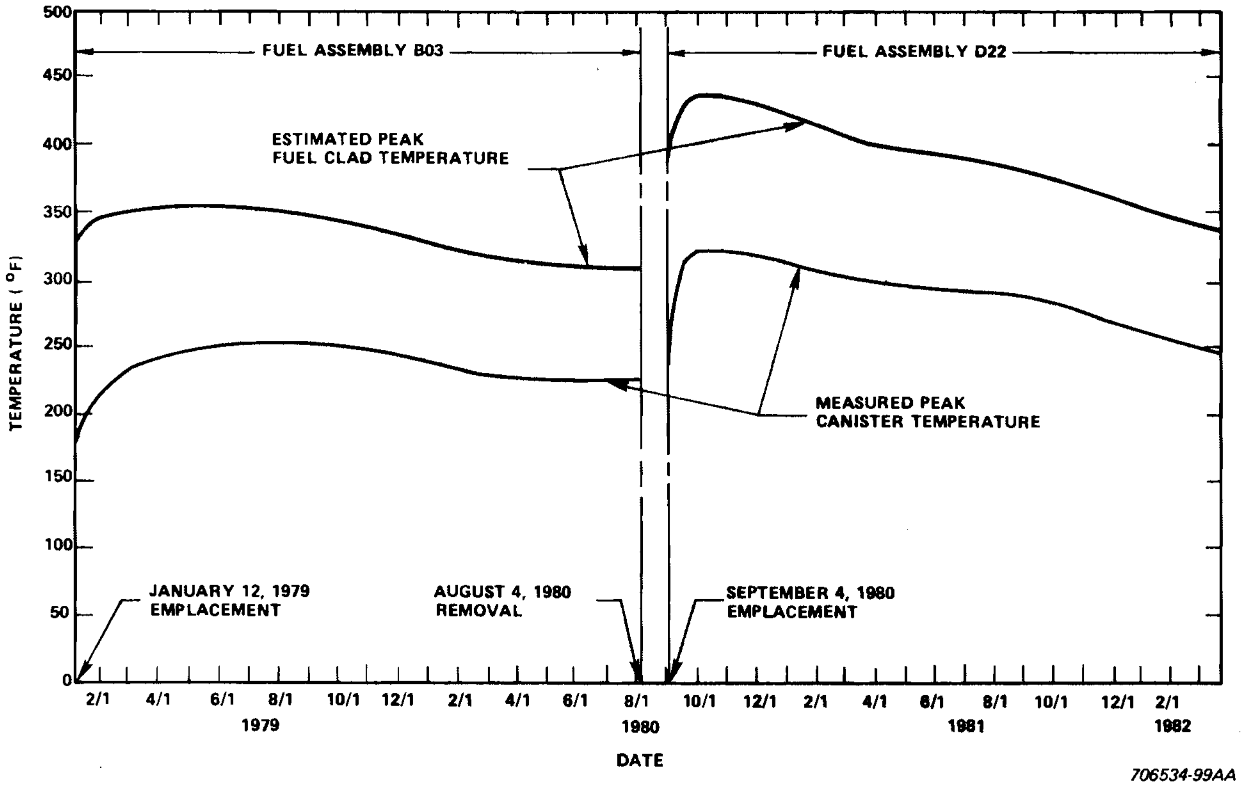


Figure 3.6-1. Drywell 5 (F/A B03 and D22) Estimated Peak Fuel Clad Temperature Distribution, January 12, 1979 to March 31, 1982

at top, depth and size of liner, depth of heat source, etc) and by the effect of soil moisture level changes on soil thermal properties.

The results of the computer thermal model evaluations are considered to be generally applicable to comparable drywell configurations. The variables having the most impact on drywell temperature predictions (axial heat flow and temperature dependent soil thermal properties) would be expected to influence any drywell configuration model predictions.

TEST DATA ACCURACY

Inaccuracies in the recorded test data could be a result of thermocouple measurement inaccuracy and thermocouple position uncertainty. The accuracy of the ungrounded Type K thermocouples used is typically ±2°F based on calibration data.

Since thermocouples are attached directly to test components, the Electrically Heated Drywell Test data recorded are judged to be within ±2°F of the actual temperatures.

For the fueled drywells, an examination of the Fuel Assembly Internal Temperature Measurement Test data was made to evaluate the effect of having canister thermocouples inside the 0.75 inch by 0.75 inch

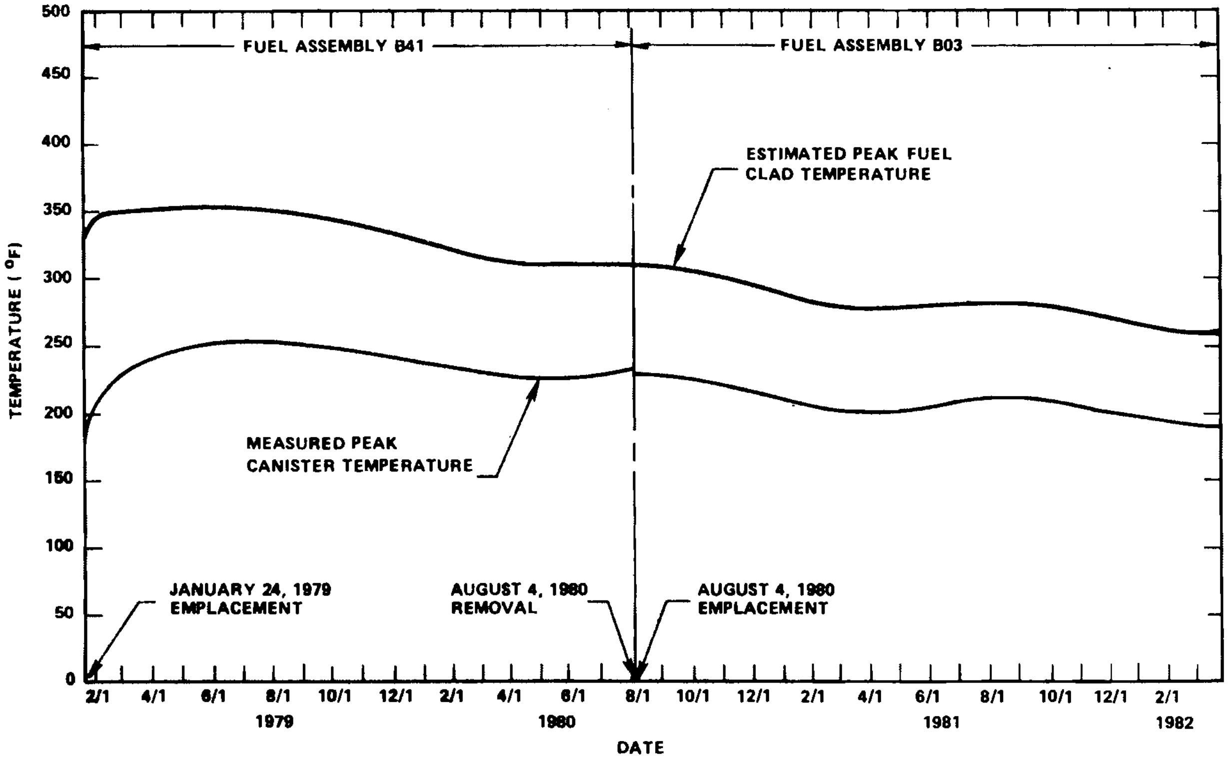


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Figure 3.6-2. Drywell 3 (F/A B41 and B03) Estimated Peak Fuel Clad Temperature Distribution, January 24, 1979 to March 31, 1982

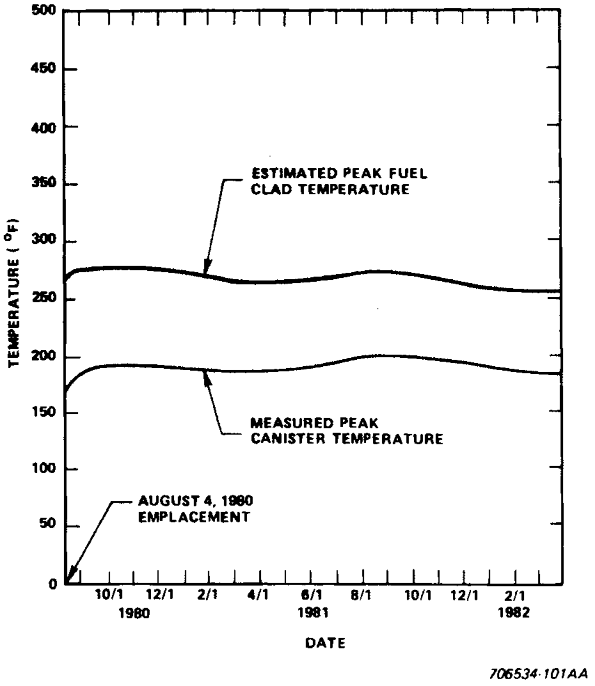

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Figure 3.6-3. Drywell 2 (F/A B41) Estimated Peak Fuel Clad Temperature Distribution, August 4, 1980 to March 31, 1982

angle instrumentation tubes. Thermocouple data showed temperatures inside the tubes were lower than those on the canister surface by a maximum of 8.5°F for fuel assembly B43 and 14.2°F for fuel assembly D15. These are expected to be the maximum inaccuracies in canister temperature measurements due to the instrumentation tubes. By using the peak measured canister temperatures for each drywell, the maximum inaccuracy due to the instrumentation tubes can be reduced. Details of the uncertainty evaluations are contained in Section M.1. For the liner thermocouples, the close proximity of the thermocouple tube to the liner wall and the geometry of a 0.062 inch thermocouple diameter inside a 0.083 inch inside diameter tube is expected to yield a smaller inaccuracy than for the canister thermocouples.

The Fueled Drywell Test data recorded are judged to be between -2 and +10.5°F of the actual canister temperatures for the B series fuel assemblies (between -2 and +16.2°F for fuel assembly D22), and between -2 and +4°F of the actual liner and soil temperatures.

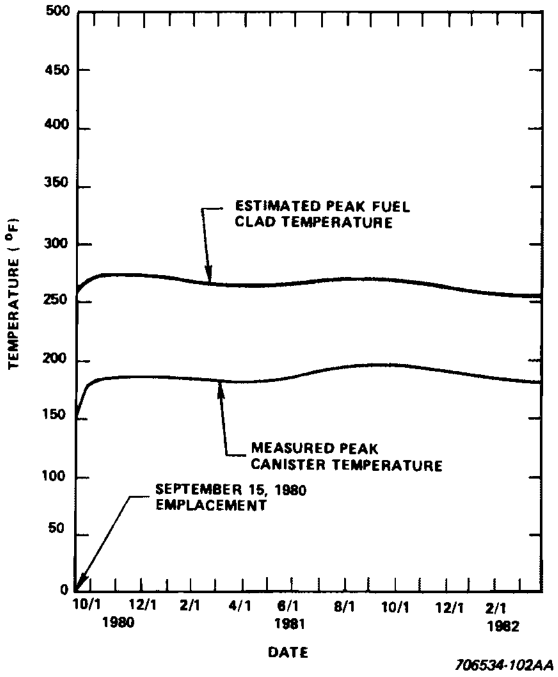

Figure 3.6-4. Drywell 1 (F/A B43) Estimated Peak Fuel Clad Temperature Distribution, September 15, 1980 to March 31, 1982

In addition to measurement uncertainty, drywell test data were examined to determine daily temperature variations relative to test data presented, differences between opposite side canister and liner thermocouple readings, and the thermocouple axial position tolerance effect on measured temperature.

Electrically Heated Drywell Test data taken at one hour intervals for two different periods were examined for variations in daily temperatures and for differences in these temperatures from the different times of test data readings in Appendix C. The results are presented in Table M-6 and show variations of up to 5°F for the canister, up to 2.7°F for the liner and as high as 28°F for soil near the ground surface. These variations were recorded during 2 kW power operation and are considered as maximum values applicable to the Fueled Drywell Test data.

Data from the Fueled Drywell Tests were examined to determine the differences in temperatures measured on both sides of the canisters and liners. Table M-4 presents the results for all drywell and fuel assembly combinations tested. The differences ranged from 0 to 12.9°F for the canister thermocouples and from 0 to 8.7°F for the liner thermocouples.

Thermocouples and heat source (either electric heater or active fuel) axial position tolerances from both drywell tests are provided in Tables M-1 and M-3, respectively. The differences between the thermocouple-measured temperature and that at the axial elevation noted for thermocouple tips for each drywell were calculated using the slope of the axial temperature profiles and the axial position tolerances. For the Electrically Heated Drywell Test, the canister, liner, grout, and soil thermocouple readings are within ±0.3°F at elevations near the canister center and ±2°F at elevations near the canister ends. For the Fueled Drywell Tests with the B series fuel assemblies, the canister thermocouple readings are within ±0.2°F for all elevations except the bottom (±1.2°F) and the liner thermocouple readings are all within ±0.4°F. For Drywell 5 with fuel assembly D22, the canister thermocouple readings are within

±0.3°F near the center (as high as ±1.9°F at the bottom) and the liner thermocouple readings are within ±0.5°F.

Other things also influenced the test data presented. Heater power variations for the Electrically Heated Drywell Test (previously discussed) are expected to have affected the temperatures relative to the power level of operation (i.e., some test data may not be representative of the indicated power level). The accuracy of the Fueled Drywell Test data presented in Appendix D has also been affected by such anomolies as thermocouple position rearrangement, thermocouple sheath cracking and subsequent failure, and improper positioning. The thermocouples affected have been previously noted. Use of the noted data should consider the period affected by these anomolies.

4.0 CONCRETE SILO TESTING

This section describes the concrete silo testing performed at E-MAD during the period December, 1978 through March, 1982. Included are the test objectives, hardware description, test operations, test results and thermal analyses for the fueled concrete silo.

4.1 TEST OBJECTIVES

The objectives of the spent fuel Concrete Silo Test (as defined for the SFHPP 1978 Demonstration) were:

- Objective 1 - To verify that spent fuel assemblies can be safely stored with passive cooling
- Objective 2 - To determine storage cell thermal properties and interface and boundary conditions to calibrate and verify thermal models

The test objectives would be met by a combination of actual test results and calibrated computer model predictions. An encapsulated spent fuel assembly was installed into a concrete silo and the thermal response of the canister, liner and surrounding concrete recorded. In addition, a computer model of the concrete silo would be prepared and predictions compared with the test results and would be used to evaluate concrete silo performance beyond the test limits.

Transient test results would be compared to computer code predictions using the thermal power versus time predicted for the actual spent fuel assembly as input. Computer model thermal property and heat transfer correlation revisions would be made as necessary to update the model for good model/test agreement. This agreement would qualify the computer model for use in evaluating the storage of various power decay heat level fuel assemblies.

4.2 HARDWARE DESCRIPTION

4.2.1 TEST ARRANGEMENT

The Concrete Silo Test hardware arrangement is shown in Figure 4.2-1. The test hardware consists of: 1) a carbon steel liner encased in a locally transportable reinforced concrete silo, 8 feet 8 inches in diameter by 21 feet high, 2) a 16 foot by 16 foot by 9 foot deep reinforced concrete foundation pad, 3) a canister assembly consisting of a canister body, closure lid and a concrete-filled shield plug to support the canister from the liner, 4) a pressurized water reactor spent fuel assembly, 5) thermocouples to measure

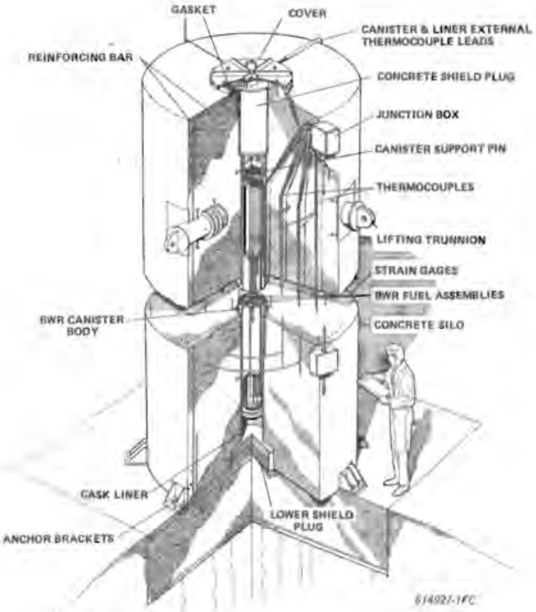

Figure 4.2-1. SFHPP Concrete Silo Configuration

temperature response, and 6) a data acquisition system to record the thermocouple data. Figure 4.2-2 shows the relative dimensions and elevations of the installed hardware. Figure 4.2-3 shows a cross section view of the silo canister and liner. A description of Concrete Silo construction and hardware installation has been provided in Appendix B.

4.2.2 CONCRETE SILO LINER

The liner is illustrated in Figures 4.2-2 and 4.2-3. The liner consists of three sections. The center portion consists of a 17 foot long section of 18 inch diameter by 0.375 inch thick pipe. The upper section is a 34 inch long by 22 inch diameter by 0.75 inch thick pipe. The upper and center sections are positioned concentrically to one another and welded to opposite sides of a 22 inch outside diameter, 17.25 inch inside diameter, 0.50 inch thick ring. This ring forms the ledge on which the 20 inch diameter shield plug (connected to the canister assembly) is supported. The lower section is 44 inches in diameter and 14 inches long. This section contains 7.5 inches of steel plate and 6 inches of concrete and provides additional shielding as the silo is transported. Welded to the upper section is a tapered canister entry flange which has a 6 inch wide by 2 inch deep notch on two opposite sides for canister instrumentation routing. The liner material is carbon steel. The liner is an integral part of the silo concrete shield. Thirty-two peripheral Nelson studs equally spaced in groups of four at eight elevations ensure interface integrity with the concrete. A photograph of the silo liners for both concrete silos constructed for the SFHPP 1978 Demonstration is shown in Figure 4.2-4.

LINER INSTRUMENTATION

There are 18 thermocouples for the silo liner. Six are installed in thermocouple wells and 12 are secured to the liner. Six tubes, 0.156 inch outside diameter and 0.086 inch inside diameter attached to the outside of the liner, serve as thermocouple wells. These extend from the liner top to 2 inches from the liner lower section. The tubes are clamped onto the liner by 11 large adjustable band clamps. The thermocouple tubes are oriented around the liner in two groups as shown in Figure 4.2-3. The two groups each contain three tubes spaced 180° apart. The tubes allow thermocouple installation at any elevation. The tube ends are swaged and tackwelded to prevent concrete from filling the tubes during construction.

The elevation of the thermocouples in the tubes is controlled by the thermocouple length. The thermocouples are inserted until the transition boot between thermocouple and extension lead (see Section 4.2.6) contacts the top of the tube thus controlling the thermocouple tip position. The thermocouples are installed in each group so one is positioned at the middle of the PWR fuel assembly active fuel length, another one foot above the bottom and the third one foot below the top. These thermocouple positions line up with thermocouple positions on the canister (see Figure 4.2-5).

During concrete silo construction, 12 additional thermocouples were

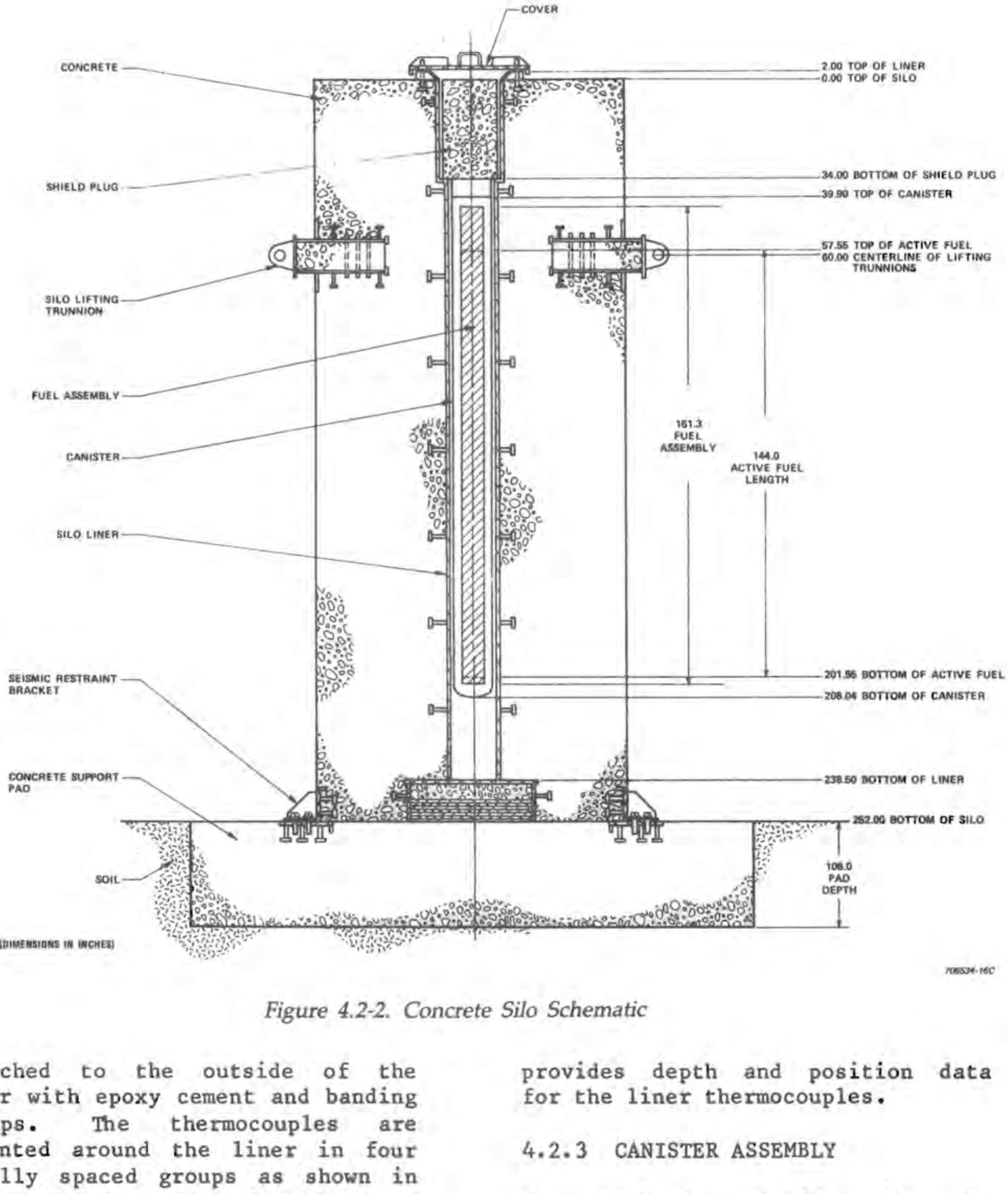

Figure 4.2-2. Concrete Silo Schematic

attached to the outside of the liner with epoxy cement and banding straps. The thermocouples are oriented around the liner in four equally spaced groups as shown in Figure 4.2-3. The elevations of the thermocouples are the same as described above. Table E-1 provides depth and position data for the liner thermocouples.

4.2.3 CANISTER ASSEMBLY

The canister assembly for the Concrete Silo Test is the same as for fueled drywell tests. It

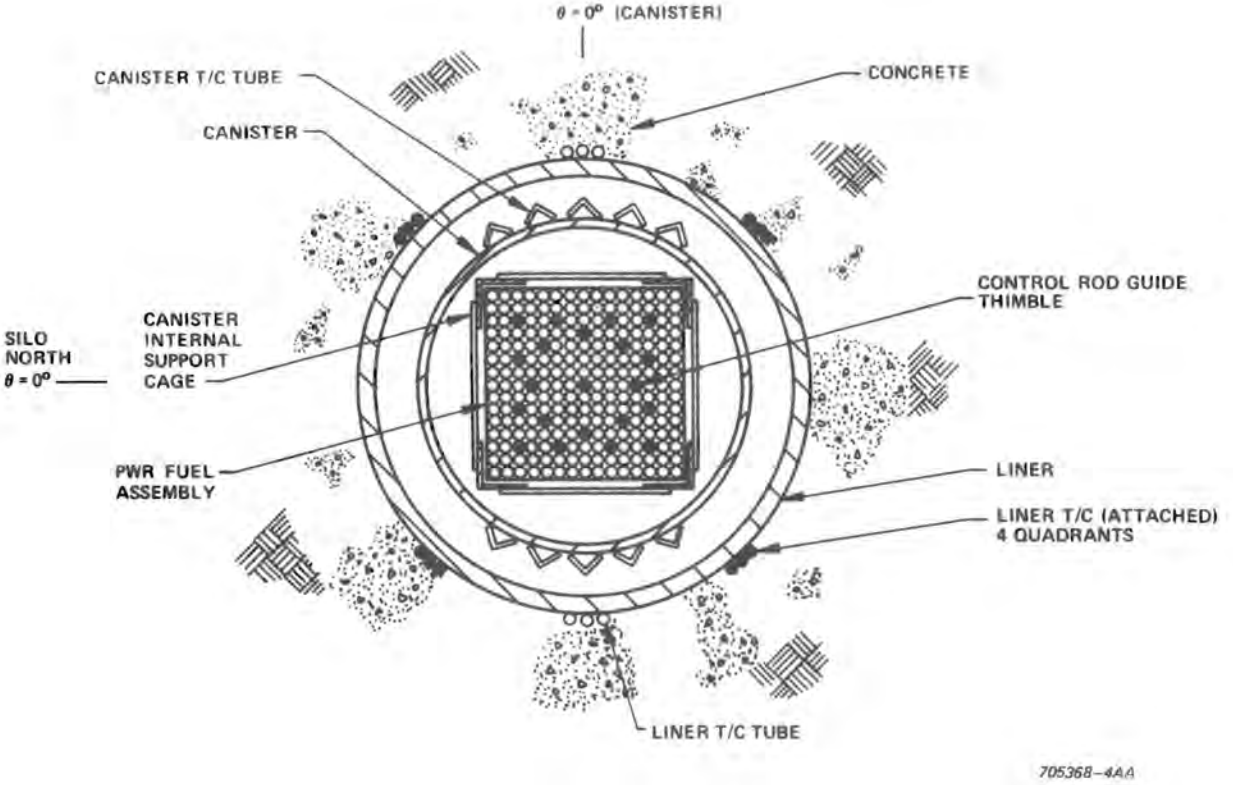

Figure 4.2-3. Concrete Silo Section View

consists of a canister body, closure lid and a shield plug and was designed to accommodate one PWR spent fuel assembly. Details of the canister configuration are provided in Section 3.2.2.3.

CANISTER INSTRUMENTATION

The canister contains ten thermocouple tubes for thermocouple insertion after emplacement. Five thermocouple tubes (described in Section 3.2.2.3) are located on opposite canister sides with the center tubes of each group 180° apart. The five tubes are spaced 15° apart and extend down the canister to lengths approximately matching the PWR fuel assembly active fuel middle, 2.5 feet above and below the middle and 1 foot from each end. The thermocouples are installed through tubes in the shield plug until the transition boot is 6 inches above the shield plug top.

The thermocouples measure temperatures at five different elevations on both canister sides to determine the axial canister temperature profile. The uppermost, middle and lowermost thermocouples are located at the same elevations as those of the liner (see Figure 4.2-5).

4.2.4 CONCRETE SILO

The concrete silo is a reinforced concrete shielded container

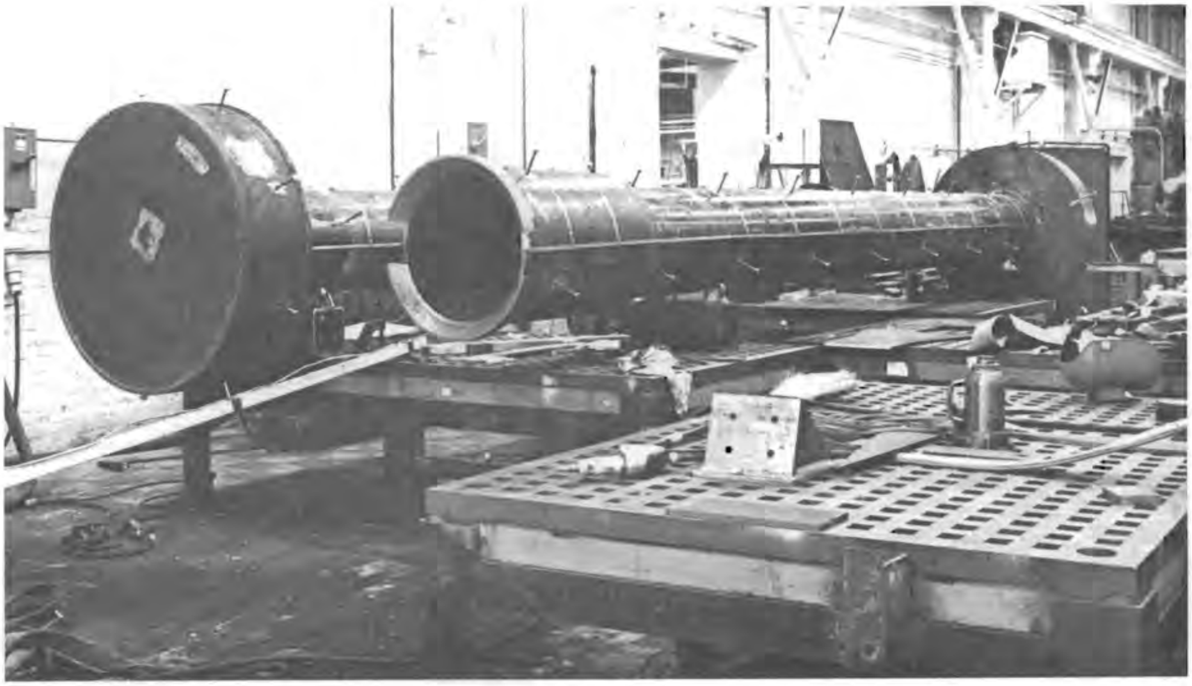

Figure 4.2-4. Concrete Silo Liners Prior to Shipping

constructed on a foundation pad. The finished size is 252 inches high by 104 inches in diameter. Three rings of reinforcing bar surround the liner. The outer ring at a 50 inch radius has 0.75 inch diameter bars placed vertically and circumferentially on 6 inch centers. At the silo top and bottom there are formed radial extensions between the liner and outer ring. The two inner rings at radii 23 and 37 inches have 12 symmetrically placed vertical bars 0.625 inch in diameter, and 3 hoops 0.5 inch in diameter. These rings position and support the thermocouples extending down from the silo top. A photograph of the silo reinforcing bar during silo construction is shown in Figure 4.2-6.

Embedded within the periphery of the outer reinforcing ring are four handling trunnions. Only two are required to handle the assembled silo weight of approximately 95 tons. The trunnions are fabricated from 10 inch diameter by 1 inch thick pipe, capped at the outer end and filled with grout. The pipe is 30 inches long and extends 6 inches past the silo surface. Welded to the pipe at this interface is a 24 inch square by 0.75 inch thick plate rolled to a 52 inch outside radius. Also welded to the pipe's embedded portion are three 15 inch diameter rings on 4 inch centers. Twenty Nelson studs welded to the plate and pipe periphery ensure concrete interface integrity.

At the concrete silo base are eight welded brackets embedded in the concrete by 8 Nelson studs. These brackets are bolted to embedments in the foundation pad to prevent

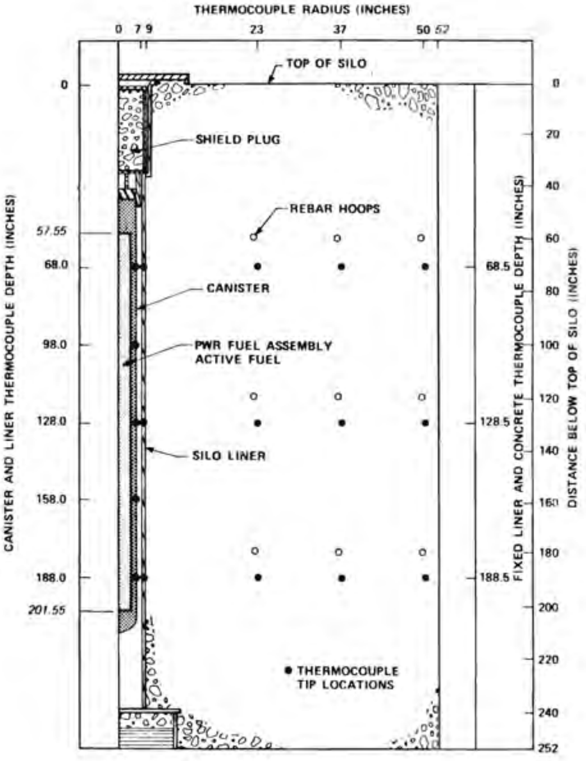

Figure 4.2-5. Concrete Silo Thermocouple Locations

the silo from tipping in response to seismic accelerations. The bracket vertical plate is 12 inches by 20 inches long by 0.75 inch thick rolled to a 52 inch outside radius. A horizontal plate (12.5 inches wide by 18 inches long by 0.75 inch thick) and three 0.75 thick gusset plates are welded to the vertical plate. This attachment prevents the silo from overturning due to a horizontal seismic loading of 0.25 g.

Following assembly of the reinforcing bar, thermocouples, trunnions and brackets, a circular concrete form is placed around the structure. The concrete placement is then completed in a single continuous pour. One hundred and fifty pound per cubic foot density concrete with an aggregate size of 1.5 inches was used for Concrete Silo No. 2 (Concrete Silo No. 1 had a 0.75 inch size aggregate). The completed concrete silo is shown in Figure 4.2-7.

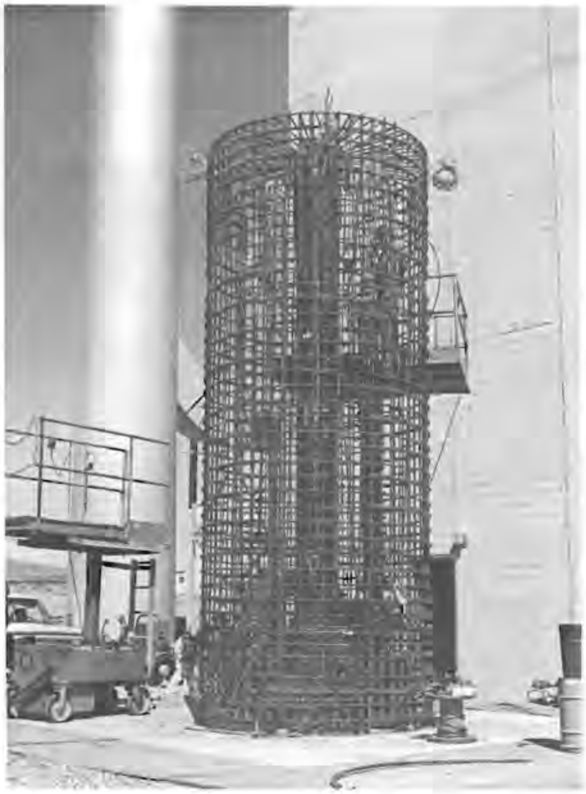

Figure 4.2-6. Concrete Silo Reinforcing Bar Assembly Completed

Other components are a silo cover and special handling sling. The cover plate has a 3 inch wide by 0.25 inch thick neoprene gasket bolted to the silo top isolating the interior from the environment. The cover is 38 inches in diameter and is shown in Figure 4.2-8. The silo cover has a 0.5 inch thick steel top plate and a 38 inch diameter by 2 inch high by 0.5 inch thick ring welded to the outside. Six radial ribs, 2 inches high, strengthen the plate. The plate is

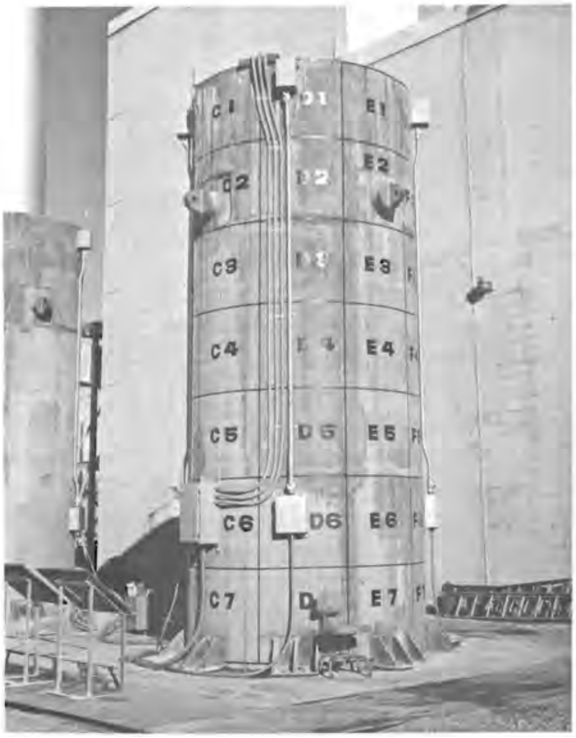

Figure 4.2-7. Completed Concrete Silo

Figure 4.2-8. Concrete Silo Cover Plate

attached by six 0.5 inch diameter anchor studs embedded in the concrete. The handling sling for the concrete silo has a rated capacity of 110 tons. The sling has two legs approximately 23 feet long. Each sling leg is a two part 2.25 inch diameter wire rope of equalizing strand-laid grommet construction made of improved plow steel. The endless strand has equalizing thimbles at both ends. The two legs are attached to a pear ring with a 137.5 ton minimum rating. A 10 inch diameter by 0.5 inch thick pipe spreads the two legs 9 feet apart 8 feet above the bottom of the legs. The sling is shown in Figure B-23 during concrete silo handling operations.

CONCRETE INSTRUMENTATION

The temperature response of the concrete silo is measured using thirty-six thermocouples throughout the silo concrete. This instrumentation has azimuthal orientations of 45, 135, 225, and 315° and is located 68.5, 128.5 and 188.5 inches below the silo top. Instrumentation is embedded in the concrete at radii of 23, 37 and 50 inches. These locations are shown in Figure 4.2-5. The thermocouple extension wires are attached to the reinforcing bar hoops at these radii using soft wire and the tips extend 8.5 inches below the hoops. Four equally spaced pull boxes are located near the silo top periphery to collect the thermocouple lead wires from each silo quadrant. The thermocouple lead wires are then routed through rigid conduit to a second set of terminal boxes located on the silo outer surface below the pull boxes. Each thermocouple terminal box contains a special chromel and alumel terminal connector for thermocouple termination.

4.2.5 STORAGE AREA

The concrete silo storage area is located on the west side of the E-MAD building within the security fenced area. This area was chosen since it is fairly level and would require a minimum of site modifications.

The two concrete silos are placed on two 16 foot by 16 foot by 3 foot deep reinforced concrete foundation pads. A 20 foot by 46 foot by 6 foot deep concrete subfoundation supports the pads. The concrete support pad centers are 26 feet apart. The first concrete silo is 27 feet south and 22 feet east of the E-MAD northeast corner permitting transporter and mobile crane access. Eight embedment plates in the pad are used to bolt the silo to the pad.

Underground conduit routes instrumentation from an enclosure in between the two silos to the instrumentation shed.

4.2.6 DATA ACQUISITION SYSTEM

The data acquisition system for the Concrete Silo Test consists of the thermocouple array, remote signal conditioning/multiplexing units, and the E-MAD data logger. The thermocouples are attached to the test hardware and the lead wires terminated at the storage site junction box as described earlier. From the storage site junction box the thermocouple leads pass through rigid underground conduit to the multiplexer unit in the instrumentation shed. Multiplexer signal cables are routed through underground conduit to the data logger (see Section A.5.5).

THERMOCOUPLES

All thermocouples used in the Concrete Silo Test consist of a Type K, chromel-alumel thermocouple with ungrounded junction enclosed in a 304 stainless steel sheath with magnesium oxide insulation. The 36 thermocouples embedded in the concrete and 12 liner thermocouples have a 0.187 inch diameter sheath with two 22 gauge Type K extension wires brazed to the thermocouple wires. The wires are enclosed in a 0.250 inch diameter by 0.028 inch thick by 2.75 inch long stainless steel transition boot crimped onto the thermocouple sheath end and filled with epoxy. The 16 thermocouples installed in the canister and liner thermocouple tubes are of similar construction and have 0.062 inch diameter sheaths and 24 gauge extension wires. The transition boot is 0.187 inch diameter by 0.010 inch thick by 2.75 inches long.

4.3 OPERATIONS

CONSTRUCTION

Concrete silo construction (shown in Figures B-18 through B-23) was completed in September, 1978. Two concrete silos were built in-place on the concrete support pads.

ENCAPSULATION

Spent fuel assembly B02 was encapsulated for concrete silo installation during the first week in December, 1978. Appendix B, Section B.2.1 describes the typical encapsulation operations. Following receipt of the shipping cask containing fuel assembly B02, the fuel assembly was removed and installed in the canister body. The closure lid was then installed and seal welded. Following the helium backfill and leak check operations, the shield plug was installed and the canister assembly placed in the transfer pit. To make room in the Hot Bay for the concrete silo and its transporter, the fuel shipping cask was returned to its trailer and released from the facility.

CANISTER AND SILO EMPLACEMENT

Concrete Silo No. 2 was moved into the Hot Bay and the main shield door closed. The silo was transported on a low-bed trailer. The canister was lifted from the transfer pit and lowered into the silo (see Figure B-60). The canister was installed with the fuel assembly serial number side toward silo orientation 45° (see Figure 4.2-3). The concrete silo was then returned to the storage area (see Figure B-61). At the storage area, the handling sling was attached to two handling trunnions and the silo lifted by a 135 ton capacity mobile crane from the trailer and placed on the storage pad. Two installation guide pins threaded into the pad bracket embedments guided the silo during the final 16 inches onto the pad. Preparing the silo for testing includes: removing the guide pins and slings, bolting the silo to the foundation pad embedments, connecting the lightning arrestor to the E-MAD grounding grid, installing the ten canister and six liner thermocouples, filling the two slots at the silo liner top with RTV silicon rubber, and securing the silo cover.

After the concrete silo was emplaced and sealed, the lead wires from the 36 concrete thermocouples and the 12 liner thermocouples were routed through flexible conduit from the terminal boxes to the storage site junction box. The lead wires from the ten canister thermocouples and six liner thermocouples, routed through another flexible conduit, were also routed to the storage site junction box. All thermocouple leads were routed to the instrumentation shed. The conduit and junction box fittings were then sealed for water tightness. Concrete Silo Test canister emplacement was completed December 7, 1978.

TEMPERATURE MONITORING

Temperature data monitoring for Concrete Silo No. 2 began from the date of silo emplacement. Data logger printouts were made at 15 minute intervals for the first hour, at one hour intervals for the next four days, at two hour intervals for the fifth day, at four hour intervals for the next three days, and then at six hour intervals until December 19, 1978. Printouts were made once each day thereafter throughout the test period at 4:00 p.m. For two periods during the Concrete Silo Test, printouts were made at one hour intervals. These occurred from March 25 to March 27, 1980 and from June 23 to June 25, 1980. In addition, printouts at four hour intervals were made from July 23 to July 27, 1979 and from January 28 to February 4, 1980.

4.4 RESULTS

This section presents the test results for Concrete Silo No. 2 containing fuel assembly B02. Temperature readings for the canister, liner, and concrete thermocouples are provided at the start of testing, for the first five days, and at two week intervals on the first and fifteenth of each month from December, 1978 through March, 1982, in Tables E-2 through E-23. Test results are also presented as illustrations in this section.

The peak measured temperatures for Concrete Silo No. 2 are presented in Figure 4.4-1 as canister, liner, and concrete temperature distributions throughout the test period. Also shown are the ambient air temperatures averaged over two week intervals (see Table 3.4-1). Peak recorded canister and liner temperatures occurred during July, 1979, at about 30 inches below the active fuel midplane. The peak canister temperature was 202°F and the peak liner temperature was 141°F. The canister and liner axial temperature profiles for the recorded peak temperatures are shown in Figure 4.4-2. The canister, liner, and concrete temperatures followed the cycling average ambient air temperatures in response to the seasonal changes. Peak temperatures recorded each year decreased with the decay heat level of fuel assembly B02.

Figures 4.4-3 and 4.4-4 show additional data during the period of peak temperature readings. Figure 4.4-3 illustrates the temperature variations recorded at four hour intervals from July 24 to 27, 1979. Shown are the peak canister and liner temperatures, the peak concrete temperatures at 23, 37, and 50 inch radii and the ambient air temperatures recorded by the E-MAD weather station. The thermal response of the concrete silo components to day/night temperature variations indicates that these variations affect the outer 15 inches of the silo concrete. Figure 4.4-4 presents concrete isotherms interpolated from

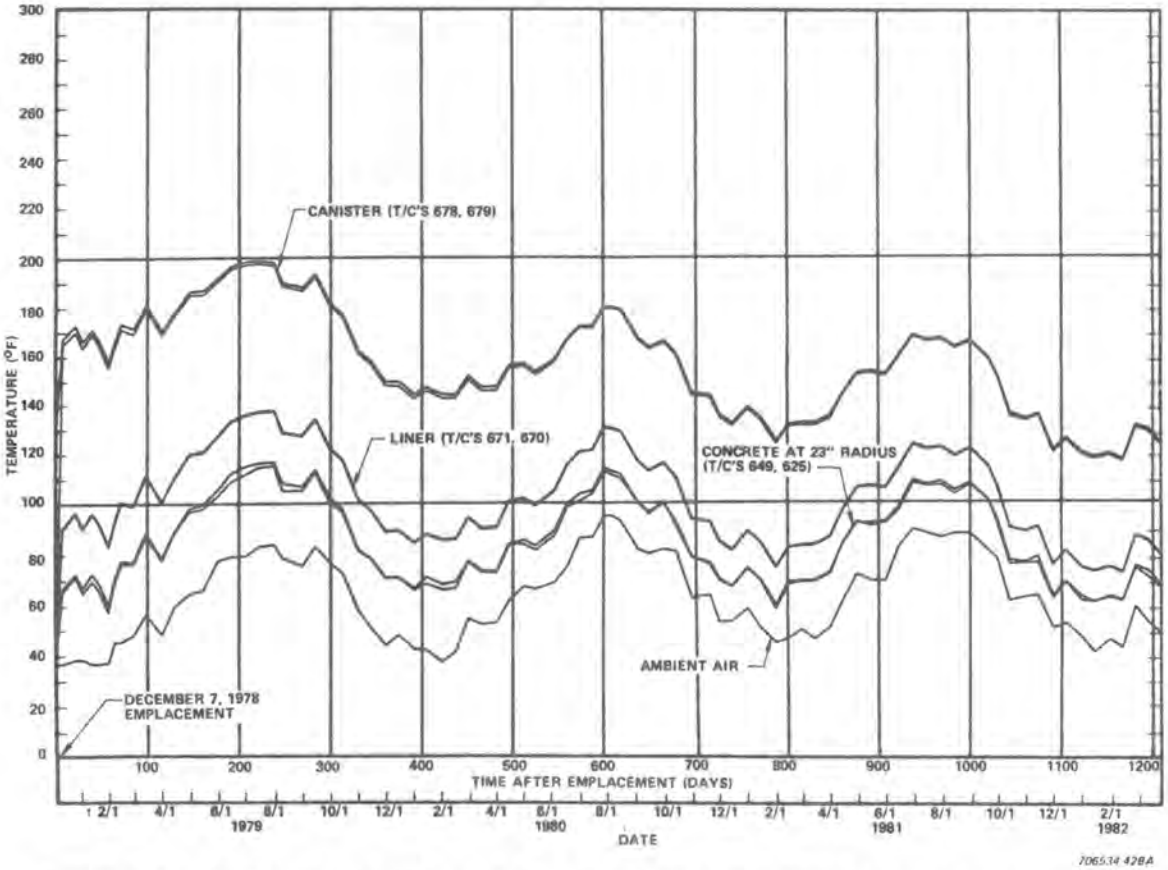

Figure 4.4-1. Concrete Silo (F/A B02) Peak Canister, Liner and Concrete at 23 Inch Radius Temperature Distributions at 128 Inches Below the Silo Top, December 7, 1978 to March 31, 1982

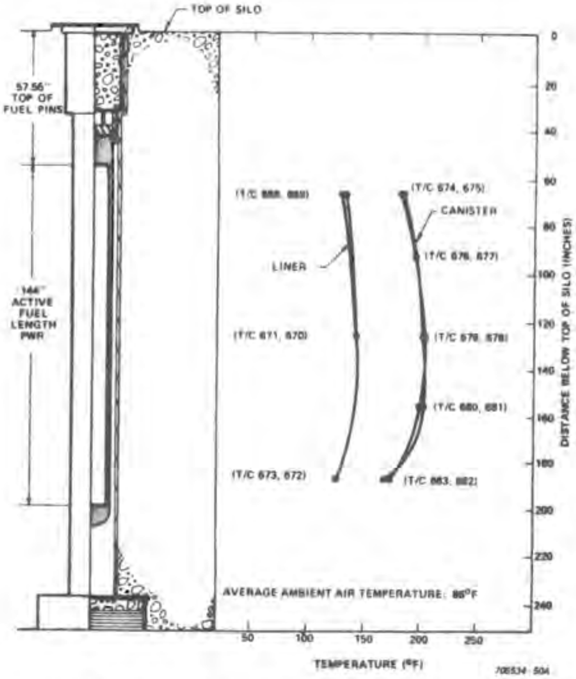

Figure 4.4-2. Concrete Silo (F/A B02) Peak Canister and Liner Axial Temperature Profiles, July 20, 1979

thermocouple readings on July 24, 1979. The average ambient air temperature for the two weeks before July 24 was 86°F.

Figures 4.4-5, 4.4-6, and 4.4-7 show temperature data during the period of the minimum temperatures during 1980 comparable to those in Figures 4.4-2, 4.4-3, and 4.4-4. The canister and liner axial temperature profiles on February 1, 1980, are shown in Figure 4.4-5 where the average ambient temperature over the previous two weeks was 37°F. The peak canister and liner temperatures (144 and 85°F respectively) are about 57°F lower than those on July 20, 1979, and again occurred at 30 inches below the active fuel midplane. The basic shape of the canister and liner profiles were similar to those on July 20, 1979. Figure 4.4-6 presents temperature distributions at four hour intervals during the period January 29, 1980, through Feburary 3, 1980. This figure shows the canister, liner, and concrete thermal response to day/night temperature changes during the winter months. The ambient air temperature changes again only affected the concrete temperature readings at the 50 and 37 inch radii. Figure 4.4-7 shows the concrete isotherms interpolated from data on February 1, 1980, for an average two week ambient temperature of 37°F.

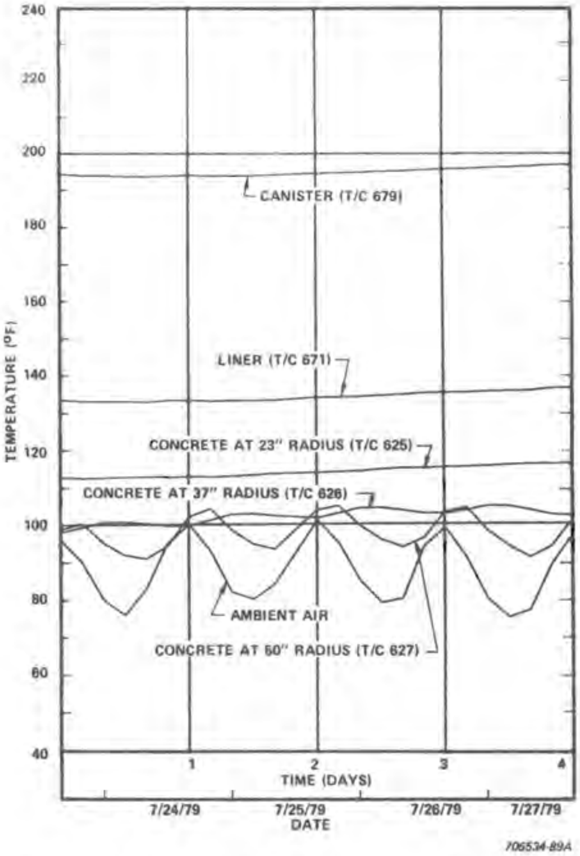

Figure 4.4-3. Concrete Silo (F/A B02) Canister, Liner and Concrete Temperature Distributions at 128 Inches Below the Silo Top at 4 Hour Intervals, July 23, 1979 to July 27, 1979

Figures 4.4-1 through 4.4-7 indicate that concrete silo thermal response is affected by ambient air

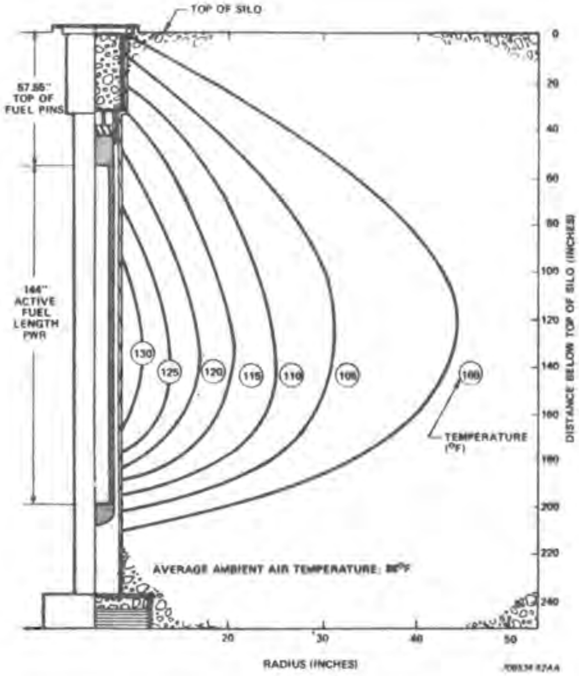

Figure 4.4-4. Concrete Silo (F/A B02) Concrete Isotherms on July 24, 1979

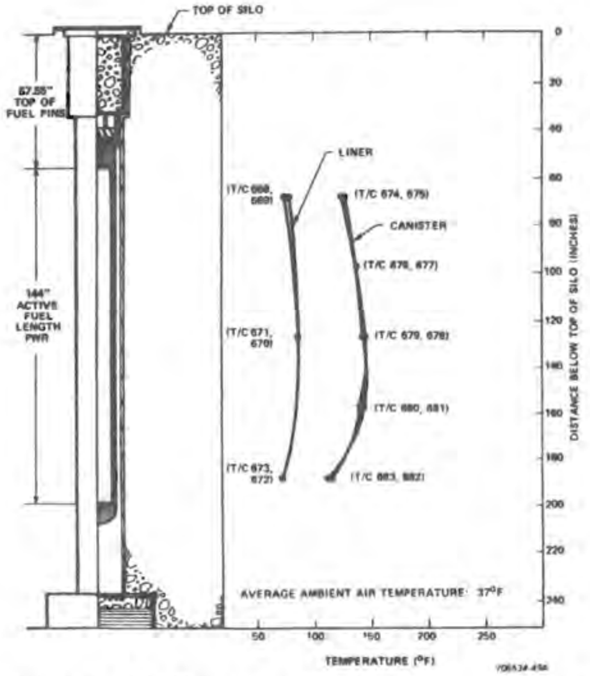

Figure 4.4-5. Concrete Silo (F/A B02) Canister and Liner Axial Temperature Profiles, February 1, 1980

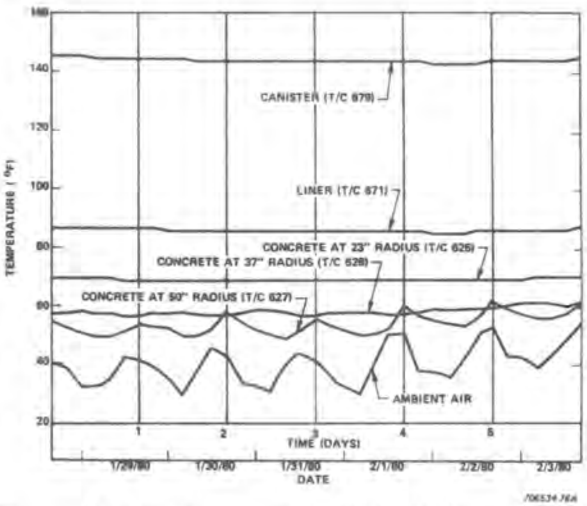

Figure 4.4-6. Concrete Silo (F/A B02) Canister, Liner and Concrete Temperature Distributions at 128 Inches Below the Silo Top at 4 Hour Intervals, January 29, 1980 to February 3, 1980

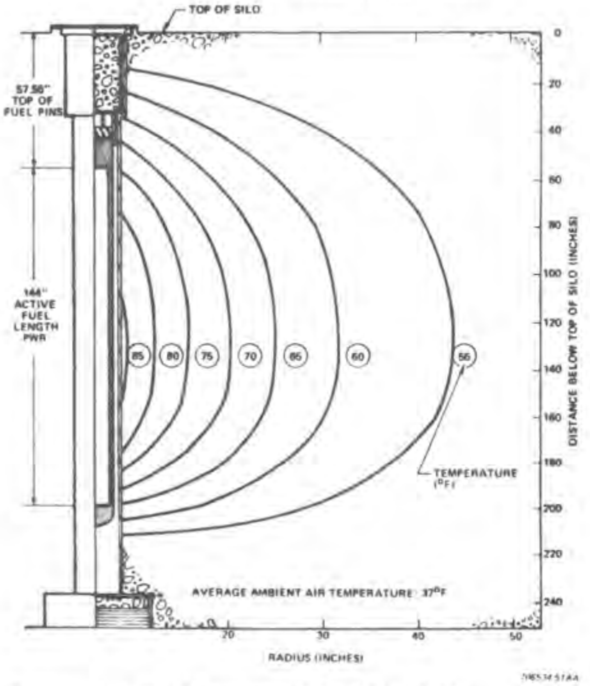

Figure 4.4-7. Concrete Silo (F/A B02) Concrete Isotherms on February 1, 1980

temperature changes as expected. The data shown on these seven figures includes the concrete thermocouple data at the 45°

location so the only influence is ambient air (discussion of silo response to solar insolation is presented later). The canister, liner, and concrete at a 23 inch radius follow the average ambient air temperature changes (Figure 4.4-1) throughout the three year test period. The concrete near the silo surface is affected by day/night variations as illustrated in Figures 4.4-3 and 4.4-6. The 50 inch radius data shows a four hour lag time for ambient temperature changes and the 37 inch radius data shows an eight hour lag time.

The silo temperatures were also influenced by the decay heat level changes in the enclosed spent fuel assembly. The canister and liner temperatures show a slight decrease for each of the successive yearly peaks and valleys in Figure 4.4-1. In addition, the decreasing decay heat is responsible for the decreasing difference between the canister and liner temperature. Figure 4.4-8 shows a comparison of peak canister axial temperature profiles on August 1 of 1979, 1980, and 1981. The decrease in temperatures follows the decrease in decay heat level; on August 1, 1979 the predicted decay heat level was 0.85 kW. As the decay heat levels dropped to 0.65 and 0.55 kW in succeeding years, the peak canister temperatures dropped by 16 and 14°F, respectively.

Based on the silo response to ambient temperatures and decay heat level, the peak canister temperatures recorded for the concrete silo at E-MAD were affected by the date of emplacement. The peak recorded temperatures occurred eight months after emplacement (July 20, 1979) when the fuel assembly decay heat level was about 0.85 kW. If the canister emplacement had occurred in late spring or early summer, higher temperatures would have been reached based on the initial decay heat level of about 1.0 kW. The winter month air temperatures (averaging about 25°F below those for the summer months) are estimated to have suppressed the peak canister temperatures by 20 to 35°F, based on the predictions for silo temperatures with a constant ambient (see Figure 4.5-10).

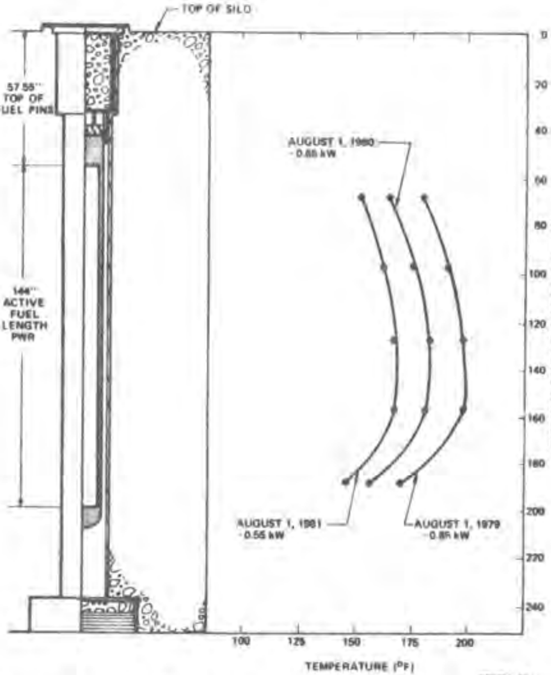

Figure 4.4-8. Concrete Silo (F/A B02) Comparison of Peak Canister Axial Temperature Profiles During Testing

The concrete silo thermal response at different axial elevations was also evaluated. Figure 4.4-9 shows radial temperature profiles at the three elevations of concrete thermocouples on August 1, 1979. Figure 4.4-10 shows the variation in concrete temperatures at the 37 inch radius at all three elevations

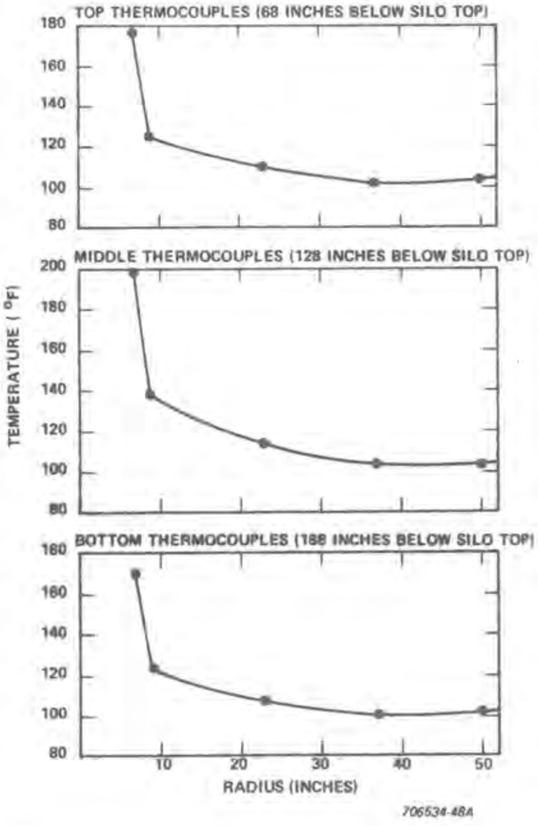

Figure 4.4-9. Concrete Silo (F/A B02) Radial Temperature Profiles, August 1, 1979

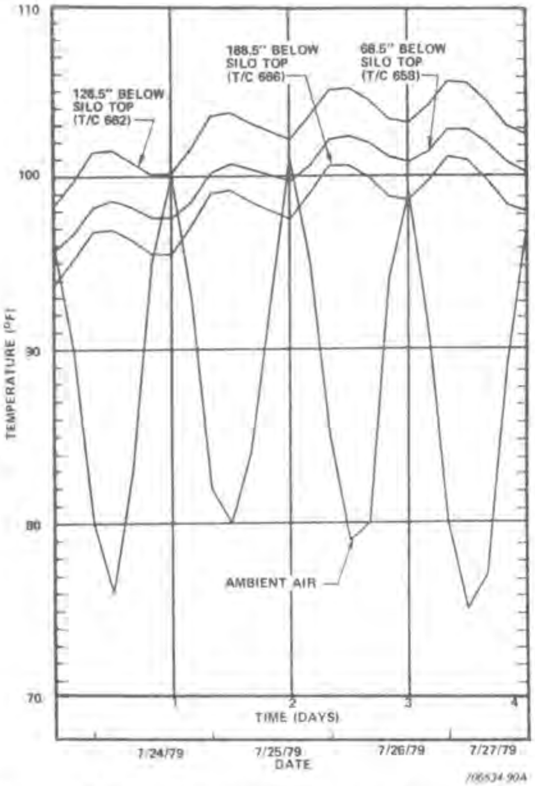

Figure 4.4-10. Concrete Silo (F/A B02) Concrete Temperature Distributions at 37 Inch Radius at Elevations 68.5, 128.5 and 188.5 Inches Below the Silo Top, July 23, 1979 to July 27, 1979

during the period July 23 to July 27, 1979. These two figures show that peak recorded temperatures occur about 128 inches below the silo top and that the temperatures near the silo top are slightly higher than those near the bottom. The thermal end effects of silo and canister configurations and the axial heat transfer from the fuel to the air at the silo top are responsible for the axial temperature differences. Comparing canister axial temperature profiles for the concrete silo and an isolated fueled drywell (Figures 4.4-2 and 3.4-15) shows they are similar in shape with lower temperatures at the lower canister end. The radial profiles in Figure 4.4-9 show similar shapes at all three elevations indicating little difference in silo material properties. The response of the 37 inch radius thermocouples to ambient air temperature changes from July 23 to July 27, 1979, shows the transient response at all three elevations is nearly similar. The data shown is again at the 45° orientation to eliminate the effect of insolation. The temperature response near the silo top during the daytime hours differs slightly from that of the other two. This is as might be expected since heat transfer from the silo top could be affected by insolation.

Azimuthal concrete silo temperature variations at the 50 inch radius near the fuel midplane are shown in Figure 4.4-11 for the four day period July 23 to July 27, 1979. This figure illustrates the influence of insolation on temperatures near the silo surface. Included on the figure are the orientations of the thermocouples and the ambient air temperatures. During this period, skies were clear the entire day.

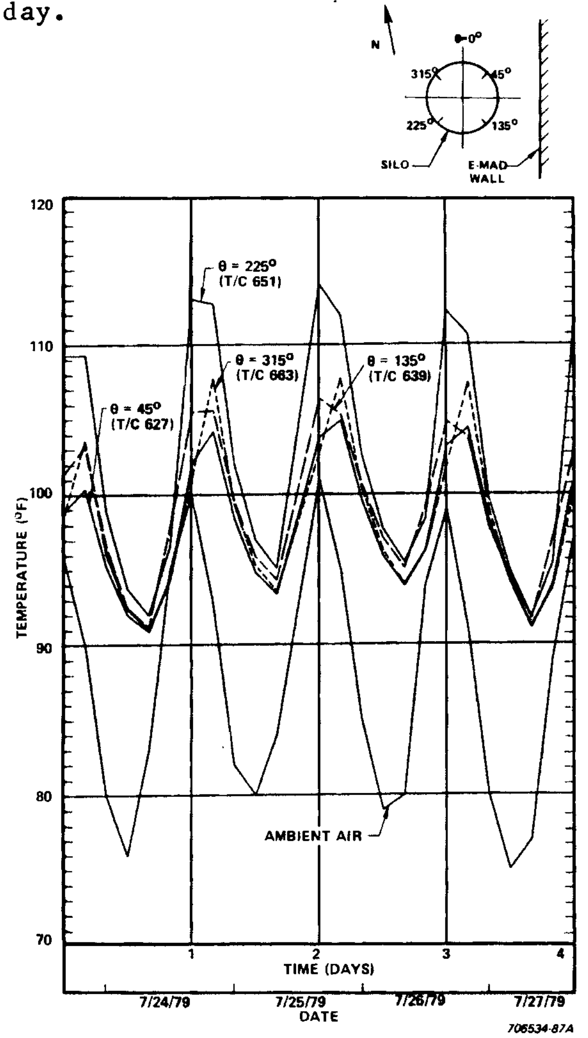

Figure 4.4-11. Concrete Silo (F/A B02) Azimuthal Concrete Temperature Distributions at 50 Inch Radius 128 Inches Below the Silo Top, July 23, 1979 to July 27, 1979

The response of each thermocouple can be explained by its position and the effect of ambient air temperature and insolation. The thermocouple at 45° (T/C 627) responded only to the ambient air temperatures with the previously noted four hour lag time. Since the concrete silo is adjacent to the E-MAD west wall, the 0 to 90° silo quadrant was never in direct sunlight. The other three thermocouples responded to the combination of ambient air temperature and insolation. The 135° thermocouple (T/C 639) responded to insolation during the late morning and early afternoon hours as noted by its increase from about noon to 4:00 p.m. and then its slight decrease until 8:00 p.m. The 225° thermocouple (T/C 651) responded similarly, however, its peak temperature was much higher since more silo surface was in direct sunlight. The thermocouple at 315° (T/C 663) responded to insolation during the afternoon and evening hours as noted by its reaching a peak at 8:00 p.m. For all three of these thermocouples, the temperatures recorded responded to the insolation with a four hour lag time.

4.5 CONCRETE SILO THERMAL ANALYSIS

The purpose of the Concrete Silo Test thermal analysis is to establish a thermal model for the silo configuration and to demonstrate that the model can produce satisfactory predictions of silo and canister temperatures. Once that goal is achieved, the model can be used with increased confidence in silo analyses involving higher decay heat levels and silo design alterations.

Concrete Silo Test predictions and data analyses have been performed using the TAP-A digital computer program, Reference 13, which calculates steady-state and transient temperature distributions in a configuration of solid materials utilizing the radiation, convection and conduction modes of heat transfer.

4.5.1 THERMAL MODEL DESCRIPTION

MODEL SIZE AND BOUNDARY CONDITIONS

The TAP-A nodal model of the concrete silo is depicted in Figure 4.5-1 and the 204 nodes representing each component are identified in Table 4.5-1. The model is two dimensional in the r and z directions (radius and depth respectively) with no variations circumferentially.

HEAT TRANSFER MECHANISMS

Heat transfer between the fuel assembly (nodes 1 to 30) and the canister is modeled by conduction. Heat transfer from the fuel to canister occurs by convection and radiation (primarily by radiation at high temperatures). Since TAP-A has no mass flow capability and therefore cannot model convection effects, a simplifying assumption was made to calculate canister temperatures. An arbitrarily chosen conductivity value represents the combination of radiation, convection, and conduction heat transfer. A temperature dependent conductivity (Figure 4.5-2), calculated over the anticipated range of canister temperatures is used in the model. The fuel assembly heat capacity is modeled accurately to produce fairly precise transient predictions.

Heat transfer from the canister to the liner and shield plug occurs by radiation, conduction and free convection with the thermal model considering all three modes. Convection and conduction calculations use the "effective thermal conductivity" approach while the radiation calculation for canister to liner heat transfer uses the same shape factor expression for concentric cylinders and emissivity values as the drywell model (see Section 3.5.1.1).

The free convection heat transfer between the canister and liner is modeled per Reference 23 by heat transfer in enclosed spaces. The function:

$$Nu = \frac{\bar{h}b}{k} = 0.065\ Gr^{1/3}\ \left(\frac{L}{b}\right)^{-1/9}$$

where:

Nu = Average Nusselt number

$\bar{h}$ = Average heat transfer coefficient

k = Thermal conductivity

b = Width of enclosed space

Gr = Grashof number

L = Heated length

is used to determine the heat transfer coefficient due to natural convection between the canister and liner. From the silo parameters, the heat transfer coefficient is 0.35 Btu/hr-ft^2-°F.

Heat transfer from the shield plug sides to the upper liner occurs primarily by radiation and free convection and by convection from the upper surface of the shield plug to the silo cover plate. For modeling purposes, conduction through an air-filled space is assumed in each direction since TAP-A has no mass flow capabilities. This simplifying assumption

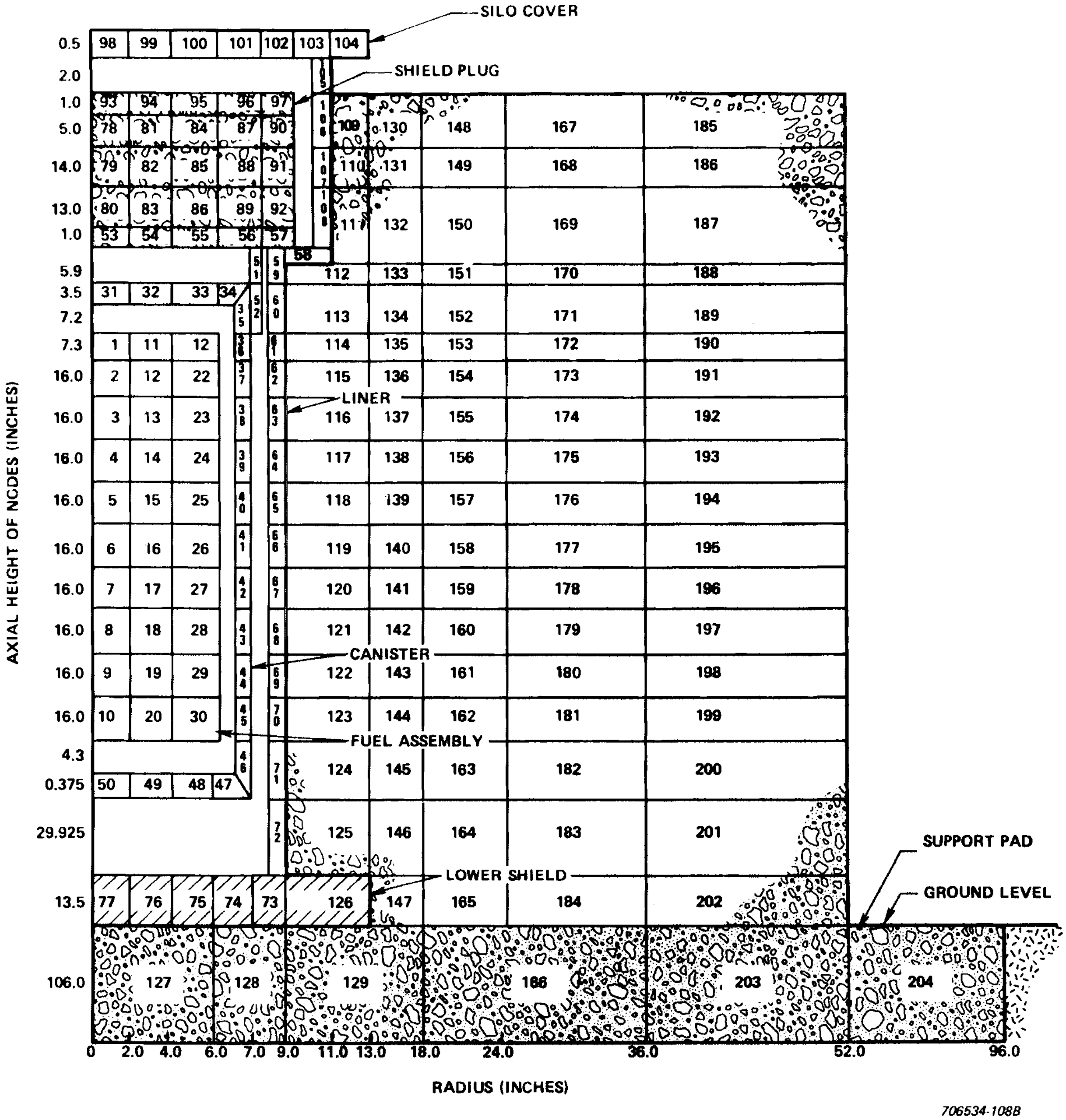

Figure 4.5-1. *Concrete Silo Thermal Model*

TABLE 4.5-1
TAP-A CONCRETE SILO MODEL NODE DESCRIPTION

Nodes	Test Components
1-30	Fuel Assembly
31-50	Canister
51-52	Shield Plug Extension
53-57	Shield Plug Bottom Plate
58	Liner Transition Ring
59-72	Liner Center Section
73-77	Liner Lower Section
78-92	Shield Plug Concrete
93-97	Shield Plug Top Plate
98-104	Silo Cover
105-108	Liner Upper Section
109-125	Concrete
126	Liner Lower Section
127-129	Concrete Pad
130-165	Concrete
166	Concrete Pad
167-202	Concrete
203-204	Concrete Pad

is acceptable since, due to the relatively small shield plug heat transfer rates, even large modeling inaccuracies in these regions would have little effect on canister temperature predictions.

The interface between two solid materials in contact will produce a certain resistance to the heat flow across the boundary. In this analysis, however, intimate contact is assumed between the liner and concrete and the contact resistance was assigned a zero value.

FUEL ASSEMBLY

The fuel assembly is modeled as a uniform axial and radial heat generating medium with a power decay shown in Figure 2.3-3. The heat source is modeled as a right circular cylinder 144 inch long and 12 inch diameter with a thermal conductivity as shown in Figure 4.5-2. No modeling of the individual fuel pins was done. An attempt was made to maintain the fuel region heat capacity to more closely predict the canister and fuel temperature during transient heatup and for ambient temperature changes.

SILO OUTSIDE SURFACE

On the outside silo surface, several heat transfer processes occur: solar insolation, solar reflection, radiation back to the sky and convection to and from the ambient air. Of these processes, solar

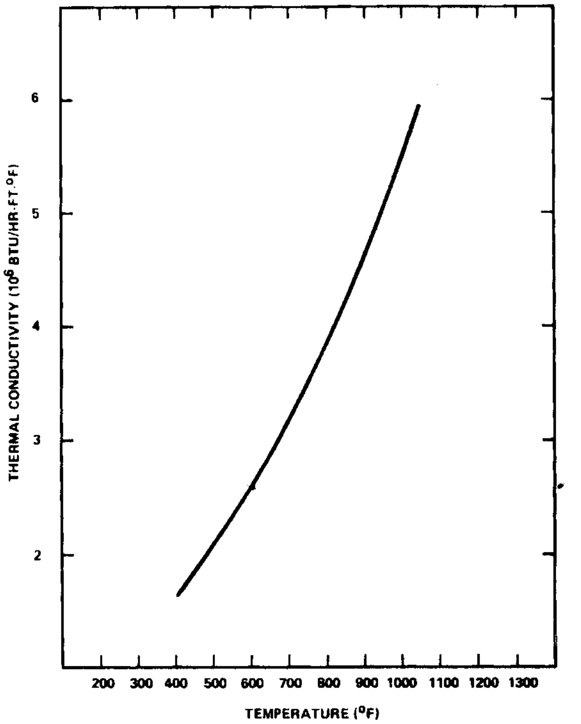

Figure 4.5-2. *Thermal Conductivity Within Modeled Fuel Assembly*

effects are not considered. Test data has shown that the daytime solar effects (on the south side of the silo) are damped out in the first 15 inches of concrete. Heat transfer by convection at the concrete/air interface is modeled by applying a convective heat transfer coefficient at the interface and monthly air temperature averages at E-MAD (see Table 3.4-1). The heat transfer coefficient is assigned a constant value of 2.0 Btu/hr-ft^2-°F (obtained from Reference 23) and applies to a wind speed of 5 to 10 miles/hour for a direction perpendicular to the silo surface.

Radiative heat transfer to the sky from the concrete silo and the silo cover plate is calculated using emissivity values from Reference 24 (p. 699) of 0.95 for the coverplate and 0.9 for the concrete.

MATERIAL PROPERTIES

The various materials and their thermal properties input to the thermal model are identified in Table 4.5-2. The physical and thermal properties of concrete were measured as a function of temperature in laboratory tests performed by Holmes and Narver, Inc. These results are shown in Table 4.5-3. An effective thermal conductivity of the concrete must take into account the reinforcing bar. A thermal conductivity value of 1.6 Btu/hr-ft-°F was determined by the calculational methods described in Reference 4.

4.5.2 COMPARISON OF MODEL PREDICTIONS WITH TEST DATA

The concrete silo model predicted temperatures over the three year period of the Concrete Silo Test. Figure 4.5-3 compares test data and predictions of monthly canister and liner maximum temperatures at the 128 inch elevation. From Figure 4.5-3, it can be concluded that the model predicts canister and liner temperatures conservatively over the complete life of the test. Therefore, using the monthly averaged air temperature approach for boundary condition is reasonable when analyzing a silo. The data shows that the solar heating effect on the south side of the silo does not greatly influence the liner temperature. Hence, solar effects can be ignored when determining liner and canister temperatures.

Figures 4.5-4 and 4.5-5 compare predicted canister and liner axial temperature profiles and test data on August 1, 1979 and August 1,

TABLE 4.5-2
MATERIAL THERMAL PROPERTIES USED IN CONCRETE SILO ANALYSIS

Material	Density (lb/in^3)	Heat Capacity (Btu/lb-°F)	Thermal Conductivity (Btu/hr-ft-°F)	Emissivity
Fuel Assembly	0.170	0.10	See Fig. 4.5-2	--
Stainless Steel	0.289	0.12	9.9	.45
Carbon Steel	0.283	0.12	23.0	.60
Concrete	0.083	0.21	1.6	.90

1981. These dates represent peak temperature times. The earlier predicted profile is slightly more conservative than the later profile, but both profiles show excellent agreement.

A comparison of predicted radial temperature profiles with test data are shown in Figures 4.5-6 and 4.5-7 for August 1, 1979 and August 1, 1981. Both profiles show the daily variation in ambient temperature is damped out quickly since the predicted canister and liner temperatures and the test data are in fairly good agreement.

4.5.3 EFFECT OF VARIABLES ON SILO TEMPERATURES

CONCRETE THERMAL CONDUCTIVITY

Figure 4.5-8 shows a comparison of canister temperature predictions and test data using a measured concrete thermal conductivity and a derived concrete thermal conductivity. The measured concrete thermal conductivity (as a function of temperature) was experimentally determined from samples taken during concrete pouring. The measured properties, listed in Table 4.5-3, were averaged at different silo levels and used as input to the TAP-A model. The derived concrete thermal conductivity is based on an evaluation of test data and the decay heat curve as explained in Reference 4.

Use of the derived thermal conductivity results in closer predictions to the test data. Since the derived conductivity takes into account the reinforcing bar installed in the silo concrete, better agreement using the derived thermal conductivity predictions would be expected.

POWER LEVEL VARIATIONS

The effect of increasing the initial decay heat level from 1 kW to 2 kW is shown in Figure 4.5-9. Shown in this figure are predicted canister temperatures using the decay heat curve from Figure 2.3-3 and test data from fuel assembly B02. Both predictions assume the concrete has derived thermal conductivities. The canister temperature of the 2 kW case converges towards the canister temperature of the 1 kW case as do the decay heat curves. Seasonal ambient temperature variations are seen in both cases, but the effect of ambient

TABLE 4.5-3
CONCRETE SILO NO. 2 MEASURED CONCRETE PROPERTIES

	Temp. (°F)	Bottom	Middle	Top*
Thermal Conductivity (Btu/hr-ft-°F)				
	Room	1.29	1.23	1.37
	100	**	1.02	1.04
	200	0.95	0.92	0.97
	300	0.90	0.90	0.91
	400	0.80	0.78	0.80
	500	0.70	0.74	0.72
	600	0.65	0.66	0.69
	700	0.54	0.51	0.62
Specific Heat (Btu/lb-°F)				
	100	0.213	0.215	0.213
	200	0.222	0.224	0.222
	300	0.232	0.234	0.232
	400	0.241	0.244	0.241
	500	0.251	0.253	0.251
	600	0.260	0.263	0.260
	700	0.270	0.272	0.270
Density (lb/ft^3)		142	145	144
Coefficient of Thermal Expansion ($10^{-6}/°F$)		6.0	6.0	6.2

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* Measurements taken from three batches of concrete used

** No data

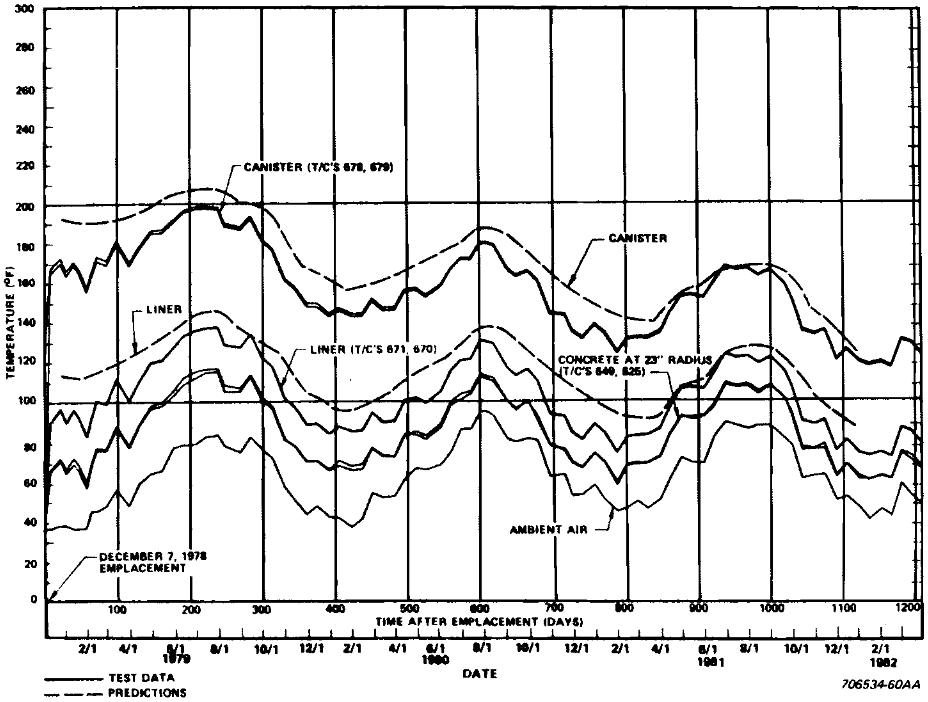

Figure 4.5-3. Concrete Silo (F/A B02) Test Data and Predictions Comparison at 128 Inches Below the Silo Top, January, 1979 to December, 1981

variation at the higher power level is not as great.

AMBIENT AIR TEMPERATURE VARIATIONS

Variation in the seasonal ambient air temperatures affects silo canister and liner temperature response. The effect of seasonal air temperature variations on temperatures at the 128 inch elevation is shown in Figure 4.5-10. Where the thermal model ambient temperature is held constant at 70°F and the temperature predictions are plotted with test data. The temperature predictions follow a sloping path dependent only on the decay heat curve. The predicted peak canister temperature of 220°F for a constant air temperature shows the effect canister emplacement during December, 1979 had on suppressing the peak canister temperature.

4.6 SILO TEMPERATURE EXTRAPOLATIONS

The peak fuel clad temperatures have been predicted for fuel assembly B02 in the E-MAD concrete silo. Figure 4.6-1 shows the peak measured canister temperatures and the estimated peak fuel clad temperatures from December 7, 1978 to March 31, 1982. The peak fuel clad temperature estimates were calculated using the method described in Section 5.6.1. The peak measured canister temperatures and the predicted fuel assembly decay heat levels (from Figure 2.3-3) were used to calculate the peak fuel clad to canister temperature difference from the relationship developed from the helium backfill Fuel Assembly Internal Temperature Measurement Tests data (see Section 5.6.1). This difference was then added to the peak measured canister

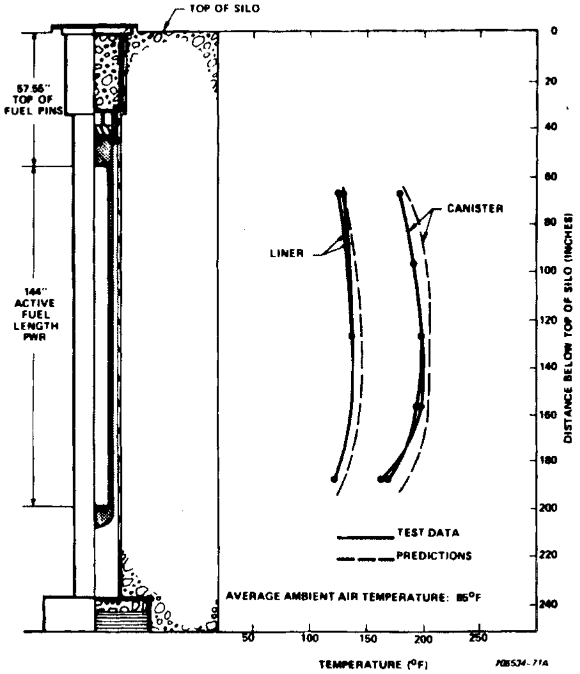

Figure 4.5-4. Concrete Silo (F/A B02) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, August 1, 1979

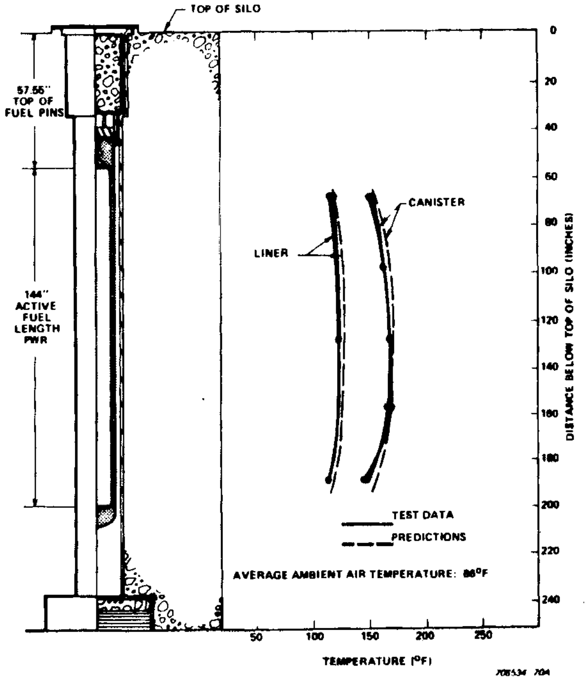

Figure 4.5-5. Concrete Silo (F/A B02) Test Data and Predictions Comparison of Canister and Liner Axial Temperature Profiles, August 1, 1981

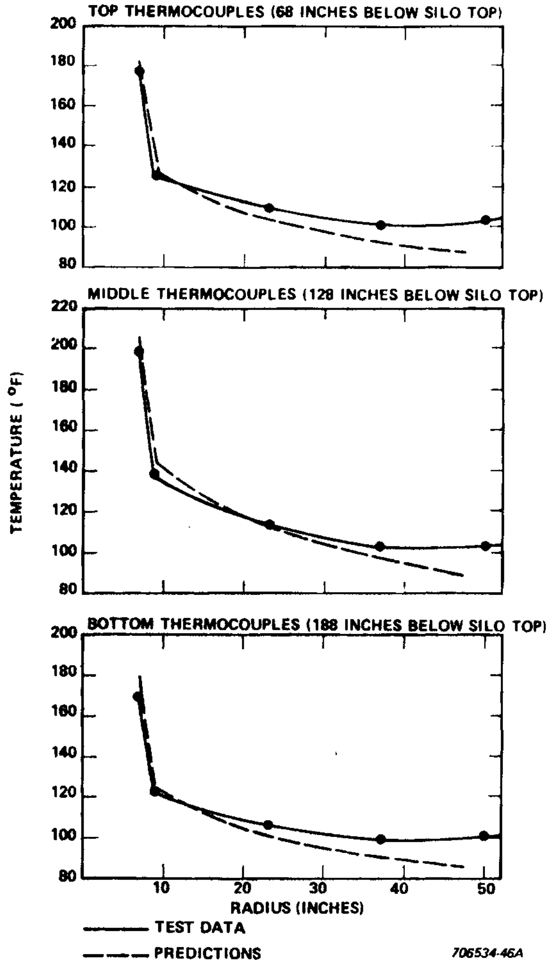

Figure 4.5-6. Concrete Silo (F/A B02) Test Data and Predictions Comparison of Radial Temperature Profiles, August 1, 1979

temperatures. The estimated peak fuel clad temperatures ranged from 315°F at emplacement, to a maximum of 322°F, to a low of 208°F in February, 1982. The peak fuel clad temperatures follow the seasonal ambient air temperature variations showing yearly maximum values of 316, 274, and 251°F for the summer months of 1979, 1980, and 1981, respectively.

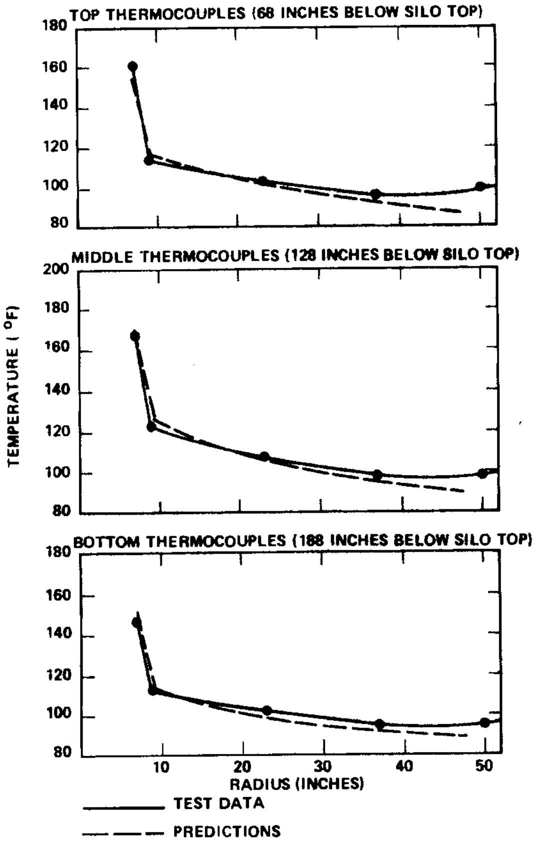

Figure 4.5-7. Concrete Silo (F/A B02) Test Data and Predictions Comparison of Radial Temperature Profiles, August 1, 1981

The error in these peak fuel clad temperature predictions was determined from measurement uncertainties and calculational method inaccuracies (see Appendix M, Section M.3). The estimated maximum errors in the peak fuel clad temperatures noted above are -5.7 to +11.9°F.

4.7 APPLICABILITY OF TEST RESULTS

APPLICATION

The results from the Concrete Silo Test conducted at E-MAD can be applied to silos of comparable configuration. The test canister temperature data is specific for the helium atmosphere encapsulation of a single PWR spent fuel assembly and the canister's enclosure in a liner surrounded by 52 inches of reinforced concrete. The location of the concrete silo adjacent to the E-MAD building west wall caused a nontypical silo response to the effects of day time insolation and night time radiation cooling. The results of the concrete silo thermal model evaluations are considered to be generally applicable to comparable silo configurations.

TEST DATA ACCURACY

Inaccuracies in the recorded test data could be a result of thermocouple measurement inaccuracy and thermocouple position uncertainty. The accuracy of the ungrounded Type K thermocouples used is typically ±2°F based on calibration data.

An examination of the Fuel Assembly Internal Temperature Measurement Test data was made to evaluate the effect of having canister thermocouples inside the 0.75 inch by 0.75 inch angle instrumentation tubes. Thermocouple data for fuel assembly B43 showed temperatures inside the tubes were lower than those on the canister surface by a maximum of 8.5°F. This is expected to be the maximum inaccuracy in canister temperature measurements due to the instrumentation tubes. Details of the position uncertainty evaluation are contained in Section M.1. For the liner thermocouples, the close proximity of the thermocouple tube to the liner wall and the geometry of a 0.062 inch thermocouple diameter inside a 0.083 inch inside diameter tube is expected to yield a smaller inaccuracy than for the canister thermocouples.

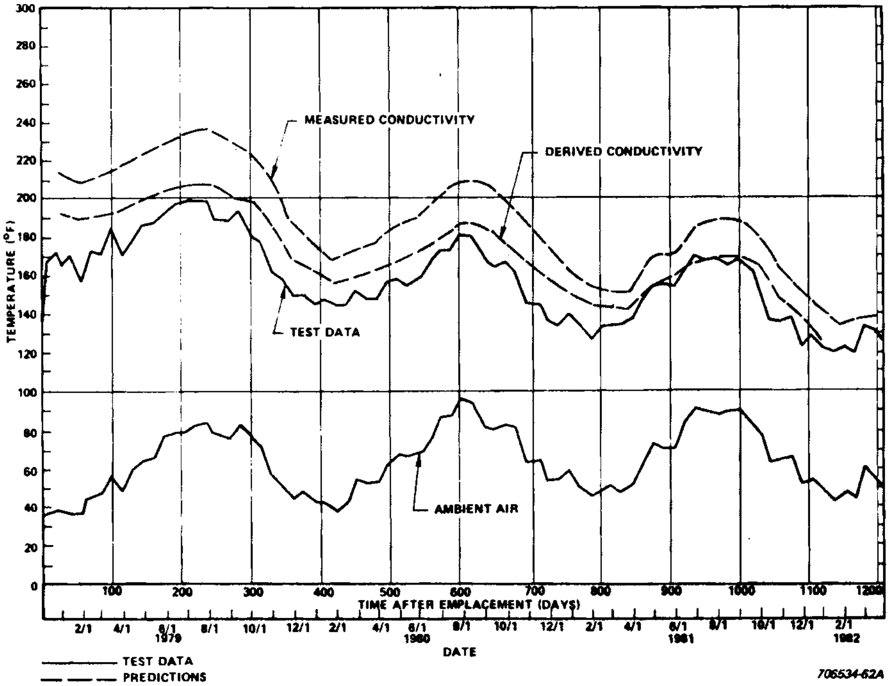

Figure 4.5-8. Concrete Silo (F/A B02) Comparison of Canister Temperature Predictions at 128 Inches Below the Silo Top for Measured and Derived Concrete Thermal Conductivity

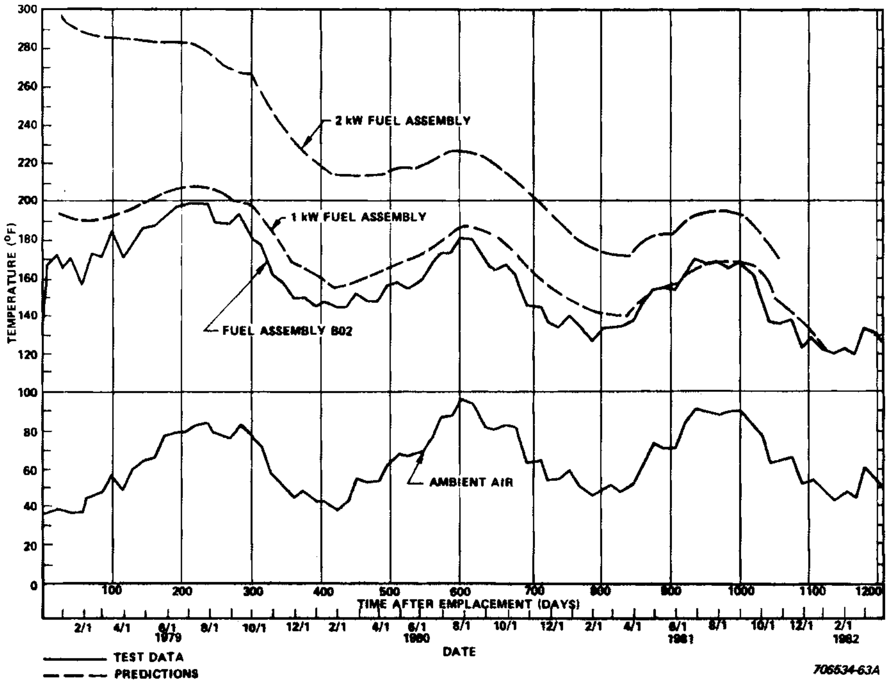

Figure 4.5-9. Concrete Silo (F/A B02) Comparison of Canister Temperature Predictions for 1 kW and 2 kW Decay Heat Level Fuel Assemblies at 128 Inches Below the Silo Top

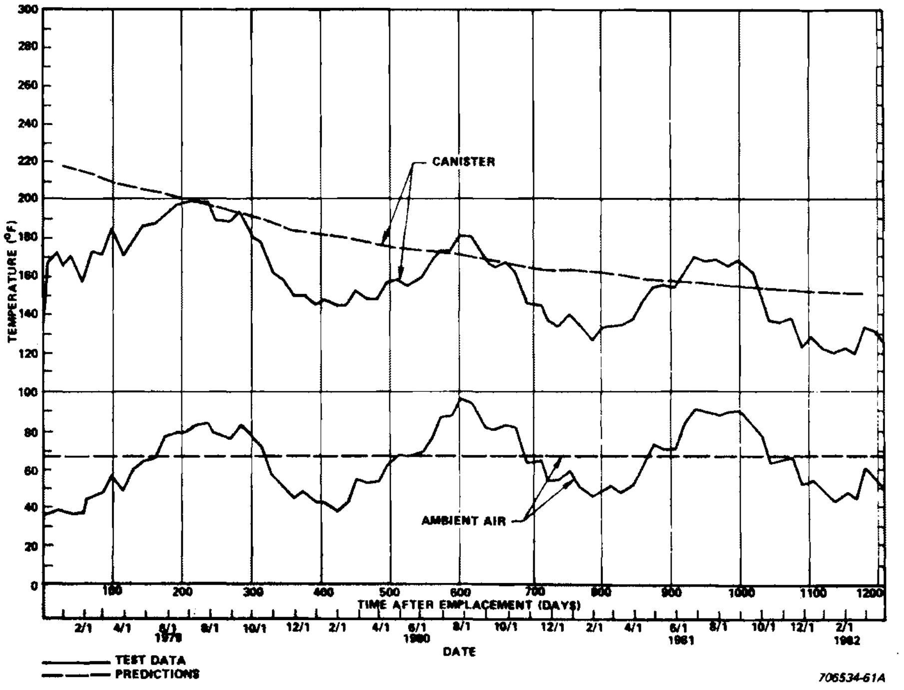

Figure 4.5-10. Concrete Silo (F/A B02) Comparison of Canister Temperature Predictions for Constant Ambient Air Temperature at 128 Inches Below the Silo Top

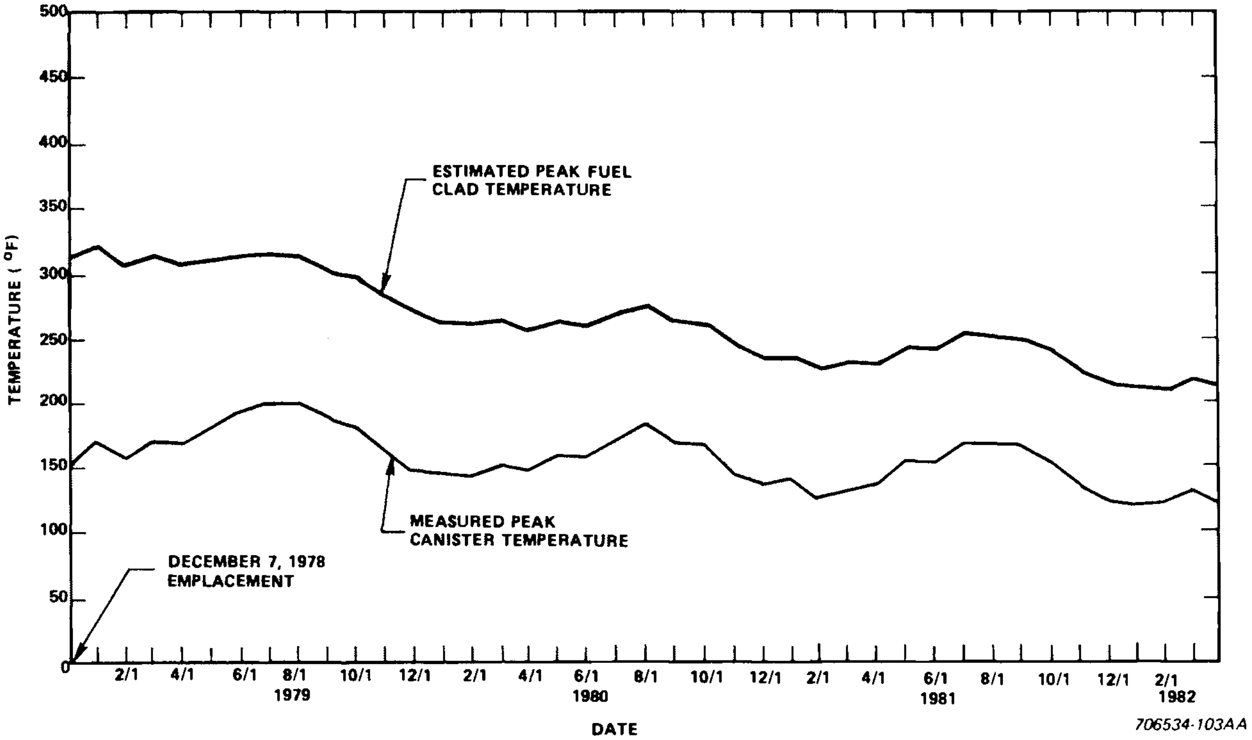

Figure 4.6-1. Concrete Silo (F/A B02) Estimated Peak Fuel Clad Temperature Distribution, December 7, 1978 to March 31, 1982

The Concrete Silo Test data recorded are judged to be between -2 and +10.5°F of the actual canister temperatures, and -2 and +4°F of the actual liner and concrete temperatures.

In addition to measurement uncertainty, Concrete Silo Test data were examined to determine daily temperature variations relative to test data presented, differences between opposite side canister and liner thermocouple readings, and the thermocouple axial position tolerance effect on measured temperatures. Table M-7 provides the range of daily temperatures and the variation in temperatures from the 4:00 p.m. readings (same time as readings provided in Appendix E). Canister and liner temperatures varied by less than 1.5°F during the four periods when hourly temperatures were recorded and by less than 1.0°F from the 4:00 p.m. readings. Concrete temperatures varied by up to 4.3°F except at the 50 inch radius where up to 18°F variations were noted. Table M-5 provides temperature differences between the canister and liner opposite side thermocouples at three thermocouple levels. These differences varied from 0 to 5.8°F. Thermocouple and heat source (active fuel) axial position tolerances are provided in Tables M-1 and M-3, respectively. The difference between the thermocouple-measured temperature and that at the elevation noted for the thermocouple tip in Table E-1 was evaluated using the slope of the axial temperature profile on July 20, 1979 and the axial position tolerances. The differences ranged from ±0.1 to ±0.9°F for both canister and liner thermocouples.

5.0 FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TESTING

The following section describes the Fuel Assembly Internal Temperature Measurement Test performed at E-MAD for two PWR fuel assemblies. Included are the test objectives, hardware descriptions, test operations, test results and thermal analyses for both fuel assemblies tested.

5.1 TEST OBJECTIVES

A primary objective of the Fuel Assembly Internal Temperature Measurement Test (as defined for the SFHPP 1978 Demonstration) was:

- Objective 1 - To provide spent fuel assembly internal temperature data under simulated dry storage cell conditions to verify that spent fuel assemblies with a decay heat level of about 1.0 kW could be stored in drywells and concrete silos at the Nevada Test Site without exceeding design temperature limits

It had been determined early in the 1978 Demonstration planning that a test to obtain fuel assembly temperature data should be conducted inside an E-MAD facility hot cell rather than to provide internal canister instrumentation in the actual storage canisters.

Other objectives were identified for the Fuel Assembly Internal Temperature Measurement Test test assembly. These objectives were:

- Objective 2 - To use the test assembly as a calorimeter to determine spent fuel assembly decay heat level by comparing canister temperatures with electric heater induced canister temperatures
- Objective 3 - To provide spent fuel assembly internal temperature data allowing determination of axial and radial temperature distribution correlations between canister and fuel cladding and aiding in computer model verification
- Objective 4 - To examine the thermal effects of various gaseous stabilizing media on canister and spent fuel assembly temperatures
- Objective 5 - To provide spent fuel assembly internal temperature data for different temperature levels experienced in similar experimental storage cells

As part of the CWSFP Program, another objective was identified. Since the results of the Phase II Test for fuel assembly B43 (approximately 1.0 kW) showed that peak fuel cladding temperatures measured for simulated storage cell conditions were well below the design limit, it was decided to evaluate fuel assembly internal temperatures for higher decay heat levels. The objective was to provide temperature data which could be used in conjunction with Electrically Heated Drywell Test and fueled Drywell Test data to determine the maximum decay heat level which drywell storage cells at the Nevada Test Site could accomodate.

5.2 HARDWARE DESCRIPTIONS

5.2.1 TEST ARRANGEMENT

The Fuel Assembly Internal Temperature Measurement Test hardware consists of a main test assembly with a number of auxiliary systems and components. The main test assembly is illustrated in Figure 5.2-1. The test assembly consists of: 1) a test stand which supports a representative storage cell liner, 2) a seismic restraint fixture providing test stand lateral support, 3) a test canister (representative of a storage canister), 4) a canister lid assembly containing instrumented tubes which are inserted into the spent fuel assembly, and 5) a PWR spent fuel assembly. Figures 5.2-2 and 5.2-3 show the relative dimensions, elevations, and configuration of the test assembly. The auxiliary equipment includes: 1) an evacuation and backfill system, 2) an electric heater assembly for test stand calibration, 3) a temporary canister lid to interface with the electric heater, 4) a test stand electric heater control panel, 5) two thermocouple and heater lead connector panels for remote connection, and 6) a data acquisition system to record thermocouple data. The test equipment arrangement in the E-MAD facility West Process Cell area is shown in Figure 5.2-4. Additional photographs of the Fuel Assembly Internal Temperature Measurement Test equipment are shown in Appendix B.

5.2.2 TEST STAND

The test stand for the Fuel Assembly Internal Temperature Measurement Test consists of a large tubular steel frame, a test stand lifting fixture, a storage cell liner, a series of band heaters, an insulation sheath along the length of the liner, an insulation plug at the bottom of the liner, thermal insulation, and a set of thermocouples. Each of these components is described below.

The test stand frame is 48 inches wide by 96 inches long by 204 inches high and is made of structural carbon steel tubing, I-beams, and angles. The outer frame members are 3 inch square by 0.25 inch thick square tubing. Each side of the stand has two sets of diagonal cross members welded between adjacent vertical tubing sections. The cross members are 3 inch by 3 inch by 0.188 inch thick angles. At the bottom of the frame, a series of four 4 inch high I-beams, two in each direction, are welded to the top of the tubing to support the liner.

A connector platform provides an area where thermocouple and heater leads and connectors are placed for remote access in the West Process Cell. The platform is located 3 feet above the test stand bottom and consists of two carbon steel angles and a plate. Two 1 inch by 1 inch angles are welded to the frame tubing and diagonal cross angles in the front and back of the stand. A 0.25 inch thick plate, 48 inches wide by 28 inches long is bolted to the two angles at four locations on each side. The test stand connector platform is visible in photographs of the completed test assembly, Figures B-67 and B-68.

Attached to the top of the test stand is the test stand lifting fixture (not shown in Figure 5.2-1). The fixture consists of two lifting arms bolted to the test stand frame and a movable cross bar assembly which interfaces with the remote overhead cranes. The two lifting arms are made of three pieces of 5 inch square by 0.5 inch thick structural carbon steel tubing welded to form an inverted "V" with a 5 inch wide flat section at

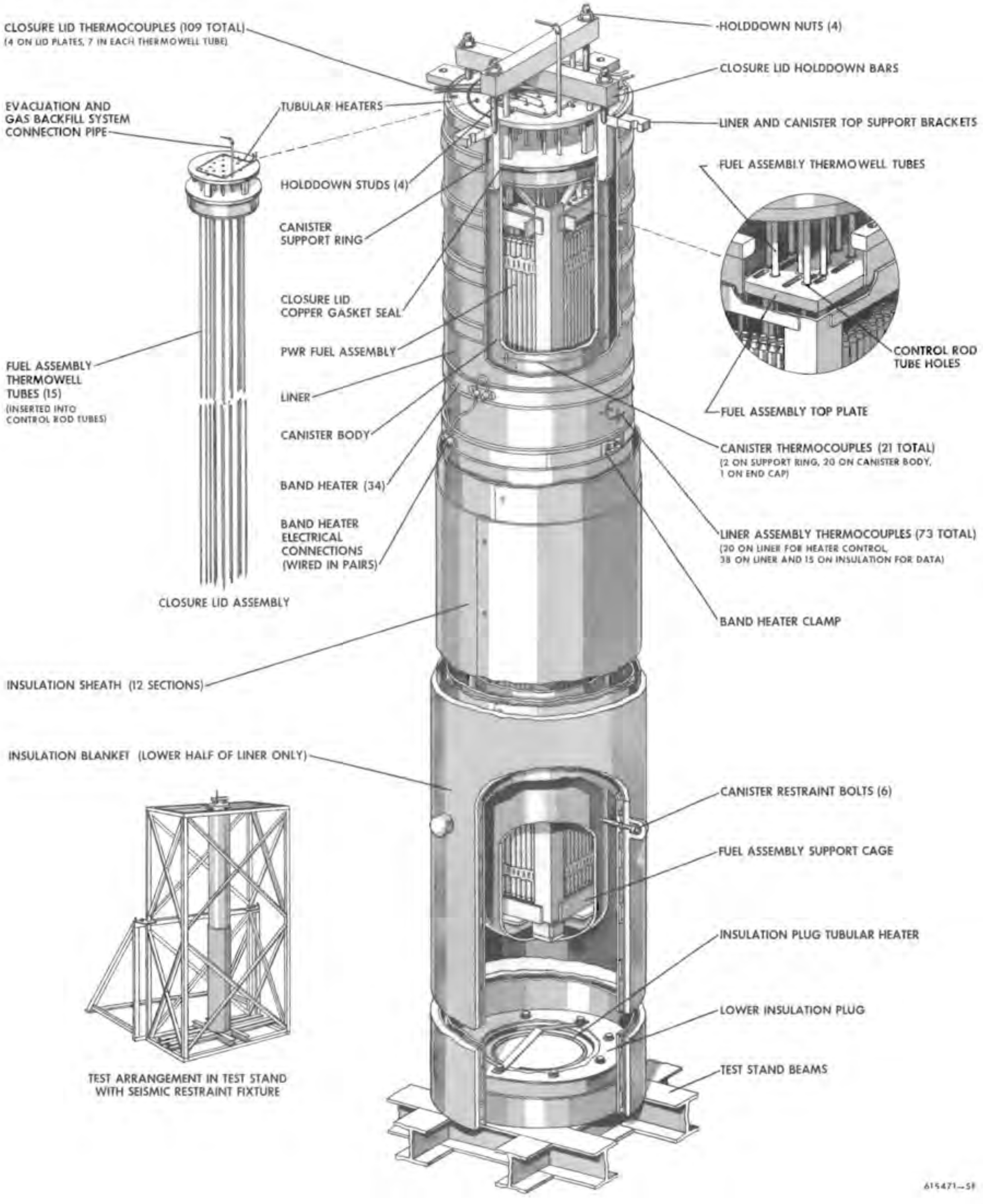

Figure 5.2-1. Fuel Assembly Internal Temperature Measurement Test Stand Arrangement

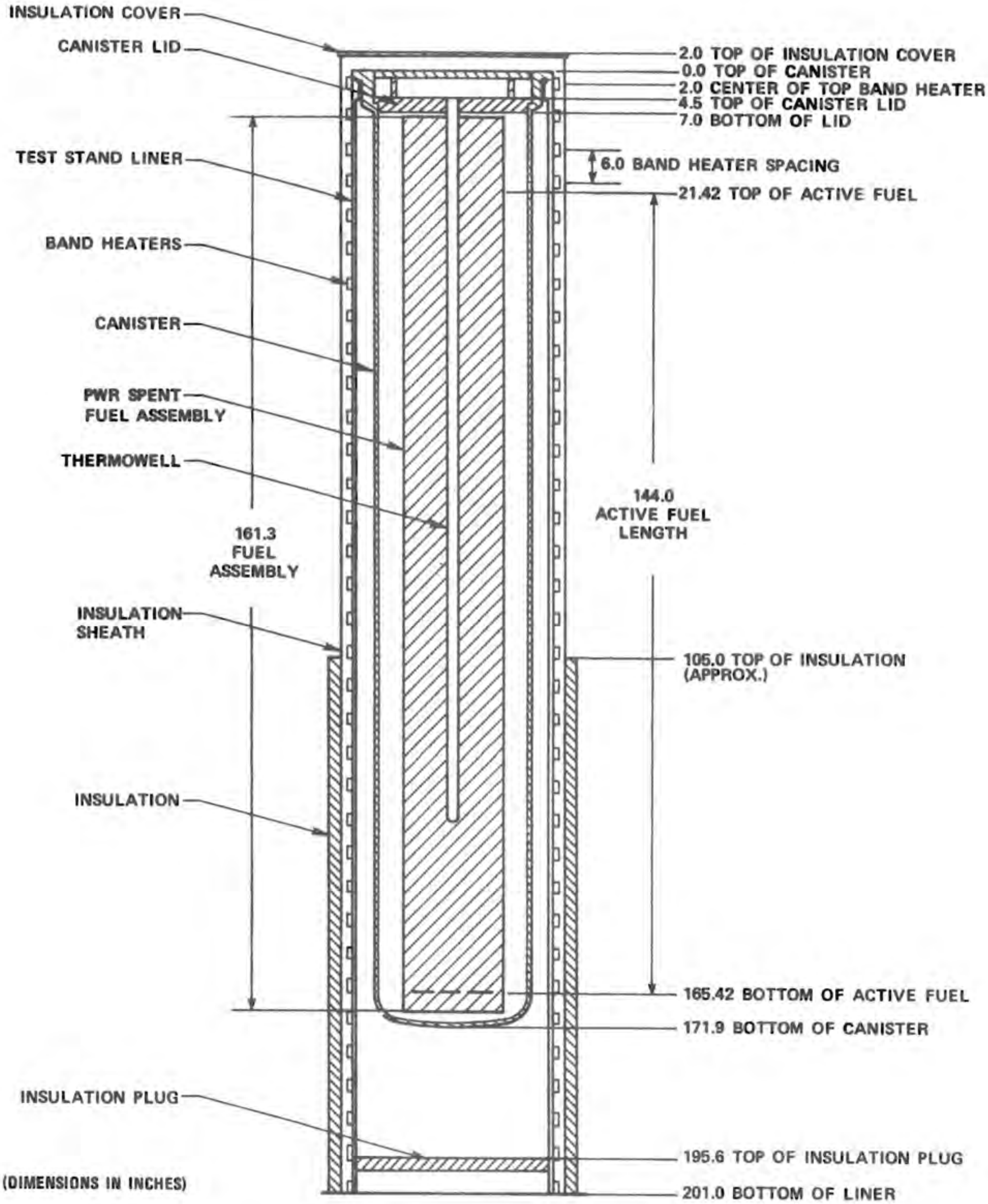

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Figure 5.2-2. Test Stand Schematic

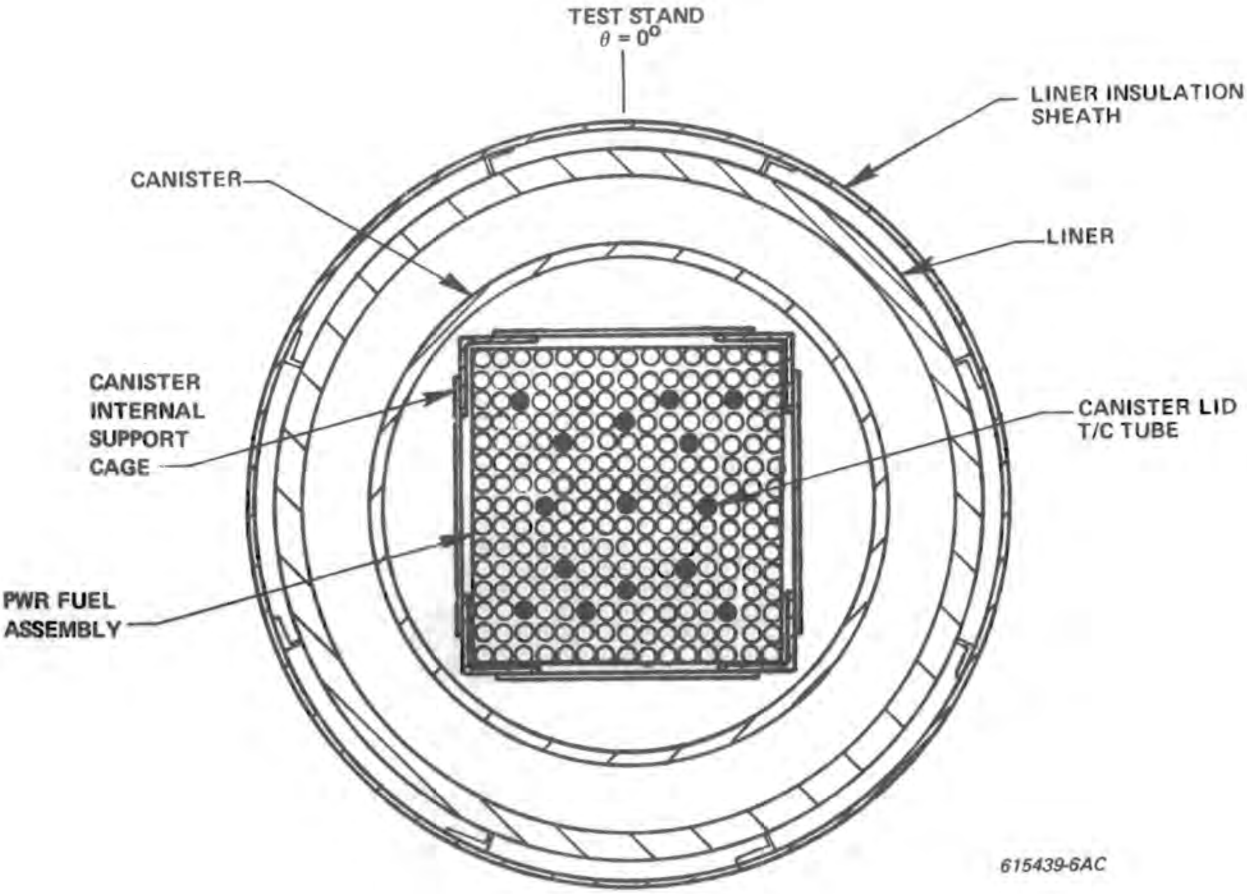

Figure 5.2-3. Test Stand Cross Section

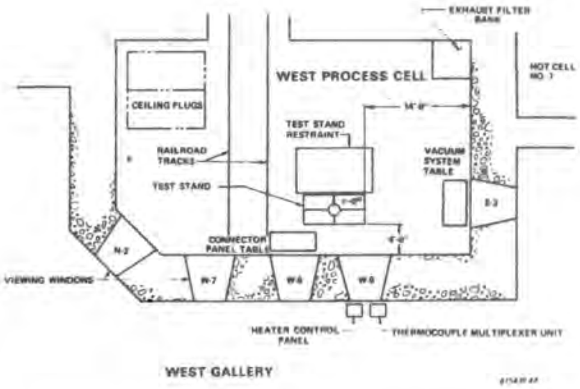

Figure 5.2-4. Fuel Assembly Internal Temperature Measurement Test Equipment Locations

the top. Both ends of lifting arms are machined to fit over the test stand frame tubing. One inch diameter bolts fit through two holes to attach the arms and test stand frame.

The test stand lifting fixture cross bar assembly is a 52.5 inch long section of 5 inch square by 0.5 inch thick structural carbon steel tubing. Two 5 inch wide by 15.75 inch high by 0.5 inch thick plates are welded to the tubing ends. After positioning between the two lifting arms, a 5 inch wide section of 3 inch by 3 inch by 0.18

inch thick carbon steel angle is bolted to the top of each plate at the end of the cross bar. A 4.5 inch long section of 0.5 inch diameter threaded bar welded to a 2 inch by 5 inch by 0.5 inch thick plate handle serves as a locking screw. This is threaded through a nut welded to each angle to hold the cross bar assembly in place. Two handles are welded to the center of cross bar assembly. The main handle is made of two 17.5 inch high by 6 inch wide by 0.62 inch thick plates welded to either side of the cross bar tube with a 2.5 inch diameter by 6.88 inch long rod welded in between. This handle is used for lifting the entire test stand. A second handle is welded to the side and aids remote movement of the cross bar assembly. The cross bar assembly is positioned at the top of the lifting arms for test stand movement and at one end of the lifting arms for fuel assembly and closure lid assembly installation. Photographs of the test stand lifting fixture are shown during test operations in Figures B-63 to B-68.

The liner is a 200 inch long section of 18 inch diameter by 0.25 inch thick carbon steel pipe welded to the test stand I-beams. The liner is supported by four channels with pinned connections at both ends accommodating liner thermal expansion. The channels are 3 inches wide by 1.5 inches deep by 0.25 inches thick. Each contains 0.25 inch thick spacer plates at the ends to interface with brackets on the liner and stand. Four brackets consisting of three sections each of 0.5 inch thick plate are welded to the liner. Each two vertical sections have holes to connect to the channel supports and each horizontal section has a threaded hole to bolt the canister to the liner. The test stand frame has four sets of two 2.25 inch by 1.25 inch by 0.5 inch thick brackets welded to the structural tubing. Holes drilled in the channels and liner and frame brackets allow 0.5 inch bolts to hold the liner top in position. Details of the liner top attachment are shown in Figures 5.2-1 and 5.2-5.

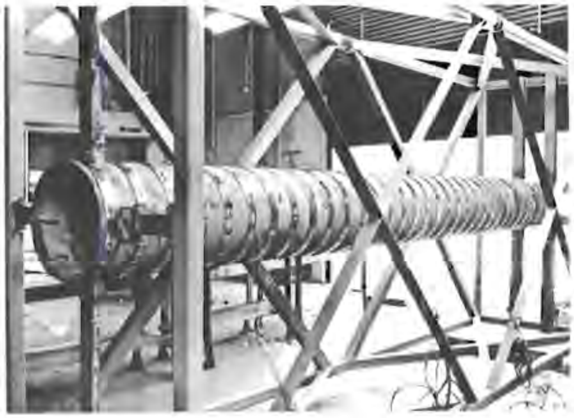

Figure 5.2-5. Test Stand Liner Showing Heaters and Thermocouples

The liner has several nonprototypical features (when compared to a storage cell liner) which interface with the test canister. At the top of the liner, a 0.25 inch deep by 2 inch wide slot allows for canister thermocouple lead routing. On the liner inside, eight 0.375 inch thick by 4.25 inch long ribs center the canister. Two 0.38 inch thick by 1.75 inch high rings are welded to the outside of the liner. Radial holes in the liner and rings allows bolts to center the lower end of the test canister and provide motion restraint under seismic loads. Two sets of six threaded holes accommodate a test canister for pressurized water reactor spent fuel and a longer test canister for boiling water reactor spent fuel.

Electric band heaters are provided on the liner outside to impose axial temperature distributions on the liner and canister. A total of 34 band heaters, located along the liner's total length, are spaced 6 inches apart with the top band heater 2 inches below the liner top. The band heaters are 2 inches wide, have an 18 inch inside diameter, and are made in two pieces for ease of installation. A band heater strap secures the two heater halves to the liner. The band heaters are held in position axially by four 0.01 inch thick stainless steel straps spot welded around the liner. The positions of the band heaters are illustrated in Figure 5.2-2. Installation photographs are shown in Figures 5.2-5 and 5.2-6.

Figure 5.2-6. Liner Heater and Thermocouple Attachment

The liner and band heaters are surrounded by a 0.025 inch thick 304 stainless steel insulation sheath. The sheath consists of 11 axial sections. The bottom ten sections are bent to form an overlapping cylinder. Each section has eight support brackets welded on the inside surface (four equally spaced at two elevations) providing axial support from two band heaters and a radial space of 1 inch from the liner. The top sheath section is made of two semicircular bands with cutouts for liner external support brackets and for routing thermocouple and heater leads. The sections are held together by self-tapping screws threaded through the section overlaps. During assembly, six small triangular sections (0.25 inches wide by 0.62 inches high) are cut and bent outward on the top or bottom edge of the sheath section to provide axial support for a blanket of 0.5 inch thick fiberglass insulation around the liner. Holes are also provided in the sheath for the canister restraint bolts. After installation, the insulation blanket is wrapped around the sheath with a layer of aluminized cloth and secured by 0.032 inch diameter wire.

An insulation plug with an electric heater in the liner bottom imposes the appropriate temperature conditions. The insulation plug consists of a 17 inch diameter by 3.38 inch high cylinder of 0.025 inch thick 304 stainless steel to which is bolted a 2 inch high insulation assembly. The insulation assembly has a 17 inch diameter top and bottom plate, an 11.5 inch diameter intermediate plate (all three are 0.025 inch thick 304 stainless steel), a 0.315 inch diameter tubular heater bent into a 9 inch diameter, a 2 inch thickness of cerablanket insulation, and eight nuts and bolts. The tubular heater is located under the top plate and above the intermediate plate and insulation. Details of the insulation plug are provided in Figure 5.2-1.

A total of 71 thermocouples are secured to the test stand. Figure 5.2-7 shows the locations of these thermocouples. Fifty-five thermocouples are attached to the liner, six are attached to the insulation sheath, five are attached to the test stand frame, three are attached to the outside of the insulation blanket, and two are attached to the top plate of the insulation plug. Of the 71 thermocouples, 53 provide test temperature data (see Section 5.2.11) and 18 provide temperature feedback to the heater controllers (see Section 5.2.9). Liner data thermocouples are located between each pair of band heaters. In addition, one thermocouple is placed above and two below the top band heater. Four thermocouples are equally spaced around the liner circumference 8 feet below the liner top. The positions of all test stand data thermocouples are tabulated in Table F-1. Liner band heater control thermocouples are positioned between every other pair of band heaters. The positions of the control thermocouples are illustrated in Figure 5.2-7, and are tabulated in Table F-1. One of the two thermocouples placed on the insulation plug top plate provides data and the other provides feedback for the plug heater controller. Thermocouples along the length of the insulation sheath and on the insulation blanket provide data for evaluating test stand performance. The five thermocouples mounted on the test stand provide ambient temperature data.

Thermocouples on the liner are placed in a 0.08 inch wide by 60° V groove cut into the liner wall and are held in position by 0.01 inch thick by 0.25 inch wide stainless steel straps spot welded to the liner. The steel straps force the thermocouple tip to touch the groove. The liner thermocouple attachment method is shown in Figure 5.2-6. Thermocouples on the insulation sheath, insulation plug and test stand are held in place by similar spot welded straps positioned about 0.5 inches from the thermocouple tip to ensure good contact.

5.2.3 SEISMIC RESTRAINT FIXTURE

A test stand seismic restraint fixture in the West Process Cell provides lateral seismic support. The seismic restraint fixture is secured to the West Process Cell floor by 1 inch diameter bolts at four points. The seismic restraint fixture is illustrated in Figure 5.2-1 and shown in actual operation in Figure B-68.

The seismic restraint fixture is a welded structure of carbon steel tubing, angle, and strip. The restraint fixture is 120 inches high and 72 inches wide and consists of a rectangular frame to interface with the test stand and a support leg structure. The top and sides of the rectangular frame are 4 inch square by 0.38 inch thick structural tubing. The bottom is a 3 inch high by 4 inch wide by 0.38 inch thick angle. Two 2 inch by 2 inch by 0.25 inch thick angles form an X-shaped support between corners. The support leg structure consists of two 4 inch square by 0.38 inch thick structural tubes welded to the frame top extending down to the floor at a 35° angle.

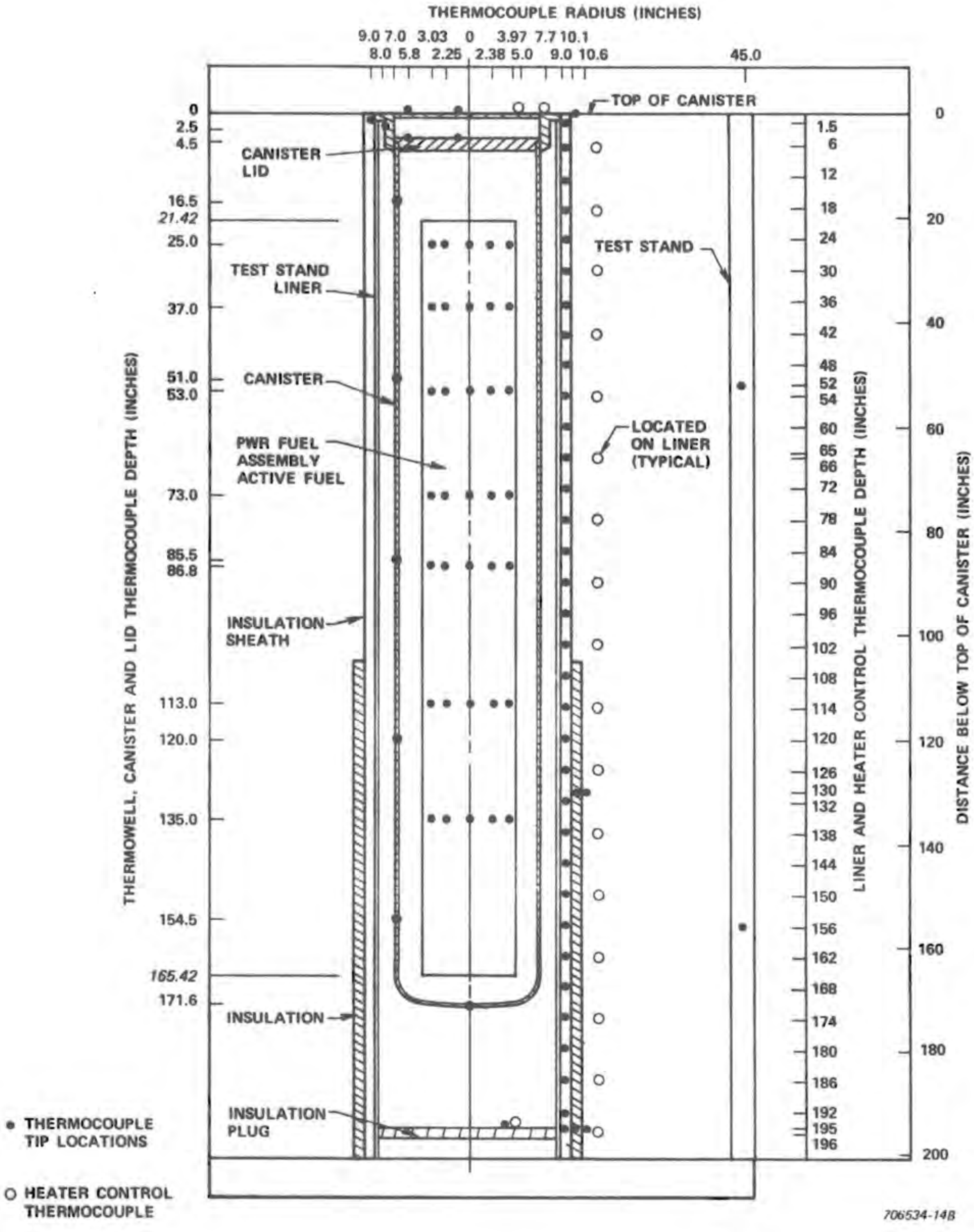

Figure 5.2-7. Test Stand Thermocouple Locations

A 5 inch wide by 0.38 inch thick strip is welded between the bottom of both legs. A 2 inch by 2 inch by 0.25 inch thick angle is attached from each leg to the frame about 6 inches above the floor.

On the top of the restraint fixture frame are two 1 inch thick carbon steel latch plates which secure the test stand to the seismic restraint fixture. Each plate is attached to the top frame tube by a 2 inch diameter bolt allowing the plate to rotate. Once the test stand has been properly positioned in the West Process Cell, the two plates are remotely rotated and locked into place by 1 inch diameter 304 stainless steel pins. The latch plates are shaped to interface with the test stand vertical structural tubing, the pivot bolt, and the locking pin.

5.2.4 TEST CANISTER

The test canister consists of a 304 stainless steel canister body and a carbon steel upper support are nearly identical to the drywell and concrete silo canisters. The test canister can accommodate one PWR spent fuel assembly. Photographs of the test canister are shown in Figures 5.2-8, 5.2-9, 5.2-10 and 5.2-11.

Figure 5.2-8. Test Canister and Canister Lid

The canister body consists of a standard 14 inch outside diameter by 0.375 inch thick by 155.1 inch long pipe to which is welded a standard 14 inch diameter by 6.5 inch high ellipsoidal end cap. The end cap has welded into it a cruciform formed of a 0.75 inch thick horizontal plate with four 0.25 inch thick vertical gussets welded to the underside. The cruciform supports the bottom of the PWR fuel assembly. Welded to the cruciform plate is a fuel assembly vertical support cage formed of four 2 inch by 2 inch by 0.18 inch thick angles. This cage is tied together on four sides at six elevations by 7.12 inch long by 2 inch high by 0.18 inch thick straps. At the cage top, eight additional straps are welded between the canister pipe and the straps to provide cage centering. This cage provides lateral support for the entire length of the PWR fuel assembly. Except for the top 9 inches, the test canister body is identical to that of the E-MAD spent fuel storage canisters. The storage canisters have a 0.937 inch thick upper section on the canister body to interface with the threaded closure lid and four support pins attach

Figure 5.2-9. Test Canister, Dummy Fuel and Canister Lid Trial Fit Using Alignment Combs

canister and shield plug (see Section 3.2.2).

The test canister upper support structure consists of a 6 inch long section of 16 inch outside diameter by 1 inch thick pipe welded to a 1 inch thick by 18.25 inch outside diameter by 14.06 inch inside diameter ring. The 16 inch diameter pipe is welded to the canister body about 2.25 inches below the top of the body pipe. The 1 inch thick ring supports the entire test canister on top of the 18 inch liner pipe. Welded to the outside of this ring are four 3 inch square by 0.75 inch thick brackets with clearance holes for the bolts to hold the test canister in the liner. The ring has four 0.75 inch diameter threaded holes on the top surface for the closure lid hold-down studs. The upper support pipe is representative of the shield plug support skirt on the storage canisters.

After the canister body is welded to the upper support, the top of the body is machined to have a 0.02 inch high, "knife-edge" at a 13.65 inch diameter. A 0.06 inch thick copper gasket is seated on the canister body top. When clamped against the canister body "knife-edge" by the closure lid (which has a matching "knife-edge"), the gasket provides a seal.

A tubular heater is attached to the top of the canister support ring to impose the desired temperatures. The heater is a 0.315 inch diameter incoloy sheath heater bent into a 17 inch diameter. The heater is clamped against the canister by five heater clips screwed into the

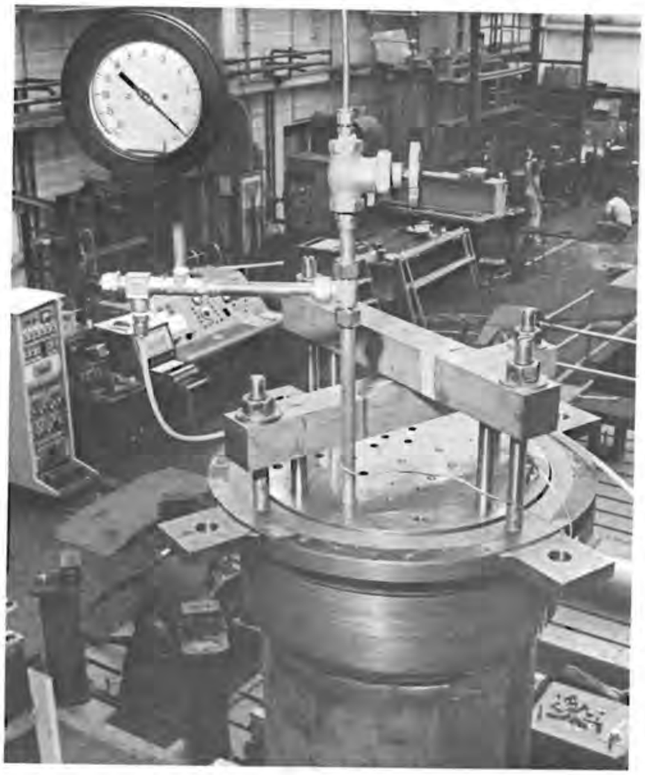

Figure 5.2-10. Test Canister and Closure Lid Assembled for Hydrotest

Figure 5.2-11. Completed Test Stand and Canister During Fitup Check

canister support ring top surface. Also attached to the top of the support ring are four closure lid holddown studs. The studs are 0.75 inch diameter, are threaded along their entire length and have a 0.131 inch wide slot at the top for tightening into the support ring. Opposite studs are 7 inches long and 9.25 inches long, respectively. The studs are made of high strength bolting material.

Twenty-four thermocouples on the test canister provide data and heater control. One thermocouple, located on the top surface of the canister support ring, provides feedback to the tubular heater controller. Another is located on the outside diameter of the support ring and a third on the outside of the support pipe. Twenty thermocouples are located at five different elevations on the outside of the canister pipe. Eight thermocouples are equally spaced around the canister circumference at the fuel midplane elevation. Four thermocouples are equally spaced around the canister at elevations about 35 inches above and below the midplane. One thermocouple is located at the center of the ellipsoidal end cap. Table F-1 provides a tabulation of canister thermocouple locations.

All but four of the canister thermocouples are attached directly to the canister components by 0.01 inch thick by 0.25 inch wide straps spot welded approximately 0.5 inches above the thermocouple tip. The remaining four thermocouples are inserted into instrumentation tubes similar to those on the storage canisters to determine the effects the instrumentation tubes have on canister temperature measurement. These thermocouples are two of the four located about 35 inches above and 35 inches below the fuel midplane elevation. The instrumentation tubes consist of 0.75 inch by 0.75 inch by 0.12 inch thick 304 stainless steel angle intermittently welded to the canister. Each of these four tubes is 15 inches long and has a 30° angle with a 0.09 inch thick triangular plate welded at the bottom. In addition to these four instrumentation tubes, 16 angles each 30 inches long were welded to the canister body to approximate the storage canister array of instrumentation tubes. The arrays of tubes are spaced 15° apart with two plain tubes located on either side of the closed tube containing the thermocouple. The tops of the four arrays of five tubes were located as follows: two arrays at 36 inches below the top of the canister with the center tubes spaced 90° apart and two arrays at 105 inches below the top of the canister with the center tubes spaced 180° from the center of the other two arrays.

5.2.5 CANISTER CLOSURE LID

The test canister closure lid assembly consists of a 304 stainless steel canister lid plate, a carbon steel cover plate, fifteen 304 stainless steel thermowell tubes, an evacuation and backfill pipe, an insulation cover, insulation, two holddown bars, a tubular heater, two alignment combs for installation, and a network of thermocouples. The canister lid plate simulates the storage canister lid and provides a sealing surface to seal the test canister. The thermowells are provided for thermocouples to be placed in close proximity to the fuel cladding for fuel assembly temperature measurement and still maintain a canister pressure boundary. Details of the closure lid assembly are illustrated in Figure 5.2-1. Photos of closure lid assembly during fabrication are shown in Figures 5.2-8 to 5.2-10 and during installation in Figures B-64 to B-66.

The canister lid is made of a 2.5 inch thick by 14 inch diameter plate. A 0.5 inch thick flange is formed by machining the lower 2 inches to a 13.34 inch diameter to interface with the inside of the canister body pipe. A "knife-edge" is machined into the lower side of the flange at a 13.65 inch diameter to provide a seal similar to that of the canister with the copper gasket placed between the canister and lid. The canister lid has fifteen 0.39 inch diameter penetrations into which are seal welded 0.375 inch diameter by 0.032 inch thick thermowell tubes. The tubes are positioned so as to be inserted into the PWR fuel assembly control rod guide thimble tubes and center instrumentation tube (see Figure F-1). The tubes have five different lengths ranging from 132.5 to 136.5 inches with a set of three tubes having the same length to simplify remote insertion into the fuel assembly. At the end of each tube is welded a 0.75 inch long plug with a spherical end. In addition to the thermowells, the lid has a 0.64 inch diameter hole into which is welded a 0.625 inch outside diameter by 0.065 inch thick 304 stainless steel evacuation and backfill pipe. The pipe is 16 inches long and extends above the closure lid cover plate.

The closure lid cover plate simulates the bottom of the storage cell shield plug and consists of a 0.5 inch thick by 13.88 inch diameter plate which is supported above the canister lid by four 1.25 inch by 0.5 inch by 4.0 inch long bars. These bars are welded to both the lid and cover plate. The cover plate has clearance holes provided above each thermowell to allow thermocouple routing and a clearance hole for the evacuation and backfill pipe. A thermocouple support bracket is welded to the top of the cover plate. A 0.315 inch diameter incoloy sheathed tubular heater is attached to the top of the cover plate by four clips screwed into the plate. The heater is bent to form a 7 inch square and provides heat to the cover plate to impose the desired temperatures on the canister lid. Four closure lid assembly lifting bail studs are attached to the cover plate. The lifting bail studs are 0.5 inch diameter threaded studs 3.5 inches long with two nuts welded to each stud. One nut is welded 1.25 inches from the end which is screwed into threaded holes in the cover plate. The other nut is welded 0.5 inches from the opposite end to interface with the insulation sheath and lifting bail.

Above the cover plate, an insulation cover is provided which supports a 0.5 inch thick layer of fiberglass insulation. The insulation cover is 20.25 inches in diameter and is made of a 0.025 inch thick 304 stainless steel sheet. The insulation cover is supported above the cover plate by three spot welded 1 inch wide by 1.5 inch high by 0.025 inch thick brackets. The 1.5 inch space created by these brackets allows thermocouple routing to the bracket on the cover plate. The insulation cover and insulation blanket have holes which allow the backfill tube, holddown studs, holddown bars, closure lid lifting bail studs, and lid tubular heater to pass through them. An aluminized cloth cover is placed over the insulation. The insulation cover is held in place by the four lifting bail studs. A jam nut on each stud holds the insulation cover, insulation and aluminized cloth against the nuts on top of the studs.

Two holddown bars and four nuts are provided with the closure lid assembly to hold the canister and lid together. The holddown bars consist of a 17.75 inch long by 2 inch square bar to which are welded two 0.75 inch diameter rods. One bar has 2.25 inch long rods while the other has 4.5 inch long rods. Each bar also has two clearance holes for the canister holddown studs. When assembled over the holddown studs, the two holddown bars criss-cross and the rods on each bar contact the closure lid cover plate. The four holddown nuts are remotely tightened to force the "knife edges" machined in the canister body top surface and closure lid flange bottom surface into the copper gasket, thus sealing the canister.

Two stainless steel alignment combs are also provided with the closure lid to assure proper spacing of the thermowells during remote installation of the lid. Each alignment comb consists of a 3 inch high by

0.25 inch thick plate to which are welded a series of twelve 0.156 diameter rods each bent to form a 9 inch long "U". The rods are bent so that one "U" is 2.15 inches wide and the other is 2.25 inches wide. The U-shaped rods are spaced to fit between adjacent thermowells and are parallel to one another. The alignment comb plates are 9.25 inches long and 7.69 inches long with a 1.5 inch long plate welded perpendicular to the shorter plate. The two combs are installed into the thermowell bundle perpendicular to one another, and the two plates are clamped together to hold both combs in place. Each alignment comb has a handle to allow remote removal from the closure lid. The two alignment combs are visible in photographs taken during closure lid fitup activities in Figures 5.2-8 and 5.2-9 and during lid remote installation in Figure B-64.

A total of 110 thermocouples are provided on the closure lid assembly. Of these, seven are placed in each of the 15 thermowells, two are attached to the closure lid, and three are attached to the cover plate. One of the three thermocouples on the cover plate provides feedback for the tubular heater controller; the other 109 thermocouples provide temperature data. The thermocouples on the closure lid and cover plates are secured by 0.01 inch thick by 0.25 inch wide spot welded straps located about 0.5 inches from the thermocouple tip. The thermocouples for each thermowell are assembled into a bundle and wire tied together to maintain tip position. The bundles are inserted into the thermowell tubes so the tips hang within the tube at the proper elevation. These thermocouples are secured to the cover plate at the thermocouple bracket by a thin plate screwed onto the bracket. The specific locations for each thermocouple on the closure lid assembly are tabulated in Table F-1.

5.2.6 EVACUATION AND BACKFILL SYSTEM

An evacuation and backfill system is provided for the Fuel Assembly Internal Temperature Measurement Test to allow the test canister to be filled with various gaseous media for fuel temperature response testing. The evacuation and backfill system is shown schematically in Figure 5.2-12. System components are located in the West Process Cell, in the operator gallery and in the adjacent hot cell (see Figure 5.2-4). The system is attached to a flexible hose on the closure lid assembly pipe after the entire test stand is positioned in the West Process Cell.

The evacuation and backfill system consists of stainless steel tubing, six valves, three pressure gages, a vacuum pump, a helium supply bottle with pressure regulator, and various fittings. A 45 foot long section of 0.5 inch diameter flexible stainless steel hose is attached to an elbow on the closure lid pipe. A quick disconnect fitting on the other end of the flexible hose remotely attaches to the mating connector fitting which is mounted to the connector panel table. From this connector, a 0.5 inch diameter rigid tube is routed around the West Process Cell wall to the vacuum system table. A 4.5 inch diameter pressure gage is provided in this line to allow system pressure reading from the operator gallery. From the pressure gage, four shutoff valves are interconnected with the vacuum pump line, the line to

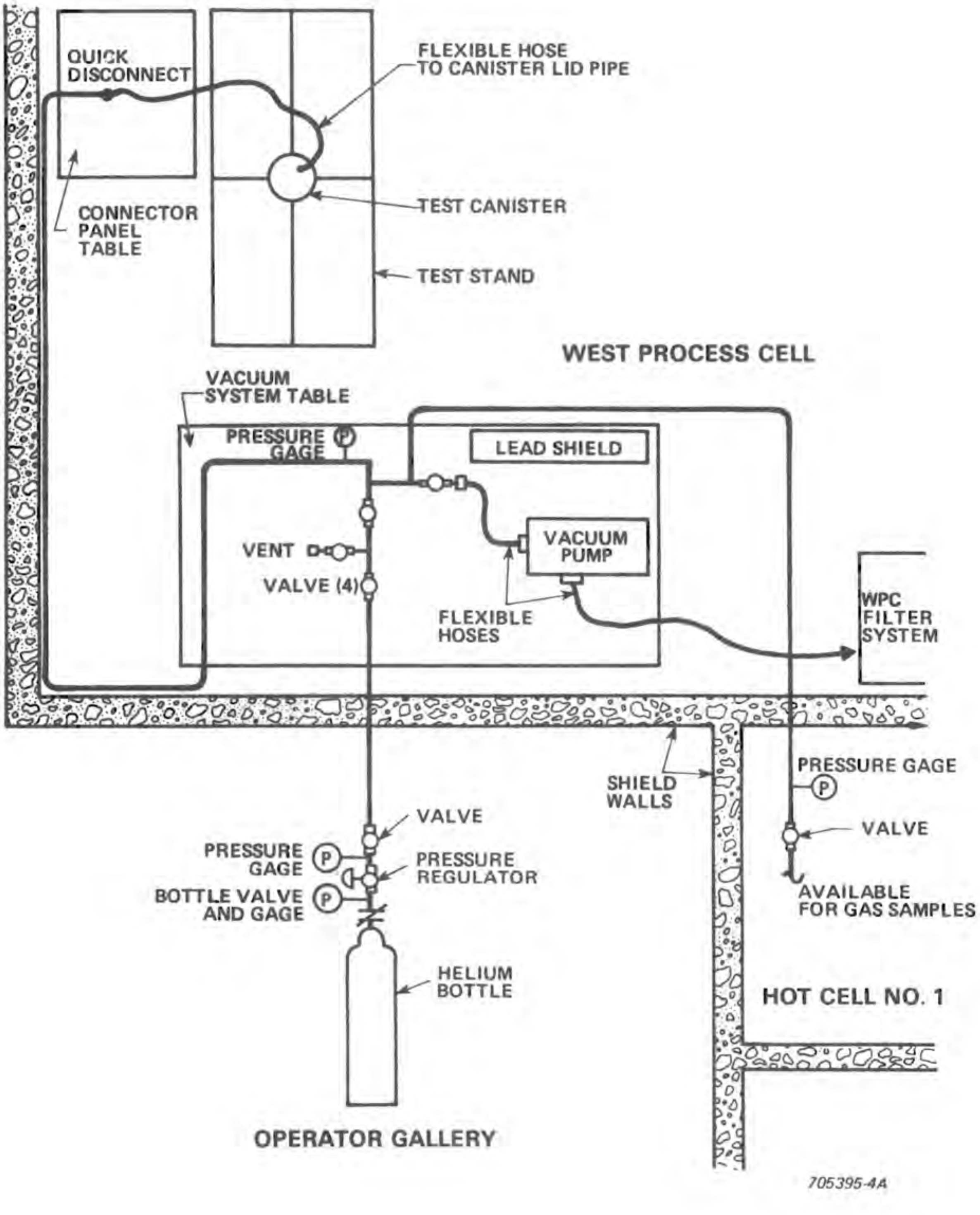

Figure 5.2-12. Evacuation and Backfill System Schematic

the helium bottle, and a vent to atmosphere to allow remote evacuation, backfill, and venting of the system. An additional line is routed to the adjacent Hot Cell No. 1 to allow for gas sampling of the test canister. The four shutoff valves on the vacuum system table were fitted with new handles to allow remote valve operation.

The vacuum pump is mounted to the vacuum system table and is connected to the valving arrangement by a flexible high pressure hose. The exhaust side of the vacuum pump is attached to a flexible hose which directs exhaust to the bank of filters in the West Process Cell. A shield consisting of a stack of 4 inch thick lead bricks is provided between the test stand and vacuum pump to limit the radiation exposure of pump components.

Solid steel tubing and compression fittings interconnect the valves with each other and with the helium bottle and gas sample port. The tubing for the helium bottle is routed through the shield wall to a shutoff valve, pressure gage, and pressure regulator attached to a standard helium bottle. The pressure gage and regulator allow for helium supply pressure control. A pressure gage, shutoff valve, and quick disconnect fitting are provided on the tubing routed to Hot Cell No. 1 for remote gas sampling capability.

5.2.7 CALIBRATION HEATER ASSEMBLY

The calibration heater assembly consists of four tubular heater elements mounted in an 8.3 inch square steel frame. Details of the heater assembly are shown in Figure 5.2-13.

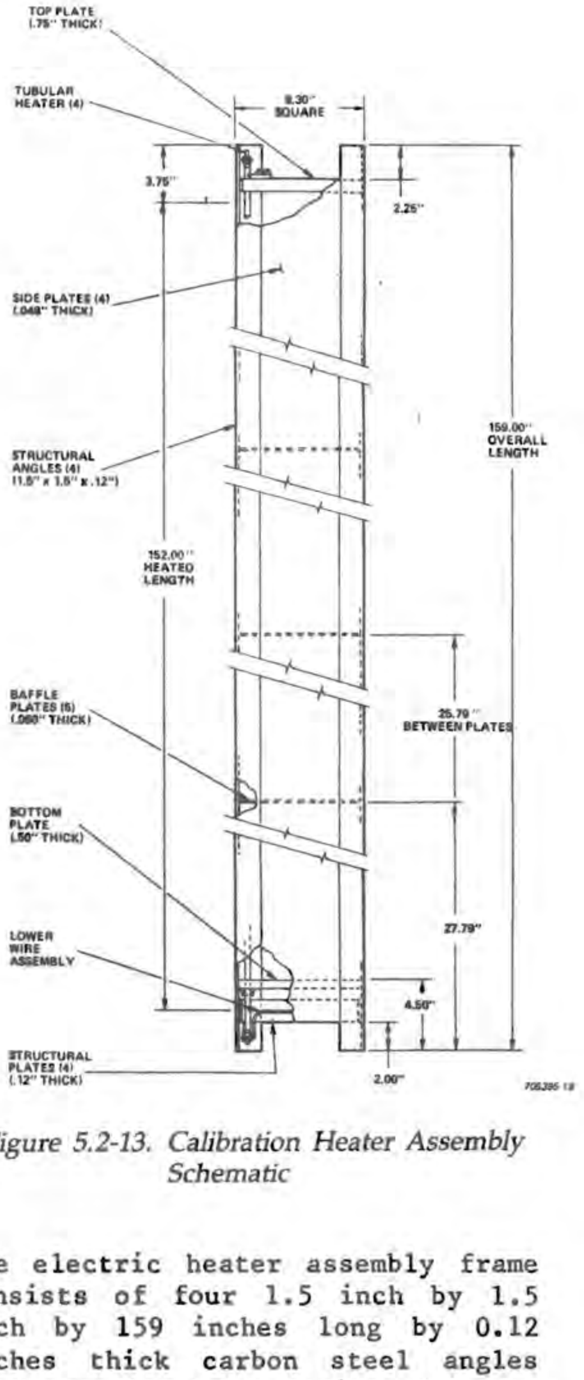

Figure 5.2-13. Calibration Heater Assembly Schematic

The electric heater assembly frame consists of four 1.5 inch by 1.5 inch by 159 inches long by 0.12 inches thick carbon steel angles tied together by a series of seven carbon steel plates welded to the angles. Five baffle plates (8.05 inch square by 0.06 inch thick) and a top and bottom plate (8.05 inch square by 0.75 inch and 0.5 inch thick, respectively) are welded at various elevations. Each plate contains nine 0.5 inch diameter holes; five allow flow through the plate and four provide clearance holes for the tubular heaters. Outside the angles, cover plates of 0.048 inch thick carbon steel enclose all but the top 2.25 inches and bottom 2 inches of the frame. At the frame bottom, four 1.5 inch high by 7.6 inch long by 0.12 inch thick support plates are welded to the inside of the angles. These plates interface with the canister cruciform plate and provide heater assembly support and vertical positioning.

One tubular heater is secured to the inside of each heater frame corner by screw mounted brackets on the top plate. The tubular heaters are 0.43 inches in diameter by 156 inches long with a 0.049 inch thick incoloy sheath. The heaters have a precision wound nickel chromium wire heating element rated at 4 kW heat output at 240 volts. They have 2 inches of unheated section at each end and have threaded stud terminals for electrical connections. A locator ring is welded to the heater sheath about 0.5 inches from one end. The heaters can operate at 1600°F at rated power.

The tubular heaters are interconnected at the top and bottom by a series of four 0.156 inch diameter 304 stainless steel wire assemblies. Each assembly has a 0.06 inch thick steel washer welded to both ends fitting over the heater stud terminal. Two wire assemblies connect adjacent heaters at the lower heater end and two wire assemblies connect adjacent heaters at the heater upper end keeping the heaters in series. All the wire assemblies are secured to the heater stud terminals between two hex nuts and then brazed to the nuts.

5.2.8 CANISTER TEMPORARY LID

A temporary lid for the test canister interfaces with the calibration heater assembly during test stand calibration. The temporary lid consists of a lid plate and a cover plate interconnected by four bars in a configuration similar to the closure lid assembly, an insulation cover, an insulation and cover cloth similar to the closure lid assembly, a holddown bar and lifting assembly, and a set of thermocouples. The temporary lid is held against the canister copper gasket by the holddown bars in the same manner as the canister closure lid. The temporary lid impedes air flow from the canister but does not act as a pressure boundary seal. The temporary lid is made of carbon steel and has no instrumentation thermowell tubes.

The temporary lid has a lid plate 14.04 inches in diameter and 1 inch thick. The lid plate is machined to form a 0.5 inch thick by 13.25 inch diameter flange at the top which interfaces with the test canister body. The cover plate is 0.5 inches thick and 13.88 inches in diameter. The two plates are attached by four 4 inch long by 1.5 inch wide by 0.25 inch thick bars. Both plates have holes for routing calibration heater electric leads.

A holddown bar assembly is welded to the top of the temporary lid cover plate. The holddown bar is the same as that used for the closure lid assembly and has two 4.5 inch long by 0.75 inch diameter rods. The holddown bar assembly positions and secures an insulation assembly (insulation cover, 0.5 inch thick insulation blanket, and aluminized cloth cover). A lifting bail, welded to the top of the holddown bar assembly, allows handling of the temporary lid in the Hot Bay.

The temporary lid has four thermocouples. Two are attached to the lid plate and two are attached to the cover plate. The locations and method of attachment are identical to those on the closure lid assembly. These thermocouples provide temperature data during test stand checkout and calibration for comparison with closure lid temperature data.

5.2.9 HEATERS AND HEATER CONTROL PANEL

A total of 37 heaters are attached to the test hardware. Thirty-four band heaters are strapped to the length of the liner and one tubular heater each is attached to the top of the liner lower insulation plug, the canister support ring, and the closure lid cover plate. High temperature radiation resistant wire connects these heaters to a set of temperature controllers mounted on the heater control panel in the operator gallery (see Figure 5.2-4). Terminal strips attached to the wires from the heaters and to the heater connector panel (described in Section 5.2.10) allow for remote completion of the heater power circuit. A grounding strap on the test stand frame is connected before any testing is done.

The liner band heaters each have a 500 watt capacity at 120 volts AC. Adjacent pairs of band heaters are wired together to an individual controller so that a different temperature can be imposed on the liner every 12 inches. This allows input of any desired axial temperature profile on the liner. The band heaters maximum power output is 17 kW. The canister lid tubular heater and the insulation plug tubular heater each have a 225 watt capacity at 120 volts AC; the canister support ring tubular heater has a capacity of 450 watts at 120 volts AC. The total heater capacity for the tubular heaters is 0.9 kW. Each of these heaters is wired separately to individual controllers.

The heaters are wired using # 12 AWG copper wire with a 600 volt, 1000°F and high radiation resistance rating. Wire terminals are crimped and brazed onto each end of the wire, and these terminals are brazed to the terminal stud nuts installed on each heater. The other wire end is attached to standard terminal strips which interface with strips on the heater connector panel. All of the wire from heaters installed on the liner and canister are routed and wire tied along the test stand tubular frame to the test stand connector platform where the wire is coiled for remote handling and connection. The closure lid heater wire hangs from the closure lid assembly, and during lid installation the wire is placed on the test stand connector platform for remote connection in the West Process Cell.

The heater control panel is a 72 inch high by 23 inch deep by 24 inch wide electrical cabinet on which are mounted 24 heater temperature controllers. Its position is shown in Figure 5.2-4. Twenty-one of the 24 controllers operate during testing. Table F-1 provides a listing of specific controllers attached to heaters and control thermocouples.

The heater temperature controllers have a 200 to 600°F variable temperature control setting, a 10 amp contact rating at 120 volts AC, a control accuracy of ±0.9°F, and are designed for use with thermocouple sensors. The ambient operating temperature range for the controllers is 30 to 130°F. A sensor protector de-energizes the load power if a control thermocouple fails.

Power leads are routed from the heater connector panel in the West Process Cell through the shield wall at window W-9 (see Figure 5.2-4). These wires are routed into the rear of the heater control cabinet and attached to terminal strips on the inside. The heater temperature controllers are connected to the terminal strips, to the input line voltage through a 10 amp fuse, and to the control (feedback) thermocouples. The control thermocouples are routed from the thermocouple connector panel in the West Process Cell through the shield wall at window W-8. These wires are taken into the cabinet top on the side opposite the heater terminal strips, and to the heater temperature controllers. Power input to the cabinet is 3 phase 120 volt, 60 hertz.

Several modifications to the heater controller circuit were made. A redundant set of 22 solid state temperature limiters was installed in the heater control cabinet and wired in parallel with the heater temperature controllers. Each is connected to the appropriate control thermocouple and is set at a temperature slightly above the heater temperature controller. An additional heater temperature controller and solid state temperature limiter were connected into the controller power input line and use a closure lid thermocouple (located near the fuel assembly midplane) to limit the fuel clad peak temperature. This controller and limiter are set at 650°F, and an alarm sounds if feedback exceeds that limit and all three phases of power into the cabinet are disconnected. These extra control features met test site personnel safety requirements and limited fuel clad temperatures to less than 700°F during testing.

5.2.10 CONNECTOR PANELS

Two separate connector panels, one for thermocouple extension leads and one for heater power leads, are mounted on the connector panel table for remote attachment of leads from the test stand. The connector panel table, in the West Process Cell, is located in front of viewing window W-8 (see Figure 5.2-4) which is adjacent to the test stand connector platform after the test stand is positioned in the cell. The connector panels are mounted at an angle to simplify remote attachment operations. The two connector panels are shown in Figures B-68 and B-69.

The thermocouple connector panel is 14 inches high by 26 inches wide and is made of 0.12 inch thick 304 stainless steel. Mounted to this connector panel are eighteen 24 pin quick disconnect connectors. Each connector has twelve 2 lead thermocouple extension wires soldered to it. The extension wires are routed through an existing West Process Cell shield wall penetration at window W-8 to the two multiplexer units located in the operator gallery (see Figure 5.2-4).

Matching quick disconnect connectors are attached to the thermocouple leads on the test stand, canister, and closure lid. After the completed test stand is positioned in the West Process Cell, all connectors from the stand are remotely attached to the designated panel connectors.

The heater connector panel is 18 inches high by 23.5 inches long and is made of 0.12 inch thick 304 stainless steel. Six terminal strips are attached to the panel; one strip has two terminals, two strips have eight terminals, and three strips have ten terminals. Heater power wires (identical to those used on the test stand, Section 5.2.9) are attached to the heater connector panel terminals via crimped-on wire terminals. These wires are routed to the heater control panel. Each heater connector panel terminal has a brass jumper strip to remotely attach matching terminal strips mounted on the test stand, canister, and closure lid heater leads. The jumper strips are 2 inches long with a hole in one end and a slot in the other end. The slot allows the test stand heater lead terminal strips to be placed against the panel mounted strips and the terminal screws tightened to complete the installation.

After all the test stand terminal strips are connected, a sheet of plexiglass placed over the heater connector panel prevents inadvertant contact with the jumper strips.

5.2.11 DATA ACQUISITION SYSTEM

The data acquisition system for the Fuel Assembly Internal Temperature Measurement Test consists of the array of thermocouples, the E-MAD data logger, and two remote signal conditioning/multiplexing units. The thermocouples are attached to the test components as described earlier. Remote attachment of thermocouples and extension wire is made in the West Process Cell to route the thermocouples through the shield wall to the multiplexer units located in the operator gallery. Multiplexer signal cables are routed through overhead cable trays to the data logger.

THERMOCOUPLES

All thermocouples consist of a Type K, chromel-alumel thermocouple with ungrounded junction enclosed in a 0.062 inch diameter 304 stainless steel sheath. Two 24 gage Type K extension wires are brazed to the thermocouple wires and are enclosed in a 0.187 inch diameter by 0.028 inch thick by 2.75 inch long stainless steel transition boot. The transition boot is crimped onto the end of the thermocouple cable sheath and filled with epoxy. The sheathed thermocouple wire is used in areas where high temperatures could exist during testing.

The thermocouple extension wires are bundled together on the test stand and on the closure lid assembly and are soldered into 24 pin quick disconnect connectors which match those on the thermocouple connector panel. Test stand (and canister) thermocouple bundles are routed and wire tied along the test stand frame and are coiled on the test stand connector platform. The thermocouple bundles on the closure lid assembly hang from the lid cover plate during installation and the connectors are positioned on the test stand connector platform as the lid is lowered into the test stand.

5.3 OPERATIONS

5.3.1 TEST SEQUENCE

The Fuel Assembly Internal Temperature Measurement Test operations were divided into three separate test phases. The Phase I test consisted of test assembly electrical checkout and calibration using the calibration heater assembly. The Phase II testing consisted of imposing various canister temperature profiles and canister internal atmospheres on the test assembly containing a PWR fuel assembly B43. Phase II test planning included test runs with no band heater power, imposing the Electrically Heated Drywell Test canister profile, imposing the Concrete Silo No. 2 canister profile, imposing the Drywell 5 canister profile and imposing various uniform canister temperature profiles ranging from 250 to 500°F. The Phase III test consisted of imposing various canister temperature profiles and canister internal atmospheres on the test assembly containing PWR fuel assembly D15. Phase III test planning included test runs with no band heater power, imposing the Electrically Heated Drywell Test canister profile, imposing the Drywell 5 canister profile, imposing the Spent Fuel Test at Climax (SFT-C) canister profile and imposing various uniform canister temperature profiles ranging from 350 to 600°F.

5.3.2 PHASE I TESTING (ELECTRICAL)

Phase I Fuel Assembly Internal Temperature Measurement Test operations consisted of the checkout and calibration of the test assembly using the calibration heater assembly and temporary canister lid. The electrical testing was performed in the West Process Cell in the same configuration to be used for spent fuel testing.

Phase I operations began in June, 1979. The assembled test stand and test canister were placed in the E-MAD Hot Bay following thermocouple and heater continuity checks. The calibration heater assembly was installed into the test canister and two electrical leads attached to the heater assembly tubular heater interconnection wires. These leads were routed through holes in the temporary canister lid as the lid was being installed. Installing the holddown bar and nuts completed the test assembly. The test assembly was then lifted and transported to the West Process Cell and lowered through the cell ceiling plug hole. It was moved into position for testing, the seismic restraint fixture latches rotated and pinned, and the thermocouple and heater connectors attached to the mating connectors in the cell. The two calibration heater assembly leads were attached to two unused terminals on the heater connector panel; and in the operator gallery, a variable voltage transformer was connected to wires leading to these two terminals. A voltmeter and ammeter connected to the transformer allowed accurate measurement of calibration heater power levels.

A data logger printout of all test thermocouples was obtained as an ambient reference temperature reading. The Phase I checkout was then performed with a 0.5 kW calibration heater power level. Prior to this however, the test assembly heater controllers were set at their minimum setting and a thermocouple data printout was compared to the reference data printout to verify heater operation. After this thermocouple and heater functional check, the calibration heater assembly power level was raised to 1.0 kW to evaluate test assembly capabilities. The test assembly heater controllers were set to predetermined values to impose the drywell canister profile on the test canister and the test assembly temperatures were allowed to stabilize. The resulting test canister temperatures were higher than those desired. Subsequently, the insulation blanket and cloth cover were removed from the top half of the test stand liner. With the insulation removed and no band heater power, another set of test canister profile data was compared to the desired drywell canister profile. In this case the temperatures were found to be lower along the entire canister length. This minimum test assembly canister profile capability for a 1.0 kW heat source meant that the Concrete Silo No. 2 temperature profile could not be imposed without major modification to the test stand. Therefore, the Concrete Silo Canister Profile Tests were eliminated.

Test assembly calibration operations followed the checkout procedures. With no band heater power, calibration heater power levels were set at 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kW. The test assembly was allowed to reach thermal stabilization between each power level. Stabilization criteria for calibration operations required that 90 percent of the test thermocouple data readings fall within ±1°F in a 30 minute period. Data logger printouts were made every 30 minutes during test assembly calibration. Once the test assembly temperatures had stabilized, the thermocouple readings were recorded and the calibration heater power level was changed. Test assembly calibration activities started on June 4, 1979 and ended on June 29, 1979.

Upon completion of Phase I, the thermocouple and heater connectors in the West Process Cell were disconnected and the test assembly returned to the Hot Bay. The holddown nuts and bar, the temporary canister lid, and the calibration heater assembly were removed from the test stand. An electrical check of the thermocouples was performed which revealed that seven data thermocouples and two heater control thermocouples had low internal resistance readings. Since improper data feedback could result, the two heater control thermocouples (TC-9 and TC-11) were disconnected and two data thermocouples located at approximately the same position (T/C's 452 and 460) attached to the heater controllers in their places. The low internal resistance readings for the seven data thermocouples (T/C's 328, 357, 383, 387, 389, 428 and 454) have been noted. The temperatures recorded by these thermocouples (provided in Appendix F) may be in error and therefore were not used in evaluating the test results.

5.3.3 PHASE II TESTING (FUEL ASSEMBLY B43)

Phase II Fuel Assembly Internal Temperature Measurement Test operations consisted of installing the spent fuel assembly into the test stand canister, placing the test assembly in the West Process Cell, conducting a fuel assembly calorimetry test, and conducting a series of simulated storage cell thermal tests and uniform canister temperature tests with either air, helium or a vacuum inside the test canister. Fuel assembly installation and test assembly completion were performed remotely in the Hot Bay. All testing was performed in the West Process Cell.

Following the Phase I testing, the test stand was placed in the Hot Bay calorimeter pit (shielded storage pit). The installation and assembly procedures are described in greater detail in Section B.2.4. On July 18, 1979, remote handling operations commenced. PWR spent fuel assembly B43 was taken from its storage canister assembly. The fuel assembly was slowly lowered into place and installed with the serial number side of the top nozzle facing test stand θ=0°.

The completed test assembly was moved to the West Process Cell and installed as described in Appendix B. Finally, an operational check of the heaters and thermocouples ensured proper operation.

Phase II tests were begun in late July, 1979. The planned testing sequence was: 1) perform the fuel calorimetry check with the band heaters off, 2) impose the drywell canister profile, 3) impose the Electrically Heated Drywell Test canister profile, and 4) impose uniform canister temperatures of 250, 300, 400 and 500°F, respectively. Each storage cell canister profile was based on a decay heat level comparable to yet slightly different from that of the fuel assembly being tested. For the Electrically Heated Drywell Test, the axial canister and liner profiles shown in Figure 5.3-1 for a 1.0 kW heater power level were originally planned to be used. However, the actual set point temperatures used are given in Table 5.3-1. The Concrete Silo No. 2 canister and liner profiles shown in Figure 5.3-2 were taken from test data on March 4, 1979 for a fuel assembly decay heat level estimated to be about 0.97 kW. The axial canister profile shown in Figure 5.3-3 was obtained from Drywell 5 on July 1, 1979 when the fuel assembly decay heat level was estimated to be about 0.87 kW. For each test profile, three tests would be run with an air, vacuum and helium backfill. The actual order in which all the tests were run is identified in Table 5.4-1.

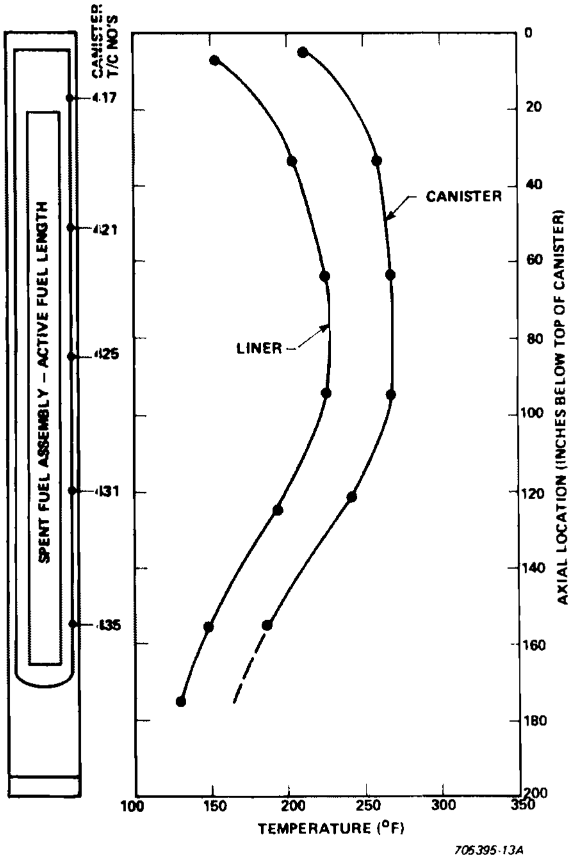

Figure 5.3-1. Electrically Heated Drywell Test Canister and Liner Temperature Profiles for the Fuel Assembly Internal Temperature Measurement Test (1.0 kW Operation, November 29, 1979)

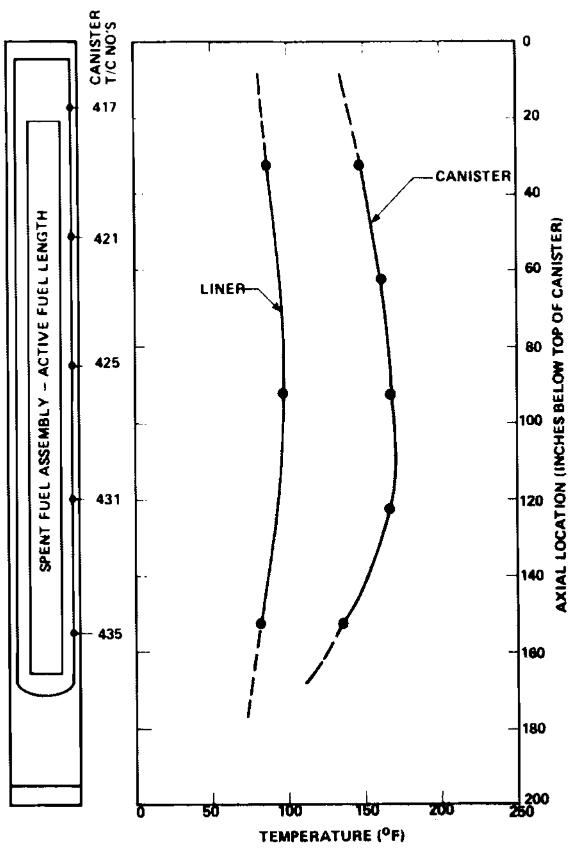

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Figure 5.3-2. Concrete Silo (F/A B02) Canister and Liner Temperature Profiles for the Fuel Assembly Internal Temperature Measurement Test (March 4, 1979)

For each backfill media, the heater controllers were set to provide a predetermined liner temperature profile (except for the no band heater tests). Once the test assembly temperatures stabilized, the heater controllers were adjusted to impose the desired canister temperature profile. The test assembly was allowed to reach thermal stabilization, and a final printout recorded. Thermal stabilization was determined by examining the center thermowell midplane thermocouple temperature (T/C 304) and six canister thermocouple temperature (T/C's 417, 421, 425, 431, 435 and 437) readings versus time. The stabilization criteria was that these seven temperatures not vary by more than ±1°F in a 30 minute period. Data logger printouts during the tests were made every four hours.

The evacuation and backfill system affected the canister backfill media changes. For the air backfill tests, the vent valve was left open to the West Process Cell atmosphere. The helium backfill was maintained at 1.0 ± 0.5 psig during each of the helium tests by the preset helium bottle supply pressure and relieved overpressure by opening the vent valve. For either of these two backfills, the test canister was evacuated prior to filling. The vacuum tests were conducted with the vacuum pump running constantly. The system pressure was maintained at about -24 inches of mercury for all vacuum testing.

The testing order varied from the original plan so that different profiles could be run with the same backfill media, shortening the overall testing time. In addition, several problems experienced in the performance of the tests resulted in rerunning several tests. After the first three No Band Heater Tests had been completed in early August, procedural problems prevented continuation with the imposed canister profile tests. Testing resumed in early September with the rerunning of the helium filled No Band Heater Test. The drywell canister profile test followed; however, on September 14 during the vacuum backfill test, a heater controller contact failed in the closed position prior to test stabilization. Further canister profile tests were subsequently halted until new solid state

TABLE 5.3-1
SET POINT TEMPERATURES FOR ELECTRICALLY HEATED DRYWELL TEST CANISTER PROFILES

Initial Tests		Rerun Tests	
T/C No.	Temp. (°F)	T/C No.	Temp. (°F)
417	235	417	244
421	270	421	276
425	275	425	270
431	252	431	250
435	207	435	195
437	180	437	157

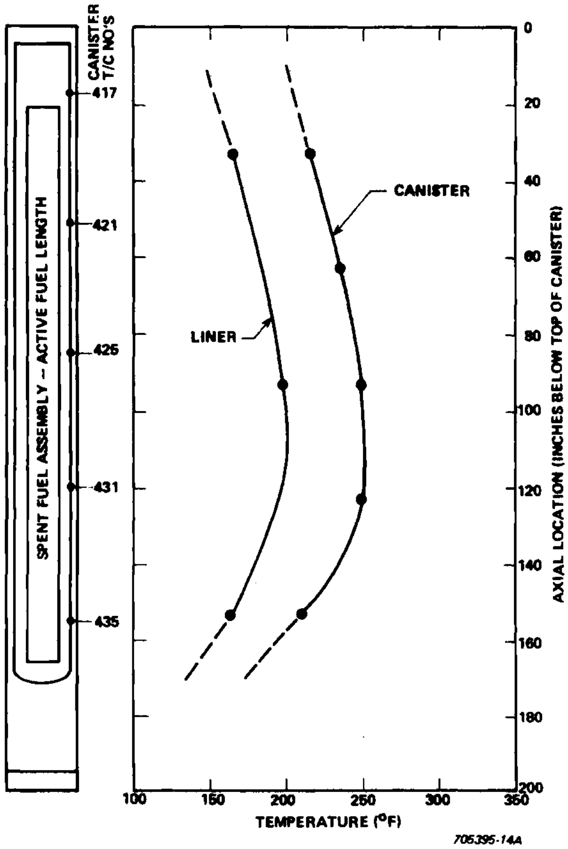

Figure 5.3-3. Drywell 5 (F/A B03) Canister and Liner Temperature Profiles for the Fuel Assembly Internal Temperature Measurement Test (July 1, 1979)

controller contacts, a new set of redundant temperature limiters and a safety alarm and heater controller shutdown circuit could be installed. The two additional No Band Heater Tests were then rerun.

Testing began again in mid-November with the rerunning of the one completed Drywell Canister Profile Test. For each canister imposed temperature test, the heater controller safety shutdown circuit limiter was set at 650°F to prevent fuel assembly clad temperatures from exceeding the design limit. All of the 18 planned canister profile tests were run in succession between November 14, 1979 and February 8, 1980. The test data for the Phase II fuel assembly tests are provided in Appendix F.

Following an evaluation of the results from the vacuum and helium backfill Electrically Heated Drywell Test Canister Profile Tests, it was determined that the canister profile had been inadvertantly transposed. The decision to rerun all three backfill tests with the Electrically Heated Drywell Test Canister profile was made. Testing resumed in June, 1980; however, prior to completing the third test (helium backfill), a leak in the evacuation and backfill system prevented stabilization. Since system examination and repair activities in the West Process Cell were limited to remote operations, this final test rerun was discontinued.

A set of gas samples was taken from the test canister before the rerun tests were performed. The operations for the gas sampling and the results are described in Appendix L. Prior to taking the gas samples, the test stand band heaters were turned on and adjusted to maintain a uniform canister temperature profile of about 500°F. The heatup began on May 30, 1980, and continued through June 4, 1980, when the samples were taken. Following gas sampling, the band heaters were turned off. Appendix L provides temperature data for the canister and thermowells during the gas sampling heated period.

5.3.4 PHASE III TESTING (FUEL ASSEMBLY D15)

Phase III test operations consisted of installing the spent fuel assembly into the test stand canister, placing the test assembly in the West Process Cell for testing, conducting a fuel assembly calorimetry test, and conducting a series of simulated storage cell thermal tests and uniform canister temperature tests with either air, helium or a vacuum inside the test canister. Fuel assembly installation and test assembly completion were performed remotely in the Hot Bay. All testing was performed in the West Process Cell. In addition to the Fuel Assembly Internal Temperature Measurement Test operations, calorimetry of the spent fuel assembly was performed prior to and after test operations using the Boiler Water Calorimeter located in the Hot Bay (see Appendix K).

Phase III operations began in September, 1980. Prior to the start of testing, a printout of all test assembly thermocouples was made with the test assembly installed in the West Process Cell. Data thermocouple 452 was found to be defective and disconnected. The test stand was then moved to the Hot Bay. On September 22, 1980, remote handling operations commenced. PWR fuel assembly D15 was taken from its storage canister assembly in which it had been temporarily stored in the Lag Storage Pit. The fuel assembly was installed with the serial number side of the top nozzle facing test stand $\theta=0°$. The installation procedure is described in detail in Appendix B.

The completed test assembly was moved to and installed in the West Process Cell using the same procedures as those followed in Phase II.

Phase III tests began in late September, 1980. The planned testing sequence was: 1) perform the fuel calorimetry check with the band heaters off, 2) impose an Electrically Heated Drywell Test canister profile, 3) impose the Drywell 5 canister profile, 4) impose the SFT-C canister profile, 5) impose uniform canister temperatures of 350, 400, 450, 500, 550 and 600°F, respectively, and 6) repeat the fuel calorimetry check with band heaters off. As in Phase II, for each test profile, a test would be run with an air, vacuum or helium backfill. Each storage cell canister profile was based on a decay heat level comparable to, yet slightly different from, that of the fuel assembly being tested. For the Electrically Heated Drywell Test, the axial canister and liner profiles shown in Figure 5.3-4 were developed by a linear interpolation for a power

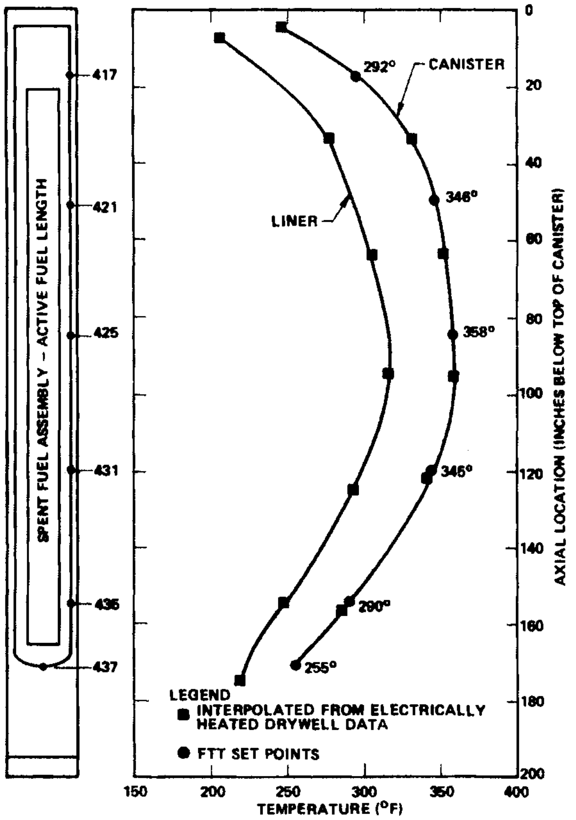

Figure 5.3-4. Set Point Temperatures Interpolated From Electrically Heated Drywell Test Canister and Liner Temperature Profiles at 1.0 kW and 2.0 kW Operation (April 1, 1979 and April 1, 1980 respectively)

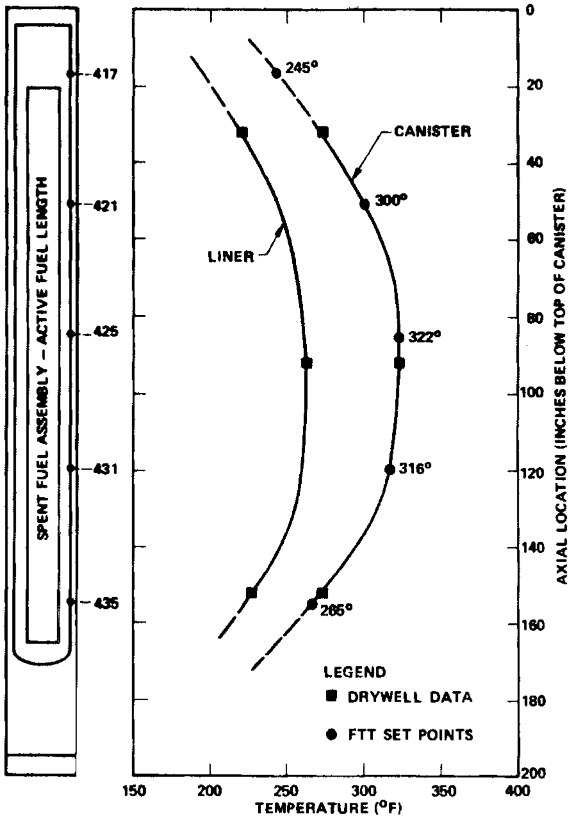

Figure 5.3-5. Set Point Temperatures Derived From Drywell 5 (F/A D22) Canister and Liner Temperature Profiles (October 15, 1980)

level of 1.4 kW using the test data from 1.0 kW and 2.0 kW power level tests on April 1, 1979 and April 1, 1980, respectively. The Drywell 5 axial canister and liner profiles shown in Figure 5.3-5 were taken from test data for fuel assembly D22 on October 15, 1980 when the fuel assembly decay heat level was estimated at about 1.22 kW. The Spent Fuel Test at Climax axial canister profile shown in Figure 5.3-6 was provided by Lawrence Livermore National Laboratory based on a best-fit evaluation of canister temperatures from data about 90 days after canister emplacement for fuel assemblies identical in decay heat to fuel assembly D15. It was also planned that the 550 and 600°F uniform canister temperature tests would be conducted only if the peak fuel clad temperature remained below 715°F.

Twenty-five of the 31 planned canister profile tests were run between September 26, 1980 and January 5, 1981. Several problems experienced in the performance of the tests and the desired shipment date for fuel assembly D15 from E-MAD to the Climax test site resulted in eliminating six of the

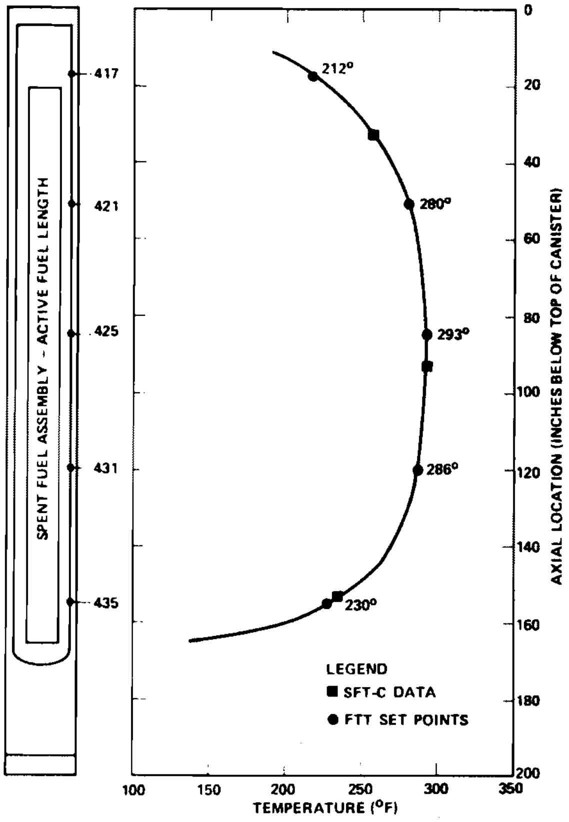

Figure 5.3-6. Set Point Temperatures Derived From Spent Fuel Test at Climax Canister Temperature Profile

test runs. In addition, the availability of the three storage cell canister axial profiles was delayed until near the end of October which altered the order in which the tests were run. Table 5.4-2 summarizes, in chronological order, the tests which were run and the appropriate data table for data from each test.

After the first three No Band Heater Tests had been completed, the 350°F Uniform Canister Temperature Profile Test with air backfill was run. During the test, it was found that a uniform 350°F profile could not be achieved. Temperatures in the canister center portion were about 15°F higher than the desired value. Temperatures on the lower end were 5 to 10°F lower than the desired value. This difference was caused by the convection-induced axial transfer of the heat applied to the canister lower portion by the liner band heaters needed to raise the canister lower end temperatures to 350°F. Because the exact 350°F uniform canister temperature profile could not be achieved for air, the helium and vacuum backfill tests at 350°F were deleted. Later (following the 550°F Uniform Canister Temperature Profile Tests), an evaluation of the canister to center thermowell temperature difference indicated that for the 600°F Uniform Canister Temperature Profile Test the fuel clad temperature limit of 715°F would be exceeded for the air and vacuum backfills. For this reason, these two tests were also deleted.

Two problems were experienced during the storage cell profile tests. The SFT-C canister axial profile was found to be slightly lower than the canister profiles for the No Band Heater Tests. Since the exact canister profile could not be achieved, it was determined that imposing canister temperatures 100°F above the noted profile would meet Lawrence Livermore National Laboratory needs. This higher temperature profile was used for the SFT-C Canister Profile Tests. To allow for the encapsulation and shipment of fuel assembly D15 to the Climax test site in early January, 1981, the last two planned air backfill tests for the Electrically Heated Drywell Test and the SFT-C canister profiles could not be run. However, prior to test assembly disassembly and transfer to the Hot Bay, a second calibration test (with band heaters off and an air backfill) was performed. Following test stand return to the Hot Bay and lid removal, the fuel assembly was removed and placed in the Boiling Water Calorimeter on January 6, 1981 for a second calorimeter reading. A previous calorimetry had been performed on fuel assembly D15 on July 8, 1980 using the Boiling Water Calorimeter.

For each backfill media, the heater controllers were set to provide a predetermined liner temperature profile (except for the No Band Heater Tests). Once the test assembly temperatures stabilized, the heater controllers were adjusted to impose the desired canister temperature profile within ±5°F for the canister profile tests and within ±10°F for the uniform canister tests. The test assembly was allowed to reach thermal stabilization, and a final printout recorded. Thermal stabilization was determined by examining the center thermowell fuel midplane thermocouple (T/C 304) temperature readings versus time. The stabilization criterion was that temperatures not vary by more than ±1°F in a 24 hour period. Data logger printouts during the tests were made every four hours.

The evacuation and backfill system affected the canister backfill media changes in the same manner as it was used in the Phase II tests. The system maintained pressure between -22 and -24 inches of mercury for all vacuum tests.

5.4 TEST RESULTS

This section presents the test results from the Fuel Assembly Internal Temperature Measurement Tests. The results are presented as figures and tables in this section, in Appendix F (thermocouple data tables) and in Appendix J (additional data curves). A results discussion of each set of tests (same canister profile condition with three backfill media) is presented. The temperatures measured in the center thermowell are considered representative of the peak fuel clad temperatures. This is based on an estimated 5 to 7°F maximum difference between fuel clad and measured temperature (see Appendix M). The results of spent fuel assembly calorimetry and the application of the test results to storage cell tests are also included.

5.4.1 PHASE I TEST RESULTS

The results of the Phase I electrical calibration heater tests performed with air in the test canister at power levels of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 kW are presented in Figure 5.4-1. The axial canister profiles provided data points used in evaluating spent fuel assembly decay heat levels. Complete data from the six test runs are provided in Appendix F, Tables F-2 to F-4. For each test run, the test stand was in the same configuration used for the spent fuel assembly tests except for the temporary lid which approximated the actual closure lid's thermal resistance.

5.4.2 PHASE II TEST RESULTS (FUEL ASSEMBLY B43)

Table 5.4-1 presents the actual test order for Phase II tests and identifies the data table in Appendix F for each test.

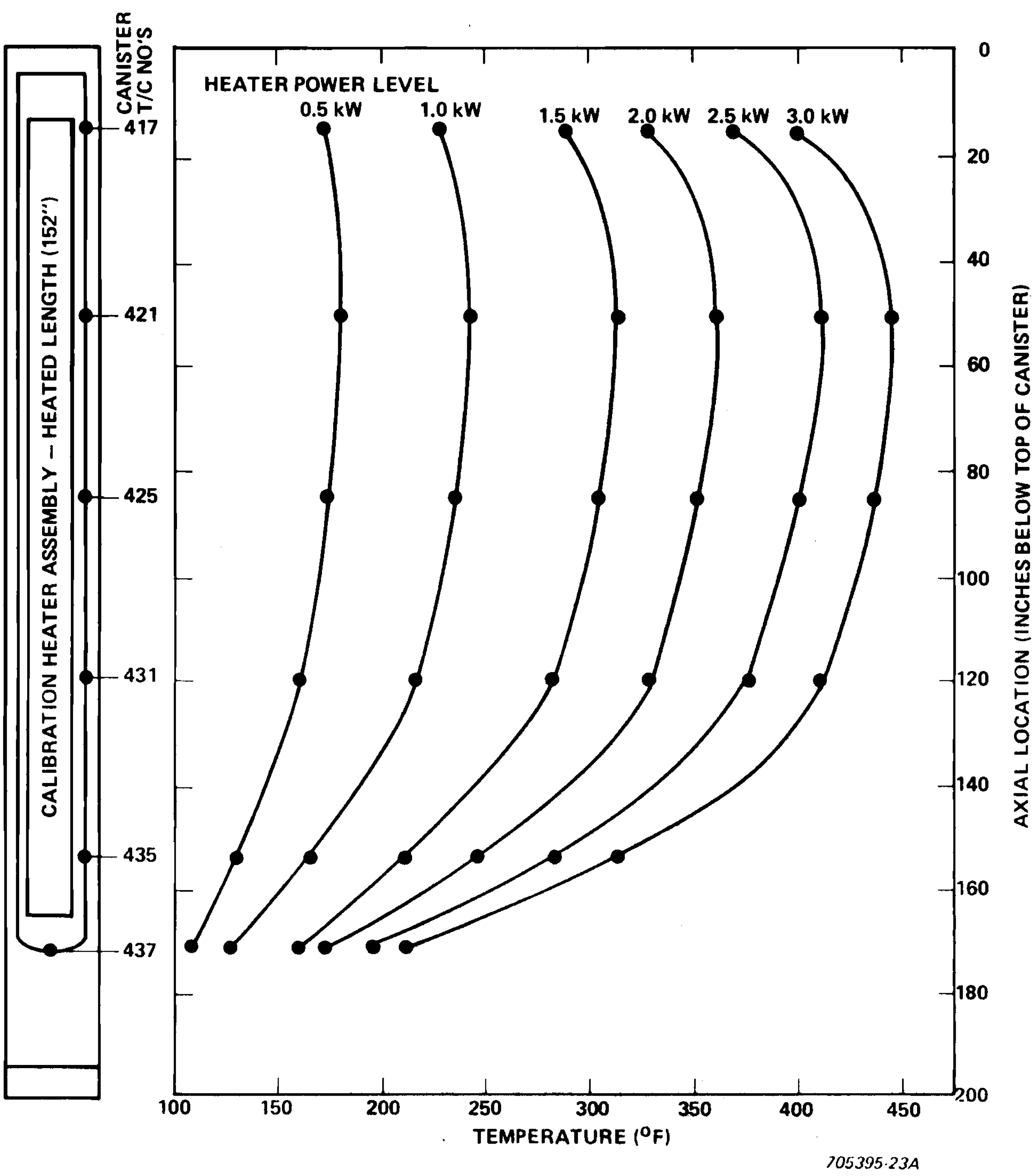

Figure 5.4-1. Canister Temperature Profiles From the Calibration Heater Phase I Tests

TABLE 5.4-1
FUEL ASSEMBLY B43 TEMPERATURE TEST SUMMARY

Test Condition	Backfill	Date Completed	Data Table
Band Heaters Off	Air	7/23/79	F-7
Band Heaters Off	Vacuum	7/25/79	F-5
Band Heaters Off	Helium	8/5/79	F-6
Band Heaters Off (Rerun)	Helium	9/11/79	F-11
Drywell Canister Profile	Helium	9/13/79	F-17
Band Heaters Off (Rerun)	Vacuum	9/18/79	F-8
Band Heaters Off (Rerun)	Air	9/20/79	F-10
Drywell Canister Profile	Air	11/14/79	F-19
Drywell Canister Profile (Rerun)	Helium	11/27/79	F-18
Drywell Canister Profile	Vacuum	11/28/79	F-16
Electrically Heated Drywell Canister Profile	Vacuum	11/29/79	F-11
Electrically Heated Drywell Canister Profile	Helium	11/30/79	F-12
250°F Uniform Canister Profile	Helium	12/6/79	F-21
300°F Uniform Canister Profile	Helium	12/7/79	F-24
400°F Uniform Canister Profile	Helium	12/11/79	F-27
500°F Uniform Canister Profile	Helium	12/17/79	F-30
500°F Uniform Canister Profile	Vacuum	12/20/79	F-29
250°F Uniform Canister Profile	Air	1/4/80	F-22
Electrically Heated Drywell Canister Profile	Air	1/10/80	F-13
300°F Uniform Canister Profile	Air	1/14/80	F-25
400°F Uniform Canister Profile	Air	1/17/80	F-28
500°F Uniform Canister Profile	Air	1/24/80	F-31
400°F Uniform Canister Profile	Vacuum	1/30/80	F-26
250°F Uniform Canister Profile	Vacuum	2/8/80	F-20
300°F Uniform Canister Profile	Vacuum	2/11/80	F-23
Electrically Heated Drywell Canister Profile (Rerun)	Air	6/17/80	F-15
Electrically Heated Drywell Canister Profile (Rerun)	Vacuum	6/25/80	F-14

5.4.2.1 SPENT FUEL ASSEMBLY CALIBRATION RESULTS

Data gathered during testing with air in the canister and no band heater power were used in determining spent fuel assembly decay heat levels. The No Band Heater Test run completed on September 20, 1979 provided a set of data at the beginning of the Phase II testing. Data acquisition continued during the delay from September to November and the data available just prior to testing resumption on November 11 provided a second set of no band heater power temperatures. After the scheduled testing was completed and prior to rerunning the Electrically Heated Drywell Test Canister Profile Tests, a third data set was gathered in April, 1980. These three canister axial temperature profiles are shown in Figure 5.4-2 along with the Phase I 0.5 and 1.0 kW canister axial temperature profiles. The profiles shown are normalized so all five data sets have a common West Process Cell ambient temperature of 80°F (ambient temperatures ranged from 71 to 82°F).

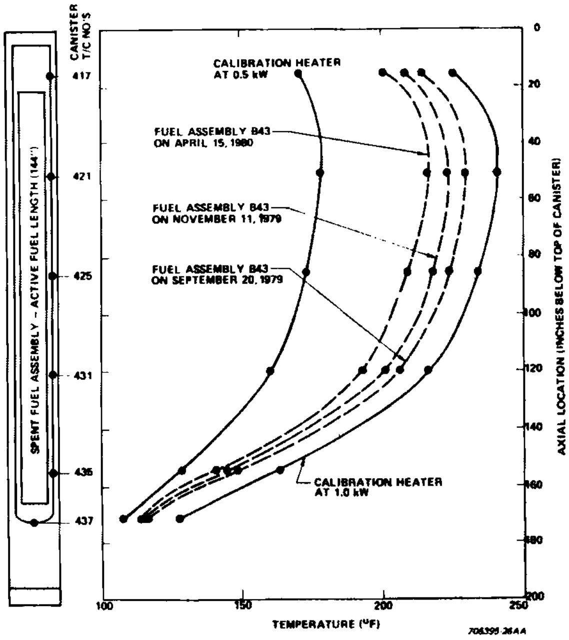

Figure 5.4-2. Fuel Assembly B43 Calibration: Canister Temperature Profiles

To determine the relative spent fuel assembly decay heat levels, the calibration heater and spent fuel assembly canister temperatures at the three elevations nearest the fuel assembly midplane (51, 86, and 120 inches below top of canister) were compared. These three data sets were judged to be least affected by canister thermal end effects. A set of canister temperature versus power level curves was established for the average thermocouple readings for each elevation using the 0.5 and 1.0 kW calibration heater test results. A straight line approximation between data points at each power level was assumed. The averaged canister temperatures for the three data sets were plotted on the curves to establish the relative power levels. Table 5.4-2 summarizes the fuel assembly decay heat levels determined by this method.

The above method of spent fuel assembly decay heat determination does not account for the differences in assembly heated lengths (152 inches for the calibration heater and 144 inches for the fuel assembly) and the nonuniform decay heat distribution in the fuel assembly. A second method of decay heat determination compares the heat fluxes to the canister (measured as the difference between the canister and ambient temperature) to account for these differences. The heated length differences effect was considered by ratioing the two lengths. The nonuniform heat distribution effect was examined using the gamma activity measurement profile obtained during the spent fuel assembly nondestructive examination. The gamma activity measured along the fuel assembly center 6 feet was 17.4 percent higher than the gamma activity for the entire fuel assembly. The combined effect of heated length difference and nonuniformity caused the canister spent fuel assembly heat flux to be 25 percent higher than the calibration heater flux. This factor applied to the canister temperature data from the 0.5 and 1.0 kW calibration heater tests resulted

TABLE 5.4-2
FUEL ASSEMBLY B43 DECAY HEAT LEVEL DETERMINED FROM TEST DATA VERSUS CALIBRATION DATA

I. Canister Temperature Comparison Method

T/C Elevation (Inches Below Top of Canister)	Date 9/20/79	 11/11/79	 4/15/80
51	0.912 kW	0.870 kW	0.790 kW
86	0.920 kW	0.870 kW	0.780 kW
120	0.915 kW	0.850 kW	0.768 kW
Average	0.916 kW	0.863 kW	0.779 kW

II. Canister/Ambient Temperature Difference Method

T/C Elevation (Inches Below Top of Canister)	Date 9/20/79	 11/11/79	 4/15/80
51	0.682 kW	0.640 kW	0.581 kW
86	0.691 kW	0.651 kW	0.585 kW
120	0.685 kW	0.642 kW	0.575 kW
Average	0.686 kW	0.644 kW	0.580 kW

III. Predicted Decay Heat

Date 9/20/79	 11/11/79	 4/15/80
0.807 kW	0.778 kW	0.698 kW

in an adjusted set of canister/ambient temperature difference versus power level curves. Again, a straight line approximation between data points was assumed. Table 5.4-2 summarizes the fuel assembly decay heat levels determined by this method.

The decay heat levels predicted from Fuel Assembly Internal Temperature Measurement Test calorimetry data by the previous two methods were compared to the decay heat curve predicted using the ORIGEN 2 code. Figure 5.4-3 shows the predicted nominal decay heat and the data points from the two previous methods. The three calorimetry data points determined by the canister temperature comparison are 12 percent higher than the nominal predicted decay heat level. The three calorimetry data points determined by the adjusted canister/ambient temperature comparison are 16 percent lower than the nominal predicted decay heat level. The differences in the decay heat levels may be attributed

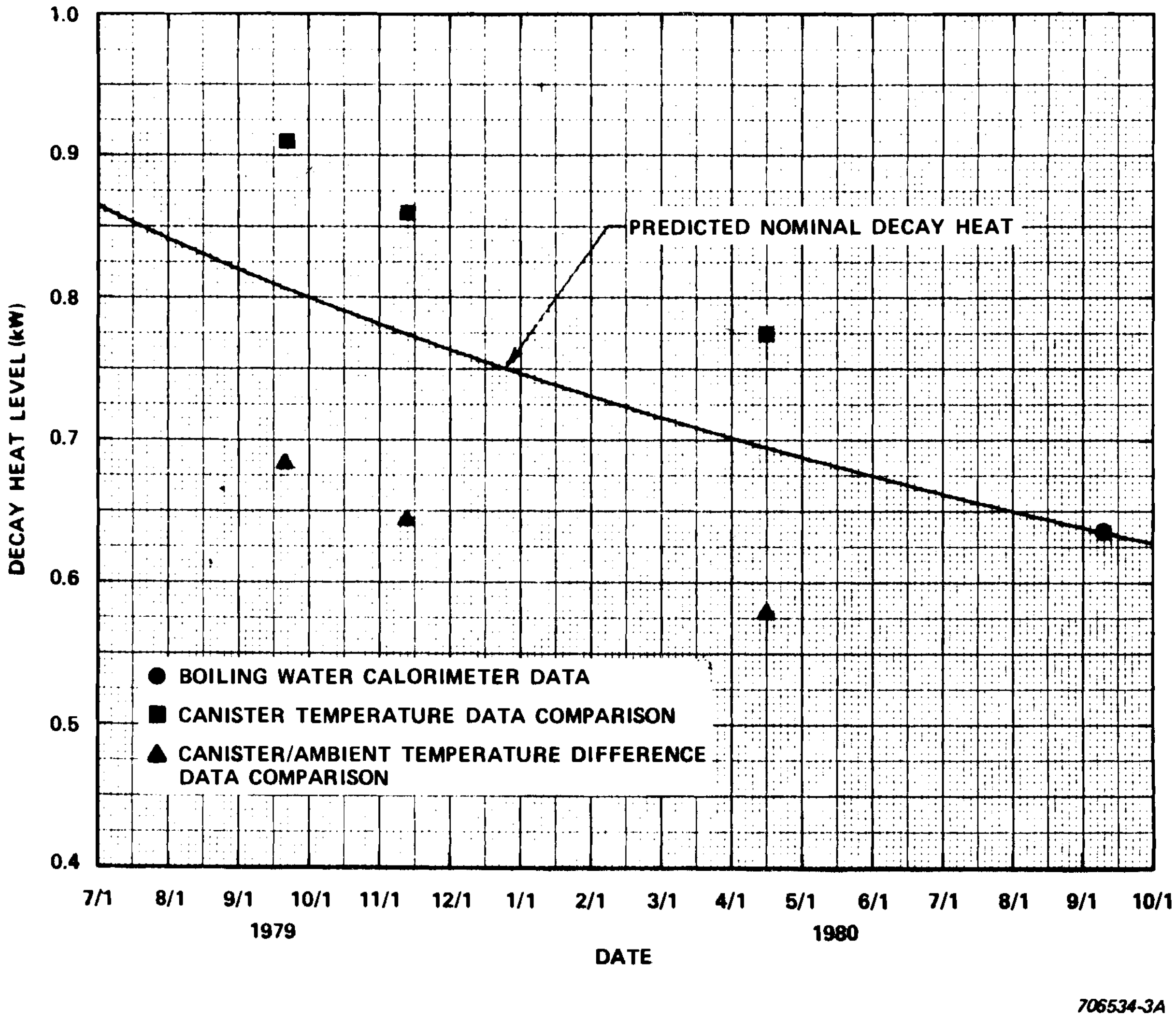

Figure 5.4-3. Comparison of Calorimetry Data With Predicted Decay Heat Curve for Fuel Assembly B43

to heat transfer inside an air filled canister and the two decay heat determination methods handling of these heat transfer effects.

If all the heat from the fuel assembly or calibration heater is transferred to the canister by convection, the canister temperature comparison method would yield fairly accurate results. In this case the heated length differences and nonuniformity would not influence canister temperatures. If, on the other hand, all the heat from the fuel assembly or calibration heater is transferred radially to the canister by conduction and radiation, the adjusted canister/ambient temperature difference comparison method would yield fairly accurate results. However, heat transfer occurs by a combination of convection, conduction, and radiation. The Phase II test results show that convection dominates the transfer modes for air in the canister, but the exact proportion could not be determined. Since some heat is transferred radially by conduction and radiation, an exact decay heat determination method has not been developed. The proportions of heat transferred axially and radially must be known to properly account for the heated length and nonuniform heat distribution differences between the two assemblies. However, the two methods used can be assumed to have provided a range encompassing the actual decay heat levels.

It can then be concluded that spent fuel assembly calibration using the Fuel Assembly Internal Temperature Measurement Test provides only a rough estimate of the spent fuel decay heat level. For this reason, the nominal predicted decay heat levels determined from Figure 5.4-3 provide a measure of relative decay heat levels for the various fuel assembly tests performed over a six month period.

5.4.2.2 NO BAND HEATER TESTS RESULTS

Two sets of tests were run without band heater power, each set with an air, vacuum and helium backfill. The first set of No Band Heater Tests was run in late July and early August, 1979. The second set of No Band Heater Tests was performed in September, 1979. Test data for the first set of vacuum, helium and air test runs are provided in Tables F-5, F-6 and F-7, respectively and the data for the second set are provided in Tables F-8, F-9 and F-10, respectively. The second set of test runs provided a better reference point for the imposed canister profile tests.

The results from the first set of No Band Heater Tests are shown in Figure 5.4-4. The figure shows the center thermowell axial temperature and canister axial temperature profiles for air, helium and vacuum backfill conditions. The tests were performed in succession with the only test condition change being the gas medium. The test results provide significant information relative to heat transfer mechanisms present. In addition, since there is no imposed liner temperature with these test results, the effects of canister, liner and closure lid thermowell configurations on fuel assembly temperatures can be evaluated.

A comparison of the canister temperature profiles in the canister middle and bottom sections shows the vacuum backfill canister

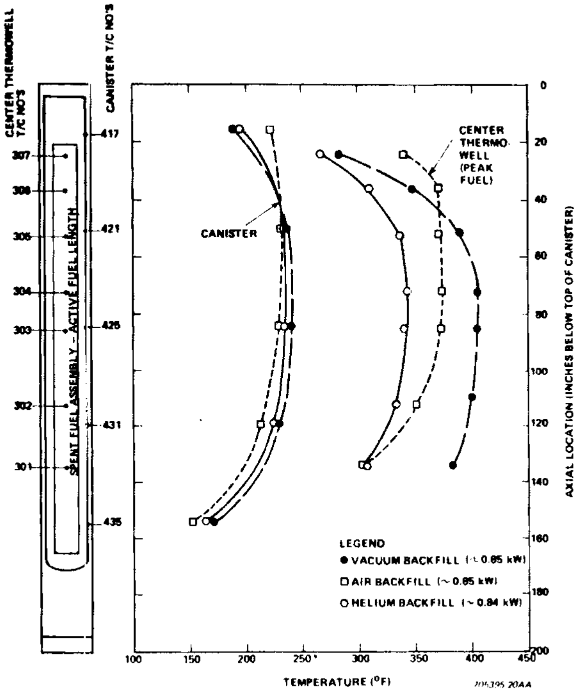

Figure 5.4-4. No Band Heater Test Temperature Profiles (F/A B43)

produced the highest canister temperatures, the helium backfill produced the next highest, and the air backfill produced the lowest. Near the canister top however, the order of temperatures was reversed, i.e., air, helium and vacuum backfills produced the highest to lowest temperatures. The maximum variation between the highest and lowest temperatures was only 20°F.

Comparing the center thermowell temperature profiles shows the helium backfill produced the lowest temperatures (except at the lowest thermocouple). In the lower and middle sections, the air backfill produced the next higher temperature and the vacuum backfill produced the highest. The air backfill temperatures in the top section were again the highest. The variation between highest and lowest temperatures ranged between 70 and 80°F.

These results can be explained by evaluating the heat transfer occurring in each backfill medium. With a vacuum, radiation should be the only means of transferring heat to the test canister. At the low temperatures (less than 400°F), the amount of heat transferred radially by radiation to the canister is less than that for either air or helium. Heat transfer at the canister top end was significantly different from the bottom end. This was due to test canister configuration (a long vertical cylindrical tube with a flat upper lid and an ellipsoidal bottom end) and 15 long thermowells inserted into the fuel assembly top.

If both canister ends were the same configuration, if the canister was horizontal rather than vertical, and assuming uniform fuel assembly decay heat distribution, both canister and center thermowell profiles should be symmetrical about the fuel assembly midplane. The two different canister end configurations and the air convection effects between the canister and liner cause the canister temperature profile for the vacuum backfill to be skewed towards the canister top.

The fuel rod temperatures should follow the canister temperatures for a vacuum except near the ends. However, the temperatures recorded near the fuel assembly top decrease below the temperatures at the fuel assembly bottom. This indicates a greater amount of heat is conducted into the canister lid. Since only radiation heat transfer is available, axial heat conduction along the 15 thermowell tubes is a plausible explanation.

A comparison of the relative radial heat flow to the canister with the relative gamma activity measured during the nondestructive testing was made. This investigated whether the drop-off in center thermowell temperature was due to a nonuniform fuel assembly decay heat profile. The gamma activity measurements made in the center instrumentation tube at 13 elevations along the fuel assembly length were averaged and normalized to the average. The normalized gamma activity data were plotted and showed a decrease in gamma activity at both fuel assembly ends. The plot is shown in Figure 5.4-5. Temperature data at five axial locations generated during the vacuum backfill No Band Heater Test (as well as the vacuum backfill Uniform Canister Temperature Profile Tests) were used to calculate relative heat flows along the canister. The absolute center thermowell and canister temperatures were raised to the fourth power and the differences averaged and normalized to the average. This provided relative heat flow values comparable to the normalized gamma activity data. These data points are included in Figure 5.4-5.

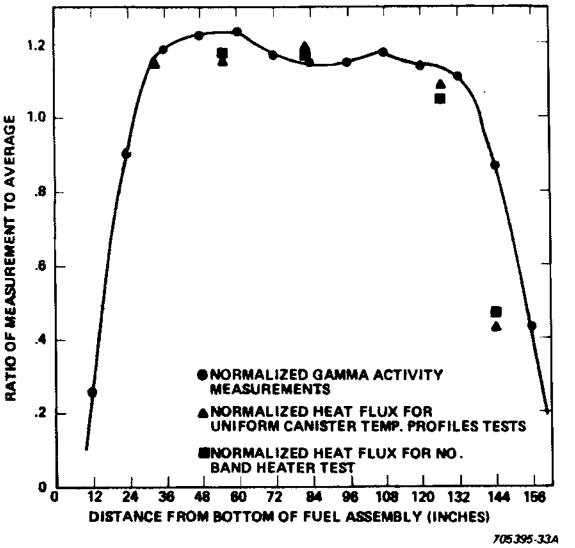

Figure 5.4-5. Comparison of Normalized Fuel Assembly Center Instrument Tube Gamma Activity Measurements with Normalized Vacuum Backfill Test Results (F/A B43)

The normalized gamma activity and heat flow comparisons at elevations 30, 52, 79, and 112 inches above the bottom of the active fuel agreed within five percent. At the top fuel assembly thermocouple (140 inches above the bottom of the active fuel), the normalized heat flow value was 51 percent of the normalized gamma value. This indicates that the spent fuel assembly temperature decrease at the fuel top is due to canister thermal end effects rather than to the nonuniform decay heat profile.

With helium and air inside the canister, radial heat transfer by conduction and axial heat transfer by convection are available. For helium backfill, the amount of radial heat conduction is higher than that for air. This is evidenced by the lowest temperature gradient between the center thermowell and canister for helium. For the air backfill case, the amount of axial heat convection is greater than that for helium. This is evidenced by the divergence of the two center thermowell temperature profiles. A comparison of the relative amount of convection within the canister was made using the difference between canister and ambient temperature as a measure of heat flux at the canister bottom and top. At the canister bottom, the canister/ambient temperature difference is lower by eight percent and 17 percent for helium and air backfills respectively when compared to the vacuum backfill. At the canister top, the canister/ambient temperature differences for helium and air backfills are seven percent and 21 percent higher than the vacuum backfill, respectively. It can be concluded that the air backfill is twice as effective as an axial heat convector than the helium backfill.

As with the vacuum backfill, both the helium and air backfill center thermowell temperature profiles decreased at the fuel assembly top. This indicates axial heat transfer through the 15 thermowells to the canister lid. This effect is greater for the helium backfill than for the air backfill as shown by the larger helium backfill temperature decrease. Since a greater amount of axial heat transfers to the upper end of the canister with the air backfill, additional heat transfer by thermowell conduction has only a slight effect on the air backfill thermowell temperatures.

5.4.3.3 ELECTRICALLY HEATED DRYWELL TEST CANISTER PROFILE TESTS RESULTS

Two sets of tests were run using the Electrically Heated Drywell Test canister profile, each set with an air, vacuum and helium backfill. The first set of tests was run in November, 1979 with vacuum and helium backfills and in January, 1980 with air backfill. An evaluation of the imposed canister profiles revealed that the vacuum and helium backfill tests had been run using an inverted canister temperature profile. All three tests were then rerun in June, 1980. A leak in the test backfill system prevented the second helium backfill test from being completed. Test data for the first set of vacuum, helium and air test runs are provided in Tables F-11, F-12 and F-13, respectively. Test data for the rerun vacuum and air test runs are provided in Tables F-14 and F-15, respectively.

Figures 5.4-6 and 5.4-7 show the axial temperature profiles imposed on the test canister, the actual canister temperature data points from the Electrically Heated Drywell Test, and the center thermowell temperatures for the initial tests and the rerun of two tests. Although the three canister profiles are slightly different, the center thermowell axial temperature profiles for each exhibit the same relationships described previously for the No Band Heater Tests. For example, the helium backfill produced the lowest center thermowell temperatures, the air backfill produced the next higher (except in the top region) and the vacuum backfill produced the highest (except in the top region).

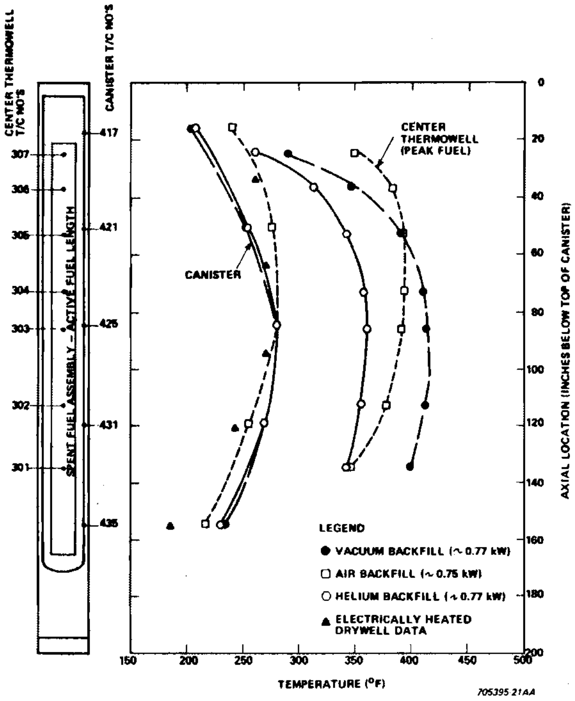

Figure 5.4-6. Electrically Heated Drywell Test Canister Profile Test Temperature Profiles (F/A B43)

Since the five test runs were performed during three time periods, the relative fuel assembly decay heat level is important for any comparison. The relative decay heat levels can be determined from the decay heat curve in Figure 5.4-3. For the initial vacuum and helium tests, the decay heat level was 0.77 kW; for the initial air test, the decay heat level was 0.75 kW; and for the air and vacuum test reruns, the decay heat level was 0.67 kW. The center thermowell and canister temperature differences for the two air backfill tests can be compared to the decay heat levels change. The temperature differences along the entire axial profile were nine percent lower for the rerun test. This compares to

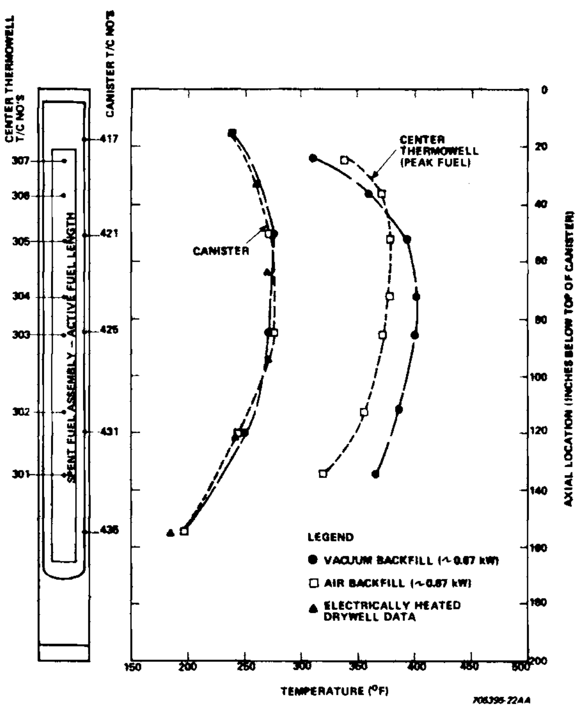

Figure 5.4-7. Rerun Electrically Heated Drywell Test Canister Profile Test Temperature Profiles (F/A B43)

an estimated 12 percent decrease in decay heat level based on the nominal predicted decay heat curve.

The initial set of canister profiles for helium and vacuum backfill differed slightly from the air backfill test and the desired profile. However, the canister temperatures at the elevation of the peak center thermowell temperature were about the same for all three backfills. Table 5.4-3 summarizes the peak center thermowell temperatures for the Electrically Heated Drywell Test Canister Profile Tests. In addition, a complete cross sectional map of canister and thermowell temperature readings for the three backfill media tests (at an elevation near the active fuel midplane) are provided in Figure J-1 in Appendix J.

5.4.2.4 DRYWELL 5 CANISTER PROFILE TESTS RESULTS

Four tests were run using the canister profile from Drywell 5. A complete set of air, helium and vacuum backfill tests was run in succession in November, 1979 following an early helium backfill test run in September, 1979. Test data from these tests are provided in Tables F-16 through F-19. The relative spent fuel assembly decay heat levels are estimated to be 0.81 kW for the early helium backfill test, 0.78 kW for the air backfill test, and 0.77 kW for the helium and vacuum backfill tests.

The results of the three sequential Drywell Canister Profile Tests are shown in Figures 5.4-8 and 5.4-9. Figure 5.4-8 presents the axial temperature profiles imposed on the canister, the actual Drywell 5

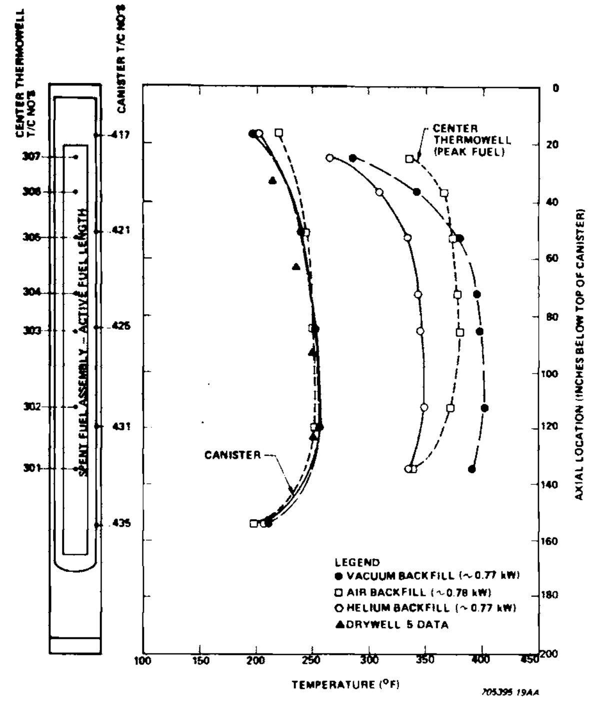

Figure 5.4-8. Drywell 5 Canister Profile Test Temperature Profiles (F/A B43)

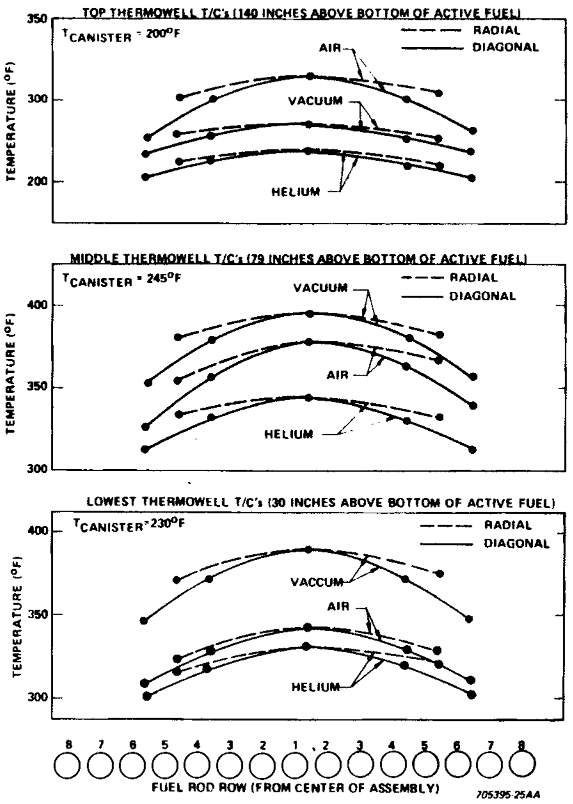

Figure 5.4-9. Drywell 5 Canister Profile Test Radial and Diagonal Temperature Profiles (F/A B43)

canister temperature data points, and the center thermowell axial temperatures for all three backfill media. Figure 5.4-9 presents three sets of radial and diagonal thermowell temperature curves for the top, middle and bottom elevation thermocouples. Table 5.4-3 summarizes the maximum temperatures recorded for each test. A complete cross sectional map of canister and thermowell temperature readings for the three backfill media (at an elevation near the active fuel midplane) are provided in Figure J-2 and in Appendix J.

The axial temperature profiles in Figure 5.4-8 are similar to those in Figure 5.4-5 for the No Band Heater Tests. The helium backfill test center thermowell temperatures are the lowest, showing a higher helium thermal conductivity. The air backfill test center thermowell temperatures are skewed toward the fuel assembly top, showing air to be a better convector than helium. The vacuum backfill test center thermowell temperatures are the highest, (except near the top) showing that radiation alone is the least effective heat transfer method. The maximum thermowell temperatures occurred at the elevation slightly above the active fuel midplane for the helium and air backfill tests. They occurred at a slightly lower elevation for the vacuum backfill test (due most likely to the higher than desired temperature profile).

Comparing the three sets of curves shown in Figure 5.4-9 confirms the heat transfer mechanisms present for each backfill. The three sets of curves show thermowell data for the center position, for two radially opposite positions, and for a pair of diagonally opposite positions at elevations 30, 79 (near midplane) and 140 inches above the bottom of the active fuel. For the vacuum backfill, where radiation alone transfers heat from the fuel rods to the canister, the radial and diagonal profiles are expected to be the steepest (from center to outer row). In addition, the profiles would not be expected to vary along the fuel assembly length (neglecting end effects). The bottom and midplane elevation profiles in Figure 5.4-9 show the vacuum backfill to be the steepest and nearly constant. However, the top elevation profiles show a very flat vacuum backfill profile with a shape similar to the helium backfill profile. This indicates that

TABLE 5.4-3
SUMMARY OF STORAGE CELL CANISTER PROFILE TESTS FOR FUEL ASSEMBLY B43

Profile and Canister Backfill	Predicted Decay Heat Level (kW)	Canister Temperature (°F)	Center Thermowell Temperature (°F)
Electrically Heated Drywell Test			
Helium	0.766	276	363
Vacuum	0.767	276	412
Air	0.745	279	393
Vacuum	0.667	271	402
Air	0.670	274	378
Drywell 5			
Helium	0.812	248	345
Helium	0.768	247	341
Vacuum	0.767	247	399
Air	0.775	244	377

heat transfer occurs by more than just radiation in the radial direction (probably by axial conduction along the 15 thermowell tubes).

For the helium backfill, the radial and diagonal profiles are expected to be the flattest since the primary heat transfer mode is by conduction in the radial direction. At all three elevations, the helium backfill profile is indeed the flattest. The profiles at the bottom and midplane elevations are nearly identical whereas the top elevation profile is much flatter. The top elevation profile shows a more uniform heat transfer across the fuel assembly width due to axial conduction to the flat canister closure lid. Axial conduction would be by the helium itself and by the 15 thermowell tubes; however, the exact effect of the tubes has not been evaluated.

With air as the canister backfill, the primary heat transfer modes are convection in the axial direction and conduction and radiation in the radial direction. The radial and diagonal profiles are expected to be somewhat flatter than those for the vacuum and yet steeper than those for the helium since the thermal conductivity of air is less than helium. The lower and midplane elevation profiles in Figure 5.4-9 show this to be the case. The top elevation air backfill profiles are very similar to helium's at the midplane elevation.

They differ from the vacuum and helium backfill profiles at higher temperatures. This is due to the dominance of convection. The air backfill convects heat from the lower end of the fuel assembly to the top raising the top fuel rod temperatures (as measured by the thermowell thermocouples). Being such a good convector, air transfers the majority of fuel rod heat upward as it rises through the fuel assembly. There it is lost to the canister body as it falls in the annulus between the fuel assembly and canister. The top elevation air backfill profiles are nearly identical to the vacuum backfill profiles at the lower two elevations. This indicates there is some radial heat transfer (assumed to be radiation) across the fuel rod bundle.

5.4.2.5 UNIFORM CANISTER TEMPERATURE PROFILE TESTS RESULTS

Uniform Canister Temperature Profile Tests were run using imposed canister temperatures of 250, 300, 400 and 500°F for the vacuum, helium and air backfills. These tests were performed from December, 1979 through February, 1980. Test data from these 12 tests are provided in Appendix F, Tables F-20 through F-31 with the three backfill tests for each canister temperature profile grouped together. The fuel assembly decay heat level decreased from an estimated 0.76 kW for the first test to 0.73 kW for the last test.

The Uniform Canister Temperature Profile Test results are presented in Figures 5.4-10 to 5.4-13 which show the axial canister and center thermowell temperature profiles for all three backfills for the 250, 300, 400 and 500°F tests, respectively. Table 5.4-4 summarizes the peak temperatures recorded for each test. Cross sectional maps of canister and thermowell temperature readings for the 500°F Uniform Canister Temperature Profile Tests at an elevation near the active fuel midplane are provided in Figure J-3 in Appendix J.

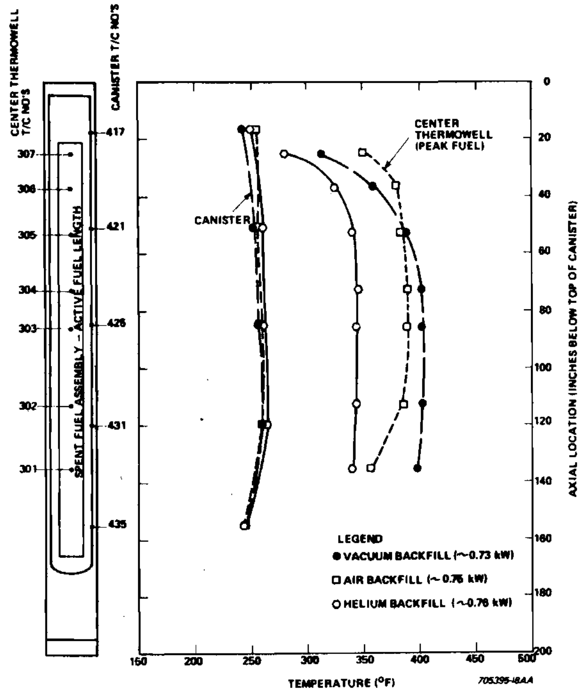

Figure 5.4-10. 250°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A B43)

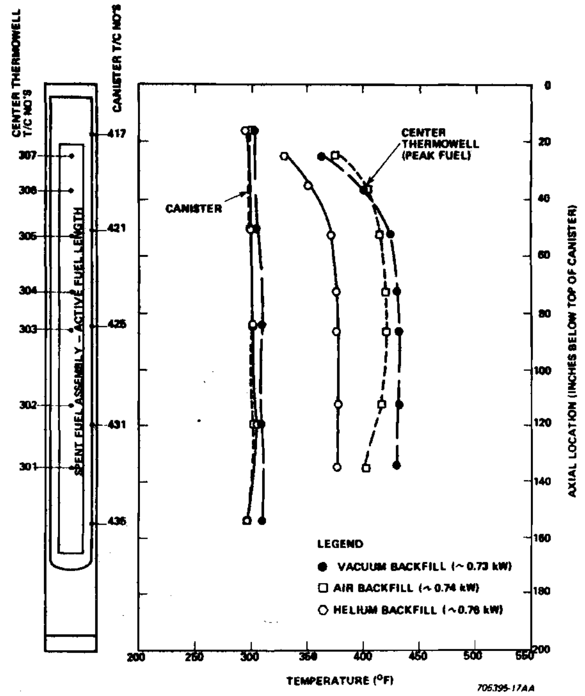

Figure 5.4-11. 300°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A B43)

The axial center thermowell temperature profiles of Figures 5.4-10 to 5.4-13 show the same basic relationships between the effects of backfill media as do the No Band Heater Tests and storage cell canister profile tests. From each figure, it is seen that air is a better axial heat convector but a poorer radial heat conductor than helium. At the fuel assembly top, the center thermowell temperatures are higher for the air backfill than for helium and vacuum backfills. This indicates that convection transported heat from the fuel assembly lower section to the top section. As the canister temperature increased, the difference between the three backfill media center thermowell temperatures decreased. The air backfill and vacuum backfill profiles are nearly identical at the 500°F uniform canister temperature (the variation being less than 5°F). For an air filled canister, as the canister and fuel rod temperatures increase, radiation transfers more heat from the fuel rods radially to the canister with less convection occurring. The helium backfill shows a lower center thermowell temperature profile than the air and vacuum backfills indicating heat transfer by radiation and conduction.

Figure 5.4-14 presents the relationship of center thermowell/canister temperature difference versus canister temperature near the active fuel midplane for all three backfills. This relationship was used to determine the applicability of the Uniform Canister Temperature Profile Test data. Data from the canister and center thermowell thermocouples located 7 and 40 inches above the active fuel midplane (where thermocouple elevations corresponded) were used.

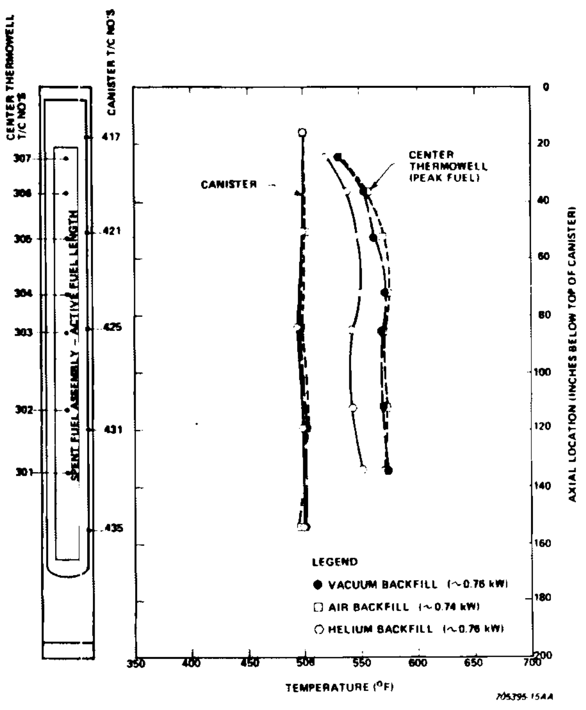

Figure 5.4-12. 400°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A B43)

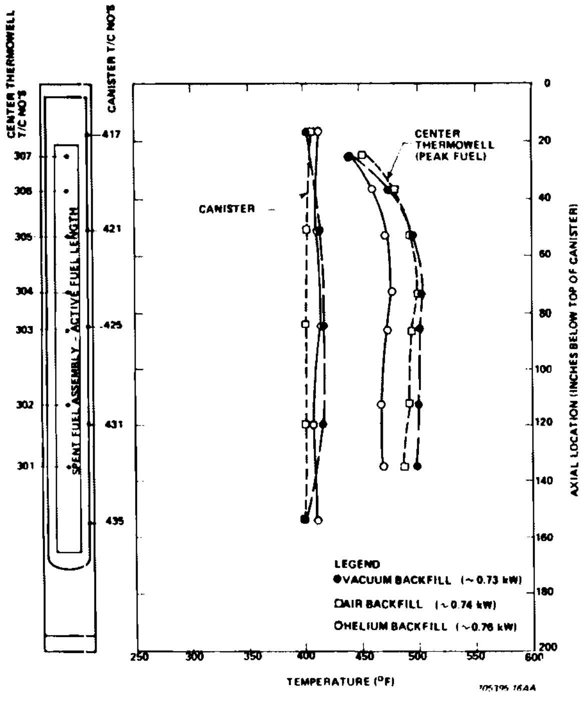

Figure 5.4-13. 500°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A B43)

These data were normalized to represent a fuel assembly decay heat level of 0.85 kW by multiplying the measured temperature difference by the ratio of this decay heat level and that for each test (see Tables 5.4-3 and 5.4-4). The curves shown were either drawn through the uniform canister temperature profile data (solid line) or were developed from a curve fit of the nonuniform canister temperature profile and data (dashed line). The nonuniform profile data for air and vacuum show a smaller center thermowell/canister temperature difference than the uniform data whereas those for helium show very little difference. The axial convection and/or conduction of heat being applied to the canister lower end to make the profile uniform can explain this phenomenon. In air, some of the extra heat convected upward is transferred to the fuel rods. For the vacuum, some of the extra heat is conducted axially up the fuel rods.

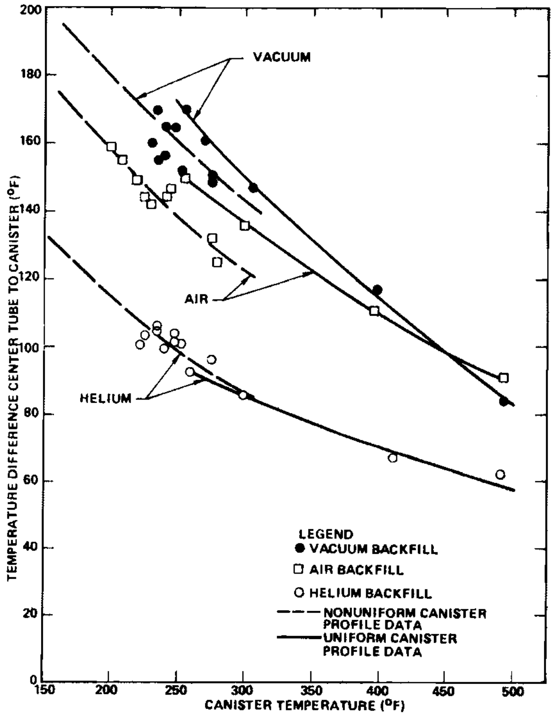

Figure 5.4-14. Center Tube/Canister Temperature Difference Versus Canister Temperature Profiles Near the Active Fuel Midplane (F/A B43)

The relationship of center thermowell/canister temperature difference versus canister temperature for each of the three backfills at five different elevations is provided in Figure J-4. These illustrations also show the difference between uniform profile data (solid lines) and nonuniform profile data (dashed lines). Also included are centerline curves which show the recorded data range. Since the measured data (not normalized) is presented, the relationships shown are slightly different from those on Figure 5.4-14. This is a result of the range of test decay heat levels (0.85 to 0.67 kW). Because of this, the relationships presented in Figure 5.4-14 are considered to be more representative than those in Figure J-4.

5.4.3 PHASE III TEST RESULTS (FUEL ASSEMBLY D15)

Table 5.4-5 presents the actual test order for Phase III tests and identifies the data table in Appendix F for each test.

5.4.3.1 SPENT FUEL ASSEMBLY CALIBRATION RESULTS

Data gathered during Phase III testing for the conditions of air in the canister and no band heater power were used to determine fuel assembly D15 decay heat levels. The No Band Heater Test run, completed on September 26, 1980, provided the first data set. After the scheduled testing was completed another set of No Band Heater Test data was gathered on January 5, 1981. Canister axial temperature

TABLE 5.4-4
SUMMARY OF UNIFORM CANISTER TEMPERATURE PROFILE TESTS FOR FUEL ASSEMBLY B43

Profile and Canister Backfill	Predicted Decay Heat Level (kW)	Canister Temperature (°F)	Center Thermowell Temperature (°F)
250°F Canister Temp			
Vacuum	0.730	254	402
Helium	0.762	259	343
Air	0.748	256	388
300°F Canister Temp			
Vacuum	0.728	305	432
Helium	0.762	298	378
Air	0.743	299	419
400°F Canister Temp			
Vacuum	0.734	398	502
Helium	0.761	410	476
Air	0.741	396	495
500°F Canister Temp			
Vacuum	0.756	491	570
Helium	0.757	489	551
Air	0.738	493	575

profiles derived from these data are shown in Figure 5.4-15 with the Phase I 1.0 and 1.5 kW canister axial temperature profiles. The profiles have been normalized so that all five data sets have a common West Process Cell ambient temperature of 80°F (ambient temperatures ranged from 76 to 85°F).

To determine the relative spent fuel assembly decay heat levels, the calibration heater and spent fuel assembly canister temperatures were compared. These two comparisons were made at the three elevations nearest the fuel assembly midplane (51, 86, and 120 inches below canister top). The data sets were judged to be least affected by canister thermal end effects. The two Fuel Assembly Internal Temperature Measurement Test methods of determining spent fuel assembly decay heat were discussed in Section 5.4.2. Table 5.4-6 summarizes the fuel assembly decay heat levels determined by both methods.

The decay heat levels predicted from these methods were compared to

TABLE 5.4-5
FUEL ASSEMBLY D15 TEMPERATURE TEST SUMMARY

Test Condition	Backfill	Date Completed	Data Table
Band Heaters Off	Air	9/26/80	F-34
Band Heaters Off	Vacuum	9/30/80	F-32
Band Heaters Off	Helium	10/3/80	F-33
350°F Uniform Canister Profile	Air	10/8/80	F-43
400°F Uniform Canister Profile	Air	10/10/80	F-45
500°F Uniform Canister Profile	Air	10/17/80	F-50
500°F Uniform Canister Profile	Vacuum	10/20/80	F-48
500°F Uniform Canister Profile	Helium	10/22/80	F-49
400°F Uniform Canister Profile	Helium	10/27/80	F-44
400°F Uniform Canister Profile	Vacuum*	10/31/80	*
450°F Uniform Canister Profile	Vacuum*	11/3/80	*
450°F Uniform Canister Profile	Helium	11/5/80	F-46
450°F Uniform Canister Profile	Air	11/7/80	F-47
550°F Uniform Canister Profile	Air	11/12/80	F-53
550°F Uniform Canister Profile	Vacuum	11/14/80	F-51
550°F Uniform Canister Profile	Helium	11/17/80	F-52
600°F Uniform Canister Profile	Helium	11/20/80	F-54
Drywell Canister Profile	Air	12/8/80	F-40
Drywell Canister Profile	Vacuum	12/10/80	F-38
Drywell Canister Profile	Helium	12/14/80	F-39
Electrically Heated Drywell Canister Profile	Helium	12/19/80	F-37
SFT-C Canister Profile	Helium	12/22/80	F-42
SFT-C Canister Profile	Vacuum	12/27/80	F-41
Electrically Heated Drywell Canister Profile	Vacuum	12/31/80	F-36
Band Heaters Off	Air	1/5/81	F-35

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*Test backfill was not vacuum; data therefore not included

the predicted decay heat curve and to the Boiling Water Calorimeter data. Figure 5.4-16 shows the predicted nominal decay heat, the data points from the two methods of Fuel Assembly Internal Temperature Measurement Test decay heat determination, and the data points from the two Boiling Water Calorimeter tests. The two calorimetry data points determined by the canister temperature comparison are six percent higher than the nominal predicted decay heat level. The

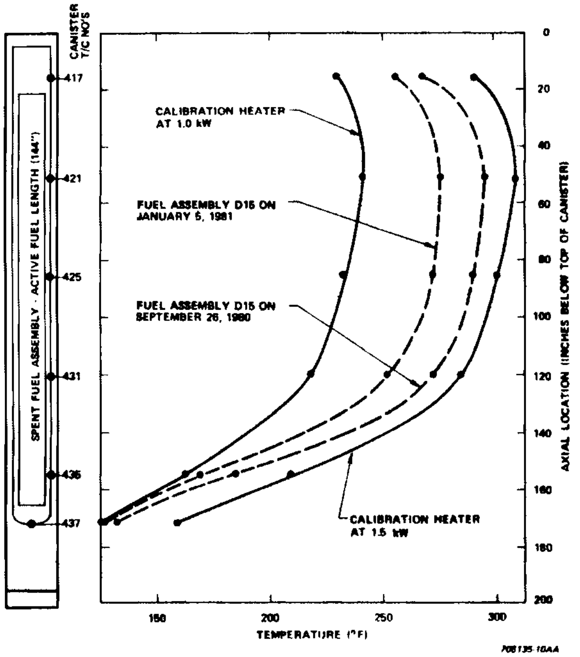

Figure 5.4-15. Fuel Assembly D15 Calibration: Canister Temperature Profiles

two calorimetry data points determined by the adjusted canister/ ambient temperature comparison are 17 percent lower than the nominal predicted decay heat level. The differences in the decay heat levels may be attributed to heat transfer actually inside an air filled canister and the two decay heat determination methods handling of these heat transfer effects.

As in the Phase II results, Phase III tests show that convection dominates the other two heat transfer modes for air in the canister. A comparison of the Fuel Assembly Internal Temperature Measurement Test calorimetry data can be made with the data from the Boiling Water Calorimeter. Results from the Boiling Water Calorimeter tests are a decay heat value of 1.423 kW on July 8, 1980 and a decay heat value of 1.125 kW on January 6, 1981 with a measurement uncertainty of ±5 percent. Both Calorimeter data points are six percent lower than the nominal predicted decay heat curve. The January 6, 1981 Calorimeter data points fall half-way between the predicted data points from the two Phase III Fuel Assembly Internal Temperature Measurement Tests done on January 5. By using a curve between the two Calorimeter data points parallel to the predicted nominal decay heat curve, comparing data for September 26, 1980 shows the Calorimeter data curve falls half-way between the Fuel Assembly Internal Temperature Measurement Test data. It can then be assumed that an average value of decay heat determined by above two methods closely approximates the actual fuel assembly decay heat level.

An exact decay heat curve for fuel assembly D15 cannot be established from the six calorimeter data points. The predicted decay heat levels determined from Figure 5.4-16 have been used to provide a measure of relative decay heat levels for the Phase III fuel assembly tests.

5.4.3.2 NO BAND HEATER TESTS RESULTS

Four tests were run without band heater power, two with an air backfill and one each with vacuum and helium backfill. The first set of three No Band Heater Tests was run in late September, 1980 immediately following spent fuel assembly installation. The second air backfill No Band Heater Test was performed in January, 1981. Test data for the first set of air, vacuum, and helium test runs are provided in Tables F-32, F-33 and

TABLE 5.4-6
FUEL ASSEMBLY D15 DECAY HEAT LEVEL DETERMINED FROM TEST DATA VERSUS CALIBRATION DATA

I. Canister Temperature Comparison Method

T/C Elevation (Inches Below Top of Canister)	Date 9/26/80	 1/5/81
51	1.40 kW	1.29 kW
86	1.42 kW	1.31 kW
120	1.41 kW	1.29 kW
Average	1.41 kW	1.30 kW

II. Canister/Ambient Temperature Difference Method

T/C Elevation (Inches Below Top of Canister)	Date 9/26/80	 1/5/81
51	1.095 kW	1.010 kW
86	1.125 kW	1.040 kW
120	1.135 kW	1.035 kW
Average	1.118 kW	1.028 kW

III. Nominal Predicted Decay Heat

Date 9/26/80	 1/5/81
1.358 kW	1.221 kW

F-34, respectively and the data for the second air test run is provided in Table F-35.

The results from the first three No Band Heater Tests are shown in Figure 5.4-17. The figure shows the center thermowell axial temperature and canister axial temperature profiles for air, helium and vacuum backfill conditions. As in Phase II, the tests were performed in succession with the only test condition change being the gas medium.

A comparison of the canister temperature profiles and the center thermowell temperature profiles yield the same results as Phase II. These results are explained in Section 5.4.2 for the Phase II No Band Heater Tests.

5.4.3.3 ELECTRICALLY HEATED DRYWELL TEST CANISTER PROFILE TESTS RESULTS

Two tests were run using the Electrically Heated Drywell Test canister profile, one with a vacuum

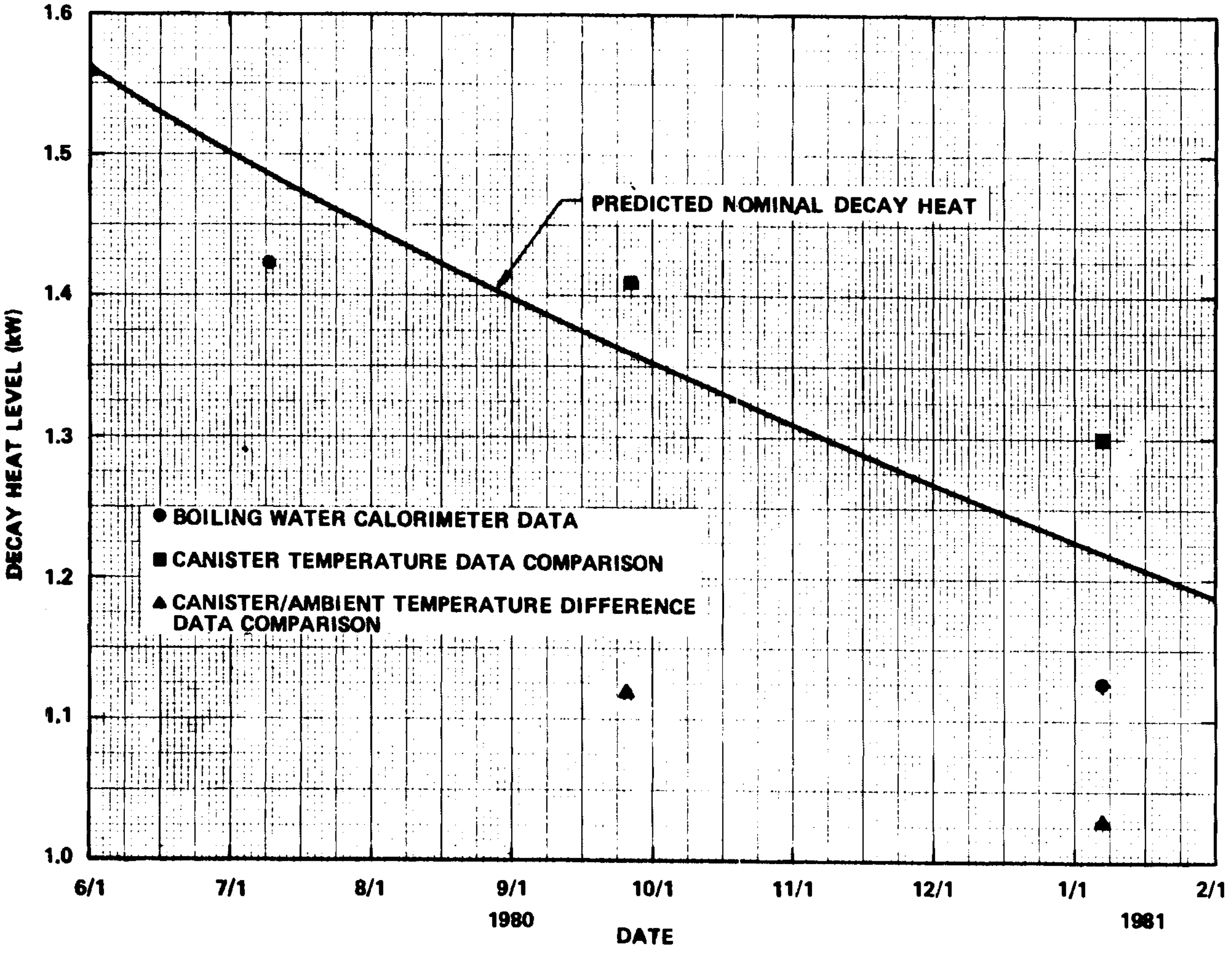

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Figure 5.4-16. Comparison of Calorimetry Data With Predicted Decay Heat Curve for Fuel Assembly D15

and one with a helium backfill. These tests were run in December, 1980. The air backfill test was not conducted due to schedular requirements for shipment of fuel assembly D15 to the SFT-C test site. Test data for the vacuum and helium test runs are provided in Tables F-36 and F-37, respectively. The relative spent fuel assembly decay heat levels are estimated to be 1.24 kW for the helium backfill test and 1.23 kW for the vacuum backfill test.

Figure 5.4-18 shows the axial profiles of the temperatures imposed on the test canister and the center thermowell temperatures. The two canister profiles are nearly identical. The center thermowell axial temperature profiles for the helium and vacuum backfill conditions exhibit the same relationships described previously for the No Band Heater Tests, i.e., the helium backfill produced the lowest center thermowell temperatures and the vacuum

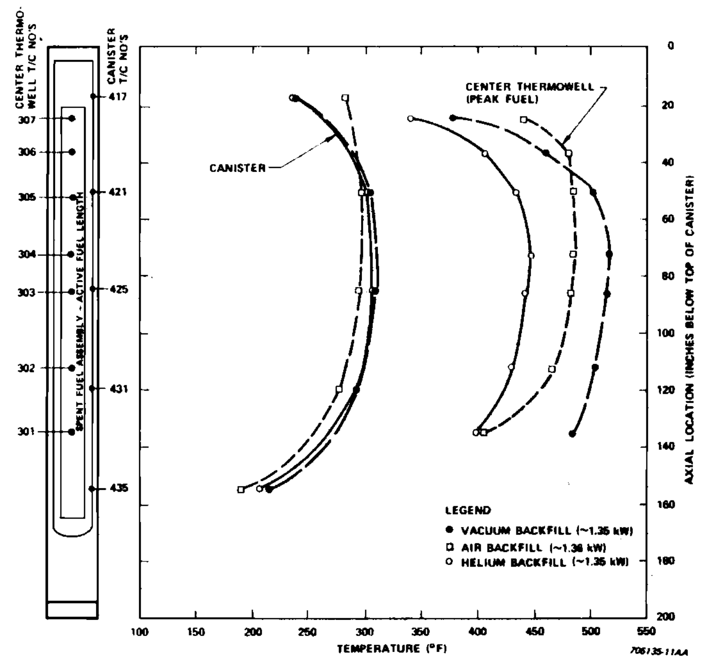

Figure 5.4-17. No Band Heater Test Temperature Profiles (F/A D15)

backfill produced the highest temperatures. A summary of the peak center thermowell temperatures for the Electrically Heated Drywell Test Canister Profile Tests is provided in Table 5.4-7. In addition, a complete cross sectional map of canister and thermowell temperature readings for the two backfill media tests (at an elevation near the active fuel midplane) are provided in Figure J-5 in Appendix J.

5.4.3.4 DRYWELL 5 CANISTER PROFILE TESTS RESULTS

Three tests were run using the canister profile from Drywell 5. A complete set of air, helium and vacuum backfill tests was run in succession in early December, 1980. Test data are provided in Tables F-38, F-39 and F-40. The relative spent fuel assembly decay heat levels are estimated to be between 1.25 kW and 1.26 kW for all three tests.

The results of the Drywell 5 Canister Profile Tests are shown in Figures 5.4-19 and 5.4-20. Figure 5.4-19 presents the axial temperature profiles imposed on the canister and the center thermowell axial temperatures for all three backfill media. Figure 5.4-20 presents three sets of radial and diagonal thermowell temperature curves for the top, middle and bottom elevation thermocouples. Table 5.4-7 summarizes the maximum temperatures recorded for each test. A complete cross sectional map of canister and thermowell temperature readings for the three backfill media (at an elevation near the active fuel midplane) are provided in Figure J-7 in Appendix J.

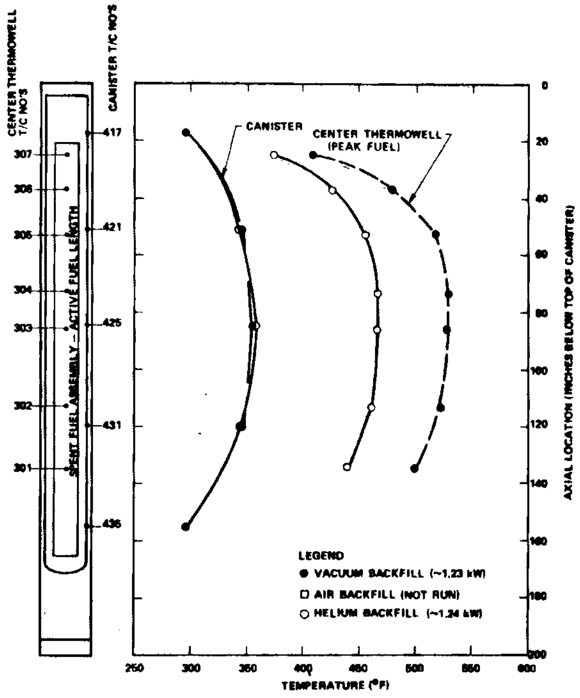

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Figure 5.4-18. Electrically Heated Drywell Test Canister Profile Test Temperature Profiles (F/A D15)

The axial temperature profiles in Figure 5.4-19 are similar to those in Figure 5.4-17 for the No Band Heater Tests and those in Figure 5.4-8 for the Drywell 5 Canister Profile Tests for fuel assembly B43. The helium backfill test center thermowell temperatures are the lowest, showing the higher helium thermal conductivity. The air backfill test center thermowell temperatures are skewed toward the fuel assembly top, showing air to be a better convector than helium. The vacuum backfill test center thermowell temperatures are the highest, showing that radiation alone is the least effective heat transfer method. The maximum thermowell temperatures occurred at the elevation slightly above the active fuel midplane for all three backfill tests. The air backfill test canister temperatures near the top of the canister are higher than the Drywell 5 canister temperatures due to the axial heat convection within the canister.

Comparing the three sets of curves shown in Figure 5.4-20 confirms the heat transfer mechanisms present for each backfill as previously discussed for Phase II. The bottom and midplane elevation profiles show the vacuum backfill to be the steepest and nearly constant. With air as the canister backfill, the primary transfer heat modes are convection in the axial direction and conduction and radiation in the radial direction. The radial and diagonal profiles are expected to be somewhat flatter than those for the vacuum and yet steeper than those for the helium since air thermal conductivity is less than helium. The lower and midplane elevation profiles in Figure 5.4-20 show this to be the case.

5.4.3.5 SPENT FUEL TEST AT CLIMAX (SFT-C) CANISTER PROFILE TEST RESULTS

Two tests were run using the SFT-C canister profile, one with vacuum and one with helium backfill. These two tests were run in late December, 1980. As previously noted, the air backfill test was not conducted due to schedular requirements for shipment of fuel assembly D15 to the SFT-C test site. Test data for the vacuum and helium test runs are provided in Tables F-41 and F-42, respectively.

Figure 5.4-21 shows the axial profiles of the temperatures imposed on the test canister, the actual canister temperature data points from the SFT-C canister, and

TABLE 5.4-7
SUMMARY OF STORAGE CELL CANISTER PROFILE TESTS FOR FUEL ASSEMBLY D15

Profile and Canister Backfill	Predicted Decay Heat Level (kW)	Canister Temperature (°F)	Center Thermowell Temperature (°F)
Electrically Heated Drywell Test			
Helium	1.242	353	464
Vacuum	1.228	348	527
Drywell 5			
Helium	1.250	319	439
Vacuum	1.254	318	511
Air	1.262	321	491
SFT-C Canister			
Helium	1.239	390*	494
Vacuum	1.232	392*	553

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* 100°F above SFT-C canister temperatures

the center thermowell temperatures. The canister temperature profile used for the two tests was 100°F higher than the SFT-C canister temperatures. The center thermowell axial temperature profiles for the helium and vacuum backfill conditions exhibit the same relationships noted previously for the No Band Heater Tests and the other two storage cell profile tests. The SFT-C Canister Profile Tests thermowell temperatures are nearly 100°F higher than those experienced by the Climax test fuel assemblies.

A summary of the peak center thermowell temperatures for the SFT-C Canister Profile Tests is included in Table 5.4-7. Cross sectional maps of canister and thermowell temperature readings for the helium and vacuum backfill tests (at an elevation near the active fuel midplane) are provided in Figure J-6 in Appendix J.

5.4.3.6 UNIFORM CANISTER TEMPERATURE PROFILE TESTS RESULTS

Fourteen Uniform Canister Temperature Profile Tests were run using imposed canister temperatures of 350, 400, 450, 500, 550 and 600°F for vacuum, helium and/or air in the canister. The vacuum and

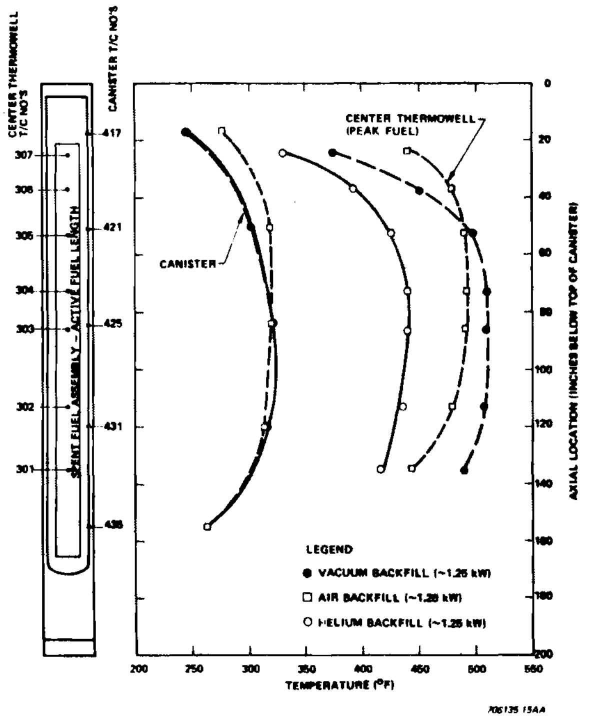

Figure 5.4-19. Drywell 5 Canister Profile Test Temperature Profiles (F/A D15)

helium backfill tests for the 350°F canister temperature and the vacuum and air backfill tests for the 600°F canister temperature were not run because of the inability to achieve a uniform profile at 350°F and the potential for violating the fuel clad temperature limit of 650°F. The 14 tests were performed from October through November, 1980. The specific test order is shown in Table 5.4-5. The fuel assembly decay heat level decreased from an estimated 1.34 kW for the first test to 1.28 kW for the last test.

Test data for 12 of the 14 tests are provided in Tables F-43 through F-54 with the backfill tests for each canister profile grouped together. A comparison of the center thermowell temperatures for the vacuum backfill tests with the

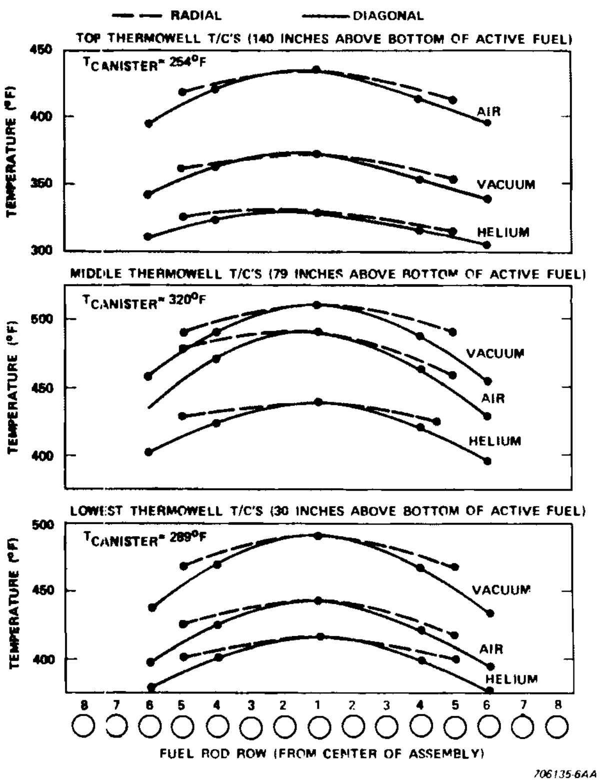

Figure 5.4-20. Drywell 5 Canister Profile Test Radial and Diagonal Temperature Profiles (F/A D15)

helium and air backfill test temperatures at 400 and 450°F was made. This comparison indicated that the actual canister backfill was not a vacuum. For both tests, the data were nearly identical to that of the helium backfill (within 5°F) which was not the case for any of the other profile or uniform canister temperature tests. Since the test results were not valid for a vacuum in the canister, these data were not included.

The Uniform Canister Temperature Profile Test results are presented in Figures 5.4-22 to 5.4-27 which show the axial canister and center thermowell temperature profiles for the 350, 400, 450, 500, 550 and 600°F tests, respectively. Table

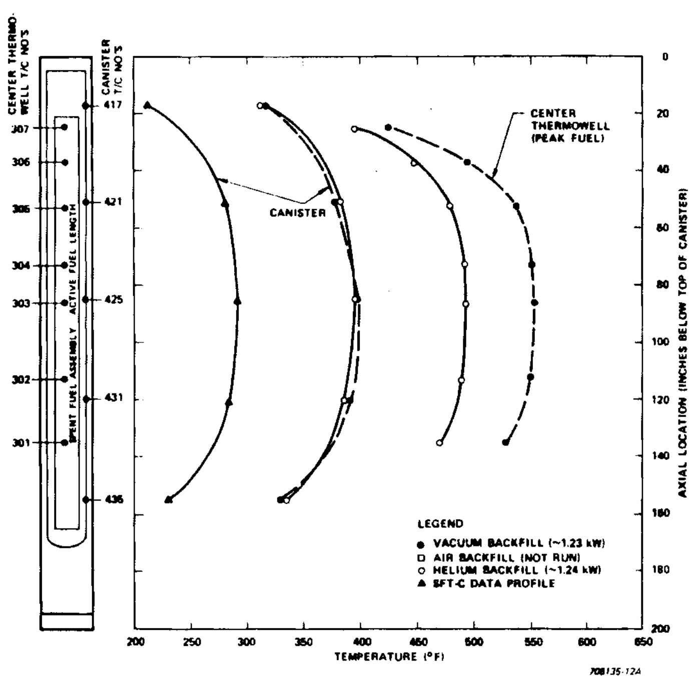

Figure 5.4-21. Spent Fuel Test at Climax Canister Profile Test Temperature Profiles (F/A D15)

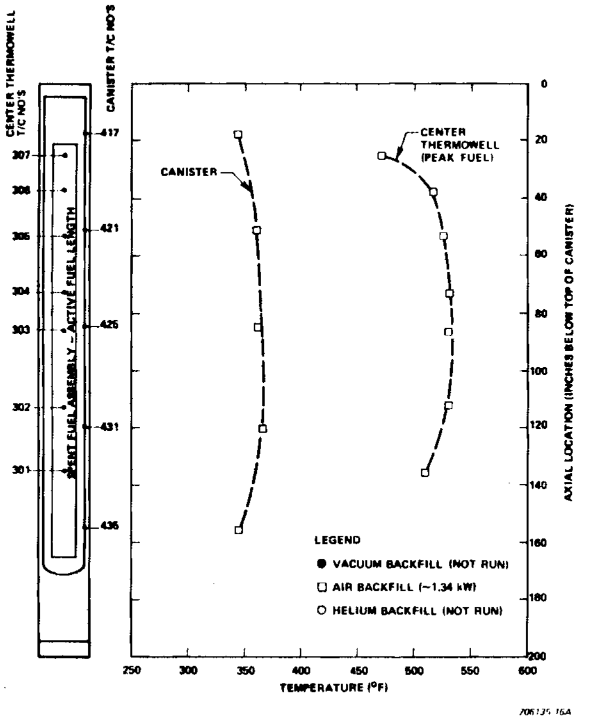

Figure 5.4-22. 350°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A D15)

5.4-8 summarizes the peak temperatures recorded for each test. A cross sectional map of canister and thermowell temperature readings for the three 550°F backfill tests, the 350°F air backfill test and, the 600°F helium backfill test at an elevation near the active fuel midplane are provided in Figures J-8, J-9 and J-10, respectively.

The axial center thermowell temperature profiles of Figures 5.4-22 to 5.4-27 show the same basic relationships between the effects of backfill media as do the No Band Heater Tests and storage cell canister profile tests. It is seen that air is better axial heat convector but a poorer radial heat conductor than helium. At the fuel assembly top, the center thermowell temperatures are higher for the air backfill than for helium and vacuum backfills. This indicates that convection transported heat from the fuel assembly lower section to the top section. As the canister temperature increased, the difference between the three backfill media center thermowell temperatures decreased. The air backfill and vacuum backfill profiles are nearly identical for the 500 and 550°F uniform canister temperatures (the variation being less than 10°F). For an air filled canister, as the canister and fuel rod temperatures increase, radiation transfers more heat from the fuel rods radially to the canister with less convection occurring. The helium backfill shows a lower center thermowell temperature profile than the air and vacuum backfills indicating radial heat transfer is by radiation and conduction.

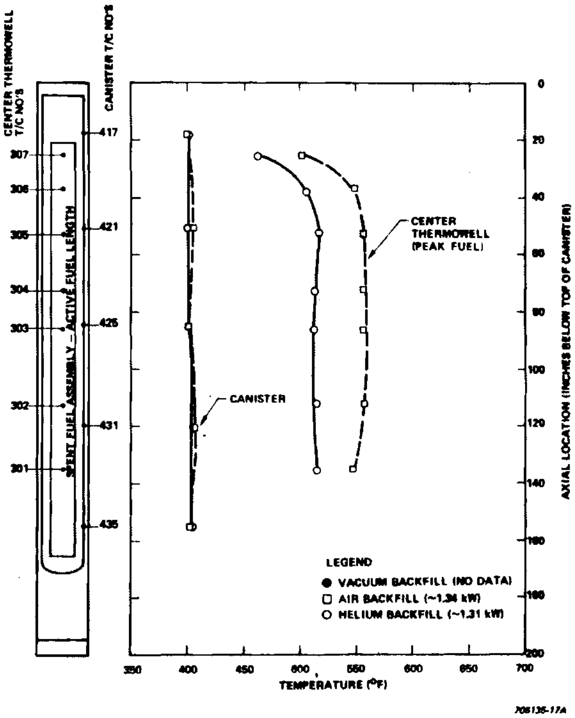

Figure 5.4-23. 400°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A D15)

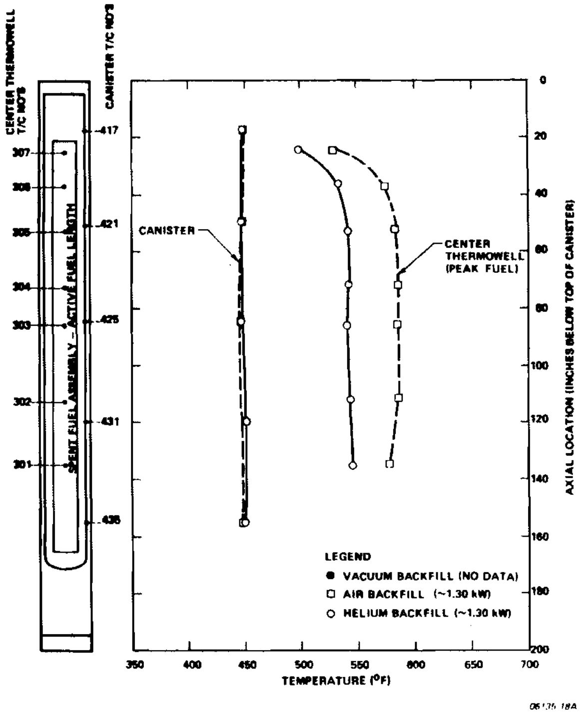

Figure 5.4-24. 450°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A D15)

The relationship between canister temperature and the difference between canister and center thermowell temperatures shown in Figure 5.4-28 illustrates the difference between results from the uniform canister profile tests and the nonuniform canister profile tests. Data from canister and center thermowell thermocouples located 7 and 40 inches above the active fuel midplane were used. These data were normalized to represent a fuel assembly decay heat level of 1.4 kW by multiplying the measured temperature difference by the ratio of this decay heat level and that for each test (see Tables 5.4-7 and 5.4-8). The curves shown were either drawn through the uniform canister temperature profile data (solid line) or were developed from a curve fit of the nonuniform canister temperature profile data (dashed line). The nonuniform profile data for helium and air show a smaller center thermowell/canister temperature difference than the uniform profile data. Although only two vacuum backfill tests were run for fuel assembly D15 (insufficient to base any conclusion), it is expected that this relationship would hold true based on the results from fuel assembly B43 (see Section 5.4.2.5). As previously noted for fuel assembly B43, the axial convection and/or conduction of heat being applied to the canister lower end to make the profile uniform can explain this phenomenon.

Figure J-11 provides the relationship of center thermowell/canister temperature difference versus canister temperature for each of the three backfills at five

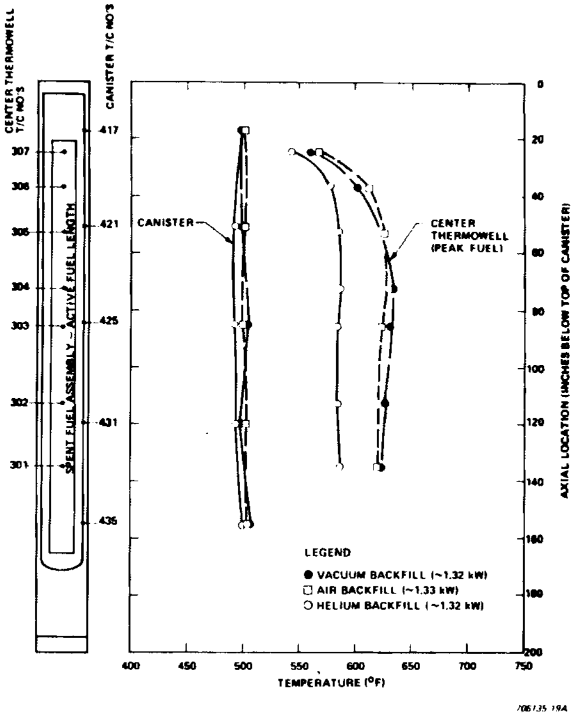

Figure 5.4-25. 500°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A D15)

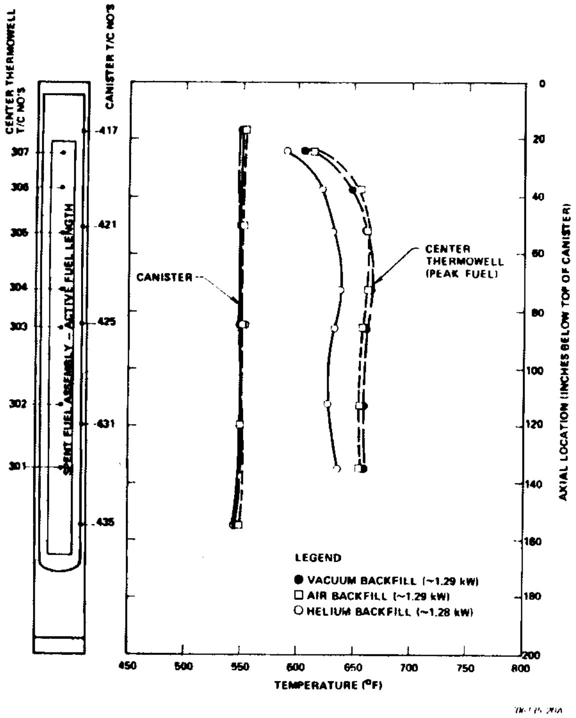

Figure 5.4-26. 550°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A D15)

elevations. These illustrations also show the difference between uniform profile data and nonuniform profile data. Also included are centerline curves which show the recorded data range.

5.5 COMPARISON OF TEST RESULTS WITH ANALYTICAL PREDICTIONS

Computer analyses performed by Westinghouse AESD and by the Pacific Northwest Laboratory (PNL) can be compared to the results of the Fuel Assembly Internal Temperature Measurement Tests. In each analysis, the model calculated fuel rod temperatures for a typical PWR fuel assembly using variable canister temperatures and fuel assembly decay heat levels. The two models are briefly described, and the results from analyses using each model are presented in the following sections. Comparisons with Fuel Assembly Internal Temperature Measurement Test data are also presented.

5.5.1 CANISTER/FUEL ROD TWO-DIMENSIONAL ANALYSIS

A radiation heat transfer code developed by Oak Ridge National Laboratory (ORNL) (Reference 25) to evaluate fuel rod temperatures inside shipping casks was used by AESD to evaluate fuel clad temperatures inside a storage cell canister. These analyses provided a conservative estimate of the fuel clad temperatures for preliminary evaluation of drywell and concrete silo spent fuel storage performance. The fuel rod bundle model used is two-dimensional and is shown in Figure 5.5-1. The ORNL code considers heat transfer by radiation only at one elevation.

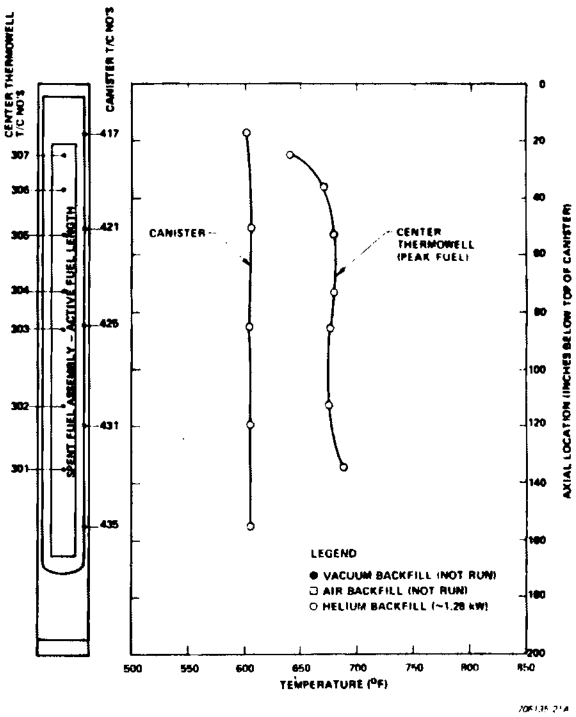

Figure 5.4-27. 600°F Uniform Canister Temperature Profile Test Temperature Profiles (F/A D15)

The model consisted of a 45° symmetric cross-sectional representation of fuel rods and canister. Eight rows of 0.422 inch diameter fuel rods spaced 0.563 inches apart in a square pattern representing the 15 by 15 rod array PWR fuel assembly were included. Six control rod guide thimble tubes were included to accurately represent the spent fuel assembly. The canister was modeled by two rows of stainless steel rods at the outside of the fuel rods. The support cage was not modeled in this analysis.

The radiation heat transfer view factors for the rod bundle were calculated based on the square pitch geometry. The view factors are 0.1197 for adjacent rods, 0.0835 for diagonal rods, and 0.0234 for secondary rods. The emissivity factor for fuel rods, control rods, and canister rods was assumed to be 0.40. The rod temperatures are also assumed to be uniform around their circumference.

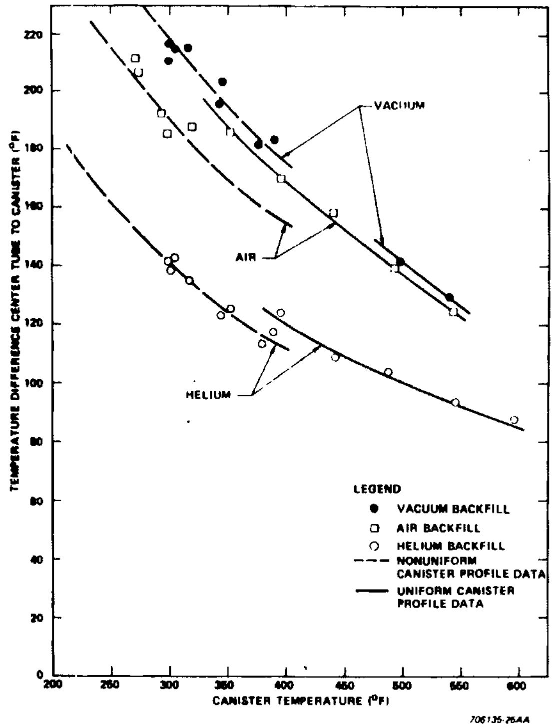

Figure 5.4-28. Center Tube/Canister Temperature Difference Versus Canister Temperature Profiles Near the Active Fuel Midplane (F/A D15)

The predicted peak fuel clad/canister temperature relationships for 1.0 and 2.0 kW decay heat levels are shown in Figure 5.5-2. Data points established by the center thermowell and average canister temperature readings at the fuel midplane elevation are included for the Phase II and Phase III tests. The data points for the Phase III tests (fuel assembly D15) are from the vacuum runs of the Drywell Canister Profile Test, the SFT-C Canister Profile Test and the 500 and 550°F Uniform Canister Temperature Profile Tests. For these four tests, the average spent fuel assembly decay heat level is 1.27 kW. The data points for the Phase II tests (fuel assembly B43) are from the 250, 300, 400 and 500°F Uniform Canister Temperature Profile Test runs with a vacuum in the canister. The estimated average spent fuel assembly decay heat level for these four tests is 0.74 kW. The position and shape of the curve drawn through the four test data points shows good agreement with the predicted peak fuel clad/canister temperature relationship.

5.5.2 CANISTER/FUEL ASSEMBLY THREE-DIMENSIONAL ANALYSIS

A finite difference computer code, HYDRA-I (Reference 26), was developed by PNL to simulate the three-dimensional performance of a spent fuel assembly contained within a canister. The code accounts for the coupled heat transfer modes of conduction, convection, and radiation. The contribution of convection is determined by calculating the velocity and pressure fields consistent with the laws of conservation of mass and momentum. Radiation exchange within the fuel assembly is between nearest and next-nearest neighbor rods. Radiation exchange between the fuel assembly and support structure and canister are also included. The code permits spatially varying boundary conditions, thermophysical properties, and power generation rates. Analyses were performed by PNL in support of the Fuel Assembly Internal Temperature Measurement Test.

A single PWR fuel assembly enclosed in a storage canister was used as the model for simulation. A cross-sectional view of the model is shown in Figure 5.5-3, which shows the fuel assembly, internal support cage, and canister. Thermowell locations in the Fuel Assembly Internal Temperature Measurement Test are indicated by the solid circles. These locations correspond to most of the control rod guide thimbles. Computational cells in the model were distributed vertically as well as horizontally to model the essential features of the support cage, fuel assembly top and bottom nozzles, and fuel rods. A separate computational cell was allocated to each fuel rod and guide thimble in the horizontal plane. Power generation rate per unit length was assumed to be a constant over the active fuel length with no power generation in the guide thimbles. A constant power generation rate throughout the entire active region was used to conservatively approximate a real spent fuel assembly.

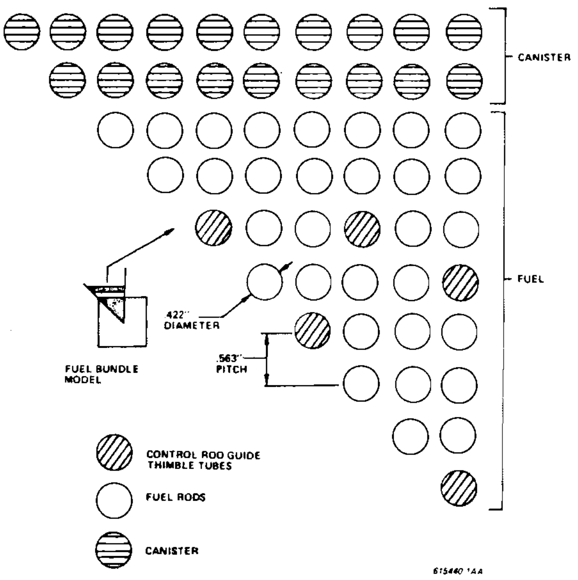

Figure 5.5-1. Two-Dimensional Canister/Fuel Rod Model

Table 5.5-1 defines the relevant physical parameters of the system.

All thermophysical properties used are based on the recommended values found in Reference 27. The effective conductivity of composite materials (i.e., fuel rods, nozzles, etc.) were calculated according to the approach outlined in Reference 28. The largest uncertainties in thermophysical

TABLE 5.4-8
SUMMARY OF UNIFORM CANISTER TEMPERATURE PROFILE TESTS FOR FUEL ASSEMBLY D15

Profile and Canister Backfill	Predicted Decay Heat Level (kW)	Canister Temperature (°F)	Center Thermowell Temperature (°F)
350°F Canister Temp			
Air	1.340	352	530
400°F Canister Temp			
Helium	1.313	395	514
Air	1.337	394	557
450°F Canister Temp			
Helium	1.300	441	546
Air	1.298	439	586
500°F Canister Temp			
Vacuum	1.323	497	633
Helium	1.320	487	587
Air	1.327	493	629
550°F Canister Temp			
Vacuum	1.288	540	664
Helium	1.285	546	637
Air	1.293	542	661
600°F Canister Temp			
Helium	1.281	595	680

TABLE 5.5-1
FUEL ASSEMBLY/CANISTER MODEL PARAMETERS

Number of Rods (including fuel rods and control rod guide thimbles)	225 (15 x 15 array)
Rod Diameter	0.422 in.
Cladding Thickness	0.0243 in.
Pitch to Diameter Ratio	1.334
Active Length (includes swelling)	145.5 in.
Overall Length (including nozzles)	159.7 in.
Emissivity of Rods	0.4
Canister Inside Diameter	13.25 in.
Canister Inside Length	161.5 in.
Emissivity of Canister and Support Cage	0.45

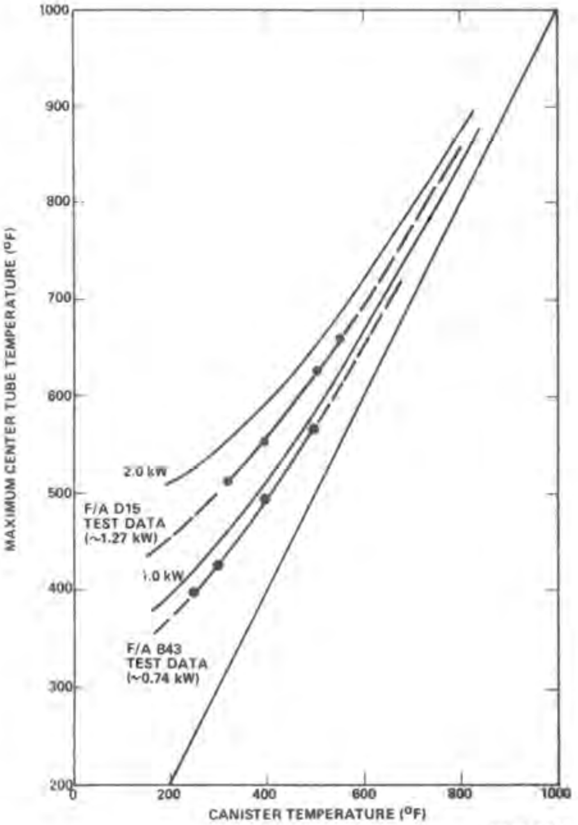

Figure 5.5-2. Comparison of Test Data With Maximum Predicted Center Tube Temperature Versus Canister Temperature (Radiation Heat Transfer Only)

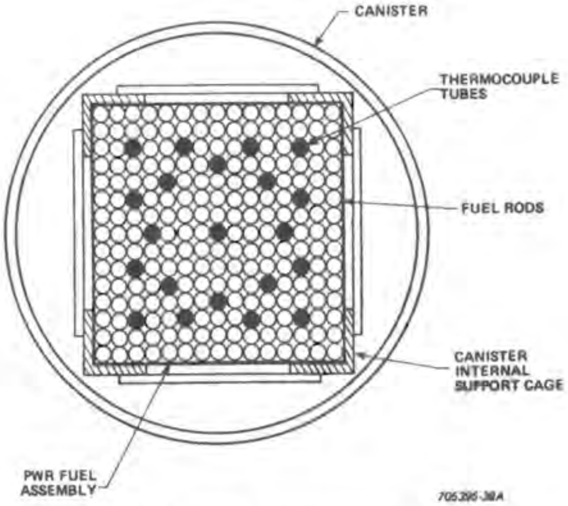

Figure 5.5-3. Three-Dimensional Canister/Fuel Assembly Model

properties are believed to be associated with the emissivities and the effective conductivity of composites as calculated by analytical methods.

Three analyses were performed using test data from the E-MAD Fueled Drywell and Electrically Heated Drywell Tests. These analyses were performed without prior knowledge or use of Fuel Assembly Internal Temperature Measurement Test data to improve agreement. The canister temperature profiles from Drywell 5 (see Figure 5.3-3) and the 1.0 and 2.0 kW Electrically Heated Drywell Test (see Figures 5.3-1 and 3.4-5) were used with the appropriate gas backfill for each. The initial conditions of average temperature and pressure were estimated at 122°F and one atmosphere to establish the total mass of gas present. The fuel assembly decay heat level was set at 0.85 kW in the first two analyses (Drywell 5 and Electrically Heated Drywell Test 1.0 kW canister profiles). In the third analysis, the fuel assembly decay heat level was set at 2.0 kW.

Figures 5.5-4 and 5.5-5 show the comparison of HYDRA-I predictions with the results from the helium filled canister Phase II Drywell 5 Canister Temperature Profile Test. In Figure 5.5-4, the predicted temperatures at the center thermowell closely match the measured temperatures. The measured centerline temperatures are a few degrees above the predicted temperatures in the central region of the active fuel length, but near the top, the measured temperature is significantly lower. This comparison of temperatures at the top shows the nonuniform heat generation rate effects in the spent fuel assembly and the canister lid heat transfer end effects. Figure 5.5-5 shows the temperatures at the control rod guide thimble locations where the predicted temperatures are about four degrees lower than the test data. One quadrant is shown since the code used quarter-symmetry. The test data shown is based on an average temperature at that location for the entire cross section.

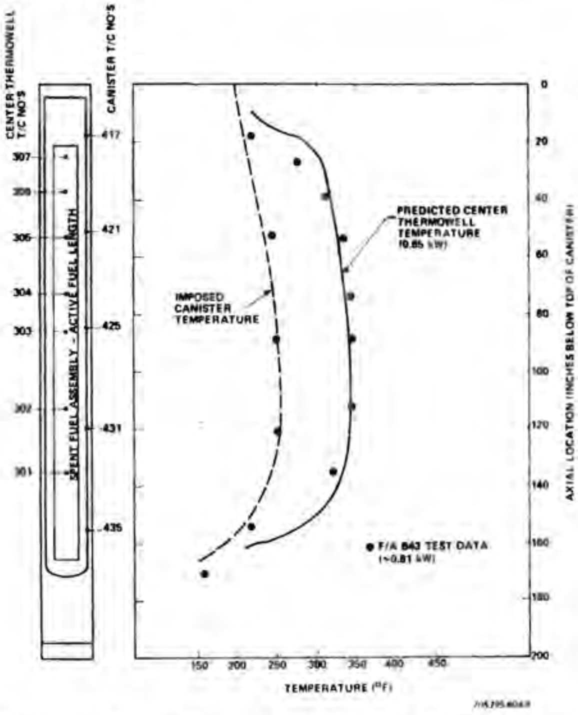

Figure 5.5-4. Comparison of Test Data With Predicted Canister and Center Thermowell Temperatures for the Helium Filled Drywell Canister (F/A B43)

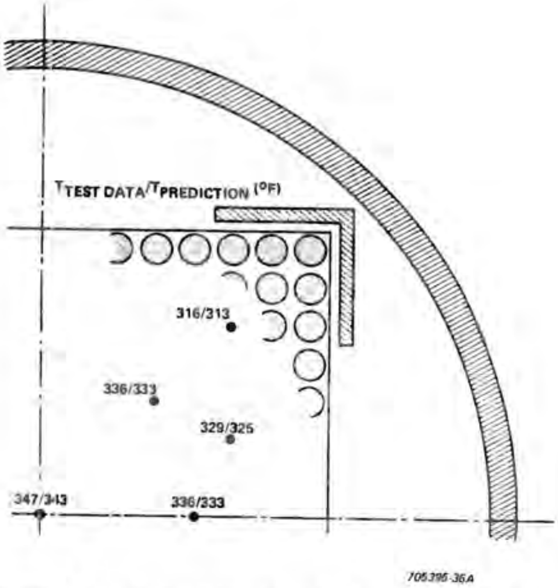

Figure 5.5-5. Comparison of Test Data With Predicted Thermowell Temperatures at the Elevation of Peak Thermowell Temperature for the Helium Filled Drywell Canister (F/A B43)

Figure 5.5-6 shows the comparison of the HYDRA-I predictions for the two air filled canister calculations with the results from the air filled canister Phase II and Phase III Electrically Heated Drywell Test Canister Profile Tests. The HYDRA-I predictions for the center thermowell temperatures are shown as solid lines. The first test data curve is from the center thermowell temperature readings for the Phase II testing. The second test data curve is an interpolation of center thermowell test data from the Phase III Drywell and 350°F Uniform Canister Temperature Profile Tests run with an air backfill. This curve approximates center thermowell temperatures for the Electrically Heated Drywell Test Profile for an approximate 1.24 kW decay heat level fuel assembly. The third test data curve shows an approximation of center thermowell temperatures for the 2.0 kW Electrically Heated Drywell Test profile and a 2.0 kW decay heat level fuel assembly. These data points were taken from the 2.0 kW curve on Figure 5.5-2 from the radiation-only computer code predictions. The results from the Uniform Canister Temperature Profile Tests for both Fuel Assembly Internal Temperature Measurement Test phases showed small differences in center thermowell temperatures for the air and vacuum

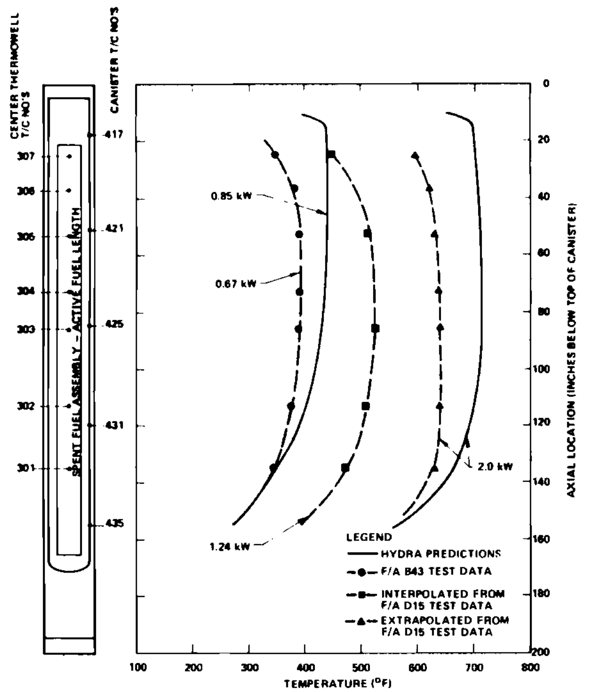

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Figure 5.5-6. Comparison of Test Data With Predicted Center Thermowell Temperatures for the Air Filled Drywell Canister

atmospheres for canister temperatures above 450°F. Since the 2.0 kW Electrically Heated Drywell Test canister profile is above 450°F for the upper 70 percent of the canister, the approximation of center thermowell temperatures shown is expected to be fairly accurate.

Comparing the two air filled drywell canister prediction curves with the test data curves shows that the code conservatively overpredicts the center thermowell temperatures by as much as 50°F for the 0.85 kW case and by as much as 100°F for the 2.0 kW case. Several explanations are possible for these discrepancies. Comparison of test data temperatures at the canister top end (for the first two curves) shows the effects of the nonuniform heat generation rate in the spent fuel assembly and the heat transfer end effects of the test canister lid and thermowells. Additionally, the decay heat level difference for the first two curves (0.67 kW for the test data run and 0.85 kW for the computer calculation) may explain the overprediction. The discrepancy at the higher power levels cannot be explained at this time.

The two analyses provided additional information on flow rates inside the fuel assembly and on the temperature differences between the fuel rods and thermowells. For the helium backfill analyses, the maximum calculated vertical flow velocities were less than 0.5 inches/second. For the air backfill analysis, the maximum calculated vertical flow velocities were 7 inches/second illustrating the greater amount of convection present in the air backfill. The calculated fuel rod temperatures differed from those calculated for the thermowells by less than 5 and 2°F for the air and helium backfills, respectively. This substantiates the conservative analysis of fuel rod clad versus measured temperature difference provided in Appendix M.

For the air backfill computer code predictions, the code experienced temperature convergence calculation problems in the region at the canister upper end. Also, fluctuations in air flow direction near the canister top were predicted. These computer code instabilities indicate that the convection heat transfer model or the thermal properties for the air backfill may be in error.

5.6 APPLICABILITY OF TEST RESULTS

The fuel assembly temperature data gathered during the Fuel Assembly

Internal Temperature Measurement Tests can be applied to the spent fuel storage cell tests at E-MAD (drywells, concrete silo and air-cooled vault), deep geologic drywells in SFT-C granite, and to storage cells of similar configurations at different temperature levels. Data gathered from all the tests have been used to develop peak fuel clad temperature versus canister temperature relationships from both test phases which can be used to estimate spent fuel temperatures in dry storage. Based on the results of the analysis presented in Appendix M, the temperature data measured in the center thermowell is considered representative of the peak fuel clad temperature.

5.6.1 PEAK FUEL CLAD TO MEASURED CANISTER TEMPERATURE RELATIONSHIPS

Figure 5.6-1 presents the peak fuel clad versus canister temperature relationships from the Phase II test data. The temperature data shown was measured at 7 inches above the active fuel midplane elevation. The three curves drawn through the air, helium, and vacuum backfill data represent the interpolated peak fuel clad versus canister temperature relationship profiles for each backfill media for an approximate 0.74 kW spent fuel assembly decay heat level. Extrapolations below the 250°F temperature were determined from center thermowell/canister temperature difference versus canister temperature curves in Figure J-4. The spread in data points in the temperature range from 230 to 300°F is due to the differences in spent fuel assembly decay heat level for each test run.

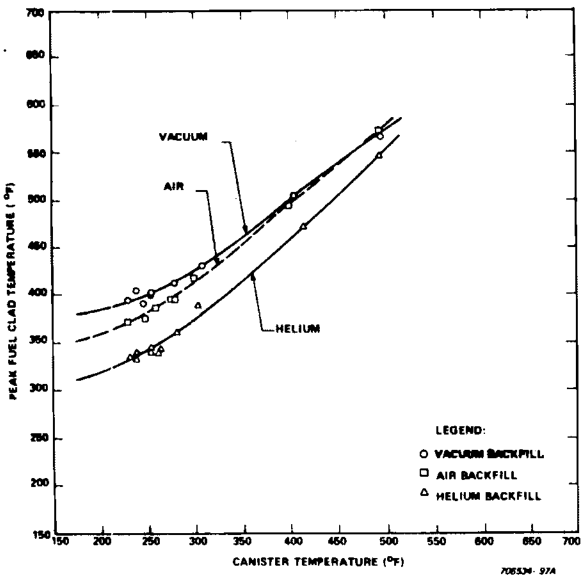

Figure 5.6-1. Peak Fuel Clad Versus Canister Temperature Relationships Developed From Phase II Test Data (F/A B43)

Figure 5.6-2 presents the peak fuel clad versus canister temperature relationships from the Phase III test data. The temperature data shown were measured at 7 inches above the active fuel midplane elevation. The three curves drawn through the air, helium, and vacuum backfill data represent the peak fuel clad versus canister temperature relationship profiles for each backfill media for an approximate 1.27 kW spent fuel assembly decay heat level.

To accurately predict peak fuel clad temperatures for spent fuel storage in canisters, both the canister temperature and spent fuel decay heat level must be considered since each has an effect on fuel clad temperature. The relationships shown in Figures 5.6-1 and 5.6-2 represent data from various

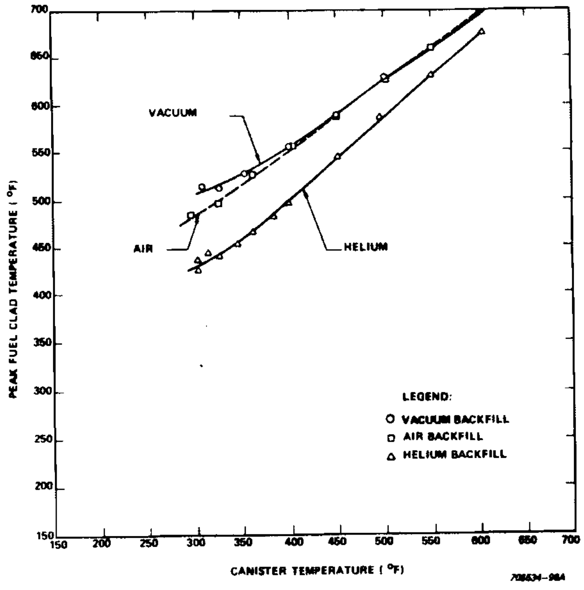

Figure 5.6-2. Peak Fuel Clad Versus Canister Temperature Relationships Developed From Phase III Test Data (F/A D15)

decay heat levels for each fuel assembly. In addition, the test data recorded does not provide sufficient information for the range of measured canister temperatures (100 to 325°F) and fuel assembly decay heat levels (1.25 to 0.5 kW) for the E-MAD spent fuel dry storage testing to make accurate predictions. For these reasons, an evaluation of the test data was made to determine the relationships of decay heat level and canister temperature to peak fuel clad temperature.

The evaluation of the center thermowell/canister temperature difference using data from the nonuniform canister temperature profile tests and the 400 and 500°F uniform canister temperature profile tests for both fuel assemblies yielded meaningful relationships for both decay heat levels and canister temperature. The center thermowell/canister temperature difference was found to be linearly proportional to the decay heat level for the helium and air backfills over the entire range of canister temperatures. When the measured temperature difference from each fuel assembly was adjusted by the ratio of the two fuel assembly decay heat levels to predict the temperature difference for the other fuel assembly, the difference between predicted and measured center thermowell/canister temperature difference was less than 5 percent for a helium backfill and less than 10 percent for an air backfill. Since the relationship of center thermowell/canister temperature difference to decay heat level was linear, the measured temperature differences for the tests were normalized to either a 0.85 kW decay heat level (fuel assembly B43 tests) or to a 1.4 kW decay heat level (fuel assembly D15 tests) so that the relationship to canister temperature could be assessed. The normalized temperature differences and the canister temperatures from the nonuniform canister profile tests data and the 500°F uniform profile tests at elevations 7 and 40 inches above the active fuel midplane were examined using the least squares criterion to determine the relationship of center thermowell/canister temperature difference to canister temperature. The relationships for the helium and air backfills were found to fit a Taylor series expansion and that for a vacuum was found to fit an exponential function. Each of the relationships is defined below:

HELIUM BACKFILL

The relationship determined from a curve fit of the normalized fuel assembly D15 data was as follows:

$$\Delta T = 340.56 - 0.9453\, T_{can} + 0.0009348\, T_{can}^{\ 2}$$

where ΔT = center thermowell/canister temperature difference, °F
T_{can} = canister temperature, °F

This relationship was adjusted to a 0.85 kW decay heat level and was found to also fit the fuel assembly B43 test data. On this basis, the relationship of peak fuel clad temperature (as determined from center thermowell measured temperature) to canister temperature and fuel assembly decay heat level is as follows:

$$T_{fuel} = T_{can} + Q\,(243.26 - 0.6752 \times T_{can} + 0.0006677\, T_{can}^{\ 2})$$

where: T_{fuel} = peak fuel clad temperature, °F
T_{can} = canister temperature, °F
Q = fuel assembly decay heat level, kW

This relationship is considered to be valid for a canister temperature range of 100 to 600°F and fuel assembly decay heat level range of 0.1 to 2.0 kW for fuel stored in 14 inch diameter stainless steel canisters.

AIR BACKFILL

The relationship of center thermowell/canister temperature difference to canister temperature was determined (from a curve fit to each set of normalized data) to be slightly different as noted below:

For fuel assembly B43 (0.85 kW):

$$\Delta T = 264.62 - 0.6551\, T_{can} + 0.000601\, T_{can}^{\ 2}$$

For fuel assembly D15 (1.4 kW):

$$\Delta T = 412.81 - 1.0220\, T_{can} + 0.0009376\, T_{can}^{\ 2}$$

These two relationships were found to be fairly accurate for decay heat levels close to the test data range yet were beyond the 10 percent difference previously noted when each expression was adjusted for the other fuel assembly decay heat level and the predictions compared to the normalized data. For this reason, two different relationships of peak fuel clad temperature versus canister temperature and fuel assembly decay heat level were developed as follows:

For fuel assembly B43:

$$T_{fuel} = T_{can} + Q\,(311.32 - 0.7707 \times T_{can} + 0.0007071\, T_{can}^{\ 2})$$

For fuel assembly D15:

$$T_{fuel} = T_{can} + Q\,(294.86 - 0.7157 \times T_{can} + 0.0006697\, T_{can}^{\ 2})$$

These two relationships are considered to be valid for a canister temperature range of 100 to 600°F for fuel assembly decay heat levels within about 30 percent of the normalized decay heat for each expression (0.5 to 1.0 kW for the first and 1.0 kW to 1.8 kW for the second).

VACUUM BACKFILL

As for the air backfill, two relationships of center thermowell/canister temperature difference to canister temperature were developed from a curve fit to each set of normalized data. These two relationships were found to only apply to decay heat levels close to those of the normalized test data. The resulting relationships of peak fuel clad temperature versus canister temperature and fuel assembly decay heat level are as follows:

For fuel assembly B43:

$$T_{fuel} = T_{can} + Q\,(334.19 \times 10^{-0.0009947T_{can}})$$

For fuel assembly D15:

$$T_{fuel} = T_{can} + Q\,(310.72 \times 10^{-0.0009947T_{can}})$$

where: T_{fuel} = peak fuel clad temperature, °F

T_{can} = canister temperature, °F

Q = fuel assembly decay heat level

These two relationships are considered to be valid for the same canister temperature and decay heat level ranges as the air backfill relationships.

Curves for vacuum, helium, and air backfills in Figure J-4 show the relationships of center thermowell/canister temperature difference versus canister temperature developed from fuel assembly B43 test data at five elevations along the fuel assembly length. For each backfill, a single curve drawn through data from the middle section of the spent fuel assembly (shown as the solid line with dashed line encompassing the spread of all data points) indicates that the relationship of fuel clad temperature to canister temperature is fairly constant in that region. For all three backfills, a different temperature relationship exists at the top of the active fuel, and for the air backfill, a separate relationship exists near the bottom of the active fuel. This indicates that test canister thermal end effects have a significant effect on the fuel clad/canister temperature relationship at the top of the fuel assembly and that convection heat transfer within the air filled canister affects the fuel clad/canister temperature relationship at the bottom of the fuel assembly.

Center thermowell/canister temperature difference versus canister temperature relationships were also evaluated for fuel assembly D15 at elevations above and below the elevation of peak thermowell temperatures. Curves for vacuum, helium, and air backfills are provided in Figure J-11 for test data at five elevations along the fuel assembly length. For each backfill, a single curve drawn through data from the middle section of the spent fuel assembly indicates that the relationship of fuel clad temperature to canister temperature is fairly constant in that region. For all three backfills, a different temperature relationship exists at the top of the active fuel. This again indicates that test canister thermal end effects have a significant effect on the fuel clad/canister temperature relationship at the top of the fuel assembly.

5.6.2 FUEL CLAD TEMPERATURE ESTIMATES

The fuel clad temperatures in the SFT-C spent fuel assemblies have been estimated using the relationship described in Section 5.6.1. Since the SFT-C canister temperature profile was below the minimum achievable using the existing test stand, the results from the helium filled test (run with a profile 100°F above actual temperatures) were not applicable. The peak measured canister temperatures for SFT-C storage of fuel assembly D40 (Reference 29) and the estimated peak fuel clad temperature are shown in Figure 5.6-3 for the period of April 18, 1980 through October 19, 1980. The peak measured canister temperatures and the predicted fuel assembly decay heat levels (from Figure 2.3-4) were used to calculate the peak fuel clad to canister temperature difference from the relationship developed from the helium backfill tests. This difference was then added to the peak measured canister temperatures. The maximum peak fuel clad temperature is estimated to have been about 451°F which occurred about one month after emplacement.

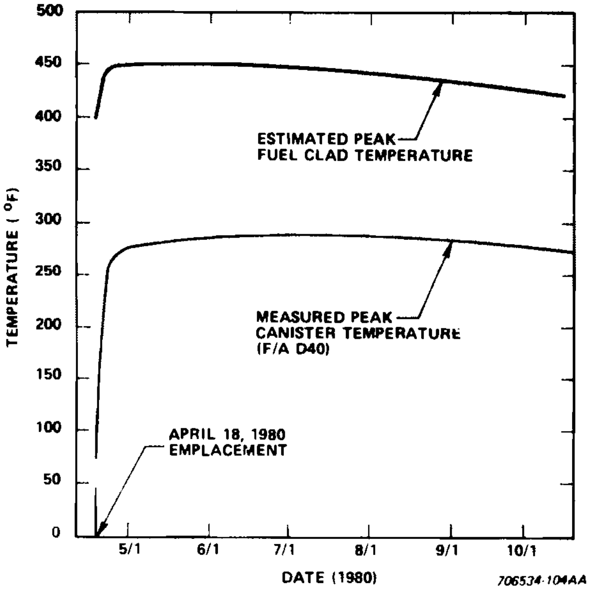

Figure 5.6-3. Spent Fuel Test at Climax Estimated Peak Fuel Clad Temperature Distribution for Fuel Assembly D40

The maximum errors in the peak fuel clad temperatures noted above are -5 to +12°F determined from measurement uncertainies and calculational method inaccuracies (see Appendix M, Section M.3).

5.6.3 TEST DATA ACCURACY

The accuracy of the ungrounded Type K thermocouples used is typically ±2°F based on calibration data.

Differences between the actual temperature of the fuel cladding and the temperatures measured during the Fuel Assembly Internal Temperature Measurements Tests are due to three factors: 1) the positional and measurement accuracy of the test thermocouples, 2) the effect of test temperature measurement configuration, and 3) the effects of heat transfer mechanisms present. Due to the test measurement configuration, the temperature measured by any thermowell thermocouple is representative of an average temperature of the eight surrounding fuel rods and not of any particular fuel rod. For the center thermowell, all eight surrounding fuel rods are expected to be at about the same temperature. For the other fourteen thermowells, the fuel rod temperatures are expected to vary due to their distance from the centerline of the fuel assembly. This is evidenced by the test data as shown in the radial and diagonal temperature profiles in Figures 5.4-9 and 5.4-20. The extent of the difference between surrounding fuel rod temperatures could not be evaluated using the Fuel Assembly Internal Temperature Measurement Test. The effects of heat transfer mechanisms present for each backfill media have been evaluated analytically. The details of the analysis are provided in Appendix M. The following paragraph summarizes the results of the analysis.

The effect of convection in helium and air backfills was evaluated to determine the difference between fuel cladding temperature and that measured in the thermowell. The axial convection of heat by air and helium was found to produce a small temperature difference since these backfill gases can effectively heat or cool the thermowell and instrument or guide tube relative to the fuel rod. The effect of the vacuum backfill was not analyzed since there is no axial convection present. The results of the analysis show that for the air backfill tests, the measured temperatures differ from the average surrounding fuel rod temperatures by a maximum of 6.5°F at the lowest thermocouple. For the helium backfill tests, the calculated temperature differences were between 1.0 and 2.0°F.

The Fuel Assembly Internal Temperature Measurement Test recorded thermowell data are judged to be between -1.0 and +4.0°F of the actual fuel clad temperatures for a helium backfill and a vacuum and between 3.0 and 8.5°F above the actual fuel clad temperatures for an air backfill. The other recorded data from thermocouples attached to test components are judged to be within ±2.0°F of the actual temperatures.

In addition to measurement uncertainties, test hardware configurations and test data were examined for positional tolerance and other effects on temperature measurements. The test thermocouple and fuel assembly active fuel position tolerances are provided in Appendix M, Tables M-1 and M-3, respectively. An evaluation of the temperature measurement variation due to thermocouple position tolerance was made using the axial temperature profiles for both sets of imposed drywell canister profile tests. The differences in thermocouple-measured temperature and that at the elevation noted for the thermocouple tip ranged from less than ±0.01 to ±1.1°F with most of the differences being less than ±0.5°F. An examination of temperature data for the eight thermocouples spaced 45° apart around the canister circumference showed a consistent variation from side to side (see temperature maps in Appendix J). This canister circumferential temperature variation, the positioning of four canister thermocouples in instrumentation tubes, and the low internal resistances determined by thermocouple electrical checks (last two noted on Table F-1) should also be taken into account when using the test data presented herein.

6.0 AIR-COOLED VAULT TESTS

The following section describes the Air-Cooled Vault Tests performed during the period October, 1979 through June, 1980 in the E-MAD Lag Storage Pit. Included are the test objectives, hardware description, test operations and test results.

6.1 TEST OBJECTIVES

The Lag Storage Pit was constructed beneath the E-MAD Hot Bay floor for the temporary storage of spent fuel assemblies before final storage emplacement. The pit has a storage capacity of 24 canisters with each holding one PWR spent fuel assembly. As part of the SFT-C Program, 13 PWR spent fuel assemblies were shipped to E-MAD for encapsulation and temporary storage prior to shipment to the SFT-C test site. Tests were defined to evaluate the Lag Storage Pit while these assemblies were at E-MAD.

The goal of these Air-Cooled Vault Tests was to provide temperature and flow data under normal operating and simulated accident conditions to verify that spent fuel assemblies with decay heat levels of about 2.0 kW could be stored in the Lag Storage Pit without violating the fuel cladding temperature limit. Lag Storage Pit ventilation tests were defined to determine the effectiveness of the cooling system design under forced air circulation (both fans on), natural convection cooling, and partial ventilation (one fan on, the other blocked). Flow velocity and temperature data from the vault outlet pipes and temperature data from at least one stored canister would be used to evaluate Lag Storage Pit performance. Testing for different spent fuel canister configurations were identified to provide performance data over a range of storage conditions.

6.2 HARDWARE DESCRIPTION

6.2.1 GENERAL ARRANGEMENT

The Air-Cooled Vault Test hardware consists of: 1) the three individual vault, air-cooled, Lag Storage Pit, 2) canister assemblies, each consisting of a canister body, a closure lid and a concrete-filled shield plug to support the canister from a liner in the Lag Storage Pit vault cover plug, 3) pressurized water reactor spent fuel assemblies, 4) outlet pipe and canister thermocouples to measure thermal response, 5) a data acquisition system to record thermocouple data, and 6) a flow velocity meter to measure Lag Storage Pit air flows.

The Lag Storage Pit consists of three individual, concrete lined vaults, each capable of holding eight individual canisters. Decay heat is dissipated through an air duct array connected to the pit. Each vault also contains a seismic grid assembly for canister stabilization. Figure 6.2-1 provides a cutaway illustration of the Lag Storage Pit. Figures 6.2-2 through 6.2-4 provide different views and section illustrations of the Lag Storage Pit configuration.

The Lag Storage Pit is located inside the E-MAD Hot Bay, adjacent to the west wall under the Hot Bay floor. The overall pit area is approximately 30 feet by 60 feet in the shape shown in Figure 6.2-2. Three pit sides have a 8 inch wide trough varying in depth from 1.63 inches to 3 inches. This trough, covered by standard open grating, is designed as a drain to prevent

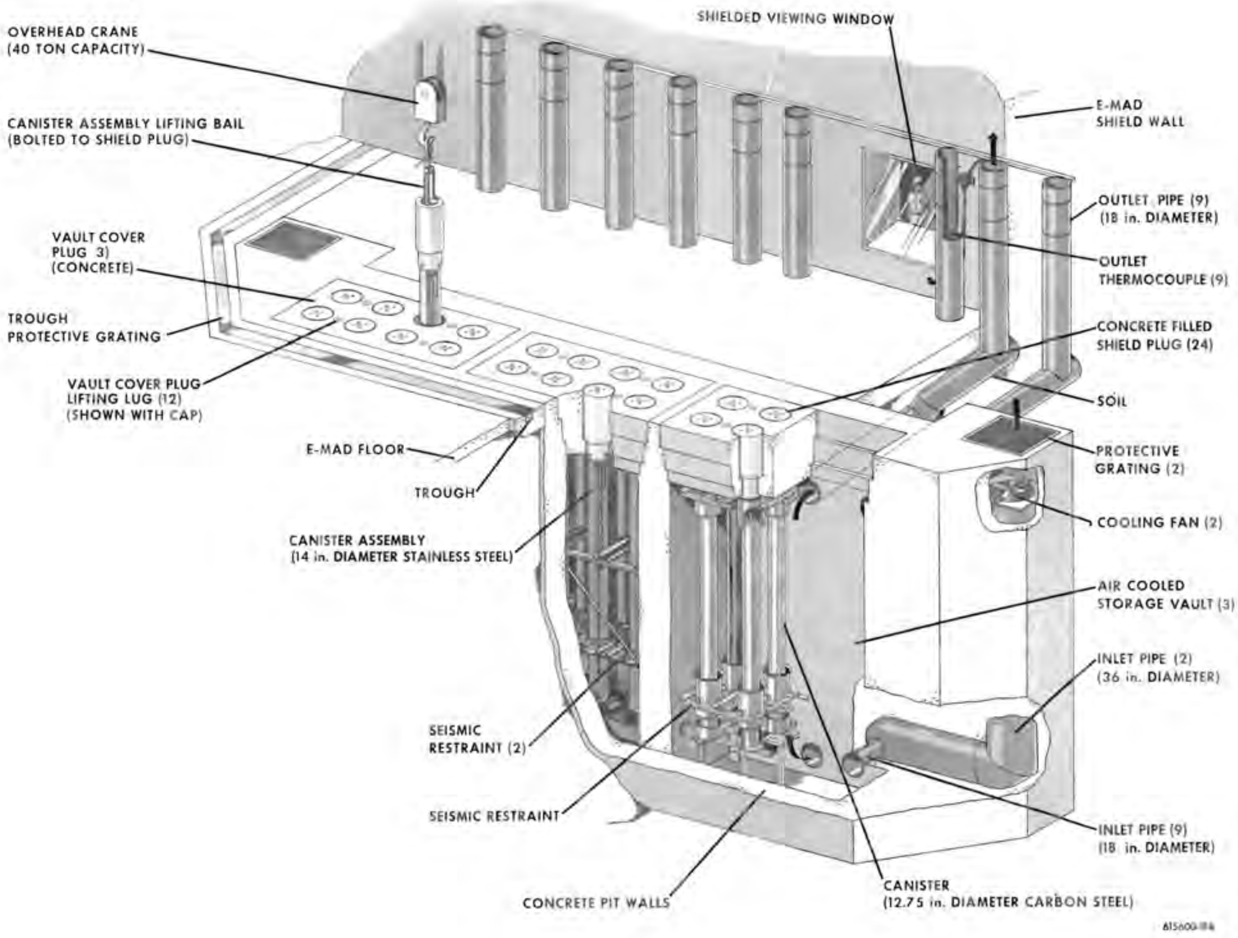

Figure 6.2-1. E-MAD Lag Storage Pit Configuration

fluid leakage into the pit. There is an existing trough on the Hot Bay west wall, one foot wide with a varying depth of 0.63 inches to 3 inches. Two 6 inch diameter steel pipes run through the pit to serve as future service conduits.

6.2.2 PIT VAULTS

There are three individual vaults located in the Lag Storage Pit. Each vault is 11 feet 8 inches long by 5 feet 8 inches wide and 22 feet 6 inches deep. Each vault has a concrete cover plug. The cover plug sides and mating top of each vault have three steps to prevent radiation streaming through the interface. The vault measures 13 feet by 7 feet at the vault top. The top step edge is protected by 3 inch by 3 inch by 10.25 inch angle to prevent the concrete from crumbling and breaking. The corners of the second and the third steps are also protected by 0.25 inch thick bent plate. The second step has a "Z" shape while the third has a small trough adding an extra precaution against fluid leakage; the 0.25 inch thick plate follows the trough and step shape.

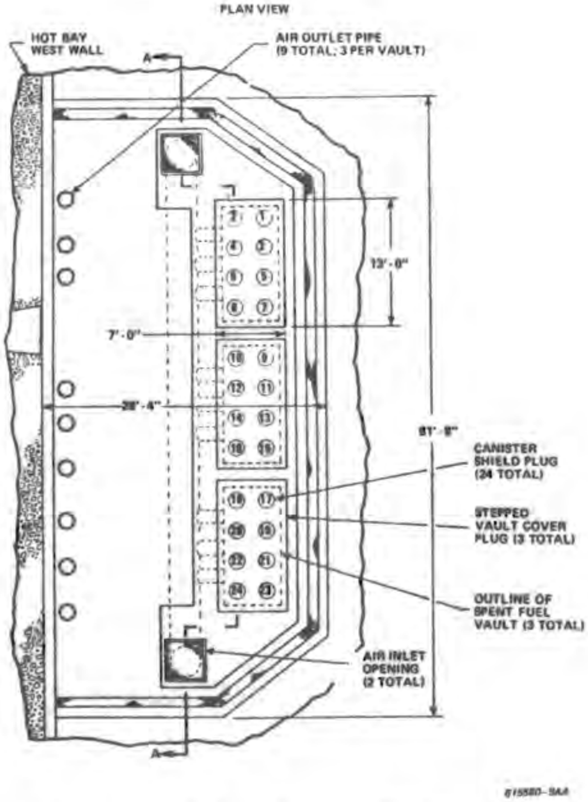

Figure 6.2-2. Lag Storage Pit Plan View at Floor Level

The walls and floor of the Lag Storage Pit vaults were constructed of reinforced concrete with a 150 pound per cubic foot density. The east and west pit walls are 20 and 36 inches thick, respectively, and the floor is 16 inches thick. The pit north and south ends have a concrete thickness varying from 20.5 to 95.5 inches thick to enclose the two 36 inch diameter inlet pipes (see Figure 6.2-2). The vaults are separated by 29 inches of concrete. This concrete neutronically decouples the fuel assemblies from those in the adjacent vault. The interior surface of each vault is painted to enhance decontamination of the porous concrete surface.

Each vault has six 18 inch diameter pipes; three outlet near the top and three inlet near the bottom. The cooling air flows in and out of these pipes through the vault area. These are described in Section 6.2.4.

6.2.3 VAULT COVER PLUGS

Each individual vault has a vault cover plug. This cover is made of reinforced concrete with a density of 150 pounds per cubic foot and has the dimensions 13 feet by 7 feet at the top. The cover plug has three steps to match the vault steps. The cover plug edges are protected against crumbling and breaking by 0.25 inch thick bent plate at the edges. The plates are mitred at the corners. The cover plug is 46 inches thick and is painted to enhance decontamination of the concrete surface. The three vault cover plugs are shown during construction in Figure 6.2-5.

The vault cover plug has eight identical single-stepped, carbon steel pipe lined holes which accept the canister shield plugs. These "liners" are similar to the drywell liner upper section. The liners are 46 inches long and consist of an upper section (22 inch diameter by 0.75 inch thick by 34 inches long) and a lower section (18 inch diameter by 0.38 inch thick by 11.5 inches long) positioned concentrically and welded to opposite sides of a 22 inch outside diameter, 17.25 inch inside diameter, 0.5 inch thick ring. The liners are symmetrically placed in the cover plug to provide 36 inch spacing between the individual canister centers. This configuration precludes spent fuel criticality under any flooding condition.

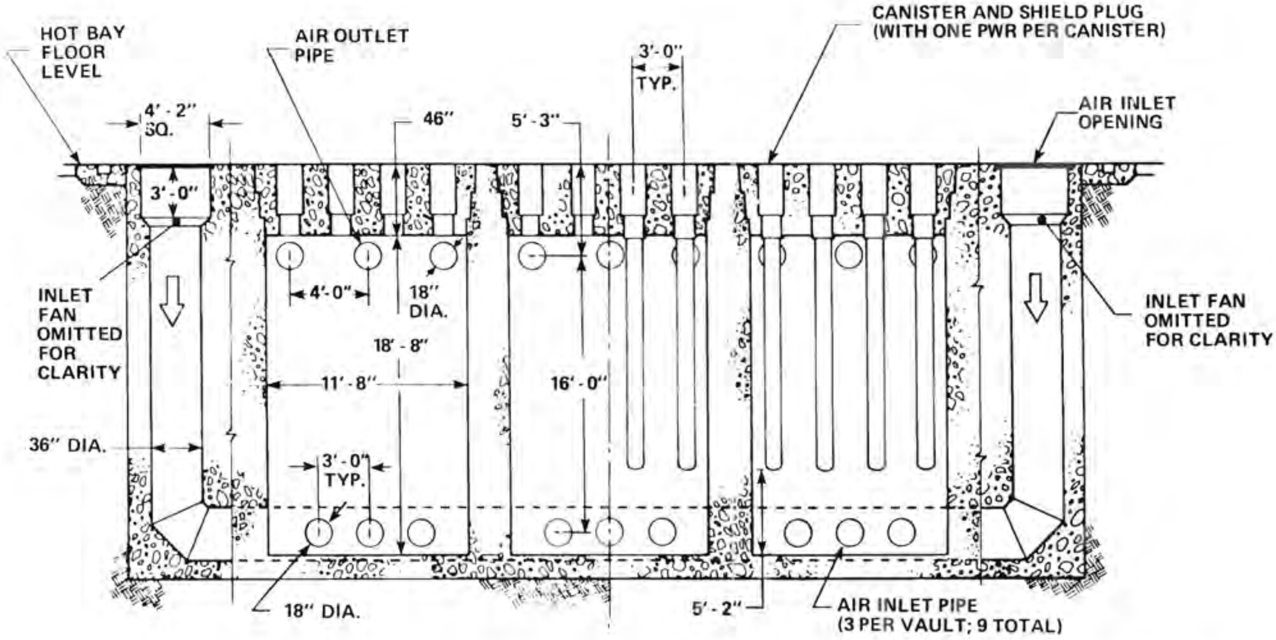

Figure 6.2-3. Lag Storage Pit Elevation View

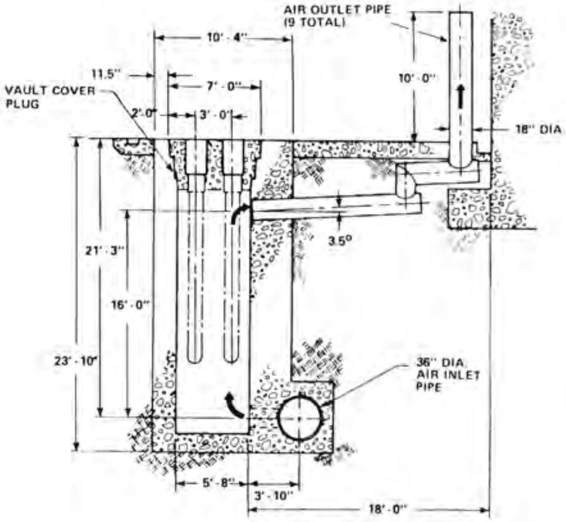

Figure 6.2-4. Lag Storage Pit Side View

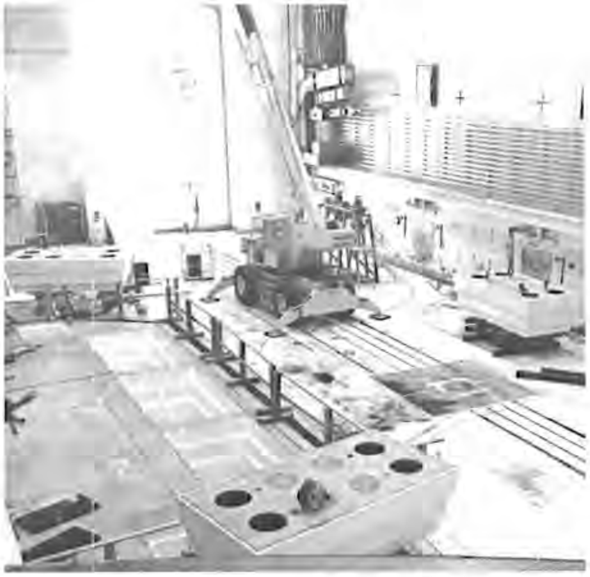

Figure 6.2-5. Lag Storage Pit and Vault Cover Plugs After Painting

Cover plug lifting and movement is accomplished by attaching lifting eyebolts in the four lifting lugs symmetrically placed in the cover plug. These lifting lug assemblies are cast into the concrete and consist of a rod attached to a sleeve at the top and a plate-type washer and nut at the rod bottom, two-thirds of the way down the plug.

6.2.4 LAG STORAGE PIT COOLING PIPE ARRANGEMENT

The Lag Storage Pit uses an array of inlet and outlet air pipes to dissipate heat from spent fuel assemblies. This system operates on natural convection or forced air circulation. Figure 6.2-4 gives a simplified view of the air cooling pipe arrangement. Figure 6.2-6 shows the outlet piping during construction.

Air enters the inlet duct from Hot Bay and flows through a 49 inch square passageway. It is then funneled into a 36 inch diameter by 0.38 inch thick pipe that begins 42 inches below floor level. This pipe extends 19 feet vertically downward. The inlet pipe extends horizontally at this elevation the entire pit length until it joins the second vertical 36 inch inlet pipe. Air enters the three individual vaults through three parallel 18 inch diameter by 0.25 inch thick inlet pipes perpendicular to the 36 inch inlet pipe. The vault inlet pipes enter each vault 21 feet below ground level and are spaced 36 inches apart.

The air heated by the canisters rises in the vault. The air exits through three 18 inch diameter by 0.25 inch thick outlet pipes, all

Figure 6.2-6. Lag Storage Pit Outlet Piping

parallel and equally spaced 54 inches apart, 5 feet below E-MAD floor level. The outlet pipes travel 11 feet 6 inches on a 3.5° slope before being stepped 27 inches up and 22.8 inches to the left or right. Two pipes are stepped different lengths (39.6 and 34.8 inches) to prevent interference with the shielded window on the west wall of the Hot Bay (see Figure 6.2-1). The outlet pipes travel 51.6 inches on a 3.5° slope to join a vertical pipe discharging into the Hot Bay 10 feet above floor level.

Two fans at the entrance of the 36 inch vertical inlet pipes provide vault air circulation. The fans are 42 inch standard, one horsepower, 240/460 volt AC exhaust fans each capable of a 17,720 cubic feet per minute flow. The two fans are located 3 feet below the Hot Bay floor. Two 49 inch square inlet ducts connect the fans to the Hot Bay. Each fan is bolted to a 2 inch by 1.5 inch by 0.25 inch thick angle attached to a support integrated in the concrete at a 45° angle. Power is supplied to the fan through 2 inch electrical conduits located in the pit area. This duct is covered by a 52 inch removable square grating for personnel protection. The grating is set into the floor on a concrete edge protected by 3.5 inch by 1.5 inch by 0.25 inch thick angle.

OUTLET PIPE INSTRUMENTATION

The nine thermocouples are located 5 feet above the Hot Bay floor inside the 18 inch outlet pipes. Each thermocouple is installed through a hole in the pipe back and fastened with clamps. The thermocouple tip is located in the pipe center. The thermocouples are fed into a 3 inch wide aluminum cable tray (made of two 21 feet long pieces) attached to the back of the outlet pipes at the top. The thermocouple extension wire is routed through the cable tray to a jack panel by gallery window W-3. A composite wire of all nine thermocouple wires is fed from this panel through a west wall pass-through to the data logger. The cable tray and jack panel can be seen in Figure 6.3-1.

6.2.5 SEISMIC GRIDS

Each vault in the Lag Storage Pit has a seismic grid assembly to maintain canister configuration in the event of seismic disturbances. The grids also hold the canisters in place should the canister assembly accidently drop into the vault. Two vaults (center and south vault) have the Type I configuration and the third, Type II.

The Type I seismic grid consists of a box-type frame structure sitting on two 3 inch by 3 inch by 0.25 inch thick angles, bolted to opposite vault walls. The frame is 11 feet 6 inches long by 5 feet 6 inches wide by 6 feet high and is constructed of structural carbon steel tubing, angles, I-beams, and flat bars. The frame has two levels: the top, which laterally constrains the canister by the grid work itself and, the bottom, with individual sections of pipe providing constraint. The upper-level outer-frame members are 2.5 inch by 2.5 inch by 0.25 inch thick angles welded to eight cross members of 1 inch by 3 inch flat bar. There are two 1 inch by 3 inch bars welded lengthwise to the 1 inch by 3 inch crossmembers. This grid work forms eight 24 inch by 24.5 inch "cell" openings for the canisters. Two

I-beams, welded to the outer member angles 33 inches from each end, serve as the supports for lifting the entire grid assembly.

The grid upper and lower levels are connected by six vertical and six diagonal supports, all made of 1.25 inch diameter by 0.25 inch thick steel tubing. The vertical supports are welded to 1 inch by 3 inch cross bars at the ends and to the horizontal 2.5 inch by 2.5 inch by 0.25 inch thick angles at the assembly lower level. The bottom is the same as the top grid frame except for no I-beam crossmembers and the eight individual cells have a pipe assembly to restrain canister movement. This pipe assembly consists of a section of 18 inch diameter by 0.38 inch thick pipe, 2.5 inches high with four sections of 2 inch outside diameter by 0.25 inch thick tubing welded to it. The four tube sections are spaced 90° apart, are centered on the pipe section and are approximately 4.5 inches long. Each assembly is welded to the grid frame cross member at the four tube sections. All eight pipe assemblies mount to the frame. Some are attached to a 2.5 inch by 2.5 inch by 0.25 inch thick angle which is then welded to a flat. Others are welded to a 1 inch by 3 inch bar with the tubing cut to accomodate the bar height. The configuration of the lower grid level is similar to that of the Type II upper grid shown in Figure 6.2-7.

The Type II seismic grid is installed in the north vault. This grid can accommodate two types of canisters. The two canister and seismic grid arrangements are shown in Figure 6.2-1. This seismic grid consists of an upper and lower grid. Both are shimmed against the wall to prevent movement during a seismic event. The upper and lower grids are shown in Figures 6.2-7 and 6.2-8.

The upper grid is a rectangular frame assembly made of 4 inch by 1.72 inch by 0.32 inch thick structural support channels. The frame is 11 feet 5.5 inches by 5 feet 5.5 inches wide by 12 inches high. There are four lengthwise channels and eight crossmember channels, spaced to provide the same eight "cell" configuration as the Type I grid. The channel crossmembers are welded to 7.5 inch by 4 inch by 0.5 inch thick steel plates which are shimmed against the wall at installation to hold the frame in place. Shimming uses adjustable bolts to locate the frame, with grout installed to hold the frame in place (shimming done to plates on east and west wall of vault). The lengthwise channels are welded to 2.5 inch by 2.5 inch by 0.25 inch thick angles bolted to the vault's north and south walls. These angles support and locate the upper grid.

Each upper grid section has an 18 inch diameter by 12 inch long by 0.75 inch thick pipe section similar to the bottom level of Type I. Four 4 inch channel sections (same as in frame structure) are welded 90° apart on the pipe. These sections are welded to the frame structure for seven of the eight sections. For the last section, a removable pipe assembly allows access to the lower grid. This assembly consists of the same type of pipe section used for the other seven. The only difference is that four 8.25 inch by 4.25 inch by 0.5 inch thick steel plates are welded to the pipe section. These plates, placed 90° apart, have

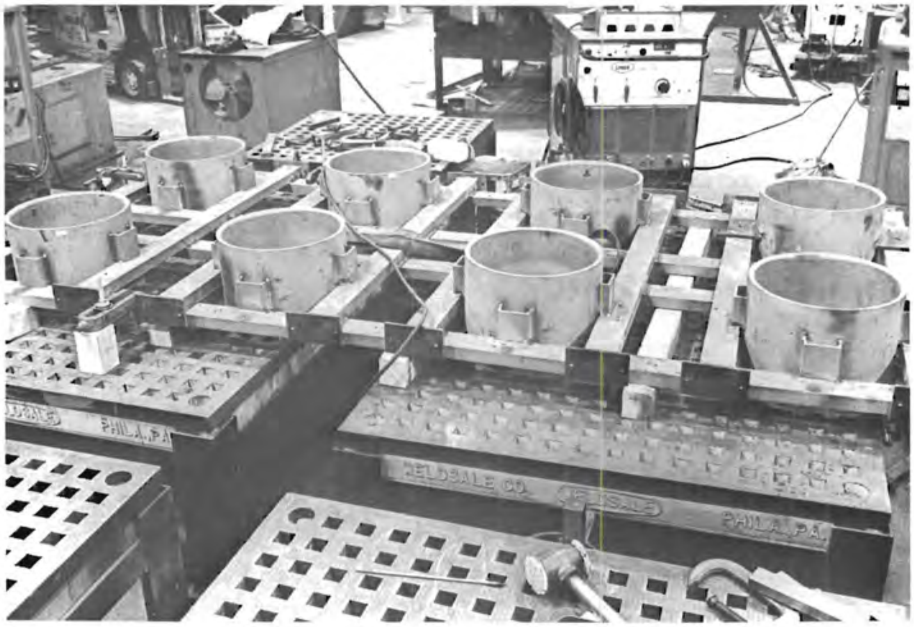

Figure 6.2-7. Lag Storage Pit Type II Upper Seismic Grid

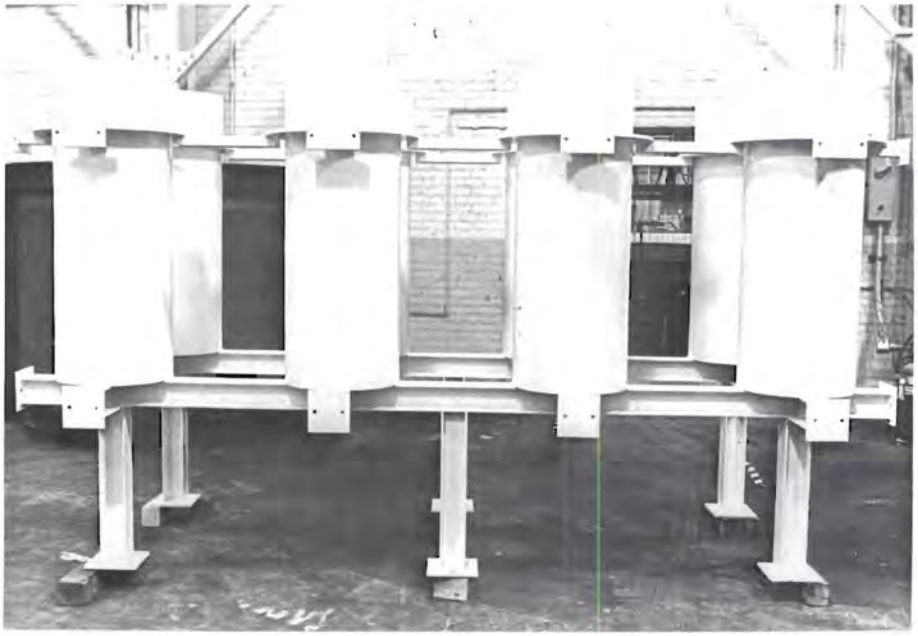

Figure 6.2-8. Lag Storage Pit Type II Lower Seismic Grid

holes for bolts to secure the pipe assembly to the frame. The upper grid pipe centerlines corresponded to the as-built centers of vault cover plug liners.

The lower seismic grid assembly consists of eight sections of 4 foot long 18 inch diameter by 0.38 inch thick pipe supported at the bottom by structural steel I-beams (4.16 inch by 4.06 inch by 0.35 inch thick). Two I-beams, 11 feet 5 inches long, are welded to four 32 inch long sections of crossmember I-beams. Eight 12.25 inch long I-beam sections are welded to the two lengthwise beams in the same line as the four crossmembers. This configuration yields eight cross areas to which the pipe sections are welded. This frame is supported by six 24.5 inch high vertical beams welded at the four corner crosses and two in the center of the two lengthwise beam supports. All the vertical supports have 8 inch square by 0.5 inch thick steel plates welded to the ends for shimming the frame in place. There are twelve 6 inch square by 0.5 inch thick steel plates welded to the eight short outer crossmembers and at both ends of the long support beams. These are also shimmed at grid installation using adjustable bolts and grout.

A 3 inch wide by 0.5 inch thick steel ring is welded to each pipe section 9 inches from the top. Ten lengths of 4 inch by 1.72 inch by 0.32 inches thick steel channel, each 16 inches long, are welded between the rings. Twelve 4.25 inch long channel sections are welded to the rings facing the vault walls and 7.5 inch by 4 inch by 0.5 inch thick steel plates are welded to the channel ends for support. These plates are shimmed against the wall using the adjustable bolt and grouted during grid installation.

6.2.6 LAG STORAGE PIT SHIELD PLUGS

The shield plugs used in the Lag Storage Pit vault covers are a duplicate of those used in the drywells (see Figure 3.2-20) with the exception of no instrumentation tubes. The shield plug is a standard 20 inch diameter by 0.25 inch thick carbon steel pipe, 34 inches long, with a 1 inch thick steel plate welded to the top and bottom. The volume between the two plates is filled with 150 pound per cubic foot density concrete for shielding. Extending from the bottom plate is a 16 inch diameter by 1.03 inch thick by 12 inch long pipe. Support pins are installed in four tapped holes 90° apart enabling the shield plug to attach to the canister assembly. Provision for lifting the shield plug is made by holes in the top cover plate to which a lifting bail is bolted. When installed in the pit, the shield plug top is at floor level.

6.2.7 CANISTER ASSEMBLY

The canister assemblies installed in the Lag Storage Pit during the period September, 1980 to March, 1982 were those constructed for the SFT-C Program described in Section 3.2.2. Of the 13 canister assemblies installed during this time, four were not welded and had an air internal atmosphere.

CANISTER INSTRUMENTATION

Two thermocouples were installed in an unwelded (air filled) canister assembly installed in the Lag Storage Pit. These thermocouples were inserted through a shield plug with instrumentation tubes into the tubes on the canister outside. Thermocouples were placed in the center tube of the three on each canister side. Table G-1 defines the location of these two thermocouples.

6.2.8 DATA ACQUISITION SYSTEM

The data acquisition system for the Air-Cooled Vault Test temperature measurement consists of the thermocouple array and the E-MAD data logger. Eleven thermocouples are located in the Lag Storage Pit hardware (previously described) and their positions are illustrated in Figure 6.2-9. An additional thermocouple, located at the weld pit table in front of Hot Bay window E-5, provides data for ambient Hot Bay air temperatures. The thermocouple leads are routed to the data logger (see Section A.5.5).

A hand-held velometer (flow meter) measured the air flow rates from the outlet pipes for the Air-Cooled Vault Ventilation Tests. The velometer, an Alnor Instruments, Inc. Model 3002, is a portable, non-electrical swinging-vane type anemometer with a range of 0 to 1000 feet per minute. The meter is analog and has the accuracy of plus or minus two percent of full scale reading.

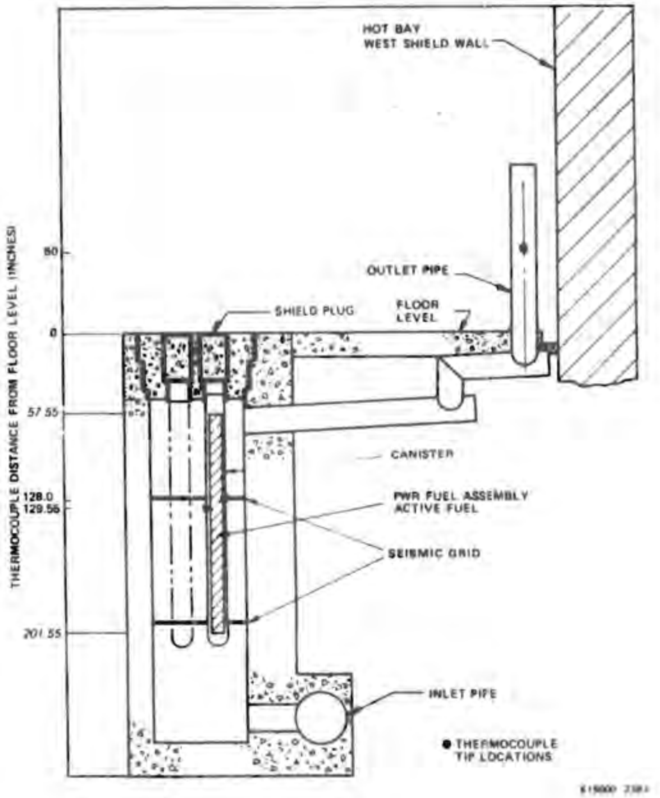

Figure 6.2-9. Lag Storage Pit Thermocouple Locations

THERMOCOUPLES

All the Air-Cooled Vault Test thermocouples are Type K, chromel-alumel thermocouples with an ungrounded junction enclosed in a 304 stainless steel sheath. Each thermocouple is brazed to an extension wire inside a 0.187 inch diameter by 0.025 inch thick by 2.75 inch long stainless steel transition boot crimped onto the thermocouple cable sheath and filled with epoxy. The thermocouples installed in the Lag Storage Pit outlet pipes are 0.125 inches in diameter and are connected to 20 gage extension wire. The thermocouples installed in the canister instrumentation tubes and at the weld pit are 0.062 inches in diameter and are attached to 24 gage extension wire.

6.3 OPERATIONS AND PROCEDURES

CONSTRUCTION

The Lag Storage Pit construction was completed in October, 1978 prior to the SFHPP 1978 Demonstration operations.

FUEL ASSEMBLY ENCAPSULATION, INSTALLATION AND REMOVAL

The 13 SFT-C Program PWR spent fuel assemblies were encapsulated prior to emplacement the Lag Storage Pit. The following presents a brief summary of the typical activities. Further details are found in Appendix B. The operations began with preparing the spent fuel shipping cask for fuel assembly unloading. Next, by remote operations, a fuel handling tool was inserted in the cask and the handling tool and fuel were lifted out. Each fuel assembly was visually examined by a remotely held TV camera and then placed in a canister located in the Hot Bay weld pit. The canister closure lid was installed and seal welded to the canister. The weld was made remotely and the completed weld visually inspected using a wall-mounted periscope. The canister was then evacuated and backfilled with helium. A sample was drawn from the vacuum chamber into a helium leak detector in the gallery and examined for helium. The shield plug was installed and the canister and shield plug were then removed to the survey pit where swipes are made of the canister surface using the master-slave manipulators. The canister was then installed in the Lag Storage Pit as shown in Figure 6.3-1.

Four of the fuel assemblies (D34, D22, D15 and D04) were placed in canisters and the closure lid installed without welding or backfilling with helium.

Table 6.3-1 provides information on the location of each of the 13 fuel assemblies in the Lag Storage Pit

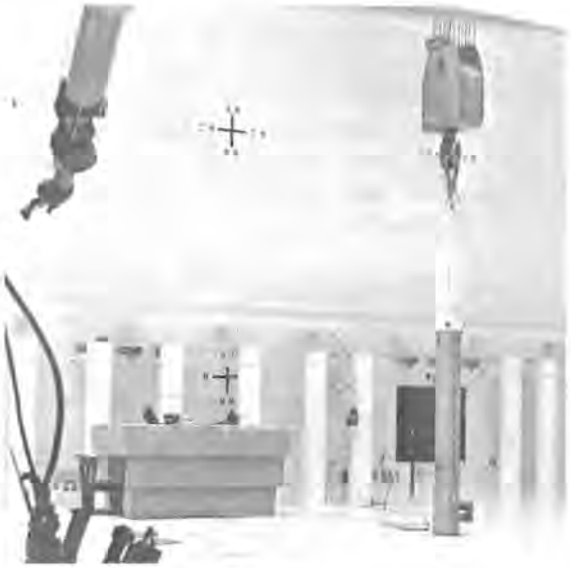

Figure 6.3-1. Canister Installation into Lag Storage Pit

TABLE 6.3-1
AIR-COOLED VAULT TEST FUEL ASSEMBLY OPERATIONS SUMMARY

Lag Storage Pit Location*	Fuel Assembly Serial No.	Date Received at E-MAD	Date Installed in LSP	Date Removed	Date Calorimetered	Date Gas Sampled
9	D40	9/21/79	9/21/79	4/14/80		
10	D46	9/24/79	9/25/79	4/28/80		
11	D47	10/1/79	10/1/79	5/7/80		
12	D09	10/9/79	10/10/79	4/30/80		
13	D18	10/20/79	10/20/79	4/21/80		
14	D16	10/22/79	10/22/79	5/19/80		
15	D34	11/1/79	11/1/79	4/24/80	4/1/80	4/1/80
16	D22	11/12/79	11/12/79	9/4/80	7/9/80	6/25/80
17	D35	11/15/79	11/15/79	5/5/80		
18	D15	11/25/79	11/27/79	9/22/80	7/8/80	4/10/80
19	D06	11/30/79	11/30/79	5/12/80		
20	D04	12/11/79	12/11/79	5/20/80	5/20/80	4/9/80
21	D01	12/12/79	12/12/79	5/14/80		

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*See Figure 6.2-2 for location identification

and then dates of installation and removal. Also included are the dates for boiling water calorimetry and gas sampling performed on the four assemblies placed in unwelded canisters. Details of the calorimetry and gas sampling operations and results are found in Appendix K and L, respectively.

TEST PROCEDURES

Two sets of ventilation tests were performed on the Lag Storage Pit for two different conditions. The first test occurred on October 10, 1979. There were four PWR fuel assemblies present in the center vault for this test. Four different configurations of the cooling system were tested: first, both fans on, neither inlet blocked; second, north fan on, neither inlet blocked; third, north fan on, south inlet blocked; and forth, natural convection, neither fan on and neither inlet blocked. Flow blockage was achieved by placing a sheet of plastic under the south inlet grate. The average flow velocities were measured using the velometer and the outlet pipe temperatures were measured using the thermocouples installed in the pipes.

The second set of ventilation tests occurred on December 4 through 7, 1979. There were 11 PWR fuel assemblies in the Lag Storage Pit for this set of tests. For these tests, the canister located in position 16 was instrumented with two thermocouples to provide canister temperature data. There were four configurations for this test: first, both fans on, neither inlet blocked; second, south fan running, neither inlet blocked; third, south ran running, north inlet blocked; fourth, natural convection, neither fan blocked and neither inlet blocked. For these tests, the outlet pipe flow velocities were measured at five different locations in the cross section of the pipe, in the center and half way between center and pipe wall at 90° intervals. For the second test, the air flow velocity out of the north inlet (with fan off) was measured. In addition, the north and south inlet fan temperatures were also recorded.

Fuel assemblies D04 and D01 were installed in the Lag Storage Pit on December 13 and 15, 1979, respectively to complete the array of fuel assemblies in the pit. Temperature data monitoring for the instrumented canister and pit outlet pipes began on December 11, 1979 at 4:00 p.m. just prior completion of fuel installation. Data logger printouts were made every eight hours at midnight, 8:00 a.m. and 4:00 p.m. thereafter until April 29, 1980. From April 29 through June 4, 1980, printouts were made at four hour intervals, starting at midnight. After June 4, when only fuel assemblies D15 and D22 remained in the pit, printouts were made every 24 hours at 4:00 p.m. Canister temperature data recording was terminated on June 22, 1980 when the thermocouples were removed (prior to fuel assembly removal for calorimetry). These thermocouples were not reinstalled.

Additional data logger printouts were made during fuel assembly gas sampling and calorimeter operations. Printouts were made at 15 minute intervals while fuel assembly D34 was out of the pit from 8:45 a.m. to 6:30 p.m. on April 1, 1980 and at 30 minute intervals thereafter until 12:30 p.m. on April 2, 1980.

Additional Lag Storage Pit performance testing temperature data was gathered during the removal of fuel assemblies from the pit. The fans were turned off from noon on April 29 to noon on May 2, from 4:00 p.m. on May 4 to 4:00 p.m. on May 9, from noon on May 19 to noon on May 22, and again from noon on June 4 to noon on June 11. The fans were turned off on June 18, 1980 when the forced cooling was considered to be unnecessary.

6.4 TEST RESULTS

This section presents the results from the Air-Cooled Vault Tests. The recorded flow velocities and temperatures for the two sets of ventilation tests are presented in Table 6.4-1 and 6.4-2. Thermocouple readings of canister, vault outlet pipes and ambient Hot Bay temperatures are provided in Appendix G. The readings include those from the second set of ventilation tests; at about one week intervals during the months of December, 1979 through May, 1980 on the first, eighth, fifteenth and twenty-second; and for different test conditions. These conditions include readings before and after removal of seven of the spent fuel assemblies in the center vault and for the additional natural circulation tests run in April, May and June.

TABLE 6.4-1
AIR-COOLED VAULT VENTILATION TEST 1 RESULTS

Date: 10/11/79
Condition: Four PWR fuel assemblies in center vault.
Ambient Hot Bay temperature: 81.7°F (Tests A & B), 79.4°F (Tests C & D)

Test A: Both fans operating, neither inlet blocked.
Test B: North fan operating, neither inlet blocked.
Test C: North fan operating, south inlet blocked.
Test D: Natural convection - neither fan operating, neither inlet blocked.

Outlet Pipe Number	Test A		Test B		Test C		Test D	
	Air Flow Velocity (FPM)	Temp (°F)	Air Flow Velocity (FPM)	Temp (°F)	Air Flow Velocity (FPM)	Temp (°F)	Air Flow Velocity (FPM)	Temp (°F)
South 1	750	78.1	180	79.1	750	78.4	50	79.6
2	700	78.3	200	79.3	700	78.5	50	79.7
3	750	78.7	200	79.4	700	78.7	75	80.1
4	850	80.6	160	91.8	650	82.8	100	93.5
5	850	84.3	170	92.1	625	86.9	100	94.1
6	825	87.3	170	93.3	650	88.3	100	96.0
7	800	78.5	140	79.1	550	78.5	50	79.6
8	750	78.3	130	79.0	550	78.2	50	79.6
North 9	750	77.8	140	78.6	550	77.9	50	79.3

6.4.1 VENTILATION TESTS

Two separate sets of ventilation tests were performed on the Lag Storage Pit, the first on October 11, 1979 and the second on December 4 through 7, 1979. There was a different configuration for each set of tests which are shown in Figure 6.4-1. The results of these tests, presented in Tables 6.4-1 and 6.4-2, include outlet pipe air flow velocity and temperature for the four flow conditions. The data in Table 6.4-2 also include steady state canister temperatures for the four operating conditions.

Comparing the data from both series of tests, it appears that the number and position of the canisters has little affect on outlet pipe flow velocity. For both fans running, outlet velocities are all in the 700 to 850 FPM range, with the center vault having the highest readings. For one fan off and neither inlet blocked, values are much lower, in the 140 to 200 FPM range. The outlet pipe velocities at the vault end opposite the operating fan are higher because the air flows through the inlet bottom pipe and out the other inlet, the path of least resistance. As much as 40 percent of the inlet flow air was measured flowing out the other unblocked inlet. The blockage of the off fan inlet produces higher outlet pipe velocities (650 FPM range) with the vault closest to the blocked inlet receiving the most air. The three outlet pipes in each pit have about the same air velocity, although values for outlets for each vault vary slightly. The results from the two natural convection tests provided comparable results. The test with eight canisters in the center vault recorded higher flow velocities. This was a result of the increased convection for more canisters and a greater thermal pressure head (caused by decay heat). In the vault with no canisters, the flow was very low or not measurable. The flow in the south vault for the second test was measurable due to the three installed canisters but was lower than the values recorded

TABLE 6.4-2
AIR-COOLED VAULT VENTILATION TEST 2 RESULTS

Condition: Eight PWR fuel assemblies in center vault, three PWR fuel assemblies in south vault.

Test A: Both fans operating, neither inlet blocked.
Date: 12/4/79
Canister T/C 908 temperature: 141.3°F
Canister T/C 909 temperature: 135.5°F
Ambient Hot Bay temperature: 67.2°F

Outlet Pipe No.	Temp (°F)	Air Flow Velocity (FPM) 1	2	3	4	5	Average Air Flow Velocity (FPM)
1	69.1	825	850	825	825	800	825
2	72.4	750	750	850	800	750	780
3	75.1	725	725	750	750	700	730
4	76.6	900	925	950	900	850	905
5	77.8	850	800	950	925	800	865
6	76.5	800	775	975	875	800	845
7	67.4	800	900	950	875	800	865
8	67.2	825	850	875	850	800	840
9	67.1	800	850	925	850	750	835

Test B: South fan operating, neither inlet blocked.
Date: 12/5/79
Canister T/C 908 temperature: 175.3°F
Canister T/C 909 temperature: 172.3°F
Ambient Hot Bay temperature: 67.8°F

Outlet Pipe No.	Temp (°F)	Air Flow Velocity (FPM) 1	2	3	4	5	Average Air Flow Velocity (FPM)
1	81.1	150	150	150	150	125	145
2	84.0	150	125	160	150	100	137
3	83.8	150	150	175	150	100	145
4	100.3	200	150	220	200	150	184
5	99.2	200	150	200	175	150	175
6	97.9	200	175	220	220	150	193
7	68.1	175	200	210	175	150	182
8	67.7	150	160	200	160	150	164
9	67.7	175	190	200	175	150	178

TABLE 6.4-2 (Continued)

Test C: South fan operating, north inlet blocked.
Date: 12/7/79
Canister T/C 908 temperature: 143.7°F
Canister T/C 909 temperature: 150.1°F
Ambient Hot Bay temperature: 68.4°F

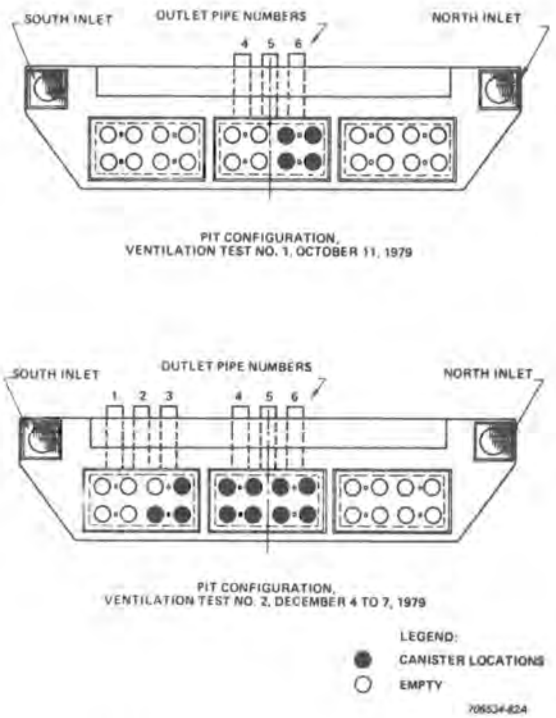
Outlet Pipe No.	Temp (°F)	Air Flow Velocity (FPM)					Average Air Flow Velocity (FPM)
		1	2	3	4	5	
1	70.3	600	650	625	625	575	610
2	70.6	575	625	650	575	500	585
3	77.4	600	600	625	600	550	595
4	79.3	650	650	675	600	600	635
5	83.6	625	675	700	625	600	645
6	83.6	650	600	650	650	575	625
7	68.6	750	825	800	725	675	755
8	68.4	700	725	850	725	600	720
9	68.2	750	775	850	725	700	760

Test D: Natural convection - neither fan operating, neither inlet blocked.
Date: 12/6/79
Canister T/C 908 temperature: 181.0°F
Canister T/C 909 temperature: 176.8°F
Ambient Hot Bay temperature: 66.8°F

Outlet Pipe No.	Temp (°F)	Air Flow Velocity (FPM)					Average Air Flow Velocity (FPM)
		1	2	3	4	5	
1	83.3	50	100	100	50	25	65
2	86.2	50	100	100	50	50	70
3	86.2	75	50	50	75	50	60
4	103.4	150	175	175	150	125	155
5	103.0	140	150	160	140	100	138
6	101.3	150	140	175	120	70	131
7	68.9						Flow Not Measurable
8	65.8						Flow Not Measurable
9	65.9						Flow Not Measurable

for the four canisters in the center vault for the first test with natural convection.

Outlet pipe temperatures were affected by the number of canisters in the vault, their location, and by the ventilation condition. Figure 6.4-1 shows which outlet pipes were affected for each of the ventilation tests. In the first set of ventilation tests, only outlet pipes 4, 5 and 6 were affected. Outlet pipe 6 temperatures were the highest for all of the test configurations because it was located nearest the four canisters in the center vault. Temperatures for outlet pipes 4 and 5 were lower than outlet pipe 6 but still were



PIT CONFIGURATION,
VENTILATION TEST NO. 1, OCTOBER 11, 1979

PIT CONFIGURATION,
VENTILATION TEST NO. 2, DECEMBER 4 TO 7, 1979

Figure 6.4-1. Lag Storage Pit Configuration for Air-Cooled Vault Ventilation Tests

influenced by the decay heat of the spent fuel in the center vault as noted when compared to outlet temperatures for the other two vaults. The outlet pipe temperatures were lowest for full ventilation (about 85°F) but became higher as one fan was shut off and then the inlet blocked. Temperatures were the highest (about 95°F) for natural convection. Temperatures for outlet pipes 1, 2, 3, 7, 8 and 9 were the same as Hot Bay ambient because no spent fuel was stored in either the north or south vaults.

For the second set of ventilation tests, the results are very similar to those for the first set relative to vault configuration and flow conditions. Some of the recorded values are higher due to the increased decay heat in the center and south vaults. Outlet pipes 1 through 6 were affected by the decay heat while outlet pipes 7, 8 and 9 were close to ambient Hot Bay temperature because no spent fuel was in the north vault. As expected, outlet pipes 4, 5, and 6 had the highest temperatures for full ventilation. Outlet pipe 3, closest to the three canisters in the south vault, has the highest temperature while outlet pipes 2 and 1 temperatures decrease as they get farther from the fuel canisters. For natural convection, the outlet pipe temperatures for the center vault are approximately equal while the south vault outlet pipe temperatures increase as the pipes get closer to the three canisters. All these results were expected based on the first set of ventilation test results.

Partial ventilation from one fan with neither inlet blocked yields results similar to natural convection with outlet pipe temperatures differing by only 2°F. Outlet pipe temperatures for the center vault differ by 3°F which may be explained by added heat from the concrete wall between the center and south vaults being picked up by the flowing air. The partial ventilation condition with the inoperative fan inlet blocked yields results similar to the full ventilation condition. Outlet pipe temperatures for the center vault show a slight difference (4°F) towards the north end which may be explained by the decay heat level being greater at that end of the vault.

The accuracy of velometer air flow readings presented in Table 6.4-1 and 6.4-2 must consider the range scale and meter graduations for the range of flow velocities measured. For flow velocities between 500 and

1000 feet per minute, meter graduations allowed readings to the nearest 25 feet per minute. For flow velocities in the range 0 to 250 feet per minute, meter graduations allowed readings to the nearest 10 feet per minute. The readings for the first set of flow tests were less accurate than those for the second since only one reading was taken. The average values from five readings is considered to be more representative of the actual flow velocities for the four test conditions evaluated.

6.4.2 LAG STORAGE PIT THERMAL RESPONSE

The effects of decreasing decay heat and canister removal from the Lag Storage Pit were evaluated using the full flow cooling data recorded between January and June of 1980. Figures 6.4-2 to 6.4-5 show the response of the outlet pipe temperatures and Figures 6.4-6 and 6.4-7 show the response of the canister temperatures to these effects.

Figure 6.4-2 illustrates the effect of decay heat level on center vault outlet pipe temperature. Since Hot Bay ambient temperatures varied throughout the period of Lag Storage Pit temperature data recording, the outlet pipe temperatures are shown as the temperature above ambient. The decay heat levels in the center vault were determined by summing the predicted decay heat

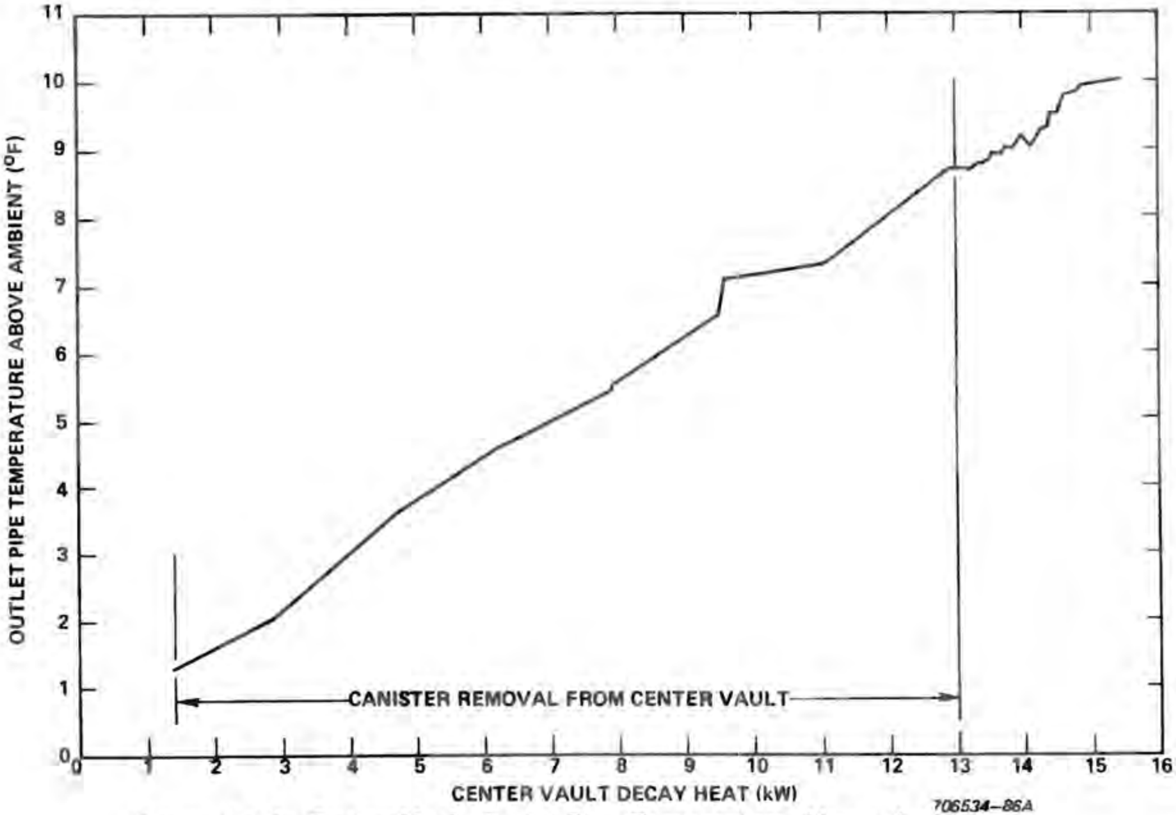


Figure 6.4-2. Center Vault Outlet Pipe Temperature Above Ambient Response to Decay Heat Level Changes in Lag Storage Pit, January 1980 to June 1980

for each of the fuel assemblies in the center vault using the decay heat curves shown in Figures 2.3-4, 2.3-5 and 2.3-6. For the thermal response evaluation, the average of outlet temperatures from the north vault were used as the ambient Hot Bay temperatures. The temperatures recorded at the weld pit table by thermocouple 901 were intended to be representative of ambient, however the recorded temperatures from this thermocouple were generally higher than those for the north vault (without any fuel) outlet pipes. The Hot Bay air conditioner, run intermittently, is expected to have affected the inlet temperatures for the Lag Storage Pit which were not reflected in the temperature measurements at the weld pit.

Figure 6.4-2 shows a nearly linear relationship between the center vault outlet pipe temperatures above ambient and the decay heat level in the vault. The largest changes in the decay heat level occurred when the seven canisters were removed, yet the relationship remained linear.

The relationships between the three center vault outlet pipe temperatures for three different canister removals are shown in Figures 6.4-3, 6.4-4 and 6.4-5. These three figures show the changes in

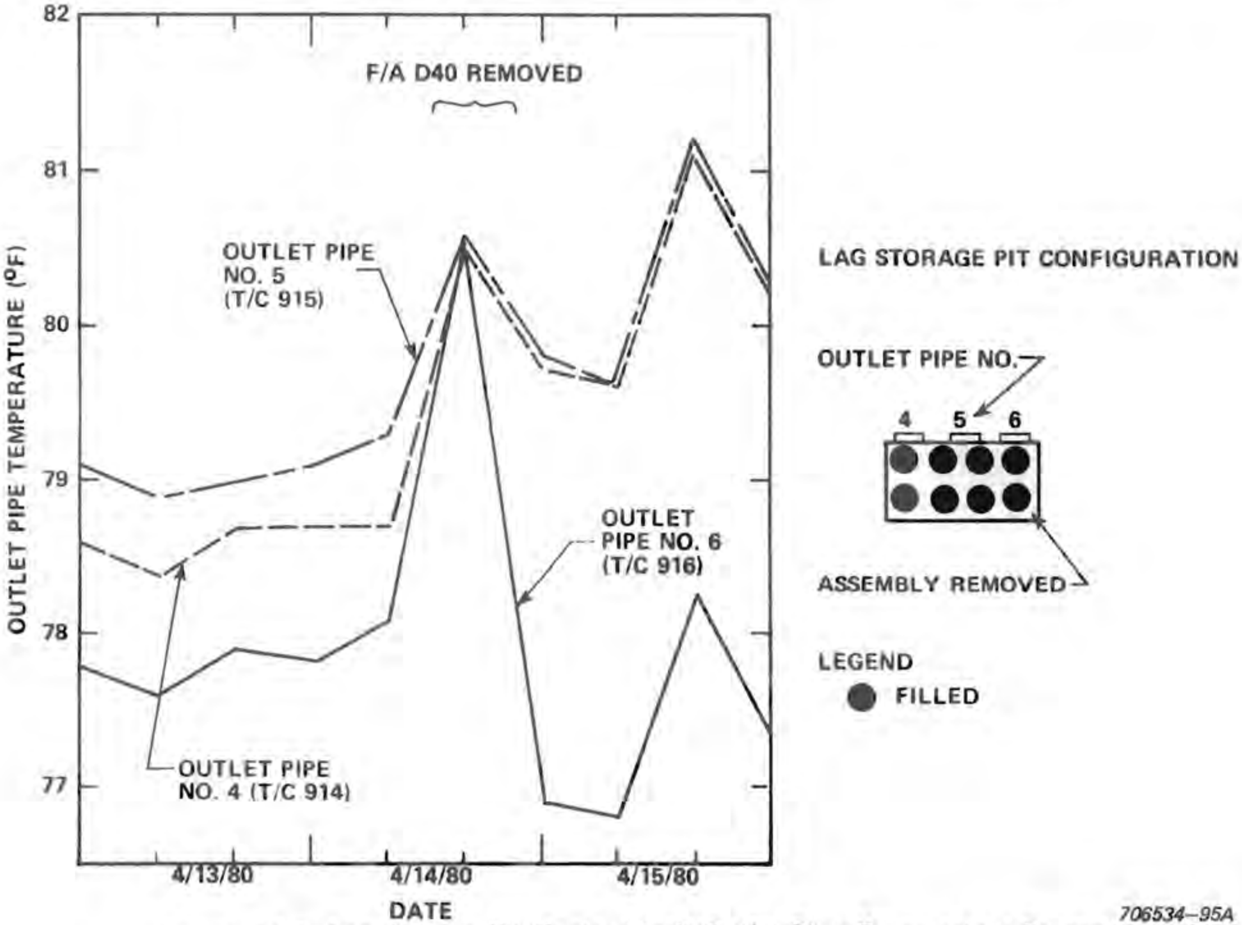


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Figure 6.4-3. Lag Storage Pit Center Vault Outlet Pipe Temperature Response to Fuel Assembly D40 Removal

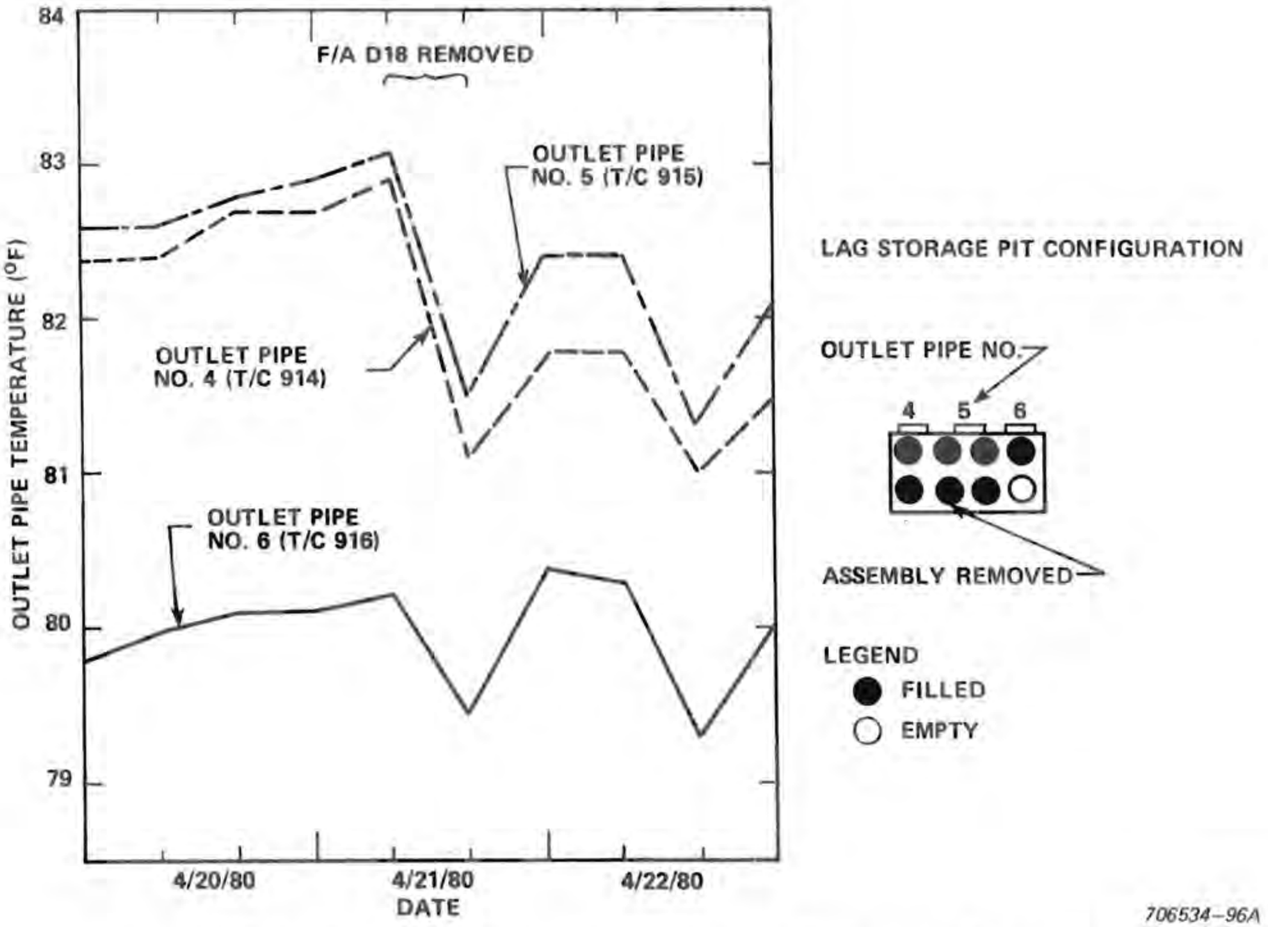

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Figure 6.4-4. Lag Storage Pit Center Vault Outlet Pipe Temperature Response to Fuel Assembly D18 Removal

outlet temperature for eight hour data recordings over three day periods for the removal of canisters containing fuel assemblies D40, D18 and D34, respectively. The removal of a canister (period during which removal occurred is noted) at the end of the vault causes the immediately adjacent outlet pipe temperature to drop in relation to the other two (for D40 and D34). In addition, for canisters removed from the center of each vault, both of the adjacent outlet pipe temperatures are affected; i.e. both adjacent outlet pipe temperatures become lower and the difference between them changes.

The curves shown in Figures 6.4-3 to 6.4-5 also show the outlet pipe temperature changes caused by Hot Bay ambient temperature changes. The 1 to 2°F changes in outlet pipe temperatures shown during the day on April 16, 22 and 23 may be a result of the Hot Bay air conditioning system or the opening of the main shield door for transporter removal from the Hot Bay. The nearly identical temperatures for all three outlet pipes at 4:00 p.m. on April 14, 1980 were affected by the absence of the shield plug in the vault cover plug during fuel assembly D40 removal. The missing plug (replaced after

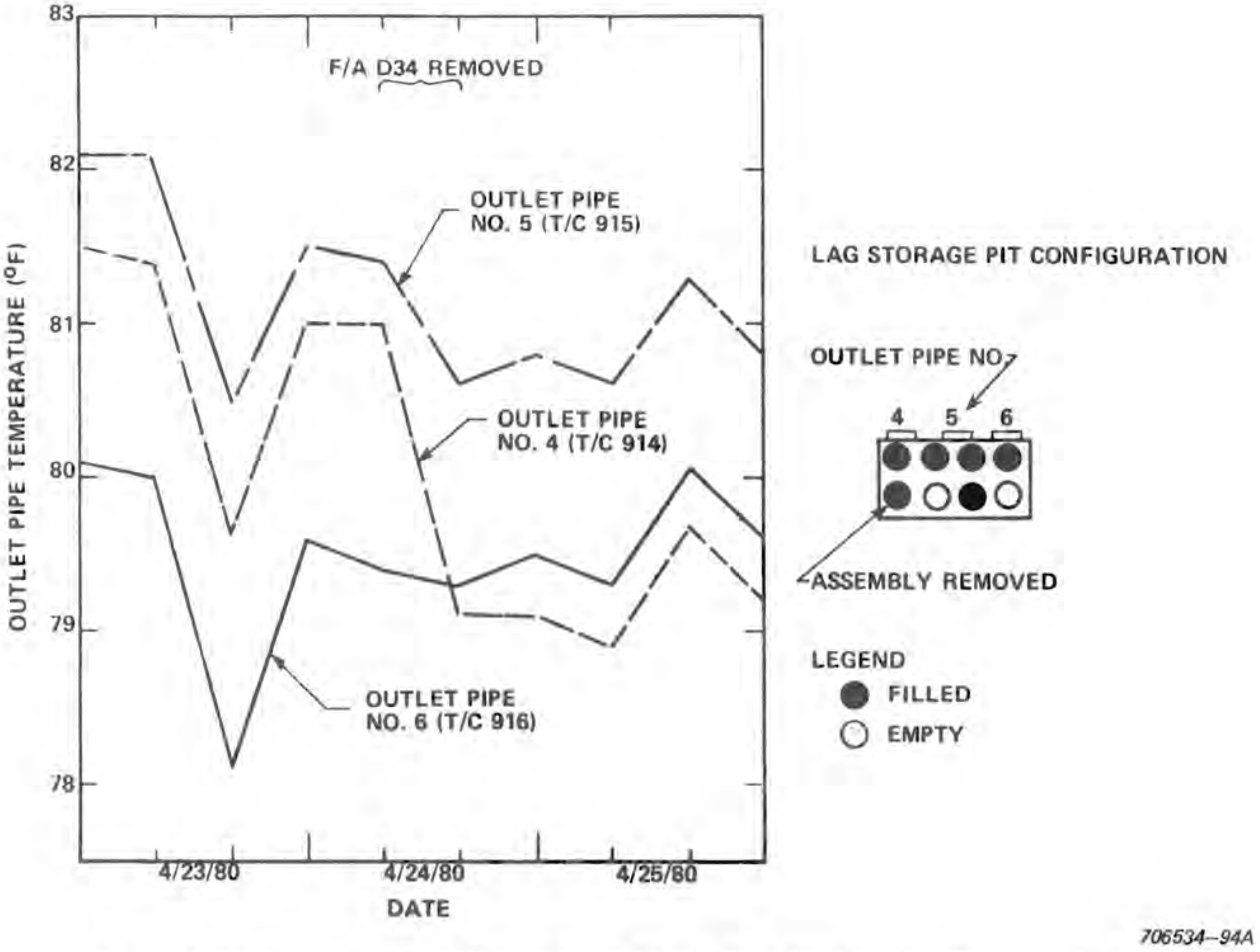

Figure 6.4-5. Lag Storage Pit Center Vault Outlet Pipe Temperature Response to Fuel Assembly D34 Removal

4:00 p.m. reading) resulted in cooling air exiting the vault through this hole in the cover plug and not through the outlet pipes.

The thermal response of the instrumented canister to changes in Lag Storage Pit flow conditions were recorded for different pit configurations. From the second set of ventilation test results, with eight canisters in the center vault, the peak canister temperatures were 141°F for full flow, 150°F for one fan operating and the other inlet blocked, 175°F for one fan operating and the other inlet open, and 181°F for natural circulation. At the end of April, 1980, full flow and natural circulation data for only four canisters in the center vault showed peak canister temperatures of 170°F for natural circulation and 147°F for full flow. Again in May, 1980 data for these two flow conditions with only fuel assembly D22 in the center vault showed peak canister temperatures were 166°F for natural circulation and 142°F for full flow. Comparing these three sets of relationships, the removal of canisters (and decay heat) from the center vault causes the canister temperature difference between full flow and natural circulation to decrease.

The thermal response of the canister to changes in decay heat levels and the removal of canisters was further evaluated using data recorded for full flow conditions. Figures 6.4-6 and 6.4-7 show the relationships determined from the data. Figure 6.4-6 shows the measured canister temperature, the canister temperature above ambient and the predicted decay heat levels in the center vault from January to June, 1980. The canister temperatures are affected by changes in Hot Bay ambient. The variations in canister temperature in the top curve on Figure 6.4-6 shows some of this variation. To better judge canister temperature response to decay heat level changes, the canister temperature above ambient was plotted versus time (center curve on Figure 6.4-6). Comparing this curve with the one for center vault decay heat versus time shows that the change in decay heat is reflected in the canister temperature above ambient. Due to the eight hour data reading frequency during the removal of canisters, some of the changes in the canister temperature above ambient curve do not represent the exact canister response to other canister removals. However, the data shown provides a reasonable indication of overall canister response.

Figure 6.4-7 shows the canister temperature response to the removal of fuel assembly D34 from data at 15 minute intervals on April 1, 1980. This assembly, located next to the instrumented canister, was removed for gas sampling and calorimetry on April 1. Both canister assembly thermocouples show a 13.5°F decrease during this period. Following fuel assembly return to the vault, canister temperatures steadily rose. Two things should

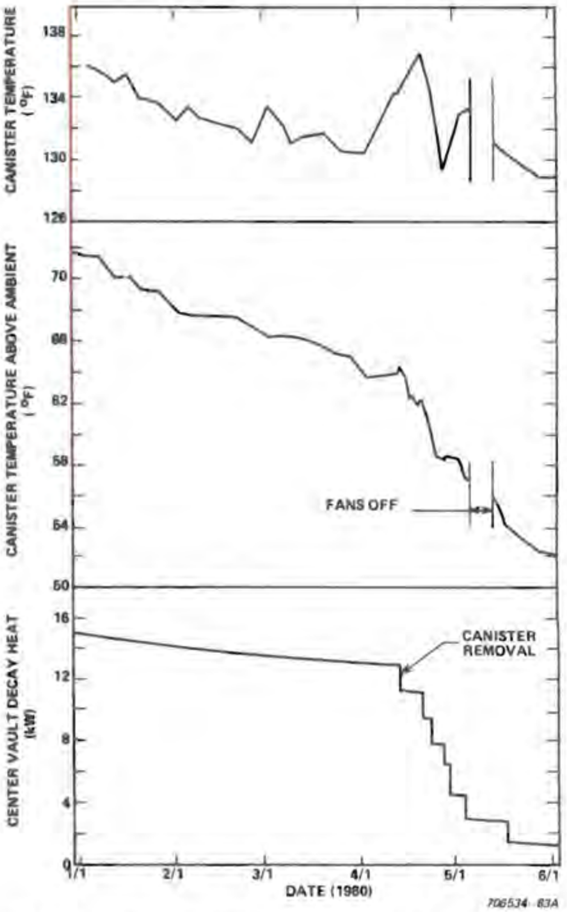

Figure 6.4-6. Canister Temperature Response to Decay Heat Level Changes in Lag Storage Pit

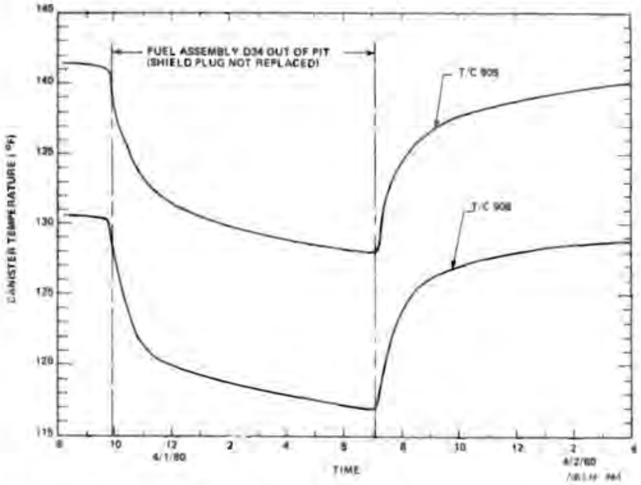

Figure 6.4-7. Lag Storage Pit Canister Temperature Response to Fuel Assembly D34 Removal

be noted. First, the shield plug for the D34 canister was not replaced in the vault cover plug. Since the opening would "short circuit" the air flow path through the vault causing the air to exit through the hole and not the outlet pipes, some of the 13.5°F temperature drop may be attributable to the air flow pattern difference. Also, the time for canister temperature to return to its normal storage temperature is about nine hours. For the data taken on days when canisters were removed and reinserted into the vault, the 4:00 p.m. and midnight readings may not be representative of normal storage, but may be reflecting a point on the transient curve.

The results of the ventilation tests and the temperature data recordings show that interim storage of spent fuel in the Lag Storage Pit maintains canister temperatures below those in drywell and concrete silo storage. The maximum recorded canister temperature of 181°F for a full center vault with only natural convection cooling is significantly lower than the maximum temperatures recorded in Drywell 5 for the same fuel assembly (323°F, see Section 3.4.2). The overall Lag Storage Pit response to 13 spent fuel assemblies with an average decay heat of nearly 2 kW at emplacement was better than had been initially predicted based on center vault thermal results. Based on data from the flow ventilation test and the temperature data from thermocouples in the Lag Storage Pit, little or no interaction between the three separate vaults was evident. Therefore the performance results for the filled center vault should be applicable to the entire vault.

6.5 AIR-COOLED VAULT TEMPERATURE EXTRAPOLATIONS

The peak fuel clad temperatures have been predicted for fuel assembly D22 in the E-MAD Lag Storage Pit. Temperature predictions were based on the peak measured canister temperatures, the predicted decay heat levels (from Figure 2.3-6), and the peak fuel clad to canister temperature difference relationship developed from the air filled Fuel Assembly Internal Temperature Measurement Tests (see Section 5.6.1). Figure 6.5-1 shows the peak measured canister temperatures and the estimated peak fuel clad temperatures from December 4, 1979 to June 22, 1980.

The peak measured canister temperatures and the predicted decay heat levels throughout the Air-Cooled Vault Test were used to calculate the peak fuel clad to canister

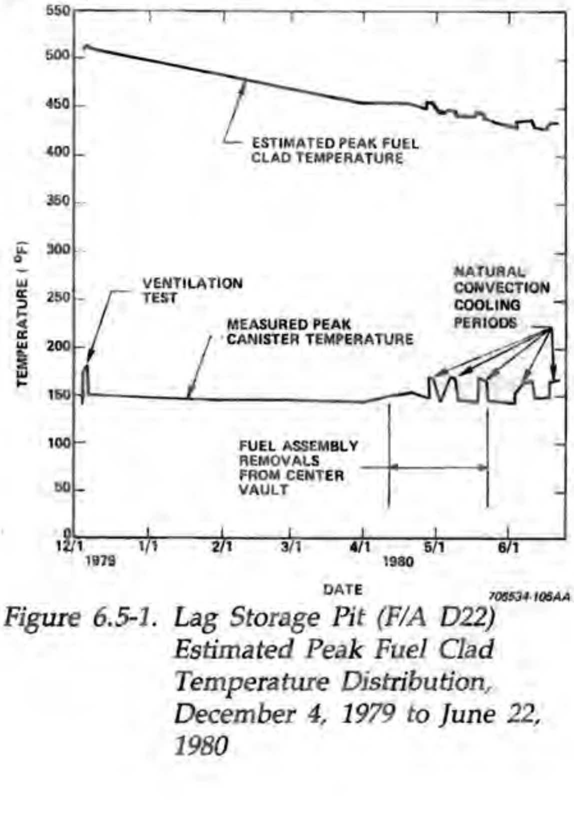

Figure 6.5-1. Lag Storage Pit (F/A D22) Estimated Peak Fuel Clad Temperature Distribution, December 4, 1979 to June 22, 1980

temperature difference from the relationship developed from the air backfill test data for fuel assembly D15. This difference was added to the peak measured canister temperatures. The maximum estimated peak fuel clad temperature of 514°F occurred during the second set of ventilation tests during natural convection cooling. The maximum estimated temperatures ranged from 498 to 455°F during the period December 7, 1979 to April 1, 1980 when the center vault was filled with eight canisters and the vault was force cooled. Noted on Figure 6.5-1 is the period of seven fuel assembly removals from the center vault when temperature readings may have been influenced by the removal of shield plugs (see Section 6.4).

The maximum error in these peak fuel clad temperature predictions was estimated at -3.4 to +18.3°F based on the temperature measurement uncertainties and calculational method inaccuracies (see Appendix M, Section M.3.).

6.6 APPLICABILITY OF TEST RESULTS

APPLICATION

The thermal test results from the Air-Cooled Vault Test conducted at E-MAD can be applied to air-cooled vaults of comparable configuration. The air flow and outlet temperature data are applicable to vaults with similar heat loads and comparable inlet and outlet air flow impedances. The canister temperature data is very specific to the configuration of the canister and vault and to the atmosphere inside the canister.

TEST DATA ACCURACY

Inaccuracies in the recorded test data could be a result of thermocouple measurement inaccuracy and thermocouple position uncertainty. The accuracy of the ungrounded Type K thermocouples used is typically ± 2°F based on calibration data.

An examination of the Fuel Assembly Internal Temperature Measurement Test data was made to evaluate the effect of having canister thermocouples hanging inside the 0.75 inch by 0.75 inch angle instrumentation tubes. Thermocouple data for fuel assembly D15 showed temperatures inside the tubes were lower than those on the canister surface by a maximum of 14.2°F. This is expected to be the maximum inaccuracy in canister temperature measurements due to the instrumentation tubes. By using the peak measured canister temperature (which was highest by a minimum of 7°F), the maximum inaccuracy in canister temperature measurement is reduced to about 7°F. Details of these evaluations are contained in Section M.1.

The Air-Cooled Vault Test recorded data are judged to be between -2 and +9°F of the actual canister temperatures (using peak recorded temperatures) and within ±2°F of the actual air temperatures.

As previously noted, the canister temperatures recorded may have been affected by removal of other canisters from the Lag Storage Pit and may not represent steady-state temperatures. Canister removals (other than those noted on Table 6.3-1) during canister temperature recording in 1980 occured on January 21, 22 and 23; on February 11, 12, 13, 14 and 15; on April 8 and 23; and on June 4. These may have affected the recorded data presented in Appendix G.

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APPENDIX A

E-MAD FACILITY AND EQUIPMENT DESCRIPTIONS

This appendix describes the facilities, buildings, installed features, and equipment at the Engine Maintenance, Assembly and Disassembly (E-MAD) facility used in support of the Spent Fuel Handling and Packaging Program (SFHPP) 1978 Demonstration Program and the Commercial Waste and Spent Fuel Packaging (CWSFP) Program. The equipment includes that from previous programs and those additions or modifications made for the spent fuel dry storage testing activities. Further details relative to safety features and assessments can be found in Reference 1.

A.1 LOCATION

The E-MAD facility is located on the Nevada Test Site in the area designated as Area 25. This location is shown on the Nevada Test Site layout in Figure A-1.

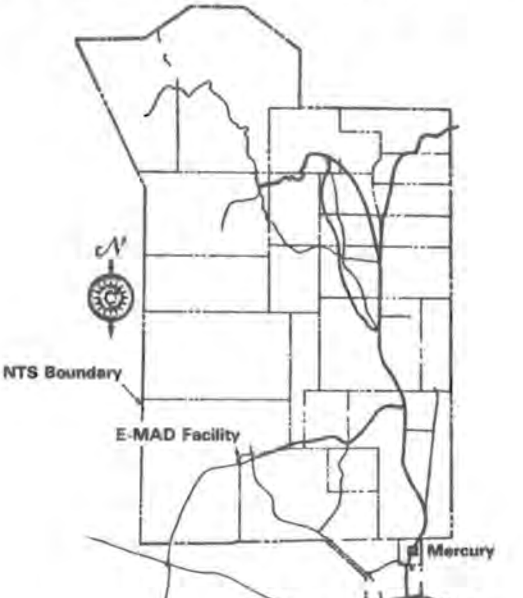

Figure A-1. E-MAD Facility Location on Nevada Test Site

A.2 E-MAD FACILITY DESCRIPTION

The Engine Maintenance, Assembly and Disassembly facility was designed to provide for assembly, disassembly and post-operative examination of highly radioactive nuclear reactors following test operations for the Rover/Nuclear Engine Rocket Vehicle Application (NERVA) Programs. The E-MAD facility plot plan is illustrated in Figure A-2 while Figure A-3 shows an aerial view prior to modifications.

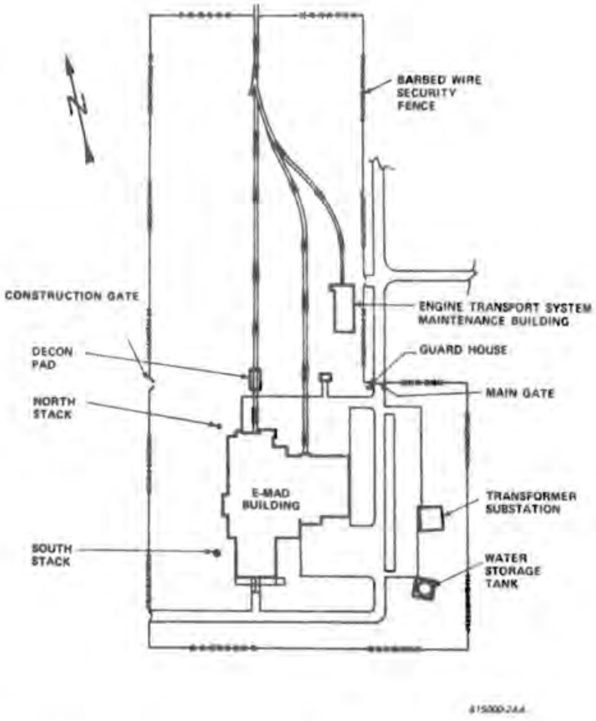

Figure A-2. E-MAD Plot Plan Prior to Demonstration Program Modifications

Figure A-3. Aerial Photograph of E-MAD Facility Prior to Demonstration Program (Photo Looking South)

E-MAD is an 80 foot high (ground to highest roof point) steel and reinforced concrete structure, is enclosed in a fenced area of 25 acres, and contains about two acres of floor space. E-MAD is situated about 3,520 feet above mean sea level.

The following sections describe some of the different areas of E-MAD and the equipment located in each. Figure A-4 provides a layout of the first floor of E-MAD. Detailed section and plan views of E-MAD are included in Reference 1.

A.2.1 COLD BAY

The Cold Bay is equipped to handle large, heavy items arriving or departing by either truck or the site Rail Transport System. The Cold Bay is used for receiving, receipt inspection and assembly of materials and equipment. The Cold Bay is also used for equipment debugging and procedure verification training prior to that done in the Hot Bay for remote handling practice.

The Cold Bay, 140 feet long by 72 feet wide by 60 feet high, is serviced by a 40-ton bridge crane with a 10-ton auxiliary hook. Both hooks have a clear lift of 45 feet. The site railroad track extends onto a turntable, permitting rotation for movement onto auxiliary rails in the central bay area. The turntable is 34 feet in diameter with a rated load of 80 tons. The turntable can handle a 100-ton static load.

A.2.2 HOT BAY

The Hot Bay is surrounded by reinforced concrete shield walls with lead glass viewing windows for personnel protection during operations involving highly radioactive materials. The Hot Bay is shown in Figure A-5. The bay is 140 feet long by 66 feet wide by 74 feet high.

The Hot Bay walls were designed to provide shielding for a radiation source of 1×10^6 R/hr with a design dose rate of 2.5 mrem/hr for all personnel access areas. In the Hot Bay, the east and north walls, and north half of the west wall are 5 feet thick, while the south wall and south half of the west wall are 6 feet thick. The roof is nominally 32 inches thick. Normal density (150 pounds per cubic foot) reinforced concrete was used in the Hot Bay walls and roof.

A Heating, Ventilating and Air Conditioning (HVAC) system provides filtered air exchange within the Hot Bay which is exhausted through

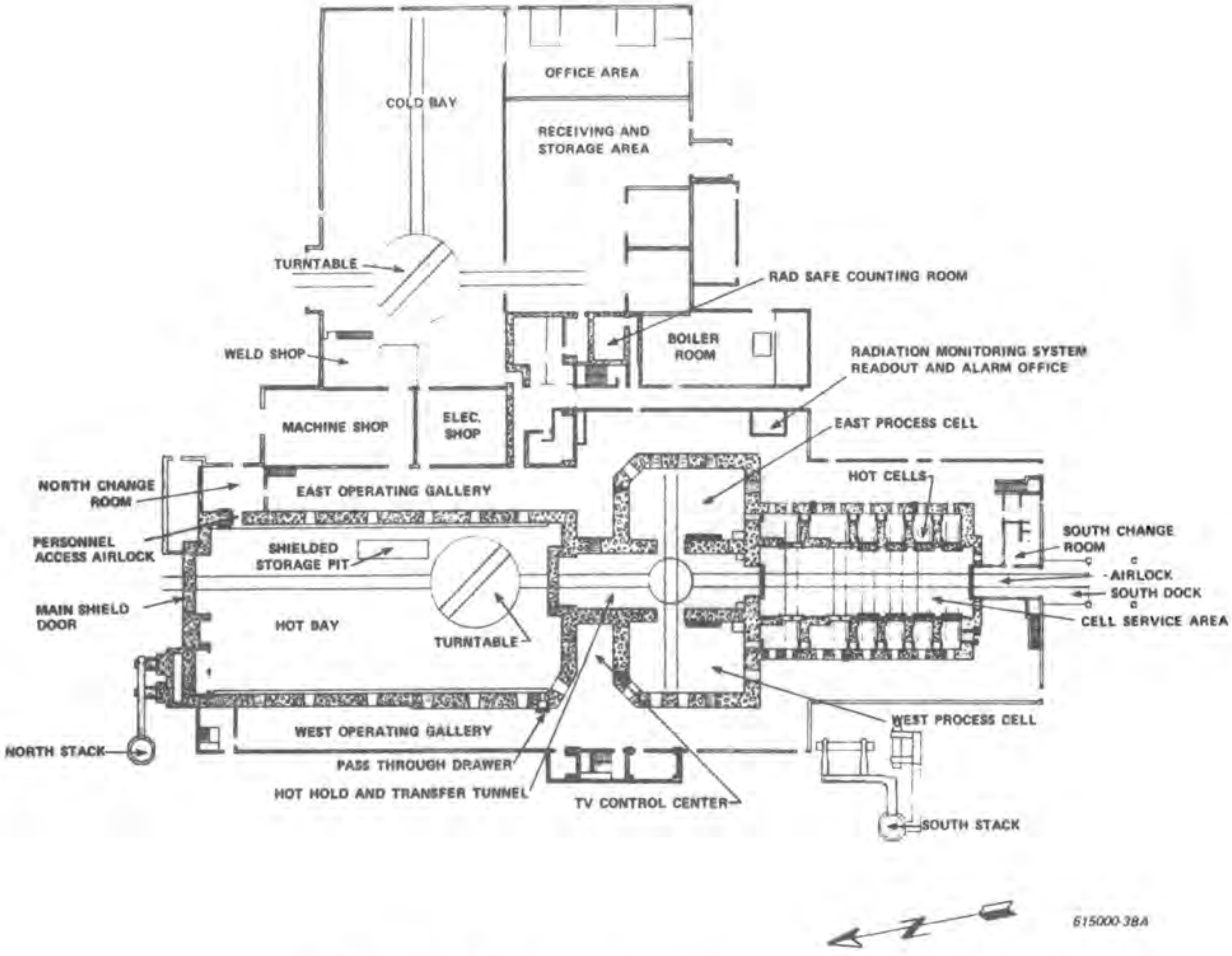

Figure A-4. First Floor Layout of E-MAD

High Efficiency Particulate Air (HEPA) filters and then to a 114 foot high exhaust stack. The ventilation exhaust stack is continuously monitored by scintillation detectors for gaseous radioactivity and by a fixed filter air sampling system to monitor integrated particulate activity to ensure radioactive discharges are maintained as low as practicable.

Two large shield doors exist in the Hot Bay for the movement of equipment. The main door to the Hot Bay is located at the north end allowing truck or railroad car access. The main door opening is 37 feet high and 22 feet wide. The door is 39 feet high by 26 feet wide by 5 feet thick and made of ordinary concrete. A second shield door exists at the south end of the Hot Bay for access into the Hot Hold and Transfer Tunnel. This door opening is 29 feet high and 18 feet wide. The door is 30 feet 9 inches high by 26 feet wide by 3 feet 7 inches thick and is made of magnetite concrete. Both doors are remotely controlled from the Master Control Room, but can be operated at local control stations when a permissive switch is operated in

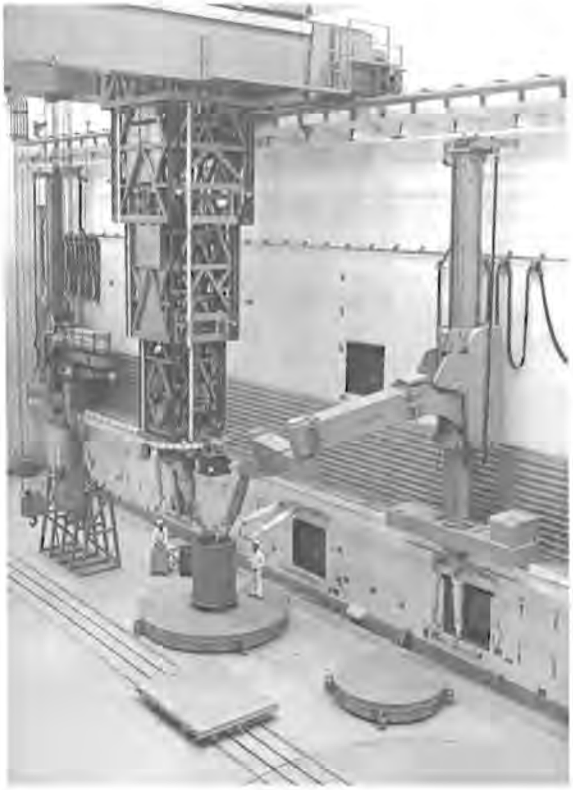

Figure A-5. Hot Bay Showing Available Remote Equipment

the Master Control Room. The local control station for the main Hot Bay shield door is located in the machinery room which the door opens into. Local control stations for the shield door at the south end of the Hot Bay are located in the Crane Maintenance Balcony and at window E-5 (window closest to this shield door from the east operating gallery).

A personnel entrance is provided in the northeast corner of the Hot Bay. The entrance has two shield doors, 7 feet 10 inches high by 5 feet 6 inches wide by 8 inches thick and made of lead. Between these doors is a 7 foot high, 4 foot wide airlock. The doors are interlocked to prevent simultaneous opening. Personnel entry into the Hot Bay is through the north change room located immediately outside. The personnel entrance doors are remotely controlled from the Master Control Room, but they can also be operated at a local push button station from outside the Hot Bay when a permissive switch is operated in the Master Control Room. Operation of the personnel entrance doors from inside the Hot Bay permits emergency egress of personnel.

A shielded storage pit is located below the Hot Bay floor. The pit is provided with a 60 inch thick concrete cover which, when installed, is flush with the Hot Bay floor. The pit is 9 feet 10 inches deep by 26 feet 4 inches long by 4 feet 6 inches wide. A fan located outside the Hot Bay provides cooling air to the pit through pipes buried in the Hot Bay floor.

The Hot Bay contains a standard-gauge railroad track on which the Railroad Transport System vehicles enter and exit the bay through the north entrance. The turntable, of identical capability as the Cold Bay turntable, allows a 360° rotation of rail vehicles.

The Hot Bay is provided with an overhead bridge crane, a main hook and an auxiliary hook. The rated capacities of the main and auxiliary hooks are 40 and 10 tons, respectively. The crane is remotely operable from portable controllers located in the galleries near shielded viewing windows. The clear lift height of both hooks is 62 feet. Crane design features include hook rotation, fail-safe mechanisms to hold the load in a fixed position in case of a power loss or mechanical drive failure, and limit switches to prevent overtravel in case of operator error or mechanical failure in the drive systems.

The Hot Bay has 17 shielded windows used for viewing Hot Bay activities. Work stations at viewing windows where floor-level activities are conducted are equipped with master-slave manipulators for handling small items. Periscopes are located at various windows to provide inspection and photographic capabilities. A pass-through drawer exists in the southwest corner of the Hot Bay. This allows contamination swipes to pass through the shield wall for checking the contamination on equipment surfaces. The drawer has lead shield doors at each end which are interlocked to prevent simultaneous opening.

In addition, the bay is equipped with a Wall-Mounted Handling System, an Overhead Positioning System (not presently in service), and a Floor-Mounted Handling System. These handling systems are equipped with special tools and fixtures to facilitate remote operations and are described in the next subsections.

WALL-MOUNTED HANDLING SYSTEM

The Wall-Mounted Handling System (WMHS) consists of two identical articulated traveling boom assemblies installed on the east wall of the Hot Bay. The two WMHS units are shown in Figure A-5. This system services the east half of the Hot Bay. Each WMHS assembly can remotely interchange manipulator heads from among two Class A (heavy duty), one Class B (intermediate duty), and one Class C (light duty) types. The maximum load carrying capability with a Class A head in any position is 600 pounds, and the wrist rotational torque capability is 400 foot-pounds. Operating controllers are a plug-in type, and stations are available at each viewing window. A permissive switch in the Master Control Room allows WMHS operation from any viewing window in the Hot Bay.

FLOOR-MOUNTED HANDLING SYSTEM

The Floor-Mounted Handling System (FMHS) consists of three 15 foot and two 9.5 foot diameter portable turntables, and a mobile carriage and dolly which travel on facility railroad tracks. Two turntables and the dolly are shown in Figure A-5.

Each portable turntable's capacity is 15 tons loaded concentrically. The turntables are remotely operable for portable controllers and are provided with remotely operating leveling jacks. The height of the portable turntables is 20.2 inches.

The mobile carriage is 17 feet long and 9 feet wide. Its loading deck is 17 inches above floor level and has an area of 16 feet 6 inches by 7 feet 4 inches. Load capacity is 30 tons. The remote handling dolly is 10 feet long and 9 feet wide. Load capacity is 25 tons. The carriage and dolly have standard-gauge railroad wheels. Two electrical bus-bars mounted between the railroad tracks supply electrical power to drive the motors. The electrified trackage is provided through the entire length of the E-MAD building, however, following modifications to the Hot Bay, electrical power is not available north of the Transfer Pit, on the turntables, in the East and West Process Cells, and on the South Dock. The mobile carriage or dolly can be used to move items out of the Hot Bay into the Hot Hold and Transfer Tunnel, into the process cells or the hot cells.

Using portable controllers, the FMHS equipment can be operated from the viewing window stations of the Hot Bay, East and West Process Cells, and Cell Service Area; from within the Hot Hold and Transfer Tunnel; or from the South Dock. Controller power is provided to local stations by a permissive switch in the Master Control Room.

A.2.3 CRANE MAINTENANCE BALCONY

The Crane Maintenance Balcony (CMB) is a concrete shielded area adjacent to the Hot Bay and above the East and West Process Cells, used for maintenancing the crane, manipulators, and other portable support equipment serving the Hot Bay. Shielding between the Crane Maintenance Balcony and the Hot Bay is provided by two concrete rolling doors. Swingout rails for the crane and OPS are provided to allow shield door operation. Shield door operation is controlled from the Master Control Room or from control stations located in each of the machinery rooms into which the shield doors open. Local control station operation is available when a permissive switch is operated in the Master Control Room. There is also access, via stepped concrete floor plugs, from the CMB into the East and West Process Cells and the Hot Hold and Transfer Tunnel. The floor of the CMB, which separates the CMB from the West Process Cell, is constructed of 6 feet of concrete. One viewing window is provided for visual observation and a personnel entrance from the third floor change room allows hands-on maintenance activities. The shield wall at the third floor level is also 6 feet of concrete. The personnel entrance doors associated with the airlock operate and are controlled in the same manner as the Hot Bay personnel entrance doors described in Section A.2.2.

A.2.4 WEST AND EAST PROCESS CELLS

The West Process Cell (WPC) is a shielded area 46 feet by 28 feet by 29 feet high with 6 foot thick reinforced concrete walls. Cell operations are viewed through four shielded windows. A PaR Model 3000 bridge-mounted rectilinear manipulator, a 15-ton overhead bridge crane, and master-slave manipulators are used for operations. The FMHS mobile carriage and dolly can transfer material between the Hot Hold and Transfer Tunnel and WPC. The door opening to the WPC is 17 feet 6 inches high by 11 feet wide. A remotely operated steel shield door, 18 feet high by 14 feet wide by 20 inches thick, isolates the WPC from the Tunnel. Removable plugs in the ceiling provide a 10 foot by 10 foot opening for access from the Crane Maintenance Balcony above. The shield door is remotely controlled from one of three local operating stations located in the WPC, in the gallery at one of the WPC shield window stations, and at a second floor window station (not currently in use). A switch in the Master Control Room selects the three operating stations.

The East Process Cell (EPC) has the same dimensions as the WPC (46 feet by 28 feet by 29 feet high). This cell has no windows or handling equipment, although there is provision for installing them. The EPC basic facility capability is the same as the WPC including shielding, although the access opening from the Crane Maintenance Balcony into the EPC is only 5 feet by 10 feet.

A.2.5 HOT HOLD AND TRANSFER TUNNEL

The Hot Hold and Transfer Tunnel (HHTT), illustrated in Figure A-6, is a concrete shielded area connecting the Hot Bay to the Cell Service Area and the East and West Process Cells. The tunnel can be isolated from each area by shield doors. The steel shield door to the Cell Service Area is 14 feet high by 12 feet 8 inches wide by 20 inches thick. The opening is 12 feet high and 11 feet wide. The shield door between the HHTT and Cell Service Area is remotely controlled from the Master Control Room. A permissive switch, operated in the Master Control Room, allows local control station operation within the HHTT. The area is served by standard-gauge railroad track and is equipped with a turntable into the West Process Cell, the East Process Cell, and the Cell Service Area. The turntable is 15 feet in diameter and has a 37.5 ton static and dynamic load capacity. Visual observation in this area is provided by the facility closed-circuit television system.

A.2.6 CELL SERVICE AREA

The Cell Service Area (CSA) interconnects the Hot Hold and Transfer Tunnel and the 12 hot cells. The CSA is illustrated in Figure A-7. The CSA is 84 feet by 27 feet by 15 feet high and is

Figure A-6. Hot Hold and Transfer Tunnel

Figure A-7. Cell Service Area

served by the FMHS mobile carriage and dolly. A rectilinear manipulator and an overhead crane provide remote handling. The CSA rectilinear manipulator has a traveling bridge, carriage, and a telescoping mast. The telescoping mast has a 1000 pound capacity and 12 foot 6 inch extension travel. The manipulator has a 750 pound shoulder hook capacity and an arm capacity of 150 pounds. Wrist torque is 420 inch-pounds. This system is remotely controlled from portable control stations in the east and west galleries and the south viewing windows of the CSA. The CSA overhead crane is mounted on the same support rail as the rectilinear manipulator. The hoist is rated at 7.5 tons and the span is 21 feet 6 inches. Control is from remote pushbutton stations in the east, west and south galleries.

The remotely controlled, steel shield door at the south end of the CSA connects the CSA to an airlock which exits to the south dock at the rear of E-MAD. The door is 12 feet 5 inches high by 12 feet 8 inches wide by 21 inches thick. The opening is 9 feet 5 inches high and 11 feet wide. This shield door is operated from a local shield window station. A selector switch in the Master Control Room provides power to the local operating station. Equipment is brought into the CSA from the outside through a rollup door in the airlock. Operation of this door is possible either from the airlock side or the outside. Personnel may enter the CSA and the hot cells through a south change room adjacent to the airlock.

A.2.7 HOT CELLS

The 12 hot cells are located on either side of the Cell Service Area. Four cells are each 16 feet by 9 feet 7 inches by 15 feet high and the remaining eight cells are each 8 feet by 9 feet 7 inches by 15 feet high. Each hot cell has a remotely controlled shield door which can isolate the cell from the CSA. The shield walls are 3 feet 9 inches thick of high density (212 pounds per cubic foot) concrete. The four larger cells each have two work stations with a shielded viewing window and penetrations through the wall for master-slave manipulators at each station. The smaller cells have one work station each. Master-slave manipulators are installed at some of these stations.

The Hot Cell Mobile Table Subsystem (HCMTS) forms part of the remote handling system used in the hot cells. A control system is provided for remote control of all HCMTS operations. The HCMTS includes a powered table in each hot cell, capable of limited travel between the cell and the adjacent Cell Service Area, and electrical controls at each cell operating position. Each table is 72 inches long by 70 inches wide by 16 inches high with a 5 ton capacity.

A.2.8 MASTER CONTROL ROOM

The Master Control Room (MCR) is located outside the southwest corner of the Hot Bay on the second floor. Access to the MCR is from the operating gallery. The MCR is used as the management control center for the Hot Bay, Crane Maintenance Balcony, Hot Hold and Transfer Tunnel, some remote handling functions, and all access doors to the shielded areas. It contains permissive controls for major operating equipment in the Hot Bay and Process Cell areas and is the coordination center for railroad movements in the E-MAD area. The MCR is illustrated in Figure A-8. The concrete walls between the MCR and the Hot Bay, the Hot Hold and Transfer Tunnel, and the West Process Cell are all 6 feet thick.

Figure A-8. Master Control Room

Equipment and systems for which permissive power is controlled include the Hot Bay overhead crane, WMHS, FMHS, shielding doors, swing-out rails, and turntables. In addition, the remote railroad switches are controlled from the MCR. Communication and visual systems controlled include the headset intercom network and the radio networks interconnecting the MCR with other on-site facilities including mobile support vehicles and the Railroad Transport System.

Numerous intercommunications stations with channel selectors are located throughout the E-MAD facility. Two radio networks are provided. The E-MAD operational network is controlled from the Master Control Room with mobile units in each of the three locomotives and in the E-MAD office. This network has eleven walkie-talkie units for use by groups in the field or for system checkout communications within the facility. The communication system is used extensively in coordination of all remote operations. Operators at local work stations are able to communicate with each other and with the Master Control Room and Television Control Center using the intercom networks.

A.2.9 TELEVISION CONTROL CENTER

Closed-circuit television is provided as an auxiliary system for the viewing of remote activities. All cameras can be remotely controlled from the Television Control Center (TVCC). The TVCC is located on the first floor directly below the Master Control Room and is illustrated in Figure A-9. The TVCC is shielded on three sides by 6 foot thick reinforced concrete walls. Monitors are provided in the MCR and Television Control

Figure A-9. Television Control Center

Center and in the operating galleries for the Hot Bay and hot cell areas.

A.2.10 RADIATION SAFETY AREAS

The E-MAD Radiation Monitoring System readouts and alarms are located in an office on the first floor in the east gallery (see Figure A-4). Change rooms are located adjacent to the Hot Bay, Cell Service Area and Crane Maintenance Balcony. Rad Safe personnel monitoring stations are located at each hot change room to provide entry and exit assistance from "hot" areas.

A Counting Room (see Figure A-4) is provided for radiation counting instruments for evaluation of swipes, air sampling filters and other samples. Information regarding radiological conditions and entry requirements for all radiation areas are maintained here. The Rad Safe monitoring staff's office is a trailer located external to the E-MAD building, but within the perimeter fence.

A.3 RAILROAD TRANSPORT SYSTEM

The Railroad Transport System (RTS) consists of standard-gauge trackage connecting E-MAD to test areas in Area 25 and specially designed rolling stock and car couplers to support operations involving highly radioactive materials. The Railroad Transport System was used to support the NERVA Rocket Engine Program and consists of the Manned Control Car, Engine Installation Vehicle, L-3 Prime Mover and other miscellaneous vehicles. The three major system components are described in this section. All three are illustrated in Figure A-10.

Figure A-10. Engine Installation Vehicle, Manned Control Car, and L-3 Locomotive as Used During the Nuclear Rocket Program

A.3.1 MANNED CONTROL CAR

The Manned Control Car (MCC) is a specially designed, 107-ton, shielded, two-man control cab locomotive equipped with controls for operation of the Railroad Transport System. The MCC control system controls the MCC, Engine Installation Vehicle and L-3. Using a remote hookup to the L-3 controls, the MCC is capable of starting, accelerating, stopping, and shutting down the L-3. In addition, the MCC control system controls all the Engine Installation Vehicle functions. The MCC has diesel engines for tractive power and primary electrical power generators and consists of an undercarriage, an engine compartment, and shielded control cab. The shielded control cab assembly is mounted on the engine compartment structure. Gamma and neutron shielding is provided in the cab walls, roof, and floor. Operational visibility in the front of the cab is provided by window assemblies of high-density glass and mineral oil and by high-density glass in the cab door. The cab shielding was designed to attenuate radiation levels on the order of 1×10^6 R/hr at a distance of approximately 100 feet to less than 25 mrem/hr in the cab. Other features of the MCC include a cab air conditioning system with HEPA filters, an emergency breathing apparatus for the crew, a radiation monitoring system to measure gamma radiation levels inside and outside the cab, and a fire control system for the engine compartments.

A.3.2 L-3 PRIME MOVER

The L-3 Prime Mover is a 500-hp, 80-ton, diesel-electric locomotive modified for use in the nuclear rocket program. The L-3 provides the tractive force to move the MCC and Engine Installation Vehicle. The Prime Mover has a separate motor generator which starts automatically and provides a backup source of electrical power if the MCC motor generator fails. The MCC normally controls the L-3, however, independent L-3 operation is possible. The L-3 also provides compressed air for braking and auxiliary compressed air and has a fire control system (similar to that in the MCC) for the engine compartments.

A.3.3 ENGINE INSTALLATION VEHICLE

The Engine Installation Vehicle (EIV) is a specially designed, 60-foot long, welded steel flatcar mounted on standard freight car trucks. The car is equipped with special bolsters, leveling jacks and an inching drive system. The equipment attached to the front carriage assembly was originally designed to transport and remotely handle a nuclear rocket engine assembly (see Figure A-10). The carriage and superstructure were designed for a maximum load of approximately 27.5 tons.

A.3.4 ENGINE TRANSPORT SYSTEM MAINTENANCE BUILDING

The Engine Transport System Maintenance Building (ETSMB) is located outside E-MAD (see Figure A-2). The building is equipped with a 10-ton overhead crane, floor pits, and parts and tool storage; and contains related maintenance equipment such as battery chargers, welders, drill press, work benches, lubricant storage building (separate), compressed air, and special maintenance tools. Both engine maintenance and car rework can be accomplished here. These facilities are also used for RTS maintenance.

A.4 E-MAD MODIFICATIONS FOR SPENT FUEL HANDLING AND PACKAGING PROGRAM (SFHPP) DEMONSTRATION

A number of modifications were made to the E-MAD facility to accommodate the SFHPP Demonstration. The major modifications in the Hot Bay involved the construction of a lag storage pit, a weld pit, a transfer pit, and a survey pit. The locations of these features are shown in Figure A-11.

A.4.1 LAG STORAGE PIT

The most significant modification is the lag storage pit which is described in detail in Section 6.2. The lag storage pit is used for the interim storage of canisterized spent fuel assemblies

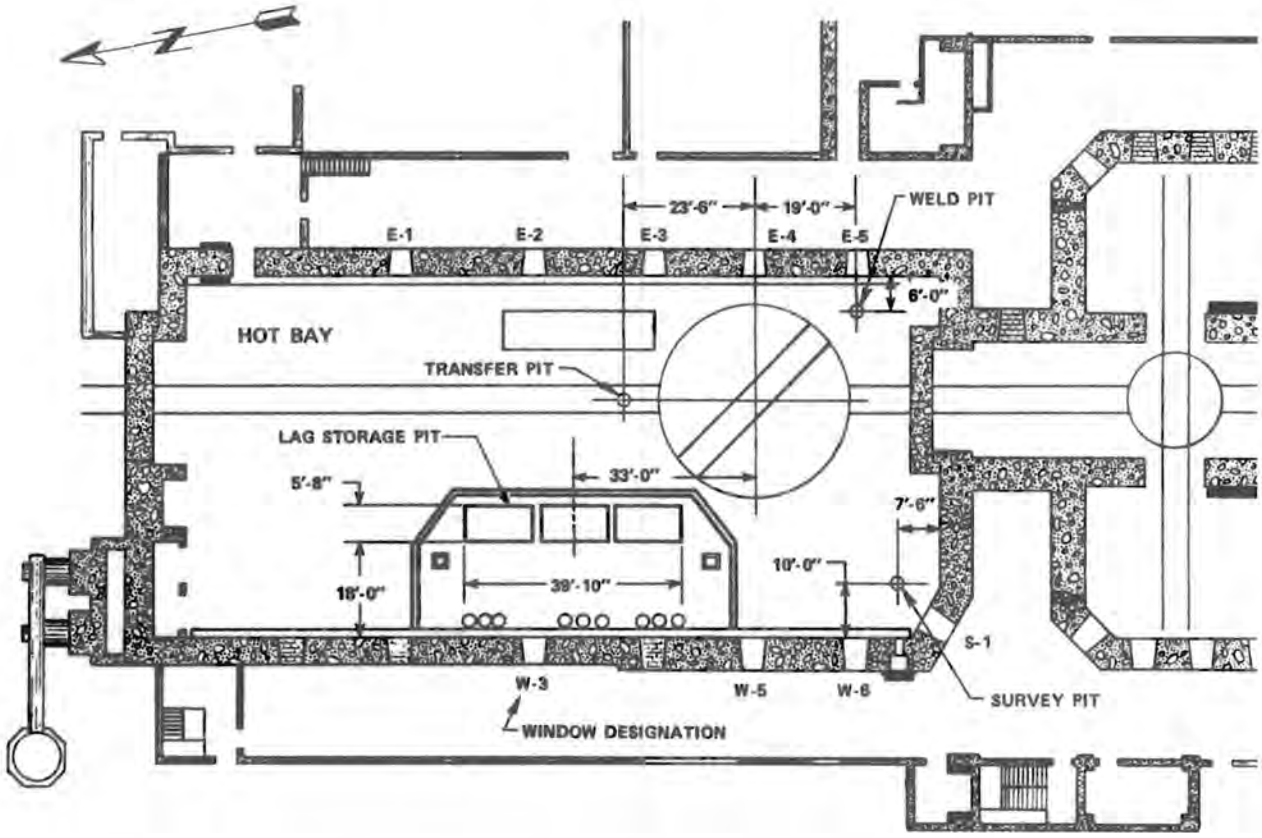

Figure A-11. First Floor Plan Showing Location of SFHPP Demonstration Program Modifications

during the interval before storage emplacement. The pit is below the Hot Bay floor adjacent to the west wall and has a storage capacity of 24 canisters, arranged in three separate 2 by 4 arrays. The three individual concrete lined vaults are 22 feet 6 inches deep by 11 feet 8 inches long by 5 feet 8 inches wide, are separated by 29 inch thick concrete walls, and are capped by 46 inch thick concrete vault cover plugs. Each vault cover plug contains eight stepped, steel-lined holes for shield plugs which support the canisters containing fuel. A steel seismic grid structure in each vault gives lateral support to the canisters under seismic events.

A.4.2 WELD PIT

The weld pit, illustrated in Figure A-12, is the central work station in the Hot Bay. The weld pit is used to accomplish closure lid installation, seal welding, weld inspection, leak checking, and shield plug attachment. The weld pit is located in the southeast corner of the Hot Bay, six feet in front of shielded viewing window E-5 (see Figure A-11). The 196 inch long pit liner is a 24 inch diameter, 0.375 inch thick, carbon steel pipe with a 25 inch diameter, 0.5 inch thick flat steel plate welded to the bottom of the pipe. The liner was grouted into a 36 inch diameter, 20 foot deep hole.

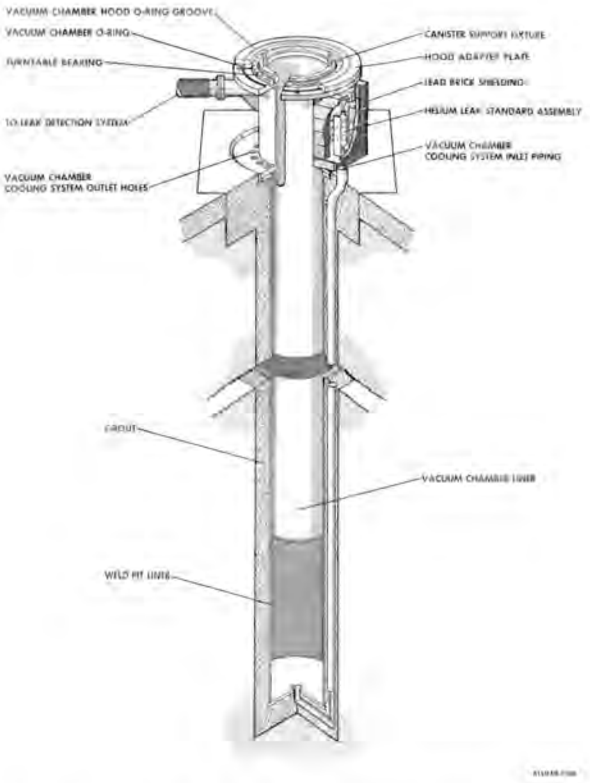

Figure A-12. Weld Pit Configuration

A 32.5 inch diameter flange is welded to the upper liner end to support the liner and vacuum chamber. The top of the liner flange is recessed 2 inches below the Hot Bay floor level. A 33 inch inside diameter welded carbon steel ring and plate form a 2.25 inch high, 2 inch wide, 0.25 inch thick angle around the corner of this recess. A 3 inch diameter pipe, welded to the bottom plate of the liner and running parallel with the liner vertical axis, provides a forced-air cooling path. When the vacuum chamber is removed from the pit, a 32.5 inch diameter, 2.0 inch thick carbon cover plate with an elastomer seal is placed over the weld pit.

The vacuum chamber sitting inside the weld pit provides canister support and forms a sealed chamber (when the separate hood is installed) for canister helium leak checking. The vacuum chamber (described as part of the leak detection system in Section A.5.3) is bolted to the pit liner through a flange connection. The canister is supported by two lugs welded to the canister body, which fit in slots in the canister support fixture of the vacuum chamber. This fixture is mounted on a bearing which permits canister rotation during canister assembly operations. With this support configuration, the canister top is 3 feet above the Hot Bay floor and canisters of different lengths (up to 19.5 feet) can be accommodated while maintaining the canister top at the same elevation.

The weld pit has a forced-air cooling system to limit canister temperatures for fuel assembly decay heat levels up to 3 kW. The cooling system consists of a ventilating fan (200 cubic foot per minute capacity) and a pipe with the appropriate fittings attached to the cooling pipe on the weld pit liner. Air pumped into the bottom of the weld pit liner flows up the annulus, between the weld pit liner and vacuum chamber, and exits the annulus through a series of holes in the vacuum chamber flange. The cooling system is designed to limit canister temperature to 300°F.

A.4.3 TRANSFER PIT

The transfer pit allows a combined canister/shield plug assembly to be raised into the EIV transfer shield (described in Section A.5.4) for transport to a storage area drywell. The transfer pit is located in the Hot Bay floor between the rails and a point which allows the EIV and MCC to be within the Hot

Bay with the main (north) shield door closed (see Figure A-11).

The transfer pit configuration (illustrated in Figure A-13) is similar to that of the drywell. The stepped transfer pit design consists of a steel liner grouted into a 30 inch diameter hole approximately 27 feet deep. The lower liner section is fabricated from 18 inch diameter, 0.375 inch thick, carbon steel pipe. The upper section, 37.5 inches long, is a 22 inch diameter, 0.75 inch thick carbon steel pipe. A 19 inch diameter, 0.5 inch thick carbon steel plate is welded to the bottom of the transfer pit liner. A 17.25 inch inside diameter, 23 inch outside diameter, 0.5 inch thick carbon steel ring connects the upper and lower liner sections. The canister is suspended from a shield plug which rests on this ring. An annular section at the top of the liner is formed by a 38 inch diameter, 0.25 inch thick, 18.5 inch long rolled plate welded to a 38.5 inch diameter, 0.5 inch thick plate. This annulus is filled with lead shot to provide additional radiation shielding when the canister is lifted into the transfer shield. A 0.5 inch thick ring is bolted over the annulus after the lead shot is installed.

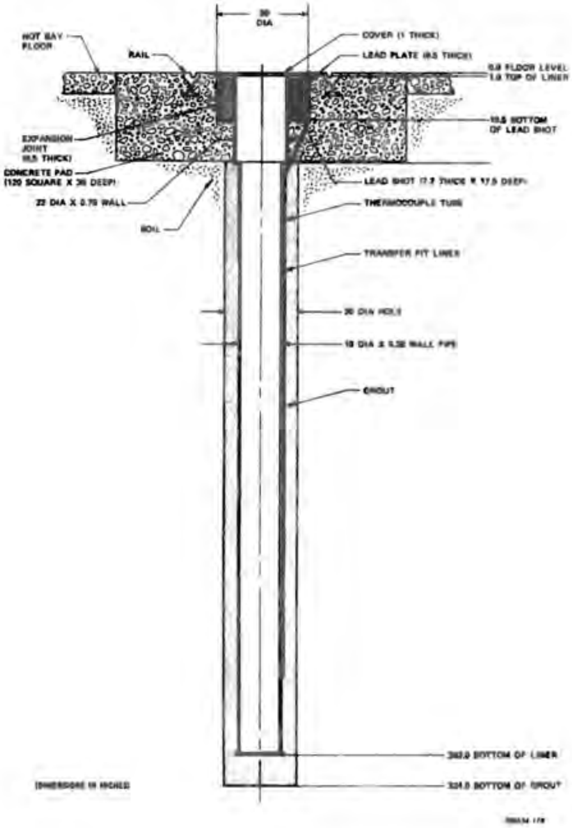

Figure A-13. Transfer Pit Schematic

The transfer pit liner is installed so that the liner top surface is 1 inch below the E-MAD floor level. This recess provides room for the transfer pit cover plate and for the EIV transfer shield to pilot into the E-MAD floor for radiation streaming attentuation. A carbon steel ring and plate are welded together, forming a 2 inch wide, 2 inch deep, 0.25 inch thick angle around this recess. A 36 inch thick concrete shield pad surrounds the transfer pit top section. This shield pad is 7 feet wide by 10 feet long. A 0.5 inch thick expansion joint between the shield pad and transfer pit liner allows for differential thermal expansion. The top 6 inches of this joint is 0.5 inch thick lead plates for added radiation shielding.

The transfer pit cover plate is 38 inches in diameter, 1 inch thick and is carbon steel. The cover plate has an elastomer O-ring to form a seal when the cover plate is bolted to the transfer pit. The pit cover plate has a fitting from which gas samples can be taken.

The transfer pit also provides access for temperature measurements on the outside of the liner. A 0.25 inch diameter, 0.035 inch thick stainless steel tube was attached to the outside of the transfer pit liner prior to its installation. This tube, extending down the liner to below the canister, is clamped to the liner in the same manner as the tubes on the outside of the drywell liners (see Section 3.2.2.2). A thermocouple can be inserted to any depth to measure transfer pit liner temperatures.

A.4.4 SURVEY PIT

The survey pit is a remote work station providing accessibility to a sealed fuel canister when suspended from the Hot Bay overhead crane. Survey swipes are obtained and evaluated for surface contamination. The pit is located in the southwest corner of E-MAD directly in front of the pass-through drawer and manipulator stations at windows W-6 and S-1 (see Figure A-11). A pit permits the canister to be lowered so its top can be reached by a manipulator.

The survey pit has a 24 inch diameter, 0.375 inch thick carbon steel pipe liner which is 130 inches long and is capped at the bottom by a 25 inch diameter, 0.5 inch thick plate. The liner has a 32.5 inch diameter, 0.5 inch thick flange at the top for support. The liner is grouted into a 30 inch diameter, 14 foot deep hole. The liner top is recessed 2 inches below the Hot Bay floor level. A 33 inch inside diameter welded ring and plate form an angle around the recess (same as the weld pit) and a 32.5 inch diameter, 2 inch thick carbon steel cover plate with an elastomer seal ring is provided. When the survey pit is not in use, this cover plate is placed over the opening.

A removable liner installed in the survey pit prevents contamination of the pit liner. This liner is stainless steel, 21 inches in diameter, 129.5 inches long, and 0.074 inches thick. A 21.5 inch diameter, 0.062 inch thick bottom plate is welded to the bottom, and a 28 inch diameter, 0.125 inch thick support flange is welded to the top.

A.5 E-MAD EQUIPMENT FOR SFHPP DEMONSTRATION

Equipment provided for the SFHPP Demonstration activities at E-MAD included: remote handling tools for fuel assemblies and canisters; remote welding equipment; remote canister evacuation, backfill, and leak detection equipment; canister transfer and drywell emplacement equipment; data acquisition equipment; additional television monitoring equipment; and a weather station. The equipment designs are described in this section. The locations of the major Hot Bay equipment are shown in Figure A-14.

A.5.1 REMOTE HANDLING TOOLS

PRESSURIZED WATER REACTOR (PWR) FUEL ASSEMBLY HANDLING TOOL

The PWR fuel assembly handling tool is used to remotely remove a fuel assembly from the shipping cask and place it in an adjacent canister. The tool (shown in Figure A-15) consists of the gripper head attached to the tool extension. The gripper head is a standard Westinghouse design and used for handling fuel assemblies in Westinghouse designed reactor plants. The tool extension is based on a standard Westinghouse design that has been modified to permit automatic operation by incorporating a pneumatic actuator. The tool has a 2000 pound load rating. The tool

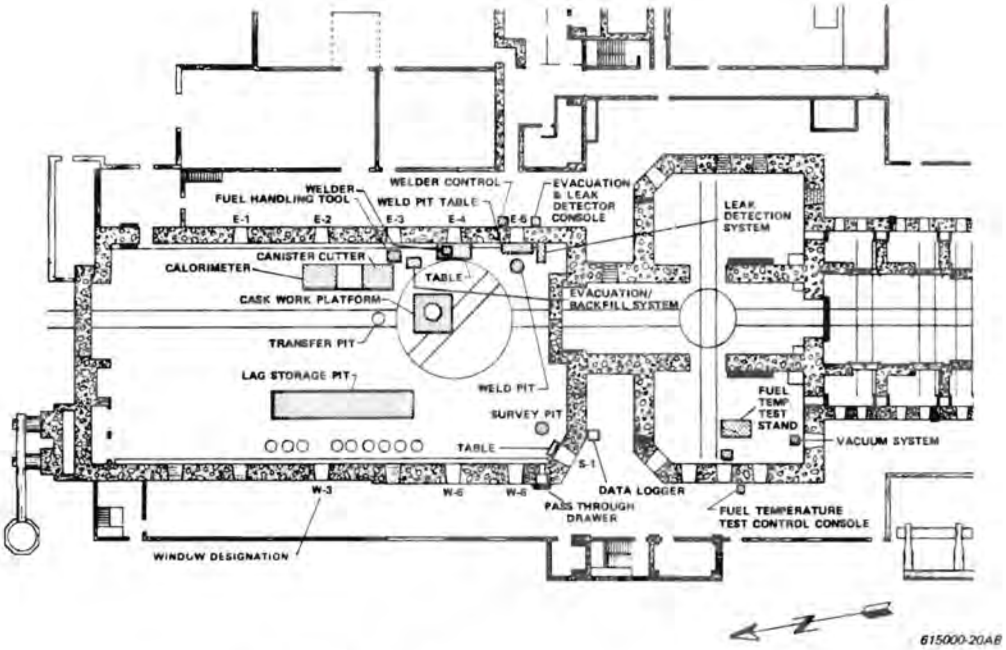

Figure A-14. SFHPP Demonstration Program Equipment Layout

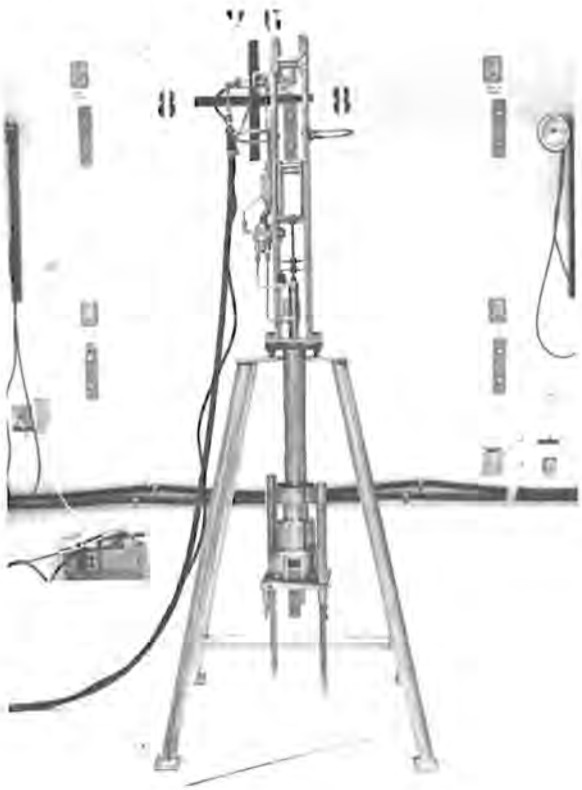

Figure A-15. PWR Fuel Assembly Handling Tool in Its Storage Stand in Hot Bay

weighs approximately 165 pounds and has an external space envelope of 8.7 inches square by 8 feet long. The tool lifting bail interfaces with either the main crane hook adapter or the Wall-Mounted Handling System.

The square gripper head has four cam-actuated fingers which engage the inner ledge of the fuel assembly top nozzle. The fingers are supported by and rotate on pins attached to the gripper head body. The fingers are actuated by a center cam cylinder. When the cam cylinder is moved down, the fingers are forced outward. Conversely, raising the cam cylinder forces the fingers inward. The cam cylinder extends into the tool extension and is connected to a pneumatic actuator. The cam cylinder is spring loaded downward to preclude unlatching if the air supply to the actuator is lost. The gripper head has one orientation pin and two alignment pins. These must be properly engaged with the nozzle before the gripper is inserted to the depth required for latching. At E-MAD, the two alignment pins were lengthened to enhance the remote insertion into the fuel assembly top nozzle when the assembly is in the shipping cask.

A solenoid operated valve controls the air pressure to the pneumatic actuator. Energizing the solenoid valve forces air into the lower air cylinder port of the actuator and simultaneously vents the top port. This action moves the actuator piston upward thereby raising the cam cylinder against the fail safe spring. When the control valve solenoid is deenergized, the top actuator port is pressurized, while the bottom port is vented, thus forcing the cam cylinder downward. If air pressure is lost, the spring forces the cam cylinder downward. If electrical power to the solenoid valve is lost, the air pressure automatically forces the actuator downward. If air pressure is lost, the tool can be released from a fuel assembly manually with the WMHS manipulator.

Up and down limit switches mounted on the tool extension activate indicator lights mounted on the valve control panel (in the operating gallery). These lights indicate whether the cam cylinder is in the full up or full down position. If the gripper head is not inserted sufficiently far into the fuel assembly nozzle to allow the fingers to engage the inner ledge, the nozzle mechanically prevents the fingers from fully extending. The inability to fully extend the fingers mechanically prevents the cam cylinder from reaching its full down position. This, in turn, prevents the down limit indicator light from being energized. When the down limit light is energized the operator is ensured that the tool is properly engaged. The down limit light is energized when the gripper head is not inserted into the fuel assembly nozzle, but this condition is easily noticable by visual observation.

When not in use, the tool is stored in a stand in the Hot Bay as shown in Figure A-15. In this position, the tool lifting bail can be engaged by the crane or the WMHS. Similarly, when the tool is placed in the stand, the bail can be disengaged from the crane or WMHS.

CANISTER HANDLING TOOL

The canister handling tool allows canisters containing spent fuel to be handled when the canister is not attached to a shield plug. The tool, illustrated in Figure A-16, mates with a canister in the same way as the shield plug (see Figure B-51).

The tool consists of a 12 inch length of 16 inch diameter, 1 inch thick, carbon steel pipe. Near the bottom of the pipe are four tapped holes, 90° apart, into which canister support pins are threaded. When installed, the support pins extend beyond the inside of the pipe and enter flat-bottomed, blind holes in the canister. An alignment keyway and two tabs on the pipe top ensure rotational and vertical alignment respectively of the support pins with the blind holes in the canister. This alignment aids remote installation.

The tool lifting bail consists of two 4 inch wide, 1 inch thick, vertical steel plates welded to either end of a horizontal length of 4 inch square, 0.5 inch thick

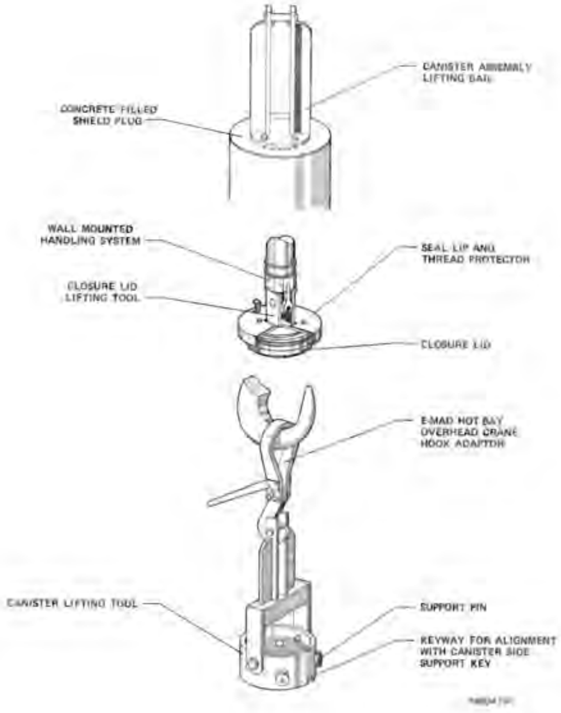

Figure A-16. Canister Assembly Handling Tools

steel tubing. The open end of the lifting bail is attached to the cylindrical pipe by means of two pins, 180° apart, allowing the lifting bail to rotate about the pins. The vertical plates are long enough so that, when the tool is attached to a canister, the bail can be rotated to one side to clear the canister top permitting the fuel assembly to be inserted into the canister. Welded to the top of the bail square tubing is a handle which mates with the crane hook. This handle has two vertical plates, each 3 inches wide and 0.75 inches thick, and two vertical support gusset plates, each 3.75 inches wide and 0.75 inches thick. A 1.5 inch diameter rod between the vertical plates interfaces with the crane hook. The load rating of the tool and lifting bail is 3000 pounds.

CLOSURE LID HANDLING TOOL

The closure lid handling tool performs two handling operations. It lifts and threads the closure lid into the canister. The tool is illustrated in Figure A-16. The tool consists of an 11 inch diameter, 0.5 inch thick, horizontal steel plate with a lifting bail to interface with the WMHS hand. The lifting bail has two vertical steel plates 6.88 inches high, 4 inches wide, and 0.5 inches thick. A 1.5 inch diameter rod between these two plates provides a bar for lifting. The horizontal plate has a 2 inch diameter hole in its center to provide clearance with the closure lid evacuation fitting and three 0.312 inch diameter clearance holes to bolt the tool to the closure lid. Extending from the bottom and welded to the horizontal plate are two 0.75 inch diameter pins which mate with blind holes in the closure lid to transfer torque. Bolted to the plate top is a nominal 14 inch diameter sheet metal cover. When the plate is attached to the closure lid by three 0.25 inch diameter bolts, the sheet metal cover protects the closure lid seal lip and threads. The tool rated lifting capacity is 175 pounds. The design torque rating is 400 foot pounds.

SHIELD PLUG/CANISTER ASSEMBLY LIFTING BAIL

The shield plug/canister assembly lifting bail allows handling of the shield plug and attached canister in the Hot Bay and during transfer to the drywells. This tool is illustrated in Figure A-16.

The tool consists of a 12 inch diameter, 0.75 inch thick plate attached to a lifting handle. The handle has two vertical steel plates, each 27.13 inches high, 3 inches wide, and 0.75 inches thick, with attached vertical support gusset plates, each 23.88 inches high, 3 inches wide, and 0.75 inches thick. A 1.75 inch diameter rod through the two vertical steel plates mates with the various crane hooks. Four 0.75 inch diameter bolts fit into four 0.812 inch diameter clearance holes in the lifting bail horizontal plate for attaching the lifting bail to a shield plug. The rated lifting capacity of the lifting bail is 4800 pounds.

A.5.2 REMOTE WELDING EQUIPMENT

The canister is sealed by fusion welding of a seal lip, machined as part of the closure lid, to the top surface of the canister body. A welding machine designed specifically for remote operation on this canister is used.

The welding machine, shown in Figure A-17, consists of a tungsten inert gas-cooled (TIG) torch attached to a support frame. The frame is motor driven about the center of the closure lid via a planetary gear arrangement. The torch position (axial and radial) is controlled and adjusted remotely from the power supply outside the Hot Bay. Special quick-disconnect fittings are used for gas and external power and a special cartridge assembly holds a weld filler wire spool (not used for the fusion weld). The welder power, control, and gas supply lines are supported from a boom assembly located on the Hot Bay wall adjacent to the weld pit. These lines are connected to the operating gallery power supply unit through pass-throughs in the shield wall and electrical connectors in the gallery wall.

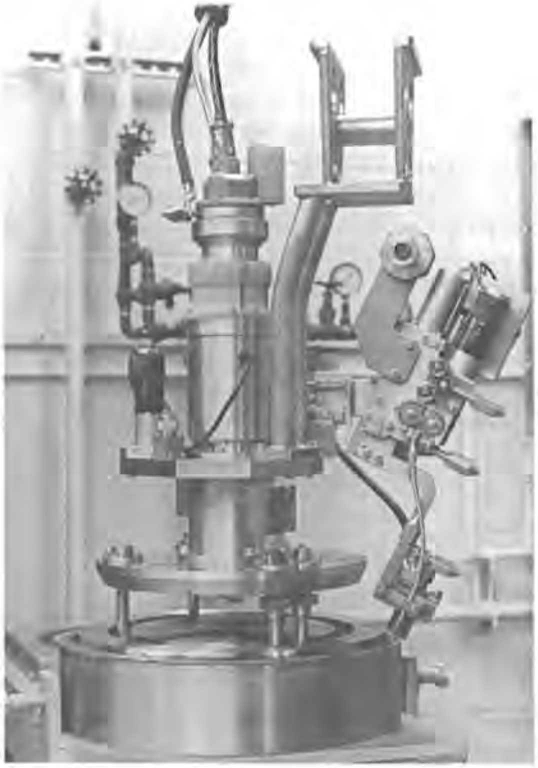

Figure A-17. Canister Closure Lid Welding Machine

The welding machine interfaces with the closure lid seal lip by means of an "L" shaped groove machined into the top surface of the lid, concentric with the seal lip (see Figure 3.2-19). The groove depth controls the elevation of the welding machine above the closure lid lip by three flat-bottom pins attached to the welding machine, which sit inside the groove. Three cam type locks are rotated into the outside edge of the groove and under the small groove flange to secure the welding machine to the closure. The machining tolerances for concentricity between the groove and the seal lip position and lock the machine in the groove, holding the torch in the proper radial position. The welding machine is located on a table in front of the shield window next to the weld pit. The welding machine is kept far enough away from spent fuel so that there is a minimum of radiation induced damage. For welding activities, the welding machine is placed on the canister in the weld pit using the Wall-Mounted Handling System. Some spare parts for remote repair or replacement activities are available on the weld pit table.

A.5.3 CANISTER EVACUATION/BACKFILL AND LEAK DETECTION SYSTEM

The canister evacuation/backfill and leak detection system consists of two subsystems. The canister evacuation/backfill subsystem includes a roughing pump and helium gas bottle attached to the fitting on the top of the canister closure lid. It evacuates the canister interior and fills it with helium. The canister leak detection subsystem consists of a roughing pump, a helium leak detector to check for helium leakage from the canister, and a helium leak standard. The pump is attached to the weld pit vacuum chamber to draw a vacuum around the canister. The two subsystems are described in the following section.

EVACUATION/BACKFILL SYSTEM

The canister evacuation/backfill system is shown schematically in Figure A-18. The system components are mounted on a mobile cart located in the Hot Bay near the weld pit. Figure A-19 shows the system components during checkout prior to shipment to E-MAD. The helium supply and canister vacuum pump are connected by aluminum and

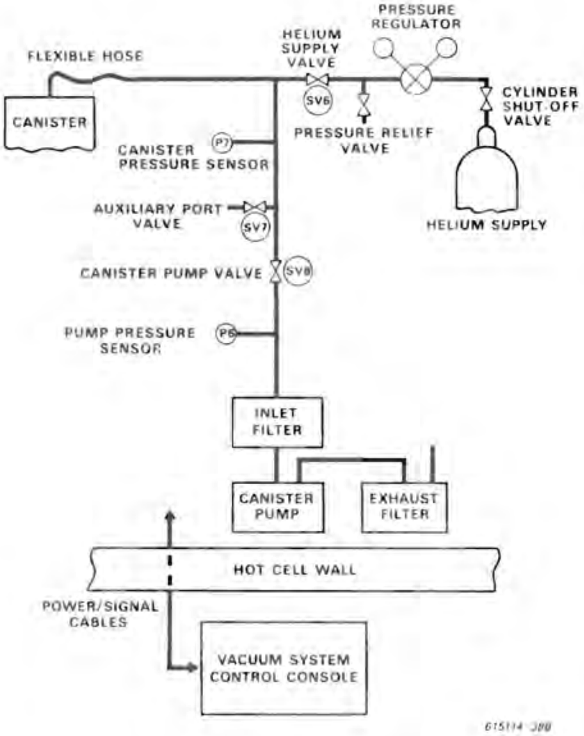

Figure A-18. Evacuation/Backfill System Schematic

Figure A-19. Canister Evacuation/Backfill System Components During Checkout stainless steel tubing and fittings to a flexible stainless steel hose through a series of electrically operated solenoid valves and a pressure sensor. This hose is attached to the fitting on the canister closure lid using master-slave manipulators (see Figure B-44). The pump and valves are remotely operated from a console located in the operating gallery. Any radioactive particulates or oil from the pump inlet and exhaust are filtered out. After evacuation, the valve to the pump is closed and the helium supply valve is opened. The helium bottle supplies helium at slightly more than one atmosphere pressure to the canister. After helium filling is complete, the flexible steel hose is removed from the closure lid and the lid seal fitting replaced.

LEAK DETECTION SYSTEM

The major components of the leak detection system are shown schematically in Figure A-20 and are shown during checkout prior to shipment to E-MAD in Figure A-21.

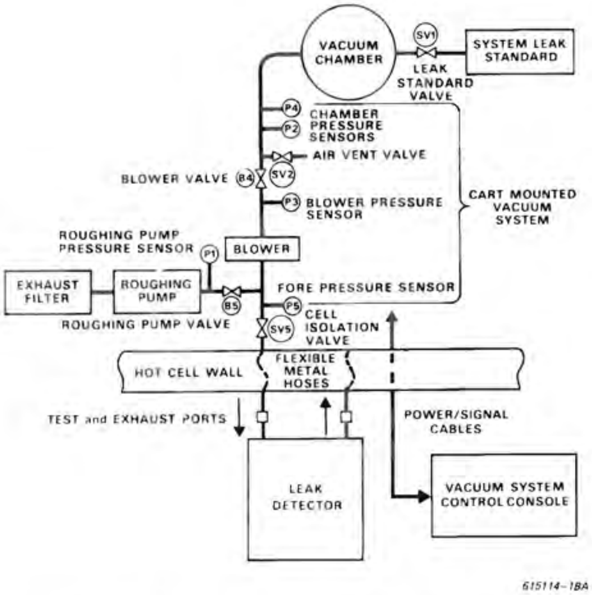

Figure A-20. Canister Leak Detection System Schematic

The leak detection system uses a stainless steel vacuum chamber located in the weld pit. With its hood in place, the vacuum chamber provides a sealed container which can be evacuated remotely to draw any helium leaking from a sealed canister into the leak detector.

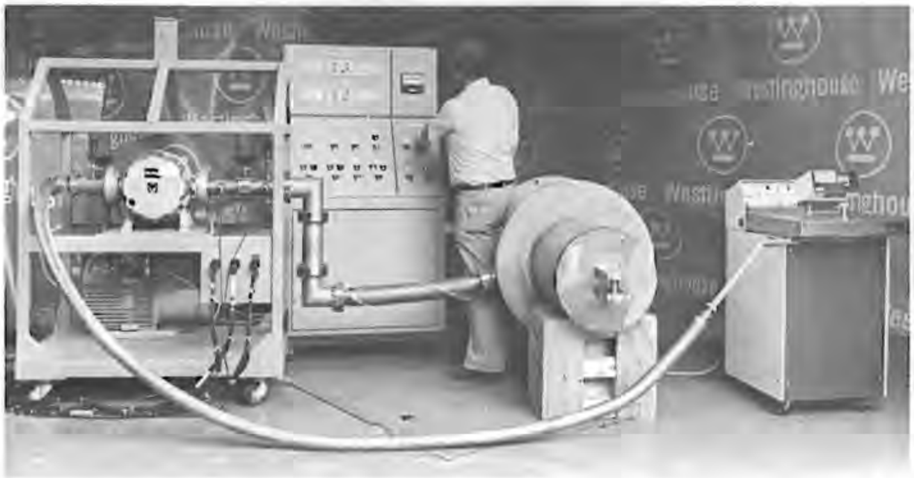

Figure A-21. Canister Leak Detection System Components During Checkout (From Left: Cart Mounted Components, Control Console, Vacuum Chamber, and Helium Leak Detector)

The vacuum chamber lower section is illustrated in Figure A-12 and the vacuum chamber hood is illustrated in Figure B-46. The vacuum chamber lower section consists of an 18 inch diameter, 0.375 inch thick pipe to which is welded a 1 inch thick bottom plate and a 32 inch diameter, 2 inch thick upper end flange. A 32 inch diameter, 1 inch thick flange is welded to the chamber pipe about 24 inches from the top flange. This second flange supports the vacuum chamber in the weld pit. The vacuum chamber lower section is 176 inches long. The upper flange is machined to provide a bolting surface for the vacuum chamber bearing (which supports the canister fixture) and a groove for the elastomer ring. To accommodate the bearing (approximately 2 inches high), a 2.38 inch thick, 32 inch diameter adapter plate with an additional elastomer seal ring was installed on the vacuum chamber upper flange.

The upper portion of the vacuum chamber lower section also contains two flanged tubes to connect the section to the other system parts. A 4 inch diameter, 0.083 inch thick tube with an appropriate flange fitting is welded to one side of the vacuum chamber. This flange attaches to the 4 inch diameter flexible stainless steel hose from the leak detection system pumps, etc. A 0.75 inch diameter, 0.035 inch thick tube with appropriate flange fitting is welded to the opposite side of the vacuum chamber. This flange is attached to a stainless steel tube from the helium leak standard.

The vacuum chamber hood is stainless steel and consists of an 18 inch diameter, 0.375 inch thick pipe with a 1 inch thick top plate and a 32 inch diameter, 1.5 inch thick flange on the bottom. The hood is 32.25 inches high with an 8 inch high lifting handle on the top. The lifting handle has two vertical steel plates (each 8 inches high, 4 inches wide, and 1 inch thick) with a 1.5 inch diameter rod welded between the plates to interface with the Hot Bay crane hooks and the WMHS.

The leak detection system components also include the roughing pump attached to the vacuum chamber by a flexible stainless steel tube (to draw the initial vacuum around the canister); a mass spectrometer type helium leak detector (to check for canister leakage of helium); and a helium leak standard (to check the system calibration). The roughing pump, vacuum blower, and associated valves, pressure gauges, and piping are mounted on a mobile cart located near the weld pit. The helium mass spectrometer leak detector located in the operating gallery is connected ahead of the roughing pump by a flexible stainless steel tube passing through the shield wall. The roughing pump and leak detector both exhaust into the Hot Bay. A helium leak standard is mounted near the weld pit and connected to the opposite side of the vacuum chamber from the roughing pump by a stainless steel tube. The standard leak is valved so that helium can be remotely supplied when needed. Lead shielding is provided between the equipment cart and the vacuum chamber and around the helium leak standard to protect system components from the deleterious effects of radiation from the fuel assembly in the weld pit.

The evacuation/backfill and leak detection system was designed for maintenance and replacement during hands-on operations in the Hot Bay. The large components, mounted on mobile carts, facilitate removal to repair areas. If a pump or valve should fail while spent fuel is in the weld pit or another unshielded position elsewhere in the Hot Bay, the fuel must be moved to the lag storage pit or transfer pit before hands-on repairs are made.

A.5.4 CANISTER TRANSFER AND DRYWELL EMPLACEMENT EQUIPMENT

TRANSFER SHIELD

The transfer shield shown in Figure A-22 transfers the canister/shield plug assemblies from the transfer pit in the Hot Bay to the drywells in the storage area. The transfer shield is mounted on the Engine Installation Vehicle (EIV) and provides personnel radiation shielding during transfer operations. Movement of the transfer shield and EIV is provided by the Manned Control Car and the L-3 locomotive. These vehicles are described in Section A.3. The transfer shield is shown mounted on the EIV in Figure A-23.

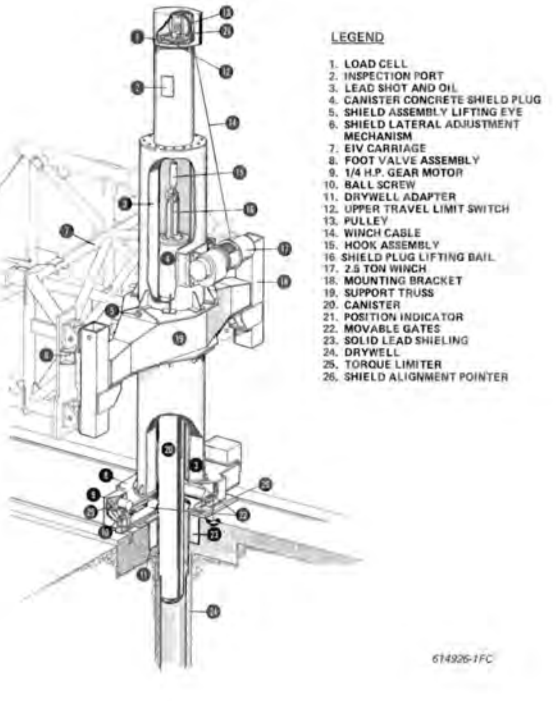

Figure A-22. EIV Transfer Shield Configuration

Figure A-23. Engine Installation Vehicle After Addition of the Transfer Shield

The transfer shield/EIV assembly has the following features:

- A drive system on the EIV moves the shield vertically, longitudinally, and laterally with respect to the EIV.

- A winch to raise and lower the canister/shield plug assembly.

- A foot valve to open and close the bottom of the shield to permit pickup and discharge of a canister assembly while providing shielding during transport.

- An electrical control system to prevent operator error and damage to equipment or exposure of personnel to excessive radiation levels.

The transfer shield assembly consists of two concentric carbon steel cylinders with the 6.5 inch annular space between the cylinders filled with 0.030 inch to 0.045 inch diameter lead shot. The lead shot is poured into the top of the shield annulus and is then vibrated and tamped into place. The void space in the lead shot is filled with neutron absorbing shielding oil. The total shield assembly is approximately 25 feet high by 3 feet in diameter. A rectangular foot valve assembly extends 3 feet on either side of the vertical centerline. The transfer shield weighs approximately 25 tons.

The shield support truss is attached to existing mounting holes on the EIV carriage. The EIV has vertical, longitudinal, and lateral carriage drives which are used to position the shield with respect to the transfer pit and drywell.

The transfer shield winch and cable assembly are designed to raise and lower a canister and shield plug having a combined weight of approximately 4000 pounds. The winch, with a rated capacity of 2.5 tons, is an electric motor driven hoist attached to the side of the shield assembly. The cable is a 6 x 37 class, steel core, high strength, steel cable which has a breaking strength greater than 12 tons. The cable is routed from the hoist drum to the top of the shield assembly, around a 11.75 inch diameter sheave, and then into the transfer shield interior to the hook assembly. The hoist has the capability for hand cranking to raise or lower a canister assembly in the event of power failure.

The foot valve assembly consists of two gates filled with 8.3 inches of lead shot. A "V" shaped interface between the gates limits radiation streaming during canister assembly transport. Each gate in the foot valve, supported by cam rollers, is individually driven by a 0.25 horsepower electric motor (with gear reducer) connected by a chain drive to a ballscrew. Limit switches control the travel of the two gates and a slip clutch is provided to protect the mechanism in the event of a limit switch malfunction. The foot valve gates also have the capability for hand cranking in the event of power failure.

An electrical control system permits remote operation of the EIV and transfer shield components. Control panels are provided in the Manned Control Car cab and at the back end of the EIV (opposite end of the EIV from the shield). A third portable control panel can operate the system from the E-MAD gallery when the EIV is located in the Hot Bay. Operation is normally controlled by the MCC panel. The electrical control system has provisions to limit winch and foot valve travel, to limit shield travel via the EIV carriage motion mechanisms, and to interlock operating modes to prevent inadvertent winch, foot valve, or shield motions from causing exposure of personnel to a bare (unshielded) canister assembly. Sensing switches are provided on the transfer shield and EIV to indicate load on the cable, winch hook full up and down position, shield full up and down position, foot valve open and closed position, and EIV lateral and longitudinal travel limit positions.

The details of transfer shield/EIV transfer operations are provided in Section B.2.2.

DRYWELL SHIELD ADAPTER

A shield adapter is installed in the annular region around the upper drywell liner during canister assembly emplacement and removal operations. This drywell shield adapter limits radiation levels in the area immediately surrounding the drywell while the canister is raised or lowered. The drywell shield adapter as installed in the drywell is illustrated in Figure A-24.

The drywell shield adapter is made of carbon steel and consists of two 17.5 inch long concentric pipes having a 22.5 inch inside diameter and a 36 inch outside diameter.

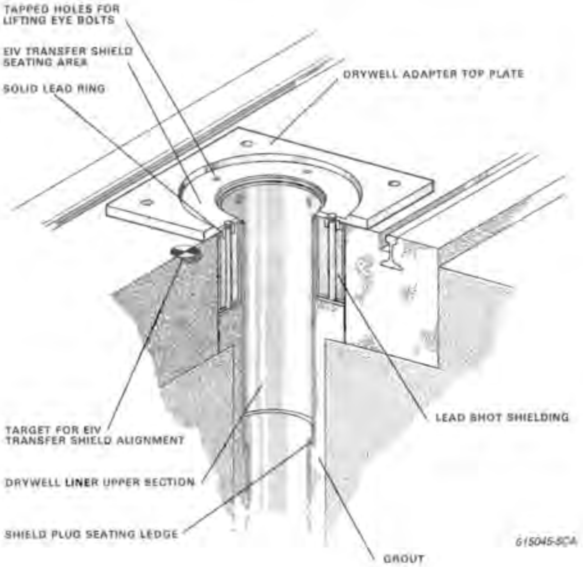

Figure A-24. Drywell Shield Adapter Configuration (Shown Installed in Drywell)

The 5.75 inch wide annulus between the pipes is filled with lead shot which was vibrated and tamped in place. A 0.5 inch thick bottom plate and a 2 inch thick top plate are welded to the two pipes. The top plate is 49 inches square and has a 1 inch deep by 39 inch diameter recess machined in the top to interface with the bottom of the transfer shield. Four 1.5 inch diameter rods were welded to the top and bottom plates to provide additional support, each having 0.5 inch diameter threaded holes fitted with lifting rings for handling the shield adapter. The adapter weighs approximately 4000 pounds.

A.5.5 DATA ACQUISITION SYSTEM

The data acquisition system for the E-MAD testing consists of arrays of thermocouples, a data logger, and remote signal conditioning/multiplexing units. The thermocouple leads are routed to multiplexer units located in the instrumentation sheds outside E-MAD. Multiplexer signal cables are routed through underground conduit to the data logger which is located inside the E-MAD building in the west operator gallery adjacent to the Television Control Center.

An Acurex Autodata IX data logger records thermocouple data. The data logger is shown in Figure A-25 in its installed configuration. The data logger is used for experiments at E-MAD (Electrically Heated Drywell Test, Drywells and Concrete Silo Tests, and Fuel Assembly Internal Temperature Measurement Test) and for monitoring spent fuel temperatures within the E-MAD hot cells. The data logger operates on 120 volt, 60 Hz AC electrical power and is rated for operation in the range of 32 to 110°F and 0 to 90

Figure A-25. Data Logger Installation in West Gallery

percent relative humidity. This data logger system was selected with capabilities to meet the present test needs of the SFHPP 1978 Demonstration as well as any future expansion needs. Some of the capabilities are as follows:

- Measurement of Type K thermocouple temperatures from up to 1000 thermocouples.
- Thermocouple open detection circuit (to determine failures).
- Remote signal conditioning and multiplexing for remote instrumentation up to 5000 feet from data logger mainframe.
- Console digital readout in identified engineering units (selectable on the front panel).
- Printer for output data with header and engineering unit identification.
- Variable scan modes (single, continuous, and intervals) with adjustable scan intervals.
- High performance analog to digital conversion.

A.5.6 TELEVISION MONITORING SYSTEM

The E-MAD facility closed circuit TV monitoring system was upgraded for the SFHPP Demonstration Program. Four cameras are fixed in the E-MAD Hot Bay; one each on the north and west walls, two on the south wall. Four cameras on portable stands (including one which is capable of being handled by the Wall-Mounted Handling System) complement the fixed positions in the Hot Bay. Cameras in the Hot Bay are used to coordinate handling operations. Two cameras are used in the West Process Cell to closely observe the Fuel Assembly Internal Temperature Measurement Test. One camera is fixed and one is portable. There are four cameras outside the E-MAD Hot Bay. Two are located outside the north shield door and are used for site security purposes. Two cameras on the west side of E-MAD provide the capability to monitor storage site activities. Two cameras mounted to the EIV side arms provide viewing of canister emplacement activities.

The cameras in and around the E-MAD building are hard wired to the Television Control Center. Remote operation of the zoom lens and pan and tilt units is controlled from the TVCC. All the cameras have a 350° minimum rotation and 160° inclination capability. Six of the eight cameras in the Hot Bay have 10:1 zoom capability. All the other cameras have a 5:1 zoom capability. All cameras have a minimum 600 line horizontal resolution and ten shades of grade scale rendition. Cameras and lenses in the Hot Bay are radiation hardened to prevent lens browning. All outside cameras, lenses, and pan and tilt units are weather resistant.

Two cameras mounted on the EIV provide video displays in the cab of the Manned Control Car. These cameras are weather resistant and have remotely operated pan, tilt, and zoom capabilities controlled from the MCC. These cameras and monitors provide visual contact during transfer shield alignment with the drywell or transfer pit using the EIV remote positioning controls.

Video monitors are located in the Master Control Room and the TVCC. Other monitors are provided at local work stations where the remote handling and welding operations are controlled. Video tape records of fuel receipt inspection and operations are made in the TVCC using existing video tape equipment.

A.5.7 WEATHER STATION

A remote weather station was installed by the National Weather Service in the northeast corner of the Electrically Heated Drywell Test fenced area (see Figure B-1) during the week of June 12, 1978. This weather station, shown in Figure A-26, provides continuous strip chart records of temperature, atmospheric pressure, humidity, wind speed and direction, and rainfall in the E-MAD storage area.

Figure A-26. E-MAD Weather Station

A.5.8 OTHER EQUIPMENT

Other equipment provided for the SFHPP Demonstration and the CWSFP Program activities at E-MAD included:

- Canister Cutting Tool
    - Installed in the Hot Bay shielded storage pit, the canister cutting tool provides capability for remote cutting of a sealed spent fuel canister for fuel assembly removal.
- BWR Fuel Assembly Handling Tool
    - This tool provides handling capability for boiling water reactor (BWR) spent fuel assemblies.
- BWR Canister Body
    - This canister body was designed to encapsulate two BWR fuel assemblies in a 14 inch diameter by 187 inch long envelope compatible with the E-MAD spent fuel canister test cells, handling equipment, and Hot Bay pits.
- Gas Sampling Equipment
    - This equipment includes the hardware to clean and evacuate gas sample bottles, to remotely attach them to storage canisters, and to take samples of canister internal atmospheres (further described in Appendix L).
- Boiling Water Calorimeter
    - Installed in the Hot Bay shielded storage pit, the calorimeter provides the capability of measuring the decay heat level of individual spent fuel assemblies (further discussed in Appendix K).

APPENDIX B

DETAILS OF STORAGE SITE CONSTRUCTION AND INSTALLATION AND SPENT FUEL HANDLING OPERATIONS

This appendix documents the operations performed to prepare the storage sites for the drywells (both fueled and electrically heated) and concrete silos. It also details the procedures used to install the test hardware and the spent fuel handling and emplacement operations performed to initiate the Drywell, Concrete Silo, and Fuel Assembly Internal Temperature Measurement Tests. In addition, the configuration of the specific storage sites are described to identify specific component locations, methods of instrumentation, etc.

B.1 STORAGE SITE CONSTRUCTION AND INSTALLATION OPERATIONS

B.1.1 ELECTRICALLY HEATED DRYWELL

The location of the electrically heated drywell relative to the E-MAD building and the other test articles is illustrated in Figure 2.2-2. Figures B-1 and B-2 show the arrangement of the electrically heated drywell and related hardware and instrumentation. The following section describes the construction operations, installation operations, and details of some auxiliary equipment for the electrically heated drywell not described in Section 3.2.1.

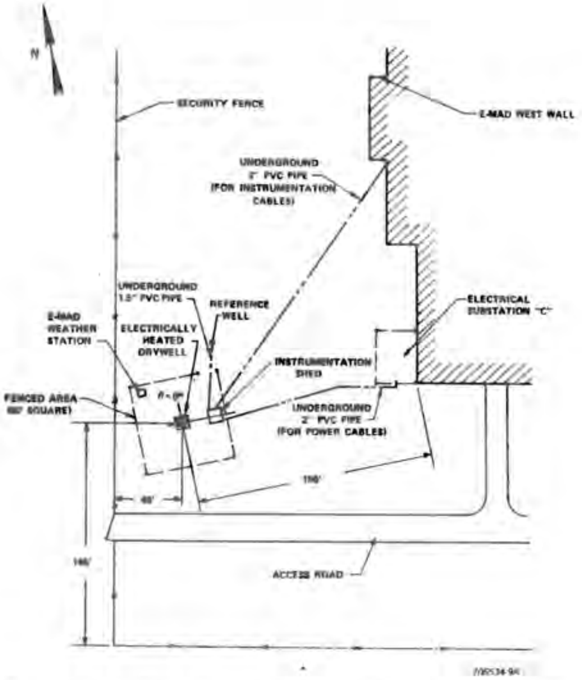

Figure B-1. Electrically Heated Drywell Area Arrangement

Electrically heated drywell storage site construction started in early 1978 with the grading of the area (Figure B-3). Next, the concrete pad for the top of the drywell was constructed. Following excavation for the 15 inch deep pad, it was formed and the rebar and other components were installed as shown in Figure B-4. These items included a 28 inch diameter cardboard form for the drywell liner hole, two 6 inch diameter PVC pipes for instrumentation well installation after pad pouring, two standpipes with attached electrical boxes for routing liner and grout thermocouples and anchors for securing the drywell cover. Three thermocouples were installed prior to pad pouring. Two were installed in a 0.5 inch diameter hole in the soil beneath the pad (thermocouples were installed and the soil tamped into place to fill the hole) and one was attached to the rebar in the pad. Included in the pad forms were two 2 by 4's to create depressions in the pad top for routing liner and grout thermocouples to the standpipes.

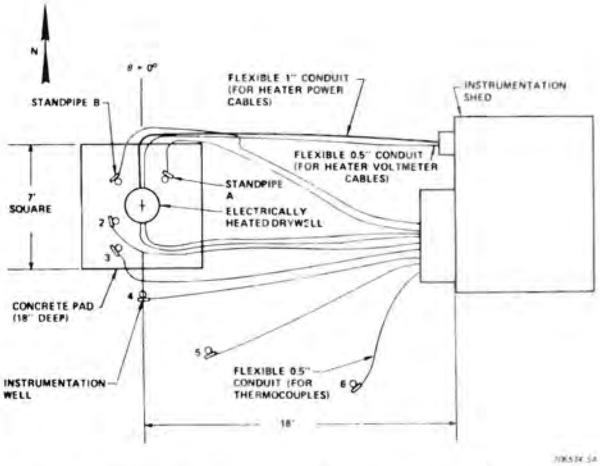

Figure B-2. Electrically Heated Drywell Instrumentation and Power Cable Routing Arrangement

The 84 inch square concrete pad was then poured and finished with a 0.5 inch slope from the 28 inch diameter cardboard form to the edges. After the pad cured and the wood

Figure B-3. Grading Completed for Electrically Heated Drywell

Figure B-4. Electrically Heated Drywell Pad Forming, Concrete Pouring Half Complete and cardboard forms were removed, a 26 inch diameter hole was drilled in the soil through the pad opening. The hole was drilled to approximately 19 feet deep. Before installing the drywell liner, the thermocouples were attached to it (see Figure 3.2-5) inside the E-MAD building. The 26 inch diameter hole had to be redrilled prior to liner installation since part had collapsed.

The liner was installed (see Figure B-5) in the hole, positioned and leveled using the four pad anchors and a special fixture. The liner and grout thermocouple extension wires were laid in the pad cutouts and inserted through openings in the standpipe electrical boxes. The liner was then grouted in place using a grout mix of two parts soil from the hole and one part Luminite cement (parts measured by weight). The grout was installed in the bottom to a level of about 2 feet and allowed to set before the rest of the grout was poured. It should be noted that twice the expected amount of grout was used to fill the hole. Finally, the grout at the pad top was finished to have a 0.38 to 0.5 inch slope from the liner to the top of the concrete pad.


Figure B-5. Electrically Heated Drywell Liner Three-Quarters Installed

Following liner installation, the five soil instrumentation wells were installed. For each well, a 3 inch diameter hole was drilled about 4 feet deeper than the length of the well (see table on Figure 3.2-1). The instrumentation well was installed (as shown in Figure B-6), the electrical box at the top of each well supported and positioned, and the hole filled with grout. Each well was situated so that the electrical box faced away from the drywell directing the attached thermocouples toward the drywell center. Figure B-7 shows an installed instrumentation well.

In addition to the instrumentation wells, a soil Reference Well was installed. The position of this Reference Well is shown in Figure B-1. The Reference Well was installed by excavating a 2 foot deep hole prior to drilling the 3 inch diameter hole for the well. The Reference Well was installed in the hole and grouted in place. Since it had no electrical box, the thermocouples were routed to the instrumentation shed in a 1.5 inch diameter PVC pipe buried about 12 inches deep. Prior to filling in

Figure B-6. Instrumentation Well Suspended Over Hole

Figure B-7. Instrumentation Well Grouted in Hole

the 2 foot deep hole, the top of the Reference Well pipe was cut off about 12 inches below ground level. The hole was then backfilled with the top thermocouple being located about 6 inches below ground level as the hole was filled.

A 96 inch by 100 inch instrumentation shed was placed 18 feet from the electrically heated drywell providing an environmentally controlled area for the power controller and the thermocouple signal conditioning/multiplexing units. As shown in Figure B-1, two 2 inch diameter PVC pipes, buried about 2 feet deep, routed cable from the instrumentation shed to the E-MAD building. One pipe carried four #2 AWG wires which were connected to the Substation C Distribution Panel to supply electric power. The other pipe allowed cable routing between the multiplexer units and the data logger inside E-MAD.

Power and instrument leads from the drywell and instrumentation wells were routed to the instrumentation shed through buried waterproof flexible conduit. Figure B-2 shows the routing of these conduit. One 0.5 inch diameter flexible conduit routed thermocouple extension wires from each instrumentation well, from each pad standpipe, and from the canister and shield plug thermocouples. A 1 inch diameter flexible conduit routed two #6 AWG wire power cables and one #10 AWG ground wire to the electric heater connections at the drywell. In addition, a 0.5 inch diameter flexible conduit routed two #20 AWG wires to the electric heater top which allowed accurate power measurements. These wires were brazed to fittings at the top of the heater conducters and attached to a digital voltmeter in the instrumentation shed. Fig-

Figure B-8. Top of Electrically Heated Drywell

ure B-8 shows the top of the electrically heated drywell with thermocouple leads, power cables, and flexible conduit.

Following hookup of the instrumentation and power cables, the flexible conduit was buried and the top surface of the entire area graded for a one percent slope away from the drywell pad. Figure B-9 shows this completed area. In addition, a 38 inch high fence enclosed the 60 foot square area around the electrically heated drywell.

B.1.2 FUELED DRYWELLS

The four drywells are located west of the E-MAD building as shown in Figure 2.2-2. Figure B-10 shows the arrangement of the drywell storage area and the related hardware and instrumentation. The

Figure B-9. View of Completed Electrically Heated Drywell

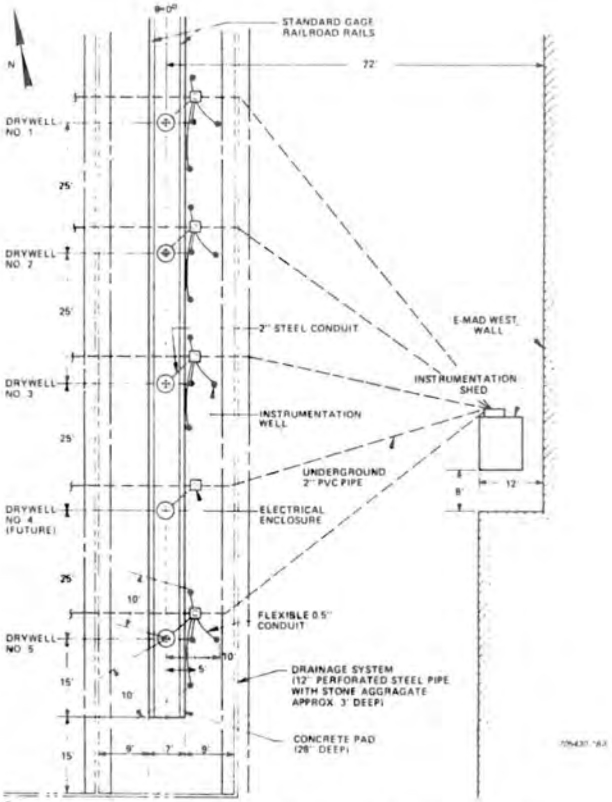

Figure B-10. Fueled Drywell Storage Area Arrangement following section describes the construction operations, the installation operations, and details of the auxiliary equipment for the drywells not described in Section 3.2.2.

Drywell storage area construction began with excavating the new drywell rail spur and storage pad. The main E-MAD railroad track extends directly north from the Hot Bay to the complex security fence and beyond as shown in Figure A-2. A switch located 100 feet south of the north fence was used to start a new drywell rail spur. The spur consists of one track paralleling the main track and descending down a 2.5 percent grade to the storage area. An additional switch was installed to allow later construction of two additional drywell storage spurs.

Excavation included removing soil to form the base for two new drywell storage pads. Three shallow trenches on either side and between these pads were also excavated to form a drainage system. This drainage system consisted of 12 inch diameter perforated corrugated metal pipe buried about 3 feet deep. A layer of 0.75 inch size stone aggragate was placed on either side and above the pipe. The three drainage ditches (two are illustrated in Figure B-10) start north of the drywell pad and extend about 15 feet beyond the pad end. Solid corrugated metal pipes connect the three drainage pipes and direct water to the security fence on the west side of the E-MAD facility. The stone aggregrate covering the drainage pipe can be seen in Figures B-11 through B-13.

Figure B-11. Drywell Storage Area Construction

Figure B-12. Drywell Storage Area Construction

Figure B-13. Drywell Concrete Pad Construction Completed

Prior to drywell concrete pad construction, underground pipe and conduit was laid for instrumentation routing for three drywell spurs. Fifteen lines of 2 inch diameter PVC pipe were installed 2 feet below ground level. The lines ran from the instrumentation shed to each of 15 drywell locations including ten future drywell locations on proposed second and third rail spurs as shown in Figure B-10. Vertical sections of metal conduit were installed at the end of each pipe for attachment to a large waterproof, dustproof electrical enclosure near each drywells.

The drywell pad is 84 inches wide by 28 inches deep by 235 feet long and was constructed in stages. First, the periphery forms, the reinforcing rod, and five 37.25 inch outside diameter drywell forms spaced at 25 foot intervals along the pad length were installed as shown in Figure B-11. The northernmost drywell form was placed 120 feet from the north end of the pad. A 2 inch diameter steel conduit was installed between the drywell form and the pad form to allow thermocouple routing to the electrical enclosure boxes. Second, 20 inches of concrete were poured and 1 inch diameter studs set every 6 feet to support the two rail tracks. Next, the two tracks were installed on 6 inch wide by 12 inch long by 0.5 inch thick plates placed over adjacent studs and supported by hex nuts threaded on the studs. The tracks were centered and leveled on the plates and secured using two rail clamps and hex nuts at each plate. The top 8 inches of concrete was poured level with the two rail top with 2 inch wide by 2.5 inch deep recesses on the inside of both rails to allow for rail car wheels. Sixteen anchors for the drywell cover plate bolts were installed around each of the drywell form. Concrete pad construction is shown in Figures B-12 and B-13.

Four drywell liners were installed for the Spent Fuel Handling and Packaging Program (SFHPP) 1978 Demonstration. Twenty-six inch diameter by 23 foot deep holes were drilled in the soil for drywell liners using the three northernmost and the southernmost concrete pad holes for alignment and spacing. After each drywell hole was drilled, a 37.25 inch diameter by 9.25 inch high by 0.062 inch thick galvanized steel sleeve was installed in the concrete pad's lower portion. This provided a slip plane for the grout installed around the liner and concrete pad. The drywell liner was then installed (see Figure B-14) and leveled at the top to within ±0.03 inches. Grout was poured into the hole until it reached a level of one to two feet above the liner bottom. After the grout set, the entire annulus between the liner and hole was filled to the top of the galvanized steel sleeve. This provided an 18.75 inch deep recess at the liner top allowing for drywell shield adapter installation.

Following construction, the soil was replaced to within 1 inch of the pad top. A one percent slope away from the pad was maintained. Four soil instrumentation wells and four electrical enclosures were then installed near each drywells. Figure B-10 shows the location and orientation of the instrumentation wells for all four drywells. Each instrumentation well was inserted into a 3.5 inch hole (see Figure B-15) drilled several feet deeper than the well and grouted in place. The electrical box of the well top

Figure B-14. Drywell Liner Installation Into Storage Area

Figure B-15. Drywell Instrumentation Well Installation

Figure B-16. Instrumentation Wells Installed in Drywell Storage Area was used to position and support the well for grouting. Flexible conduit from the instrumentation wells was attached to the nearby electrical enclosure and the thermocouple leads coiled inside. Figure B-16 shows the sixteen instrumentation wells installed in the drywell storage area.

B.1.3 CONCRETE SILOS

The concrete silo storage area is located adjacent to the Engine Maintenance Assembly and Disassembly (E-MAD) building as shown in Figure 2.2-2. Figure B-17 illustrates the concrete silo area arrangement and all related hardware and instrumentation. The following section describes the storage area construction operations, details of some auxiliary equipment, and construction and assembly operations for the concrete silos not described in Section 4.2.

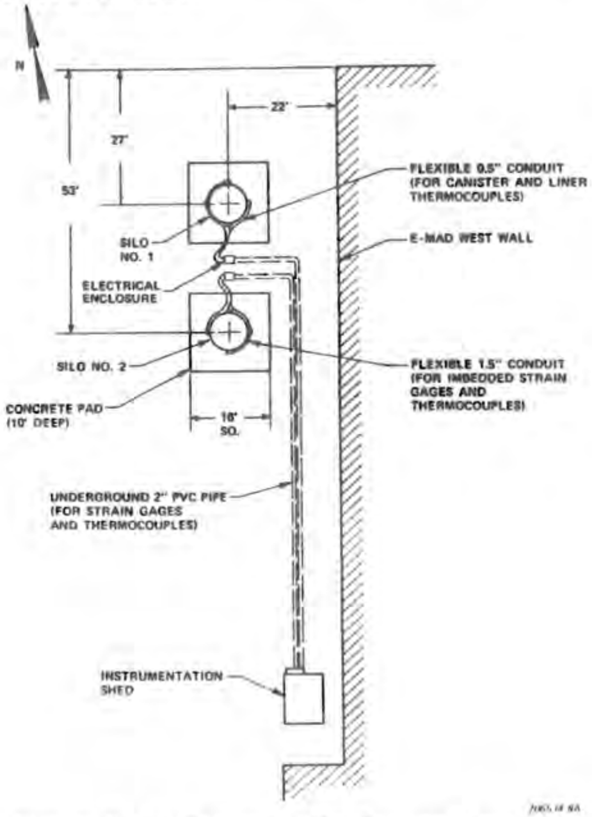

Figure B-17. Concrete Silo Storage Area Arrangement

Concrete silo storage area construction started in conjunction with drywell storage area construction. Site preparation commenced with excavating a 20 foot wide by 46 foot long by 9 foot deep hole. This hole was filled to a depth of 6 feet with a lean concrete mix to act as a foundation for the concrete silo support pads. Two individual concrete pads, each 16 feet square by 46 inches deep, were formed on the foundation. Figure B-18 shows the forming and construction operations. Rebar was installed in the form and eight silo holddown plates located so as to be embedded in the concrete pad. These holddown plates consist of a 14 inch by 18 inch by 0.75 inch thick plates to which are welded six 0.75 inch diameter by 8 inch long Nelson studs. Four 2.5 inch square by 3 inch long bars are welded to the holddown plate bottom and have threaded holes for holddown bolts. Following concrete support pad curing, the forms were removed and the soil backfilled against the support pads. Figure B-19 shows the finished pads. The rebar in the two support pads and two copper wires for each silo were connected to the E-MAD electrical ground grid system. The two loose wires attached to each silo ground the entire unit.

Next, four 2 inch diameter PVC pipes were installed 2 feet underground for routing instrumentation leads from the two silos to the instrumentation shed. Vertical sections of steel pipe were installed at the end of each pipe. Two pipes each were attached to the two large waterproof, dustproof electrical enclosures located between the silo support pads (see Figure B-17) to allow separate routing of thermocouples and strain gages for each silo. Flexible 1.5 inch diameter waterproof conduits attached to the electrical enclos-

Figure B-18. Concrete Silo Support Pad Forming

Figure B-19. Concrete Silo Support Pads-Construction Completed ures routed thermocouple and strain gage wires from the terminal boxes on the silo to the electrical enclosure and instrumentation shed.

Concrete silo assembly began inside E-MAD by installing 12 thermocouples on the liner. The liner was then moved to the support pad and rebar construction and concrete thermocouple and strain gage installation were performed. Figure B-20 shows the partially assembled rebar "cages" for both silos. The liner and rebar was connected to a #1/0 24 strand copper wire at the silo top and bottom. Attachment connectors were installed so as to be on the silo exterior after the concrete was poured. Thermocouple and strain gage extension wires were routed inside the silo to four 12 inch by 8 inch by 8 inch pull boxes located in four quadrants at the silo top. These boxes were also installed on the silo exterior.

In addition to the four pull boxes and four ground wire connectors, other items were installed on the silo rebar cage or were attached to the concrete form (shown in Figure B-21) prior to pouring. The four lifting trunnions and eight holddown plates were positioned in the form. Six holddown studs and two 6 inch wide by 2 inch deep troughs (used to route liner and canister thermocouples) were positioned at the silo top. Concrete was poured for one silo at a time with both using the same form (shown in Figure B-22). Both silos used concrete with a density of 150 pounds per cubic foot. Silo No. 1 was poured first and had a 0.75 inch aggregrate; silo No. 2 had a 1.5 inch aggregrate.

Figure B-20. Concrete Silo Liners on Pads During Rebar Installation

Figure B-21. Form for Concrete Silo Being Prepared for Concrete Pouring

Figure B-22. Pouring of Concrete Into Form (Silo No. 2)

After the silo concrete cured, the forms were removed and additional hardware added. Some of this hardware is visible in Figure B-23. One and a half inch diameter steel conduit connected the pull boxes at the silo top with terminal boxes attached 5 feet from the silo bottom. Fittings provided in the steel conduit and below the terminal boxes sealed the conduit after installation. The embedded thermocouple and strain gage extension wires were routed through the conduit to the terminal boxes and attached to terminal strips. Two 24 strand copper wires were installed between the ground wire connectors. A fitting at the top of each silo side was attached to 0.6 inch diameter by 18 inch long solid copper lightning rods.

Figure B-23. Completed Concrete Silo (Shown During Dry Run of Handling and Operations)

To complete silo construction operations, cover plates were installed to keep water out of the liners. A grid pattern of letters and numbers added to the silo exterior identified elevation and azimuthal position for radiation and thermal measurements.

B.2 SPENT FUEL HANDLING OPERATIONS

This section describes the major process steps involved in spent fuel handling operations. The operations include the receipt, inspection, and encapsulation of the spent fuel assemblies; the emplacement of the completed canister assemblies into interim storage in the E-MAD facility; the transfer of encapsulated fuel assemblies into the drywells and the concrete silo; and the transfer of spent fuel assemblies into the test stand for subsequent fuel assembly internal temperature measurement testing. This description is extensively supplemented by sketches and photographs to illustrate the process steps, the equipment, and system components. Their designs were strongly influenced by the need for compatibility with the E-MAD facility, the desire to use existing E-MAD features and equipment, and the desire to provide a high degree of safety and a high success probability without costly and time-consuming interim modifications. Design considerations related to high volume production had low priority. Equipment used for the spent fuel operations is further described in Appendix A.

B.2.1 FUEL ASSEMBLY ENCAPSULATION AND TRANSFER TO INTERIM STORAGE

PREPARATION FOR FUEL ASSEMBLY UNLOADING FROM THE SHIPPING CASK

The spent fuel shipping cask, transporter trailer, and truck tractor are washed down at another Nevada Test Site location to remove road dirt prior to arrival at E-MAD. The shipping cask is visually inspected for damage, and then the vehicle backed into the Hot Bay. Shipping cask vendor instructions are followed to prepare the transporter and cask for cask off-loading. Using the cask lifting yoke and the E-MAD overhead crane, the cask is upended, lifted off the transporter, and placed in the cask work platform. These steps are illustrated in Figures B-24 through B-26. Hands-on cask operations include installing of the cask vent line, venting the cask internal pressure through the Hot Bay ventilation system stack, removing of the cask closure lid holddown bolts (Figure B-27), and attaching of the lid lifting fixture. During the venting operation, a sample of the cask internal atmosphere is drawn with a vacuum bottle and analyzed for the presence of ^{85}Kr. This analysis ascertains any fuel cladding damage that might have occurred during shipping.

Figure B-24. Spent Fuel Shipping Cask Being Upended in Hot Bay

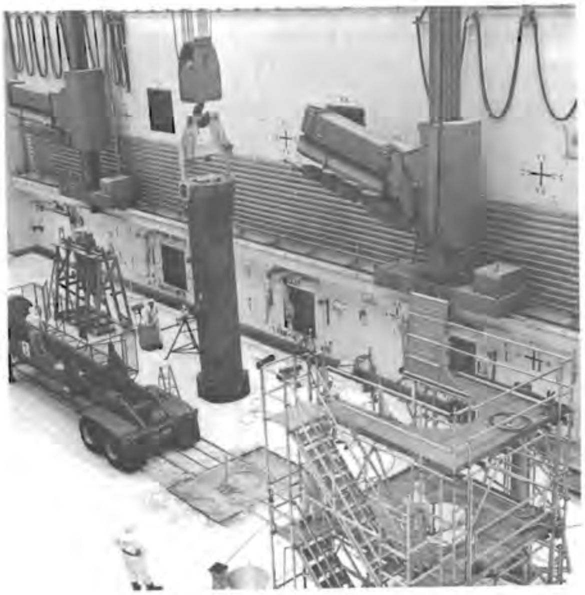

Figure B-25. Shipping Cask Being Moved From the Transporter to the Hot Bay Cask Work Platform

Figure B-26. Shipping Cask Positioned in Cask Work Platform

Figure B-27. Shipping Cask Closure Lid Holddown Bolts Being Removed

While the shipping cask is being prepared for fuel unloading, an empty canister is placed in the weld pit and the necessary equipment prepared. Figures B-28 and B-29 show the empty canister ready for fuel installation. Figure B-30 shows some canister encapsulation equipment during dry run operations.

UNLOADING OF FUEL ASSEMBLY FROM SHIPPING CASK AND PLACEMENT INTO CANISTER IN WELD PIT

After the cask unloading preparations are completed, subsequent operations are performed remotely. Next the overhead crane removes the shipping cask closure lid and places it on its stand to allow access to the fuel assembly (see Figure B-31). The overhead crane picks up the PWR fuel assembly handling tool from its stand and inserts the tool into the shipping cask engaging the fuel assembly top nozzle. The overhead crane then lifts the fuel assembly out of the shipping cask, and holds it while each assembly is visually examined along the full length of each side by a TV camera. This camera is held by one of the Wall-Mounted Handling System manipulators (Figure B-32). Video tape records are made for future reference. After this examination, the fuel assembly is moved to the weld pit and placed into an empty canister (Figures B-33 and B-34).

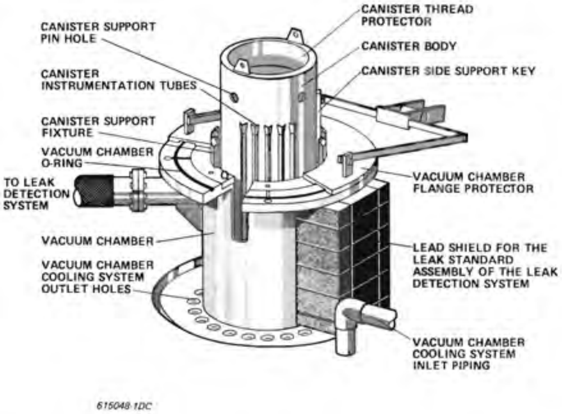

Figure B-28. Weld Pit With Empty Canister Arrangement

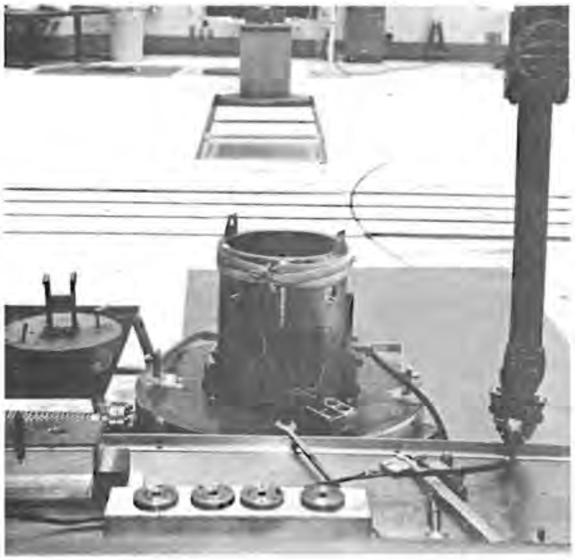

Figure B-29. Empty Canister in Weld Pit Ready to Receive Fuel Assembly (Note Heat Tape Near Top of Canister Body)

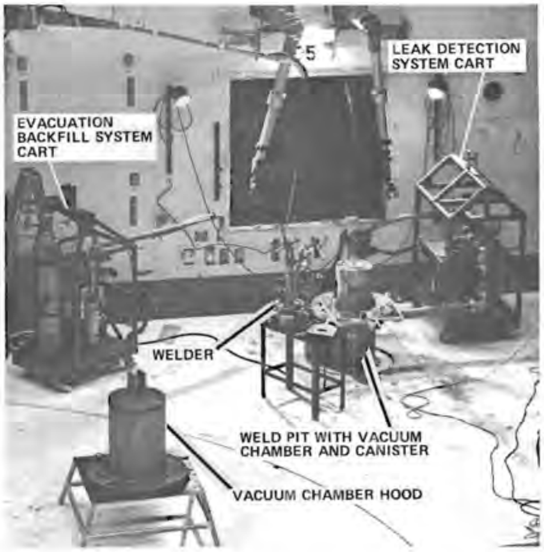

Figure B-30. Canister Encapsulation Equipment (Shown During Dry Run Operations)

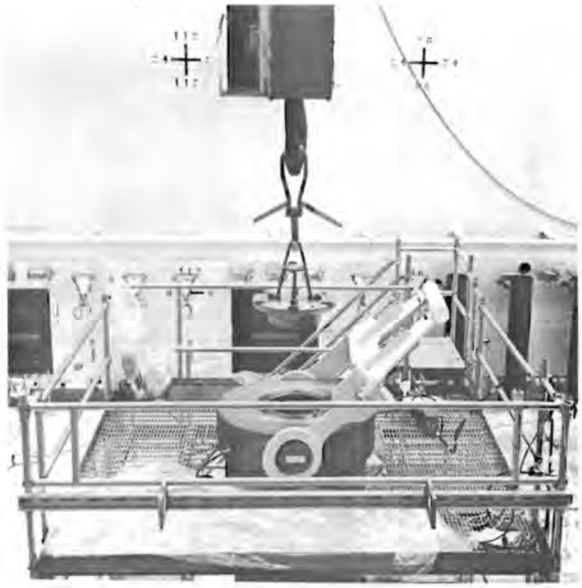

Figure B-31. Shipping Cask Closure Lid Being Remotely Removed

INSTALLATION AND WELDING OF CANISTER CLOSURE LID

After installing the fuel assembly into the canister, the canister thread protector is removed (Figure B-35). The closure lid is picked

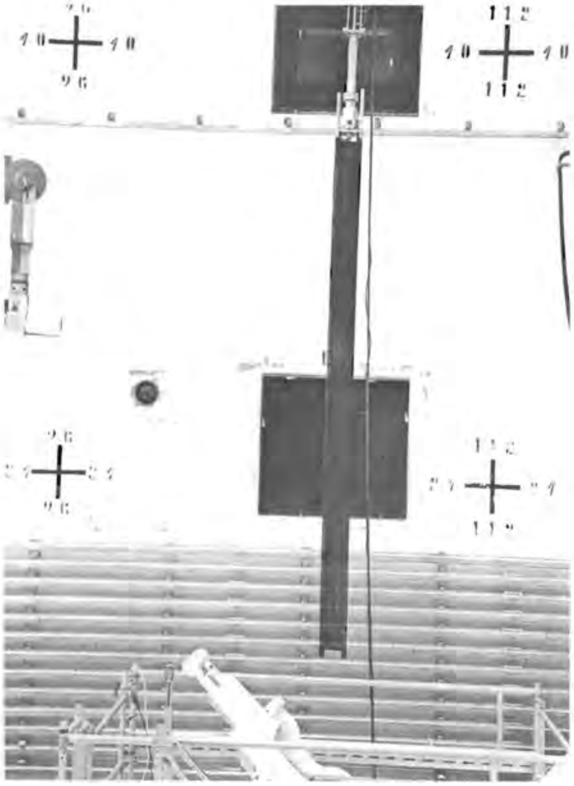

Figure B-32. PWR Fuel Assembly Suspended From the Overhead Crane While Being Examined by a TV Camera

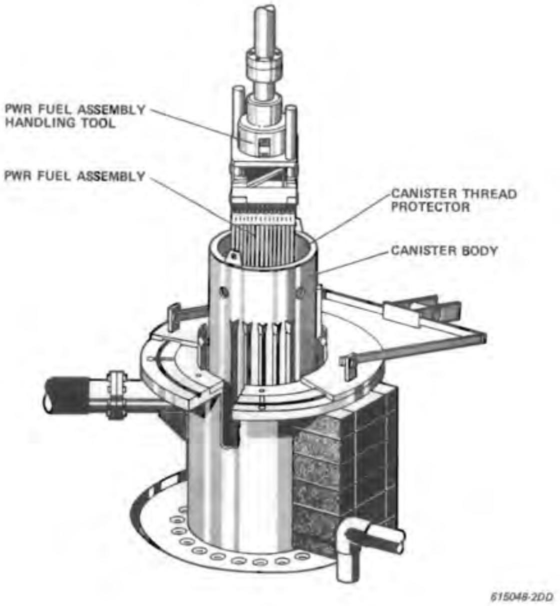

Figure B-33. PWR Fuel Assembly Installation Arrangement

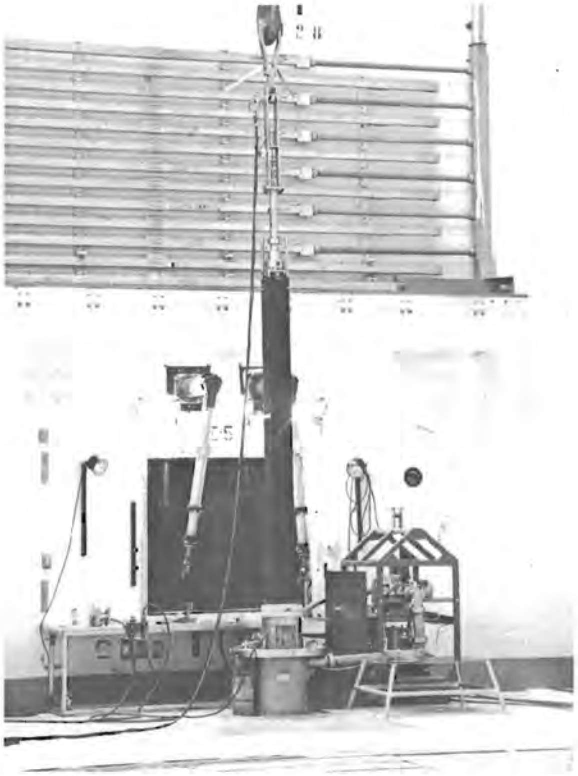

Figure B-34. PWR Fuel Assembly Suspended From Overhead Crane Being Lowered Into Canister in Weld Pit

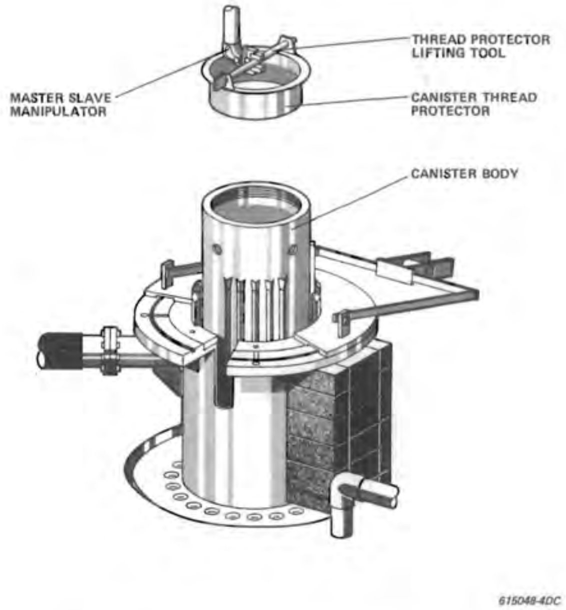

Figure B-35. Canister Thread Protector Removal Arrangement up, aligned over the canister, and lowered into the canister top (Figures B-36 and B-37). The closure lid seal lip and thread protector (illustrated in Figure B-36) is removed, and the closure lid torque tool threads the closure lid into the canister upper body as shown in Figures B-38 and B-39. With the closure lid fully threaded in, a Wall-Mounted Handling System manipulator installs the seal welding machine on the closure lid.

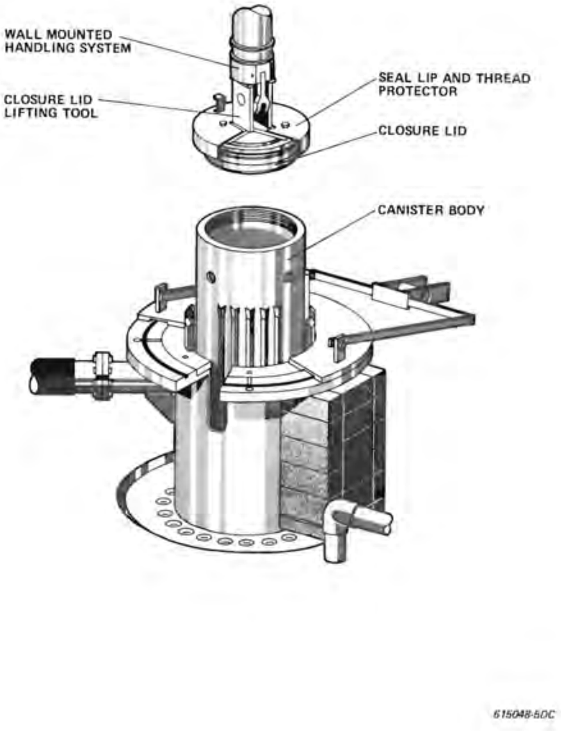

Figure B-36. Canister Closure Lid Alignment Arrangement

The canister is sealed by fusion welding a small lip, machined as part of the closure lid, to the top surface of the canister body. This fusion weld is accomplished by a welding machine, Figures B-40 and B-41, designed specifically for remote operation on a canister.

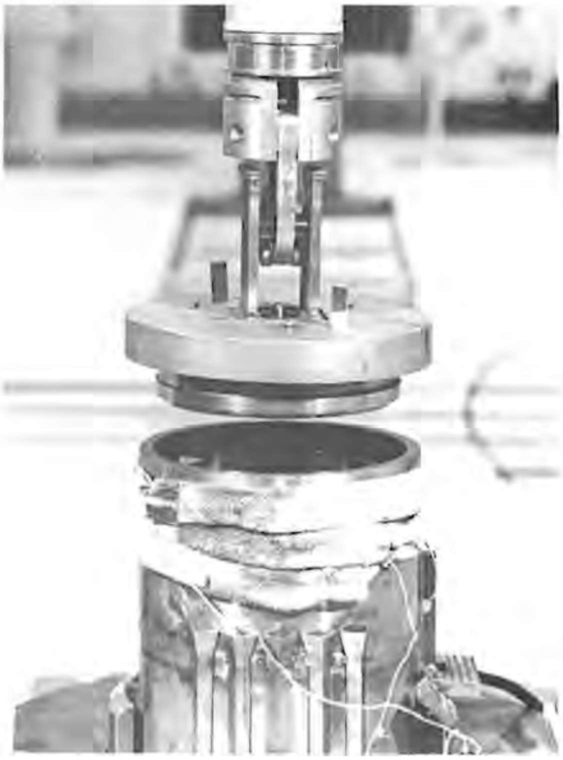

Figure B-37. Canister Closure Lid Being Installed in Canister

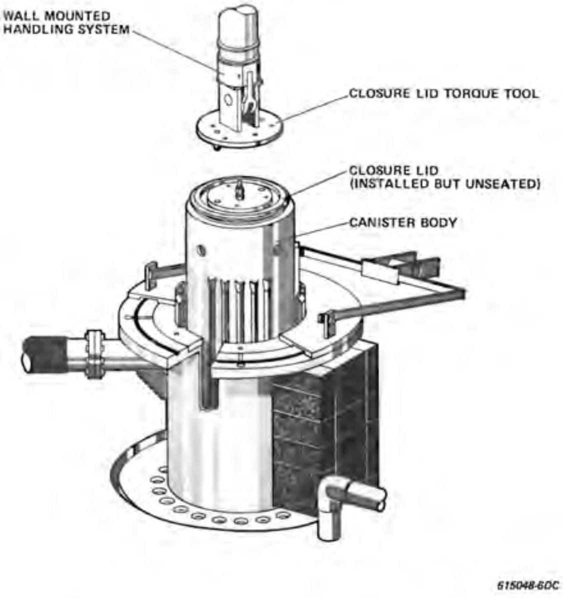

Figure B-38. Canister Closure Lid Threading Arrangement

Figure B-39. Canister Closure Lid Being Threaded Into Canister

The welding machine sits in an "L" shaped groove in the top surface of the closure lid. Three flat-bottom pins attached to the welding machine align the welding machine with the closure lid. Three cam-type locks fit into the lid groove, and are rotated by master-slave manipulators to secure the welding machine to the closure lid. During canister body and closure lid welding, a grounding wire is attached to the canister side support key (shown in Figure B-40). Figure B-41 shows the welding machine during remote welding of a closure lid. Figure B-42 shows a photograph, taken through a E-MAD periscope, of the completed seal weld.

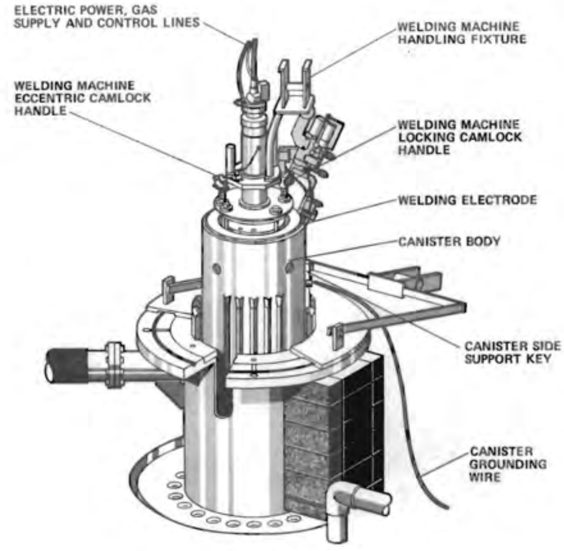

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Figure B-40. Canister Closure Lid Seal Welding Arrangement

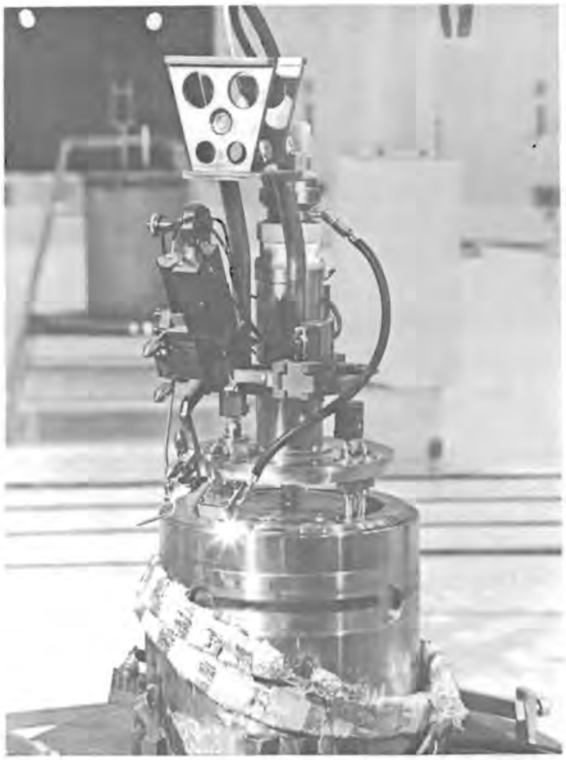

Figure B-41. Canister Closure Lid Being Seal Welded

Figure B-42. Periscope View of Completed Seal Weld

CANISTER EVACUATION AND HELIUM BACKFILL

Following seal welding, the canister is evacuated and backfilled with helium to a pressure of approximately one atmosphere. First, the Evacuation/Backfill System is moved near the weld pit. The flexible stainless steel hose is attached to the fitting on the canister closure lid using two master-slave manipulators (see Figures B-43 and B-44). Once the canister is evacuated, the pump valve is closed and the helium supply valve opened. After helium filling is complete, the flexible steel hose is removed and the fitting on the closure lid capped, using the master-slave manipulators, (see Figure B-45), and torqued.

LEAK TEST OF COMPLETED CANISTER

After helium backfill is complete, the overhead crane places the vacuum chamber hood over the weld pit (see Figures B-46 and B-47) for the helium leak check. Leak Detection System helium leak check operations are performed from a specially designed console in the east operating gallery shown in Figure B-48.

The Leak Detection System roughing pump draws a vacuum to seal the vacuum chamber and evacuates the chamber to a pressure of less than 0.5 millimeters of mercury. At the same time, the electrically-operated valve is activated to open the vacuum chamber to the mass spectrometer. The helium leak standard valve is opened and the combined standard leak and canister leak rates measured. The helium leak standard is then isolated and the canister leak rate alone measured. When the leak check is completed and the canister helium leakage is

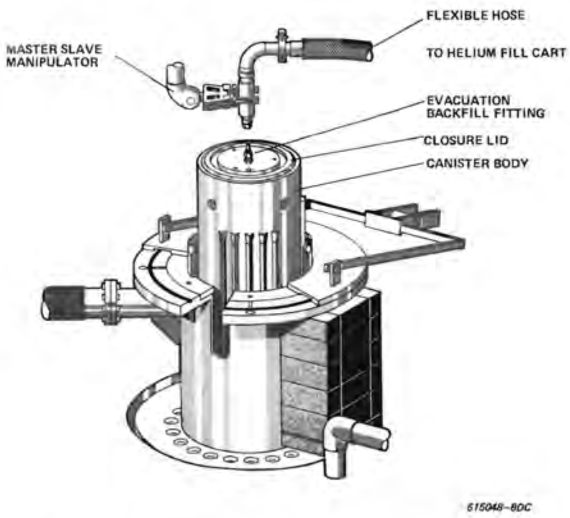

Figure B-43. Evacuation/Backfill System to Canister Attachment Arrangement

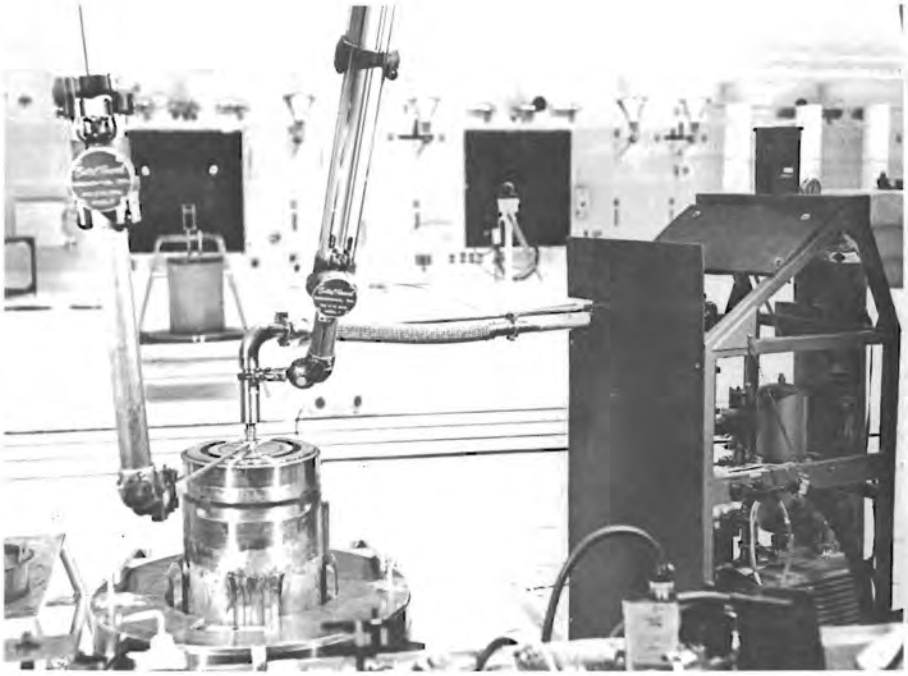

Figure B-44. Installation of Evacuation/Backfill System Hose

Figure B-45. Installing Closure Lid Seal Fitting After Evacuation and Backfill

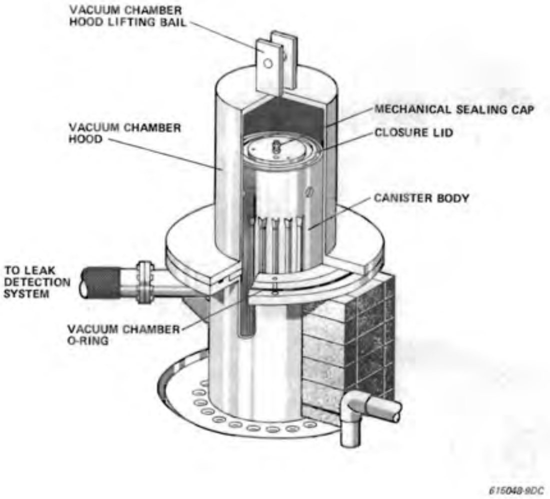

Figure B-46. Canister Leak Check Arrangement

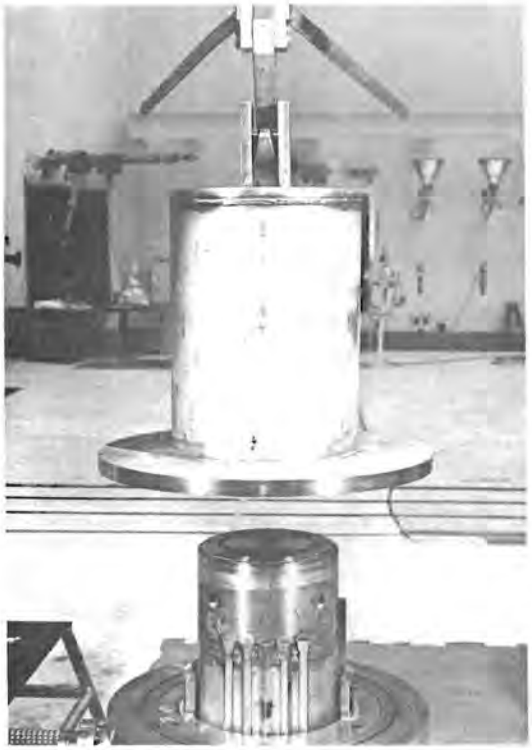

Figure B-47. Vacuum Chamber Hood Being Installed in Preparation for Canister Leak Check

Figure B-48. Leak Detection System Console During Canister Leak Check Operations

found to be less than 10^{-5} atm-cc/sec, the vacuum chamber is returned to atmospheric pressure and the chamber hood removed.

INSTALLATION OF CANISTER ASSEMBLY SHIELD PLUG

After the vacuum chamber hood is removed, the overhead crane picks up a shield plug and places it on the canister (see Figures B-49 and B-50). As shown in Figure B-51, the keyway in the shield plug extension mates with the support key on the canister body. The shield plug vertical alignment pipe resting on the canister closure lid automatically aligns the canister support pins with the flat-bottomed holes in the canister body. To complete the shield plug attachment operation a support pin torque tool held by the Wall-Mounted Handling System threads the support pins in to mate with the canister body holes.

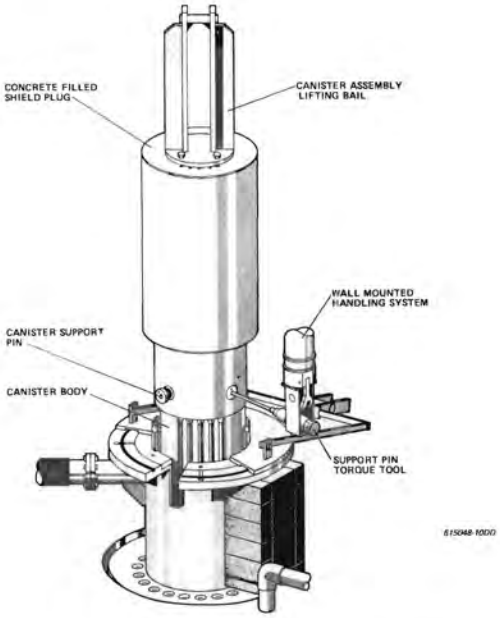

Figure B-49. Shield Plug to Canister Attachment Arrangement

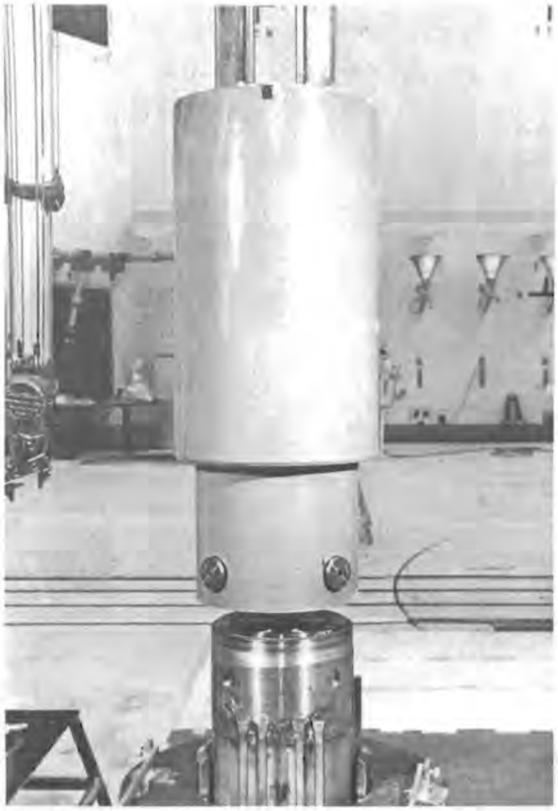

Figure B-50. Shield Plug Being Lowered Over Canister in Preparation for Attachment to Canister

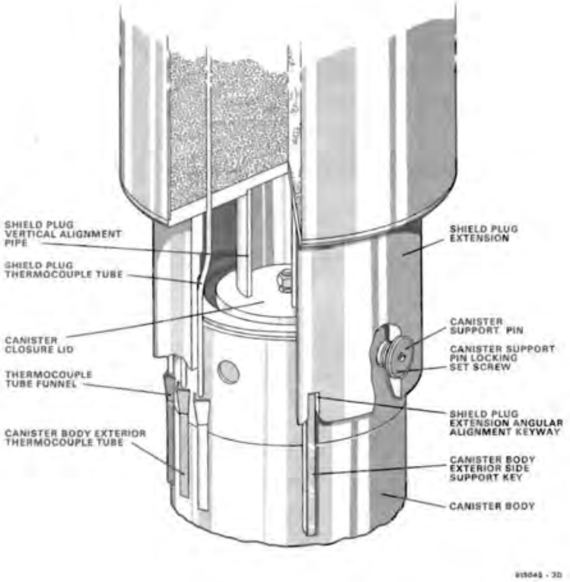

Figure B-51. Canister and Shield Plug Mating Arrangement

SURFACE CONTAMINATION CHECK OF COMPLETED CANISTER ASSEMBLY

After the shield plug is connected to the canister, the overhead crane moves the canister assembly to the survey pit located in the southwest corner of the Hot Bay. This pit is located in front of the pass-through drawer and the master-slave manipulators at viewing windows W-6 and S-1 (see Figure B-52). The survey pit permits the canister assembly to be lowered sufficiently so that the canister top can be reached by the manipulator. The canister is moved vertically while the manipulator operator takes swipes of the canister (see Figure B-53). The swipes are then placed in the pass-through drawer for transfer to the operating gallery for surface contamination counting.

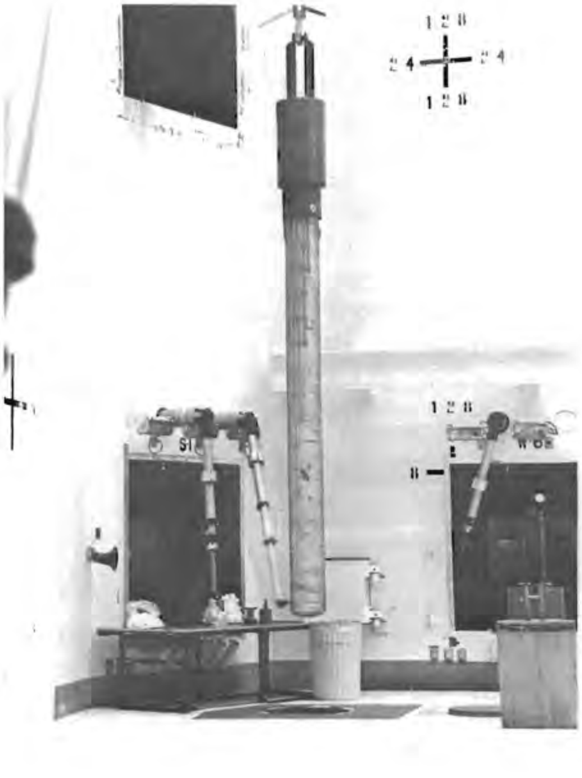

Figure B-52. Canister Assembly Suspended Above Survey Pit

Figure B-53. Canister and Shield Plug Being Remotely Swiped at Survey Pit for Contamination Check

TRANSFER OF CANISTER ASSEMBLY TO INTERIM STORAGE

At this point, the canister assembly can be inserted into the lag storage pit for temporary storage or inserted into the transfer pit for transfer to a drywell or concrete silo. The transfer pit location permits the canister assembly to be picked up by a vehicle for movement to an outside drywell. Figure B-54 shows the canister assembly being lowered into the transfer pit.

B.2.2 CANISTER ASSEMBLY TRANSFER TO THE DRYWELL

Prior to transferring the canister assembly to the drywell, a lifting bail is installed on the shield plug while in the transfer pit. The Engine Installation Vehicle and transfer shield are moved into the Hot Bay by the Manned Control Car and L-3 locomotive and centered over the transfer pit as shown in Figure B-55. Transfer shield positioning and shield equipment operation is performed from inside the Manned Control Car. The shield foot valve opens and the transfer shield hook assembly lowered. The hook is manually engaged on the lifting bail and the shield lowered until it rests on the transfer pit top. The canister and shield plug are then raised into the transfer shield and the foot valve closed. The transfer shield is raised prior to removing the rail vehicles, shield and canister from the Hot Bay.

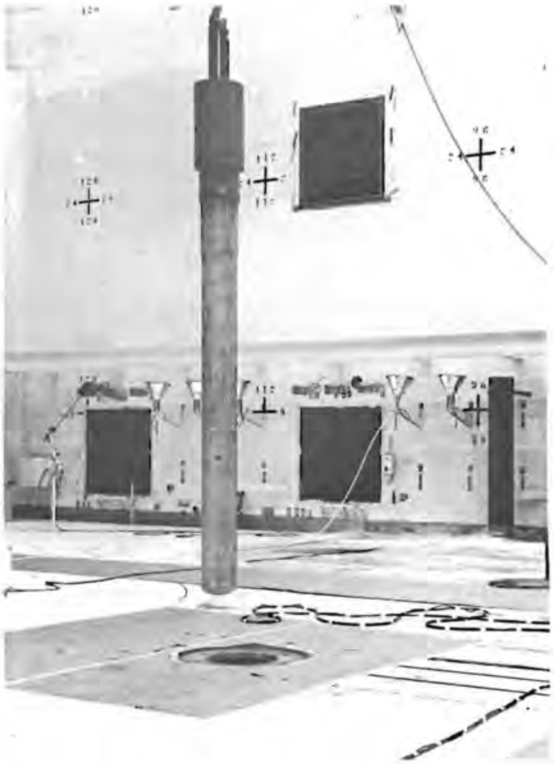

Figure B-54. Placing Completed Canister Assembly in Hot Bay Transfer Pit

The rail vehicles move the transfer shield and canister assembly out to the storage site and position the transfer shield directly above a drywell. The drywell shield adapter is installed in the drywell prior to canister movement to the storage area. The transfer shield alignment is accomplished by a pointer on the shield and a target on the drywell concrete pad (see Figure B-57). Television cameras at the drywell allow Manned Control Car operators to view the pointer and target and position the shield centerline to within 0.25 inches of the drywell centerline. The transfer shield is lowered until it rests on top of the drywell shield adapter as shown in Figure B-56. The foot valve is opened and the canister lowered into position. Figure B-57 illustrates the arrangement of the transfer shield, drywell, canister, and adapter during canister emplacement operations. After the transfer shield is raised, the hook is removed and raised into the shield, the foot

Figure B-55. Positioning Transfer Shield Over Hot Bay Transfer Pit

Figure B-56. Transfer Shield Positioned Over Drywell Emplacing Canister Assembly in Drywell

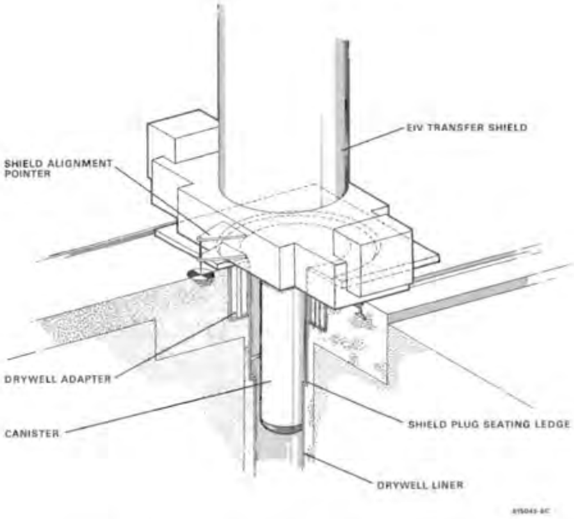

Figure B-57. Transfer Shield, Drywell Adapter and Drywell Arrangement During Canister Emplacement valve closed, and the rail vehicles moved to a parking location. Figure B-58 shows the transfer completed in Drywell 5.

Figure B-58. Transfer of Canister to Drywell Completed

To complete the drywell operations, the drywell shield adapter is moved using a mobile crane, the lifting bail removed, the thermocouples inserted through the shield plug and liner as shown in Figure B-59, the instrumentation connections made at the multiplexer unit, and the cover secured over the drywell.

B.2.3 CANISTER ASSEMBLY TRANSFER TO THE CONCRETE SILO

If, a canister assembly is to be transferred to a concrete silo rather than to a drywell, a different transfer mode is used. The concrete silo is locally transportable by truck to permit remote loading of a canister into the silo in the E-MAD Hot Bay. To move the concrete silo into the Hot Bay, a low-bed trailer and a large mobile crane, both with a 135-ton capacity, are used. The crane and low-bed trailer with tractor are positioned next to the silo storage pad, the silo handling sling attached to two of the silo lifting trunnions, and the silo lifted and placed on the trailer. The silo moves into the Hot Bay for remote canister assembly installation.

Figure B-59. Insertion of Thermocouples Into Drywell and Into Canister Through Shield Plug

With the Hot Bay shield door closed, the Hot Bay overhead crane lifts the canister assembly from the transfer pit (or lag storage pit) and places it in the concrete silo. Figure B-60 shows a canister assembly being lowered into a silo. This figure shows closed circuit TV cameras held by the two Wall-Mounted Handling System units. Following canister assembly emplacement, the lifting bail is removed and the silo cover installed as a hands-on operation. The concrete silo and canister assembly are then moved to the storage pad.

Figure B-60. Completed Canister Assembly Being Remotely Lowered Into Concrete Silo in Hot Bay

At the storage pad, the silo handling sling is attached to two lifting trunnions and the silo is off loaded onto the storage pad (see Figures B-61 and B-62). Four installation guide pins, threaded into the pad holddown plate embedments, guide the silo as it is lowered the final 16 inches. Once the silo is in place, the guide pins and handling sling are removed, and it is bolted to the pad. To complete operations, the lightning arrestors are connected to the E-MAD electrical grounding system, the cover is removed and the canister and liner thermocouples are installed. These thermocouples are routed through two flexible conduits and the two passages for these conduit at the

Figure B-61. Concrete Silo Transfer From Trailer to Storage Pad

Figure B-62. Concrete Silo With Canister Assembly Being Lowered Onto Storage Pad silo top filled with RTV silicon sealant. In addition, the remaining silo thermocouples and strain gages are connected to extension wires at the silo-mounted junction boxes, the instrumentation extension wires routed and connected to the multiplexer unit, the silo-mounted conduit and junction box fittings sealed for water tightness, and the silo cover replaced and secured.

B.2.4 FUEL ASSEMBLY INSTALLATION AND TRANSFER FOR INTERNAL TEMPERATURE MEASUREMENT TESTING

The remote operations conducted prior to the performance of Fuel Assembly Internal Temperature Measurement Tests consist of fuel assembly installation into the test stand, test stand closure lid installation and securing (all in the Hot Bay), transfer of the test stand to the West Process Cell and test stand instrumentation and power lead hookup. Prior to Hot Bay remote operations, the test stand is placed in the calorimeter pit (shielded storage pit) and the canister closure copper gasket replaced. The canister closure lid assembly is placed near the test stand on a specially constructed support stand. These operations are performed hands-on.

The pressurized water reactor (PWR) spent fuel assembly is first moved to the weld pit in its canister assembly which has been temporarily stored in the E-MAD transfer pit or lag storage pit. The canister assembly shield plug and closure lid are removed to allow fuel handling tool access to the top of the fuel assembly. The fuel handling tool is engaged in the fuel assembly using the Wall-Mounted Handling System. The fuel assembly is removed from the canister, is moved to above the test stand canister, and slowly lowered into place (see Figure B-63). The canister closure lid assembly is lifted by the Wall-Mounted Handling System, positioned above the fuel assembly, (see Figure B-64) and slowly inserted (see Figure B-65). The alignment combs used to keep the closure lid thermowells in place are removed as the lid assembly is lowered and the lower end of the thermocouple leads, the heater leads, and the flexible hose for evacuation and backfill are placed on the test stand connector platform. The lid lifting fixture is then removed and the two holddown bars and four holddown nuts in-

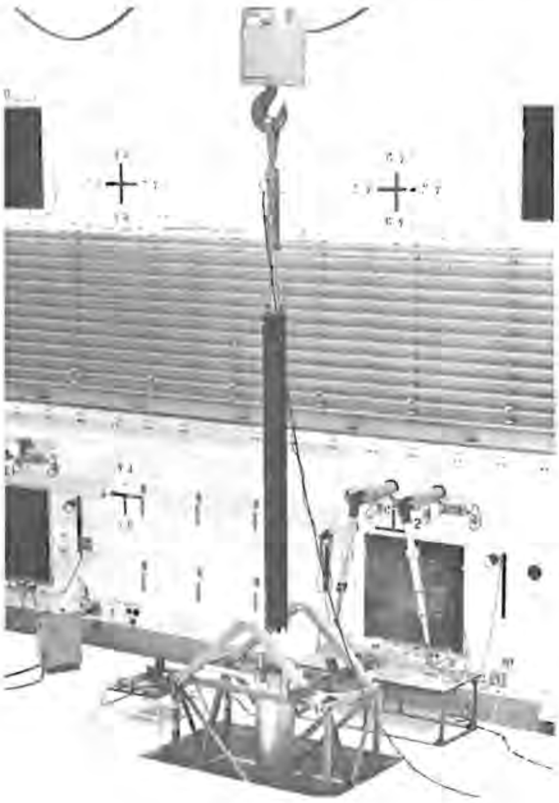

Figure B-63. Installation of PWR Spent Fuel Assembly Into Test Stand Canister in Hot Bay

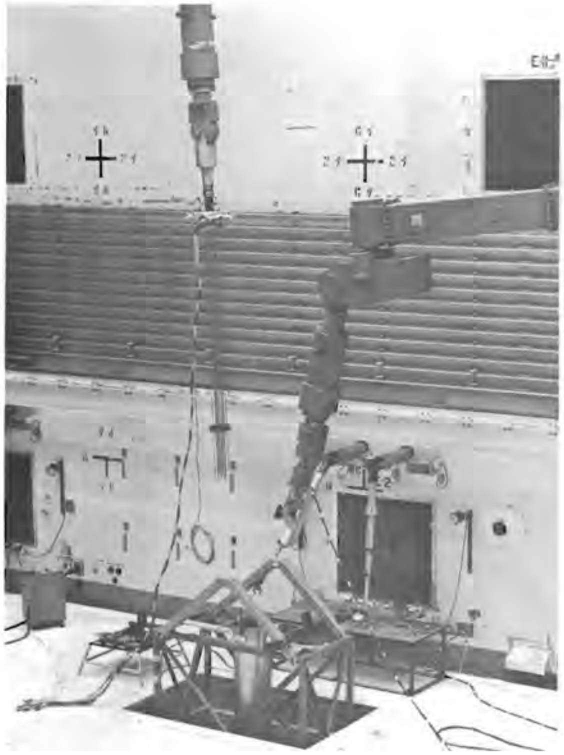

Figure B-64. Installation of Canister Lid Into Fuel Assembly in Test Canister

stalled and tightened using a specially designed torque tool (see Figure B-66). This seals the lid and canister on the copper gasket. The test stand lifting fixture crossbar is moved to its center position and secured for test assembly transport to the West Process Cell.

The completed test assembly is lifted from the calorimeter pit by the Hot Bay overhead crane (see Figure B-67), transported above the West Process Cell, and lowered through the ceiling shield plug hole. Once in the cell, the West Process Cell overhead crane moves the test assembly into testing position (see Figure B-68). The overhead manipulator rotates the seismic restraint fixture latch plates and pins them in place holding the test stand. The thermocouple lead and canister lid flexible hose quick disconnects are joined to mating connectors on the thermocouple connector panel and on the table inside the cell using

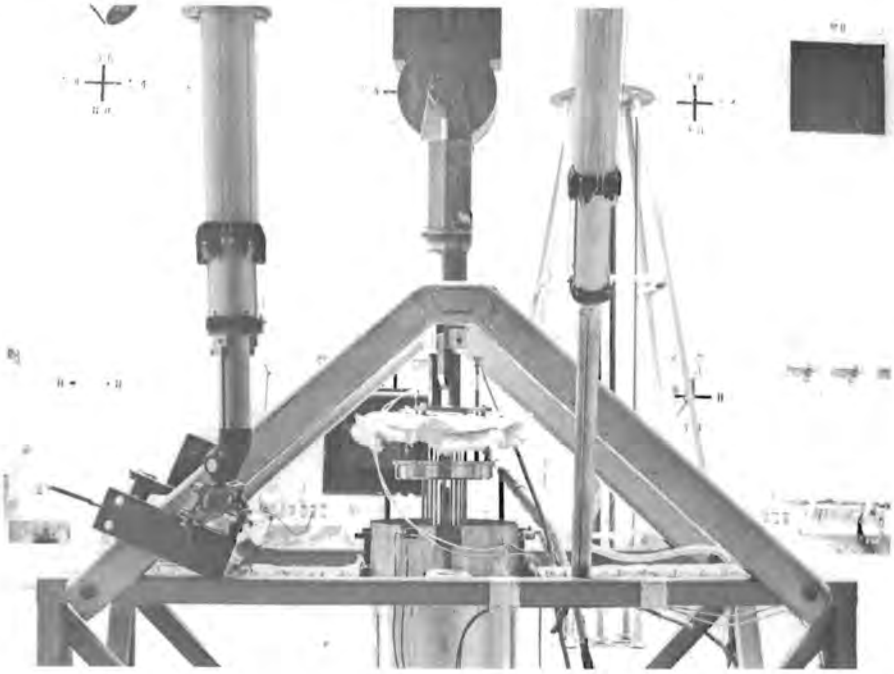

Figure B-65. Canister Lid Nearly Fully Installed

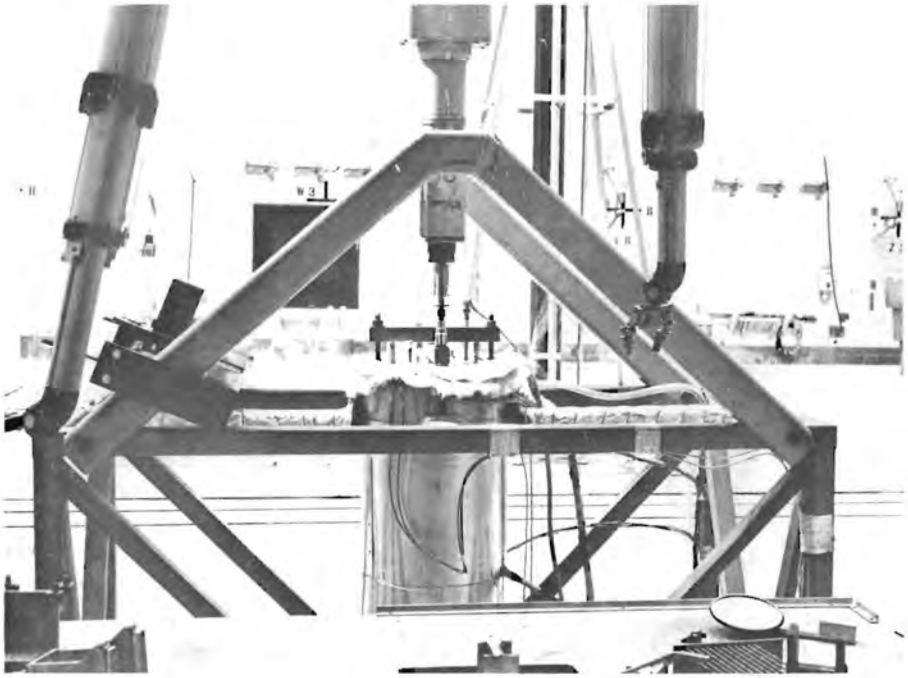

Figure B-66. Installation of Holddown Bars and Nuts

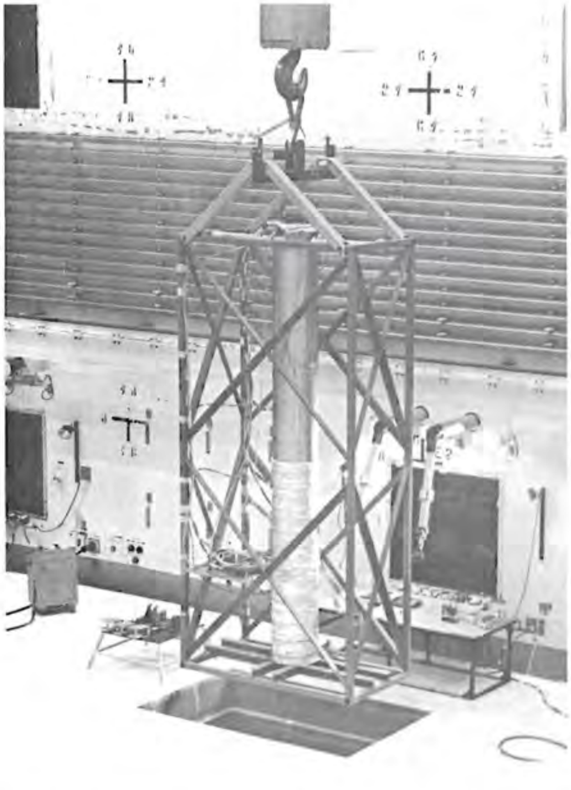

Figure B-67. Completed Test Assembly Being Lifted Prior to Transport to West Process Cell

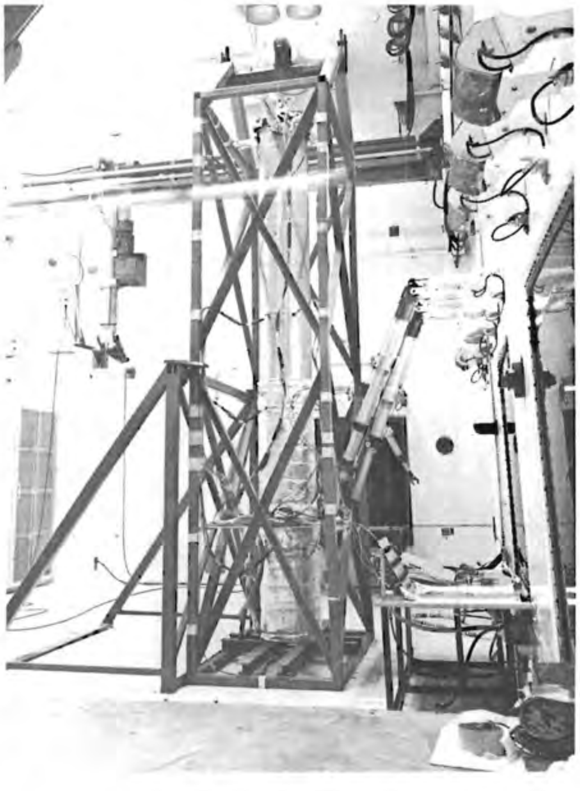

Figure B-68. Completed Test Assembly in Place in West Process Cell master-slave manipulators. The heater lead terminal strips are connected to the heater connector panel terminal strips by sliding the heater strip under the jumper bars on the panel strip and tightening the heater strip screws (see Figure B-69). A plexiglass sheet is then installed on the heater connector panel to prevent inadvertant contact with the exposed heater terminal jumper bars. Finally, an operational check of the heaters and thermocouples ensures proper operation.

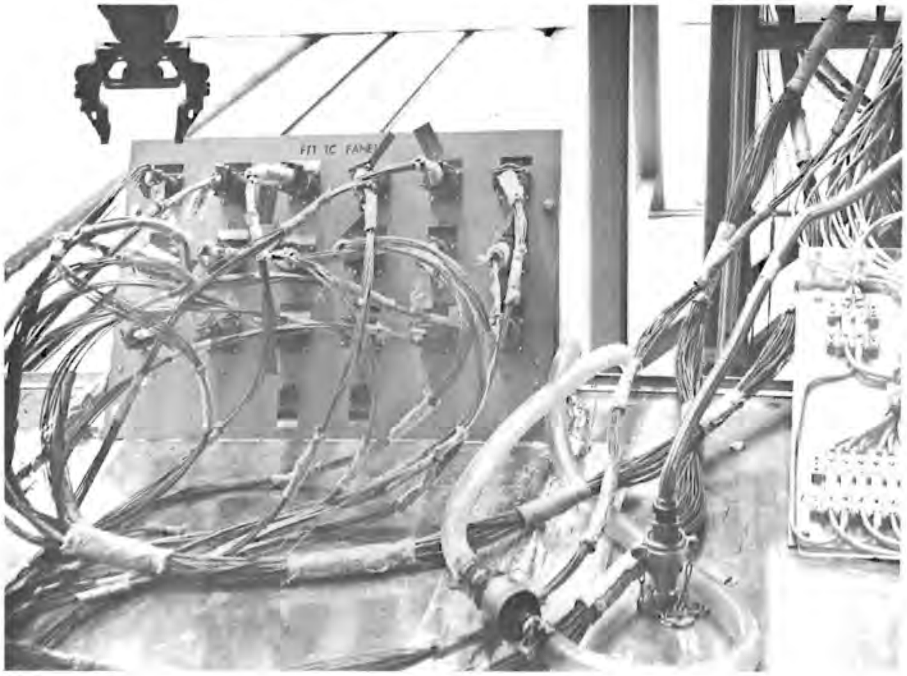

Figure B-69. Connection of Thermocouple Connectors and Heater Terminal Strip Connectors

APPENDIX C

ELECTRICALLY HEATED DRYWELL TEST DATA

Test data are provided in this Appendix for the Electrically Heated Drywell Tests. Table C-1 provides the detailed identification and the location of the test thermocouples. Figures C-1 and C-2 show these locations (Figure C-2 provides a revised thermocouple location identification for readings after February 6, 1979). Tables C-1 through C-33 provide thermocouple readings at the times and for the test operating conditions shown below:

Table No.	Date	Total Operating Hours	Operating Condition
C-2	3/6/78	–	Start of Test - 0.5 kW Power Heatup Check
C-2	3/7/78	0	Start of 3 kW Power Operation
C-3	3/8/78	24	24 Hours at 3 kW
C-3	3/9/78	48	48 Hours at 3 kW
C-4	3/10/78	72	72 Hours at 3 kW
C-4	3/11/78	96	96 Hours at 3 kW
C-5	3/12/78	120	120 Hours at 3 kW
C-5	3/15/78	192	192 Hours at 3 kW
C-6	4/1/78	599	599 Hours at 3 kW
C-6	4/15/78	935	935 Hours at 3 kW
C-7	5/1/78	1320	1320 Hours at 3 kW, Start of 1 kW Power Operation
C-7	5/2/78	1344	24 Hours at 1 kW
C-8	5/3/78	1368	48 Hours at 1kW
C-8	5/4/78	1392	72 Hours at 1kW
C-9	5/5/78	1416	96 Hours at 1 kW
C-9	5/6/78	1440	120 Hours at 1 kW
C-10	5/15/78	1656	336 Hours at 1 kW
C-10	6/1/78	2064	744 Hours at 1 kW
C-11	7/1/78	2784	1464 Hours at 1 kW
C-11	8/1/78	3528	2208 Hours at 1 kW
C-12	9/1/78	4272	2952 Hours at 1 kW
C-12	10/1/78	4997	3677 Hours at 1 kW

Table No.	Date	Total Operating Hours	Operating Condition
C-13	11/1/78	5741	4421 Hours at 1 kW
C-13	12/1/78	6461	5141 Hours at 1 kW
C-14	1/1/79	7205	5885 Hours at 1 kW
C-14	2/1/79	7949	6629 Hours at 1 kW
C-15	3/1/79	8621	7301 Hours at 1 kW
C-15	4/1/79	9365	8045 Hours at 1 kW
C-16	4/26/79	9961	8641 Hours at 1 kW, Start of 2 kW Power Operation
C-16	4/27/79	9985	24 Hours at 2 kW
C-17	4/28/79	10,009	48 Hours at 2 kW
C-17	4/29/79	10,033	72 Hours at 2 kW
C-18	4/30/79	10,057	96 Hours at 2 kW
C-18	5/1/79	10,081	120 Hours at 2 kW
C-19	5/15/79	10,417	456 Hours at 2 kW
C-19	6/1/79	10,829	868 Hours at 2 kW
C-20	7/1/79	11,549	1588 Hours at 2 kW
C-20	8/1/79	12,293	2332 Hours at 2 kW
C-21	9/1/79	13,037	3076 Hours at 2 kW
C-21	10/1/79	13,757	3796 Hours at 2 kW
C-22	11/1/79	14,501	4540 Hours at 2 kW
C-22	12/1/79	15,221	5260 Hours at 2 kW
C-23	1/1/80	15,965	6004 Hours at 2 kW
C-23	2/1/80	16,709	6748 Hours at 2 kW
C-24	3/1/80	17,405	7444 Hours at 2 kW
C-24	3/15/80	17,741	7780 Hours at 2 kW
C-25	4/1/80	18,145	8184 Hours at 2 kW, Start of 3 kW Power Operation
C-25	4/2/80	18,169	24 Hours at 3 kW
C-26	4/3/80	18,193	48 Hours at 3 kW
C-26	4/4/80	18,217	72 Hours at 3 kW
C-27	4/5/80	18,241	96 Hours at 3 kW
C-27	4/6/80	18,265	120 Hours at 3 kW
C-28	4/15/80	18,485	340 Hours at 3 kW
C-28	5/1/80	18,869	724 Hours at 3 kW

Table No.	Date	Total Operating Hours	Operating Condition
C-29	6/1/80	19,613	1468 Hours at 3 kW
C-29	7/1/80	20,333	2188 Hours at 3 kW
C-30	8/1/80	21,077	2932 Hours at 3 kW
C-30	9/2/80	21,845	3700 Hours at 3 kW
C-31	10/1/80	22,541	4396 Hours at 3 kW
C-31	10/8/80	22,709	4564 Hours at 3 kW
C-32	11/1/80	23,285	5140 Hours at 3 kW
C-32	12/1/80	24,005	5860 Hours at 3 kW
C-33	12/30/80	24,701	6556 Hours at 3 kW

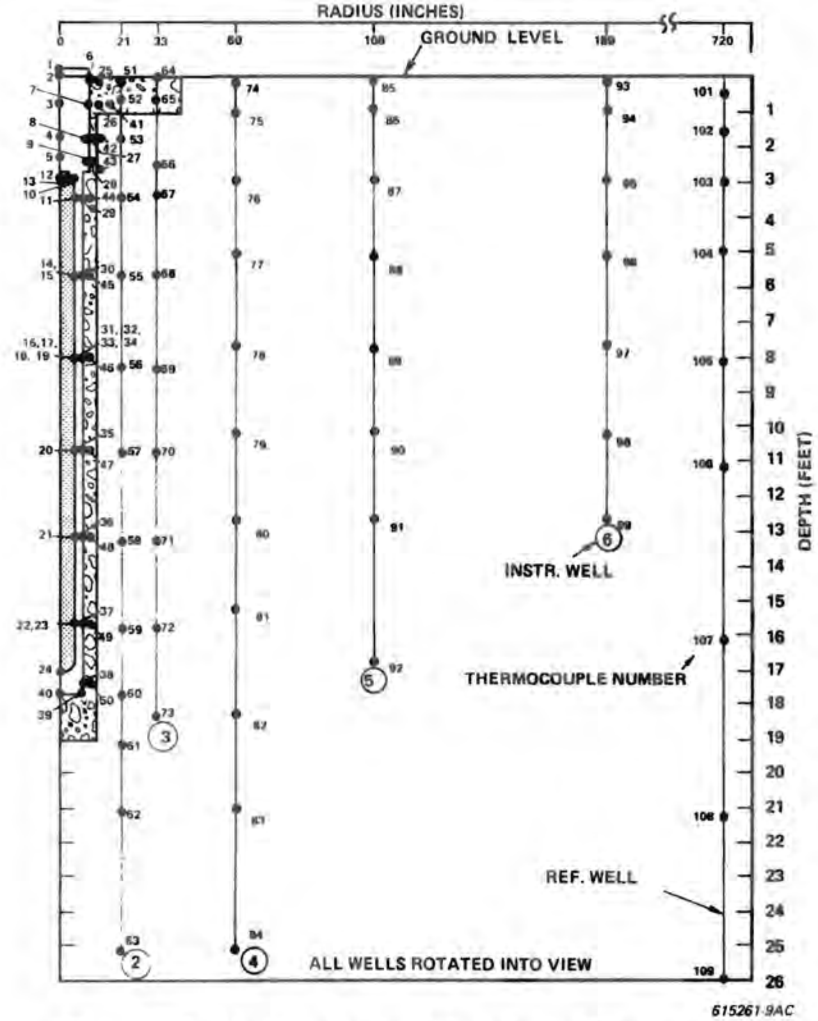

Figure C-1. Identification and Location of Thermocouples

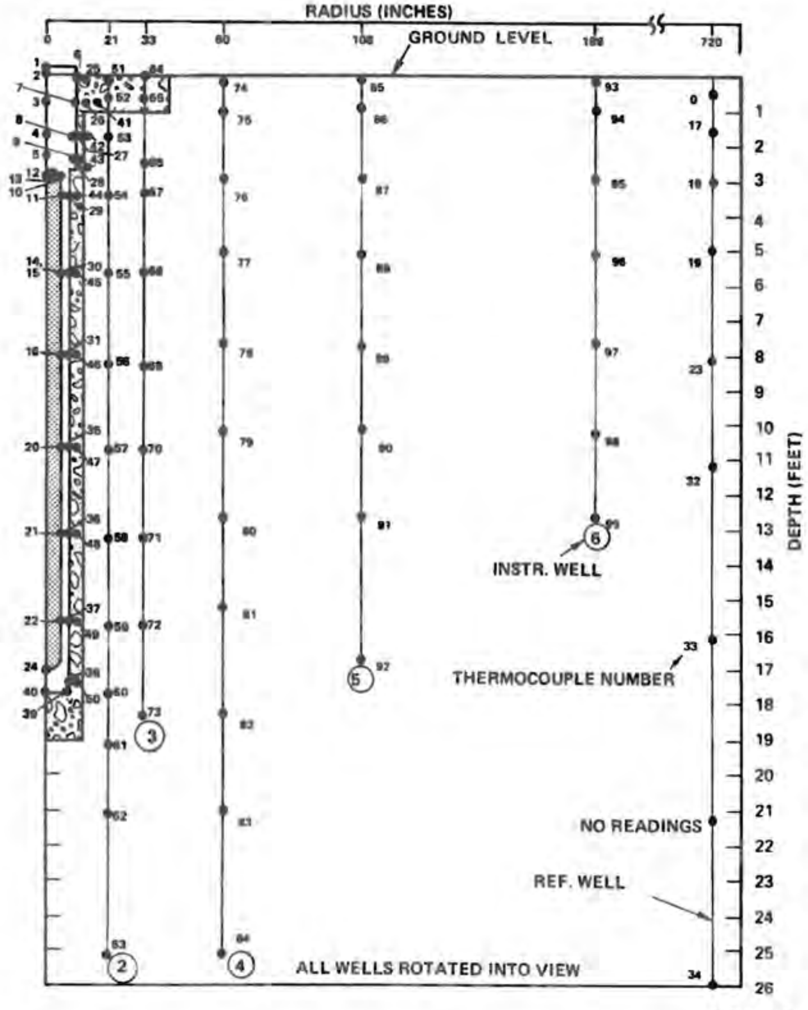

Figure C-2. Identification and Location of Thermocouples After February 6, 1979

TABLE C-1

ELECTRICALLY HEATED DRYWELL THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
001	-2.4*	0	-	On Bottom of Drywell Cover Plate
002	0.0	0.7	180	On Top Plate of Plug
003	7.9	0.7	180	7.6" Below Top of Concrete, Inside Plug
004	20.0	0.7	180	19.7" Below Top of Concrete, Inside Plug
005	28.2	0.7	180	27.9" Below Top of Concrete, Inside Plug
006	0.0	9.7	135	On Plug Liner, At Top Plate
007	7.9	9.7	135	On Plug Liner, 7.6" Below Top of Concrete
008	20.0	9.7	135	On Plug Liner, 19.7" Below Top of Concrete
009	28.2	9.7	135	On Plug Liner, 27.9" Below Top of Concrete
010	34.3	8.0	135	On Outside of Plug, 36.4" Below Top of Plug
011	39.7	8.0	135	On Outside of Plug, 41.8" Below Top of Plug
012	36.6	0	-	Center of Canister Lid
013	36.6	6.8	135	Top Rim of Canister
014	66.1	7.0	0	Side of Canister, 29.5" Below Top of Canister
015	66.1	7.0	135	Side of Canister, 29.5" Below Top of Canister
016	96.6	7.0	0	Side of Canister, 60.0" Below Top of Canister
017**	96.6	7.0	90	Side of Canister, 60.0" Below Top of Canister
018**	96.6	7.0	180	Side of Canister, 60.0" Below Top of Canister
019**	96.6	7.0	270	Side of Canister, 60.0" Below Top of Canister
020	127.0	7.0	0	Side of Canister, 90.4" Below Top of Canister
021	157.4	7.0	180	Side of Canister, 120.8" Below Top of Canister
022	187.8	7.0	180	Side of Canister, 151.2" Below Top of Canister
023**	187.8	7.0	315	Side of Canister, 151.2" Below Top of Canister
024	203.1	0	-	Center of Canister Bottom Cap
025	-1.2*	10.4	30	On Liner, 1.2" Below Top of Liner
026	6.4	10.4	0	On Liner, 8.8" Below Top of Liner
027	19.8	10.4	0	On Liner, 22.2" Below Top of Liner
028	28.2	10.4	0	On Liner, 30.6" Below Top of Liner
029	39.7	9.0	0	On Liner, 42.1" Below Top of Liner
030	65.8	9.0	0	On Liner, 68.2" Below Top of Liner
031	96.3	9.0	0	On Liner, 98.7" Below Top of Liner
032**	96.3	9.0	90	On Liner, 98.7" Below Top of Liner
033**	96.3	9.0	180	On Liner, 98.7" Below Top of Liner
034**	96.3	9.0	270	On Liner, 98.7" Below Top of Liner
035	126.7	9.0	0	On Liner, 129.1" Below Top of Liner

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* Reference ground level is 2.4" below top rim of liner

** Thermocouples at these locations disconnected from data logger on 2/6/79, data channels were reconnected to Reference Well thermocouples

TABLE C-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
036	157.1	9.0	0	On Liner, 159.5" Below Top of Liner
037	187.5	9.0	0	On Liner, 189.9" Below Top of Liner
038	207.2	9.0	0	On Liner, 209.6" Below Top of Liner
039	212.3	8.0	0	On Liner Bottom Plate
040	212.3	0	-	Center of Liner Bottom Plate
041	6.4	15.5	315	In Concrete Pad
042	19.8	15.5	315	Below Pad
043	30.2	15.5	315	Below Pad
044	39.7	10.8	315	Supported Off Liner, 42.1" Below Top of Liner
045	65.8	10.8	315	Supported Off Liner, 68.2" Below Top of Liner
046	96.3	10.8	315	Supported Off Liner, 98.7" Below Top of Liner
047	126.7	10.8	315	Supported Off Liner, 129.1" Below Top of Liner
048	157.1	10.8	315	Supported Off Liner, 159.5" Below Top of Liner
049	187.5	10.8	315	Supported Off Liner, 189.9" Below Top of Liner
050	207.2	10.8	315	Supported Off Liner, 209.6" Below Top of Liner
051	1.0	21	240	Instrumentation Well 2
052	7.6	21	240	Instrumentation Well 2
053	19.8	21	240	Instrumentation Well 2
054	40.9	21	240	Instrumentation Well 2
055	68.2	21	240	Instrumentation Well 2
056	98.6	21	240	Instrumentation Well 2
057	129.0	21	240	Instrumentation Well 2
058	159.4	21	240	Instrumentation Well 2
059	189.8	21	240	Instrumentation Well 2
060	213.2	21	240	Instrumentation Well 2
061	229.7	21	240	Instrumentation Well 2
062	253.7	21	240	Instrumentation Well 2
063	301.7	21	240	Instrumentation Well 2
064	1.0	33	210	Instrumentation Well 3
065	7.6	33	210	Instrumentation Well 3
066	30.2	33	210	Instrumentation Well 3
067	40.9	33	210	Instrumentation Well 3
068	68.2	33	210	Instrumentation Well 3
069	98.6	33	210	Instrumentation Well 3
070	129.0	33	210	Instrumentation Well 3
071	159.4	33	210	Instrumentation Well 3
072	189.8	33	210	Instrumentation Well 3
073	219.2	33	210	Instrumentation Well 3
074	1.5	60	180	Instrumentation Well 4
075	12.1	60	180	Instrumentation Well 4
076	34.9	60	180	Instrumentation Well 4

TABLE C-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
077	60.7	60	180	Instrumentation Well 4
078	91.1	60	180	Instrumentation Well 4
079	121.5	60	180	Instrumentation Well 4
080	151.9	60	180	Instrumentation Well 4
081	182.3	60	180	Instrumentation Well 4
082	219.2	60	180	Instrumentation Well 4
083	253.7	60	180	Instrumentation Well 4
084	301.7	60	180	Instrumentation Well 4
085	1.5	108	155	Instrumentation Well 5
086	12.1	108	155	Instrumentation Well 5
087	34.9	108	155	Instrumentation Well 5
088	60.7	108	155	Instrumentation Well 5
089	91.1	108	155	Instrumentation Well 5
090	121.5	108	155	Instrumentation Well 5
091	151.9	108	155	Instrumentation Well 5
092	200.1	108	155	Instrumentation Well 5
093	1.5	189	130	Instrumentation Well 6
094	12.1	189	130	Instrumentation Well 6
095	34.9	189	130	Instrumentation Well 6
096	60.7	189	130	Instrumentation Well 6
097	91.1	189	130	Instrumentation Well 6
098	121.5	189	130	Instrumentation Well 6
099	151.9	189	130	Instrumentation Well 6
101/000**	6.0	720	30	Reference Well
102/017**	18.0	720	30	Reference Well
103/018**	36.0	720	30	Reference Well
104/019**	60.0	720	30	Reference Well
105/023**	96.0	720	30	Reference Well
106/032**	132.0	720	30	Reference Well
107/033**	192.0	720	30	Reference Well
108*	252.0	720	30	Reference Well
109/034**	312.0	720	30	Reference Well

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*Thermocouple disconnected from data logger on 3/6/78 following failure of thermocouple

**Thermocouples reconnected to these data channels on 2/6/79

TABLE C-2 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 3/6/78 TIME: 3:51 p.m.
OPERATING HOURS: 0 POWER LEVEL: 1/2 kW (Heatup Check)
TOTAL OPERATING HOURS: N/A

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	53.0	054	57.9	081	68.5	109	69.8
026	55.0	053	52.4	080	66.8	108	
025	59.5	052	53.7	079	62.5	107	66.7
024	68.2	051	62.6	078	59.3	106	61.8
023	72.1	050	70.3	077	55.5	105	57.8
022	72.3	049	68.4	076	52.0	104	54.2
021	78.1	048	67.0	075	46.8	103	52.1
020	75.4	047	65.3	074	54.9	102	48.9
019	74.0	046	63.3	073	69.0	101	64.5
018	74.5	045	61.1	072	67.9	100	
017	74.0	044	57.4	071	66.3	099	63.3
016	73.6	043	54.2	070	64.4	098	60.6
015	73.2	042	52.7	069	63.5	097	57.1
014	71.7	041	52.9	068	60.0	096	54.0
013	59.4	040	69.3	067	56.5	095	51.4
012	51.7	039	68.8	066	54.2	094	48.0
011	59.4	038	68.9	065	55.3	093	58.1
010	57.7	037	68.5	064	69.8	092	67.1
009	55.8	036	67.1	063	70.9	091	64.0
008	54.7	035	65.6	062	72.0	090	61.2
007	56.8	034	64.0	061	71.5	089	58.3
006	61.3	033	64.3	060	70.9	088	55.1
005	55.2	032	64.3	059	70.3	087	52.3
004	54.2	031	63.9	058	69.3	086	48.4
003	58.6	030	61.9	057	66.9	085	54.8
002	62.5	029	57.1	056	64.4	084	70.3
001	83.5	028	54.4	055	61.5	083	70.8
000						082	70.1

DATE: 3/7/78 TIME: 10:57 a.m.
OPERATING HOURS: 0 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 0

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	58.8	054	59.7	081	68.6	109	69.8
026	55.9	053	55.0	080	68.7	108	
025	61.3	052	51.6	079	62.5	107	66.6
024	85.3	051	56.4	078	59.1	106	61.6
023	93.9	050	71.8	077	55.5	105	57.8
022	94.3	049	74.1	076	51.8	104	54.1
021	109.2	048	77.2	075	47.6	103	51.9
020	114.0	047	77.4	074	46.0	102	49.4
019	115.2	046	76.3	073	69.1	101	57.7
018	116.4	045	75.0	072	67.9	100	
017	116.4	044	68.7	071	66.2	099	63.3
016	116.3	043	57.8	070	64.3	098	60.6
015	117.7	042	55.4	069	63.4	097	57.2
014	117.6	041	51.6	068	59.9	096	53.9
013	101.6	040	71.5	067	56.3	095	51.3
012	114.3	039	71.3	066	54.5	094	48.4
011	91.9	038	71.9	065	50.5	093	48.3
010	85.1	037	76.4	064	58.6	092	67.1
009	73.5	036	80.4	063	70.8	091	64.2
008	63.5	035	81.3	062	71.6	090	61.4
007	59.4	034	80.7	061	71.3	089	58.5
006	64.0	033	81.7	060	70.5	088	55.0
005	67.0	032	81.4	059	70.7	087	52.2
004	60.5	031	80.7	058	70.2	086	48.9
003	60.0	030	79.2	057	68.5	085	47.5
002	67.2	029	71.5	056	66.1	084	70.3
001	97.8	028	64.1	055	63.5	083	70.8
000						082	70.1

TABLE C-3 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 3/8/78 TIME: 11:07 a.m.
OPERATING HOURS: 24 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 24

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	82.5	054	75.1	081	68.4	109	69.6
026	67.5	053	61.7	080	68.6	108	
025	68.5	052	55.8	079	62.5	107	66.4
024	157.8	051	61.8	078	59.2	106	61.4
023	216.3	050	83.5	077	55.3	105	57.8
022	216.0	049	109.3	076	51.9	104	54.1
021	285.3	048	133.2	075	48.5	103	52.2
020	301.3	047	144.0	074	49.3	102	51.0
019	299.2	046	143.6	073	68.9	101	60.3
018	306.6	045	142.1	072	68.4	100	
017	306.6	044	116.7	071	67.3	099	63.3
016	304.6	043	75.0	070	65.7	098	60.8
015	310.5	042	66.5	069	64.8	097	57.4
014	305.9	041	57.6	068	61.6	096	54.2
013	218.5	040	83.6	067	57.9	095	51.5
012	262.9	039	83.6	066	58.3	094	49.3
011	198.7	038	89.4	065	52.1	093	51.1
010	173.3	037	122.7	064	60.8	092	67.1
009	132.1	036	151.2	063	70.7	091	64.2
008	98.8	035	164.7	062	71.5	090	61.4
007	77.7	034	165.5	061	71.0	089	58.5
006	75.7	033	168.4	060	71.5	088	55.2
005	119.0	032	167.7	059	77.3	087	52.2
004	94.5	031	165.5	058	83.8	086	49.3
003	80.3	030	160.8	057	85.5	085	49.9
002	80.1	029	130.0	056	84.0	084	70.3
001	102.1	028	102.0	055	81.5	083	70.6
000						082	70.0

DATE: 3/9/78 TIME: 11:07 a.m.
OPERATING HOURS: 48 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 48

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	96.3	054	92.0	081	68.1	109	69.5
026	77.5	053	70.8	080	66.3	108	
025	72.7	052	60.8	079	62.2	107	66.3
024	174.3	051	58.3	078	59.0	106	61.3
023	235.0	050	92.8	077	55.1	105	57.7
022	234.3	049	127.5	076	52.0	104	54.0
021	308.4	048	161.8	075	49.0	103	52.6
020	325.0	047	175.5	074	48.5	102	51.9
019	321.5	046	174.1	073	88.8	101	53.7
018	328.9	045	169.7	072	70.7	100	
017	328.9	044	138.8	071	72.4	099	63.1
016	326.4	043	89.9	070	72.6	098	60.4
015	331.3	042	77.9	069	71.7	097	57.0
014	326.1	041	64.5	068	68.2	096	53.8
013	238.9	040	92.8	067	83.2	095	51.5
012	281.7	039	92.9	066	60.3	094	50.2
011	220.8	038	100.4	065	54.2	093	50.4
010	194.5	037	141.8	064	57.0	092	66.9
009	153.1	036	179.7	063	70.4	091	63.9
008	118.2	035	194.6	062	71.0	090	61.2
007	92.1	034	194.8	061	71.1	089	58.4
006	84.8	033	198.1	060	74.1	088	55.0
005	143.2	032	197.5	059	87.6	087	52.1
004	115.5	031	194.8	058	102.2	086	49.8
003	94.6	030	187.1	057	109.3	085	49.7
002	87.7	029	151.1	056	107.7	084	70.1
001	76.0	028	120.7	055	104.2	083	70.2
000						082	69.6

TABLE C-4 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 3/10/78 TIME: 11:10 a.m.
OPERATING HOURS: 72 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 72

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	107.2	054	105.4	081	68.4	109	69.3
026	83.7	053	77.8	080	67.0	108	
025	82.8	052	63.4	079	62.9	107	66.8
024	184.9	051	65.7	078	59.8	106	61.2
023	240.3	050	100.7	077	55.8	105	57.5
022	245.5	049	140.8	076	52.8	104	54.0
021	319.6	048	179.3	075	48.9	103	52.8
020	334.3	047	198.5	074	53.6	102	51.8
019	331.6	046	200.0	073	69.9	101	62.6
018	338.9	045	187.9	072	74.9	100	
017	338.9	044	152.3	071	80.2	099	63.2
016	338.4	043	100.1	070	82.8	098	60.6
015	340.2	042	86.3	069	91.8	097	57.2
014	336.1	041	67.8	068	77.5	096	54.1
013	248.7	040	100.2	067	69.9	095	51.9
012	290.5	039	100.1	066	65.6	094	50.4
011	231.3	038	109.1	065	55.1	093	52.6
010	205.4	037	155.3	064	60.0	092	67.1
009	164.1	036	190.3	063	70.4	091	64.1
008	128.5	035	207.6	062	71.1	090	61.3
007	101.0	034	208.7	061	72.0	089	58.5
006	96.0	033	213.1	060	77.6	088	55.1
005	154.9	032	209.9	059	97.1	087	52.3
004	128.1	031	207.5	058	118.2	086	50.2
003	103.2	030	204.0	057	127.9	085	51.8
002	100.6	029	163.8	056	126.5	084	70.1
001	120.9	028	131.5	055	121.8	083	70.3
000						082	69.7

DATE: 3/11/78 TIME: 11:10 a.m.
OPERATING HOURS: 96 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 96

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	115.4	054	114.9	081	68.7	109	69.2
026	88.3	053	83.2	080	67.8	108	
025	79.5	052	67.5	079	64.2	107	65.8
024	192.3	051	57.0	078	61.0	106	61.1
023	255.0	050	108.3	077	56.8	105	57.4
022	253.9	049	150.4	076	53.6	104	54.1
021	328.3	048	195.2	075	49.8	103	53.1
020	343.8	047	205.7	074	47.4	102	52.4
019	338.9	046	205.1	073	70.6	101	49.9
018	348.0	045	198.2	072	79.0	100	
017	346.7	044	165.1	071	87.3	099	62.8
016	343.7	043	107.8	070	92.2	098	60.3
015	346.0	042	92.5	069	91.6	097	56.9
014	343.5	041	72.8	068	85.9	096	53.8
013	255.8	040	105.8	067	75.9	095	51.8
012	297.2	039	105.9	066	70.2	094	51.0
011	237.6	038	115.4	065	57.0	093	49.1
010	212.6	037	164.3	064	52.8	092	66.7
009	171.6	036	205.7	063	70.0	091	63.7
008	130.0	035	216.4	062	70.7	090	61.0
007	105.2	034	214.9	061	72.7	089	58.2
006	93.2	033	223.9	060	80.5	088	54.9
005	163.0	032	218.6	059	104.9	087	52.3
004	133.8	031	214.9	058	129.1	086	51.1
003	107.0	030	206.7	057	139.1	085	49.2
002	93.5	029	188.8	056	139.6	084	70.0
001	64.9	028	143.4	055	132.8	083	69.8
000						082	69.4

TABLE C-5 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 3/12/78 TIME: 11:10 a.m.
OPERATING HOURS: 120 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 120

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	118.6	054	122.2	081	69.6	109	69.2
026	85.0	053	83.6	080	69.5	108	
025	75.2	052	62.0	079	66.4	107	65.9
024	197.1	051	50.1	078	63.2	106	61.2
023	261.0	050	111.8	077	58.7	105	57.4
022	259.7	049	160.0	076	54.8	104	54.2
021	331.2	048	204.4	075	46.6	103	52.4
020	350.4	047	205.5	074	44.5	102	44.3
019	344.2	046	205.2	073	72.1	101	45.2
018	354.4	045	202.5	072	83.4	100	
017	351.4	044	171.1	071	94.3	099	62.8
016	348.1	043	113.5	070	100.4	098	60.3
015	348.4	042	95.7	069	101.4	097	56.9
014	345.6	041	68.5	068	94.3	096	53.8
013	256.7	040	111.0	067	81.6	095	51.9
012	294.1	039	111.0	066	73.6	094	47.6
011	240.3	038	121.0	065	52.3	093	45.8
010	213.3	037	172.8	064	47.3	092	66.6
009	176.0	036	206.4	063	70.0	091	63.6
008	139.5	035	227.1	062	70.7	090	60.9
007	104.8	034	225.4	061	73.8	089	58.2
006	91.1	033	234.1	060	83.6	088	54.9
005	170.7	032	227.7	059	111.9	087	52.3
004	136.8	031	225.0	058	137.7	086	47.8
003	105.0	030	207.5	057	147.6	085	44.9
002	93.5	029	193.2	056	150.1	084	69.9
001	63.9	028	149.7	055	141.2	083	69.6
000						082	69.5

DATE: 3/15/78 TIME: 11:10 a.m.
OPERATING HOURS: 192 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 192

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	131.5	054	135.5	081	74.3	109	69.0
026	100.0	053	95.3	080	76.6	108	
025	92.5	052	73.8	079	75.8	107	65.5
024	205.4	051	71.0	078	72.5	106	60.7
023	268.2	050	124.3	077	66.0	105	57.1
022	266.7	049	177.8	076	58.7	104	53.6
021	336.2	048	208.4	075	49.7	103	51.3
020	363.4	047	218.0	074	52.9	102	50.1
019	357.2	046	218.5	073	77.6	101	64.9
018	365.0	045	206.1	072	97.2	100	
017	360.9	044	185.2	071	110.8	099	62.9
016	358.9	043	125.0	070	118.8	098	60.4
015	358.4	042	106.7	069	122.4	097	57.2
014	352.1	041	79.9	068	113.8	096	54.2
013	256.2	040	122.7	067	94.2	095	51.3
012	289.2	039	123.2	066	83.5	094	48.8
011	245.2	038	133.6	065	61.0	093	51.6
010	220.8	037	186.6	064	61.2	092	56.8
009	185.1	036	212.6	063	70.0	091	64.1
008	153.8	035	252.1	062	71.6	090	61.5
007	122.1	034	249.3	061	78.1	089	58.7
006	113.2	033	254.8	060	93.2	088	55.3
005	185.5	032	248.1	059	135.2	087	52.1
004	157.5	031	246.3	058	153.3	086	48.9
003	122.5	030	221.4	057	163.3	085	51.2
002	117.1	029	200.8	056	168.1	084	69.7
001	125.2	028	160.9	055	158.4	083	69.9
000						082	71.0

TABLE C-6 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/1/78 TIME: 10:00 a.m.
OPERATING HOURS: 599 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 599

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	150.6	054	166.6	081	97.7	109	68.1
026	113.7	053	118.1	080	105.1	108	
025	104.1	052	86.3	079	106.7	107	64.2
024	232.9	051	68.9	078	104.5	106	60.1
023	296.0	050	151.1	077	96.2	105	58.2
022	295.5	049	204.1	076	83.9	104	58.7
021	401.1	048	258.1	075	63.3	103	59.0
020	440.0	047	316.0	074	53.5	102	53.7
019	424.5	046	304.7	073	99.1	101	54.6
018	435.3	045	274.0	072	128.9	100	
017	433.9	044	204.9	071	145.2	099	62.2
016	427.3	043	150.1	070	149.7	098	60.2
015	422.6	042	130.2	069	153.5	097	58.1
014	409.0	041	93.6	068	147.6	096	58.2
013	285.7	040	149.2	067	126.5	095	59.5
012	322.8	039	149.0	066	111.7	094	56.3
011	280.9	038	160.3	065	70.1	093	51.6
010	249.5	037	206.3	064	60.6	092	70.6
009	204.2	036	294.4	063	70.5	091	71.7
008	179.0	035	351.3	062	80.5	090	70.8
007	140.1	034	339.1	061	97.2	089	68.7
006	122.0	033	345.8	060	119.2	088	66.4
005	204.0	032	346.0	059	163.5	087	65.0
004	180.9	031	338.0	058	184.9	086	58.5
003	136.5	030	305.9	057	186.9	085	52.2
002	123.8	029	220.2	056	189.4	084	69.6
001	96.6	028	180.0	055	187.3	083	73.9
000						082	83.6

DATE: 4/15/78 TIME: 10:00 a.m.
OPERATING HOURS: 935 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 935

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	164.8	054	173.7	081	108.4	109	67.8
026	128.9	053	130.5	080	116.0	108	
025	115.7	052	99.2	079	117.2	107	63.7
024	250.0	051	78.9	078	114.3	106	60.6
023	316.2	050	166.2	077	103.8	105	59.1
022	315.6	049	207.4	076	90.5	104	58.7
021	444.5	048	325.7	075	74.0	103	61.2
020	481.7	047	372.2	074	63.9	102	62.5
019	464.2	046	358.9	073	110.6	101	67.3
018	475.3	045	323.4	072	141.8	100	
017	473.1	044	223.5	071	155.4	099	63.3
016	466.8	043	161.8	070	158.3	098	62.0
015	460.7	042	142.8	069	160.8	097	50.2
014	443.5	041	107.9	068	153.6	096	59.3
013	309.6	040	163.6	067	133.5	095	60.9
012	349.7	039	163.6	066	120.5	094	62.7
011	306.9	038	175.0	065	80.8	093	59.7
010	270.7	037	220.3	064	68.2	092	76.3
009	216.3	036	359.0	063	72.7	091	79.3
008	192.2	035	406.2	062	87.6	090	78.2
007	160.5	034	391.7	061	107.9	089	76.7
006	137.8	033	397.5	060	133.2	088	72.1
005	206.8	032	397.2	059	178.6	087	69.2
004	198.8	031	389.9	058	191.9	086	66.3
003	155.3	030	353.8	057	222.8	085	61.6
002	135.9	029	247.5	056	215.2	084	71.1
001	100.7	028	193.8	055	190.2	083	79.0
000						082	92.3

TABLE C-7 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 5/1/78 TIME: 11:00 a.m.
OPERATING HOURS: 1320 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 1320

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	171.6	054	175.7	081	115.8	109	66.8
026	130.1	053	133.2	080	123.0	108	
025	113.4	052	98.9	079	123.7	107	63.1
024	266.6	051	69.7	078	121.2	106	60.8
023	340.7	050	180.9	077	111.0	105	60.5
022	339.4	049	220.8	076	96.0	104	61.6
021	481.5	048	374.6	075	74.1	103	63.4
020	515.8	047	415.8	074	56.4	102	61.2
019	496.3	046	402.8	073	120.2	101	55.2
018	508.0	045	365.3	072	149.7	100	
017	506.7	044	256.5	071	161.4	099	65.0
016	499.8	043	166.5	070	162.6	098	64.2
015	494.2	042	146.5	069	165.0	097	63.2
014	473.5	041	108.0	068	158.9	096	63.4
013	334.6	040	176.0	067	138.1	095	64.3
012	372.7	039	176.3	066	124.0	094	61.3
011	335.7	038	187.6	065	79.4	093	54.4
010	298.7	037	243.9	064	61.0	092	81.5
009	231.5	036	407.5	063	75.5	091	85.4
008	197.7	035	450.5	062	94.2	090	85.5
007	166.4	034	433.5	061	117.9	089	83.4
006	140.4	033	439.5	060	146.0	088	79.0
005	216.6	032	440.5	059	186.5	087	74.3
004	204.0	031	433.1	058	204.2	086	66.0
003	160.2	030	395.0	057	267.3	085	55.9
002	140.8	029	280.9	056	259.5	084	73.2
001	88.0	028	208.3	055	204.0	083	84.1
000						082	99.5

DATE: 5/2/78 TIME: 11:00 a.m.
OPERATING HOURS: 24 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 1344

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	159.0	054	169.4	081	116.5	109	67.0
026	124.0	053	129.6	080	123.6	108	
025	116.8	052	98.8	079	124.3	107	63.3
024	215.1	051	88.0	078	121.7	106	61.1
023	259.8	050	170.3	077	111.7	105	60.7
022	259.1	049	207.8	076	95.8	104	61.8
021	355.4	048	310.5	075	73.5	103	62.9
020	387.4	047	352.2	074	70.2	102	60.1
019	375.5	046	341.6	073	120.9	101	75.2
018	379.7	045	306.0	072	149.2	100	
017	379.0	044	223.5	071	161.4	099	65.4
016	377.1	043	157.8	070	162.7	098	64.6
015	364.6	042	140.7	069	165.0	097	63.7
014	354.9	041	106.5	068	158.6	096	63.9
013	262.3	040	166.8	067	137.3	095	64.1
012	284.6	039	166.9	066	122.9	094	60.6
011	261.5	038	174.6	065	80.7	093	61.5
010	240.0	037	217.4	064	77.2	092	82.1
009	205.1	036	322.7	063	75.9	091	86.1
008	182.2	035	362.1	062	94.8	090	86.2
007	149.5	034	350.3	061	118.4	089	84.1
006	136.6	033	351.4	060	143.9	088	79.6
005	199.7	032	352.2	059	178.7	087	74.1
004	178.9	031	350.7	058	200.2	086	65.2
003	144.2	030	317.4	057	262.7	085	64.4
002	136.3	029	235.4	056	254.6	084	73.4
001	135.8	028	187.0	055	200.4	083	84.7
000						082	100.1

TABLE C-8 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 5/3/78
TIME: 11:00 a.m.
OPERATING HOURS: 48
POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 1368

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	149.3	054	161.6	081	117.0	109	67.1
026	117.0	053	126.3	080	124.1	108	
025	108.8	052	99.2	079	124.9	107	63.4
024	205.0	051	91.1	078	122.2	106	61.2
023	245.6	050	163.3	077	112.2	105	60.9
022	245.2	049	199.1	076	95.9	104	61.9
021	326.8	048	280.0	075	78.1	103	62.9
020	356.4	047	320.0	074	76.7	102	64.6
019	344.9	046	309.8	073	120.2	101	80.1
018	349.4	045	276.7	072	146.2	100	
017	349.4	044	207.5	071	158.9	099	65.8
016	346.8	043	150.6	070	160.9	098	65.0
015	337.0	042	135.3	069	163.0	097	64.2
014	327.5	041	104.4	068	155.7	096	64.2
013	246.5	040	160.8	067	134.5	095	64.1
012	267.5	039	160.9	066	121.0	094	64.7
011	244.6	038	167.9	065	85.0	093	67.8
010	225.2	037	206.8	064	82.8	092	82.6
009	194.4	036	291.7	063	76.4	091	86.7
008	167.8	035	328.4	062	95.4	090	86.8
007	136.2	034	317.9	061	118.3	089	84.7
006	125.9	033	318.3	060	140.1	088	80.0
005	185.9	032	318.8	059	171.2	087	74.3
004	160.8	031	318.0	058	192.5	086	69.5
003	130.5	030	287.3	057	248.6	085	71.1
002	126.0	029	218.1	056	240.9	084	73.7
001	133.1	028	176.4	055	191.0	083	85.4
000						082	100.8

DATE: 5/4/78
TIME: 11:00 a.m.
OPERATING HOURS: 72
POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 1392

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	144.2	054	155.5	081	116.7	109	67.1
026	113.6	053	123.7	080	123.7	108	
025	103.0	052	99.7	079	124.5	107	63.3
024	198.5	051	88.9	078	121.9	106	61.2
023	236.7	050	158.1	077	111.7	105	61.0
022	236.1	049	191.5	076	96.1	104	61.9
021	311.3	048	262.1	075	80.4	103	63.6
020	338.5	047	298.6	074	76.8	102	67.1
019	328.9	046	289.3	073	118.7	101	77.6
018	332.8	045	259.2	072	142.7	100	
017	332.4	044	197.6	071	155.3	099	65.8
016	329.9	043	145.5	070	157.8	098	64.9
015	321.0	042	131.5	069	159.7	097	64.2
014	313.2	041	103.9	068	151.8	096	64.2
013	237.6	040	156.1	067	131.3	095	64.5
012	258.2	039	156.2	066	119.2	094	67.0
011	233.6	038	162.6	065	86.8	093	68.4
010	215.8	037	198.7	064	82.2	092	82.7
009	186.8	036	273.6	063	76.4	091	86.8
008	159.8	035	307.4	062	95.4	090	86.9
007	130.5	034	298.0	061	116.9	089	84.8
006	119.1	033	298.3	060	136.5	088	80.1
005	177.2	032	298.5	059	165.1	087	74.8
004	153.3	031	298.0	058	185.3	086	72.0
003	125.2	030	270.0	057	235.0	085	72.2
002	118.6	029	207.8	056	228.2	084	73.6
001	117.2	028	169.8	055	182.9	083	85.4
000						082	100.7

TABLE C-9 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 5/5/78 TIME: 11:00 a.m.
OPERATING HOURS: 96 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 1416

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	138.5	054	151.3	081	116.2	109	67.1
026	105.2	053	126.6	080	123.3	108	
025	88.3	052	94.8	079	124.0	107	63.4
024	193.8	051	77.2	078	121.4	106	61.3
023	230.2	050	154.6	077	111.0	105	61.2
022	230.1	049	185.7	076	96.6	104	62.2
021	300.9	048	250.2	075	80.6	103	64.6
020	326.7	047	283.2	074	66.3	102	67.9
019	317.4	046	275.2	073	117.2	101	68.9
018	320.9	045	247.8	072	139.7	100	
017	321.0	044	191.1	071	152.0	099	65.9
016	318.8	043	141.5	070	154.6	098	65.2
015	310.2	042	128.0	069	156.4	097	64.3
014	303.7	041	97.8	068	148.3	096	64.3
013	231.9	040	152.9	067	128.8	095	65.2
012	252.5	039	152.6	066	117.8	094	67.7
011	227.1	038	158.8	065	82.4	093	61.6
010	210.4	037	192.5	064	68.8	092	82.9
009	180.8	036	261.3	063	78.5	091	87.0
008	151.6	035	292.6	062	95.6	090	87.2
007	120.8	034	284.1	061	115.8	089	85.2
006	105.9	033	284.5	060	133.3	088	80.5
005	169.2	032	285.0	059	160.5	087	75.8
004	144.7	031	284.3	058	179.7	086	72.9
003	114.6	030	258.7	057	224.1	085	65.1
002	105.1	029	200.8	056	218.2	084	74.0
001	94.8	028	165.8	055	176.7	083	85.6
000						082	100.7

DATE: 5/6/78 TIME: 11:00 a.m.
OPERATING HOURS: 120 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 1440

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	131.3	054	147.6	081	115.5	109	67.1
026	97.7	053	114.5	080	122.6	108	
025	83.9	052	86.8	079	123.2	107	63.4
024	189.9	051	74.3	078	120.6	106	61.5
023	224.9	050	151.6	077	110.3	105	61.2
022	224.7	049	181.3	076	96.4	104	62.4
021	292.9	048	241.3	075	76.0	103	65.0
020	317.8	047	271.8	074	65.4	102	64.0
019	308.3	046	264.6	073	115.8	101	67.2
018	312.5	045	239.3	072	137.1	100	
017	312.2	044	185.2	071	148.9	099	66.1
016	309.9	043	136.4	070	151.7	098	65.5
015	302.3	042	122.0	069	153.3	097	64.5
014	295.7	041	90.3	068	145.3	096	64.7
013	225.2	040	150.1	067	126.3	095	65.7
012	246.3	039	149.8	066	114.8	094	63.8
011	220.2	038	155.7	065	76.0	093	58.9
010	203.9	037	187.6	064	68.8	092	83.2
009	173.7	036	252.2	063	76.7	091	87.2
008	143.7	035	281.4	062	95.6	090	87.5
007	113.3	034	273.8	061	114.7	089	85.5
006	100.7	033	274.2	060	131.5	088	81.0
005	160.3	032	274.6	059	156.9	087	76.4
004	135.7	031	273.8	058	175.1	086	68.8
003	107.2	030	250.1	057	215.5	085	62.1
002	100.9	029	194.4	056	210.2	084	74.2
001	99.4	028	159.6	055	171.8	083	85.7
000						082	100.6

TABLE C-10 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 5/15/78 TIME: 11:00 a.m.
OPERATING HOURS: 336 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 1656

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	127.8	054	133.7	081	109.0	109	66.9
026	106.0	053	112.2	080	114.2	108	
025	101.1	052	94.4	079	114.0	107	63.4
024	172.0	051	87.2	078	111.4	106	61.9
023	202.6	050	136.2	077	103.5	105	62.3
022	202.5	049	161.1	076	94.5	104	64.9
021	263.0	048	208.3	075	84.7	103	69.7
020	285.2	047	231.6	074	78.5	102	74.5
019	278.4	046	227.9	073	107.4	101	81.1
018	281.8	045	209.9	072	123.3	100	
017	281.1	044	167.1	071	132.2	099	67.7
016	280.4	043	128.3	070	133.8	098	67.2
015	274.2	042	118.3	069	135.2	097	66.7
014	270.0	041	98.9	068	126.9	096	67.6
013	208.2	040	135.3	067	115.6	095	71.1
012	228.4	039	135.3	066	108.7	094	78.6
011	201.8	038	140.2	065	86.3	093	74.6
010	187.3	037	166.5	064	82.5	092	84.6
009	161.5	036	218.4	063	76.1	091	88.5
008	137.7	035	242.5	062	93.6	090	88.6
007	115.6	034	238.1	061	107.0	089	86.8
006	107.2	033	238.8	060	119.2	088	83.1
005	150.9	032	238.7	059	139.7	087	81.2
004	132.3	031	237.7	058	153.1	086	80.2
003	112.2	030	220.2	057	181.6	085	77.0
002	106.6	029	175.5	056	178.1	084	75.3
001	107.9	028	149.3	055	150.9	083	86.1
000						082	97.7

DATE: 6/1/78 TIME: 11:00 a.m.
OPERATING HOURS: 744 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 2064

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	125.9	054	129.0	081	101.7	109	66.5
026	100.0	053	110.6	080	105.5	108	
025	103.0	052	94.4	079	105.1	107	63.6
024	161.7	051	93.9	078	103.6	106	63.2
023	190.8	050	126.5	077	98.8	105	65.0
022	190.7	049	149.5	076	93.1	104	68.7
021	249.7	048	191.8	075	85.2	103	73.7
020	273.6	047	217.3	074	85.0	102	77.1
019	268.7	046	215.3	073	100.1	101	86.8
018	272.4	045	199.9	072	113.6	100	
017	272.1	044	161.1	071	121.5	099	70.0
016	270.9	043	125.6	070	122.3	098	70.2
015	266.1	042	116.0	069	124.9	097	70.9
014	262.1	041	97.8	068	121.0	096	72.8
013	202.7	040	125.6	067	111.6	095	76.5
012	222.6	039	125.9	066	106.1	094	79.3
011	195.8	038	130.4	065	87.0	093	78.5
010	181.9	037	154.5	064	91.2	092	83.7
009	156.8	036	201.9	063	78.5	091	86.9
008	134.3	035	228.7	062	89.9	090	87.3
007	114.9	034	226.0	061	100.2	089	86.6
006	110.3	033	227.1	060	110.3	088	84.5
005	146.9	032	226.7	059	129.2	087	83.9
004	129.3	031	225.5	058	141.5	086	82.2
003	112.1	030	210.3	057	168.3	085	81.4
002	111.3	029	169.4	056	165.6	084	76.0
001	127.6	028	146.5	055	142.1	083	84.7
000						082	93.1

TABLE C-11 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 7/1/78 TIME: 11:00 a.m.
OPERATING HOURS: 1464 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 2784

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	129.3	054	131.3	081	97.8	109	66.0
026	109.8	053	113.5	080	101.9	108	
025	108.6	052	098.1	079	102.4	107	64.7
024	156.3	051	096.8	078	103.3	106	66.7
023	185.2	050	121.6	077	101.6	105	70.9
022	184.6	049	144.2	076	96.7	104	76.3
021	243.6	048	182.3	075	88.9	103	80.1
020	270.9	047	214.1	074	88.0	102	81.5
019	268.1	046	213.8	073	95.8	101	90.1
018	271.9	045	199.9	072	108.8	100	
017	271.9	044	162.3	071	117.6	099	73.0
016	270.4	043	128.3	070	118.6	098	74.7
015	267.6	042	119.0	069	123.4	097	77.3
014	262.6	041	102.0	068	122.4	096	80.8
013	204.3	040	120.5	067	114.4	095	83.7
012	223.7	039	121.0	066	109.0	094	84.7
011	197.6	038	125.3	065	90.6	093	82.3
010	183.2	037	148.8	064	94.0	092	82.4
009	159.1	036	193.3	063	77.8	091	86.0
008	137.2	035	225.7	062	86.9	090	87.6
007	119.1	034	224.5	061	95.9	089	89.0
006	114.3	033	226.1	060	105.5	088	89.5
005	149.7	032	225.6	059	124.0	087	89.2
004	132.5	031	224.5	058	138.6	086	86.2
003	116.7	030	210.6	057	165.5	085	84.6
002	115.4	029	171.4	056	164.3	084	75.7
001	132.5	028	149.0	055	143.1	083	82.7
000						082	89.7

DATE: 8/1/78 TIME: 11:00 a.m.
OPERATING HOURS: 2208 POWER LEVEL: 1kW
TOTAL OPERATING HOURS: 3528

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	139.0	054	138.1	081	98.9	109	66.1
026	119.9	053	122.7	080	103.7	108	
025	119.4	052	108.1	079	107.0	107	66.1
024	158.2	051	107.6	078	109.2	106	70.5
023	187.5	050	122.4	077	108.7	105	75.3
022	187.0	049	144.2	076	106.3	104	82.1
021	247.6	048	182.8	075	100.5	103	87.6
020	278.1	047	219.7	074	99.6	102	90.9
019	276.6	046	220.6	073	98.3	101	101.3
018	280.7	045	206.7	072	112.3	100	
017	280.9	044	169.7	071	122.0	099	77.2
016	279.1	043	134.7	070	123.6	098	79.7
015	277.2	042	126.3	069	126.6	097	82.9
014	271.1	041	109.8	068	127.2	096	87.5
013	214.4	040	119.5	067	121.3	095	91.8
012	233.4	039	120.7	066	117.3	094	95.0
011	207.8	038	125.3	065	100.4	093	92.8
010	193.8	037	149.6	064	102.4	092	84.0
009	169.1	036	195.5	063	78.1	091	88.5
008	147.8	035	232.2	062	87.0	090	90.9
007	130.0	034	232.2	061	95.8	089	93.4
006	126.6	033	234.0	060	106.1	088	95.4
005	160.0	032	233.7	059	125.1	087	97.0
004	143.4	031	232.2	058	141.8	086	96.5
003	127.8	030	218.7	057	170.7	085	95.3
002	127.8	029	180.9	056	170.7	084	76.6
001	153.4	028	158.6	055	149.0	083	83.3
000						082	90.4

TABLE C-12 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 9/1/78 TIME: 11:00 a.m.
OPERATING HOURS: 2952 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 4272

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	131.0	054	133.0	081	100.6	109	66.4
026	110.3	053	114.9	080	105.7	108	
025	109.5	052	98.9	079	109.0	107	69.1
024	156.2	051	98.8	078	110.2	106	73.8
023	184.4	050	122.2	077	107.8	105	78.3
022	183.8	049	142.9	076	102.3	104	82.1
021	242.3	048	179.6	075	93.6	103	84.4
020	271.8	047	215.7	074	93.8	102	84.4
019	270.6	046	216.5	073	99.2	101	95.4
018	274.3	045	202.5	072	113.1	100	
017	274.4	044	164.5	071	123.1	099	80.2
016	272.6	043	127.5	070	126.3	098	82.9
015	270.3	042	118.2	069	127.2	097	85.6
014	264.8	041	100.4	068	125.4	096	87.5
013	207.6	040	119.1	067	117.2	095	88.8
012	226.1	039	120.6	066	111.5	094	87.8
011	200.9	038	124.6	065	91.8	093	86.2
010	186.7	037	148.1	064	92.9	092	85.5
009	162.4	036	192.0	063	78.5	091	91.0
008	139.8	035	227.4	062	87.4	090	93.6
007	120.9	034	227.5	061	96.6	089	95.4
006	116.1	033	229.0	060	106.6	088	94.9
005	152.4	032	228.3	059	125.0	087	93.5
004	134.6	031	227.3	058	141.2	086	89.4
003	117.9	030	213.5	057	170.7	085	88.6
002	116.8	029	175.3	056	170.9	084	76.9
001	133.9	028	151.5	055	149.7	083	83.9
000						082	91.4

DATE: 10/1/78 TIME: 4:00 p.m.
OPERATING HOURS: 3677 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 4997

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	128.5	054	129.1	081	101.4	109	66.8
026	111.4	053	110.2	080	105.7	108	
025	111.9	052	99.3	079	107.5	107	70.6
024	157.8	051	97.4	078	106.9	106	74.0
023	186.4	050	123.3	077	102.5	105	75.9
022	185.9	049	144.4	076	96.6	104	77.4
021	245.0	048	181.8	075	89.5	103	79.3
020	274.7	047	217.8	074	105.4	102	79.9
019	272.3	046	218.6	073	100.1	101	100.7
018	276.2	045	203.7	072	114.1	100	
017	276.5	044	163.4	071	123.6	099	81.3
016	275.0	043	123.4	070	127.5	098	82.7
015	272.1	042	113.7	069	125.1	097	83.0
014	266.7	041	100.4	068	120.9	096	82.7
013	207.0	040	120.8	067	111.9	095	83.1
012	226.0	039	122.4	066	106.4	094	83.2
011	200.8	038	126.1	065	95.2	093	97.5
010	186.1	037	149.6	064	104.8	092	86.8
009	160.8	036	194.2	063	79.1	091	91.4
008	138.2	035	229.6	062	88.3	090	92.6
007	121.5	034	229.7	061	97.5	089	92.2
006	118.3	033	231.0	060	107.7	088	89.8
005	150.2	032	230.7	059	126.2	087	87.6
004	132.5	031	229.6	058	142.6	086	85.0
003	120.7	030	215.3	057	172.6	085	100.3
002		029	174.4	056	172.3	084	77.6
001	123.0	028	149.3	055	150.4	083	84.7
000						082	92.4

TABLE C-13 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 11/1/78 TIME: 4:01 p.m.
OPERATING HOURS: 4421 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 5741

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	113.3	054	121.1	081	101.3	109	67.6
026	89.7	053	92.8	080	105.0	108	
025	84.5	052	77.1	079	105.8	107	71.2
024	157.9	051	67.5	078	104.1	106	73.6
023	186.2	050	123.8	077	97.2	105	74.4
022	185.7	049	144.7	076	85.5	104	72.7
021	244.6	048	183.2	075	68.1	103	69.3
020	273.5	047	218.6	074	65.3	102	61.5
019	271.3	046	218.9	073	100.1	101	62.0
018	274.5	045	202.6	072	113.9	100	
017	274.1	044	156.5	071	123.3	099	80.4
016	273.0	043	110.1	070	128.8	098	81.1
015	268.3	042	97.5	069	125.0	097	80.6
014	263.4	041	78.5	068	116.9	096	77.8
013	199.5	040	121.2	067	103.0	095	73.0
012	219.6	039	122.7	066	93.1	094	63.0
011	193.5	038	126.3	065	71.3	093	63.9
010	178.1	037	149.8	064	66.7	092	86.5
009	150.2	036	195.2	063	79.3	091	90.3
008	124.0	035	229.8	062	88.6	090	90.8
007	101.3	034	229.4	061	98.0	089	89.7
006	92.1	033	230.3	060	108.0	088	84.8
005	137.8	032	229.8	059	126.6	087	77.0
004	117.0	031	229.1	058	142.5	086	64.6
003	98.6	030	213.0	057	174.1	085	65.8
002	91.5	029	166.9	056	173.7	084	78.3
001	67.4	028	137.7	055	150.8	083	85.1
000						082	92.7

DATE: 12/1/78 TIME: 4:00 p.m.
OPERATING HOURS: 5141 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 6461

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	102.4	054	107.7	081	100.0	109	67.9
026	78.4	053	80.2	080	102.4	108	
025	70.6	052	65.4	079	101.1	107	70.7
024	157.3	051	51.3	078	96.1	106	70.3
023	185.6	050	123.1	077	84.8	105	67.4
022	185.0	049	143.3	076	70.0	104	60.3
021	243.4	048	181.3	075	56.2	103	54.3
020	269.4	047	213.0	074	48.3	102	49.3
019	265.0	046	211.5	073	99.7	101	46.1
018	268.0	045	193.4	072	112.8	100	
017	268.0	044	145.1	071	121.0	099	78.6
016	267.0	043	97.6	070	126.5	098	77.1
015	260.9	042	85.1	069	119.4	097	73.1
014	256.5	041	67.1	068	105.5	096	65.7
013	189.8	040	120.8	067	88.2	095	57.6
012	210.6	039	122.1	066	78.3	094	50.6
011	183.1	038	126.6	065	58.1	093	48.4
010	167.7	037	148.4	064	48.2	092	86.1
009	139.4	036	192.9	063	79.7	091	88.1
008	113.1	035	224.2	062	88.7	090	86.4
007	91.0	034	221.9	061	97.8	089	81.8
006	81.7	033	222.6	060	107.2	088	72.3
005	126.8	032	222.5	059	125.0	087	61.2
004	106.3	031	221.8	058	139.8	086	52.0
003	88.3	030	204.1	057	170.1	085	48.4
002	81.4	029	156.0	056	167.4	084	78.9
001	50.1	028	126.8	055	142.2	083	85.4
000						082	92.4

TABLE C-14 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 1/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 5885 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 7205

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	94.8	054	102.2	081	97.6	109	68.3
026	67.8	053	71.8	080	98.7	108	
025	60.8	052	54.3	079	95.6	107	68.8
024	156.1	051	46.7	078	89.2	106	65.4
023	184.5	050	122.3	077	77.7	105	60.5
022	183.9	049	142.2	076	63.3	104	52.8
021	242.2	048	181.3	075	46.5	103	47.3
020	266.1	047	210.2	074	43.7	102	39.8
019	261.5	046	207.9	073	98.8	101	38.9
018	264.4	045	189.5	072	111.0	100	
017	264.4	044	140.3	071	118.2	099	74.8
016	263.3	043	91.1	070	123.8	098	71.4
015	258.1	042	77.2	069	115.4	097	65.9
014	252.6	041	56.0	068	99.2	096	58.3
013	185.7	040	121.1	067	82.3	095	50.7
012	206.8	039	121.5	066	71.5	094	41.0
011	180.4	038	125.3	065	47.6	093	41.1
010	163.6	037	147.5	064	43.6	092	84.3
009	133.7	036	192.3	063	80.0	091	84.0
008	105.8	035	221.3	062	88.4	090	80.6
007	82.1	034	218.4	061	97.2	089	74.4
006	72.8	033	219.2	060	106.3	088	64.7
005	120.4	032	219.0	059	123.8	087	54.3
004	98.2	031	218.4	058	137.5	086	42.3
003	78.9	030	200.5	057	167.8	085	41.9
002	72.5	029	151.3	056	164.0	084	79.2
001	49.2	028	121.0	055	138.3	083	85.0
000						082	91.3

DATE: 2/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 6629 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 7949

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	88.7	054	97.5	081	94.6	109	68.0
026	62.9	053	65.5	080	95.3	108	
025	57.5	052	49.7	079	91.5	107	66.1
024	154.5	051	41.8	078	85.3	106	61.7
023	182.7	050	120.4	077	73.4	105	56.5
022	182.2	049	140.1	076	58.3	104	49.2
021	240.6	048	180.1	075	41.9	103	42.7
020	263.1	047	207.1	074	36.0	102	37.0
019	257.8	046	204.6	073	96.7	101	32.6
018	261.0	045	185.7	072	108.3	100	
017	260.9	044	135.3	071	114.7	099	71.0
016	260.1	043	85.3	070	121.3	098	67.3
015	253.6	042	71.3	069	113.0	097	61.6
014	249.4	041	52.0	068	95.3	096	53.8
013	180.3	040	118.2	067	77.3	095	45.4
012	201.7	039	118.9	066	65.8	094	37.0
011	174.0	038	122.8	065	43.5	093	33.6
010	157.9	037	145.4	064	39.3	092	81.7
009	127.9	036	190.9	063	79.4	091	80.4
008	99.6	035	218.0	062	87.2	090	76.5
007	75.9	034	214.7	061	95.3	089	70.4
006	68.4	033	215.4	060	104.2	088	60.6
005	113.8	032	215.4	059	121.2	087	49.2
004	91.6	031	214.9	058	134.5	086	38.8
003	73.1	030	196.8	057	164.9	085	33.8
002	68.8	029	146.2	056	161.3	084	78.8
001	53.2	028	115.3	055	135.1	083	83.8
000						082	89.3

TABLE C-15 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 3/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 7301 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 8621

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	103.7	054	105.4	081	94.1	109	
026	79.2	053	81.9	080	94.4	108	
025	73.3	052	66.0	079	90.5	107	
024	156.9	051	54.9	078	85.4	106	
023	55.0	050	121.3	077	76.4	105	
022	185.7	049	142.3	076	66.9	104	
021	246.3	048	184.8	075	57.8	103	
020	269.9	047	212.7	074	51.8	102	
019	52.0	046	211.1	073	96.7	101	
018	50.7	045	192.8	072	108.3	100	
017	50.7	044	144.7	071	114.4	099	69.8
016	267.9	043	98.1	070	122.3	098	66.0
015	262.1	042	86.5	069	114.7	097	61.2
014	257.0	041	68.3	068	97.9	096	56.2
013	191.1	040	119.1	067	85.0	095	53.2
012	211.8	039	120.0	066	77.8	094	51.8
011	184.7	038	123.8	065	58.7	093	50.5
010	169.0	037	147.9	064	52.2	092	81.1
009	140.4	036	196.1	063	60.2	091	79.3
008	114.0	035	224.2	062	87.4	090	75.4
007	90.2	034	67.3	061	95.5	089	70.1
006	80.6	033	64.0	060	104.4	088	63.0
005	128.4	032	58.9	059	122.0	087	57.5
004	107.3	031	221.9	058	136.0	086	53.5
003	86.9	030	204.0	057	167.9	085	51.4
002	79.8	029	155.8	056	164.9	084	79.4
001	56.2	028	127.7	055	139.6	083	83.9
000	49.8					082	89.1

DATE: 4/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 8045 POWER LEVEL: 1 kW
TOTAL OPERATING HOURS: 9365

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	106.0	054	108.3	081	93.3	109	
026	84.7	053	84.6	080	94.1	108	
025	80.1	052	74.0	079	91.4	107	
024	156.7	051	70.2	078	88.0	106	
023	57.2	050	120.9	077		105	
022	186.2	049	142.5	076	80.6	104	
021	247.5	048	186.0	075	61.0	103	
020	270.8	047	213.6	074	71.4	102	
019	56.3	046	212.3	073	96.0	101	
018	55.1	045	194.6	072	107.6	100	
017	54.7	044	146.4	071	114.0	099	69.1
016	268.8	043	100.1	070	124.0	098	66.5
015	262.8	042	88.7	069	117.9	097	63.5
014	258.4	041	74.8	068	101.5	096	60.3
013	192.4	040	118.8	067	88.5	095	57.2
012	213.1	039	119.8	066	80.8	094	54.8
011	185.9	038	123.7	065	69.7	093	65.3
010	170.4	037	148.4	064	73.4	092	80.0
009	142.6	036	197.4	063	79.8	091	78.8
008	117.0	035	225.1	062	86.9	090	76.2
007	97.7	034	66.7	061	94.8	089	72.7
006	92.6	033	62.6	060	104.0	088	67.4
005	130.0	032	58.8	059	121.7	087	61.5
004	110.4	031	223.0	058	136.8	086	57.0
003	96.3	030	205.6	057	169.5	085	68.7
002	93.1	029	157.4	056	167.5	084	78.8
001	90.5	028	129.2	055	142.9	083	83.2
000	70.5					082	88.2

TABLE C-16 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/26/79
TIME: 12:00 Noon
OPERATING HOURS: 0
POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 9961

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	119.0	054	115.8	081	93.1	109	
026	101.0	053	98.3	080	94.2	108	
025	102.1	052	87.7	079	92.3	107	
024	156.9	051	89.3	078	90.3	106	
023	59.6	050	121.0	077	86.1	105	
022	186.4	049	143.1	076	80.8	104	
021	247.9	048	187.5	075	76.3	103	
020	271.5	047	215.2	074	81.5	102	
019	62.0	046	214.9	073	95.9	101	
018	64.1	045	198.5	072	107.4	100	
017	67.5	044	153.6	071	113.9	099	69.5
016	270.3	043	111.0	070	125.1	098	67.5
015	265.1	042	101.9	069	120.3	097	66.1
014	260.5	041	89.7	068	105.5	096	65.7
013	198.8	040	118.5	067	97.2	095	66.9
012	218.7	039	119.8	066	92.0	094	69.3
011	192.5	038	123.8	065	82.1	093	78.0
010	177.7	037	149.2	064	83.6	092	79.9
009	151.8	036	198.8	063	79.5	091	79.3
008	128.3	035	226.9	062	86.3	090	77.4
007	111.3	034	66.2	061	94.2	089	75.3
006	108.8	033	62.2	060	103.5	088	72.7
005	140.8	032	59.5	059	121.3	087	71.4
004	123.0	031	225.6	058	137.6	086	71.3
003	110.3	030	309.3	057	170.5	085	79.8
002	110.9	029	164.6	056	169.4	084	78.2
001	137.9	028	139.1	055	146.7	083	82.8
000	92.0					082	87.8

DATE: 4/27/79
TIME: 12:00 Noon
OPERATING HOURS: 24
POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 9985

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	129.9	054	120.1	081	93.2	109	
026	105.6	053	101.7	080	94.3	108	
025	105.9	052	88.3	079	92.5	107	
024	188.7	051	89.3	078	90.6	106	
023	59.7	050	126.8	077	86.5	105	
022	236.2	049	160.3	076	81.7	104	
021	324.0	048	221.7	075	77.5	103	
020	349.4	047	251.4	074	81.4	102	
019	62.2	046	250.9	073	96.0	101	
018	64.9	045	234.4	072	107.7	100	
017	68.4	044	176.5	071	114.2	099	69.6
016	346.7	043	117.8	070	125.3	098	67.8
015	344.6	042	107.0	069	120.6	097	66.4
014	335.9	041	91.6	068	106.0	096	66.1
013	248.8	040	125.5	067	98.3	095	67.8
012	278.1	039	126.6	066	93.7	094	70.6
011	240.7	038	132.4	065	81.7	093	77.8
010	217.5	037	170.7	064	83.4	092	80.0
009	176.8	036	243.1	063	79.6	091	79.5
008	142.1	035	275.3	062	86.4	090	77.6
007	117.8	034	66.5	061	94.4	089	75.5
006	114.4	033	62.2	060	104.1	088	73.0
005	159.9	032	59.9	059	125.0	087	72.3
004	135.2	031	273.0	058	141.7	086	72.4
003	117.6	030	255.3	057	175.4	085	79.5
002	117.8	029	194.1	056	174.7	084	78.3
001	143.3	028	158.4	055	152.0	083	82.9
000	92.9					082	87.9

TABLE C-17 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/28/79 TIME: 12:00 Noon
OPERATING HOURS: 48 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 10,009

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	137.0	054	126.3	081	93.3	109	
026	109.9	053	105.9	080	94.3	108	
025	108.6	052	91.1	079	92.7	107	
024	195.7	051	92.8	078	90.9	106	
023	59.9	050	131.3	077	87.0	105	
022	245.3	049	168.6	076	82.8	104	
021	337.8	048	236.9	075	78.3	103	
020	365.4	047	269.1	074	84.0	102	
019	62.4	046	268.9	073	96.4	101	
018	65.5	045	251.3	072	109.5	100	
017	68.9	044	188.3	071	115.8	099	69.8
016	361.9	043	124.3	070	126.5	098	68.0
015	360.7	042	112.3	069	122.0	097	66.7
014	349.8	041	94.9	068	107.5	096	66.5
013	259.5	040	129.9	067	100.7	095	68.6
012	288.7	039	131.0	066	96.0	094	71.5
011	252.5	038	137.1	065	83.1	093	79.1
010	228.7	037	179.1	064	86.8	092	80.1
009	186.8	036	258.9	063	79.6	091	79.6
008	150.8	035	293.7	062	86.4	090	77.8
007	124.6	034	66.5	061	94.6	089	75.8
006	120.7	033	62.2	060	105.7	088	73.4
005	169.9	032	60.0	059	130.4	087	73.2
004	143.9	031	291.3	058	148.8	086	73.3
003	124.2	030	272.7	057	185.5	085	81.2
002	124.0	029	206.4	056	185.1	084	78.3
001	151.5	028	167.3	055	161.5	083	83.0
000	94.9					082	88.0

DATE: 4/29/79 TIME: 12:00 Noon
OPERATING HOURS: 72 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 10,033

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	141.9	054	130.8	081	93.3	109	
026	114.3	053	109.3	080	94.3	108	
025	112.2	052	94.2	079	92.6	107	
024	200.1	051	94.1	078	91.0	106	
023	60.1	050	134.4	077	87.3	105	
022	250.9	049	173.7	076	83.4	104	
021	346.0	048	246.3	075	79.4	103	
020	375.5	047	281.5	074	86.0	102	
019	62.8	046	281.1	073	96.7	101	
018	66.1	045	262.1	072	111.3	100	
017	69.9	044	195.5	071	117.9	099	69.6
016	371.7	043	128.5	070	128.6	098	67.9
015	369.8	042	116.1	069	124.3	097	66.7
014	359.0	041	98.2	068	109.7	096	66.7
013	266.4	040	133.1	067	103.2	095	69.2
012	295.0	039	134.0	066	98.2	094	72.4
011	260.0	038	140.4	065	85.2	093	80.8
010	236.0	037	184.2	064	88.3	092	79.9
009	192.8	036	268.7	063	79.4	091	79.4
008	156.2	035	305.7	062	86.3	090	77.7
007	129.2	034	66.5	061	95.0	089	75.7
006	124.5	033	62.2	060	107.4	088	73.6
005	175.7	032	60.0	059	134.3	087	73.7
004	149.5	031	303.2	058	154.2	086	74.3
003	128.9	030	283.6	057	194.4	085	83.5
002	127.6	029	214.2	056	194.1	084	78.2
001	130.8	028	173.0	055	169.0	083	82.8
000	91.7					082	87.8

TABLE C-18 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/30/79 TIME: 12:00 Noon
OPERATING HOURS: 96 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 10,057

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	145.7	054	134.5	081	93.6	109	
026	117.0	053	112.5	080	94.7	108	
025	116.3	052	95.8	079	92.8	107	
024	201.9	051	93.4	078	91.4	106	
023	60.2	050	136.8	077	88.0	105	
022	252.8	049	177.1	076	84.5	104	
021	349.6	048	252.6	075	80.3	103	
020	380.4	047	289.8	074	84.4	102	
019	63.3	046	289.2	073	97.6	101	
018	67.0	045	269.3	072	113.4	100	
017	70.8	044	200.5	071	120.3	099	69.6
016	376.5	043	132.1	070	131.5	098	67.9
015	373.8	042	119.4	069	127.2	097	66.7
014	362.3	041	100.1	068	112.3	096	66.9
013	269.6	040	134.9	067	105.8	095	69.8
012	297.7	039	136.4	066	100.8	094	73.1
011	263.7	038	142.7	065	86.0	093	80.3
010	239.3	037	187.8	064	86.7	092	79.9
009	196.8	036	274.6	063	79.5	091	79.5
008	159.8	035	313.5	062	86.5	090	77.8
007	132.4	034	66.3	061	95.7	089	76.0
006	126.4	033	62.3	060	109.2	088	74.1
005	180.0	032	59.9	059	137.6	087	74.5
004	152.9	031	310.6	058	158.7	086	75.0
003	131.4	030	289.6	057	201.9	085	82.4
002	129.2	029	219.1	056	201.6	084	78.1
001	143.7	028	177.1	055	175.1	083	82.8
000	94.3					082	88.0

DATE: 5/1/79 TIME: 12:00 Noon
OPERATING HOURS: 120 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 10,081

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	148.3	054	137.3	081	94.0	109	
026	117.4	053	114.7	080	95.0	108	
025	114.7	052	95.3	079	93.0	107	
024	205.4	051	89.7	078	91.7	106	
023	60.3	050	138.9	077	88.7	105	
022	257.2	049	180.5	076	85.3	104	
021	355.9	048	259.5	075	80.5	103	
020	387.5	047	298.1	074	78.4	102	
019	63.8	046	297.4	073	98.2	101	
018	67.6	045	276.7	072	114.9	100	
017	71.1	044	205.5	071	122.2	099	69.5
016	383.3	043	134.5	070	134.0	098	67.9
015	380.0	042	121.6	069	129.8	097	66.7
014	369.0	041	100.2	068	114.5	096	67.1
013	275.1	040	136.7	067	107.9	095	70.2
012	303.0	039	138.2	066	102.6	094	73.3
011	268.6	038	144.7	065	83.8	093	73.5
010	244.2	037	191.5	064	80.2	092	79.7
009	200.8	036	282.0	063	79.3	091	79.3
008	162.6	035	322.0	062	86.4	090	77.7
007	132.9	034	66.1	061	96.3	089	76.0
006	124.7	033	62.1	060	110.5	088	74.3
005	183.3	032	59.8	059	140.1	087	75.0
004	155.7	031	318.6	058	162.0	086	75.0
003	130.9	030	296.7	057	208.0	085	75.4
002	127.0	029	224.2	056	207.6	084	78.1
001	135.2	028	180.6	055	179.8	083	82.6
000	86.1					082	88.0

TABLE C-19 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 5/15/79 TIME: 12:00 Noon
OPERATING HOURS: 456 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 10,417

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	162.4	054	154.2	081	101.9	109	
026	128.9	053	125.8	080	104.5	108	
025	125.7	052	104.7	079	103.3	107	
024	229.4	051	102.0	078	103.5	106	
023	62.5	050	156.1	077	99.4	105	
022	291.6	049	203.3	076	92.8	104	
021	392.0	048	303.2	075	85.9	103	
020	423.6	047	343.2	074	90.1	102	
019	65.5	046	339.8	073	108.0	101	
018	68.9	045	312.5	072	128.6	100	
017	73.1	044	230.9	071	139.1	099	70.5
016	415.9	043	147.0	070	161.4	098	69.5
015	410.2	042	133.5	069	155.7	097	69.4
014	397.5	041	110.4	068	132.2	096	69.9
013	296.3	040	153.8	067	121.3	095	72.0
012	323.7	039	154.2	066	113.8	094	76.0
011	292.7	038	161.9	065	92.0	093	82.1
010	266.9	037	228.6	064	93.4	092	81.1
009	219.6	036	326.1	063	79.7	091	81.7
008	177.5	035	366.3	062	90.1	090	81.0
007	145.0	034	66.3	061	105.4	089	80.1
006	136.8	033	62.4	060	124.8	088	78.2
005	198.9	032	61.5	059	156.3	087	77.6
004	169.1	031	359.9	058	190.9	086	78.3
003	142.9	030	332.5	057	251.1	085	85.6
002	139.1	029	249.1	056	250.0	084	78.1
001	144.4	028	196.7	055	214.8	083	84.3
000	193.4					082	92.5

DATE: 6/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 868 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 10,829

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	172.8	054	168.9	081	107.8	109	
026	136.2	053	133.8	080	111.9	108	
025	130.3	052	112.9	079	111.9	107	
024	250.6	051	104.3	078	113.5	106	
023	85.8	050	167.4	077	110.8	105	
022	317.9	049	239.7	076	104.3	104	
021	412.8	048	328.8	075	93.6	103	
020	441.3	047	365.8	074	104.4	102	
019	72.2	046	360.9	073	113.7	101	
018	76.6	045	332.3	072	133.8	100	
017	78.6	044	248.1	071	147.5	099	71.8
016	432.6	043	155.8	070	177.0	098	71.9
015	428.9	042	141.6	069	171.4	097	73.0
014	413.2	041	118.0	068	143.4	096	76.5
013	311.7	040	166.6	067	132.8	095	80.2
012	338.2	039	167.5	066	124.3	094	81.5
011	309.9	038	176.1	065	101.7	093	94.5
010	283.2	037	261.4	064	107.8	092	83.7
009	233.8	036	351.9	063	80.7	091	85.9
008	188.3	035	388.8	062	94.1	090	86.4
007	154.2	034	65.8	061	111.7	089	86.9
006	145.8	033	62.8	060	132.4	088	87.4
005	211.1	032	62.9	059	159.4	087	87.5
004	178.4	031	381.0	058	211.7	086	85.0
003	151.7	030	352.5	057	272.0	085	99.8
002	148.0	029	266.6	056	270.7	084	78.7
001	148.7	028	208.5	055	229.8	083	86.7
000	103.0					082	96.8

TABLE C-20 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 7/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 1588 POWER LEVEL: 2 KW
TOTAL OPERATING HOURS: 11,549

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	186.5	054	188.8	081	113.9	109	
026	150.9	053	144.4	080	119.7	108	
025	145.1	052	124.0	079	120.9	107	
024	285.5	051	112.1	078	123.2	106	
023	71.2	050	172.3	077	120.2	105	
022	354.9	049	283.0	076	113.9	104	
021	442.2	048	355.7	075	103.7	103	
020	466.5	047	386.9	074	110.0	102	
019	78.0	046	380.6	073	118.7	101	
018	83.2	045	351.6	072	137.7	100	
017	85.8	044	266.0	071	160.7	099	76.3
016	456.1	043	165.0	070	193.9	098	78.0
015	451.3	042	152.9	069	188.2	097	80.0
014	435.9	041	130.8	068	154.1	096	83.8
013	329.6	040	189.8	067	141.1	095	88.0
012	358.0	039	188.8	066	133.5	094	90.8
011	327.4	038	204.3	065	111.9	093	102.6
010	300.8	037	301.4	064	113.5	092	88.6
009	249.0	036	380.6	063	82.9	091	93.1
008	200.8	035	411.8	062	98.8	090	95.0
007	165.3	034	66.2	061	118.0	089	96.2
006	153.7	033	64.7	060	137.8	088	96.4
005	225.4	032	67.6	059	168.4	087	96.4
004	191.9	031	402.4	058	234.5	086	94.6
003	162.8	030	373.6	057	290.4	085	105.9
002	154.9	029	284.0	056	288.4	084	80.5
001	136.1	028	222.4	055	250.4	083	90.2
000	107.9					082	101.9

DATE: 8/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 2332 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 12,293

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	193.2	054	201.5	081	119.1	109	
026	157.2	053	149.0	080	125.5	108	
025	154.9	052	130.0	079	127.1	107	
024	323.8	051	122.3	078	129.6	106	
023	75.9	050	175.4	077	126.0	105	
022	379.1	049	314.4	076	118.4	104	
021	452.8	048	374.1	075	108.3	103	
020	472.2	047	400.1	074	123.3	102	
019	82.9	046	392.9	073	122.5	101	
018	87.7	045	362.8	072	142.4	100	
017	90.7	044	276.1	071	176.9	099	80.9
016	461.0	043	171.2	070	208.1	098	83.4
015	454.9	042	157.0	069	202.2	097	86.0
014	439.0	041	136.1	068	167.3	096	89.5
013	333.8	040	244.1	067	145.0	095	92.8
012	360.3	039	240.0	066	137.1	094	95.6
011	333.8	038	260.2	065	118.2	093	112.4
010	307.4	037	332.3	064	126.4	092	93.0
009	256.7	036	397.7	063	85.1	091	98.9
008	207.7	035	423.9	062	102.0	090	101.4
007	173.4	034	65.8	061	121.4	089	103.0
006	165.6	033	66.7	060	140.7	088	102.7
005	234.7	032	70.9	059	188.0	087	101.6
004	196.9	031	413.2	058	254.5	086	99.8
003	172.0	030	383.0	057	306.1	085	117.6
002	168.4	029	293.2	056	303.1	084	82.4
001	167.2	028	231.2	055	266.0	083	93.5
000	121.6					082	105.9

TABLE C-21 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 9/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 3076 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 13,037

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	189.4	054	206.8	081	122.5	109	
026	148.2	053	142.1	080	129.2	108	
025	142.7	052	120.1	079	131.2	107	
024	354.7	051	107.4	078	131.2	106	
023	77.4	050	228.4	077	125.1	105	
022	403.9	049	337.6	076	114.5	104	
021	471.1	048	390.1	075	100.1	103	
020	486.2	047	411.7	074	107.9	102	
019	82.0	046	403.2	073	124.7	101	
018	83.8	045	371.8	072	149.1	100	
017	83.6	044	280.3	071	189.3	099	84.4
016	473.5	043	168.9	070	218.2	098	86.5
015	464.0	042	150.9	069	210.8	097	87.9
014	448.8	041	126.6	068	176.3	096	89.0
013	337.4	040	283.3	067	142.1	095	89.1
012	363.7	039	279.9	066	131.5	094	87.6
011	338.0	038	297.4	065	107.1	093	99.6
010	310.1	037	356.5	064	109.1	092	96.4
009	257.2	036	414.8	063	86.6	091	102.7
008	204.6	035	437.2	062	103.9	090	104.7
007	165.5	034	66.1	061	123.2	089	104.8
006	153.3	033	69.0	060	142.2	088	102.2
005	234.3	032	73.5	059	204.1	087	97.8
004	191.2	031	424.7	058	268.8	086	91.7
003	162.2	030	392.0	057	316.2	085	102.6
002	154.8	029	297.2	056	312.0	084	83.9
001	139.3	028	230.6	055	274.4	083	95.7
000	104.5					082	108.6

DATE: 10/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 3796 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 13,757

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	189.3	054	211.9	081	124.6	109	
026	145.7	053	139.2	080	131.5	108	
025	140.1	052	116.3	079	135.3	107	
024	375.1	051	105.4	078	132.5	106	
023	78.4	050	259.7	077	125.2	105	
022	420.2	049	356.1	076	112.7	104	
021	481.9	048	405.2	075	95.8	103	
020	494.3	047	423.7	074	101.3	102	
019	81.8	046	414.3	073	126.3	101	
018	82.0	045	382.1	072	156.7	100	
017	79.8	044	287.3	071	198.7	099	86.4
016	481.4	043	171.1	070	225.6	098	88.2
015	470.9	042	148.5	069	218.8	097	89.2
014	455.5	041	122.7	068	184.6	096	89.3
013	342.9	040	310.5	067	143.2	095	87.4
012	368.0	039	307.2	066	128.9	094	83.0
011	344.1	038	323.0	065	102.6	093	95.0
010	315.9	037	375.4	064	102.6	092	98.6
009	261.4	036	429.4	063	88.1	091	104.8
008	206.3	035	449.0	062	105.7	090	106.4
007	164.5	034	66.7	061	124.9	089	108.1
006	152.1	033	70.6	060	144.1	088	102.5
005	237.6	032	74.9	059	216.1	087	96.1
004	190.4	031	435.6	058	280.2	086	87.4
003	160.6	030	401.7	057	325.3	085	98.3
002	153.8	029	304.2	056	320.9	084	85.4
001	128.7	028	234.4	055	283.3	083	97.6
000	98.2					082	110.7

TABLE C-22 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 11/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 4540 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 14,501

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	174.9	054	206.2	081	125.3	109	
026	128.8	053	123.7	080	132.2	108	
025	121.3	052	96.6	079	137.6	107	
024	388.3	051	79.3	078	129.4	106	
023	74.8	050	278.1	077	118.1	105	
022	430.9	049	365.2	076	100.4	104	
021	489.9	048	410.9	075	77.9	103	
020	500.0	047	427.7	074	75.7	102	
019	73.8	046	416.9	073	127.0	101	
018	69.7	045	382.6	072	163.1	100	
017	63.0	044	282.2	071	205.7	099	86.3
016	485.8	043	160.0	070	231.0	098	86.8
015	470.9	042	133.7	069	223.0	097	85.6
014	458.7	041	103.5	068	186.1	096	81.8
013	337.9	040	326.5	067	136.2	095	75.2
012	365.0	039	323.7	066	115.5	094	65.4
011	338.4	038	337.7	065	81.7	093	71.2
010	309.7	037	385.2	064	76.9	092	99.3
009	252.7	036	436.3	063	88.6	091	104.7
008	194.5	035	453.7	062	106.3	090	105.0
007	149.2	034	66.5	061	125.6	089	102.3
006	132.8	033	70.9	060	145.2	088	94.9
005	227.2	032	73.6	059	224.3	087	83.6
004	177.2	031	439.0	058	287.1	086	69.7
003	144.4	030	402.9	057	330.1	085	72.3
002	132.9	029	299.4	056	324.3	084	86.1
001	88.7	028	224.8	055	284.4	083	98.3
000	69.3					082	111.4

DATE: 12/1/79 TIME: 4:00 p.m.
OPERATING HOURS: 5260 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 15,221

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	167.8	054	199.8	081	125.1	109	
026	122.2	053	116.1	080	131.9	108	
025	114.5	052	90.1	079	137.9	107	
024	395.7	051	76.1	078	124.4	106	
023	68.6	050	288.0	077	108.7	105	
022	436.3	049	368.7	076	89.4	104	
021	493.3	048	412.2	075	68.7	103	
020	501.1	047	427.1	074	71.4	102	
019	63.6	046	415.1	073	127.4	101	
018	58.3	045	379.5	072	167.4	100	
017	53.5	044	277.3	071	209.0	099	85.0
016	486.4	043	154.1	070	232.1	098	83.4
015	471.1	042	126.4	069	222.3	097	79.3
014	458.2	041	96.7	068	182.3	096	72.0
013	334.9	040	335.5	067	128.7	095	63.6
012	363.2	039	332.7	066	106.3	094	56.1
011	337.0	038	345.8	065	74.7	093	65.3
010	307.0	037	389.5	064	72.2	092	99.6
009	247.9	036	438.3	063	89.6	091	103.3
008	188.9	035	453.6	062	107.1	090	101.5
007	143.6	034	67.2	061	125.9	089	95.9
006	128.4	033	70.5	060	146.4	088	85.1
005	221.8	032	70.6	059	228.5	087	72.0
004	171.5	031	437.9	058	288.9	086	60.2
003	139.2	030	400.7	057	329.2	085	67.8
002	129.2	029	295.2	056	322.0	084	87.2
001	86.9	028	219.4	055	280.1	083	99.3
000	63.5					082	112.0

TABLE C-23 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 1/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 6004 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 15,965

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	166.4	054	199.8	081	124.3	109	
026	119.8	053	113.0	080	131.9	108	
025	112.7	052	86.4	079	138.2	107	
024	405.3	051	74.1	078	122.2	106	
023	63.5	050	300.0	077	103.7	105	
022	444.2	049	377.2	076	83.8	104	
021	498.5	048	419.1	075	62.8	103	
020	504.5	047	432.2	074	70.2	102	
019	57.8	046	419.5	073	127.4	101	
018	52.4	045	382.7	072	171.0	100	
017	47.8	044	278.8	071	212.4	099	82.5
016	489.1	043	154.4	070	234.3	098	79.7
015	472.8	042	123.5	069	223.6	097	74.5
014	460.4	041	93.5	068	182.3	096	66.3
013	336.0	040	347.7	067	126.3	095	57.8
012	364.1	039	345.1	066	102.4	094	50.2
011	337.6	038	357.0	065	70.3	093	61.5
010	307.7	037	398.4	064	72.4	092	98.8
009	248.2	036	445.2	063	90.3	091	100.8
008	188.3	035	458.6	062	107.5	090	97.8
007	142.0	034	67.5	061	126.1	089	91.2
006	127.8	033	68.9	060	148.7	088	79.5
005	221.8	032	66.8	059	234.1	087	65.9
004	170.4	031	442.1	058	293.7	086	54.2
003	137.9	030	403.8	057	332.8	085	64.2
002	129.2	029	296.7	056	324.7	084	87.9
001	94.9	028	219.9	055	281.9	083	99.6
000	60.3					082	111.7

DATE: 2/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 6,748 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 16,709

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	160.5	054	196.1	081	123.1	109	
026	114.3	053	111.0	080	131.8	108	
025	107.6	052	84.5	079	137.9	107	
024	400.8	051	74.1	078	120.7	106	
023	59.6	050	299.6	077	100.2	105	
022	438.0	049	372.1	076	81.3	104	
021	490.5	048	412.6	075	60.8	103	
020	495.6	047	424.7	074	71.8	102	
019	54.8	046	411.7	073	126.5	101	
018	51.3	045	375.1	072	172.2	100	
017	47.6	044	272.9	071	212.6	099	80.0
016	480.4	043	151.5	070	233.3	098	76.5
015	464.1	042	120.2	069	221.8	097	70.7
014	452.2	041	90.9	068	180.1	096	63.0
013	329.1	040	345.7	067	124.1	095	56.0
012	357.4	039	343.3	066	100.2	094	49.4
011	331.0	038	354.2	065	69.9	093	63.0
010	301.2	037	392.9	064	74.8	092	97.5
009	241.7	036	438.0	063	90.7	091	98.4
008	182.6	035	450.2	062	107.2	090	94.7
007	136.8	034	67.5	061	125.2	089	87.5
006	124.3	033	66.8	060	149.4	088	76.1
005	215.5	032	63.5	059	234.0	087	63.9
004	165.1	031	433.7	058	291.3	086	52.9
003	132.8	030	396.2	057	328.7	085	65.0
002	126.3	029	290.5	056	320.1	084	88.3
001	104.7	028	214.8	055	277.2	083	99.3
000	64.0					082	110.9

TABLE C-24 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 3/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 7,444 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 17,405

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	166.2	054	195.3	081	122.5	109	
026	119.8	053	119.2	080	132.2	108	
025	108.9	052	91.8	079	138.4	107	
024	410.2	051	74.2	078	120.9	106	
023	58.3	050	308.4	077	99.6	105	
022	446.7	049	380.4	076	84.5	104	
021	497.9	048	420.3	075	68.6	103	
020	502.4	047	431.8	074	63.9	102	
019	55.6	046	416.3	073	125.9	101	
018	55.2	045	380.9	072	174.2	100	
017	55.2	044	277.6	071	214.9	099	77.8
016	486.2	043	154.6	070	235.1	098	74.1
015	469.5	042	128.2	069	223.4	097	68.8
014	457.5	041	98.2	068	180.6	096	62.5
013	334.8	040	356.1	067	122.5	095	58.9
012	362.7	039	353.6	066	105.1	094	56.6
011	336.5	038	364.0	065	75.5	093	59.8
010	306.8	037	401.9	064	67.0	092	96.0
009	248.4	036	446.0	063	90.4	091	96.4
008	189.6	035	457.6	062	106.4	090	92.5
007	142.5	034	67.2	061	124.6	089	85.6
006	126.3	033	65.1	060	151.3	088	75.5
005	223.5	032	61.4	059	237.9	087	66.8
004	173.8	031	440.5	058	295.3	086	60.1
003	137.5	030	401.9	057	332.6	085	61.6
002	126.5	029	295.8	056	323.7	084	88.1
001	84.8	028	220.0	055	279.7	083	98.6
000	60.3					082	109.8

DATE: 3/15/80 TIME: 4:00 p.m.
OPERATING HOURS: 7,780 POWER LEVEL: 2 kW
TOTAL OPERATING HOURS: 17,741

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	162.4	054	164.6	081	122.7	109	
026	122.3	053	119.1	080	132.7	108	
025	116.4	052	94.2	079	139.0	107	
024	413.6	051	79.8	078	121.4	106	
023	57.9	050	310.6	077	99.2	105	
022	450.1	049	382.1	076	84.5	104	
021	500.5	048	421.2	075	69.0	103	
020	503.0	047	430.9	074	77.2	102	
019	55.2	046	416.0	073	125.9	101	
018	54.4	045	374.0	072	175.3	100	
017	55.1	044	263.9	071	215.8	099	77.3
016	486.3	043	145.7	070	235.7	098	73.8
015	466.7	042	127.2	069	223.2	097	68.6
014	456.2	041	100.5	068	169.0	096	62.0
013	327.7	040	359.1	067	121.2	095	57.9
012	356.8	039	356.7	066	108.1	094	56.5
011	327.7	038	367.1	065	79.5	093	69.0
010	298.5	037	404.2	064	80.2	092	95.7
009	240.2	036	447.3	063	90.5	091	96.0
008	184.6	035	457.2	062	106.5	090	92.2
007	142.5	034	67.1	061	128.0	089	85.5
006	128.9	033	64.4	060	152.4	088	74.8
005	217.8	032	60.8	059	239.1	087	65.8
004	171.9	031	438.7	058	296.0	086	60.2
003	139.3	030	397.2	057	332.5	085	71.3
002	130.7	029	286.1	056	322.5	084	88.0
001	107.1	028	212.1	055	269.9	083	98.4
000	71.1					082	109.6

TABLE C-25 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/1/80 TIME: 12:00 Noon
OPERATING HOURS: 0 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,145

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	160.8	054	163.4	081	122.6	109	
026	117.6	053	119.2	080	132.9	108	
025	107.7	052	90.0	079	138.9	107	
024	406.7	051	70.1	078	121.3	106	
023	58.0	050	307.6	077	102.8	105	
022	441.7	049	376.4	076	88.7	104	
021	489.7	048	414.0	075	70.5	103	
020	490.7	047	422.3	074	61.6	102	
019	56.9	046	406.0	073	125.4	101	
018	56.5	045	362.9	072	175.0	100	
017	55.5	044	257.8	071	214.8	099	76.6
016	473.8	043	144.9	070	233.5	098	73.2
015	454.0	042	127.6	069	217.6	097	68.6
014	442.5	041	96.7	068	156.9	096	63.6
013	320.6	040	354.3	067	123.4	095	60.6
012	349.0	039	351.9	066	110.4	094	57.1
011	321.7	038	361.8	065	72.7	093	55.7
010	292.4	037	397.7	064	62.5	092	95.0
009	236.4	036	438.8	063	90.1	091	95.4
008	182.3	035	446.8	062	105.8	090	91.6
007	139.3	034	66.7	061	124.8	089	85.6
006	125.7	033	63.7	060	152.3	088	77.0
005	214.9	032	60.1	059	237.6	087	69.3
004	170.3	031	427.6	058	293.1	086	61.2
003	134.6	030	385.3	057	327.7	085	57.5
002	126.3	029	279.1	056	315.1	084	87.8
001	110.6	028	208.1	055	258.5	083	98.0
000	63.5					082	109.0

DATE: 4/2/80 TIME: 12:00 Noon
OPERATING HOURS: 24 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,169

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	168.6	054	166.7	081	122.7	109	
026	123.0	053	119.7	080	133.1	108	
025	118.6	052	90.1	079	139.0	107	
024	465.2	051	75.5	078	121.4	106	
023	58.1	050	334.3	077	103.1	105	
022	507.1	049	413.0	076	88.9	104	
021	562.5	048	455.6	075	69.3	103	
020	563.1	047	462.2	074	64.2	102	
019	57.0	046	444.5	073	125.6	101	
018	56.5	045	398.9	072	175.2	100	
017	54.3	044	279.6	071	215.1	099	76.7
016	542.4	043	148.3	070	233.7	098	73.4
015	522.2	042	129.3	069	217.6	097	68.8
014	507.0	041	97.8	068	157.0	096	64.0
013	361.4	040	398.9	067	123.8	095	60.8
012	396.6	039	395.4	066	110.6	094	55.9
011	362.9	038	407.7	065	73.1	093	59.3
010	326.4	037	446.9	064	64.9	092	95.2
009	257.2	036	493.6	063	90.4	091	95.5
008	193.3	035	502.3	062	106.0	090	91.8
007	146.4	034	66.8	061	129.5	089	85.8
006	135.8	033	63.7	060	153.2	088	77.4
005	232.9	032	60.2	059	240.3	087	69.6
004	182.0	031	479.6	058	297.1	086	60.1
003	144.6	030	432.4	057	332.0	085	61.2
002	139.8	029	306.7	056	319.6	084	87.9
001	141.8	028	223.4	055	262.8	083	98.1
000	75.4					082	109.2

TABLE C-26 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/3/80 TIME: 12:00 Noon
OPERATING HOURS: 48 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,193

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	176.0	054	171.9	081	122.7	109	
026	128.9	053	123.5	080	133.1	108	
025	123.7	052	93.6	079	139.0	107	
024	484.7	051	80.4	078	121.5	106	
023	58.1	050	352.8	077	103.3	105	
022	526.1	049	434.2	076	89.0	104	
021	579.6	048	476.4	075	70.6	103	
020	579.5	047	481.5	074	67.8	102	
019	57.1	046	463.7	073	125.8	101	
018	56.6	045	417.1	072	176.0	100	
017	55.3	044	292.8	071	216.4	099	76.7
016	558.6	043	153.2	070	234.5	098	73.4
015	535.9	042	133.8	069	218.3	097	68.8
014	522.1	041	101.9	068	157.7	096	64.1
013	373.7	040	420.4	067	125.0	095	60.8
012	408.5	039	416.5	066	111.8	094	57.1
011	375.3	038	428.9	065	75.8	093	62.0
010	337.3	037	468.7	064	69.2	092	95.1
009	268.2	036	514.6	063	90.4	091	95.5
008	202.0	035	522.0	062	106.1	090	91.8
007	153.4	034	66.7	061	131.8	089	85.9
006	141.8	033	63.7	060	154.9	088	77.6
005	244.1	032	60.1	059	246.9	087	69.6
004	190.6	031	498.5	058	306.1	086	61.3
003	151.6	030	450.7	057	341.8	085	64.3
002	145.8	029	320.4	056	329.3	084	87.9
001	142.5	028	232.9	055	272.0	083	98.1
000	76.4					082	109.2

DATE: 4/4/80 TIME: 12:00 Noon
OPERATING HOURS: 72 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,217

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	182.1	054	176.6	081	122.7	109	
026	133.2	053	127.8	080	133.1	108	
025	126.2	052	97.1	079	139.0	107	
024	500.2	051	83.4	078	121.4	106	
023	58.2	050	365.0	077	103.5	105	
022	542.1	049	447.5	076	89.4	104	
021	595.6	048	491.6	075	72.3	103	
020	595.3	047	497.3	074	73.0	102	
019	57.3	046	478.5	073	126.2	101	
018	56.9	045	431.0	072	177.7	100	
017	56.6	044	302.8	071	219.1	099	76.6
016	573.0	043	157.6	070	236.5	098	73.3
015	550.7	042	138.3	069	220.4	097	68.8
014	535.1	041	105.8	068	159.3	096	64.1
013	383.8	040	435.7	067	127.0	095	61.0
012	418.8	039	431.4	066	113.9	094	58.6
011	386.9	038	444.2	065	78.1	093	64.3
010	347.9	037	484.6	064	75.4	092	95.1
009	276.3	036	531.4	063	90.4	091	95.4
008	208.5	035	539.1	062	106.0	090	91.8
007	158.0	034	66.7	061	132.2	089	85.9
006	144.0	033	63.6	060	157.1	088	77.6
005	252.1	032	60.1	059	253.5	087	69.9
004	197.1	031	514.3	058	314.4	086	62.7
003	156.0	030	464.8	057	351.2	085	67.9
002	147.7	029	330.4	056	338.6	084	87.8
001	123.8	028	240.5	055	280.4	083	98.0
000	71.0					082	109.1

TABLE C-27 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/5/80 TIME: 12:00 Noon
OPERATING HOURS: 96 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,241

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	185.9	054	181.0	081	122.9	109	
026	136.4	053	130.4	080	133.3	108	
025	130.3	052	98.9	079	139.1	107	
024	510.2	051	83.9	078	121.6	106	
023	58.2	050	373.8	077	104.0	105	
022	552.6	049	456.4	076	90.1	104	
021	605.6	048	501.7	075	72.3	103	
020	605.0	047	507.6	074	71.3	102	
019	57.4	046	487.9	073	126.9	101	
018	57.1	045	439.1	072	180.0	100	
017	56.2	044	308.8	071	222.4	099	76.7
016	581.4	043	160.7	070	239.5	098	73.3
015	560.3	042	141.2	069	223.4	097	68.8
014	542.9	041	108.0	068	161.3	096	64.2
013	389.7	040	446.1	067	129.2	095	61.4
012	424.3	039	441.7	066	116.0	094	58.3
011	393.7	038	454.9	065	78.9	093	64.6
010	354.0	037	495.9	064	73.1	092	95.1
009	281.4	036	542.3	063	90.4	091	95.5
008	212.5	035	549.9	062	106.1	090	91.8
007	161.5	034	66.7	061	132.7	089	86.0
006	147.9	033	63.6	060	159.2	088	77.7
005	257.0	032	60.1	059	259.0	087	70.3
004	200.9	031	524.0	058	321.6	086	62.5
003	159.5	030	473.2	057	359.6	085	67.2
002	151.5	029	336.8	056	346.8	084	87.8
001	135.0	028	245.4	055	287.9	083	98.1
000	76.4					082	109.2

DATE: 4/6/80 TIME: 12:00 Noon
OPERATING HOURS: 120 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,265

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	189.2	054	184.8	081	123.2	109	
026	139.8	053	132.9	080	133.6	108	
025	135.1	052	101.6	079	139.5	107	
024	519.3	051	86.4	078	121.8	106	
023	58.3	050	381.6	077	104.6	105	
022	562.1	049	464.9	076	90.8	104	
021	614.1	048	511.0	075	73.8	103	
020	612.5	047	516.3	074	71.7	102	
019	57.5	046	496.0	073	127.7	101	
018	57.4	045	446.2	072	182.3	100	
017	57.3	044	314.3	071	225.7	099	76.6
016	588.7	043	163.3	070	243.0	098	73.4
015	568.0	042	144.0	069	226.7	097	68.9
014	549.1	041	110.9	068	163.7	096	64.5
013	395.0	040	455.8	067	131.2	095	61.8
012	429.3	039	451.3	066	118.0	094	59.6
011	400.2	038	464.8	065	81.4	093	65.7
010	359.8	037	506.5	064	73.3	092	95.1
009	286.0	036	552.2	063	90.4	091	95.5
008	216.3	035	559.0	062	106.3	090	91.8
007	165.6	034	66.7	061	133.6	089	86.1
006	153.5	033	63.5	060	161.3	088	77.9
005	261.5	032	60.0	059	263.6	087	70.6
004	204.7	031	532.2	058	327.4	086	63.8
003	163.8	030	480.3	057	366.4	085	68.3
002	157.4	029	342.0	056	353.5	084	87.8
001	147.7	028	249.5	055	294.1	083	98.2
000	81.0					082	109.3

TABLE C-28 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 4/15/80 TIME: 4:00 p.m.
OPERATING HOURS: 340 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,485

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	206.8	054	208.1	081	128.1	109	
026	158.1	053	147.7	080	140.1	108	
025	151.6	052	119.0	079	146.7	107	
024	565.5	051	104.9	078	128.6	106	
023	59.0	050	423.1	077	113.6	105	
022	611.4	049	518.9	076	100.4	104	
021	656.9	048	562.4	075	86.3	103	
020	648.4	047	560.2	074	98.2	102	
019	59.7	046	533.6	073	133.9	101	
018	61.6	045	476.5	072	197.2	100	
017	65.3	044	337.9	071	246.7	099	76.7
016	618.6	043	176.5	070	267.1	098	73.6
015	596.7	042	158.5	069	248.3	097	70.0
014	574.3	041	128.6	068	178.5	096	66.9
013	416.0	040	506.8	067	144.4	095	66.5
012	449.5	039	501.7	066	131.1	094	68.2
011	423.0	038	515.6	065	100.1	093	87.6
010	381.4	037	563.3	064	102.1	092	95.3
009	306.2	036	603.2	063	90.6	091	96.0
008	234.3	035	602.7	062	108.8	090	92.6
007	183.3	034	66.6	061	152.6	089	87.6
006	169.1	033	63.4	060	173.0	088	81.1
005	281.4	032	60.1	059	288.3	087	76.1
004	225.0	031	570.0	058	360.5	086	73.3
003	183.1	030	512.3	057	402.8	085	91.3
002	173.5	029	366.7	056	385.3	084	87.7
001	141.1	028	268.8	055	320.7	083	98.9
000	91.4					082	111.5

DATE: 5/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 724 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 18,869

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	214.1	054	232.8	081	134.8	109	
026	153.3	053	150.1	080	149.6	108	
025	138.6	052	112.3	079	158.0	107	
024	609.5	051	83.9	078	137.7	106	
023	61.4	050	462.0	077	123.8	105	
022	656.2	049	566.3	076	107.8	104	
021	698.8	048	606.1	075	84.0	103	
020	687.4	047	602.7	074	68.8	102	
019	64.0	046	570.7	073	139.8	101	
018	65.2	045	508.3	072	213.2	100	
017	63.8	044	359.6	071	268.2	099	76.8
016	653.9	043	183.0	070	291.9	098	74.7
015	625.0	042	162.6	069	268.8	097	72.5
014	603.6	041	122.9	068	193.9	096	71.2
013	436.4	040	554.7	067	151.3	095	70.0
012	468.9	039	548.5	066	136.8	094	66.1
011	445.3	038	562.2	065	91.3	093	66.2
010	401.7	037	611.5	064	71.5	092	96.8
009	320.8	036	648.6	063	91.3	091	98.6
008	242.9	035	645.5	062	112.1	090	96.4
007	179.6	034	66.3	061	158.5	089	93.2
006	156.8	033	63.1	060	186.2	088	88.1
005	295.5	032	61.1	059	314.3	087	81.4
004	237.4	031	608.6	058	392.3	086	71.5
003	176.3	030	545.2	057	435.3	085	68.1
002	159.6	029	388.4	056	413.7	084	88.3
001	89.3	028	282.1	055	343.5	083	100.7
000	65.1					082	115.4

TABLE C-29 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 6/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 1468 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 19,613

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	229.4	054	258.9	081	143.7	109	
026	173.4	053	161.5	080	161.8	108	
025	165.4	052	129.9	079	171.4	107	
024	634.6	051	108.8	078	145.8	106	
023	64.7	050	487.2	077	131.3	105	
022	681.2	049	593.4	076	115.4	104	
021	721.7	048	632.3	075	96.0	103	
020	710.6	047	629.3	074	98.1	102	
019	67.7	046	593.6	073	147.1	101	
018	69.7	045	529.1	072	229.1	100	
017	71.3	044	378.2	071	289.1	099	79.3
016	675.5	043	200.4	070	313.0	098	78.5
015	644.8	042	173.0	069	286.7	097	77.4
014	622.2	041	140.5	068	213.2	096	76.6
013	452.8	040	582.3	067	156.3	095	76.3
012	484.6	039	575.8	066	143.1	094	76.1
011	462.7	038	589.8	065	107.3	093	88.7
010	418.4	037	639.3	064	101.5	092	100.8
009	338.0	036	676.3	063	107.0	091	104.6
008	259.7	035	673.3	062	116.3	090	103.5
007	198.6	034	65.6	061	149.0	089	101.2
006	182.0	033	63.2	060	201.8	088	95.7
005	313.1	032	63.0	059	334.2	087	89.1
004	256.6	031	633.0	058	415.4	086	82.5
003	196.0	030	566.8	057	460.1	085	93.3
002	185.6	029	408.1	056	434.5	084	89.3
001	147.2	028	300.2	055	365.3	083	103.7
000						082	120.0

DATE: 7/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 2188 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 20,333

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	246.0	054	284.1	081	152.5	109	
026	184.7	053	173.0	080	173.1	108	
025	174.6	052	136.6	079	182.7	107	
024	653.6	051	113.5	078	154.6	106	
023	69.2	050	508.0	077	140.7	105	
022	699.6	049	615.2	076	127.2	104	
021	740.0	048	654.2	075	107.0	103	
020	729.0	047	651.7	074	101.3	102	
019	75.2	046	616.4	073	155.6	101	
018	79.9	045	552.3	072	243.9	100	
017	82.2	044	400.4	071	305.6	099	83.0
016	694.8	043	227.7	070	330.1	098	83.1
015	661.6	042	183.3	069	304.2	097	83.7
014	638.5	041	148.4	068	238.7	096	85.1
013	471.5	040	604.1	067	173.2	095	87.8
012	501.5	039	597.6	066	153.1	094	87.2
011	484.1	038	611.1	065	114.4	093	96.3
010	438.7	037	660.9	064	102.0	092	104.8
009	357.6	036	698.4	063	97.3	091	109.9
008	276.7	035	695.4	062	166.1	090	109.9
007	209.6	034	65.5	061	146.5	089	108.7
006	189.7	033	64.4	060	215.1	088	105.1
005	333.2	032	65.6	059	351.4	087	101.1
004	277.9	031	655.7	058	434.7	086	93.6
003	202.7	030	587.0	057	479.8	085	100.0
002	192.8	029	429.7	056	455.9	084	90.9
001	134.9	028	322.0	055	388.8	083	106.8
000						082	123.9

TABLE C-30 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 8/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 2932 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 21,077

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	265.3	054	305.6	081	161.8	109	
026	205.8	053	185.9	080	184.7	108	
025	196.1	052	154.4	079	194.0	107	
024	672.6	051	132.7	078	164.9	106	
023	74.6	050	529.1	077	148.9	105	
022	716.3	049	636.3	076	136.3	104	
021	756.0	048	675.1	075	119.5	103	
020	745.7	047	673.6	074	124.1	102	
019	83.2	046	639.6	073	164.1	101	
018	89.0	045	575.1	072	257.3	100	
017	92.9	044	421.6	071	320.6	099	87.6
016	711.7	043	252.1	070	346.7	098	89.1
015	674.1	042	191.8	069	322.6	097	90.8
014	652.9	041	166.0	068	262.9	096	93.8
013	489.3	040	626.0	067	194.1	095	97.0
012	517.9	039	619.3	066	165.9	094	99.0
011	500.0	038	632.2	065	130.6	093	115.0
010	457.3	037	681.3	064	127.3	092	108.9
009	377.5	036	718.7	063	97.8	091	115.5
008	297.6	035	716.4	062	112.7	090	116.5
007	231.4	034	65.7	061	164.4	089	116.7
006	210.8	033	66.2	060	228.1	088	114.5
005	353.8	032	69.6	059	367.8	087	111.0
004	299.8	031	677.6	058	453.6	086	106.2
003	241.0	030	607.0	057	499.5	085	120.6
002	216.7	029	451.5	056	477.6	084	93.1
001	175.3	028	343.8	055	411.7	083	109.9
000	127.9					082	128.1

DATE: 9/2/80 TIME: 4:00 p.m.
OPERATING HOURS: 3700 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 21,845

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	266.6	054	311.9	081	169.7	109	
026	199.6	053	179.6	080	193.9	108	
025	187.3	052	142.8	079	202.9	107	
024	680.8	051	117.7	078	173.0	106	
023	78.2	050	539.1	077	148.5	105	
022	723.4	049	643.8	076	131.5	104	
021	761.5	048	681.2	075	109.6	103	
020	752.7	047	680.8	074	112.1	102	
019	82.8	046	650.0	073	171.1	101	
018	84.1	045	585.1	072	265.9	100	
017	84.1	044	427.9	071	329.5	099	92.2
016	721.4	043	258.6	070	356.4	098	94.1
015	682.1	042	190.4	069	334.6	097	94.9
014	665.0	041	155.8	068	275.9	096	94.6
013	496.1	040	636.9	067	199.6	095	92.7
012	524.1	039	630.0	066	166.1	094	89.5
011	508.3	038	642.3	065	117.5	093	102.4
010	464.4	037	688.8	064	113.5	092	112.4
009	381.8	036	725.0	063	98.9	091	120.2
008	298.6	035	723.6	062	85.3	090	121.3
007	227.0	034	66.0	061	184.9	089	120.6
006	202.9	033	68.7	060	237.1	088	116.1
005	356.8	032	73.5	059	375.8	087	106.4
004	300.2	031	687.9	058	461.9	086	96.5
003	238.1	030	619.0	057	507.5	085	107.3
002	208.7	029	460.1	056	487.8	084	94.8
001	160.5	028	348.6	055	422.0	083	112.2
000	114.3					082	131.1

TABLE C-31 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 10/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 4396 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 22,541

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	273.3	054	316.6	081	175.4	109	
026	202.3	053	180.9	080	199.6	108	
025	191.5	052	142.1	079	207.6	107	
024	687.9	051	120.8	078	178.4	106	
023	77.0	050	547.1	077	145.8	105	
022	730.0	049	650.5	076	128.2	104	
021	767.9	048	687.6	075	106.7	103	
020	759.0	047	687.2	074	116.6	102	
019	79.8	046	657.6	073	176.9	101	
018	81.0	045	593.4	072	272.4	100	
017	81.4	044	434.8	071	335.6	099	94.2
016	727.9	043	266.4	070	362.1	098	94.9
015	688.1	042	202.1	069	341.2	097	93.9
014	673.3	041	154.9	068	282.2	096	91.7
013	502.5	040	645.4	067	203.2	095	89.1
012	530.7	039	638.5	066	168.1	094	86.7
011	515.8	038	650.6	065	116.2	093	103.1
010	470.8	037	696.0	064	117.4	092	114.8
009	387.4	036	731.8	063	100.6	091	121.9
008	303.5	035	730.5	062		090	121.8
007	232.0	034	66.5	061	180.5	089	119.3
006	210.6	033	70.3	060	244.4	088	112.0
005	362.2	032	74.1	059	382.4	087	102.7
004	305.3	031	695.7	058	468.3	086	93.6
003	241.2	030	627.6	057	513.0	085	109.6
002	215.8	029	468.8	056	494.3	084	96.4
001	172.9	028	354.9	055	428.4	083	114.3
000	112.8					082	133.5

DATE: 10/8/80 TIME: 4:00 p.m.
OPERATING HOURS: 4564 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 22,709

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	276.7	054	320.1	081	176.4	109	
026	202.8	053	182.9	080	200.6	108	
025	190.2	052	141.4	079	208.6	107	
024	697.0	051	116.5	078	180.0	106	
023	76.8	050	553.9	077	146.4	105	
022	740.1	049	658.0	076	129.1	104	
021	778.4	048	695.6	075	106.7	103	
020	769.6	047	695.4	074	109.4	102	
019	80.2	046	665.6	073	178.3	101	
018	81.9	045	600.2	072	274.2	100	
017	81.8	044	439.9	071	337.7	099	94.2
016	739.1	043	270.3	070	364.3	098	94.7
015	698.3	042	206.4	069	343.7	097	93.7
014	681.8	041	154.4	068	285.0	096	91.9
013	508.5	040	654.2	067	205.8	095	90.0
012	537.2	039	647.0	066	170.3	094	86.6
011	522.2	038	659.4	065	115.0	093	99.5
010	476.5	037	705.2	064	109.9	092	114.9
009	391.7	036	741.6	063	100.7	091	121.9
008	306.1	035	740.6	062		090	121.6
007	232.0	034	66.5	061	181.4	089	119.1
006	206.5	033	70.4	060	246.6	088	112.3
005	366.4	032	74.0	059	385.4	087	103.5
004	309.1	031	705.4	058	471.8	086	93.6
003	241.3	030	635.5	057	516.7	085	104.9
002	211.6	029	474.8	056	498.4	084	96.6
001	152.9	028	359.4	055	432.5	083	114.5
000	104.8					082	133.8

TABLE C-32 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 11/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 5140 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 23,285

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	232.6	054	306.6	081	179.7	109	
026	186.6	053	167.1	080	203.6	108	
025	171.5	052	121.1	079	211.2	107	
024	664.0	051	95.8	078	183.2	106	
023	74.5	050	529.0	077	140.2	105	
022	703.9	049	627.1	076	116.1	104	
021	741.1	048	663.0	075	88.7	103	
020	732.7	047	663.7	074	82.5	102	
019	73.0	046	636.0	073	180.8	101	
018	69.3	045	574.6	072	274.6	100	
017	65.0	044	421.1	071	336.4	099	94.3
016	705.1	043	256.1	070	362.8	098	93.9
015	666.5	042	195.0	069	342.7	097	91.2
014	653.9	041	135.5	068	282.5	096	85.1
013	488.7	040	622.0	067	196.8	095	77.3
012	517.8	039	615.9	066	157.2	094	69.0
011	500.5	038	627.3	065	95.6	093	77.4
010	457.7	037	669.9	064	83.7	092	115.8
009	375.9	036	704.8	063	101.6	091	122.1
008	293.9	035	704.1	062		090	120.8
007	218.5	034	67.1	061	180.5	089	116.4
006	188.9	033	71.2	060	246.5	088	105.4
005	362.0	032	73.7	059	378.0	087	90.7
004	321.3	031	671.8	058	460.9	086	75.9
003	222.1	030	608.3	057	504.0	085	80.7
002	191.3	029	455.6	056	486.0	084	97.8
001	121.4	028	348.9	055	420.4	083	115.6
000						082	134.9

DATE: 12/1/80 TIME: 4:00 p.m.
OPERATING HOURS: 5860 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 24,701

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	257.3	054	297.7	081	178.9	109	
026	177.5	053	160.0	080	201.2	108	
025	162.6	052	109.8	079	207.5	107	
024	653.1	051	83.6	078	180.6	106	
023	69.2	050	520.1	077	133.2	105	
022	692.0	049	616.0	076	106.3	104	
021	727.7	048	650.2	075	77.9	103	
020	719.9	047	650.2	074	69.9	102	
019	64.4	046	624.0	073	180.3	101	
018	59.9	045	564.1	072	269.2	100	
017	54.6	044	412.8	071	327.8	099	93.1
016	692.4	043	250.2	070	352.1	098	91.1
015	654.4	042	191.1	069	332.5	097	86.0
014	642.5	041	125.2	068	273.2	096	77.4
013	479.9	040	612.0	067	188.3	095	68.3
012	509.0	039	605.8	066	149.2	094	59.0
011	491.1	038	616.8	065	83.8	093	64.6
010	448.7	037	657.8	064	71.5	092	115.4
009	367.8	036	691.2	063	102.2	091	120.1
008	287.0	035	690.3	062		090	116.9
007	210.6	034	67.8	061	174.6	089	110.2
006	180.7	033	70.9	060	243.7	088	96.9
005	355.0	032	71.1	059	369.7	087	81.0
004	316.8	031	659.1	058	449.3	086	65.4
003	213.7	030	597.0	057	490.9	085	68.9
002	182.9	029	446.1	056	473.5	084	98.8
001	110.3	028	336.8	055	409.3	083	115.5
000	61.2					082	134.3

TABLE C-33 ELECTRICALLY HEATED DRYWELL THERMOCOUPLE DATA

DATE: 12/30/80 TIME: 4:00 p.m.
OPERATING HOURS: 6556 POWER LEVEL: 3 kW
TOTAL OPERATING HOURS: 24,701

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
027	259.7	054	297.6	081	178.7	109	
026	179.8	053	162.9	080	199.9	108	
025	165.9	052	113.6	079	205.1	107	
024	647.2	051	88.8	078	179.0	106	
023	64.3	050	515.8	077	131.2	105	
022	685.9	049	610.7	076	104.5	104	
021	721.8	048	644.5	075	79.6	103	
020	713.7	047	644.6	074	76.5	102	
019	60.7	046	618.8	073	181.4	101	
018	58.1	045	560.4	072	268.4	100	
017	56.1	044	411.8	071	326.0	099	90.1
016	687.5	043	251.6	070	349.2	098	86.8
015	649.8	042	193.5	069	329.6	097	81.1
014	639.2	041	127.8	068	270.8	096	73.1
013	478.0	040	606.4	067	188.1	095	66.3
012	506.9	039	600.4	066	149.9	094	60.2
011	487.5	038	611.0	065	87.4	093	68.4
010	447.0	037	651.8	064	77.9	092	113.7
009	368.2	036	684.8	063	102.4	091	117.0
008	288.7	035	684.2	062		090	112.4
007	213.6	034	67.7	061	174.9	089	105.1
006	184.2	033	69.2	060	244.3	088	92.5
005	355.9	032	67.1	059	368.3	087	79.1
004	321.3	031	653.5	058	446.6	086	66.8
003	216.5	030	592.6	057	487.9	085	73.7
002	185.6	029	445.0	056	470.5	084	98.9
001	115.1	028	337.3	055	407.2	083	115.3
000	65.3					082	133.9

APPENDIX D

SPENT FUEL DRYWELL TEST DATA

Test data are provided in this Appendix for the Spent Fuel Drywell Tests. The data is divided into four separate series of tables for each of the four drywells (5, 3, 2, and 1). Each table number includes the drywell number (i.e., D5-1 for Drywell 5, etc.). Figure D-1 is included in this Appendix to identify and locate the drywell soil instrumentation wells. The identification and location of the thermocouples for each drywell are provided in Tables D5-1, D5-8, D3-1, D2-1, and D1-1 for Drywell 5 with Fuel Assembly B03; Drywell 5 with Fuel Assembly D22, Drywell 3, Drywell 2, and Drywell 1, respectively. Test data for Drywell 5 is provided in Tables D5-2 through D5-7 for Fuel Assembly B03 and in Tables D5-9 through D5-14 for Fuel Assembly D22. Test data for Drywell 3 is provided in Tables D3-2 through D3-7 for Fuel Assembly B41 and in Tables D3-8 through D3-13 for Fuel Assembly B03. Test data for Drywells 2 and 1 are provided in Tables D2-2 through D2-7 and Tables D1-2 through D1-7, respectively. The data tables provide thermocouple readings at the times and for the test operating hours as follows:

Drywell 5 Phase I: Fuel Assembly B03

Table No.	Date	Operating Hours
D5-2	1/12/79	0
-2	1/13/79	25
-2	1/14/79	49
-2	1/15/79	73
-2	1/16/79	97
-2	1/17/79	121
-2	2/1/79	485
-2	2/15/79	821
D5-3	3/1/79	1,157
-3	3/15/79	1,493
-3	4/1/79	1,901
-3	4/15/79	2,237
-3	5/1/79	2,621
-3	5/16/79	2,985
-3	6/1/79	3,365
-3	6/15/79	3,701
D5-4	7/1/79	4,085
-4	7/15/79	4,421
-4	8/1/79	4,829
-4	8/15/79	5,165
-4	9/1/79	5,573
-4	9/15/79	5,909
-4	10/1/79	6,293
-4	10/15/79	6,629
D5-5	11/1/79	7,037
-5	11/15/79	7,373
-5	12/1/79	7,757
-5	12/15/79	8,093
-5	1/1/80	8,501
-5	1/15/80	8,837
-5	2/1/80	9,245
-5	2/15/80	9,581

Table No.	Date	Operating Hours	Table No.	Date	Operating Hours
Drywell 5 Phase I: Fuel Assembly B03 (Cont'd)					
D5-6	3/1/80	9,941	D5-7	7/1/80	12,869
-6	3/15/80	10,277	-7	7/15/80	13,205
-6	4/1/80	10,685	-7	8/1/80	13,613
-6	4/15/80	11,021			
-6	5/1/80	11,405			
-6	5/15/80	11,741			
-6	6/1/80	12,149			
-6	6/15/80	12,485			
Drywell 5 Phase II: Fuel Assembly D22					
D5-9	9/4/80	1	D5-12	6/15/81	6,817
-9	9/5/80	25	-12	7/1/81	7,201
-9	9/6/80	49	-12	7/15/81	7,537
-9	9/7/80	73	-12	8/1/81	7,945
-9	9/8/80	97	-12	8/15/81	8,281
-9	9/9/80	121	-12	9/1/81	8,689
-9	9/15/80	265	-12	9/21/81	9,169
-9	10/1/80	649	-12	10/1/81	9,409
D5-10	10/15/80	985	D5-13	10/15/81	9,745
-10	11/1/80	1,393	-13	11/1/81	10,153
-10	11/15/80	1,729	-13	11/15/81	10,489
-10	12/1/80	2,113	-13	12/1/81	10,873
-10	12/15/80	2,449	-13	12/15/81	11,209
-10	1/1/81	2,857	-13	1/1/82	11,617
-10	1/15/81	3,193	-13	1/15/82	11,953
-10	2/1/81	3,601	-13	2/1/82	12,361
D5-11	2/15/81	3,937	D5-14	2/15/82	12,697
-11	3/1/81	4,273	-14	3/1/82	13,033
-11	3/15/81	4,609	-14	3/15/82	13,369
-11	4/1/81	5,017	-14	3/31/82	13,753
-11	4/15/81	5,353			
-11	5/1/81	5,737			
-11	5/15/81	6,073			
-11	6/1/81	6,481			
Drywell 3 Phase I: Fuel Assembly B41					
D3-2	1/25/79	16.5	D3-3	3/1/79	864
-2	1/25/79	24	-3	3/15/79	1,200
-2	1/26/79	48	-3	4/1/79	1,608
-2	1/27/79	72	-3	4/15/79	1,944
-2	1/28/79	96	-3	5/1/79	2,328
-2	1/29/79	120	-3	5/16/79	2,692
-2	2/1/79	192	-3	6/1/79	3,072
-2	2/15/79	528	-3	6/15/79	3,408

Drywell 3 Phase I: Fuel Assembly B41 (Cont'd)

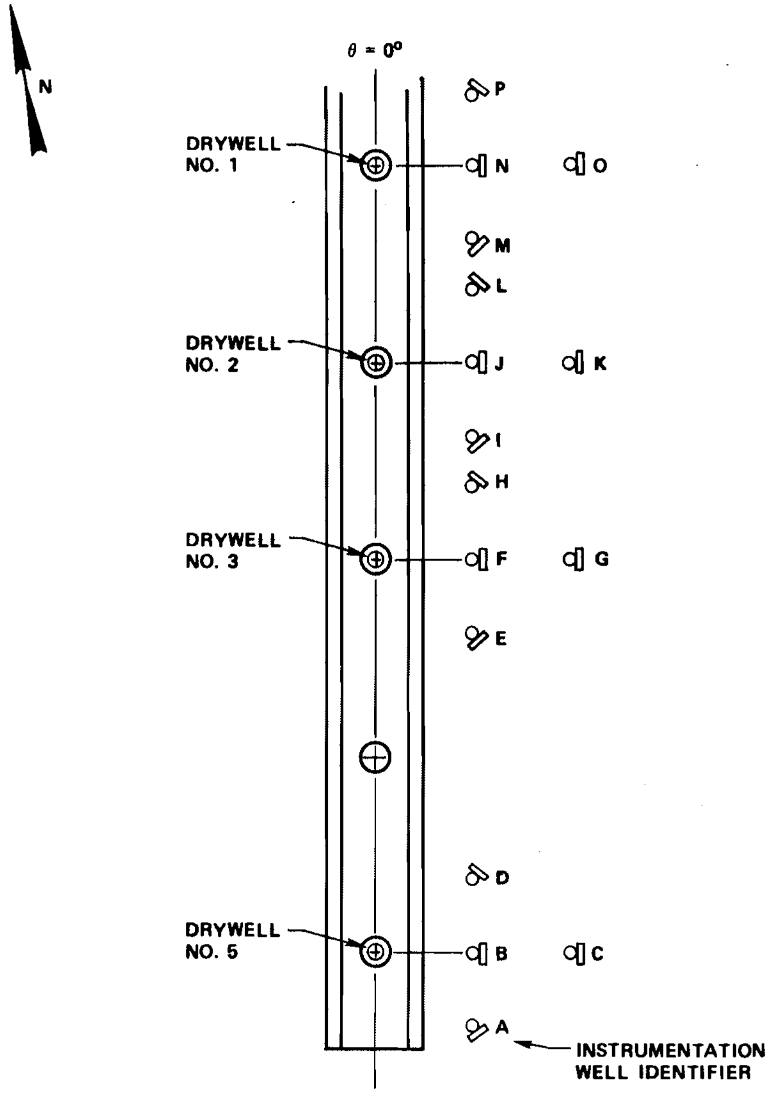
Table No.	Date	Operating Hours	Table No.	Date	Operating Hours
D3-4	7/1/79	3,792	D3-6	3/1/80	9,648
-4	7/15/79	4,128	-6	3/15/80	9,984
-4	8/1/79	4,536	-6	4/1/80	10,392
-4	8/15/79	4,872	-6	4/15/80	10,728
-4	9/1/79	5,280	-6	5/1/80	11,112
-4	9/15/79	5,616	-6	5/15/80	11,448
-4	10/1/79	6,000	-6	6/1/80	11,856
-4	10/15/79	6,336	-6	6/15/80	12,192
D3-5	11/1/79	6,744	D3-7	7/1/80	12,576
-5	11/15/79	7,080	-7	7/15/80	12,912
-5	12/1/79	7,464	-7	8/1/80	13,320
-5	12/15/79	7,800			
-5	1/1/80	8,208			
-5	1/15/80	8,544			
-5	2/1/80	8,952			
-5	2/15/80	9,288			

Drywell 3 Phase II: Fuel Assembly B03

Table No.	Date	Operating Hours	Table No.	Date	Operating Hours
D3-8	8/5/80	13,416	D3-11	8/1/81	22,080
-8	8/15/80	13,656	-11	8/15/81	22,416
-8	9/2/80	14,088	-11	9/1/81	22,824
-8	9/15/80	14,400	-11	9/21/81	23,304
-8	10/1/80	14,784	-11	10/1/81	23,544
-8	10/15/80	15,120	-11	10/15/81	23,880
-8	11/1/80	15,528	-11	11/1/81	24,288
-8	11/15/80	15,864	-11	11/15/81	24,624
D3-9	12/1/80	16,248	D3-12	12/1/81	25,008
-9	12/15/80	16,584	-12	12/15/81	25,344
-9	1/1/81	16,992	-12	1/1/82	25,752
-9	1/15/81	17,328	-12	1/15/82	26,088
-9	2/1/81	17,736	-12	2/1/82	26,496
-9	2/15/81	18,072	-12	2/15/82	26,832
-9	3/1/81	18,408	-12	3/1/82	27,168
-9	3/15/81	18,744	-12	3/15/82	27,504
D3-10	4/1/81	19,152	D3-13	3/31/82	27,888
-10	4/15/81	19,488			
-10	5/1/81	19,872			
-10	5/15/81	20,208			
-10	6/1/81	20,616			
-10	6/15/81	20,952			
-10	7/1/81	21,336			
-10	7/15/81	21,672			

Table No.	Date	Operating Hours	Table No.	Date	Operating Hours
Drywell 2 Fuel Assembly B41					
D2-2	8/7/80	66	D2-5	5/15/81	6,810
-2	8/8/80	90	-5	6/1/81	7,218
-2	8/9/80	114	-5	6/15/81	7,554
-2	8/10/80	138	-5	7/1/81	7,938
-2	8/11/80	162	-5	7/15/81	8,274
-2	8/12/80	186	-5	8/1/81	8,682
-2	8/15/80	258	-5	8/15/81	9,018
-2	9/2/80	690	-5	9/1/81	9,426
D2-3	9/15/80	1,002	D2-6	9/21/81	9,906
-3	10/1/80	1,386	-6	10/1/81	10,146
-3	10/15/80	1,722	-6	10/15/81	10,482
-3	11/1/80	2,130	-6	11/1/81	10,890
-3	11/15/80	2,466	-6	11/15/81	11,226
-3	12/1/80	2,850	-6	12/1/81	11,610
-3	12/15/80	3,186	-6	12/15/81	11,946
-3	1/1/81	3,594	-6	1/1/82	12,354
D2-4	1/15/81	3,930	D2-7	1/15/82	12,690
-4	2/1/81	4,338	-7	2/1/82	13,098
-4	2/15/81	4,674	-7	2/15/82	13,434
-4	3/1/81	5,010	-7	3/1/82	13,770
-4	3/15/81	5,346	-7	3/15/82	14,106
-4	4/1/81	5,754	-7	3/31/82	14,490
-4	4/15/81	6,090			
-4	5/1/81	6,474			
Drywell 1 Fuel Assembly B43					
D1-2	9/15/80	0	D1-4	3/1/81	4,012
-2	9/16/80	24	-4	3/15/81	4,348
-2	9/17/80	48	-4	4/1/81	4,756
-2	9/18/80	72	-4	4/15/81	5,092
-2	9/19/80	96	-4	5/1/81	5,476
-2	9/20/80	120	-4	5/15/81	5,812
-2	10/1/80	388	-4	6/1/81	6,220
-2	10/15/80	724	-4	6/15/81	6,556
D1-3	11/1/80	1,132	D1-5	7/1/81	6,940
-3	11/15/80	1,468	-5	7/15/81	7,276
-3	12/1/80	1,852	-5	8/1/81	7,684
-3	12/15/81	2,188	-5	8/15/81	8,020
-3	1/1/81	2,596	-5	9/1/81	8,428
-3	1/15/81	2,932	-5	9/21/81	8,908
-3	2/1/81	3,340	-5	10/1/81	9,148
-3	2/15/81	3,676	-5	10/15/81	9,484

Table No.	Date	Operating Hours	Table No.	Date	Operating Hours
Drywell 1 Fuel Assembly B43 (Cont'd)					
D1-6	11/1/81	9,892	D1-7	3/1/82	12,772
-6	11/15/81	10,228	-7	3/15/82	13,108
-6	12/1/81	10,612	-7	3/31/82	13,492
-6	12/15/81	10,948			
-6	1/1/82	11,356			
-6	1/15/82	11,692			
-6	2/1/82	12,100			
-6	2/15/82	12,436			



706534-19A

Figure D-1. Drywell Instrumentation Well Identification

TABLE D5-1

DRYWELL 5 THERMOCOUPLE LOCATIONS
PHASE I: FUEL ASSEMBLY B03

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
861	203.5	120	150	Instrumentation Well A*
862	203.5	60	90	Instrumentation Well B
863	203.5	120	90	Instrumentation Well C
864	203.5	120	30	Instrumentation Well D
865	205.75	9	30	Liner
866	205.75	9	210	Liner
867	205.75	9	90	Liner
868	206.0	7	30	Canister
869	206.0	7	210	Canister
870	176.0	7	15	Canister
871	176.0	7	195	Canister
872	143.5	120	150	Instrumentation Well A
873	143.5	60	90	Instrumentation Well B
874	143.5	120	90	Instrumentation Well C
875	143.5	120	30	Instrumentation Well D
876	145.75	9	0	Liner
877	205.75**	9	180	Liner
878	145.75	9	90	Liner
879	146.0	7	0	Canister
880	146.0	7	180	Canister
881	116.0	7	345	Canister
882	116.0	7	165	Canister
883	83.5	120	150	Instrumentation Well A
884	83.5	60	90	Instrumentation Well B
885	83.5	120	90	Instrumentation Well C
886	83.5	120	30	Instrumentation Well D
887	85.75	9	330	Liner
888	85.75	9	150	Liner
889	85.75	9	90	Liner
890	86.0	7	330	Canister
891	86.0	7	150	Canister

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*See Figure D-1 for Instrumentation Well identification

**Broken thermocouple was replaced by longer length thermocouple, original thermocouple depth was 145.75 inches

TABLE D5-2 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 1/12/79
TIME: 11:00 a.m.
OPERATING HRS: 0

T/C No.	Temp(°F)
891	53.4
890	57.1
889	56.5
888	58.0
887	58.7
886	55.5
885	56.1
884	55.5
883	55.7
882	56.6
881	56.7
880	56.7
879	56.9
878	56.8
877	55.9
876	55.8
875	62.3
874	62.4
873	62.0
872	62.2
871	57.1
870	55.8
869	57.6
868	56.8
867	56.2
866	55.5
865	52.5
864	65.8
863	66.2
862	65.4
861	66.3

DATE: 1/13/79
TIME: 12:00 noon
OPERATING HRS: 25

T/C No.	Temp(°F)
891	137.8
890	147.0
889	90.7
888	88.7
887	91.5
886	55.3
885	55.9
884	55.4
883	55.6
882	166.1
881	163.1
880	172.7
879	165.9
878	101.8
877	
876	100.4
875	62.1
874	62.5
873	61.8
872	62.4
871	172.0
870	166.7
869	141.0
868	139.0
867	89.3
866	90.5
865	89.9
864	65.9
863	66.1
862	65.6
861	66.2

DATE: 1/14/79
TIME: 12:00 noon
OPERATING HRS: 49

T/C No.	Temp(°F)
891	147.1
890	155.9
889	100.2
888	97.9
887	100.9
886	55.2
885	55.9
884	55.4
883	55.5
882	175.6
881	172.6
880	183.6
879	176.9
878	114.0
877	
876	112.6
875	62.0
874	62.3
873	61.8
872	62.2
871	182.8
870	177.5
869	149.9
868	147.6
867	97.9
866	99.1
865	98.5
864	65.9
863	66.1
862	65.6
861	66.2

DATE: 1/15/79
TIME: 12:00 noon
OPERATING HRS: 73

T/C No.	Temp(°F)
891	152.0
890	161.7
889	106.2
888	103.8
887	106.8
886	55.1
885	55.7
884	55.6
883	55.4
882	181.8
881	178.3
880	190.3
879	183.4
878	121.7
877	
876	120.3
875	61.7
874	62.1
873	61.9
872	62.1
871	189.8
870	184.3
869	155.3
868	152.9
867	103.4
866	104.7
865	104.0
864	65.8
863	65.8
862	65.7
861	66.0

DATE: 1/16/79
TIME: 12:00 noon
OPERATING HRS: 97

T/C No.	Temp(°F)
891	155.9
890	166.0
889	110.4
888	108.3
887	111.0
886	55.1
885	55.4
884	56.1
883	55.2
882	186.3
881	182.6
880	194.5
879	187.7
878	127.1
877	
876	125.8
875	61.4
874	62.1
873	62.2
872	62.1
871	194.4
870	189.2
869	158.9
868	156.7
867	107.3
866	108.9
865	108.0
864	65.7
863	65.6
862	65.8
861	65.7

DATE: 1/17/79
TIME: 12:00 noon
OPERATING HRS: 121

T/C No.	Temp(°F)
891	158.8
890	169.2
889	113.6
888	111.4
887	114.3
886	55.0
885	55.4
884	56.6
883	55.1
882	189.5
881	185.8
880	199.1
879	191.2
878	131.2
877	
876	129.9
875	61.2
874	61.9
873	62.8
872	61.9
871	197.7
870	192.7
869	161.8
868	159.7
867	110.5
866	112.0
865	111.1
864	65.5
863	65.5
862	66.2
861	65.6

DATE: 2/1/79
TIME: 4:00 p.m.
OPERATING HRS: 485

T/C No.	Temp(°F)
891	161.4
890	188.0
889	130.8
888	127.7
887	131.8
886	54.5
885	55.0
884	64.6
883	54.6
882	183.9
881	189.3
880	200.5
879	208.0
878	154.1
877	129.9
876	152.6
875	60.9
874	61.4
873	73.9
872	61.3
871	216.5
870	215.7
869	162.5
868	154.5
867	129.6
866	131.0
865	130.1
864	65.0
863	65.1
862	73.7
861	65.3

DATE: 2/15/79
TIME: 4:00 p.m.
OPERATING HRS: 821

T/C No.	Temp(°F)
891	171.1
890	194.6
889	137.7
888	134.7
887	138.7
886	55.5
885	55.7
884	69.0
883	55.5
882	195.7
881	195.8
880	208.7
879	215.7
878	164.5
877	137.9
876	163.8
875	62.6
874	63.2
873	79.7
872	63.2
871	224.7
870	223.8
869	169.4
868	161.7
867	137.6
866	139.1
865	138.0
864	66.7
863	66.6
862	78.9
861	66.7

TABLE D5-3 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 3/1/79
TIME: 4:00 p.m.
OPERATING HRS: 1157

T/C No.	Temp(°F)
891	169.6
890	197.5
889	141.7
888	138.7
887	142.9
886	58.4
885	58.4
884	73.3
883	58.3
882	192.6
881	202.3
880	214.4
879	220.8
878	171.2
877	142.8
876	170.6
875	63.7
874	64.2
873	82.5
872	64.2
871	229.4
870	228.3
869	173.4
868	165.7
867	142.3
866	143.8
865	142.7
864	67.1
863	67.1
862	81.0
861	67.3

DATE: 3/15/79
TIME: 4:00 p.m.
OPERATING HRS: 1493

T/C No.	Temp(°F)
891	175.8
890	201.4
889	146.2
888	142.9
887	147.8
886	61.2
885	61.7
884	76.9
883	61.8
882	200.8
881	207.4
880	217.8
879	224.8
878	177.1
877	147.6
876	176.4
875	65.2
874	65.6
873	84.7
872	65.6
871	233.3
870	232.3
869	176.7
868	169.1
867	146.9
866	148.5
865	147.7
864	68.4
863	68.4
862	83.0
861	68.5

DATE: 4/1/79
TIME: 4:00 p.m.
OPERATING HRS: 1901

T/C No.	Temp(°F)
891	179.3
890	203.6
889	148.4
888	144.7
887	150.3
886	63.5
885	64.0
884	79.4
883	64.2
882	202.8
881	206.8
880	221.1
879	228.2
878	181.3
877	152.2
876	180.8
875	67.0
874	67.2
873	86.6
872	67.4
871	236.6
870	235.5
869	180.1
868	172.3
867	151.3
866	153.0
865	152.4
864	69.2
863	69.3
862	84.4
861	69.4

DATE: 4/15/79
TIME: 4:00 p.m.
OPERATING HRS: 2237

T/C No.	Temp(°F)
891	177.8
890	205.8
889	150.8
888	147.0
887	153.1
886	65.7
885	66.3
884	81.7
883	66.5
882	208.7
881	211.6
880	224.1
879	230.6
878	184.7
877	155.3
876	184.1
875	68.3
874	68.5
873	87.7
872	68.6
871	238.9
870	237.6
869	182.1
868	174.6
867	154.3
866	155.9
865	155.4
864	69.9
863	70.0
862	85.1
861	70.1

DATE: 5/1/79
TIME: 4:00 p.m.
OPERATING HRS: 2621

T/C No.	Temp(°F)
891	195.2
890	205.9
889	149.4
888	146.4
887	151.6
886	69.1
885	69.5
884	84.9
883	69.9
882	224.9
881	226.3
880	240.1
879	235.4
878	187.2
877	166.1
876	185.5
875	69.5
874	69.8
873	88.9
872	70.0
871	244.4
870	242.1
869	202.7
868	204.9
867	165.3
866	167.0
865	165.7
864	70.5
863	70.5
862	85.8
861	70.7

DATE: 5/16/79
TIME: 8:00 p.m.
OPERATING HRS: 2985

T/C No.	Temp(°F)
891	196.1
890	207.1
889	151.6
888	148.4
887	153.3
886	72.4
885	72.4
884	88.0
883	72.8
882	226.4
881	227.6
880	242.0
879	236.8
878	189.9
877	168.1
876	188.2
875	70.9
874	71.5
873	90.0
872	71.7
871	245.7
870	243.6
869	204.0
868	206.4
867	167.5
866	169.2
865	167.8
864	71.2
863	70.9
862	86.3
861	71.1

DATE: 6/1/79
TIME: 4:00 p.m.
OPERATING HRS: 3365

T/C No.	Temp(°F)
891	200.2
890	210.9
889	161.6
888	157.7
887	164.8
886	76.8
885	77.3
884	92.3
883	77.9
882	229.4
881	231.8
880	245.1
879	240.6
878	195.0
877	163.0
876	194.5
875	73.2
874	73.4
873	92.1
872	73.6
871	248.4
870	246.1
869	206.0
868	208.1
867	162.1
866	163.3
865	163.0
864	72.0
863	72.1
862	87.1
861	72.2

DATE: 6/15/79
TIME: 4:00 p.m.
OPERATING HRS: 3701

T/C No.	Temp(°F)
891	203.1
890	212.4
889	164.5
888	161.0
887	167.4
886	80.3
885	80.8
884	95.6
883	81.5
882	232.5
881	233.8
880	247.4
879	242.8
878	197.5
877	164.8
876	197.1
875	75.2
874	75.5
873	93.9
872	75.9
871	250.1
870	248.0
869	207.4
868	209.6
867	164.0
866	165.2
865	164.9
864	73.1
863	73.1
862	88.2
861	73.3

TABLE D5-4 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 7/1/79		DATE: 7/15/79		DATE: 8/1/79		DATE: 8/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 4085		OPERATING HRS: 4421		OPERATING HRS: 4829		OPERATING HRS: 5165	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	203.1	891	204.3	891	204.9	891	205.9
890	214.2	890	215.3	890	216.1	890	216.4
889	166.1	889	167.8	889	169.1	889	170.6
888	162.6	888	164.4	888	165.9	888	167.1
887	169.6	887	171.4	887	173.5	887	174.5
886	83.0	886	85.2	886	88.2	886	90.2
885	83.3	885	85.3	885	88.3	885	90.3
884	98.0	884	99.9	884	102.6	884	104.3
883	84.0	883	86.1	883	89.1	883	91.0
882	233.7	882	234.8	882	235.5	882	235.8
881	235.1	881	235.8	881	236.8	881	237.0
880	249.3	880	250.0	880	250.9	880	251.0
879	244.0	879	245.1	879	245.8	879	246.3
878	199.4	878	200.9	878	202.4	878	203.3
877	166.5	877	168.0	877	169.8	877	170.7
876	199.1	876	200.8	876	202.3	876	203.2
875	77.4	875	79.3	875	81.5	875	83.2
874	77.8	874	79.6	874	81.7	874	83.5
873	95.7	873	97.2	873	99.0	873	100.5
872	78.2	872	80.1	872	82.3	872	84.0
871	251.3	871	252.1	871	252.8	871	253.3
870	249.3	870	250.1	870	250.8	870	251.2
869	208.3	869	209.1	869	210.3	869	210.9
868	210.6	868	211.3	868	212.5	868	213.0
867	165.6	867	167.1	867	169.1	867	170.1
866	166.9	866	168.3	866	170.2	866	171.2
865	166.4	865	168.0	865	169.9	865	170.8
864	74.3	864	75.5	864	77.1	864	78.4
863	74.1	863	75.3	863	77.0	863	78.2
862	89.2	862	90.2	862	91.6	862	92.6
861	74.4	861	75.6	861	77.2	861	78.5

DATE: 9/1/79		DATE: 9/15/79		DATE: 10/1/79		DATE: 10/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 5573		OPERATING HRS: 5909		OPERATING HRS: 6293		OPERATING HRS: 6629	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	204.2	891	204.8	891	203.3	891	203.1
890	215.2	890	215.5	890	214.2	890	213.6
889	169.8	889	170.9	889	170.5	889	169.7
888	166.1	888	166.9	888	165.9	888	164.7
887	173.9	887	174.8	887	174.5	887	173.5
886	89.3	886	89.8	886	90.0	886	88.7
885	89.5	885	89.8	885	90.4	885	89.2
884	103.0	884	103.3	884	103.3	884	101.9
883	89.8	883	90.3	883	90.7	883	89.4
882	234.1	882	234.3	882	233.6	882	231.2
881	235.5	881	235.8	881	234.5	881	233.2
880	249.7	880	249.8	880	248.7	880	246.9
879	244.9	879	244.8	879	243.7	879	242.6
878	202.8	878	203.0	878	202.3	878	201.6
877	171.4	877	172.0	877	172.0	877	172.3
876	202.5	876	202.8	876	202.0	876	201.3
875	84.6	875	85.0	875	85.8	875	86.2
874	84.8	874	85.4	874	85.8	874	86.3
873	101.3	873	101.5	873	101.9	873	102.1
872	85.2	872	85.7	872	86.2	872	86.5
871	252.5	871	252.3	871	251.6	871	250.7
870	250.6	870	250.3	870	249.4	870	248.6
869	211.1	869	211.2	869	210.9	869	210.8
868	213.3	868	213.2	868	212.8	868	212.6
867	170.9	867	171.5	867	171.5	867	171.6
866	172.0	866	172.5	866	172.4	866	172.7
865	171.6	865	172.1	865	172.2	865	172.4
864	79.8	864	80.7	864	81.3	864	82.1
863	79.7	863	80.6	863	81.2	863	82.0
862	93.6	862	94.3	862	94.5	862	95.2
861	79.9	861	80.9	861	81.5	861	82.3

TABLE D5-5 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 11/1/79		DATE: 11/15/79		DATE: 12/1/79		DATE: 12/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 7037		OPERATING HRS: 7373		OPERATING HRS: 7757		OPERATING HRS: 8093	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	200.1	891	196.4	891	193.0	891	191.1
890	210.3	890	206.9	890	203.0	890	201.0
889	166.3	889	163.2	889	159.9	889	158.0
888	161.2	888	157.9	888	154.6	888	152.7
887	169.9	887	166.8	887	163.2	887	161.2
886	84.7	886	80.9	886	76.9	886	74.3
885	85.5	885	81.9	885	78.0	885	75.4
884	97.7	884	93.8	884	89.7	884	87.3
883	85.4	883	81.5	883	77.4	883	74.9
882	227.3	882	224.0	882	220.0	882	217.6
881	229.6	881	225.9	881	222.2	881	219.8
880	243.6	880	240.0	880	236.2	880	234.0
879	239.5	879	236.4	879	232.7	879	229.8
878	199.1	878	196.5	878	193.3	878	190.8
877	171.7	877	170.8	877	169.3	877	168.0
876	198.8	876	196.0	876	192.7	876	190.2
875	85.3	875	84.2	875	82.5	875	80.6
874	85.4	874	84.3	874	82.7	874	80.9
873	100.9	873	99.5	873	97.5	873	95.5
872	85.7	872	84.4	872	82.8	872	80.9
871	248.7	871	246.0	871	243.1	871	240.8
870	246.6	870	243.9	870	241.1	870	238.8
869	209.9	869	208.7	869	207.1	869	205.2
868	211.6	868	210.4	868	208.8	868	207.0
867	170.9	867	170.1	867	168.8	867	167.1
866	171.9	866	171.0	866	169.9	866	168.3
865	171.6	865	170.7	865	169.3	865	167.6
864	81.9	864	81.8	864	81.8	864	80.9
863	81.8	863	81.9	863	81.7	863	80.8
862	94.8	862	94.3	862	94.1	862	92.9
861	82.1	861	82.1	861	82.1	861	81.2

DATE: 1/1/80		DATE: 1/15/80		DATE: 2/1/80		DATE: 2/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 8501		OPERATING HRS: 8837		OPERATING HRS: 9245		OPERATING HRS: 9581	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	188.4	891	185.4	891	182.7	891	182.0
890	197.6	890	195.6	890	193.2	890	192.1
889	155.1	889	152.1	889	149.6	889	148.2
888	149.8	888	147.7	888	145.3	888	144.3
887	158.0	887	156.1	887	153.7	887	152.1
886	71.3	886	69.2	886	67.5	886	67.0
885	72.4	885	70.3	885	68.2	885	67.5
884	84.2	884	82.0	884	80.3	884	79.7
883	71.8	883	69.6	883	67.9	883	67.3
882	214.2	882	212.4	882	209.4	882	208.0
881	216.7	881	214.1	881	211.3	881	210.2
880	230.4	880	228.3	880	225.3	880	224.0
879	226.9	879	224.9	879	221.8	879	220.4
878	187.9	878	186.0	878	183.3	878	182.0
877	166.3	877	164.9	877	163.2	877	162.0
876	187.5	876	185.4	876	182.9	876	181.5
875	78.6	875	77.0	875	75.1	875	73.9
874	78.9	874	77.3	874	75.5	874	74.3
873	93.4	873	91.7	873	89.7	873	88.5
872	78.9	872	77.3	872	75.5	872	74.3
871	237.8	871	235.7	871	232.9	871	231.5
870	235.9	870	233.9	870	231.3	870	229.8
869	203.4	869	201.7	869	199.7	869	198.5
868	205.1	868	203.4	868	201.3	868	200.1
867	165.6	867	164.9	867	163.0	867	160.9
866	166.7	866	165.3	866	163.6	866	162.5
865	166.1	865	164.7	865	162.9	865	161.8
864	80.1	864	79.1	864	78.0	864	77.2
863	79.9	863	79.0	863	77.9	863	77.0
862	91.9	862	90.8	862	89.7	862	88.7
861	80.3	861	79.3	861	78.1	861	77.3

TABLE D5-6 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 3/1/80		DATE: 3/15/80		DATE: 4/1/80		DATE: 4/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 9941		OPERATING HRS: 10,277		OPERATING HRS: 10,685		OPERATING HRS: 11,021	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	180.6	891	178.5	891	178.5	891	179.5
890	190.5	890	188.3	890	188.3	890	188.9
889	146.9	889	145.0	889	145.6	889	147.5
888	142.9	888	140.8	888	141.4	888	142.8
887	151.2	887	149.1	887	149.6	887	150.9
886	66.5	886	66.4	886	66.8	886	68.0
885	66.9	885	66.4	885	66.9	885	68.5
884	79.1	884	78.7	884	78.9	884	80.1
883	66.8	883	66.8	883	67.1	883	68.6
882	206.4	882	204.3	882	204.4	882	204.6
881	208.2	881	206.2	881	206.0	881	206.7
880	222.1	880	219.7	880	219.7	880	219.6
879	218.5	879	216.3	879	215.9	879	216.2
878	179.8	878	177.7	878	177.6	878	177.6
877	160.8	877	159.6	877	158.5	877	158.2
876	179.6	876	177.2	876	177.3	876	177.6
875	73.1	875	72.5	875	71.8	875	71.7
874	73.4	874	72.8	874	72.0	874	71.6
873	87.8	873	87.0	873	86.1	873	85.8
872	73.5	872	72.9	872	72.2	872	71.7
871	229.4	871	227.3	871	226.6	871	226.1
870	227.8	870	225.8	870	225.1	870	224.3
869	197.0	869	195.6	869	194.6	869	193.7
868	198.5	868	197.1	868	196.2	868	195.1
867	156.3	867	153.9	867	153.3	867	152.4
866	161.2	866	159.9	866	159.2	866	158.4
865	160.7	865	159.4	865	158.6	865	158.2
864	76.6	864	75.9	864	75.2	864	74.7
863	76.4	863	75.8	863	75.1	863	74.6
862	88.1	862	87.3	862	86.6	862	85.8
861	76.6	861	75.9	861	75.3	861	74.6

DATE: 5/1/80		DATE: 5/15/80		DATE: 6/1/80		DATE: 6/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 11,405		OPERATING HRS: 11,741		OPERATING HRS: 12,149		OPERATING HRS: 12,485	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	180.2	891	178.7	891	179.4	891	180.2
890	189.9	890	188.0	890	188.2	890	188.5
889	149.1	889	147.2	889	148.4	889	149.7
888	144.1	888	143.4	888	144.3	888	145.5
887	151.6	887	151.1	887	151.6	887	152.7
886	71.1	886	73.0	886	74.9	886	76.4
885	71.3	885	73.4	885	75.4	885	77.1
884	83.1	884	84.7	884	86.5	884	88.1
883	71.6	883	73.5	883	75.5	883	77.4
882	205.7	882	204.4	882	204.3	882	205.8
881	207.3	881	205.9	881	206.1	881	206.7
880	220.7	880	218.7	880	218.6	880	219.7
879	216.9	879	215.0	879	214.8	879	215.3
878	178.6	878	177.3	878	177.5	878	178.0
877	157.8	877	156.4	877	156.1	877	156.1
876	178.6	876	177.3	876	177.4	876	178.0
875	71.8	875	72.4	875	73.4	875	74.1
874	72.0	874	72.4	874	73.4	874	74.2
873	85.9	873	86.1	873	86.9	873	87.6
872	72.2	872	72.6	872	73.6	872	74.3
871	226.4	871	224.0	871	223.4	871	223.5
870	224.7	870	222.1	870	221.7	870	221.8
869	193.2	869	191.0	869	190.6	869	190.3
868	194.8	868	192.6	868	192.2	868	191.9
867	152.1	867	150.6	867	151.1	867	152.0
866	158.2	866	156.6	866	156.5	866	156.4
865	157.8	865	156.3	865	156.3	865	156.3
864	74.2	864	73.7	864	74.0	864	74.1
863	74.0	863	73.6	863	73.8	863	74.1
862	85.4	862	84.7	862	84.9	862	85.0
861	74.2	861	73.7	861	73.9	861	74.1

TABLE D5-7 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 7/1/80		DATE: 7/15/80		DATE: 8/1/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 12,869		OPERATING HRS: 13,205		OPERATING HRS: 13,613	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	183.2	891	183.4	891	186.9
890	191.9	890	192.1	890	195.9
889	153.2	889	154.4	889	157.9
888	149.0	888	150.1	888	153.8
887	156.3	887	157.3	887	161.0
886	80.3	886	82.8	886	86.8
885	80.6	885	83.1	885	86.8
884	91.8	884	94.1	884	98.1
883	81.3	883	83.7	883	87.6
882	208.9	882	209.1	882	212.8
881	210.2	881	210.6	881	214.1
880	222.7	880	222.9	880	226.5
879	218.0	879	218.4	879	221.8
878	180.7	878	181.3	878	184.6
877	157.3	877	157.6	877	159.2
876	180.7	876	181.3	876	184.7
875	75.7	875	77.1	875	79.5
874	75.8	874	77.1	874	79.6
873	89.2	873	90.4	873	92.7
872	76.1	872	77.4	872	80.0
871	225.6	871	225.6	871	228.0
870	223.7	870	223.8	870	226.3
869	191.2	869	191.2	869	193.2
868	192.9	868	192.8	868	194.8
867	153.5	867	153.8	867	156.5
866	157.5	866	157.6	866	159.9
865	157.3	865	157.6	865	159.8
864	74.7	864	75.1	864	77.2
863	74.6	863	75.0	863	76.8
862	85.6	862	85.8	862	88.0
861	74.8	861	75.1	861	77.1

TABLE D5-8

DRYWELL 5 THERMOCOUPLE LOCATIONS
PHASE II: FUEL ASSEMBLY D22

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
861	203.5	120	150	Instrumentation Well A*
862	203.5	60	90	Instrumentation Well B
863	203.5	120	90	Instrumentation Well C
864	203.5	120	30	Instrumentation Well D
865	205.75	9	30	Liner
866	77.75	9	210	Liner
867**				None Installed
868	206.0	7	30	Canister
869	206.0	7	210	Canister
870†	18.75			Coiled in Upper Annulus
871†	18.75			Coiled in Upper Annulus
872	143.5	120	150	Instrumentation Well A
873	143.5	60	90	Instrumentation Well B
874	143.5	120	90	Instrumentation Well C
875	143.5	120	30	Instrumentation Well D
876	145.75	9	0	Liner
877**				None Installed
878	145.75	9	90	Liner
879	146.0	7	0	Canister
880	146.0	7	180	Canister
881†	18.75			Coiled in Upper Annulus
882†	18.75			Coiled in Upper Annulus
883	83.5	120	150	Instrumentation Well A
884	83.5	60	90	Instrumentation Well B
885	83.5	120	90	Instrumentation Well C
886	83.5	120	30	Instrumentation Well D
887	85.75	9	330	Liner
888**				None Installed
889	85.75	9	90	Liner
890	86.0	7	330	Canister
891	86.0	7	150	Canister

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* See Figure D-1 for Instrumentation Well identification

**Broken thermocouples were not replaced

† These thermocouples not installed since canister has only six instrumentation tubes, not ten

TABLE D5-9 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 9/4/80		DATE: 9/5/80		DATE: 9/6/80		DATE: 9/7/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 1		OPERATING HRS: 25		OPERATING HRS: 49		OPERATING HRS: 73	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	95.4	891	203.6	891	219.7	891	228.5
890	124.7	890	211.6	890	225.1	890	233.6
889	112.6	889	144.2	889	158.7	889	167.8
888		888		888		888	
887	114.9	887	144.1	887	157.6	887	166.2
886	87.9	886	87.7	886	87.5	886	87.4
885	87.5	885	87.4	885	87.3	885	87.2
884	90.8	884	90.4	884	90.3	884	90.4
883	88.0	883	87.9	883	87.7	883	87.6
882		882		882		882	
881		881		881		881	
880	100.9	880	239.8	880	258.3	880	270.1
879	96.5	879	231.4	879	249.4	879	260.7
878	115.1	878	160.2	878	182.4	878	196.6
877		877		877		877	
876	116.1	876	159.2	876	181.0	876	194.9
875	81.3	875	81.4	875	81.4	875	81.3
874	81.5	874	81.4	874	81.4	874	81.3
873	85.2	873	85.1	873	85.0	873	85.0
872	81.8	872	81.7	872	81.7	872	81.6
871		871		871		871	
870		870		870		870	
869	117.6	869	189.8	869	206.3	869	217.0
868	111.1	868	189.8	868	206.4	868	217.0
867		867		867		867	
866	103.6	866	128.5	866	141.1	866	148.8
865	100.4	865	133.7	865	151.7	865	163.7
864	77.9	864	77.7	864	77.7	864	77.6
863	77.5	863	77.6	863	77.5	863	77.3
862	81.7	862	81.5	862	81.4	862	81.1
861	77.5	861	77.6	861	77.7	861	77.5

DATE: 9/8/80		DATE: 9/9/80		DATE: 9/15/80		DATE: 10/1/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 97		OPERATING HRS: 121		OPERATING HRS: 265		OPERATING HRS: 649	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	234.9	891	239.2	891	253.6	891	267.4
890	239.1	890	243.7	890	258.1	890	271.4
889	174.4	889	178.9	889	197.2	889	215.6
888		888		888		888	
887	172.4	887	177.6	887	194.8	887	212.0
886	87.3	886	87.2	886	86.5	886	86.5
885	87.1	885	86.9	885	86.4	885	86.6
884	90.8	884	91.3	884	95.5	884	102.2
883	87.6	883	87.4	883	86.8	883	86.9
882		882		882		882	
881		881		881		881	
880	278.3	880	284.1	880	303.0	880	318.8
879	268.9	879	274.7	879	293.6	879	308.9
878	206.7	878	214.1	878	237.4	878	256.2
877		877		877		877	
876	204.8	876	212.1	876	235.2	876	254.0
875	81.3	875	81.2	875	81.1	875	82.5
874	81.3	874	81.1	874	81.1	874	82.5
873	85.3	873	85.6	873	90.5	873	100.1
872	61.6	872	81.4	872	81.4	872	82.8
871		871		871		871	
870		870		870		870	
869	224.9	869	230.8	869	250.0	869	265.4
868	224.9	868	230.8	868	250.0	868	265.4
867		867		867		867	
866	154.6	866	158.8	866	173.5	866	189.4
865	172.5	865	179.4	865	201.5	865	219.6
864	77.5	864	77.4	864	77.6	864	79.1
863	77.2	863	77.2	863	77.3	863	78.7
862	81.2	862	81.3	862	84.6	862	92.4
861	77.4	861	77.3	861	77.5	861	78.9

TABLE D5-10 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 10/15/80		DATE: 11/1/80		DATE: 11/15/80		DATE: 12/1/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 985		OPERATING HRS: 1393		OPERATING HRS: 1729		OPERATING HRS: 2113	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	272.3	891	269.9	891	269.4	891	266.0
890	275.5	890	273.9	890	273.2	890	269.5
889	221.7	889	221.8	889	221.3	889	218.0
888		888		888		888	
887	214.7	887	214.5	887	213.3	887	212.9
886	87.9	886	85.6	886	83.6	886	79.8
885	88.3	885	86.4	885	84.5	885	81.0
884	105.5	884	103.7	884	102.0	884	98.2
883	88.6	883	86.2	883	84.3	883	80.5
882		882		882		882	
881		881		881		881	
880	323.2	880	322.3	880	321.3	880	318.1
879	313.6	879	312.4	879	311.6	879	308.2
878	261.7	878	261.8	878	261.6	878	258.6
877		877		877		877	
876	259.3	876	259.5	876	259.2	876	256.3
875	84.5	875	86.0	875	85.8	875	85.1
874	84.5	874	85.9	874	86.0	874	85.3
873	104.4	873	106.6	873	106.7	873	105.9
872	84.8	872	86.2	872	86.1	872	85.4
871		871		871		871	
870		870		870		870	
869	271.0	869	272.3	869	272.3	869	271.0
868	270.8	868	272.2	868	272.2	868	270.8
867		867		867		867	
866	195.8	866	194.8	866	194.8	866	191.2
865	226.0	865	228.6	865	228.7	865	227.8
864	81.5	864	83.2	864	84.1	864	84.5
863	81.3	863	83.0	863	83.8	863	84.2
862	97.0	862	99.5	862	100.6	862	100.9
861	81.6	861	83.4	861	84.3	861	84.7

DATE: 12/15/80		DATE: 1/1/81		DATE: 1/15/81		DATE: 2/1/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 2449		OPERATING HRS: 2857		OPERATING HRS: 3193		OPERATING HRS: 3601	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	262.5	891	260.2	891	258.4	891	254.5
890	266.3	890	264.6	890	262.9	890	259.3
889	215.7	889	214.4	889	213.2	889	210.0
888		888		888		888	
887	211.2	887	210.3	887	209.2	887	206.1
886	77.4	886	76.8	886	75.1	886	73.7
885	78.7	885	77.1	885	76.3	885	75.1
884	95.7	884	94.3	884	93.4	884	91.7
883	78.1	883	76.5	883	75.8	883	74.5
882		882		882		882	
881		881		881		881	
880	315.1	880	312.7	880	310.4	880	306.6
879	305.1	879	302.9	879	300.6	879	296.8
878	255.9	878	253.9	878	252.0	878	248.9
877		877		877		877	
876	253.6	876	251.7	876	250.0	876	246.8
875	84.0	875	82.5	875	81.7	875	80.7
874	84.2	874	82.8	874	82.0	874	80.9
873	104.7	873	103.1	873	102.2	873	101.0
872	84.2	872	82.8	872	82.0	872	80.8
871		871		871		871	
870		870		870		870	
869	71.6	869	267.2	869	265.4	869	263.1
868	269.2	868	267.0	868	265.2	868	262.7
867		867		867		867	
866	269.1	866	188.0	866	186.4	866	183.5
865	188.7	865	224.8	865	223.3	865	221.5
864	226.5	864	83.9	864	83.4	864	82.7
863	84.4	863	83.7	863	83.2	863	82.7
862	84.2	862	100.0	862	99.3	862	98.6
861	100.6	861	84.0	861	83.4	861	82.9

TABLE D5-11 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 2/15/81
TIME: 4:00 p.m.
OPERATING HRS: 3937

T/C No.	Temp(°F)
891	251.4
890	255.8
889	207.7
888	
887	203.6
886	72.3
885	73.0
884	90.1
883	72.6
882	
881	
880	304.2
879	293.3
878	245.8
877	
876	244.0
875	79.3
874	79.9
873	99.5
872	80.0
871	
870	
869	259.5
868	259.8
867	
866	181.2
865	218.1
864	81.7
863	81.2
862	97.2
861	81.5

DATE: 3/1/81
TIME: 4:00 p.m.
OPERATING HRS: 4273

T/C No.	Temp(°F)
891	251.0
890	254.7
889	207.8
888	
887	203.6
886	73.0
885	73.9
884	90.7
883	73.7
882	
881	
880	302.4
879	291.9
878	244.3
877	
876	242.1
875	78.4
874	78.8
873	98.5
872	78.7
871	
870	
869	258.6
868	258.8
867	
866	181.7
865	217.5
864	81.5
863	81.4
862	96.8
861	81.6

DATE: 3/15/81
TIME: 4:00 p.m.
OPERATING HRS: 4609

T/C No.	Temp(°F)
891	248.6
890	252.9
889	206.1
888	
887	204.7
886	72.2
885	73.0
884	89.4
883	72.8
882	
881	
880	299.8
879	289.0
878	241.9
877	
876	239.9
875	78.0
874	78.2
873	97.8
872	78.3
871	
870	
869	256.2
868	256.6
867	
866	180.0
865	215.5
864	80.9
863	80.8
862	96.1
861	81.0

DATE: 4/1/81
TIME: 4:00 p.m.
OPERATING HRS: 5017

T/C No.	Temp(°F)
891	247.6
890	251.2
889	205.7
888	
887	201.6
886	72.8
885	73.5
884	89.9
883	73.4
882	
881	
880	297.4
879	287.1
878	240.2
877	
876	238.2
875	77.3
874	77.6
873	96.8
872	77.6
871	
870	
869	254.2
868	254.4
867	
866	179.7
865	213.6
864	80.2
863	80.1
862	95.3
861	80.3

DATE: 4/15/81
TIME: 4:00 p.m.
OPERATING HRS: 5353

T/C No.	Temp(°F)
891	248.6
890	251.9
889	206.5
888	
887	202.9
886	74.3
885	74.9
884	91.2
883	75.0
882	
881	
880	296.9
879	286.6
878	240.3
877	
876	238.4
875	77.5
874	77.6
873	96.9
872	77.6
871	
870	
869	252.7
868	252.8
867	
866	181.3
865	212.7
864	79.9
863	79.7
862	94.9
861	79.9

DATE: 5/1/81
TIME: 4:00 p.m.
OPERATING HRS: 5737

T/C No.	Temp(°F)
891	249.7
890	253.3
889	207.8
888	
887	204.3
886	77.3
885	77.6
884	94.0
883	77.8
882	
881	
880	296.4
879	286.6
878	240.6
877	
876	238.9
875	78.0
874	78.2
873	97.1
872	78.4
871	
870	
869	251.4
868	251.5
867	
866	183.6
865	211.7
864	79.8
863	79.5
862	94.8
861	79.6

DATE: 5/15/81
TIME: 4:00 p.m.
OPERATING HRS: 6073

T/C No.	Temp(°F)
891	249.9
890	253.6
889	209.3
888	
887	205.8
886	80.6
885	80.8
884	96.9
883	81.1
882	
881	
880	296.1
879	286.5
878	240.7
877	
876	238.8
875	78.9
874	79.0
873	97.9
872	79.1
871	
870	
869	250.6
868	250.7
867	
866	184.9
865	211.2
864	79.8
863	79.5
862	94.5
861	79.6

DATE: 6/1/81
TIME: 4:00 p.m.
OPERATING HRS: 6481

T/C No.	Temp(°F)
891	249.4
890	251.8
889	209.0
888	
887	204.7
886	82.1
885	82.4
884	98.2
883	82.5
882	
881	
880	293.1
879	283.7
878	239.2
877	
876	237.4
875	80.5
874	80.7
873	99.2
872	80.9
871	
870	
869	248.4
868	248.6
867	
866	184.6
865	210.2
864	80.4
863	80.0
862	95.0
861	80.2

TABLE D5-12 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 6/15/81
TIME: 4:00 p.m.
OPERATING HRS: 6817

T/C No.	Temp(°F)
891	249.4
890	253.6
889	211.0
888	
887	207.5
886	85.0
885	85.4
884	101.1
883	85.9
882	
881	
880	293.2
879	283.9
878	239.6
877	
876	237.8
875	81.4
874	81.5
873	99.7
872	81.7
871	
870	
869	247.6
868	247.7
867	
866	187.0
865	209.7
864	80.8
863	80.5
862	95.3
861	80.6

DATE: 7/1/81
TIME: 4:00 p.m.
OPERATING HRS: 7201

T/C No.	Temp(°F)
891	250.6
890	254.8
889	212.6
888	
887	209.3
886	88.7
885	88.9
884	104.4
883	89.5
882	
881	
880	293.5
879	284.3
878	240.3
877	
876	238.7
875	83.0
874	83.1
873	101.1
872	83.5
871	
870	
869	246.5
868	246.8
867	
866	189.1
865	209.2
864	81.2
863	80.8
862	95.6
861	80.9

DATE: 7/15/82
TIME: 4:00 p.m.
OPERATING HRS: 7537

T/C No.	Temp(°F)
891	250.7
890	254.4
889	212.9
888	
887	209.7
886	91.6
885	91.7
884	107.0
883	92.4
882	
881	
880	293.5
879	284.2
878	240.4
877	
876	239.0
875	84.7
874	84.9
873	102.6
872	85.2
871	
870	
869	245.8
868	246.0
867	
866	189.8
865	208.8
864	81.8
863	81.5
862	96.1
861	81.6

DATE: 8/1/81
TIME: 4:00 p.m.
OPERATING HRS: 7945

T/C No.	Temp(°F)
891	251.1
890	254.8
889	211.6
888	
887	208.3
886	92.0
885	92.2
884	107.2
883	92.7
882	
881	
880	290.9
879	285.3
878	242.1
877	
876	240.6
875	88.7
874	88.7
873	106.1
872	89.0
871	
870	
869	246.6
868	246.6
867	
866	191.4
865	209.9
864	84.4
863	84.1
862	98.4
861	84.3

DATE: 8/15/81
TIME: 4:00 p.m.
OPERATING HRS: 8281

T/C No.	Temp(°F)
891	250.0
890	253.6
889	211.0
888	
887	207.5
886	93.0
885	93.1
884	107.9
883	93.7
882	
881	
880	289.8
879	284.1
878	241.4
877	
876	239.9
875	89.9
874	90.0
873	107.0
872	90.4
871	
870	
869	245.9
868	246.0
867	
866	191.1
865	209.5
864	85.5
863	85.2
862	99.3
861	85.4

DATE: 9/1/81
TIME: 4:00 p.m.
OPERATING HRS: 8689

T/C No.	Temp(°F)
891	249.3
890	252.4
889	210.1
888	
887	206.6
886	93.5
885	93.5
884	108.0
883	94.0
882	
881	
880	288.3
879	283.2
878	240.6
877	
876	239.1
875	91.1
874	91.1
873	107.9
872	91.5
871	
870	
869	245.0
868	245.1
867	
866	190.5
865	208.8
864	86.5
863	86.2
862	100.0
861	86.4

DATE: 9/21/81
TIME: 4:00 p.m.
OPERATING HRS: 9169

T/C No.	Temp(°F)
891	245.2
890	248.1
889	206.6
888	
887	202.9
886	92.6
885	92.7
884	106.5
883	93.0
882	
881	
880	285.4
879	280.5
878	238.6
877	
876	237.0
875	92.9
874	92.8
873	109.2
872	93.1
871	
870	
869	243.5
868	243.6
867	
866	186.7
865	207.5
864	87.6
863	87.2
862	100.6
861	87.5

DATE: 10/1/81
TIME: 4:00 p.m.
OPERATING HRS: 9409

T/C No.	Temp(°F)
891	243.3
890	245.8
889	204.6
888	
887	200.9
886	91.6
885	92.0
884	105.4
883	92.4
882	
881	
880	283.6
879	278.9
878	236.8
877	
876	235.3
875	92.9
874	92.8
873	109.1
872	93.2
871	
870	
869	242.4
868	242.3
867	
866	184.5
865	206.6
864	87.8
863	87.6
862	100.8
861	87.9

TABLE D5-13 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 10/15/81		DATE: 11/1/81		DATE: 11/15/81		DATE: 12/1/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 9745		OPERATING HRS: 10,153		OPERATING HRS: 10,489		OPERATING HRS: 10,873	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	238.7	891	233.5	891	231.6	891	226.3
890	241.8	890	237.5	890	234.8	890	230.1
889	200.6	889	195.9	889	193.5	889	188.6
888		888		888		888	
887	196.9	887	192.8	887	190.2	887	185.3
886	89.0	886	84.8	886	82.5	886	79.6
885	89.6	885	85.7	885	83.4	885	80.4
884	102.6	884	98.4	884	96.0	884	92.9
883	89.8	883	85.5	883	83.0	883	79.9
882		882		882		882	
881		881		881		881	
880	280.1	880	275.8	880	273.4	880	269.1
879	275.0	879	271.0	879	268.5	879	264.0
878	233.5	878	229.8	878	227.3	878	223.3
877		877		877		877	
876	231.8	876	228.2	876	225.7	876	221.8
875	92.5	875	91.0	875	89.7	875	88.0
874	92.4	874	91.0	874	89.8	874	88.3
873	108.4	873	106.6	873	105.2	873	103.4
872	92.7	872	91.1	872	89.8	872	88.3
871		871		871		871	
870		870		870		870	
869	240.9	869	238.5	869	236.7	869	234.3
868	240.8	868	238.5	868	236.8	868	234.5
867		867		867		867	
866	180.0	866	175.7	866	173.5	866	168.6
865	205.0	865	202.9	865	201.1	865	198.9
864	88.0	864	88.0	864	87.8	864	87.2
863	87.8	863	87.8	863	87.5	863	86.9
862	100.6	862	100.4	862	100.0	862	99.2
861	88.2	861	88.1	861	87.8	861	87.2

DATE: 12/15/81		DATE: 1/1/82		DATE: 1/15/82		DATE: 2/1/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 11,209		OPERATING HRS: 11,617		OPERATING HRS: 11,953		OPERATING HRS: 12,361	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	223.6	891	219.3	891	216.3	891	212.6
890	227.1	890	223.5	890	219.2	890	216.7
889	185.5	889	181.7	889	178.6	889	176.1
888		888		888		888	
887	182.2	887	178.6	887	175.0	887	173.1
886	75.9	886	73.0	886	70.0	886	67.9
885	76.7	885	73.9	885	70.9	885	68.9
884	89.3	884	86.2	884	83.2	884	81.2
883	76.2	883	73.3	883	70.2	883	68.3
882		882		882		882	
881		881		881		881	
880	265.9	880	262.4	880	257.4	880	254.8
879	260.6	879	257.1	879	252.1	879	249.5
878	220.0	878	216.5	878	212.6	878	209.4
877		877		877		877	
876	218.5	876	214.8	876	210.9	876	207.9
875	86.3	875	84.2	875	82.5	875	80.4
874	86.6	874	84.5	874	82.8	874	80.6
873	101.6	873	99.3	873	97.5	873	95.3
872	86.5	872	84.3	872	82.7	872	80.5
871		871		871		871	
870		870		870		870	
869	232.1	869	229.6	869	226.5	869	224.0
868	232.2	868	229.7	868	226.6	868	224.1
867		867		867		867	
866	165.8	866	161.8	866	158.6	866	156.5
865	196.9	865	194.4	865	192.1	865	189.6
864	86.6	864	85.5	864	84.6	864	83.3
863	86.3	863	85.3	863	84.3	863	83.1
862	98.5	862	97.3	862	96.4	862	94.9
861	86.6	861	85.5	861	84.6	861	83.3

TABLE D5-14 DRYWELL NO. 5 THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 2/15/82		DATE: 3/1/82		DATE: 3/15/82		DATE: 3/31/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 12,697		OPERATING HRS: 13,033		OPERATING HRS: 13,369		OPERATING HRS: 13,753	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
891	211.0	891	212.2	891	212.0	891	207.9
890	214.7	890	215.5	890	214.7	890	211.2
889	174.1	889	175.4	889	175.2	889	172.0
888		888		888		888	
887	171.1	887	172.2	887	171.8	887	168.7
886	66.7	886	67.5	886	68.5	886	68.0
885	67.6	885	68.3	885	69.2	885	68.4
884	79.8	884	80.8	884	81.7	884	80.8
883	66.9	883	67.9	883	68.9	883	68.3
882		882		882		882	
881		881		881		881	
880	252.0	880	251.5	880	250.2	880	246.9
879	247.0	879	246.1	879	245.0	879	242.0
878	207.2	878	206.6	878	205.6	878	203.3
877		877		877		877	
876	205.7	876	204.9	876	204.0	876	201.7
875	78.9	875	77.8	875	77.4	875	77.2
874	79.3	874	78.1	874	77.7	874	77.4
873	93.9	873	92.7	873	92.3	873	91.9
872	79.1	872	78.0	872	77.6	872	77.3
871		871		871		871	
870		870		870		870	
869	221.8	869	220.4	869	218.9	869	216.8
868	221.9	868	220.4	868	218.9	868	216.8
867		867		867		867	
866	154.5	866	156.5	866	156.3	866	152.7
865	187.6	865	186.5	865	185.1	865	183.5
864	82.2	864	81.3	864	80.4	864	79.8
863	82.0	863	81.1	863	80.1	863	79.5
862	93.8	862	92.9	862	92.0	862	91.2
861	82.1	861	81.2	861	80.4	861	79.7

TABLE D3-1

DRYWELL 3 THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
824	203.5	120	150	Instrumentation Well E*
825	203.5	60	90	Instrumentation Well F
826	203.5	120	90	Instrumentation Well G
827	203.5	120	30	Instrumentation Well H
828	205.75	9	30	Liner
829	205.75	9	210	Liner
830	205.75	9	90	Liner
831	206.0	7	30	Canister
832	206.0	7	210	Canister
833	176.0	7	15	Canister
834	176.0	7	195	Canister
835	143.5	120	150	Instrumentation Well E
836	143.5	60	90	Instrumentation Well F
837	143.5	120	90	Instrumentation Well G
838	143.5	120	30	Instrumentation Well H
839	145.75	9	0	Liner
840	145.75	9	180	Liner
841	145.75	9	90	Liner
842	146.0	7	0	Canister
843	146.0	7	180	Canister
844	116.0	7	345	Canister
845	116.0	7	165	Canister
846	83.5	120	150	Instrumentation Well E
847	83.5	60	90	Instrumentation Well F
848	83.5	120	90	Instrumentation Well G
849	83.5	120	30	Instrumentation Well H
850	85.75	9	330	Liner
851	85.75	9	150	Liner
852	85.75	9	90	Liner
853	86.0	7	330	Canister
854	86.0	7	150	Canister

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*See Figure D-1 for Instrumentation Well identification

TABLE D3-2 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 1/25/79
TIME: 8:32 a.m.
OPERATING HRS: 16.5

T/C No.	Temp(°F)
854	35.6
853	35.6
852	35.6
851	35.3
850	35.6
849	52.7
848	53.3
847	52.9
846	52.6
845	35.5
844	35.6
843	35.4
842	35.6
841	35.8
840	35.4
839	34.8
838	60.5
837	60.6
836	60.1
835	60.4
834	34.8
833	34.6
832	34.8
831	34.8
830	34.9
829	35.1
828	35.4
827	65.6
826	69.4
825	65.2
824	65.6

DATE: 1/25/79
TIME: 4:00 p.m.
OPERATING HRS: 24

T/C No.	Temp(°F)
854	128.9
853	150.6
852	83.2
851	81.0
850	84.0
849	52.6
848	53.2
847	52.8
846	52.5
845	134.9
844	159.6
843	170.6
842	171.0
841	98.5
840	98.8
839	98.2
838	60.4
837	60.5
836	60.0
835	60.2
834	172.9
833	147.1
832	112.7
831	129.0
830	86.5
829	
828	88.3
827	65.5
826	69.2
825	65.0
824	65.4

DATE: 1/26/79
TIME: 4:00 p.m.
OPERATING HRS: 48

T/C No.	Temp(°F)
854	137.4
853	159.9
852	92.7
851	89.7
850	94.0
849	52.4
848	53.1
847	52.8
846	52.4
845	145.8
844	169.1
843	181.1
842	182.0
841	111.0
840	111.2
839	110.6
838	60.3
837	60.4
836	60.0
835	60.1
834	184.1
833	160.8
832	120.3
831	137.1
830	95.8
829	
828	97.3
827	65.4
826	69.1
825	65.0
824	65.4

DATE: 1/27/79
TIME: 4:00 p.m.
OPERATING HRS: 72

T/C No.	Temp(°F)
854	143.1
853	166.3
852	98.7
851	95.9
840	100.2
849	52.4
848	53.1
847	53.0
846	52.4
845	151.4
844	175.3
843	187.6
842	188.8
841	118.8
840	118.8
839	118.3
838	60.3
837	60.4
836	60.2
835	60.0
834	190.6
833	168.1
832	125.5
831	142.5
830	101.3
829	
828	103.2
827	65.4
826	65.4
825	65.2
824	65.3

DATE: 1/28/79
TIME: 4:00 p.m.
OPERATING HRS: 96

T/C No.	Temp(°F)
854	147.7
853	170.5
852	103.1
851	100.1
850	104.6
849	52.3
848	53.0
847	53.3
846	52.3
845	155.4
844	179.8
843	192.0
842	193.7
841	124.3
840	124.2
839	123.7
838	60.2
837	60.2
836	60.6
835	60.0
834	195.6
833	173.9
832	129.1
831	146.1
830	105.5
829	
828	107.4
827	65.3
826	65.3
825	65.4
824	65.2

DATE: 1/29/79
TIME: 4:00 p.m.
OPERATING HRS: 120

T/C No.	Temp(°F)
854	151.4
853	173.3
852	106.6
851	103.4
850	108.1
849	52.2
848	52.8
847	53.7
846	52.2
845	157.9
844	182.8
843	195.6
842	196.9
841	128.4
840	128.3
839	127.7
838	60.1
837	60.1
836	61.2
835	59.9
834	198.9
833	175.8
832	132.0
831	148.9
830	108.8
829	
828	110.5
827	65.2
826	65.2
825	65.9
824	65.1

DATE: 2/1/79
TIME: 4:00 p.m.
OPERATING HRS: 192

T/C No.	Temp(°F)
854	154.9
853	179.8
852	113.1
851	109.9
850	114.8
849	51.7
848	52.3
847	55.3
846	51.6
845	163.4
844	189.2
843	202.4
842	203.6
841	136.5
840	136.4
839	135.9
838	59.7
837	59.7
836	63.7
835	59.5
834	205.8
833	184.1
832	137.8
831	154.6
830	115.3
829	
828	117.2
827	64.8
826	64.9
825	67.5
824	64.8

DATE: 2/15/79
TIME: 4:00 p.m.
OPERATING HRS: 528

T/C No.	Temp(°F)
854	169.7
853	192.5
852	127.7
851	124.3
840	129.2
849	51.8
848	52.5
847	62.8
846	51.8
845	177.3
844	203.2
843	216.8
842	218.6
841	153.6
840	153.6
839	153.0
838	60.5
837	60.5
836	74.7
835	60.4
834	221.4
833	199.5
832	152.0
831	168.1
830	130.9
829	
828	132.1
827	65.5
826	65.8
825	75.6
824	65.7

TABLE D3-3 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 3/1/79
TIME: 4:00 p.m.
OPERATING HRS: 864

T/C No.	Temp(°F)
854	179.6
853	197.0
852	133.5
851	130.2
850	134.4
849	54.4
848	54.6
847	68.7
846	54.3
845	188.0
844	207.8
843	221.9
842	224.2
841	160.7
840	160.2
839	160.2
838	61.9
837	62.3
836	80.0
835	62.1
834	228.2
833	207.6
832	158.6
831	174.4
830	138.3
829	
828	139.0
827	66.5
826	66.3
825	79.9
824	66.0

DATE: 3/15/79
TIME: 4:00 p.m.
OPERATING HRS: 1200

T/C No.	Temp(°F)
854	179.7
853	201.6
852	138.5
851	135.2
850	139.5
849	57.9
848	58.2
847	73.4
846	58.0
845	192.0
844	212.4
843	226.5
842	228.4
841	166.0
840	165.6
839	165.5
838	63.7
837	63.8
836	83.6
835	63.5
834	233.0
833	213.8
832	162.9
831	178.3
830	143.4
829	
828	145.0
827	67.7
826	67.8
825	82.8
824	67.5

DATE: 4/1/79
TIME: 4:00 p.m.
OPERATING HRS: 1608

T/C No.	Temp(°F)
854	180.6
853	202.9
852	140.7
851	137.4
850	141.8
849	60.8
848	61.1
847	77.1
846	60.8
845	193.1
844	214.4
843	229.2
842	231.9
841	170.3
840	170.4
839	169.7
838	65.3
837	65.7
836	86.1
835	65.4
834	236.5
833	219.2
832	176.1
831	181.5
830	147.9
829	151.5
828	150.2
827	68.9
826	68.9
825	84.9
824	68.5

DATE: 4/15/79
TIME: 4:00 p.m.
OPERATING HRS: 1944

T/C No.	Temp(°F)
854	181.7
853	205.3
852	142.9
851	139.5
840	143.8
849	63.0
848	63.0
847	79.4
846	62.9
845	196.2
844	217.0
843	232.0
842	234.5
841	173.4
840	174.2
839	173.7
838	67.1
837	67.5
836	88.1
835	67.3
834	239.7
833	221.1
832	178.8
831	184.2
830	151.6
829	154.9
828	153.4
827	69.8
826	69.8
825	86.1
824	69.4

DATE: 5/1/79
TIME: 4:00 p.m.
OPERATING HRS: 2328

T/C No.	Temp(°F)
854	192.7
853	202.9
852	143.2
851	139.9
850	144.5
849	66.7
848	66.4
847	82.9
846	66.3
845	215.1
844	221.4
843	233.3
842	235.0
841	177.4
840	177.9
839	177.0
838	68.5
837	68.8
836	89.5
835	68.7
834	244.2
833	241.3
832	203.1
831	203.5
830	162.9
829	167.1
828	163.3
827	70.5
826	70.6
825	86.9
824	70.3

DATE: 5/16/79
TIME: 8:00 a.m.
OPERATING HRS: 2692

T/C No.	Temp(°F)
854	194.4
853	204.8
852	145.4
851	142.0
850	146.9
849	69.8
848	69.6
847	86.0
846	69.8
845	216.9
844	223.7
843	234.7
842	237.3
841	180.9
840	181.5
839	180.3
838	70.6
837	70.7
836	91.3
835	70.6
834	246.2
833	243.2
832	205.0
831	205.2
830	166.1
829	169.6
828	165.9
827	71.0
826	71.4
825	87.4
824	71.1

DATE: 6/1/79
TIME: 4:00 p.m.
OPERATING HRS: 3072

T/C No.	Temp(°F)
854	198.6
853	207.5
852	153.9
851	151.0
850	153.9
849	74.7
848	74.2
847	90.7
846	74.6
845	220.6
844	226.3
843	238.2
842	240.2
841	186.0
840	186.6
839	186.0
838	72.6
837	73.0
836	93.0
835	72.8
834	248.8
833	245.9
832	206.1
831	206.7
830	159.3
829	163.0
828	161.5
827	72.3
826	72.4
825	88.6
824	72.0

DATE: 6/15/79
TIME: 4:00 p.m.
OPERATING HRS: 3408

T/C No.	Temp(°F)
854	200.9
853	209.8
852	156.4
851	153.9
840	156.6
849	78.5
848	78.0
847	94.1
846	78.4
845	223.0
844	229.0
843	240.4
842	242.6
841	189.2
840	189.7
839	189.0
838	75.0
837	75.2
836	95.1
835	75.2
834	250.6
833	247.8
832	207.7
831	208.2
830	161.4
829	165.0
828	163.4
827	73.3
826	73.5
825	89.5
824	73.2

TABLE D3-4 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 7/1/79		DATE: 7/15/79		DATE: 8/1/79		DATE: 8/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 3792		OPERATING HRS: 4128		OPERATING HRS: 4536		OPERATING HRS: 4872	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	202.3	854	203.7	854	205.1	854	204.6
853	211.1	853	212.3	853	213.4	853	213.9
852	158.8	852	160.4	852	162.1	852	162.9
851	155.8	851	157.6	851	159.4	851	159.9
850	158.6	850	160.4	850	162.1	840	162.9
849	81.3	849	83.8	849	86.8	849	88.7
848	80.9	848	83.3	848	86.2	848	88.2
847	96.6	847	96.7	847	101.3	847	103.0
846	80.4	846	83.7	846	86.7	846	88.6
845	224.5	845	226.0	845	226.8	845	227.5
844	230.5	844	231.6	844	232.8	844	233.2
843	242.0	843	243.0	843	244.2	843	244.9
842	244.2	842	245.5	842	246.2	842	247.0
841	191.5	841	193.2	841	195.0	841	196.2
840	192.5	840	194.4	840	196.3	840	197.7
839	191.3	839	193.0	839	194.8	839	196.2
838	77.6	838	79.5	838	81.8	838	83.6
837	77.5	837	79.4	837	81.7	837	83.4
836	97.2	836	98.7	836	100.6	836	102.0
835	77.7	835	79.6	835	81.9	835	83.7
834	252.2	834	252.8	834	253.6	834	254.2
833	249.1	833	250.0	833	250.7	833	251.4
832	208.8	832	209.4	832	210.2	832	210.8
831	209.2	831	209.9	831	210.8	831	211.3
830	163.4	830	164.8	830	166.1	830	167.1
829	166.7	829	168.1	829	169.6	829	170.4
828	165.2	828	166.8	828	168.3	828	170.3
827	74.6	827	75.7	827	77.3	827	78.6
826	74.7	826	76.0	826	77.5	826	78.7
825	90.5	825	91.6	825	92.8	825	93.8
824	74.6	824	75.8	824	77.3	824	78.6

DATE: 9/1/79		DATE: 9/15/79		DATE: 10/1/79		DATE: 10/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 5280		OPERATING HRS: 5616		OPERATING HRS: 6000		OPERATING HRS: 6336	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	203.1	854	202.9	854	201.1	854	200.3
853	212.7	853	213.1	853	212.3	853	211.1
852	161.6	852	162.2	852	161.1	852	160.5
851	158.7	851	159.2	851	158.2	851	157.6
850	162.0	850	162.7	850	162.2	840	161.6
849	87.6	849	87.9	849	87.7	849	86.5
848	87.4	848	87.4	848	87.4	848	86.5
847	101.8	847	101.6	847	101.4	847	100.2
846	87.5	846	87.5	846	87.4	846	86.5
845	226.0	845	225.9	845	224.8	845	223.7
844	232.3	844	232.3	844	231.2	844	230.1
843	243.5	843	243.3	843	242.3	843	241.0
842	246.2	842	245.7	842	244.7	842	243.9
841	196.1	841	196.3	841	195.9	841	195.5
840	197.5	840	197.7	840	197.1	840	196.5
839	196.1	839	196.3	839	196.4	839	195.7
838	85.1	838	85.6	838	86.3	838	86.2
837	84.9	837	85.5	837	86.2	837	86.3
836	103.0	836	103.2	836	103.3	836	103.1
835	85.1	835	85.6	835	86.3	835	86.4
834	253.4	834	252.8	834	252.2	834	251.0
833	250.6	833	250.2	833	249.8	833	248.6
832	210.8	832	210.6	832	210.4	832	209.7
831	211.1	831	211.0	831	210.7	831	210.0
830	167.5	830	167.8	830	167.6	830	167.2
829	171.0	829	171.4	829	171.4	829	171.5
828	172.2	828	171.5	828	170.7	828	170.6
827	80.0	827	80.9	827	81.7	827	82.5
826	80.1	826	80.9	826	81.6	826	82.3
825	94.8	825	95.5	825	95.9	825	96.4
824	80.1	824	80.9	824	81.4	824	82.2

TABLE D3-5 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 11/1/79
TIME: 4:00 p.m.
OPERATING HRS: 6744

T/C No.	Temp(°F)
854	195.8
853	208.5
852	156.6
851	153.7
850	158.9
849	82.6
848	83.1
847	96.3
846	82.7
845	220.1
844	227.1
843	238.1
842	241.5
841	193.2
840	194.5
839	193.4
838	85.0
837	85.1
836	101.6
835	85.2
834	248.5
833	246.4
832	208.6
831	208.8
830	166.2
829	170.7
828	173.9
827	82.3
826	82.1
825	96.0
824	82.2

DATE: 11/15/79
TIME: 4:00 p.m.
OPERATING HRS: 7080

T/C No.	Temp(°F)
854	192.5
853	205.8
852	153.3
851	150.6
850	156.0
849	78.9
848	79.6
847	92.6
846	78.9
845	216.9
844	224.0
843	234.9
842	238.5
841	190.9
840	192.0
839	191.1
838	83.9
837	84.3
836	100.3
835	84.3
834	245.9
833	244.1
832	207.5
831	207.6
830	165.4
829	169.5
828	178.6
827	82.3
826	82.1
825	95.9
824	82.3

DATE: 12/1/79
TIME: 4:00 p.m.
OPERATING HRS: 7464

T/C No.	Temp(°F)
854	189.3
853	202.2
852	150.0
851	147.1
850	152.4
849	74.6
848	75.7
847	88.3
846	74.7
845	212.9
844	220.4
843	231.3
842	234.7
841	187.8
840	189.0
839	188.0
838	82.4
837	82.6
836	98.5
835	82.6
834	242.9
833	241.0
832	205.9
831	205.8
830	164.1
829	168.0
828	176.2
827	81.9
826	82.0
825	95.2
824	82.0

DATE: 12/15/79
TIME: 4:00 p.m.
OPERATING HRS: 7800

T/C No.	Temp(°F)
854	186.8
853	200.4
852	147.6
851	144.9
840	150.6
849	71.9
848	73.0
847	85.7
846	72.1
845	210.3
844	218.3
843	228.7
842	232.8
841	185.6
840	186.9
839	185.9
838	80.5
837	80.8
836	96.5
835	80.7
834	240.7
833	238.8
832	204.4
831	204.2
830	162.9
829	166.5
828	173.7
827	81.2
826	81.4
825	94.3
824	81.4

DATE: 1/1/80
TIME: 4:00 p.m.
OPERATING HRS: 8208

T/C No.	Temp(°F)
854	184.4
853	197.3
852	145.0
851	142.3
850	147.8
849	68.8
848	70.1
847	82.6
846	69.0
845	207.5
844	215.1
843	225.6
842	229.8
841	182.9
840	184.2
839	183.4
838	78.6
837	78.9
836	94.4
835	78.7
834	237.9
833	236.1
832	202.6
831	202.2
830	161.3
829	164.8
828	168.4
827	80.3
826	80.5
825	93.2
824	80.5

DATE: 1/15/80
TIME: 4:00 p.m.
OPERATING HRS: 8544

T/C No.	Temp(°F)
854	183.2
853	195.4
852	143.3
851	141.0
850	145.8
849	66.7
848	67.9
847	80.5
846	66.9
845	205.9
844	213.7
843	223.7
842	228.0
841	181.2
840	182.4
839	181.8
838	76.8
837	77.3
836	92.6
835	77.1
834	235.8
833	234.1
832	200.8
831	200.8
830	159.9
829	163.5
828	175.0
827	79.5
826	79.7
825	92.3
824	79.7

DATE: 2/1/80
TIME: 4:00 p.m.
OPERATING HRS: 8952

T/C No.	Temp(°F)
854	180.3
853	193.0
852	141.3
851	138.9
850	143.7
849	65.1
848	66.1
847	78.6
846	65.2
845	203.0
844	210.8
843	221.0
842	225.1
841	178.9
840	180.2
839	179.5
838	75.1
837	75.4
836	90.8
835	75.2
834	232.9
833	231.3
832	198.8
831	198.5
830	158.0
829	161.7
828	164.3
827	78.1
826	78.5
825	91.0
824	78.5

DATE: 2/15/80
TIME: 4:00 p.m.
OPERATING HRS: 9288

T/C No.	Temp(°F)
854	179.4
853	192.1
852	140.4
851	138.0
840	142.8
849	64.6
848	65.5
847	78.0
846	64.8
845	201.7
844	209.5
843	219.7
842	223.8
841	177.8
840	179.1
839	178.1
838	73.7
837	74.0
836	89.4
835	73.8
834	231.5
833	229.8
832	197.4
831	197.1
830	156.9
829	160.5
828	
827	77.3
826	77.7
825	90.7
824	77.7

TABLE D3-6 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 3/1/80		DATE: 3/15/80		DATE: 4/1/80		DATE: 4/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 9648		OPERATING HRS: 9984		OPERATING HRS: 10,392		OPERATING HRS: 10,728	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	179.6	854	177.6	854	176.3	854	176.0
853	190.1	853	189.6	853	187.7	853	186.6
852	140.1	852	139.1	852	137.7	852	136.5
851	137.7	851	136.3	851	134.8	851	133.1
850	141.0	850	140.2	850	138.1	840	136.8
849	64.1	849	63.9	849	63.9	849	65.3
848	64.8	848	64.2	848	64.3	848	65.3
847	77.3	847	76.9	847	76.6	847	77.6
846	64.2	846	64.0	846	64.1	846	65.0
845	201.4	845	199.4	845	198.0	845	197.4
844	207.9	844	206.7	844	205.0	844	204.3
843	218.8	843	217.1	843	215.5	843	214.8
842	222.5	842	221.2	842	219.1	842	218.0
841	176.8	841	175.7	841	174.4	841	173.6
840	178.0	840	176.8	840	175.6	840	174.6
839	177.2	839	176.0	839	174.5	839	174.3
838	72.8	838	72.1	838	71.5	838	71.1
837	73.2	837	72.6	837	71.6	837	71.6
836	88.4	836	87.6	836	86.8	836	86.4
835	73.0	835	72.4	835	71.6	835	71.6
834	230.1	834	228.5	834	226.9	834	225.7
833	228.3	833	226.9	833	225.1	833	224.2
832	195.8	832	194.5	832	193.3	832	191.9
831	195.7	831	194.5	831	193.1	831	192.1
830	155.7	830	154.5	830	153.5	830	152.5
829	159.5	829	158.4	829	157.1	829	156.6
828		828		828		828	
827	76.6	827	75.9	827	75.1	827	74.8
826	77.0	826	76.3	826	75.5	826	75.0
825	89.4	825	88.7	825	87.7	825	87.3
824	77.0	824	76.3	824	75.5	824	74.8

DATE: 5/1/80		DATE: 5/15/80		DATE: 6/1/80		DATE: 6/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 11,112		OPERATING HRS: 11,448		OPERATING HRS: 11,856		OPERATING HRS: 12,192	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	178.3	854	177.2	854	177.7	854	179.2
853	188.4	853	187.1	853	186.9	853	187.6
852	140.0	852	139.4	852	139.9	852	141.4
851	136.8	851	136.4	851	136.9	851	138.5
850	139.8	850	139.4	850	139.9	840	141.1
849	68.4	849	70.4	849	72.5	849	74.4
848	68.4	848	70.2	848	72.3	848	74.0
847	80.6	847	82.4	847	84.3	847	86.1
846	68.3	846	70.2	846	72.3	846	74.2
845	199.1	845	197.8	845	198.2	845	199.3
844	205.6	844	204.0	844	203.7	844	203.9
843	216.1	843	214.3	843	214.3	843	215.1
842	219.2	842	217.1	842	217.1	842	217.4
841	174.7	841	173.6	841	173.9	841	174.6
840	175.8	840	174.6	840	174.7	840	175.4
839	174.9	839	173.9	839	174.4	839	175.2
838	71.2	838	71.8	838	73.0	838	73.9
837	71.4	837	72.1	837	73.3	837	74.4
836	86.4	836	86.6	836	87.7	836	88.3
835	71.4	835	72.1	835	73.3	835	74.3
834	226.1	834	224.1	834	223.8	834	224.1
833	224.0	833	222.2	833	221.8	833	222.0
832	191.2	832	189.2	832	188.6	832	188.3
831	191.4	831	189.3	831	189.0	831	188.7
830	152.2	830	150.6	830	150.6	830	150.5
829	155.8	829	154.4	829	154.1	829	154.2
828		828		828		828	
827	74.0	827	73.7	827	73.8	827	74.1
826	74.4	826	73.9	826	74.1	826	74.1
825	86.5	825	85.9	825	86.0	825	86.1
824	74.5	824	73.8	824	73.9	824	73,9

TABLE D3-7 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 7/1/80		DATE: 7/15/80		DATE: 8/1/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 12,576		OPERATING HRS: 12,912		OPERATING HRS: 13,320	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	182.9	854	183.4	854	187.6
853	190.5	853	191.3	853	194.1
852	145.4	852	146.6	852	150.5
851	142.3	851	143.4	851	147.5
850	144.6	850	145.8	850	149.3
849	78.3	849	80.7	849	84.7
848	77.8	848	80.1	848	84.1
847	89.8	847	92.2	847	96.0
846	78.1	846	80.6	846	84.8
845	202.5	845	203.2	845	206.6
844	207.1	844	207.6	844	210.3
843	217.9	843	218.6	843	221.3
842	220.1	842	220.5	842	223.3
841	177.1	841	177.9	841	180.7
840	178.0	840	178.6	840	181.6
839	177.6	839	178.6	839	180.8
838	75.8	838	77.4	838	79.3
837	75.9	837	77.6	837	79.3
836	90.2	836	91.7	836	93.8
835	76.0	835	77.8	835	79.7
834	226.3	834	226.6	834	228.2
833	224.0	833	224.4	833	225.9
832	189.4	832	189.4	832	190.2
831	189.9	831	189.9	831	190.9
830	151.7	830	152.1	830	153.8
829	155.2	829	155.3	829	156.6
828		828		828	
827	74.7	827	75.3	827	76.5
826	74.9	826	75.4	826	76.8
825	86.8	825	87.2	825	88.4
824	74.8	824	75.3	824	76.9

TABLE D3-8 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 8/5/80		DATE: 8/15/80		DATE: 9/2/80		DATE: 9/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 13,416		OPERATING HRS: 13,656		OPERATING HRS: 14,088		OPERATING HRS: 14,400	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	180.0	854	184.9	854	181.9	854	177.0
853	189.5	853	194.8	853	193.5	853	192.2
852	145.2	852	149.0	852	146.4	852	143.7
851	142.5	851	146.5	851	144.7	851	142.6
850	146.2	850	150.2	850	149.1	840	147.8
849	85.6	849	87.2	849	87.2	849	86.4
848	85.0	848	86.6	848	86.7	848	85.8
847	96.9	847	98.2	847	97.9	847	96.8
846	85.7	846	87.2	846	86.9	846	85.9
845	201.8	845	208.0	845	205.7	845	202.9
844	205.4	844	211.0	844	210.2	844	209.1
843		843	222.4	843	221.1	843	218.6
842	215.3	842	220.8	842	220.0	842	218.3
841	175.4	841	181.4	841	180.7	841	179.1
840	176.5	840	182.5	840	182.2	840	180.8
839	175.4	839	-	839	-	839	-
838	79.9	838	81.2	838	83.2	838	83.9
837	79.8	837	81.2	837	83.1	837	83.7
836	94.3	836	95.3	836	97.0	836	97.3
835	80.2	835	81.5	835	83.6	835	84.0
834	221.9	834	228.4	834	227.7	834	226.3
833	220.4	833	226.9	833	226.3	833	225.1
832	182.3	832	189.2	832	189.4	832	189.2
831	172.4	831	178.0	831	178.2	831	178.1
830	149.5	830	153.9	830	154.4	830	154.3
829	152.0	829	156.8	829	157.4	829	157.2
828		828	-	828	-	828	-
827	76.7	827	77.4	827	78.8	827	79.7
826	77.0	826	77.6	826	78.9	826	79.7
825	88.5	825	89.0	825	90.3	825	90.9
824	77.1	824	77.8	824	79.2	824	80.0

DATE: 10/1/80		DATE: 10/15/80		DATE: 11/1/80		DATE: 11/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 14,784		OPERATING HRS: 15,120		OPERATING HRS: 15,528		OPERATING HRS: 15,864	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	177.3	854	177.6	854	172.9	854	171.3
853	190.7	853	190.6	853	186.6	853	184.5
852	141.2	852	142.1	852	137.5	852	135.5
851	140.3	851	141.2	851	137.1	851	135.2
850	146.2	850	146.0	850	142.1	840	140.2
849	84.9	849	84.9	849	81.5	849	79.0
848	84.3	848	84.3	848	81.2	848	78.8
847	95.0	847	95.1	847	91.5	847	89.0
846	84.5	846	84.6	846	80.8	846	78.3
845	201.8	845	201.9	845	197.6	845	195.5
844	207.0	844	207.4	844	202.9	844	201.0
843	217.1	843	216.8	843	212.6	843	210.4
842	216.6	842	216.8	842	213.0	842	211.1
841	177.7	841	177.4	841	174.0	841	172.1
840	179.4	840	179.0	840	175.7	840	173.7
839	-	839	-	839	-	839	-
838	84.3	838	84.3	838	84.3	838	83.2
837	83.9	837	83.6	837	83.6	837	82.2
836	97.2	836	96.8	836	96.4	836	94.8
835	84.2	835	83.9	835	83.7	835	82.2
834	224.9	834	224.2	834	221.0	834	218.9
833	223.7	833	223.1	833	220.1	833	218.1
832	188.5	832	188.0	832	186.8	832	185.4
831	177.7	831	177.2	831	176.0	831	174.9
830	154.1	830	153.4	830	152.4	830	151.1
829	156.8	829	156.7	829	155.6	829	154.6
828	-	828	-	828	-	828	-
827	80.6	827	81.4	827	82.1	827	82.2
826	80.4	826	80.8	826	81.1	826	81.1
825	91.4	825	91.6	825	91.9	825	91.6
824	80.6	824	81.1	824	-	824	-

TABLE D3-9 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 12/1/80		DATE: 12/15/80		DATE: 1/1/81		DATE: 1/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 16,248		OPERATING HRS: 16,584		OPERATING HRS: 16,992		OPERATING HRS: 17,328	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	167.0	854	164.4	854	163.5	854	162.3
853	180.7	853	178.1	853	176.9	853	175.7
852	130.9	852	128.4	852	127.6	852	126.3
851	131.0	851	128.4	851	127.3	851	126.3
850	136.1	850	133.5	850	132.5	840	131.5
849	74.8	849	72.1	849	70.1	849	69.3
848	74.7	848	71.8	848	69.8	848	68.9
847	84.7	847	81.9	847	79.9	847	78.9
846	73.8	846	70.8	846	68.8	846	67.9
845	191.0	845	188.1	845	186.8	845	185.6
844	197.1	844	194.1	844	192.8	844	191.7
843	206.3	843	203.2	843	201.7	843	200.2
842	207.1	842	204.3	842	202.6	842	201.4
841	168.6	841	166.0	841	164.3	841	162.7
840	170.3	840	167.4	840	165.8	840	164.3
839	-	839	-	839	-	839	-
838	81.9	838	80.6	838	78.8	838	77.6
837	80.9	837	79.7	837	77.6	837	76.4
836	93.3	836	91.6	836	89.7	836	88.5
835	80.8	835	79.4	835	77.2	835	76.0
834	215.7	834	213.1	834	211.6	834	209.8
833	215.0	833	212.5	833	210.8	833	209.2
832	183.9	832	182.5	832	181.1	832	179.9
831	173.4	831	172.1	831	170.7	831	169.6
830	149.7	830	148.4	830	147.1	830	145.9
829	153.0	829	151.6	829	150.1	829	149.0
828	-	828	-	828	-	828	-
827	82.1	827	81.8	827	80.9	827	80.4
826	80.8	826	80.3	826	79.4	826	78.8
825	91.2	825	90.6	825	89.5	825	88.9
824	-	824	-	824	-	824	-

DATE: 2/1/81		DATE: 2/15/81		DATE: 3/1/81		DATE: 3/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 17,736		OPERATING HRS: 18,072		OPERATING HRS: 18,408		OPERATING HRS: 18,744	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	164.8	854	169.7	854	170.2	854	168.5
853	178.5	853	174.7	853	173.9	853	174.1
852	124.7	852	123.6	852	124.0	852	122.9
851	127.9	851	127.5	851	128.2	851	126.9
850	-	850	-	850	-	840	-
849	68.3	849	65.7	849	66.4	849	65.7
848	67.8	848	65.4	848	65.8	848	64.9
847	77.8	847	75.2	847	75.9	847	75.0
846	66.6	846	64.2	846	65.0	846	64.1
845	189.3	845	188.1	845	188.3	845	186.8
844	188.3	844	186.2	844	186.1	844	184.9
843	196.9	843	195.1	843	195.2	843	193.6
842	190.4	842	189.0	842	189.2	842	187.8
841	155.6	841	153.6	841	153.5	841	152.3
840	158.9	840	157.0	840	156.7	840	155.6
839	-	839	-	839	-	839	-
838	76.1	838	75.9	838	75.1	838	74.5
837	74.9	837	74.4	837	73.4	837	72.8
836	86.9	836	86.1	836	85.1	836	84.5
835	74.4	835	74.0	835	72.9	835	72.4
834	203.7	834	202.6	834	202.4	834	200.9
833	201.0	833	199.7	833	199.4	833	198.0
832	175.3	832	174.4	832	173.6	832	172.4
831	167.1	831	166.1	831	165.3	831	164.2
830	142.7	830	141.9	830	141.1	830	140.1
829	146.3	829	143.9	829	143.4	829	142.2
828	-	828	-	828	-	828	-
827	79.7	827	78.6	827	78.1	827	77.4
826	77.9	826	76.9	826	76.3	826	75.7
825	88.1	825	86.5	825	85.8	825	85.2
824	77.7	824	76.5	824	75.8	824	75.2

TABLE D3-10 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 4/1/81
TIME: 4:00 p.m.
OPERATING HRS: 19,152

T/C No.	Temp(°F)
854	168.7
853	173.4
852	123.1
851	127.3
850	-
849	66.0
848	65.0
847	75.2
846	64.5
845	186.7
844	184.6
843	193.5
842	187.6
841	152.0
840	155.3
839	-
838	73.7
837	72.0
836	83.7
835	71.6
834	200.2
833	197.5
832	171.6
831	163.4
830	139.2
829	141.4
828	-
827	76.8
826	75.0
825	84.4
824	74.4

DATE: 4/15/81
TIME: 4:00 p.m.
OPERATING HRS: 19,488

T/C No.	Temp(°F)
854	170.7
853	174.1
852	125.3
851	129.4
850	-
849	67.8
848	66.3
847	76.8
846	65.9
845	188.3
844	185.6
843	194.8
842	189.0
841	153.3
840	156.5
839	-
838	73.6
837	71.9
836	83.6
835	71.5
834	200.8
833	198.5
832	171.2
831	163.1
830	139.0
829	141.6
828	-
827	76.8
826	74.7
825	84.6
824	74.3

DATE: 5/1/81
TIME: 4:00 p.m.
OPERATING HRS: 19,872

T/C No.	Temp(°F)
854	172.3
853	175.6
852	126.8
851	130.9
850	-
849	71.1
848	69.2
847	79.7
846	69.0
845	190.0
844	187.1
843	196.0
842	190.3
841	154.6
840	157.9
839	-
838	73.8
837	72.0
836	84.1
835	71.6
834	201.2
833	199.1
832	171.0
831	162.9
830	139.2
829	141.7
828	-
827	76.4
826	74.5
825	84.3
824	74.2

DATE: 5/15/81
TIME: 4:00 p.m.
OPERATING HRS: 20,208

T/C No.	Temp(°F)
854	175.0
853	177.2
852	130.3
851	134.3
840	-
849	74.5
848	72.1
847	83.0
846	72.2
845	192.2
844	188.8
843	198.1
842	192.2
841	156.6
840	159.6
839	-
838	74.9
837	73.0
836	84.9
835	72.7
834	202.2
833	200.6
832	171.1
831	163.2
830	139.4
829	142.2
828	-
827	76.5
826	74.3
825	84.4
824	73.8

DATE: 6/1/81
TIME: 4:00 p.m.
OPERATING HRS: 20,616

T/C No.	Temp(°F)
854	175.0
853	177.2
852	130.8
851	134.8
850	
849	76.3
848	74.1
847	84.6
846	74.3
845	192.1
844	189.1
843	198.1
842	192.6
841	157.2
840	160.4
839	
838	76.5
837	74.4
836	86.6
835	74.3
834	202.6
833	200.7
832	171.4
831	163.3
830	139.8
829	142.2
828	1798.9
827	76.9
826	74.9
825	84.8
824	74.5

DATE: 6/15/81
TIME: 4:00 p.m.
OPERATING HRS: 20,952

T/C No.	Temp(°F)
854	176.5
853	173.8
852	132.4
851	137.4
850	
849	79.5
848	77.0
847	87.7
846	77.6
845	193.3
844	183.7
843	201.5
842	197.0
841	161.0
840	163.2
839	
838	77.5
837	75.3
836	87.6
835	75.3
834	205.6
833	204.7
832	172.3
831	163.9
830	140.9
829	143.4
828	635.1
827	77.3
826	75.1
825	85.2
824	74.9

DATE: 7/1/81
TIME: 4:00 p.m.
OPERATING HRS: 21,336

T/C No.	Temp(°F)
854	179.3
853	175.8
852	136.5
851	140.5
850	-
849	83.4
848	81.0
847	91.3
846	81.6
845	195.9
844	186.0
843	204.0
842	199.6
841	163.5
840	165.6
839	-
838	79.4
837	77.0
836	89.5
835	76.9
834	207.5
833	206.6
832	173.1
831	164.6
830	141.8
829	144.3
828	-
827	78.0
826	75.8
825	85.8
824	75.5

DATE: 7/15/81
TIME: 4:00 p.m.
OPERATING HRS: 21,672

T/C No.	Temp(°F)
854	180.7
853	177.4
852	138.7
851	142.4
840	
849	86.4
848	84.0
847	94.2
846	84.6
845	197.3
844	187.7
843	205.0
842	200.9
841	165.1
840	167.1
839	
838	81.5
837	79.0
836	91.5
835	79.0
834	208.4
833	207.5
832	173.8
831	165.1
830	142.6
829	145.0
828	
827	78.9
826	76.6
825	86.7
824	76.3

TABLE D3-11 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 8/1/81
TIME: 4:00 p.m.
OPERATING HRS: 22,080

T/C No.	Temp(°F)
854	182.8
853	179.5
852	141.3
851	144.9
850	
849	89.1
848	86.7
847	96.8
846	87.2
845	198.8
844	189.0
843	206.8
842	202.2
841	167.0
840	169.1
839	
838	85.0
837	82.7
836	94.9
835	82.7
834	210.5
833	209.7
832	175.7
831	167.1
830	144.9
829	147.1
828	
827	81.4
826	79.9
825	89.1
824	78.8

DATE: 8/15/81
TIME: 4:00 p.m.
OPERATING HRS: 22,416

T/C No.	Temp(°F)
854	182.9
853	179.8
852	141.6
851	145.2
850	
849	90.1
848	87.7
847	97.8
846	88.2
845	198.8
844	189.2
843	206.8
842	202.3
841	167.5
840	169.5
839	
838	86.5
837	84.2
836	96.2
835	84.3
834	210.6
833	209.9
832	176.1
831	167.6
830	145.4
829	147.7
828	
827	82.4
826	80.1
825	90.0
824	79.8

DATE: 9/1/81
TIME: 4:00 p.m.
OPERATING HRS: 22,824

T/C No.	Temp(°F)
854	182.8
853	180.2
852	141.6
851	145.3
850	
849	90.5
848	88.3
847	98.0
846	88.4
845	198.9
844	189.5
843	206.7
842	202.2
841	167.7
840	169.7
839	
838	87.8
837	85.6
836	97.4
835	85.5
834	210.8
833	210.1
832	176.5
831	168.0
830	145.9
829	148.2
828	
827	83.6
826	81.2
825	91.1
824	81.0

DATE: 9/21/81
TIME: 4:00 p.m.
OPERATING HRS: 23,304

T/C No.	Temp(°F)
854	180.5
853	178.3
852	139.4
851	143.1
840	
849	89.2
848	87.1
847	96.6
846	86.9
845	196.9
844	187.9
843	205.0
842	200.4
841	166.4
840	168.4
839	
838	88.9
837	86.6
836	98.0
835	86.6
834	209.5
833	208.8
832	176.3
831	168.1
830	145.9
829	148.3
828	
827	84.9
826	82.3
825	92.1
824	82.1

DATE: 10/1/81
TIME: 4:00 p.m.
OPERATING HRS: 23,544

T/C No.	Temp(°F)
854	179.2
853	177.7
852	138.2
851	142.0
850	
849	88.0
848	86.1
847	95.6
846	86.1
845	195.6
844	186.7
843	203.6
842	199.5
841	165.5
840	167.6
839	
838	88.8
837	86.6
836	98.0
835	86.5
834	208.8
833	207.8
832	176.2
831	167.9
830	145.8
829	148.1
828	
827	85.3
826	82.7
825	92.4
824	82.6

DATE: 10/15/81
TIME: 4:00 p.m.
OPERATING HRS: 23,880

T/C No.	Temp(°F)
854	175.4
853	175.5
852	134.7
851	138.6
850	
849	85.4
848	84.1
847	93.1
846	83.8
845	192.1
844	184.2
843	200.4
842	195.9
841	162.5
840	164.8
839	
838	88.6
837	86.4
836	97.5
835	86.2
834	206.4
833	205.1
832	175.4
831	167.2
830	145.1
829	147.4
828	
827	85.7
826	83.1
825	92.6
824	83.0

DATE: 11/1/81
TIME: 4:00 p.m.
OPERATING HRS: 24,288

T/C No.	Temp(°F)
854	172.0
853	172.8
852	131.5
851	135.1
850	
849	81.4
848	80.3
847	89.0
846	79.7
845	188.6
844	181.4
843	196.9
842	192.7
841	159.4
840	161.7
839	
838	87.1
837	85.2
836	95.8
835	85.0
834	203.6
833	202.1
832	174.0
831	166.1
830	143.9
829	146.2
828	
827	85.8
826	83.2
825	92.5
824	83.0

DATE: 11/15/81
TIME: 4:00 p.m.
OPERATING HRS: 24,624

T/C No.	Temp(°F)
854	170.7
853	171.1
852	129.8
851	133.5
840	
849	79.1
848	78.1
847	86.8
846	77.4
845	187.0
844	179.6
843	195.3
842	191.0
841	157.7
840	160.1
839	
838	85.9
837	84.0
836	94.6
835	83.6
834	202.3
833	200.8
832	173.2
831	165.3
830	143.1
829	145.4
828	
827	85.4
826	83.0
825	92.1
824	82.8

TABLE D3-12 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 12/1/81		DATE: 12/15/81		DATE: 1/1/82		DATE: 1/15/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 25,008		OPERATING HRS: 25,344		OPERATING HRS: 25,752		OPERATING HRS: 26,088	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	166.8	854	165.1	854	162.5	854	159.5
853	168.1	853	167.5	853	165.3	853	163.3
852	126.3	852	124.2	852	121.4	852	118.6
851	129.9	851	127.8	851	125.0	851	122.1
850		850		850		840	
849	76.2	849	72.7	849	69.8	849	66.9
848	75.5	848	72.0	848	69.2	848	66.5
847	84.0	847	80.6	847	77.7	847	74.7
846	74.5	846	70.8	846	67.9	846	65.0
845	183.2	845	181.4	845	178.8	845	175.9
844	176.6	844	178.3	844	176.2	844	174.0
843	191.9	843	189.0	843	186.5	843	183.6
842	187.6	842	184.7	842	181.8	842	178.9
841	154.6	841	151.8	841	149.2	841	146.5
840	157.0	840	154.5	840	151.9	840	149.3
839		839		839		839	
838	84.5	838	82.8	838	80.9	838	79.1
837	82.5	837	81.0	837	79.0	837	77.3
836	93.0	836	91.3	836	89.2	836	87.5
835	82.1	835	80.5	835	78.4	835	76.7
834	199.3	834	196.5	834	194.2	834	191.4
833	197.5	833	194.3	833	191.7	833	188.6
832	171.7	832	170.0	832	168.5	832	166.8
831	164.0	831	162.5	831	161.2	831	159.6
830	141.8	830	140.2	830	138.6	830	137.1
829	144.0	829	142.4	829	140.9	829	139.3
828		828		828		828	
827	84.8	827	84.3	827	83.3	827	82.5
826	82.5	826	82.0	826	81.1	826	80.3
825	91.4	825	90.8	825	89.7	825	88.8
824	82.3	824	81.7	824	80.7	824	79.9

DATE: 2/1/82		DATE: 2/15/82		DATE: 3/1/82		DATE: 3/15/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 26,496		OPERATING HRS: 26,832		OPERATING HRS: 27,168		OPERATING HRS: 27,504	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
854	157.7	854	156.6	854	157.7	854	158.0
853	161.2	853	159.6	853	158.0	853	157.9
852	116.7	852	115.6	852	116.9	852	117.2
851	120.3	851	119.1	851	120.2	851	120.6
850		850		850		840	
849	64.9	849	63.7	849	64.5	849	65.5
848	64.3	848	63.1	848	63.5	848	64.4
847	72.7	847	71.5	847	72.4	847	73.3
846	62.9	846	61.7	846	62.8	846	63.7
845	173.8	845	172.5	845	173.3	845	173.6
844	171.7	844	170.1	844	165.9	844	165.9
843	181.4	843	180.3	843	181.7	843	182.1
842	176.7	842	175.6	842	177.5	842	177.8
841	144.4	841	143.0	841	144.3	841	144.7
840	147.2	840	145.9	840	146.7	840	147.0
839		839		839		839	
838	77.0	838	75.6	838	74.4	838	73.9
837	75.4	837	74.0	837	72.7	837	72.3
836	85.4	836	84.0	836	83.0	836	82.7
835	74.6	835	73.2	835	71.9	835	71.6
834	189.4	834	188.2	834	189.4	834	189.5
833	186.7	833	185.4	833	187.4	833	187.7
832	165.1	832	164.0	832	163.9	832	163.7
831	158.2	831	157.1	831	156.7	831	156.4
830	135.6	830	134.4	830	134.2	830	133.8
829	137.9	829	136.8	829	136.7	829	136.5
828		828		828		828	
827	81.3	827	80.3	827	79.4	827	78.6
826	79.1	826	78.2	826	77.4	826	76.6
825	87.7	825	86.7	825	85.9	825	85.2
824	78.6	824	77.7	824	76.8	824	76.0

TABLE D3-13 DRYWELL NO. 3 THERMOCOUPLE DATA, FUEL ASSEMBLY: B03

DATE: 3/31/82
TIME: 4:00 p.m.
OPERATING HRS: 27,888

T/C No.	Temp(°F)
854	156.3
853	156.6
852	115.8
851	119.2
850	
849	64.9
848	63.7
847	72.6
846	63.2
845	172.0
844	164.4
843	180.5
842	176.6
841	143.4
840	145.7
839	
838	73.6
837	72.0
836	82.4
835	71.4
834	188.0
833	186.2
832	162.6
831	155.5
830	133.0
829	135.6
828	
827	78.0
826	76.0
825	84.6
824	75.5

TABLE D2-1

DRYWELL 2 THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
787	203.5	120	150	Instrumentation Well I*
788	203.5	60	90	Instrumentation Well J
789	203.5	120	90	Instrumentation Well K
790	203.5	120	30	Instrumentation Well L
791	205.75	9	30	Liner
792	205.75	9	210	Liner
793	205.75	9	90	Liner
794	206.0	7	30	Canister
795	206.0	7	210	Canister
796	176.0	7	15	Canister
797	176.0	7	195	Canister
798	143.5	120	150	Instrumentation Well I
799	143.5	60	90	Instrumentation Well J
800	143.5	120	90	Instrumentation Well K
801	143.5	120	30	Instrumentation Well L
802	145.75	9	0	Liner
803	145.75	9	180	Liner
804	145.75	9	90	Liner
805	146.0	7	0	Canister
806	146.0	7	180	Canister
807	116.0	7	345	Canister
808	116.0	7	165	Canister
809	83.5	120	150	Instrumentation Well I
810	83.5	60	90	Instrumentation Well J
811	83.5	120	90	Instrumentation Well K
812	83.5	120	30	Instrumentation Well L
813	85.75	9	330	Liner
814	85.75	9	150	Liner
815	85.75	9	90	Liner
816	86.0	7	330	Canister
817	86.0	7	150	Canister

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*See Figure D-1 for Instrumentation Well identification

TABLE D2-2 DRYWELL NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 8/7/80		DATE: 8/8/80		DATE: 8/9/80		DATE: 8/10/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 66		OPERATING HRS: 90		OPERATING HRS: 114		OPERATING HRS: 138	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	144.9	817	147.9	817	149.9	817	150.5
816	150.5	816	153.7	816	156.1	816	157.7
815	108.2	815	111.5	815	113.9	815	115.6
814	106.6	814	109.8	814	112.1	814	113.7
813	107.6	813	110.9	813	113.4	813	115.3
812		812		812		812	
811		811		811		811	
810		810		810		810	
809		809		809		809	
808	157.5	808	160.7	808	163.2	808	166.2
807	159.7	807	163.2	807	165.6	807	167.2
806	163.3	806	167.1	806	170.1	806	172.8
805	161.8	805	165.6	805	168.4	805	170.9
804	109.9	804	114.2	804	117.5	804	120.3
803	110.2	803	114.4	803	117.7	803	120.5
802	110.2	802	114.3	802	117.5	802	120.3
801		801		801		801	
800		800		800		800	
799		799		799		799	
798		798		798		798	
797	159.9	797	163.8	797	166.7	797	169.0
796	157.6	796	161.4	796	164.3	796	166.7
795	128.9	795	131.9	795	134.0	795	135.8
794	130.2	794	133.2	794	135.4	794	137.3
793	90.5	793	93.5	793	95.8	793	97.6
792	90.9	792	93.9	792	96.2	792	98.1
791	90.8	791	93.8	791	96.0	791	97.9
790	65.8	790	66.0	790	66.0	790	66.0
789	68.5	789	68.7	789	68.7	789	68.8
788	68.3	788	68.7	788	69.0	788	69.2
787	71.1	787	71.3	787	71.2	787	71.3

DATE: 8/11/80		DATE: 8/12/80		DATE: 8/15/80		DATE: 9/2/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 162		OPERATING HRS: 186		OPERATING HRS: 258		OPERATING HRS: 690	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	151.6	817	152.6	817	155.2	817	160.7
816	159.0	816	160.2	816	162.9	816	168.8
815	117.0	815	118.3	815	121.6	815	128.7
814	115.1	814	116.5	814	119.6	814	126.6
813	116.7	813	118.1	813	121.4	813	128.5
812		812		812		812	
811		811		811		811	
810		810		810		810	
809		809		809		809	
808	168.2	808	169.9	808	173.1	808	181.1
807	168.8	807	170.2	807	173.3	807	180.6
806	174.9	806	176.6	806	180.5	806	189.6
805	172.9	805	174.6	805	178.2	805	187.0
804	122.6	804	124.5	804	128.8	804	139.9
803	122.9	803	124.8	803	129.2	803	140.5
802	122.6	802	124.5	802	128.8	802	139.8
801		801		801		801	
800		800		800		800	
799		799		799		799	
798		798		798		798	
797	171.0	797	172.7	797	176.9	797	186.6
796	168.7	796	170.3	796	174.2	796	183.9
795	137.5	795	138.9	795	142.9	795	152.3
794	138.8	794	140.1	794	144.0	794	153.5
793	99.4	793	100.9	793	104.4	793	115.1
792	100.0	792	101.4	792	105.0	792	116.0
791	99.6	791	101.1	791	104.6	791	115.3
790	66.2	790	66.3	790	66.7	790	70.1
789	68.9	789	69.2	789	69.3	789	70.4
788	69.8	788	70.4	788	71.5	788	78.3
787	71.4	787	71.7	787	71.8	787	73.6

TABLE D2-3 DRYWELL NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 9/15/80		DATE: 10/1/80		DATE: 10/15/80		DATE: 11/1/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 1,002		OPERATING HRS: 1,386		OPERATING HRS: 1,722		OPERATING HRS: 2,130	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	162.2	817	161.6	817	161.8	817	158.6
816	169.9	816	169.6	816	170.0	816	167.0
815	129.9	815	130.4	815	130.9	815	127.8
814	127.6	814	128.3	814	128.6	814	125.3
813	129.7	813	130.0	813	130.5	813	127.3
812		812	81.0	812	81.2	812	78.2
811		811	81.4	811	81.6	811	78.8
810		810	90.7	810	91.1	810	88.1
809		809	84.0	809	84.4	809	81.4
808	176.3	808	183.1	808	183.7	808	180.4
807	181.7	807	181.8	807	182.6	807	179.5
806	189.9	806	192.3	806	193.1	806	190.7
805	188.5	805	189.4	805	190.4	805	188.2
804	142.6	804	144.3	804	145.4	804	144.5
803	143.2	803	145.0	803	146.2	803	145.5
802	142.3	802	144.0	802	145.0	802	144.0
801		801	79.7	801	80.7	801	81.6
800		800	80.4	800	81.4	800	82.0
799		799	92.0	799	93.2	799	93.9
798		798	82.5	798	83.0	798	83.5
797	189.3	797	190.8	797	191.8	797	191.2
796	186.3	796	188.1	796	188.9	796	188.0
795	155.6	795	157.5	795	158.7	795	159.2
794	156.5	794	158.7	794	159.8	794	160.1
793	118.6	793	121.3	793	122.7	793	123.6
792	119.6	792	122.2	792	123.4	792	124.1
791	118.7	791	121.3	791	122.8	791	123.6
790	72.0	790	74.3	790	75.6	790	77.1
789	72.4	789	74.7	789	75.6	789	77.3
788	81.7	788	84.8	788	85.9	788	87.6
787	75.5	787	77.8	787	78.8	787	80.4

DATE: 11/15/80		DATE: 12/1/80		DATE: 12/15/80		DATE: 1/1/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 2,466		OPERATING HRS: 2,850		OPERATING HRS: 3,186		OPERATING HRS: 3,594	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	156.9	817	153.4	817	151.4	817	150.7
816	165.3	816	161.9	816	160.0	816	159.2
815	126.1	815	122.5	815	120.6	815	119.8
814	123.6	814	119.9	814	117.7	814	117.1
813	125.6	813	122.0	813	120.1	813	119.2
812	75.9	812	72.2	812	69.8	812	68.3
811	76.4	811	72.7	811	70.4	811	68.6
810	85.9	810	82.0	810	79.6	810	78.1
809	79.1	809	75.2	809	72.6	809	70.8
808	179.2	808	175.8	808	173.4	808	172.9
807	178.0	807	174.7	807	172.4	807	171.8
806	189.6	806	186.8	806	184.9	806	184.1
805	187.1	805	184.6	805	182.5	805	181.6
804	143.7	804	141.8	804	140.4	804	139.6
803	144.8	803	143.0	803	141.5	803	140.6
802	143.2	802	141.2	802	139.9	802	139.0
801	81.2	801	80.5	801	79.5	801	78.1
800	81.5	800	80.6	800	79.4	800	77.9
799	93.2	799	92.3	799	91.0	799	89.4
798	83.0	798	82.1	798	80.8	798	79.2
797	190.6	797	189.3	797	187.8	797	186.9
796	187.5	796	186.0	796	184.5	796	183.8
795	159.2	795	158.9	795	158.2	795	157.3
794	160.2	794	159.8	794	159.0	794	158.4
793	123.8	793	123.7	793	123.3	793	122.7
792	124.5	792	124.3	792	123.8	792	123.3
791	123.9	791	123.8	791	123.4	791	122.8
790	77.9	790	78.6	790	78.7	790	78.5
789	77.5	789	77.9	789	78.1	789	77.7
788	87.8	788	88.1	788	88.2	788	87.9
787	80.5	787	80.8	787	81.0	787	80.6

TABLE D2-4 DRYWELL NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 1/15/81
TIME: 4:00 p.m.
OPERATING HRS: 3,930

T/C No.	Temp(°F)
817	149.9
816	158.2
815	118.9
814	116.2
813	118.4
812	67.7
811	67.8
810	77.4
809	70.1
808	172.0
807	170.7
806	183.1
805	181.0
804	139.0
803	140.0
802	138.6
801	77.4
800	77.1
799	88.5
798	78.2
797	186.2
796	183.0
795	156.8
794	157.8
793	122.2
792	122.8
791	122.3
790	78.2
789	77.1
788	87.2
787	79.8

DATE: 2/1/81
TIME: 4:00 p.m.
OPERATING HRS: 4,338

T/C No.	Temp(°F)
817	148.3
816	156.6
815	117.6
814	114.8
813	117.1
812	66.5
811	66.7
810	76.0
809	69.2
808	170.0
807	169.3
806	181.5
805	179.8
804	138.1
803	139.3
802	137.6
801	76.7
800	75.9
799	87.7
798	77.1
797	185.3
796	181.9
795	156.2
794	156.9
793	121.8
792	122.3
791	121.9
790	77.7
789	76.4
788	86.3
787	78.9

DATE: 2/15/81
TIME: 4:00 p.m.
OPERATING HRS: 4,674

T/C No.	Temp(°F)
817	147.3
816	155.9
815	116.4
814	113.8
813	115.8
812	65.1
811	65.1
810	74.7
809	66.7
808	168.7
807	167.7
806	180.4
805	178.5
804	137.2
803	137.9
802	136.5
801	75.6
800	75.2
799	86.2
798	75.9
797	183.9
796	180.6
795	154.9
794	155.9
793	120.7
792	121.3
791	120.9
790	77.2
789	76.7
788	86.8
787	79.3

DATE: 3/1/81
TIME: 4:00 p.m.
OPERATING HRS: 5,010

T/C No.	Temp(°F)
817	147.7
816	156.2
815	117.0
814	114.3
813	116.4
812	65.6
811	65.5
810	75.2
809	67.4
808	169.1
807	168.2
806	180.6
805	178.7
804	137.3
803	137.9
802	136.8
801	75.0
800	74.5
799	85.5
798	75.0
797	183.8
796	180.6
795	154.6
794	155.6
793	120.4
792	120.9
791	120.5
790	76.7
789	76.2
788	86.3
787	78.7

DATE: 3/15/81
TIME: 4:00 p.m.
OPERATING HRS: 5,346

T/C No.	Temp(°F)
817	146.9
816	155.1
815	116.4
814	113.6
813	115.8
812	64.9
811	64.8
810	74.3
809	66.6
808	168.3
807	166.8
806	179.9
805	178.0
804	137.1
803	137.7
802	137.6
801	74.6
800	73.9
799	85.0
798	74.5
797	183.3
796	179.5
795	154.2
794	155.2
793	120.3
792	120.8
791	120.4
790	76.4
789	75.7
788	85.8
787	78.2

DATE: 4/1/81
TIME: 4:00 p.m.
OPERATING HRS: 5,754

T/C No.	Temp(°F)
817	148.0
816	155.9
815	117.3
814	114.7
813	116.6
812	65.7
811	65.3
810	75.1
809	67.1
808	169.4
807	167.9
806	180.9
805	178.6
804	137.8
803	138.5
802	137.2
801	74.1
800	73.3
799	84.6
798	74.1
797	183.8
796	180.2
795	154.1
794	155.1
793	120.4
792	120.8
791	120.5
790	76.1
789	75.3
788	85.5
787	77.7

DATE: 4/15/81
TIME: 4:00 p.m.
OPERATING HRS: 6,090

T/C No.	Temp(°F)
817	150.0
816	157.5
815	119.5
814	116.9
813	119.0
812	67.5
811	66.9
810	76.8
809	69.0
808	171.2
807	169.9
806	182.5
805	180.1
804	139.1
803	140.2
802	138.7
801	74.5
800	73.4
799	84.9
798	74.1
797	184.9
796	181.3
795	154.5
794	155.4
793	121.3
792	121.5
791	121.3
790	76.2
789	75.0
788	85.1
787	77.4

DATE: 5/1/81
TIME: 4:00 p.m.
OPERATING HRS: 6,474

T/C No.	Temp(°F)
817	152.3
816	159.4
815	121.8
814	119.8
813	121.3
812	70.8
811	70.0
810	80.1
809	73.2
808	173.7
807	172.1
806	184.7
805	181.8
804	141.4
803	142.3
802	140.8
801	75.2
800	74.1
799	85.6
798	75.0
797	186.1
796	182.9
795	154.9
794	156.0
793	121.8
792	122.3
791	122.0
790	76.1
789	74.7
788	85.0
787	76.8

TABLE D2-5 DRYWELL NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 5/15/81		DATE: 6/1/81		DATE: 6/15/81		DATE: 7/1/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 6,810		OPERATING HRS: 7,218		OPERATING HRS: 7,554		OPERATING HRS: 7,938	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	155.0	817	155.6	817	159.0	817	162.1
816	161.7	816	162.7	816	165.5	816	168.6
815	125.0	815	125.9	815	129.6	815	132.9
814	122.4	814	123.7	814	127.5	814	130.8
813	124.4	813	125.4	813	129.0	813	132.3
812	73.9	812	76.3	812	79.5	812	83.5
811	73.4	811	75.2	811	78.4	811	82.2
810	83.2	810	85.2	810	88.4	810	92.2
809	75.8	809	77.7	809	81.0	809	84.9
808	176.4	808	177.4	808	180.9	808	184.2
807	174.7	807	176.0	807	179.0	807	182.3
806	187.0	806	188.6	806	191.2	806	194.2
805	184.1	805	185.4	805	188.1	805	190.9
804	143.3	804	145.6	804	148.1	804	150.9
803	144.6	803	146.7	803	149.2	803	152.0
802	142.7	802	145.2	802	147.7	802	150.5
801	76.5	801	78.3	801	79.5	801	81.4
800	74.9	800	77.0	800	78.1	800	79.9
799	86.9	799	88.3	799	89.3	799	91.3
798	75.9	798	77.8	798	78.6	798	80.8
797	187.9	797	189.0	797	190.5	797	192.6
796	184.6	796	185.8	796	187.5	796	189.8
795	155.7	795	156.6	795	157.1	795	158.3
794	156.7	794	157.6	794	158.2	794	159.5
793	122.9	793	123.9	793	125.0	793	126.3
792	123.1	792	124.3	792	125.2	792	126.7
791	123.1	791	124.1	791	125.2	791	126.7
790	76.5	790	76.9	790	77.4	790	78.2
789	74.9	789	75.4	789	75.7	789	76.6
788	85.1	788	85.7	788	86.0	788	87.0
787	77.0	787	77.4	787	77.7	787	78.5

DATE: 7/15/81		DATE: 8/1/81		DATE: 8/15/81		DATE: 9/1/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 8,274		OPERATING HRS: 8,682		OPERATING HRS: 9,018		OPERATING HRS: 9,426	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	163.7	817	165.6	817	166.1	817	166.4
816	170.4	816	172.7	816	173.1	816	173.1
815	135.0	815	137.4	815	138.1	815	138.5
814	132.9	814	135.2	814	135.8	814	135.9
813	134.5	813	137.0	813	137.6	813	137.9
812	86.6	812	89.6	812	90.7	812	91.2
811	85.2	811	88.3	811	89.3	811	89.8
810	95.2	810	98.0	810	98.9	810	99.2
809	87.9	809	90.3	809	91.2	809	91.6
808	185.9	808	187.3	808	188.1	808	188.6
807	184.1	807	185.9	807	186.2	807	186.7
806	195.9	806	197.6	806	198.2	806	199.0
805	192.5	805	194.3	805	195.0	805	195.7
804	152.9	804	155.1	804	156.2	804	157.9
803	154.0	803	156.2	803	157.3	803	158.4
802	152.5	802	154.7	802	155.9	802	156.8
801	83.5	801	86.0	801	87.6	801	89.0
800	82.0	800	84.5	800	85.9	800	87.4
799	93.2	799	95.3	799	96.7	799	97.7
798	82.8	798	84.9	798	85.4	798	87.6
797	194.1	797	195.8	797	196.8	797	197.6
796	191.4	796	192.8	796	192.8	796	194.6
795	159.3	795	160.8	795	161.8	795	162.8
794	160.6	794	161.9	794	162.2	794	163.9
793	127.6	793	129.4	793	130.7	793	131.9
792	127.7	792	129.5	792	130.2	792	132.5
791	128.0	791	129.8	791	131.3	791	132.4
790	79.2	790	80.6	790	81.4	790	82.9
789	77.4	789	80.0	789	81.7	789	82.3
788	87.9	788	90.2	788	90.9	788	92.2
787	79.4	787	82.0	787	83.8	787	84.2

TABLE D2-6 DRYWELL NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 9/21/81		DATE: 10/1/81		DATE: 10/15/81		DATE: 11/1/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 9,906		OPERATING HRS: 10,146		OPERATING HRS: 10,482		OPERATING HRS: 10,890	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	164.9	817	163.5	817	160.0	817	156.7
816	172.1	816	171.1	816	168.4	816	165.2
815	137.4	815	136.3	815	133.1	815	129.8
814	134.5	814	133.3	814	129.9	814	126.3
813	136.8	813	135.6	813	132.4	813	129.2
812	90.2	812	89.4	812	86.8	812	82.4
811	89.3	811	88.3	811	85.6	811	81.6
810	98.2	810	97.2	810	94.2	810	89.9
809	90.5	809	89.2	809	86.4	809	82.5
808	187.1	808	185.7	808	182.5	808	178.9
807	185.4	807	184.2	807	181.1	807	177.7
806	198.1	806	197.0	806	194.4	806	191.3
805	195.1	805	194.2	805	191.9	805	189.1
804	157.2	804	156.4	804	154.6	804	152.0
803	158.5	803	157.9	803	156.2	803	153.9
802	156.7	802	156.2	802	154.3	802	151.9
801	90.1	801	90.2	801	89.9	801	88.5
800	88.4	800	88.6	800	88.3	800	86.9
799	98.4	799	98.5	799	98.0	799	96.2
798	88.5	798	88.5	798	88.0	798	86.7
797	197.7	797	197.6	797	196.5	797	194.6
796	194.6	796	194.2	796	192.7	796	190.9
795	163.6	795	163.9	795	163.8	795	163.3
794	164.6	794	164.7	794	164.5	794	164.3
793	133.0	793	133.5	793	133.5	793	133.3
792	138.9	792	140.2	792	139.8	792	139.5
791	133.5	791	134.1	791	134.1	791	133.7
790	83.9	790	84.5	790	84.9	790	85.2
789	83.4	789	83.9	789	84.3	789	84.5
788	93.1	788	93.4	788	93.7	788	93.7
787	85.4	787	85.8	787	86.3	787	86.5

DATE: 11/15/81		DATE: 12/1/81		DATE: 12/15/81		DATE: 1/1/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 11,226		OPERATING HRS: 11,610		OPERATING HRS: 11,946		OPERATING HRS: 12,354	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
817	155.1	817	151.6	817	149.4	817	147.0
816	163.8	816	160.9	816	158.5	816	156.2
815	127.9	815	124.7	815	122.1	815	119.4
814	124.6	814	121.4	814	118.6	814	115.8
813	127.2	813	124.1	813	121.3	813	118.7
812	79.8	812	76.8	812	73.2	812	70.4
811	79.1	811	76.4	811	72.9	811	70.1
810	87.5	810	84.6	810	81.2	810	78.4
809	80.2	809	77.3	809	73.8	809	70.9
808	177.5	808	173.7	808	170.8	808	168.6
807	176.2	807	172.9	807	170.5	807	168.2
806	189.9	806	186.6	806	184.2	806	181.7
805	187.9	805	184.9	805	182.6	805	180.6
804	150.8	804	148.6	804	146.1	804	144.0
803	152.5	803	150.0	803	148.0	803	145.7
802	150.6	802	148.2	802	146.0	802	143.8
801	87.1	801	85.6	801	83.9	801	81.8
800	85.6	800	84.2	800		800	
799	94.7	799	93.1	799	91.3	799	89.3
798	85.4	798	84.2	798	82.5	798	80.4
797	193.4	797	191.3	797	189.5	797	187.7
796	189.9	796	187.9	796	185.9	796	184.1
795	162.7	795	161.8	795	161.0	795	159.9
794	163.8	794	162.9	794	161.0	794	160.8
793	132.8	793	132.0	793	131.2	793	130.1
792	139.4	792	137.5	792		792	
791	133.4	791	132.6	791	132.0	791	132.1
790	84.9	790	84.3	790	83.7	790	82.7
789	84.2	789	83.6	789	83.1	789	82.2
788	93.2	788	92.6	788	91.9	788	90.9
787	86.1	787	85.4	787	84.9	787	84.0

TABLE D2-7 DRYWELL NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B41

DATE: 1/15/82
TIME: 4:00 p.m.
OPERATING HRS: 12,690

T/C No.	Temp(°F)
817	144.4
816	153.9
815	116.9
814	113.4
813	116.4
812	67.5
811	67.4
810	75.5
809	68.0
808	166.1
807	165.5
806	179.3
805	178.0
804	
803	143.5
802	141.8
801	80.2
800	
799	87.5
798	78.8
797	185.5
796	182.0
795	158.7
794	159.7
793	129.1
792	
791	133.8
790	82.0
789	81.3
788	89.9
787	83.1

DATE: 2/1/82
TIME: 4:00 p.m.
OPERATING HRS: 13,098

T/C No.	Temp(°F)
817	143.3
816	152.4
815	115.6
814	112.1
813	115.0
812	65.4
811	65.4
810	73.5
809	66.0
808	164.8
807	164.2
806	178.0
805	176.1
804	
803	142.1
802	140.0
801	78.1
800	
799	85.5
798	76.8
797	184.2
796	180.3
795	157.5
794	158.5
793	128.0
792	
791	133.4
790	80.7
789	80.3
788	88.7
787	82.0

DATE: 2/15/82
TIME: 4:00 p.m.
OPERATING HRS: 13,434

T/C No.	Temp(°F)
817	141.8
816	151.1
815	114.2
814	110.8
813	113.7
812	64.0
811	63.9
810	72.2
809	64.9
808	163.4
807	162.8
806	176.7
805	175.1
804	
803	140.9
802	138.9
801	76.6
800	
799	84.1
798	75.4
797	183.1
796	179.3
795	156.6
794	157.6
793	127.3
792	
791	132.4
790	79.8
789	79.3
788	87.7
787	81.0

DATE: 3/1/82
TIME: 4:00 p.m.
OPERATING HRS: 13,770

T/C No.	Temp(°F)
817	143.7
816	152.0
815	115.8
814	112.7
813	115.2
812	64.6
811	64.3
810	72.9
809	65.6
808	165.4
807	164.1
806	178.1
805	176.3
804	
803	141.4
802	139.6
801	75.5
800	
799	83.1
798	74.2
797	183.4
796	179.8
795	156.1
794	157.2
793	125.9
792	
791	
790	79.1
789	78.2
788	86.7
787	79.8

DATE: 3/15/82
TIME: 4:00 p.m.
OPERATING HRS: 14,106

T/C No.	Temp(°F)
817	144.0
816	152.3
815	116.2
814	113.2
813	115.6
812	65.6
811	65.2
810	73.8
809	66.6
808	165.8
807	164.5
806	178.5
805	176.5
804	
803	141.7
802	139.8
801	75.0
800	74.0
799	82.8
798	73.8
797	183.5
796	179.9
795	155.7
794	156.8
793	126.5
792	
791	
790	78.1
789	77.5
788	86.0
787	79.0

DATE: 3/31/82
TIME: 4:00 p.m.
OPERATING HRS: 14,490

T/C No.	Temp(°F)
817	142.9
816	151.6
815	115.4
814	112.2
813	114.9
812	65.2
811	64.7
810	73.3
809	66.0
808	164.9
807	163.4
806	177.3
805	175.4
804	
803	
802	139.1
801	74.8
800	73.7
799	82.5
798	73.5
797	182.5
796	178.9
795	155.1
794	156.1
793	125.9
792	
791	
790	77.5
789	76.8
788	85.4
787	78.5

TABLE D1-1

DRYWELL 1 THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance Below Ground Level (In.)	Radius (In.)	Orientation (Degrees)	Location
750	203.5	120	150	Instrumentation Well M*
751	203.5	60	90	Instrumentation Well N
752	203.5	120	90	Instrumentation Well O
753	203.5	120	30	Instrumentation Well P
754	205.75	9	30	Liner
755	205.75	9	210	Liner
756	205.75	9	90	Liner
757	206.0	7	30	Canister
758	206.0	7	210	Canister
759	176.0	7	15	Canister
760	176.0	7	195	Canister
761	143.5	120	150	Instrumentation Well M
762	143.5	60	90	Instrumentation Well N
763	143.5	120	90	Instrumentation Well O
764	143.5	120	30	Instrumentation Well P
765	145.75	9	0	Liner
766	145.75	9	180	Liner
767	145.75	9	90	Liner
768	146.0	7	0	Canister
769	146.0	7	180	Canister
770	116.0	7	345	Canister
771	116.0	7	165	Canister
772	83.5	120	150	Instrumentation Well M
773	83.5	60	90	Instrumentation Well N
774	83.5	120	90	Instrumentation Well O
775	83.5	120	30	Instrumentation Well P
776	85.75	9	330	Liner
777	85.75	9	150	Liner
778	85.75	9	90	Liner
779	86.0	7	330	Canister
780	86.0	7	150	Canister

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*See Figure D-1 for Instrumentation Well identification

TABLE D1-2 DRYWELL NO. 1 THERMOCOUPLE DATA, FUEL ASSEMBLY: B43

DATE: 9/15/80		DATE: 9/16/80		DATE: 9/17/80		DATE: 9/18/80	
TIME: 12:00 Noon		TIME: 12:00 Noon		TIME: 12:00 Noon		TIME: 12:00 Noon	
OPERATING HRS: 0		OPERATING HRS: 24		OPERATING HRS: 48		OPERATING HRS: 72	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
780	98.1	780	134.0	780	139.3	780	142.2
779	90.1	779	140.5	779	145.9	779	149.3
778	89.6	778	97.3	778	101.7	778	106.3
777	112.7	777	95.6	777	101.1	777	104.2
776	99.6	776	97.4	776	101.7	776	106.3
775	78.5	775	78.5	775	78.7	775	78.2
774	78.5	774	78.3	774	76.7	774	77.9
773	78.4	773	78.3	773	78.6	773	78.2
772	79.2	772	78.9	772	77.2	772	78.5
771	88.9	771	144.4	771	149.9	771	152.9
770	89.4	770	150.4	770	155.0	770	159.5
769	114.7	769	150.6	769	156.9	769	161.0
768	91.9	768	152.1	768	156.7	768	162.5
767	86.6	767	98.9	767	106.4	767	110.9
766	87.1	766	99.3	766	104.8	766	111.2
765	86.3	765	98.9	765	106.3	765	110.6
764	73.7	764	73.7	764	72.1	764	73.6
763	73.1	763	73.3	763	73.7	763	73.1
762	73.7	762	73.6	762	72.3	762	73.6
761	73.8	761	73.9	761	74.6	761	73.8
760	105.5	760	150.1	760	155.7	760	160.9
759	97.0	759	148.3	759	155.3	759	159.4
758	89.2	758	122.1	758	125.7	758	130.4
757	95.5	757	122.2	757	127.7	757	130.5
756	92.3	756	84.3	756	87.6	756	92.4
755	95.5	755	84.3	755	89.8	755	92.5
754	89.4	754	84.2	754	87.3	754	92.3
753	68.8	753	68.9	753	69.7	753	68.9
752	69.1	752	68.9	752	67.6	752	68.9
751	68.9	751	69.0	751	69.9	751	69.1
750	69.5	750	69.4	750	68.8	750	69.2

DATE: 9/19/80		DATE: 9/20/80		DATE: 10/1/80		DATE: 10/15/80	
TIME: 12:00 Noon		TIME: 12:00 Noon		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 96		OPERATING HRS: 120		OPERATING HRS: 388		OPERATING HRS: 724	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
780	144.6	780	146.4	780	154.9	780	158.2
779	152.0	779	154.2	779	163.7	779	167.8
778	109.1	778	111.1	778	121.4	778	125.9
777	106.8	777	109.0	777	118.9	777	123.4
776	109.0	776	111.2	776	121.7	776	126.1
775	78.1	775	78.1	775	77.8	775	78.9
774	78.0	774	77.7	774	77.7	774	78.5
773	78.5	773	78.8	773	82.9	773	86.6
772	78.6	772	78.5	772	78.4	772	79.4
771	155.7	771	157.9	771	169.0	771	173.5
770	162.5	770	164.6	770	175.0	770	179.3
769	164.1	769	166.8	769	179.7	769	184.7
768	165.6	768	168.1	768	180.3	768	185.0
767	114.6	767	117.6	767	131.7	767	137.7
766	115.0	766	117.8	766	132.2	766	138.3
765	114.3	765	117.3	765	131.5	765	137.5
764	73.7	764	73.8	764	74.6	764	75.8
763	73.2	763	73.4	763	74.3	763	75.6
762	74.2	762	74.7	762	81.7	762	86.5
761	73.9	761	74.1	761	75.1	761	76.8
760	164.5	760	167.0	760	179.9	760	185.2
759	162.6	759	165.2	759	177.9	759	183.5
758	133.0	758	135.1	758	146.0	758	151.3
757	132.9	757	135.1	757	146.0	757	151.4
756	95.1	756	97.3	756	109.2	756	114.8
755	95.2	755	97.3	755	109.2	755	115.0
754	95.0	754	97.0	754	108.9	754	114.6
753	69.1	753	69.2	753	70.1	753	71.8
752	69.2	752	69.1	752	70.2	752	71.6
751	69.6	751	69.9	751	74.7	751	79.1
750	69.7	750	69.6	750	70.9	750	72.6

TABLE D1-3 DRYWELL NO. 1 THERMOCOUPLE DATA, FUEL ASSEMBLY: B43

DATE: 11/1/80
TIME: 4:00 p.m.
OPERATING HRS: 1,132

T/C No.	Temp(°F)
780	156.0
779	165.8
778	124.3
777	121.7
776	124.4
775	76.3
774	76.4
773	85.6
772	77.0
771	173.2
770	177.9
769	185.0
768	185.0
767	139.3
766	140.1
765	139.1
764	77.2
763	77.2
762	89.6
761	78.5
760	186.7
759	185.3
758	154.2
757	154.3
756	118.3
755	118.6
754	118.0
753	73.8
752	73.5
751	82.6
750	74.7

DATE: 11/15/80
TIME: 4:00 p.m.
OPERATING HRS: 1,468

T/C No.	Temp(°F)
780	154.8
779	164.9
778	123.5
777	120.9
776	123.7
775	74.2
774	74.6
773	84.1
772	75.2
771	173.0
770	177.3
769	185.0
768	185.1
767	139.7
766	140.7
765	139.5
764	77.2
763	77.6
762	90.3
761	78.9
760	187.5
759	185.5
758	155.2
757	155.2
756	119.5
755	119.8
754	119.2
753	74.6
752	74.4
751	84.1
750	75.9

DATE: 12/1/80
TIME: 4:00 p.m.
OPERATING HRS: 1,852

T/C No.	Temp(°F)
780	152.0
779	162.2
778	120.6
777	117.8
776	120.8
775	70.5
774	71.3
773	81.0
772	71.8
771	170.4
770	174.8
769	183.0
768	183.1
767	138.5
766	139.6
765	138.3
764	76.7
763	77.0
762	90.1
761	78.5
760	186.6
759	184.8
758	155.6
757	155.7
756	120.3
755	120.5
754	119.9
753	75.4
752	75.2
751	85.2
750	76.9

DATE: 12/15/80
TIME: 4:00 p.m.
OPERATING HRS: 2,188

T/C No.	Temp(°F)
780	150.4
779	160.1
778	118.6
777	115.9
776	118.8
775	67.8
774	68.8
773	78.7
772	69.4
771	168.7
770	172.7
769	181.3
768	181.4
767	137.3
766	138.4
765	137.2
764	75.5
763	76.1
762	89.2
761	77.5
760	185.6
759	183.6
758	155.3
757	155.5
756	120.2
755	120.5
754	119.9
753	75.5
752	75.4
751	85.4
750	77.2

DATE: 1/1/81
TIME: 4:00 p.m.
OPERATING HRS: 2,596

T/C No.	Temp(°F)
780	150.2
779	159.6
778	118.2
777	115.4
776	118.4
775	66.2
774	67.3
773	77.2
772	68.0
771	168.3
770	172.4
769	180.8
768	180.8
767	136.8
766	137.9
765	136.5
764	74.0
763	74.7
762	88.0
761	76.4
760	185.1
759	183.2
758	155.2
757	155.2
756	120.2
755	120.3
754	119.8
753	75.2
752	75.4
751	85.4
750	77.3

DATE: 1/15/81
TIME: 4:00 p.m.
OPERATING HRS: 2,932

T/C No.	Temp(°F)
780	149.2
779	158.9
778	117.5
777	114.7
776	117.7
775	65.6
774	66.7
773	76.7
772	67.5
771	167.6
770	171.5
769	180.0
768	180.3
767	136.3
766	137.5
765	136.0
764	73.2
763	74.0
762	87.4
761	75.7
760	184.6
759	182.7
758	154.9
757	154.9
756	119.9
755	120.2
754	119.6
753	75.0
752	75.2
751	85.2
750	77.2

DATE: 2/1/81
TIME: 4:00 p.m.
OPERATING HRS: 3,340

T/C No.	Temp(°F)
780	147.3
779	157.8
778	116.5
777	113.9
776	116.8
775	65.0
774	65.8
773	76.1
772	66.7
771	165.9
770	170.1
769	178.7
768	179.1
767	135.9
766	136.8
765	135.7
764	72.4
763	73.4
762	86.7
761	75.2
760	183.7
759	182.1
758	154.4
757	154.7
756	119.8
755	120.1
754	119.3
753	74.7
752	74.7
751	85.0
750	76.7

DATE: 2/15/81
TIME: 4:00 p.m.
OPERATING HRS: 3,676

T/C No.	Temp(°F)
780	147.2
779	155.6
778	114.5
777	111.7
776	114.7
775	61.9
774	63.2
773	73.2
772	64.1
771	164.5
770	168.4
769	177.1
768	177.6
767	134.2
766	135.5
765	133.9
764	71.0
763	71.9
762	85.3
761	73.8
760	182.4
759	180.7
758	153.5
757	153.5
756	119.0
755	119.0
754	118.5
753	73.7
752	74.1
751	84.2
750	76.3

TABLE D1-4 DRYWELL NO. 1 THERMOCOUPLE DATA, FUEL ASSEMBLY: B43

DATE: 3/1/81		DATE: 3/15/81		DATE: 4/1/81		DATE: 4/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 4,012		OPERATING HRS: 4,348		OPERATING HRS: 4,756		OPERATING HRS: 5,092	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
780	147.6	780	146.9	780	147.7	780	149.8
779	155.9	779	152.4	779	153.1	779	155.3
778	115.2	778	114.7	778	115.4	778	118.0
777	112.3	777	111.9	777	112.6	777	115.7
776	115.3	776	114.8	776	115.6	776	118.3
775	62.4	775	62.1	775	63.0	775	65.6
774	63.4	774	63.1	774	63.8	774	66.1
773	73.6	773	73.2	773	74.0	773	76.6
772	64.4	772	64.1	772	65.1	772	67.5
771	164.2	771	163.8	771	164.6	771	167.1
770	168.7	770	167.9	770	168.7	770	171.0
769	177.1	769	176.6	769	177.3	769	179.3
768	177.4	768	177.1	768	177.6	768	179.2
767	134.2	767	134.1	767	134.6	767	136.5
766	135.4	766	135.4	766	136.0	766	137.7
765	133.9	765	133.9	765	134.5	765	136.3
764	70.0	764	69.8	764	69.6	764	70.1
763	70.9	763	70.6	763	70.3	763	71.0
762	84.3	762	84.1	762	83.8	762	84.3
761	72.8	761	72.6	761	72.4	761	73.1
760	182.2	760	181.7	760	182.0	760	183.0
759	180.4	759	180.0	759	180.3	759	181.7
758	153.0	758	152.5	758	152.4	758	152.8
757	152.9	757	152.5	757	152.5	757	153.0
756	118.5	756	118.4	756	118.4	756	119.1
755	118.5	755	118.5	755	118.4	755	119.2
754	118.1	754	118.1	754	118.0	754	118.7
753	73.0	753	72.7	753	72.4	753	72.8
752	73.4	752	73.2	752	73.0	752	73.2
751	83.6	751	83.3	751	83.1	751	83.4
750	75.7	750	75.5	750	75.4	750	75.6

DATE: 5/1/81		DATE: 5/15/81		DATE: 6/1/81		DATE: 6/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 5,476		OPERATING HRS: 5,812		OPERATING HRS: 6,220		OPERATING HRS: 6,556	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
780	152.3	780	154.6	780	155.0	780	158.4
779	158.1	779	160.5	779	160.9	779	164.2
778	121.3	778	123.9	778	125.0	778	128.7
777	118.7	777	121.6	777	122.6	777	126.3
776	121.5	776	124.0	776	125.3	776	128.9
775	69.1	775	72.5	775	74.6	775	78.0
774	69.6	774	72.6	774	75.0	774	78.1
773	79.8	773	83.0	773	85.0	773	88.2
772	71.1	772	74.3	772	76.7	772	80.0
771	169.7	771	171.7	771	172.6	771	175.7
770	173.8	770	175.9	770	176.7	770	179.8
769	181.8	769	183.8	769	184.7	769	187.6
768	181.7	768	183.6	768	184.6	768	187.1
767	138.8	767	141.0	767	142.8	767	145.4
766	140.1	766	142.1	766	144.2	766	146.7
765	138.5	765	140.5	765	142.2	765	144.7
764	71.3	764	72.2	764	74.3	764	75.4
763	71.9	763	73.0	763	74.8	763	75.9
762	85.5	762	86.5	762	88.4	762	89.4
761	74.1	761	75.3	761	77.3	761	78.4
760	184.0	760	185.3	760	186.6	760	188.2
759	183.5	759	185.0	759	185.9	759	187.8
758	153.3	758	153.9	758	154.6	758	155.3
757	153.5	757	154.0	757	154.6	757	155.4
756	119.8	756	120.4	756	121.7	756	122.7
755	119.9	755	120.5	755	121.7	755	122.7
754	119.5	754	120.0	754	121.3	754	122.2
753	72.9	753	73.0	753	73.8	753	74.3
752	73.5	752	73.4	752	74.3	752	74.7
751	83.6	751	83.8	751	84.5	751	85.0
750	76.0	750	75.8	750	76.9	750	77.4

TABLE D1-5 DRYWELL NO. 1 THERMOCOUPLE DATA, FUEL ASSEMBLY: B43

DATE: 7/1/81
TIME: 4:00 p.m.
OPERATING HRS: 6940

T/C No.	Temp(°F)
780	161.8
779	167.4
778	132.2
777	129.9
776	132.4
775	82.0
774	82.1
773	92.0
772	84.0
771	179.1
770	183.1
769	190.7
768	190.2
767	148.7
766	149.8
765	147.9
764	77.4
763	77.9
762	91.3
761	80.4
760	190.6
759	190.1
758	156.4
757	156.7
756	124.0
755	123.9
754	123.6
753	75.1
752	75.6
751	85.8
750	78.3

DATE: 7/15/81
TIME: 4:00 p.m.
OPERATING HRS: 7276

T/C No.	Temp(°F)
780	163.9
779	169.6
778	134.7
777	132.1
776	134.8
775	85.1
774	85.1
773	95.0
772	87.1
771	180.7
770	185.4
769	192.7
768	192.3
767	151.2
766	152.1
765	150.3
764	79.6
763	79.9
762	93.3
761	82.5
760	192.4
759	191.9
758	157.6
757	157.8
756	125.4
755	125.3
754	125.0
753	76.0
752	76.5
751	86.7
750	79.3

DATE: 8/1/81
TIME: 4:00 p.m.
OPERATING HRS: 7684

T/C No.	Temp(°F)
780	166.4
779	172.3
778	137.7
777	135.2
776	137.8
775	88.7
774	88.5
773	98.4
772	90.6
771	183.9
770	188.2
769	195.2
768	194.7
767	153.9
766	154.9
765	153.3
764	82.5
763	82.9
762	96.0
761	85.6
760	194.8
759	194.9
758	160.1
757	160.3
756	128.1
755	128.1
754	127.7
753	78.6
752	79.0
751	89.2
750	81.8

DATE: 8/15/81
TIME: 4:00 p.m.
OPERATING HRS: 8020

T/C No.	Temp(°F)
780	166.6
779	173.0
778	137.9
777	136.2
776	137.9
775	89.8
774	88.5
773	99.4
772	90.4
771	185.2
770	188.0
769	196.2
768	194.6
767	155.4
766	155.0
765	154.6
764	82.9
763	84.7
762	96.1
761	87.6
760	195.1
759	196.3
758	160.2
757	161.6
756	128.3
755	129.6
754	127.9
753	80.3
752	79.3
751	91.1
750	82.6

DATE: 9/1/81
TIME: 4:00 p.m.
OPERATING HRS: 8428

T/C No.	Temp(°F)
780	167.4
779	173.1
778	138.8
777	136.3
776	138.9
775	89.9
774	90.0
773	99.6
772	91.9
771	185.3
770	189.4
769	196.9
768	196.5
767	156.3
766	157.2
765	155.6
764	85.5
763	85.9
762	98.5
761	88.6
760	196.9
759	197.0
758	161.9
757	162.1
756	130.3
755	130.3
754	129.9
753	81.0
752	81.3
751	91.2
750	84.1

DATE: 9/21/81
TIME: 4:00 p.m.
OPERATING HRS: 8908

T/C No.	Temp(°F)
780	165.8
779	171.9
778	137.6
777	134.8
776	137.6
775	88.7
774	89.1
773	98.4
772	90.9
771	183.6
770	188.0
769	196.1
768	195.8
767	156.2
766	157.2
765	155.5
764	86.4
763	86.9
762	99.2
761	89.4
760	197.0
759	197.0
758	162.7
757	162.8
756	131.4
755	131.4
754	130.9
753	82.1
752	82.5
751	92.3
750	85.2

DATE: 10/1/81
TIME: 4:00 p.m.
OPERATING HRS: 9148

T/C No.	Temp(°F)
780	164.8
779	170.8
778	136.6
777	133.8
776	136.6
775	87.9
774	88.3
773	97.6
772	90.1
771	183.2
770	187.2
769	195.4
768	195.2
767	155.8
766	156.9
765	155.2
764	86.5
763	87.0
762	99.1
761	89.6
760	197.0
759	196.9
758	162.9
757	163.1
756	131.6
755	132.2
754	131.2
753	82.5
752	83.0
751	92.7
750	85.8

DATE: 10/15/81
TIME: 4:00 p.m.
OPERATING HRS: 9484

T/C No.	Temp(°F)
780	161.7
779	168.0
778	133.5
777	130.6
776	133.5
775	84.9
774	85.5
773	94.6
772	87.2
771	179.8
770	184.1
769	192.8
768	192.7
767	154.1
766	155.2
765	153.6
764	85.9
763	86.6
762	98.4
761	89.0
760	195.7
759	195.5
758	162.7
757	162.8
756	131.5
755	132.2
754	131.0
753	82.7
752	83.1
751	92.7
750	85.8

TABLE D1-6 DRYWELL NO. 1 THERMOCOUPLE DATA, FUEL ASSEMBLY: B43

DATE: 11/1/81		DATE: 11/15/81		DATE: 12/1/81		DATE: 12/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 9892		OPERATING HRS: 10,228		OPERATING HRS: 10,612		OPERATING HRS: 10,948	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
780	158.5	780	156.8	780	153.3	780	151.0
779	165.0	779	163.4	779	160.1	779	157.9
778	130.3	778	128.5	778	125.3	778	122.9
777	127.3	777	125.4	777	121.8	777	119.3
776	130.3	776	128.6	776	125.3	776	122.9
775	80.9	775	78.1	775	74.7	775	71.1
774	81.8	774	79.3	774	76.3	774	72.7
773	90.6	773	88.1	773	84.8	773	81.4
772	82.9	772	80.3	772	77.3	772	73.6
771	176.7	771	175.2	771	171.2	771	169.0
770	181.0	770	179.5	770	175.9	770	173.6
769	189.8	769	188.5	769	184.8	769	182.6
768	190.4	768	189.0	768	186.1	768	184.0
767	151.8	767	150.6	767	148.0	767	146.0
766	152.9	766	151.7	766	149.1	766	147.1
765	151.4	765	150.3	765	149.1	765	147.7
764	84.6	764	83.3	764	81.5	764	79.9
763	85.4	763	84.2	763	82.4	763	80.9
762	97.0	762	95.6	762	93.8	762	92.1
761	87.7	761	86.3	761	84.5	761	82.8
760	193.9	760	193.2	760	191.0	760	189.2
759	194.0	759	192.9	759	190.8	759	189.1
758	162.4	758	162.0	758	161.1	758	160.2
757	162.5	757	162.1	757	161.0	757	160.2
756	131.4	756	131.1	756	130.2	756	129.4
755	135.1	755	137.3	755		755	
754	131.0	754	130.6	754	129.8	754	129.0
753	83.1	753	82.8	753	82.1	753	81.6
752	83.5	752	83.3	752	82.8	752	82.3
751	92.8	751	92.5	751	91.7	751	91.1
750	86.2	750	86.1	750	85.5	750	84.8

DATE: 1/1/82		DATE: 1/15/82		DATE: 2/1/82		DATE: 2/15/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 11,356		OPERATING HRS: 11,692		OPERATING HRS: 12,100		OPERATING HRS: 12,436	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
780	148.6	780	145.9	780	144.2	780	142.7
779	155.5	779	153.1	779	151.2	779	149.8
778	120.1	778	117.6	778	115.7	778	11.40
777	116.6	777	114.0	777	112.3	777	110.6
776	120.2	776	117.7	776	115.8	776	114.2
775	68.0	775	65.3	775	63.0	775	61.9
774	69.8	774	67.2	774	64.8	774	63.7
773	78.4	773	75.6	773	73.4	773	72.3
772	70.5	772	67.9	772	65.5	772	64.5
771	166.5	771	163.8	771	161.7	771	160.4
770	171.1	770	168.7	770	166.4	770	165.1
769	180.1	769	177.6	769	175.4	769	173.9
768	181.9	768	179.5	768	177.3	768	175.8
767	143.7	767	141.7	767	140.0	767	138.5
766	144.8	766	142.8	766	140.8	766	139.4
765	145.1	765	143.2	765	141.2	765	139.7
764	77.5	764	76.1	764	73.9	764	72.5
763	78.6	763	77.2	763	75.2	763	73.7
762	89.7	762	88.4	762	86.2	762	84.8
761	80.6	761	79.2	761	77.1	761	75.6
760	187.3	760	185.5	760	183.5	760	182.2
759	187.4	759	185.2	759	183.6	759	182.3
758	159.2	758	158.0	758	156.8	758	155.9
757	159.2	757	157.9	757	156.8	757	155.8
756	128.3	756	127.5	756	126.3	756	125.5
755		755		755		755	
754	127.8	754	127.0	754	125.8	754	125.0
753	80.8	753	79.8	753	78.8	753	77.9
752	81.3	752	80.7	752	79.5	752	78.7
751	90.1	751	89.3	751	88.1	751	87.2
750	83.7	750	83.2	750	81.9	750	81.1

TABLE D1-7 DRYWELL NO. 1 THERMOCOUPLE DATA, FUEL ASSEMBLY: B43

DATE: 3/1/82
TIME: 4:00 p.m.
OPERATING HRS: 12,772

T/C No.	Temp(°F)
780	144.6
779	151.5
778	116.1
777	112.8
776	116.4
775	62.9
774	64.3
773	73.1
772	65.3
771	162.1
770	166.9
769	175.4
768	176.8
767	139.1
766	140.0
765	
764	71.3
763	72.6
762	83.6
761	74.4
760	182.6
759	182.5
758	155.3
757	155.3
756	125.0
755	
754	124.6
753	77.0
752	77.9
751	86.4
750	80.3

DATE: 3/15/82
TIME: 4:00 p.m.
OPERATING HRS: 13,108

T/C No.	Temp(°F)
780	145.3
779	152.3
778	117.3
777	114.0
776	117.5
775	64.1
774	65.4
773	74.2
772	66.4
771	163.2
770	167.4
769	176.3
768	177.6
767	139.5
766	140.6
765	
764	70.8
763	72.0
762	83.2
761	73.9
760	183.0
759	182.9
758	154.9
757	154.9
756	124.5
755	
754	124.1
753	76.1
752	77.0
751	85.6
750	79.3

DATE: 3/31/82
TIME: 4:00 p.m.
OPERATING HRS: 13,492

T/C No.	Temp(°F)
780	143.4
779	150.7
778	115.3
777	112.0
776	115.8
775	63.9
774	64.9
773	73.8
772	66.1
771	161.2
770	165.9
769	174.5
768	176.2
767	138.6
766	139.5
765	
764	70.8
763	71.9
762	83.1
761	73.8
760	181.7
759	181.7
758	154.3
757	154.2
756	124.0
755	
754	123.6
753	75.5
752	76.4
751	85.0
750	78.8

APPENDIX E

CONCRETE SILO TEST DATA

Test data are provided in this Appendix for the Concrete Silo Test. Table E-1 provides the detailed identification and the location of the test thermocouples. Tables E-2 through E-23 provide thermocouple readings at the times and for the test operating hours shown below:

Table No.	Date	Operating Hours
E-2	12/7/78	0
-2	12/8/78	24
-2	12/9/78	44
-2	12/11/78	97
E-3	12/12/78	119
-3	12/15/78	193
-3	1/1/79	601
-3	1/15/79	937
E-4	2/1/79	1,345
-4	2/15/79	1,681
-4	3/1/79	2,017
-4	3/15/79	2,353
E-5	4/1/79	2,761
-5	4/15/79	3,097
-5	5/1/79	3,481
-5	5/15/79	3,821
E-6	6/1/79	4,225
-6	6/15/79	4,561
-6	7/1/79	4,945
-6	7/15/79	5,281
E-7	8/1/79	5,689
-7	8/15/79	6,025
-7	9/1/79	6,433
-7	9/15/79	6,769
E-8	10/1/79	7,153
-8	10/15/79	7,489
-8	11/1/79	7,897
-8	11/15/79	8,233
E-9	12/1/79	8,617
-9	12/15/79	8,953
-9	1/1/80	9,361
-9	1/15/80	9,697
E-10	2/1/80	10,105
-10	2/15/80	10,441
-10	3/1/80	10,801
-10	3/15/80	11,137
E-11	4/1/80	11,545
-11	4/15/80	11,881
-11	5/1/80	12,265
-11	5/15/80	12,601
E-12	6/1/80	13,009
-12	6/15/80	13,345
-12	7/1/80	13,729
-12	7/15/80	14,065
E-13	8/1/80	14,473
-13	8/15/80	14,809
-13	9/2/80	15,241
-13	9/15/80	15,553
E-14	10/1/80	15,937
-14	10/15/80	16,273
-14	11/1/80	16,681
-14	11/15/80	17,017
E-15	12/1/80	17,401
-15	12/15/80	17,737
-15	1/1/81	18,145
-15	1/15/81	18,481

Table No.	Date	Operating Hours	Table No.	Date	Operating Hours
E-16	2/1/81	18,889	E-20	10/1/81	24,697
-16	2/15/81	19,225	-20	10/15/81	25,033
-16	3/1/81	19,561	-20	11/1/81	25,441
-16	3/15/81	19,897	-20	11/15/81	25,777
E-17	4/1/81	20,305	E-21	12/1/81	26,161
-17	4/15/81	20,641	-21	12/15/81	26,497
-17	5/1/81	21,025	-21	1/1/82	26,905
-17	5/15/81	21,361	-21	1/15/82	27,241
E-18	6/1/81	21,769	E-22	2/1/82	27,649
-18	6/15/81	22,105	-22	2/15/82	27,985
-18	7/1/81	22,489	-22	3/1/82	28,321
-18	7/15/81	22,825	-22	3/15/82	28,657
E-19	8/1/81	23,233	E-23	3/31/82	29,041
-19	8/15/81	23,569			
-19	9/1/81	23,977			
-19	9/21/81	24,457			

TABLE E-1

CONCRETE SILO 2 THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance Below Top of Silo (In.)	Radius (In.)	Orientation* (Degrees)	Location
620	68.5	9	45	Liner
621	68.5	23	45	Silo Concrete
622	68.5	37	45	Silo Concrete
623	68.5	50	45	Silo Concrete
624	128.5	9	45	Liner
625	128.5	23	45	Silo Concrete
626	128.5	37	45	Silo Concrete
627	128.5	50	45	Silo Concrete
628	188.5	9	45	Liner
629	188.5	23	45	Silo Concrete
630	188.5	37	45	Silo Concrete
631	188.5	50	45	Silo Concrete
632	68.5	9	135	Liner
633	68.5	23	135	Silo Concrete
634	68.5	37	135	Silo Concrete
635	68.5	50	135	Silo Concrete
636	128.5	9	135	Liner
637	128.5	23	135	Silo Concrete
638	128.5	37	135	Silo Concrete
639	128.5	50	135	Silo Concrete
640	188.5	9	135	Liner
641	188.5	23	135	Silo Concrete
642	188.5	50	135	Silo Concrete
643	188.5	37	135	Silo Concrete
644	68.5	9	225	Liner
645	68.5	23	225	Silo Concrete
646	68.5	37	225	Silo Concrete
647	68.5	50	225	Silo Concrete
648	128.5	9	225	Liner
649	128.5	23	225	Silo Concrete
650	128.5	37	225	Silo Concrete
651	128.5	50	225	Silo Concrete
652	188.5	9	225	Liner
653	188.5	23	225	Silo Concrete
654	188.5	37	225	Silo Concrete
655	188.5	50	225	Silo Concrete
656	68.5	9	315	Liner
657	68.5	23	315	Silo Concrete
658	68.5	37	315	Silo Concrete
659	68.5	50	315	Silo Concrete

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*Azimuth orientation is from North = 0° clockwise

TABLE E-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Top of Silo (In.)	Radius (In.)	Orientation* (Degrees)	Location
660	128.5	9	315	Liner
661	128.5	23	315	Silo Concrete
662	128.5	37	315	Silo Concrete
663	128.5	50	315	Silo Concrete
664	188.5	9	315	Liner
665	188.5	23	315	Silo Concrete
666	188.5	37	315	Silo Concrete
667	188.5	50	315	Silo Concrete
668	68.0	9	270	Liner
669	68.0	9	90	Liner
670	128.0	9	270	Liner
671	128.0	9	90	Liner
672	188.0	9	270	Liner
673	188.0	9	90	Liner
674	68.0	7	240	Canister
675	68.0	7	60	Canister
676	98.0	7	255	Canister
677	98.0	7	75	Canister
678	128.0	7	270	Canister
679	128.0	7	90	Canister
680	158.0	7	285	Canister
681	158.0	7	105	Canister
682	188.0	7	300	Canister
683	188.0	7	120	Canister

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*Azimuth orientation is from North = 0° clockwise

TABLE E-2 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 12/7/78		DATE: 12/8/78		DATE: 12/9/78		DATE: 12/11/78	
TIME: 3:00 p.m.		TIME: 3:00 p.m.		TIME: 11:00 a.m.		TIME: 4:00 p.m.	
OPERATING HRS: 0		OPERATING HRS: 24		OPERATING HRS: 44		OPERATING HRS: 97	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	38.1	683	112.4	683	113.5	683	117.6
682	37.3	682	118.5	682	119.8	682	123.9
681	40.0	681	150.2	681	152.4	681	158.1
680	37.9	680	145.0	680	146.9	680	152.8
679	37.3	679	147.3	679	149.3	679	155.3
678	40.9	678	149.6	678	151.9	678	157.7
677	48.4	677	143.8	677	145.4	677	151.0
676	46.6	676	142.1	676	144.1	676	149.6
675	39.5	675	131.6	675	133.2	675	138.7
674	46.7	674	128.2	674	129.4	674	135.4
673	34.9	673	58.5	673	59.5	673	64.2
672	34.8	672	41.6	672	34.1	672	50.1
671	35.8	671	69.2	671	72.1	671	79.2
670	36.0	670	69.2	670	72.2	670	79.4
669	47.6	669	63.7	669	65.0	669	72.1
668	44.2	668	59.4	668	61.2	668	67.4
667	34.3	667	30.6	667	29.8	667	44.9
666	34.7	666	32.3	666	33.0	666	41.1
665	40.0	665	40.2	665	40.7	665	45.6
664	53.1	664	57.4	664	58.7	664	62.5
663	34.5	663	31.2	663	30.1	663	46.8
662	34.4	662	32.6	662	34.2	662	43.9
661	39.5	661	42.2	661	44.2	661	51.7
660	58.1	660	68.5	660	71.5	660	78.1
659	34.1	659	31.3	659	30.3	659	47.4
658	33.9	658	32.0	658	33.2	658	42.3
657	38.5	657	40.4	657	41.7	657	48.5
656	52.6	656	59.8	656	61.6	656	67.5
655	38.4	655	42.6	655	34.1	655	58.9
654	37.4	654	35.6	654	38.2	654	46.6
653	41.5	653	42.4	653	43.7	653	49.6
652	53.3	652	57.7	652	58.8	652	63.4
651	46.3	651	54.1	651	34.5	651	72.7
650	36.6	650	35.8	650	39.5	650	50.2
649	40.6	649	43.8	649	47.1	649	55.6
648	58.6	648	69.2	648	72.5	648	79.7
647	48.5	647	55.8	647	34.1	647	73.5
646	35.7	646	34.4	646	37.8	646	48.2
645	39.7	645	42.7	645	45.1	645	52.6
644	55.1	644	62.9	644	65.1	644	71.4
643	38.1	643	36.5	643	38.3	643	46.3
642	36.8	642	35.5	642	33.5	642	52.9
641	42.2	641	44.1	641	45.2	641	50.9
640	53.2	640	57.7	640	58.8	640	63.3
639	38.9	639	40.3	639	34.4	639	57.9
638	37.4	638	36.2	638	39.4	638	49.8
637	41.9	637	46.8	637	49.9	637	58.2
636	58.8	636	69.4	636	72.8	636	79.9
635	39.2	635	40.1	635	33.9	635	57.3
634	36.4	634	34.9	634	37.4	634	47.7
633	40.5	633	44.8	633	46.4	633	53.9
632	55.7	632	64.9	632	67.1	632	73.6
631	35.3	631	32.1	631	32.0	631	47.0
630	36.1	630	34.6	630	35.2	630	43.3
629	41.1	629	42.7	629	43.3	629	48.0
628	53.2	628	57.5	628	58.8	628	62.7
627	36.5	627	33.3	627	32.8	627	49.3
626	35.6	626	34.4	626	36.2	626	45.9
625	41.0	625	46.5	625	48.0	625	56.1
624	58.3	624	68.8	624	71.6	624	78.4
623	36.3	623	33.1	623	31.7	623	48.7
622	35.2	622	34.1	622	35.3	622	44.2
621	39.1	621	42.9	621	44.1	621	50.6
620	53.5	620	62.6	620	64.5	620	70.4

TABLE E-3 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 12/12/78		DATE: 12/15/78		DATE: 1/1/78		DATE: 1/15/79	
TIME: 2:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 119		OPERATING HRS: 193		OPERATING HRS: 601		OPERATING HRS: 937	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	120.5	683	128.6	683	129.3	683	130.9
682	126.8	682	135.0	682	135.4	682	136.6
681	161.2	681	169.7	681	170.1	681	171.4
680	156.0	680	164.6	680	164.7	680	166.1
679	158.5	679	167.1	679	167.3	679	169.0
678	161.0	678	169.9	678	169.2	678	170.0
677	154.0	677	162.1	677	162.2	677	163.8
676	153.3	676	160.7	676	161.1	676	162.5
675	141.7	675	149.6	675	149.6	675	151.3
674	138.8	674	146.9	674	146.2	674	148.2
673	67.2	673	75.5	673	77.1	673	78.9
672	53.2	672	58.0	672	77.0	672	78.8
671	82.6	671	92.2	671	94.3	671	96.0
670	83.2	670	92.6	670	94.5	670	96.3
669	75.8	669	84.7	669	85.1	669	87.3
668	71.3	668	80.0	668	80.0	668	82.4
667	43.0	667	49.3	667	39.4	667	45.7
666	42.7	666	48.4	666	43.8	666	50.3
665	48.2	665	55.5	665	55.4	665	59.0
664	65.7	664	73.9	664	75.5	664	77.5
663	46.0	663	51.5	663	41.0	663	47.0
662	45.9	662	52.8	662	49.0	662	55.3
661	54.9	661	63.3	661	63.7	661	67.2
660	81.9	660	91.4	660	93.1	660	95.2
659	47.0	659	51.6	659	39.3	659	45.1
658	44.6	658	51.1	658	46.6	658	53.2
657	51.7	657	59.8	657	59.2	657	63.3
656	71.2	656	80.2	656	80.7	656	83.3
655	56.1	655	64.8	655	50.4	655	45.5
654	48.6	654	53.9	654	50.4	654	52.9
653	52.6	653	59.5	653	59.7	653	61.1
652	66.6	652	74.7	652	76.2	652	77.6
651	66.7	651	78.9	651	64.1	651	47.7
650	52.3	650	58.8	650	55.5	650	57.5
649	59.3	649	67.2	649	67.8	649	69.2
648	83.7	648	92.9	648	94.7	648	96.1
647	68.2	647	79.8	647	63.8	647	46.4
646	50.1	646	56.3	646	52.1	646	54.6
645	56.2	645	63.8	645	63.2	645	65.1
644	75.1	644	83.9	644	84.7	644	86.6
643	48.7	643	54.4	643	51.3	643	54.2
642	50.5	642	57.9	642	45.0	642	45.7
641	54.0	641	61.3	641	61.6	641	63.3
640	66.4	640	74.7	640	76.1	640	77.7
639	57.4	639	63.7	639	50.1	639	47.4
638	52.1	638	58.7	638	55.6	638	58.4
637	61.9	637	70.4	637	71.3	637	72.7
636	83.6	636	93.1	636	95.2	636	96.5
635	57.8	635	62.8	635	48.8	635	46.2
634	49.8	634	56.2	634	51.7	634	54.8
633	57.6	633	65.6	633	65.0	633	67.1
632	77.2	632	86.3	632	86.9	632	88.9
631	45.8	631	51.2	631	41.1	631	46.2
630	45.0	630	50.8	630	46.8	630	51.8
629	56.9	629	58.4	629	58.7	629	61.4
628	65.8	628	74.0	628	75.7	628	77.4
627	48.3	627	54.6	627	43.7	627	47.7
626	48.0	626	54.6	626	51.3	626	56.1
625	59.5	625	68.4	625	69.4	625	72.1
624	82.2	624	91.6	624	93.4	624	95.2
623	47.7	623	53.7	623	42.5	623	46.5
622	46.6	622	53.2	622	49.2	622	54.4
621	54.0	621	62.4	621	61.6	621	65.1
620	74.1	620	83.2	620	83.6	620	86.0

TABLE E-4 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 2/1/79		DATE: 2/15/79		DATE: 3/1/79		DATE: 3/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 1345		OPERATING HRS: 1681		OPERATING HRS: 2017		OPERATING HRS: 2353	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	118.3	683	132.8	683	132.5	683	143.3
682	124.2	682	138.5	682	138.2	682	148.7
681	158.3	681	172.6	681	171.6	681	181.6
680	153.3	680	167.2	680	166.6	680	177.0
679	155.9	679	170.9	679	169.0	679	179.5
678	158.2	678	172.2	678	171.3	678	181.4
677	150.9	677	165.8	677	164.1	677	174.0
676	149.7	676	164.8	676	162.5	676	173.3
675	138.7	675	153.6	675	151.8	675	161.7
674	135.0	674	150.4	674	149.5	674	158.6
673	66.6	673	83.0	673	82.5	673	94.5
672	66.7	672	82.8	672	82.5	672	94.5
671	83.2	671	100.3	671	98.9	671	111.3
670	83.5	670	100.5	670	99.2	670	111.7
669	74.3	669	92.3	669	90.9	669	102.9
668	69.6	668	87.6	668	86.5	668	98.3
667	40.2	667	55.1	667	51.6	667	64.0
666	40.5	666	55.5	666	56.1	666	66.4
665	47.9	665	64.2	665	64.2	665	75.5
664	65.5	664	81.6	664	81.7	664	93.4
663	43.7	663	57.6	663	53.2	663	66.4
662	45.5	662	60.7	662	60.8	662	71.7
661	55.8	661	72.7	661	72.3	661	84.0
660	82.8	660	99.7	660	98.6	660	110.8
659	42.0	659	57.7	659	51.5	659	65.0
658	42.8	658	59.0	658	58.8	658	69.5
657	51.4	657	69.2	657	68.2	657	79.8
656	70.6	656	88.3	656	87.2	656	99.0
655	40.0	655	66.1	655	52.2	655	65.5
654	42.1	654	59.9	654	60.8	654	70.7
653	49.4	653	66.8	653	67.9	653	78.5
652	65.5	652	82.0	652	82.2	652	93.8
651	45.4	651	83.8	651	56.1	651	70.9
650	47.4	650	65.5	650	65.4	650	76.1
649	57.1	649	75.1	649	75.9	649	86.8
648	83.3	648	100.6	648	100.0	648	111.9
647	43.7	647	84.7	647	55.2	647	69.7
646	44.1	646	63.0	646	62.7	646	73.2
645	52.6	645	71.7	645	71.9	645	82.7
644	73.6	644	91.7	644	91.0	644	102.7
643	42.8	643	60.2	643	61.4	643	71.1
642	38.7	642	60.1	642	51.8	642	64.6
641	51.3	641	68.3	641	69.5	641	80.2
640	65.5	640	81.9	640	82.2	640	93.8
639	42.5	639	66.0	639	53.5	639	66.8
638	47.6	638	65.4	638	65.3	638	75.7
637	60.3	637	78.2	637	78.7	637	89.6
636	83.7	636	100.8	636	100.4	636	112.3
635	41.2	635	65.8	635	52.7	635	65.9
634	43.8	634	62.6	634	61.9	634	72.3
633	54.4	633	73.3	633	73.2	633	84.1
632	75.7	632	93.8	632	93.1	632	104.7
631	37.6	631	54.8	631	51.6	631	63.2
630	40.9	630	57.2	630	57.3	630	67.2
629	49.8	629	66.5	629	66.4	629	77.5
628	65.4	628	81.7	628	81.6	628	93.3
627	40.7	627	58.4	627	52.9	627	65.4
626	45.3	626	61.7	626	61.4	626	71.8
625	60.0	625	77.3	625	76.6	625	88.2
624	82.7	624	99.7	624	98.4	624	110.7
623	39.4	623	57.9	623	51.9	623	64.5
622	43.1	622	60.5	622	59.9	622	70.3
621	52.9	621	71.1	621	69.9	621	81.4
620	73.3	620	91.2	620	89.8	620	101.6

TABLE E-5 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 4/1/79		DATE: 4/15/79		DATE: 5/1/79		DATE: 5/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 8:00 p.m.	
OPERATING HRS: 2761		OPERATING HRS: 3097		OPERATING HRS: 3481		OPERATING HRS: 3821	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	132.7	683	141.8	683	150.0	683	148.8
682	137.8	682	146.6	682	154.9	682	153.9
681	170.5	681	178.9	681	186.8	681	185.2
680	165.8	680	174.5	680	182.3	680	181.0
679	168.7	679	177.0	679	185.0	679	183.4
678	170.5	678	178.5	678	186.5	678	185.1
677	163.3	677	171.7	677	179.8	677	178.2
676	162.2	676	170.8	676	178.6	676	177.7
675	151.5	675	159.7	675	167.5	675	166.1
674	148.8	674	157.2	674	164.8	674	163.7
673	84.5	673	94.2	673	103.6	673	102.7
672	84.4	672	94.1	672	103.4	672	102.9
671	100.5	671	110.2	671	119.6	671	118.7
670	100.8	670	110.5	670	120.1	670	119.2
669	92.1	669	102.5	669	111.7	669	111.4
668	87.6	668	98.2	668	107.5	668	107.4
667	58.8	667	76.7	667	76.2	667	87.4
666	58.6	666	71.7	666	78.5	666	83.2
665	66.5	665	77.5	665	86.7	665	87.2
664	83.1	664	92.8	664	102.4	664	102.1
663	62.5	663	79.8	663	78.3	663	90.4
662	63.4	662	76.2	662	83.5	662	87.5
661	74.5	661	85.4	661	94.7	661	94.9
660	99.8	660	109.5	660	119.1	660	118.5
659	63.7	659	81.1	659	76.5	659	87.6
658	61.2	658	74.0	658	81.1	658	85.0
657	70.2	657	81.5	657	90.7	657	91.2
656	88.4	656	98.5	656	108.1	656	107.7
655	69.1	655	82.8	655	77.2	655	87.2
654	63.4	654	75.9	654	81.7	654	85.6
653	69.5	653	80.6	653	88.8	653	89.1
652	83.6	652	93.4	652	102.7	652	102.2
651	81.7	651	96.7	651	83.6	651	94.4
650	68.4	650	80.8	650	86.5	650	90.9
649	77.2	649	88.4	649	96.6	649	96.7
648	100.9	648	111.0	648	120.0	648	119.2
647	81.3	647	97.3	647	82.7	647	93.2
646	65.6	646	78.5	646	83.9	646	88.8
645	72.9	645	84.6	645	93.1	645	93.4
644	91.7	644	102.2	644	111.5	644	111.0
643	62.9	643	75.6	643	81.7	643	85.2
642	63.3	642	79.5	642	76.7	642	86.1
641	70.3	641	81.3	641	89.8	641	90.1
640	83.2	640	93.2	640	102.5	640	102.1
639	69.5	639	84.3	639	79.3	639	88.3
638	67.4	638	80.3	638	85.8	638	89.9
637	79.3	637	90.4	637	98.7	637	98.8
636	100.7	636	110.9	636	120.2	636	119.5
635	69.1	635	83.9	635	78.4	635	87.7
634	64.4	634	77.7	634	82.9	634	87.6
633	73.8	633	85.4	633	93.9	633	94.4
632	93.4	632	104.0	632	113.2	632	112.8
631	57.4	631	75.2	631	75.5	631	85.1
630	59.3	630	71.9	630	78.8	630	83.0
629	68.1	629	78.8	629	87.9	629	88.2
628	82.9	628	92.6	628	102.1	628	101.7
627	60.9	627	80.5	627	78.5	627	88.3
626	63.6	626	76.3	626	83.1	626	87.2
625	78.1	625	88.6	625	97.9	625	97.8
624	99.7	624	109.5	624	118.9	624	118.3
623	60.0	623	80.2	623	77.8	623	88.0
622	61.7	622	74.6	622	82.0	622	85.5
621	71.3	621	82.5	621	91.9	621	92.3
620	90.7	620	100.8	620	110.4	620	110.1

TABLE E-6 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 6/1/79		DATE: 6/15/79		DATE: 7/1/79		DATE: 7/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 4225		OPERATING HRS: 4561		OPERATING HRS: 4945		OPERATING HRS: 5281	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	156.8	683	161.9	683	164.0	683	164.8
682	161.2	682	166.4	682	168.4	682	169.1
681	192.4	681	197.1	681	198.6	681	198.9
680	187.6	680	193.1	680	194.6	680	195.1
679	190.5	679	195.3	679	197.1	679	197.5
678	191.9	678	196.5	678	198.4	678	198.6
677	185.0	677	189.7	677	191.5	677	132.0
676	183.5	676	188.6	676	190.5	676	191.2
675	172.6	675	177.3	675	179.0	675	179.8
674	169.9	674	174.7	674	176.7	674	177.7
673	111.7	673	117.7	673	120.3	673	121.8
672	111.3	672	117.4	672	120.2	672	121.7
671	127.4	671	133.2	671	135.7	671	137.0
670	127.5	670	133.3	670	136.0	670	137.4
669	119.1	669	125.1	669	127.9	669	129.4
668	114.6	668	120.6	668	123.5	668	125.3
667	85.4	667	91.0	667	93.3	667	99.7
666	85.1	666	91.8	666	95.4	666	98.6
665	94.2	665	100.8	665	103.9	665	105.8
664	110.4	664	116.5	664	119.4	664	120.7
663	88.2	663	93.5	663	95.2	663	102.4
662	89.8	662	96.3	662	100.0	662	103.3
661	102.0	661	108.2	661	111.4	661	113.4
660	126.8	660	132.7	660	135.4	660	136.6
659	90.0	659	94.6	659	96.1	659	104.1
658	87.8	658	94.2	658	98.0	658	101.3
657	97.8	657	104.4	657	107.7	657	109.6
656	115.2	656	121.5	656	124.3	656	125.7
655	89.8	655	92.3	655	93.9	655	102.6
654	87.3	654	93.2	654	96.6	654	100.5
653	95.6	653	101.6	653	104.6	653	107.1
652	110.4	652	116.4	652	119.2	652	120.8
651	99.6	651	103.1	651	103.5	651	112.8
650	91.9	650	97.4	650	100.9	650	105.2
649	103.1	649	108.7	649	111.8	649	114.5
648	127.4	648	133.0	648	135.6	648	137.1
647	99.5	647	103.3	647	103.5	647	113.0
646	89.2	646	94.9	646	98.6	646	102.8
645	99.2	645	105.3	645	108.5	645	111.1
644	118.1	644	124.1	644	127.1	644	128.6
643	88.0	643	94.3	643	97.8	643	101.1
642	87.6	642	90.9	642	93.0	642	101.3
641	96.8	641	103.1	641	106.3	641	108.3
640	110.1	640	116.2	640	119.3	640	120.7
639	93.0	639	95.5	639	96.4	639	105.7
638	91.9	638	97.9	638	101.4	638	105.1
637	105.6	637	111.6	637	114.6	637	116.7
636	127.5	636	133.4	636	136.0	636	137.3
635	92.6	635	94.9	635	96.0	635	105.2
634	88.9	634	95.1	634	98.6	634	102.6
633	100.4	633	106.8	633	110.0	633	112.1
632	119.9	632	126.1	632	129.0	632	130.4
631	84.7	631	89.8	631	92.7	631	98.7
630	85.8	630	92.6	630	96.2	630	98.8
629	95.7	629	102.2	629	105.3	629	106.9
628	110.3	628	116.4	628	119.2	628	120.5
627	89.8	627	94.9	627	96.7	627	103.7
626	90.1	626	96.4	626	99.9	626	102.9
625	105.6	625	112.0	625	115.0	625	116.4
624	126.8	624	132.7	624	135.4	624	136.5
623	89.2	623	94.2	623	96.3	623	103.1
622	88.6	622	95.4	622	99.1	622	101.7
621	98.9	621	105.8	621	109.0	621	110.7
620	117.5	620	123.9	620	120.8	620	128.0

TABLE E-7 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 8/1/79		DATE: 8/15/79		DATE: 9/1/79		DATE: 9/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 5689		OPERATING HRS: 6025		OPERATING HRS: 6433		OPERATING HRS: 6769	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	164.9	683	157.0	683	155.3	683	161.0
682	169.1	682	161.5	682	159.6	682	165.1
681	198.6	681	190.6	681	188.5	681	193.8
680	194.7	680	186.6	680	184.5	680	189.8
679	196.9	679	188.8	679	186.7	679	192.3
678	198.0	678	189.9	678	188.1	678	193.5
677	191.5	677	182.6	677	181.2	677	187.0
676	190.8	676	181.8	676	180.4	676	186.2
675	179.3	675	170.5	675	169.4	675	175.1
674	177.3	674	168.1	674	166.9	674	173.1
673	122.4	673	114.1	673	112.8	673	119.6
672	122.3	672	114.0	672	112.8	672	119.5
671	137.4	671	128.6	671	127.2	671	134.0
670	137.7	670	128.9	670	127.5	670	134.3
669	129.5	669	119.9	669	119.4	669	126.5
668	125.3	668	115.4	668	115.2	668	122.3
667	100.5	667	88.7	667	88.3	667	91.9
666	98.7	666	89.0	666	87.9	666	93.4
665	106.0	665	97.4	665	96.2	665	102.6
664	121.3	664	113.4	664	111.9	664	118.3
663	103.1	663	91.2	663	90.6	663	93.8
662	103.2	662	93.4	662	92.1	662	97.6
661	113.6	661	104.5	661	103.2	661	109.8
660	136.8	660	128.4	660	126.7	660	133.3
659	103.5	659	91.6	659	91.7	659	94.6
658	101.1	658	90.5	658	90.0	658	95.9
657	109.5	657	99.9	657	99.2	657	106.0
656	125.7	656	116.4	656	115.8	656	122.6
655	105.1	655	91.2	655	93.8	655	101.1
654	101.1	654	90.6	654	91.5	654	97.6
653	107.9	653	98.3	653	98.5	653	105.7
652	121.6	652	113.1	652	112.1	652	118.9
651	115.5	651	102.3	651	105.2	651	113.4
650	106.1	650	94.8	650	95.7	650	102.1
649	115.2	649	105.1	649	105.1	649	112.5
648	137.5	648	128.7	648	127.5	648	134.3
647	115.5	647	102.2	647	105.5	647	113.8
646	103.6	646	91.8	646	93.1	646	99.6
645	111.5	645	100.7	645	101.5	645	109.0
644	128.8	644	119.1	644	118.7	644	125.9
643	101.9	643	91.1	643	91.9	643	98.1
642	103.1	642	89.7	642	91.6	642	97.8
641	109.1	641	99.9	641	99.7	641	106.7
640	121.3	640	113.1	640	111.9	640	116.7
639	107.8	639	93.8	639	95.9	639	103.3
638	105.8	638	94.8	638	95.4	638	101.5
637	117.4	637	107.8	637	107.6	637	114.8
636	137.6	636	128.9	636	127.7	636	134.5
635	107.4	635	93.1	635	95.4	635	102.7
634	103.1	634	91.4	634	92.6	634	98.8
633	112.5	633	102.1	633	102.6	633	110.0
632	130.5	632	120.9	632	120.6	632	127.7
631	99.2	631	87.7	631	87.9	631	91.3
630	99.0	630	89.5	630	88.8	630	94.6
629	107.3	629	99.0	629	97.9	629	104.4
628	121.1	628	113.2	628	111.7	628	118.3
627	104.1	627	92.2	627	92.1	627	95.8
626	103.0	626	93.3	626	92.4	626	98.1
625	116.7	625	104.2	625	106.8	625	113.4
624	136.8	624	128.4	624	126.8	624	133.3
623	103.4	623	91.5	623	91.6	623	95.2
622	101.6	622	91.5	622	91.1	622	97.1
621	110.6	621	101.1	621	100.6	621	107.4
620	126.0	620	118.8	620	118.1	620	125.0

TABLE E-8 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 10/1/79		DATE: 10/15/79		DATE: 11/1/79		DATE: 11/15/79	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 7153		OPERATING HRS: 7489		OPERATING HRS: 7897		OPERATING HRS: 8233	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	150.3	683	145.3	683	130.2	683	125.4
682	154.4	682	149.5	682	134.5	682	129.5
681	182.8	681	177.7	681	162.6	681	157.0
680	178.6	680	173.5	680	158.6	680	153.6
679	180.9	679	176.0	679	161.0	679	156.5
678	181.9	678	177.1	678	162.2	678	157.9
677	175.6	677	170.7	677	156.0	677	151.7
676	174.2	676	169.6	676	154.9	676	150.7
675	163.9	675	159.4	675	145.2	675	141.1
674	161.2	674	156.9	674	142.7	674	138.5
673	108.4	673	103.8	673	88.2	673	83.9
672	108.1	672	103.5	672	88.2	672	83.6
671	122.3	671	117.4	671	101.5	671	97.0
670	122.3	670	117.5	670	101.8	670	97.1
669	114.5	669	109.5	669	93.7	669	90.3
668	110.2	668	105.2	668	89.6	668	86.3
667	86.4	667	76.3	667	62.1	667	64.6
666	84.7	666	77.4	666	61.9	666	61.3
665	92.3	665	86.9	665	70.8	665	67.8
664	107.4	664	102.5	664	86.5	664	82.0
663	88.9	663	78.5	663	63.8	663	66.3
662	88.6	662	81.5	662	65.6	662	64.9
661	98.9	661	93.4	661	77.1	661	74.1
660	121.8	660	116.6	660	100.0	660	95.7
659	88.7	659	78.5	659	63.8	659	67.1
658	86.4	658	79.3	658	63.5	658	63.3
657	94.9	657	89.4	657	73.2	657	71.0
656	110.9	656	105.8	656	89.9	656	86.4
655	91.7	655	84.7	655	70.2	655	78.5
654	87.3	654	82.5	654	67.6	654	66.3
653	94.2	653	89.9	653	74.9	653	71.5
652	107.6	652	103.0	652	87.3	652	82.9
651	100.2	651	99.3	651	86.7	651	92.7
650	91.3	650	86.5	650	72.3	650	70.6
649	100.5	649	96.2	649	81.3	649	77.6
648	122.5	648	117.7	648	101.6	648	96.9
647	99.7	647	99.9	647	87.0	647	93.4
646	88.8	646	83.8	646	69.6	646	68.5
645	96.7	645	92.3	645	77.3	645	74.7
644	113.8	644	109.0	644	93.4	644	89.6
643	88.0	643	83.1	643	67.3	643	66.3
642	88.9	642	81.0	642	65.2	642	71.2
641	95.6	641	91.3	641	75.6	641	72.4
640	107.4	640	102.9	640	87.0	640	82.6
639	93.5	639	86.4	639	71.7	639	76.8
638	91.6	638	86.3	638	71.5	638	69.5
637	103.4	637	98.9	637	83.6	637	79.9
636	122.9	636	118.0	636	101.8	636	97.1
635	92.9	635	85.4	635	71.1	635	76.2
634	88.7	634	83.1	634	68.7	634	67.6
633	98.3	633	93.6	633	78.3	633	75.7
632	115.8	632	110.8	632	95.1	632	91.3
631	86.1	631	75.7	631	61.5	631	64.2
630	85.7	630	78.6	630	63.2	630	62.6
629	94.2	629	89.0	629	72.8	629	69.6
628	107.4	628	102.5	628	86.3	628	81.9
627	90.0	627	80.3	627	65.7	627	68.8
626	89.1	626	82.2	626	66.4	626	66.0
625	102.7	625	97.5	625	81.1	625	77.9
624	121.9	624	116.7	624	100.1	624	95.8
623	89.2	623	79.5	623	164.9	623	68.2
622	87.4	622	80.7	622	64.6	622	64.5
621	96.4	621	91.0	621	74.5	621	72.4
620	113.2	620	108.1	620	91.9	620	88.4

TABLE E-9 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 12/1/79		DATE: 12/15/79		DATE: 1/1/80		DATE: 1/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 8617		OPERATING HRS: 8593		OPERATING HRS: 9361		OPERATING HRS: 9697	
T/C No.	**Temp(°F)**	**T/C No.**	**Temp(°F)**	**T/C No.**	**Temp(°F)**	**T/C No.**	**Temp(°F)**
683	117.2	683	117.4	683	112.4	683	115.0
682	121.8	682	121.8	682	116.8	682	119.4
681	149.4	681	149.4	681	144.1	681	146.8
680	145.4	680	145.9	680	140.5	680	143.1
679	147.9	679	147.6	679	142.7	679	145.7
678	149.5	678	149.5	678	144.4	678	147.2
677	143.3	677	143.0	677	138.1	677	141.1
676	142.5	676	142.1	676	137.1	676	139.8
675	132.9	675	132.6	675	127.9	675	130.8
674	130.0	674	129.9	674	125.1	674	127.4
673	75.6	673	76.1	673	71.2	673	74.5
672	75.8	672	76.2	672	71.3	672	74.6
671	88.5	671	89.0	671	83.9	671	87.5
670	88.8	670	89.2	670	84.2	670	87.5
669	81.9	669	82.0	669	77.2	669	81.2
668	78.2	668	78.2	668	73.6	668	77.4
667	57.4	667	55.2	667	52.5	667	55.5
666	54.7	666	53.4	666	50.5	666	55.4
665	60.5	665	60.4	665	56.4	665	61.2
664	74.4	664	74.8	664	70.1	664	73.6
663	59.4	663	57.6	663	54.9	663	57.4
662	58.2	662	57.1	662	54.1	662	58.9
661	66.6	661	66.6	661	62.5	661	67.0
660	87.8	660	88.3	660	83.4	660	87.1
659	59.5	659	57.7	659	55.2	659	57.1
658	56.2	658	55.0	658	52.1	658	57.4
657	63.2	657	62.9	657	59.1	657	64.3
656	78.4	656	78.3	656	74.0	656	78.1
655	67.9	655	68.1	655	66.1	655	64.2
654	59.6	654	58.8	654	54.8	654	56.9
653	64.0	653	64.2	653	59.6	653	62.1
652	75.1	652	75.6	652	70.9	652	73.7
651	81.9	651	83.4	651	80.5	651	79.4
650	63.5	650	62.9	650	58.8	650	60.6
649	70.1	649	70.2	649	65.5	649	67.7
648	89.1	648	89.4	648	84.5	648	87.2
647	82.4	647	83.9	647	81.0	647	80.3
646	61.5	646	60.4	646	56.4	646	58.5
645	66.8	645	66.6	645	62.1	645	64.9
644	81.7	644	81.6	644	76.8	644	80.2
643	59.5	643	59.0	643	55.0	643	57.6
642	63.1	642	62.1	642	59.4	642	59.0
641	65.1	641	65.4	641	60.7	641	63.4
640	75.1	640	75.4	640	70.6	640	73.5
639	67.9	639	67.8	639	65.3	639	64.2
638	63.0	638	62.5	638	58.5	638	61.0
637	72.2	637	72.7	637	67.8	637	70.4
636	89.2	636	89.7	636	84.5	636	87.6
635	67.0	635	66.7	635	64.4	635	63.4
634	60.5	634	59.7	634	55.9	634	58.8
633	67.8	633	67.8	633	63.3	633	66.3
632	83.2	632	83.4	632	78.5	632	82.0
631	57.5	631	55.9	631	53.0	631	55.6
630	55.9	630	54.9	630	51.8	630	56.4
629	62.4	629	62.5	629	58.3	629	62.7
628	74.3	628	74.7	628	70.0	628	73.7
627	61.3	627	59.9	627	57.1	627	59.3
626	59.1	626	58.2	626	54.9	626	59.5
625	70.2	625	70.5	625	66.0	625	70.5
624	87.8	624	88.2	624	83.2	624	87.2
623	60.8	623	59.1	623	56.4	623	59.0
622	57.5	622	56.5	622	53.2	622	58.3
621	64.7	621	64.6	621	60.5	621	65.7
620	80.6	620	80.7	620	76.1	620	80.3

TABLE E-10 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 2/1/80		DATE: 2/15/80		DATE: 3/1/80		DATE: 3/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 10,105		OPERATING HRS: 10,441		OPERATING HRS: 10,801		OPERATING HRS: 11,137	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	112.5	683	113.0	683	120.6	683	115.9
682	116.8	682	117.3	682	124.6	682	120.0
681	143.7	681	144.2	681	151.0	681	146.5
680	140.2	680	140.6	680	147.4	680	143.5
679	142.7	679	143.4	679	150.2	679	145.7
678	144.3	678	144.7	678	151.8	678	147.3
677	138.1	677	138.6	677	145.9	677	141.4
676	137.1	676	137.2	676	145.1	676	140.1
675	127.9	675	128.4	675	135.8	675	131.3
674	124.7	674	125.3	674	133.3	674	128.9
673	72.5	673	73.1	673	81.6	673	77.2
672	72.6	672	73.1	672	81.6	672	77.2
671	85.1	671	86.0	671	94.1	671	89.5
670	85.4	670	86.1	670	94.4	670	89.9
669	78.9	669	79.4	669	88.1	669	83.7
668	75.1	668	75.6	668	84.7	668	80.4
667	54.0	667	52.5	667	59.6	667	61.5
666	51.8	666	52.8	666	60.8	666	58.7
665	58.1	665	58.7	665	67.0	665	63.5
664	71.4	664	72.1	664	80.3	664	75.7
663	56.7	663	54.9	663	61.4	663	64.1
662	55.4	662	56.3	662	64.3	662	62.3
661	64.1	661	64.7	661	73.2	661	69.6
660	84.7	660	85.4	660	93.1	660	88.6
659	57.6	659	55.5	659	60.8	659	65.6
658	53.7	658	54.6	658	62.9	658	60.8
657	61.1	657	61.7	657	70.4	657	66.7
656	75.6	656	76.2	656	84.8	656	80.3
655	64.8	655	54.9	655	63.6	655	68.2
654	54.0	654	54.2	654	65.9	654	63.6
653	59.9	653	60.0	653	70.9	653	67.2
652	71.7	652	72.3	652	81.1	652	76.7
651	79.6	651	62.6	651	66.2	651	82.8
650	57.7	650	57.9	650	69.6	650	67.4
649	65.5	649	65.8	649	76.8	649	73.0
648	85.2	648	85.9	648	94.3	648	89.9
647	81.7	647	63.3	647	65.0	647	82.8
646	55.8	646	55.6	646	67.5	646	65.4
645	62.8	645	62.7	645	74.0	645	70.2
644	78.0	644	78.6	644	87.8	644	83.4
643	54.6	643	55.0	643	65.5	643	62.9
642	58.7	642	53.2	642	62.3	642	64.1
641	61.2	641	61.6	641	71.7	641	67.6
640	71.5	640	72.1	640	81.0	640	76.4
639	64.7	639	56.2	639	64.6	639	68.5
638	58.0	638	58.4	638	68.5	638	66.3
637	68.0	637	68.7	637	78.6	637	74.6
636	85.3	636	86.2	636	94.6	636	89.9
635	65.6	635	56.1	635	64.0	635	68.2
634	56.1	634	55.8	634	66.4	634	64.4
633	64.2	633	64.5	633	74.8	633	70.9
632	79.7	632	80.4	632	89.5	632	84.9
631	54.1	631	53.0	631	60.4	631	60.6
630	53.0	630	53.9	630	61.8	630	59.4
629	59.9	629	60.5	629	68.6	629	64.7
628	71.3	628	72.0	628	80.1	628	75.6
627	58.6	627	56.0	627	62.5	627	65.6
626	56.1	626	57.0	626	65.0	626	62.8
625	67.6	625	68.4	625	76.4	625	72.5
624	84.7	624	85.5	624	93.1	624	88.6
623	58.2	623	55.6	623	62.1	623	65.6
622	54.8	622	55.6	622	64.1	622	61.6
621	62.7	621	63.2	621	71.8	621	67.9
620	77.8	620	78.5	620	86.9	620	82.4

TABLE E-11 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 4/1/80		DATE: 4/15/80		DATE: 5/1/80		DATE: 5/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 11,543		OPERATING HRS: 11,881		OPERATING HRS: 12,265		OPERATING HRS: 12,601	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	116.9	683	125.9	683	126.9	683	124.0
682	120.9	682	129.5	682	130.8	682	127.7
681	146.9	681	155.7	681	156.6	681	153.0
680	143.3	680	152.3	680	153.2	680	149.6
679	145.9	679	154.9	679	155.9	679	152.0
678	147.4	678	156.1	678	157.1	678	153.1
677	141.4	677	150.5	677	150.9	677	147.1
676	140.8	676	149.2	676	150.0	676	146.4
675	131.4	675	140.4	675	140.5	675	136.9
674	128.8	674	138.0	674	137.7	674	134.1
673	78.0	673	88.2	673	89.3	673	86.8
672	78.3	672	88.0	672	89.4	672	86.8
671	90.1	671	100.5	671	101.7	671	98.7
670	90.6	670	100.7	670	102.0	670	98.8
669	83.8	669	94.6	669	95.0	669	91.9
668	80.6	668	91.2	668	91.5	668	88.4
667	54.8	667	75.2	667	66.5	667	69.2
666	56.6	666	69.3	666	69.3	666	67.5
665	63.4	665	74.5	665	75.9	665	73.8
664	76.8	664	86.4	664	88.4	664	85.9
663	57.8	663	78.9	663	68.6	663	72.4
662	50.2	662	72.9	662	73.4	662	71.1
661	69.5	661	80.8	661	82.2	661	79.7
660	89.3	660	99.3	660	101.1	660	98.2
659	57.8	659	80.5	659	67.1	659	73.0
658	58.6	658	71.5	658	71.5	658	69.2
657	66.2	657	77.8	657	78.9	657	76.2
656	80.7	656	91.0	656	92.1	656	89.0
655	61.4	655	83.7	655	64.8	655	72.4
654	61.5	654	73.7	654	71.6	654	68.9
653	66.9	653	77.6	653	77.3	653	74.7
652	77.6	652	87.2	652	88.3	652	85.8
651	70.6	651	97.0	651	70.9	651	78.6
650	65.1	650	77.7	650	75.6	650	72.4
649	72.5	649	83.6	649	83.2	649	80.2
648	90.5	648	100.8	648	101.3	648	98.5
647	69.5	647	96.5	647	69.1	647	77.4
646	62.6	646	75.8	646	72.8	646	69.9
645	69.3	645	80.8	645	79.8	645	76.7
644	83.5	644	93.9	644	94.2	644	91.0
643	60.7	643	73.3	643	71.7	643	69.1
642	57.4	642	79.4	642	65.6	642	70.4
641	67.5	641	78.0	641	78.3	641	75.6
640	77.2	640	86.8	640	88.3	640	85.6
639	61.9	639	85.5	639	68.0	639	74.2
638	63.9	638	77.0	638	75.1	638	72.3
637	74.2	637	85.2	637	85.2	637	82.2
636	90.4	636	100.6	636	101.8	636	98.7
635	61.8	635	85.6	635	66.5	635	73.7
634	61.6	634	75.2	634	72.5	634	69.8
633	70.1	633	81.4	633	81.0	633	77.9
632	85.0	632	95.4	632	95.9	632	92.6
631	54.2	631	73.5	631	66.3	631	68.2
630	57.2	630	69.5	630	70.1	630	67.3
629	64.8	629	75.6	629	77.1	629	74.7
628	76.6	628	86.2	628	88.2	628	85.6
627	58.0	627	79.5	627	69.4	627	72.3
626	60.3	626	73.2	626	73.6	626	70.7
625	72.2	625	83.3	625	85.0	625	82.3
624	89.1	624	99.4	624	101.1	624	98.1
623	57.9	623	79.6	623	69.1	623	72.1
622	59.2	622	72.1	622	72.5	622	69.3
621	67.3	621	78.7	621	80.0	621	76.9
620	82.6	620	92.8	620	94.1	620	90.8

TABLE E-12 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 6/1/80		DATE: 6/15/80		DATE: 7/1/80		DATE: 7/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 13,009		OPERATING HRS: 13,345		OPERATING HRS: 13,729		OPERATING HRS: 14,065	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	127.5	683	135.9	683	144.7	683	144.9
682	131.1	682	139.2	682	148.0	682	148.2
681	156.1	681	164.2	681	172.7	681	172.7
680	152.9	680	160.9	680	169.3	680	169.4
679	155.3	679	163.4	679	172.0	679	171.7
678	156.2	678	164.3	678	172.9	678	172.6
677	150.7	677	158.7	677	167.5	677	167.0
676	150.0	676	157.9	676	166.9	676	166.4
675	140.5	675	148.5	675	156.9	675	156.3
674	137.8	674	145.5	674	154.6	674	153.6
673	90.9	673	100.0	673	109.2	673	109.5
672	90.9	672	99.7	672	109.2	672	109.4
671	102.7	671	111.8	671	121.4	671	121.4
670	102.9	670	111.8	670	121.6	670	121.5
669	96.6	669	105.5	669	115.2	669	115.0
668	93.4	668	101.9	668	111.7	668	111.4
667	75.7	667	85.4	667	88.9	667	91.6
666	73.9	666	81.4	666	89.3	666	89.7
665	79.0	665	87.2	665	96.4	665	96.6
664	90.0	664	98.7	664	108.4	664	108.4
663	79.3	663	89.0	663	91.9	663	95.3
662	77.4	662	84.9	662	93.3	662	93.5
661	84.8	661	93.1	661	102.4	661	102.5
660	102.2	660	111.1	660	120.8	660	120.8
659	80.4	659	91.3	659	91.0	659	98.2
658	75.6	658	83.2	658	91.8	658	92.1
657	81.6	657	89.9	657	99.5	657	99.3
656	93.6	656	102.2	656	112.2	656	111.7
655	77.6	655	90.1	655	87.9	655	95.1
654	75.2	654	82.3	654	90.9	654	91.4
653	80.1	653	87.8	653	97.3	653	97.5
652	89.9	652	98.5	652	108.2	652	108.5
651	86.5	651	99.2	651	95.6	651	104.8
650	78.7	650	85.7	650	94.5	650	94.9
649	85.5	649	93.3	649	102.9	649	103.0
648	102.5	648	111.4	648	120.9	648	121.1
647	86.1	647	98.6	647	94.4	647	104.4
646	76.6	646	83.8	646	92.3	646	92.8
645	82.5	645	90.3	645	100.2	645	100.0
644	95.7	644	104.1	644	114.3	644	113.9
643	75.1	643	82.5	643	91.2	643	91.9
642	75.9	642	86.7	642	87.0	642	93.1
641	80.4	641	88.4	641	98.2	641	98.2
640	89.6	640	98.2	640	108.1	640	108.0
639	80.3	639	92.7	639	89.8	639	98.0
638	78.2	638	85.6	638	94.3	638	94.9
637	87.0	637	95.2	637	105.0	637	105.0
636	102.7	636	111.4	636	121.5	636	121.3
635	80.1	635	92.8	635	89.1	635	97.9
634	76.2	634	83.6	634	92.2	634	92.8
633	83.3	633	91.4	633	101.3	633	101.1
632	97.2	632	105.7	632	115.9	632	115.4
631	74.2	631	83.6	631	86.3	631	90.1
630	73.4	630	81.3	630	89.5	630	89.9
629	79.5	629	88.0	629	97.4	629	97.4
628	89.7	628	98.4	628	108.1	628	108.2
627	79.2	627	89.1	627	89.2	627	94.2
626	76.8	626	84.7	626	92.7	626	93.1
625	86.9	625	95.6	625	105.0	625	104.9
624	102.1	624	111.2	624	120.7	624	120.8
623	79.2	623	89.0	623	89.0	623	93.8
622	75.7	622	83.5	622	92.0	622	92.0
621	82.2	621	90.7	621	100.3	621	99.9
620	95.3	620	104.1	620	114.0	620	113.6

TABLE E-13 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 8/1/80		DATE: 8/15/80		DATE: 9/2/80		DATE: 9/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 14,473		OPERATING HRS: 14,809		OPERATING HRS: 15,241		OPERATING HRS: 15,553	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	153.3	683	151.7	683	139.7	683	136.5
682	156.7	682	155.0	682	143.0	682	139.9
681	181.0	681	179.1	681	166.8	681	163.5
680	178.1	680	175.8	680	163.7	680	160.5
679	180.5	679	178.5	679	166.1	679	162.7
678	181.3	678	179.3	678	166.9	678	163.7
677	175.8	677	173.8	677	161.5	677	157.9
676	175.3	676	173.2	676	160.8	676	157.2
675	165.1	675	163.0	675	151.3	675	147.7
674	163.0	674	160.7	674	149.3	674	145.6
673	119.0	673	117.3	673	105.1	673	101.7
672	118.9	672	117.2	672	104.8	672	101.5
671	131.0	671	129.0	671	116.4	671	112.8
670	131.5	670	129.2	670	116.5	670	113.0
669	124.5	669	122.4	669	110.1	669	106.3
668	121.1	668	118.8	668	106.5	668	102.9
667	100.9	667	90.2	667	86.4	667	80.9
666	99.4	666	93.0	666	84.8	666	80.4
665	105.6	665	102.7	665	91.2	665	87.9
664	117.6	664	115.9	664	103.4	664	100.5
663	104.7	663	93.2	663	88.7	663	83.7
662	103.5	662	96.9	662	88.1	662	83.9
661	111.9	661	108.6	661	96.9	661	93.4
660	130.3	660	128.1	660	115.2	660	112.0
659	106.6	659	94.6	659	90.7	659	84.4
658	102.1	658	95.8	658	87.1	658	82.4
657	108.9	657	105.6	657	93.9	657	90.2
656	121.3	656	119.1	656	106.6	656	103.2
655	104.4	655	92.9	655	94.1	655	85.6
654	101.9	654	96.3	654	89.6	654	84.2
653	107.3	653	104.6	653	94.3	653	90.1
652	117.9	652	116.2	652	104.2	652	100.8
651	114.4	651	104.2	651	105.6	651	93.0
650	105.8	650	99.5	650	93.1	650	87.5
649	113.1	649	109.8	649	99.6	649	95.3
648	130.8	648	128.6	648	106.2	648	112.7
647	113.7	647	103.6	647	105.1	647	91.8
646	103.4	646	96.9	646	90.9	646	85.1
645	109.9	645	106.7	645	96.6	645	92.1
644	123.6	644	121.4	644	109.2	644	105.6
643	101.6	643	96.7	643	89.8	643	84.7
642	102.6	642	91.5	642	91.7	642	84.0
641	107.7	641	105.7	641	95.2	641	91.3
640	117.5	640	115.9	640	103.9	640	100.8
639	106.6	639	95.5	639	96.1	639	87.3
638	104.9	638	99.2	638	92.8	638	87.3
637	114.5	637	112.1	637	101.5	637	97.3
636	130.8	636	128.9	636	116.4	636	113.0
635	106.2	635	95.0	635	95.6	635	86.6
634	102.6	634	96.6	634	90.5	634	84.8
633	110.5	633	107.9	633	97.5	633	93.1
632	125.0	632	123.0	632	110.8	632	107.1
631	99.3	631	89.1	631	87.1	631	81.3
630	99.5	630	94.2	630	86.3	630	82.0
629	106.5	629	104.2	629	93.0	629	89.7
628	117.6	628	115.9	628	103.5	628	100.4
627	103.1	627	92.3	627	91.3	627	84.5
626	102.9	626	97.0	626	89.4	626	84.8
625	114.1	625	111.7	625	100.0	625	96.5
624	130.2	624	128.0	624	115.4	624	112.1
623	102.7	623	92.0	623	91.1	623	84.0
622	101.8	622	96.3	622	88.3	622	83.6
621	109.2	621	106.5	621	95.1	621	91.4
620	123.0	620	120.9	620	108.5	620	105.1

TABLE E-14 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 10/1/80		DATE: 10/15/80		DATE: 11/1/80		DATE: 11/15/80	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 15,937		OPERATING HRS: 16,273		OPERATING HRS: 16,681		OPERATING HRS: 17,017	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	138.8	683	134.1	683	117.6	683	116.8
682	141.9	682	137.4	682	120.8	682	120.1
681	165.6	681	160.7	681	144.3	681	143.4
680	162.4	680	157.4	680	140.9	680	140.1
679	165.1	679	159.9	679	143.8	679	142.9
678	166.1	678	160.9	678	144.7	678	143.9
677	160.5	677	154.8	677	139.5	677	138.1
676	159.9	676	154.1	676	138.5	676	136.9
675	150.7	675	144.7	675	130.0	675	128.6
674	149.0	674	142.4	674	127.6	674	126.2
673	104.7	673	99.3	673	83.0	673	82.1
672	104.6	672	99.1	672	83.7	672	81.7
671	115.9	671	110.0	671	93.6	671	92.5
670	116.2	670	110.0	670	93.5	670	92.5
669	110.2	669	102.6	669	87.8	669	85.9
668	106.6	668	98.8	668	84.3	668	82.3
667	87.5	667	63.7	667	66.7	667	55.2
666	84.5	666	70.9	666	63.7	666	57.2
665	90.7	665	83.2	665	69.6	665	66.6
664	102.8	664	97.8	664	81.4	664	80.4
663	90.6	663	66.0	663	68.8	663	56.4
662	88.0	662	74.5	662	66.8	662	60.56
661	96.5	661	88.4	661	74.8	661	71.8
660	114.7	660	108.7	660	92.2	660	91.2
659	92.9	659	65.5	659	69.2	659	56.4
658	87.0	658	73.0	658	65.4	658	59.3
657	93.7	657	85.0	657	72.0	657	68.9
656	106.3	656	99.6	656	84.5	656	82.8
655	101.3	655	71.4	655	75.5	655	65.0
654	90.9	654	76.0	654	68.9	654	63.3
653	95.0	653	86.1	653	73.3	653	70.4
652	104.0	652	98.3	652	82.2	652	81.2
651	114.7	651	82.5	651	86.9	651	78.9
650	94.4	650	78.6	650	72.7	650	66.5
649	100.4	649	90.5	649	78.5	649	75.1
648	116.2	648	109.7	648	93.7	648	92.4
647	114.5	647	80.9	647	86.0	647	77.9
646	92.6	646	75.4	646	70.9	646	64.0
645	97.6	645	86.8	645	75.5	645	71.8
644	109.5	644	101.9	644	87.4	644	85.4
643	90.7	643	77.0	643	69.0	643	63.5
642	96.4	642	67.1	642	71.7	642	60.4
641	95.6	641	87.6	641	74.1	641	71.5
640	103.6	640	98.2	640	82.0	640	81.0
639	102.5	639	72.4	639	77.0	639	64.1
638	93.7	638	78.9	638	72.7	638	75.8
637	101.9	637	93.3	637	80.6	637	77.3
636	116.0	636	109.9	636	94.0	636	92.6
635	102.3	635	72.5	635	76.7	635	63.4
634	92.0	634	75.7	634	70.9	634	63.1
633	98.2	633	88.3	633	76.6	633	72.9
632	110.8	632	103.4	632	88.9	632	86.8
631	88.5	631	63.3	631	67.1	631	56.2
630	86.5	630	72.7	630	75.4	630	59.7
629	92.6	629	85.7	629	71.5	629	69.2
628	103.0	628	98.0	628	81.4	628	80.5
627	92.6	627	65.6	627	70.2	627	58.7
626	89.6	626	75.1	626	68.3	626	62.4
625	99.6	625	92.4	625	78.1	625	76.0
624	114.8	624	108.9	624	92.3	624	91.3
623	92.6	623	65.4	623	69.8	623	58.4
622	88.5	622	74.1	622	66.7	622	61.0
621	95.1	621	85.3	621	73.3	621	70.4
620	108.4	620	101.4	620	86.1	620	84.4

TABLE E-15 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 12/1/80		DATE: 12/15/80		DATE: 1/1/81		DATE: 1/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 17,401		OPERATING HRS: 17,737		OPERATING HRS: 18,145		OPERATING HRS: 18,481	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	108.4	683	105.1	683	112.3	683	107.6
682	111.7	682	108.2	682	115.5	682	110.9
681	135.2	681	131.6	681	138.7	681	134.1
680	132.0	680	128.3	680	135.4	680	130.7
679	135.0	679	131.2	679	138.1	679	133.7
678	135.9	678	132.2	678	139.1	678	134.8
677	130.7	677	127.0	677	133.9	677	129.4
676	129.8	676	125.9	676	133.0	676	128.3
675	121.6	675	118.0	675	124.7	675	120.2
674	119.0	674	115.2	674	122.3	674	117.5
673	74.2	673	70.8	673	78.1	673	73.6
672	73.8	672	70.4	672	77.8	672	73.4
671	84.7	671	81.1	671	88.7	671	84.1
670	84.3	670	80.7	670	88.5	670	83.9
669	79.1	669	75.8	669	83.3	669	78.5
668	75.7	668	72.3	668	79.9	668	75.1
667	55.8	667	58.6	667	60.4	667	56.1
666	55.1	666	53.1	666	58.8	666	54.9
665	61.3	665	58.0	665	64.8	665	60.9
664	72.4	664	69.0	664	76.7	664	72.1
663	57.4	663	60.6	663	61.8	663	58.5
662	58.2	662	55.8	662	61.9	662	57.9
661	66.2	661	62.9	661	70.0	661	66.0
660	83.1	660	79.7	660	87.4	660	82.9
659	57.6	659	62.1	659	61.6	659	59.2
658	57.4	658	55.1	658	61.1	658	57.0
657	64.1	657	60.7	657	67.8	657	63.6
656	76.1	656	72.6	656	80.2	656	75.5
655	65.8	655	71.9	655	71.9	655	64.7
654	60.3	654	58.8	654	64.9	654	59.9
653	64.6	653	61.9	653	69.0	653	64.2
652	73.4	652	70.1	652	77.7	652	73.0
651	76.8	651	83.5	651	82.1	651	76.1
650	63.2	650	61.9	650	68.2	650	63.0
649	68.9	649	66.3	649	73.8	649	68.9
648	84.3	648	81.1	648	88.8	648	84.0
647	75.6	647	82.8	647	80.5	647	75.9
646	61.2	646	60.1	646	66.3	646	61.1
645	66.5	645	63.7	645	71.2	645	66.2
644	78.4	644	75.0	644	82.8	644	77.8
643	60.8	643	58.7	643	64.9	643	59.9
642	61.8	642	65.7	642	67.3	642	60.4
641	65.5	641	62.5	641	69.8	641	64.9
640	73.2	640	69.7	640	77.4	640	72.6
639	65.7	639	71.1	639	71.3	639	64.8
638	63.4	638	61.6	638	67.8	638	62.6
637	71.3	637	68.4	637	75.9	637	70.8
636	83.7	636	81.4	636	89.2	636	84.1
635	64.7	635	70.6	635	70.2	635	64.4
634	61.6	634	59.8	634	65.8	634	60.5
633	67.9	633	64.9	633	72.2	633	67.1
632	79.9	632	76.5	632	84.3	632	79.2
631	57.1	631	59.8	631	61.7	631	56.5
630	57.5	630	55.4	630	61.0	630	56.8
629	63.3	629	60.2	629	67.1	629	62.9
628	72.6	628	69.2	628	76.7	628	72.2
627	59.6	627	63.3	627	64.3	627	59.5
626	60.0	626	58.2	626	63.8	626	59.5
625	69.7	625	66.5	625	73.7	625	69.2
624	83.4	624	80.1	624	87.6	624	83.1
623	59.4	623	63.1	623	63.9	623	59.3
622	59.1	622	56.6	622	62.6	622	58.3
621	65.4	621	62.1	621	69.2	621	64.8
620	77.6	620	74.1	620	81.8	620	77.1

TABLE E-16 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 2/1/81		DATE: 2/15/81		DATE: 3/1/81		DATE: 3/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 18,889		OPERATING HRS: 19,225		OPERATING HRS: 19,561		OPERATING HRS: 19,897	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	98.0	683	105.3	683	106.6	683	106.2
682	101.3	682	108.6	682	110.1	682	109.8
681	124.3	681	131.5	681	132.5	681	132.1
680	121.3	680	128.6	680	129.4	680	129.2
679	124.0	679	131.0	679	131.4	679	131.3
678	124.9	678	131.9	678	132.6	678	132.5
677	119.4	677	127.0	677	127.2	677	127.3
676	118.0	676	126.5	676	126.5	676	126.8
675	110.6	675	118.0	675	117.8	675	118.2
674	107.5	674	115.6	674	115.5	674	116.2
673	64.2	673	71.2	673	72.3	673	72.4
672	63.9	672	71.3	672	72.7	672	72.8
671	74.2	671	81.9	671	82.5	671	82.8
670	73.9	670	82.1	670	82.9	670	83.1
669	68.1	669	77.3	669	76.8	669	77.7
668	64.6	668	74.4	668	74.0	668	75.0
667	47.0	667	60.2	667	52.1	667	58.7
666	44.6	666	56.2	666	55.6	666	55.5
665	51.3	665	60.3	665	61.1	665	60.9
664	62.7	664	70.4	664	72.1	664	71.9
663	48.9	663	62.9	663	52.9	663	61.6
662	47.2	662	59.2	662	58.7	662	58.5
661	55.9	661	65.5	661	66.1	661	66.1
660	72.8	660	81.7	660	82.5	660	82.7
659	50.3	659	64.5	659	50.4	659	62.9
658	46.2	658	58.1	658	56.9	658	57.3
657	53.3	657	63.2	657	63.0	657	63.5
656	65.2	656	74.4	656	74.6	656	75.2
655	61.0	655	72.1	655	50.7	655	66.8
654	48.5	654	59.0	654	58.9	654	59.9
653	53.7	653	62.3	653	63.6	653	63.7
652	63.1	652	70.9	652	72.5	652	72.5
651	74.6	651	85.7	651	53.2	651	78.5
650	51.2	650	62.7	650	61.9	650	63.1
649	57.8	649	67.4	649	68.3	649	68.5
648	73.8	648	82.5	648	83.2	648	83.3
647	75.7	647	85.7	647	51.6	647	77.4
646	49.5	646	61.2	646	59.4	646	61.3
645	54.9	645	65.4	645	65.1	645	65.9
644	67.1	644	76.7	644	76.9	644	77.6
643	48.5	643	59.2	643	59.1	643	59.4
642	53.2	642	66.6	642	51.6	642	63.1
641	54.4	641	63.1	641	64.4	641	64.3
640	62.8	640	70.6	640	72.3	640	72.1
639	59.1	639	73.6	639	53.2	639	67.7
638	50.9	638	63.0	638	61.8	638	62.6
637	59.9	637	69.6	637	70.2	637	70.2
636	73.8	636	82.6	636	83.6	636	83.5
635	60.8	635	73.7	635	51.3	635	67.5
634	49.5	634	61.6	634	59.2	634	60.9
633	56.1	633	66.6	633	66.1	633	66.8
632	68.5	632	78.3	632	78.4	632	78.9
631	47.6	631	60.1	631	51.9	631	58.3
630	46.3	630	57.3	630	56.3	630	56.5
629	53.2	629	61.8	629	62.5	629	62.5
628	62.6	628	70.5	628	72.1	628	71.9
627	51.2	627	64.1	627	52.8	627	61.6
626	48.7	626	60.2	626	59.0	626	59.3
625	59.4	625	68.3	625	68.8	625	68.8
624	73.2	624	81.8	624	82.5	624	82.5
623	51.1	623	64.3	623	51.9	623	61.6
622	47.2	622	59.3	622	57.6	622	58.2
621	54.3	621	64.6	621	64.0	621	64.6
620	66.7	620	76.5	620	76.3	620	77.0

TABLE E-17 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 4/1/81		DATE: 4/15/81		DATE: 5/1/81		DATE: 5/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 20,305		OPERATING HRS: 20,641		OPERATING HRS: 21,205		OPERATING HRS: 21,361	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	109.5	683	119.0	683	127,1	683	128.3
682	112.7	682	122.0	682	130.0	682	131.3
681	134.8	681	144.4	681	152.1	681	153.2
680	132.0	680	141.3	680	149.4	680	150.0
679	134.0	679	143.9	679	152.1	679	153.0
678	135.4	678	144.7	678	153.0	678	153.9
677	130.1	677	140.0	677	148.1	677	148.8
676	129.3	676	139.4	676	148.0	676	148.3
675	120.9	675	130.8	675	138.8	675	139.2
674	118.7	674	128.8	674	137.1	674	137.4
673	75.7	673	86.4	673	95.3	673	96.2
672	76.0	672	86.2	672	95.3	672	96.3
671	85.8	671	96.7	671	105.8	671	106.3
670	86.1	670	96.8	670	106.1	670	106.9
669	80.8	669	92.0	669	101.1	669	101.2
668	78.0	668	89.1	668	98.3	668	98.2
667	63.8	667	77.2	667	86.1	667	75.7
666	60.4	666	71.7	666	81.3	666	76.9
665	64.6	665	75.6	665	84.8	665	84.4
664	75.2	664	85.2	664	94.0	664	95.4
663	66.0	663	81.0	663	90.0	663	79.2
662	63.2	662	74.9	662	84.7	662	80.1
661	69.5	661	81.0	661	90.3	661	89.4
660	85.7	660	96.1	660	105.0	660	105.9
659	66.4	659	84.8	659	93.6	659	80.4
658	61.8	658	74.3	658	84.0	658	79.2
657	66.8	657	78.9	657	88.2	657	87.1
656	78.2	656	89.3	656	98.2	656	98.7
655	66.4	655	83.6	655	93.0	655	77.9
654	63.4	654	75.7	654	85.1	654	80.0
653	67.1	653	78.7	653	87.6	653	86.2
652	75.7	652	86.1	652	94.9	652	95.7
651	70.2	651	96.4	651	103.7	651	86.4
650	66.3	650	79.2	650	88.6	650	82.8
649	71.6	649	83.6	649	92.4	649	90.5
648	86.3	648	97.2	648	105.8	648	106.3
647	69.2	647	96.0	647	103.3	647	85.0
646	64.3	646	77.5	646	86.8	646	80.4
645	69.0	645	81.2	645	90.2	645	88.0
644	80.5	644	91.6	644	100.4	644	100.5
643	63.4	643	75.1	643	84.6	643	80.0
642	64.8	642	80.3	642	90.6	642	76.2
641	67.7	641	78.6	641	87.4	641	86.9
640	75.3	640	85.6	640	94.2	640	95.3
639	67.1	639	84.8	639	95.2	639	80.5
638	66.4	638	78.5	638	87.9	638	82.5
637	73.6	637	84.8	637	93.5	637	92.4
636	86.7	636	97.2	636	105.8	636	106.6
635	66.8	635	84.8	635	95.2	635	80.4
634	64.6	634	76.9	634	86.6	634	80.4
633	70.2	633	81.7	633	90.7	633	89.1
632	82.0	632	92.8	632	101.8	632	101.9
631	63.0	631	76.0	631	85.4	631	73.7
630	61.0	630	72.2	630	81.7	630	77.5
629	65.8	629	76.5	629	85.4	629	85.3
628	75.1	628	85.1	628	93.8	628	95.0
627	65.2	627	80.2	627	89.4	627	76.3
626	63.6	626	75.3	626	84.7	626	79.9
625	72.0	625	83.2	625	91.8	625	91.7
624	85.6	624	96.0	624	104.8	624	105.7
623	65.1	623	80.5	623	89.7	623	76.7
622	62.3	622	74.1	622	83.9	622	79.3
621	67.9	621	79.1	621	88.4	621	87.6
620	80.0	620	90.5	620	99.5	620	99.9

TABLE E-18 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 6/1/81		DATE: 6/15/81		DATE: 7/1/81		DATE: 7/15/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 21,769		OPERATING HRS: 22,105		OPERATING HRS: 22,409		OPERATING HRS: 22,825	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	126.9	683	134.8	683	143.5	683	141.9
682	129.8	682	137.8	682	146.4	682	144.8
681	151.6	681	159.2	681	167.9	681	165.9
680	148.9	680	156.6	680	165.3	680	162.9
679	151.6	679	159.0	679	167.8	679	165.7
678	152.4	678	160.0	678	168.3	678	166.5
677	147.5	677	154.4	677	163.6	677	161.4
676	147.3	676	153.9	676	163.4	676	161.3
675	138.1	675	144.7	675	153.6	675	151.6
674	136.4	674	143.2	674	152.2	674	150.0
673	95.4	673	103.4	673	113.0	673	111.4
672	95.4	672	103.5	672	113.0	672	111.4
671	105.6	671	113.5	671	123.3	671	121.3
670	106.0	670	114.1	670	123.8	670	121.8
669	100.8	669	107.4	669	117.6	669	115.6
668	98.0	668	104.4	668	114.7	668	112.6
667	86.8	667	82.9	667	96.2	667	97.0
666	82.8	666	82.3	666	96.0	666	96.0
665	85.8	665	90.9	665	101.9	665	100.6
664	94.3	664	102.3	664	111.7	664	110.2
663	90.5	663	86.4	663	99.7	663	100.8
662	86.0	662	85.9	662	99.7	662	99.4
661	91.0	661	96.2	661	107.4	661	105.9
660	105.2	660	113.1	660	122.7	660	120.7
659	93.5	659	89.6	659	102.1	659	103.1
658	85.1	658	84.8	658	98.6	658	98.2
657	88.9	657	93.3	657	104.8	657	103.1
656	98.2	656	104.9	656	115.1	656	113.0
655	89.8	655	87.1	655	97.4	655	97.9
654	84.5	654	84.3	654	97.8	654	97.8
653	87.1	653	92.1	653	103.0	653	101.9
652	94.8	652	102.6	652	112.1	652	110.6
651	98.8	651	96.0	651	107.0	651	106.9
650	87.7	650	87.4	650	101.0	650	101.1
649	91.7	649	96.6	649	107.8	649	106.6
648	105.4	648	113.4	648	123.1	648	121.2
647	98.2	647	95.1	647	106.4	647	106.5
646	85.9	646	84.8	646	98.9	646	99.0
645	89.5	645	93.6	645	105.2	645	103.8
644	99.9	644	106.6	644	116.9	644	114.8
643	83.9	643	84.7	643	98.0	643	97.6
642	87.8	642	85.1	642	96.4	642	96.2
641	87.0	641	92.7	641	103.5	641	102.2
640	94.2	640	102.1	640	111.8	640	110.3
639	91.6	639	89.8	639	99.6	639	99.7
638	87.1	638	86.8	638	100.6	638	100.3
637	92.9	637	98.1	637	109.2	637	107.7
636	105.5	636	113.2	636	123.1	636	121.2
635	91.6	635	89.7	635	99.2	635	99.5
634	85.8	634	84.4	634	98.6	634	98.2
633	90.1	633	94.2	633	105.9	633	104.2
632	101.2	632	107.7	632	118.0	632	116.0
631	85.1	631	81.8	631	94.6	631	94.6
630	82.3	630	82.8	630	96.1	630	95.6
629	86.1	629	91.7	629	102.5	629	101.0
628	94.4	628	102.2	628	111.7	628	110.0
627	88.8	627	85.4	627	97.8	627	97.9
626	85.4	626	85.4	626	98.9	626	98.3
625	92.4	625	98.2	625	109.1	625	107.3
624	105.1	624	112.8	624	122.5	624	120.5
623	89.0	623	85.1	623	97.8	623	98.1
622	84.6	622	84.3	622	98.1	622	97.3
621	89.0	621	93.4	621	104.8	621	103.0
620	99.8	620	106.3	620	116.4	620	114.3

TABLE E-19 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 8/1/81		DATE: 8/15/81		DATE: 9/1/81		DATE: 9/21/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 23,233		OPERATING HRS: 23,569		OPERATING HRS: 23,977		OPERATING HRS: 24,457	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	144.2	683	140.8	683	143.5	683	136.4
682	146.9	682	143.5	682	146.3	682	139.2
681	168.0	681	164.5	681	167.1	681	159.9
680	165.3	680	161.6	680	164.3	680	157.2
679	166.3	679	162.8	679	165.4	679	158.2
678	167.0	678	163.4	678	166.2	678	159.0
677	161.9	677	158.2	677	161.3	677	154.2
676	161.5	676	157.6	676	161.1	676	154.1
675	152.2	675	148.5	675	151.6	675	144.7
674	150.6	674	146.7	674	150.0	674	143.6
673	112.2	673	108.8	673	111.8	673	104.7
672	112.1	672	108.6	672	111.7	672	104.5
671	122.1	671	118.5	671	121.6	671	114.2
670	122.4	670	118.8	670	121.9	670	114.5
669	117.6	669	113.6	669	117.2	669	110.3
668	114.4	668	110.4	668	114.1	668	107.3
667	94.7	667	93.0	667	93.6	667	87.4
666	94.4	666	91.0	666	93.4	666	87.5
665	101.5	665	97.8	665	100.8	665	94.0
664	112.1	664	108.7	664	111.7	664	104.4
663	97.8	663	96.0	663	96.4	663	90.0
662	97.8	662	94.3	662	96.7	662	90.7
661	106.6	661	102.8	661	105.8	661	98.9
660	122.6	660	119.0	660	121.9	660	114.5
659	99.1	659	98.4	659	97.1	659	90.3
658	95.7	658	91.9	658	94.7	658	88.6
657	102.9	657	98.8	657	102.1	657	95.3
656	113.6	656	109.7	656	113.2	656	106.2
655	97.6	655	96.6	655	98.6	655	94.4
654	96.3	654	92.7	654	96.8	654	91.4
653	102.1	653	98.3	653	102.2	653	96.0
652	111.5	652	107.9	652	111.2	652	104.2
651	107.0	651	108.0	651	110.4	651	107.7
650	99.0	650	95.7	650	99.6	650	94.3
649	106.9	649	103.2	649	107.0	649	100.8
648	122.2	648	118.7	648	121.7	648	114.7
647	106.7	647	107.7	647	110.3	647	107.8
646	97.2	646	93.6	646	97.8	646	92.7
645	104.1	645	100.0	645	104.3	645	98.2
644	115.9	644	112.0	644	115.8	644	108.9
643	97.1	643	93.1	643	97.3	643	91.8
642	96.6	642	94.9	642	96.9	642	92.2
641	103.2	641	99.6	641	103.3	641	97.0
640	111.5	640	108.1	640	111.3	640	104.2
639	99.7	639	98.9	639	100.4	639	96.3
638	99.0	638	95.3	638	99.3	638	93.7
637	108.2	637	104.5	637	108.3	637	101.8
636	122.0	636	118.5	636	121.7	636	114.4
635	99.4	635	98.5	635	99.9	635	95.7
634	96.9	634	92.8	634	97.3	634	91.8
633	104.7	633	100.5	633	104.8	633	98.5
632	116.9	632	112.9	632	116.8	632	109.7
631	93.5	631	90.6	631	92.8	631	86.6
630	94.3	630	90.5	630	93.8	630	88.0
629	102.1	629	98.4	629	101.8	629	95.0
628	111.6	628	108.2	628	111.3	628	104.1
627	97.2	627	94.9	627	96.4	627	90.3
626	97.5	626	93.7	626	96.9	626	91.0
625	108.4	625	104.8	625	107.9	625	100.9
624	122.0	624	118.4	624	121.3	624	113.9
623	97.2	623	95.0	623	96.6	623	90.5
622	96.7	622	92.5	622	96.3	622	90.2
621	104.0	621	99.8	621	103.6	621	96.9
620	115.8	620	111.9	620	115.4	620	108.4

TABLE E-20 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 10/1/81		DATE: 10/15/81		DATE: 11/1/81		DATE: 11/15/81	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 24,697		OPERATING HRS: 25,033		OPERATING HRS: 25,441		OPERATING HRS: 25,777	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	129.1	683	113.9	683	111.6	683	113.3
682	131.9	682	117.1	682	114.4	682	116.2
681	152.5	681	137.1	681	135.1	681	136.9
680	149.5	680	134.6	680	132.1	680	134.1
679	150.7	679	134.9	679	133.1	679	135.4
678	151.5	678	136.2	678	134.0	678	135.9
677	146.2	677	130.6	677	128.9	677	131.2
676	145.8	676	129.9	676	128.1	676	130.3
675	137.0	675	121.6	675	120.2	675	122.3
674	135.0	674	119.6	674	118.3	674	119.9
673	96.9	673	81.0	673	79.1	673	81.1
672	96.8	672	81.1	672	78.8	672	80.7
671	106.1	671	89.5	671	88.1	671	90.2
670	106.3	670	89.9	670	88.0	670	90.0
669	101.6	669	84.7	669	84.0	669	86.5
668	98.3	668	81.8	668	80.9	668	83.4
667	78.8	667	60.4	667	68.2	667	67.6
666	79.9	666	62.9	666	63.7	666	65.8
665	86.2	665	70.0	665	68.6	665	71.4
664	96.8	664	81.5	664	79.0	664	81.4
663	80.6	663	62.0	663	69.8	663	69.3
662	82.6	662	65.4	662	66.1	662	68.4
661	90.6	661	74.2	661	73.0	661	75.7
660	106.4	660	90.4	660	88.3	660	90.7
659	79.9	659	60.2	659	70.3	659	69.2
658	80.4	658	62.6	658	63.7	658	66.3
657	86.8	657	70.0	657	69.2	657	72.4
656	97.6	656	81.4	656	79.9	656	82.8
655	84.3	655	60.6	655	78.4	655	74.5
654	82.1	654	64.7	654	67.1	654	67.0
653	87.2	653	70.9	653	70.6	653	71.7
652	96.2	652	80.7	652	78.7	652	80.4
651	96.4	651	64.3	651	93.2	651	87.2
650	84.6	650	67.0	650	70.5	650	69.6
649	91.5	649	74.9	649	75.2	649	75.6
648	106.2	648	90.1	648	88.7	648	90.1
647	96.3	647	63.3	647	93.3	647	87.2
646	82.6	646	64.6	646	68.9	646	67.9
645	88.6	645	71.6	645	72.3	645	73.4
644	99.9	644	83.6	644	82.5	644	84.6
643	83.0	643	65.5	643	66.9	643	67.9
642	81.2	642	60.4	642	72.6	642	70.5
641	88.6	641	72.5	641	71.3	641	72.9
640	96.3	640	80.8	640	78.5	640	80.4
639	85.0	639	62.0	639	79.0	639	74.3
638	84.7	638	67.1	638	70.1	638	70.1
637	93.3	637	76.7	637	76.8	637	77.9
636	106.3	636	90.1	636	88.6	636	90.4
635	84.6	635	61.2	635	79.5	635	73.9
634	82.5	634	64.3	634	68.5	634	68.3
633	89.6	633	72.4	633	73.1	633	74.7
632	101.1	632	84.7	632	83.8	632	85.9
631	77.6	631	59.0	631	67.1	631	67.1
630	80.4	630	62.9	630	64.3	630	66.3
629	87.6	629	71.3	629	70.0	629	72.6
628	96.6	628	81.0	628	78.6	628	80.9
627	81.2	627	60.9	627	71.6	627	70.6
626	83.2	626	65.3	626	67.3	626	69.0
625	93.2	625	76.6	625	75.7	625	78.1
624	106.2	624	89.8	624	88.1	624	90.5
623	81.1	623	60.3	623	71.4	623	70.7
622	82.0	622	64.0	622	65.7	622	68.1
621	88.6	621	71.6	621	71.0	621	74.1
620	100.0	620	83.6	620	82.2	620	84.9

TABLE E-21 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 12/1/81		DATE: 12/15/81		DATE: 1/1/82		DATE: 1/15/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 26,161		OPERATING HRS: 26,497		OPERATING HRS: 26,905		OPERATING HRS: 27,241	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	98.8	683	103.6	683	97.4	683	95.6
682	101.9	682	106.6	682	100.5	682	98.6
681	122.2	681	126.9	681	120.9	681	118.8
680	119.4	680	124.6	680	118.3	680	116.0
679	120.0	679	125.1	679	119.1	679	117.2
678	121.2	678	126.2	678	120.2	678	118.3
677	115.7	677	121.2	677	115.1	677	113.5
676	115.0	676	120.8	676	114.4	676	113.1
675	107.2	675	112.6	675	106.6	675	105.2
674	105.0	674	110.7	674	104.3	674	103.2
673	66.0	673	71.2	673	64.9	673	63.3
672	66.3	672	71.2	672	64.9	672	63.4
671	74.6	671	80.2	671	73.7	671	72.2
670	74.8	670	80.4	670	73.7	670	72.2
669	70.2	669	76.4	669	69.9	669	68.8
668	67.3	668	73.6	668	67.1	668	66.1
667	50.6	667	56.1	667	53.1	667	51.5
666	49.6	666	55.5	666	52.2	666	48.7
665	55.8	665	61.0	665	56.0	665	53.4
664	66.4	664	71.3	664	65.5	664	63.4
663	52.3	663	57.8	663	53.2	663	53.6
662	52.1	662	58.3	662	54.5	662	51.1
661	59.9	661	65.4	661	60.1	661	57.7
660	75.4	660	80.6	660	74.5	660	72.5
659	51.7	659	56.8	659	51.3	659	53.6
658	49.5	658	56.2	658	52.0	658	49.2
657	56.0	657	62.2	657	56.8	657	54.5
656	66.9	656	73.0	656	66.7	656	65.1
655	62.5	655	65.5	655	63.4	655	65.4
654	53.2	654	60.1	654	53.4	654	52.9
653	57.6	653	63.7	653	56.4	653	56.2
652	66.0	652	71.2	652	64.6	652	63.5
651	75.9	651	76.4	651	72.1	651	78.0
650	55.6	650	62.9	650	56.1	650	55.6
649	61.4	649	67.9	649	60.4	649	60.2
648	75.3	648	80.9	648	74.0	648	72.9
647	75.6	647	75.5	647	70.2	647	77.7
646	53.5	646	61.1	646	54.5	646	54.0
645	58.3	645	65.4	645	57.9	645	58.0
644	69.1	644	75.5	644	68.5	644	67.7
643	53.2	643	60.3	643	53.6	643	53.1
642	56.2	642	62.0	642	57.8	642	59.0
641	58.6	641	64.7	641	57.7	641	57.0
640	65.9	640	71.2	640	64.7	640	63.3
639	61.1	639	65.6	639	60.8	639	64.4
638	55.1	638	62.5	638	56.0	638	55.3
637	62.9	637	69.6	637	62.3	637	61.7
636	75.2	636	81.0	636	74.2	636	72.8
635	60.3	635	64.6	635	59.9	635	63.8
634	52.8	634	60.6	634	54.2	634	53.7
633	59.2	633	66.2	633	58.9	633	58.6
632	70.2	632	76.6	632	69.7	632	68.8
631	50.6	631	56.5	631	52.0	631	52.0
630	50.5	630	56.5	630	51.8	630	49.6
629	57.4	629	62.5	629	57.0	629	54.8
628	66.0	628	70.9	628	64.9	628	63.0
627	54.2	627	59.4	627	54.6	627	56.0
626	53.1	626	59.3	626	54.6	626	52.4
625	62.5	625	68.1	625	62.2	625	60.0
624	75.0	624	80.3	624	74.0	624	72.1
623	54.0	623	59.2	623	54.4	623	56.0
622	51.7	622	58.3	622	53.4	622	51.4
621	58.0	621	64.1	621	58.3	621	56.5
620	69.2	620	75.1	620	68.8	620	67.4

TABLE E-22 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 2/1/82		DATE: 2/15/82		DATE: 3/1/82		DATE: 3/15/82	
TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.		TIME: 4:00 p.m.	
OPERATING HRS: 27,649		OPERATING HRS: 27,985		OPERATING HRS: 28,321		OPERATING HRS: 28,657	
T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
683	96.8	683	94.2	683	108.3	683	106.7
682	99.8	682	97.0	682	111.1	682	109.7
681	120.2	681	117.6	681	131.5	681	129.8
680	117.3	680	115.0	680	128.9	680	126.8
679	118.6	679	116.3	679	130.2	679	128.5
678	119.8	678	117.2	678	131.2	678	129.6
677	114.9	677	112.8	677	126.4	677	124.6
676	114.3	676	112.2	676	125.6	676	124.2
675	106.6	675	104.5	675	117.6	675	115.9
674	104.4	674	102.5	674	115.6	674	113.8
673	64.8	673	62.3	673	76.9	673	75.1
672	64.9	672	62.3	672	76.8	672	75.2
671	73.8	671	71.6	671	86.1	671	84.1
670	73.9	670	71.6	670	86.3	670	84.4
669	70.5	669	68.7	669	82.4	669	80.5
668	67.9	668	66.0	668	79.7	668	77.8
667	50.7	667	57.4	667	61.8	667	56.2
666	50.3	666	51.9	666	63.1	666	59.0
665	55.6	665	54.1	665	67.4	665	65.6
664	65.2	664	62.4	664	77.0	664	75.7
663	52.3	663	60.1	663	62.5	663	57.7
662	52.8	662	54.4	662	66.0	662	61.7
661	59.9	661	58.7	661	72.1	661	69.8
660	74.4	660	72.1	660	86.6	660	84.9
659	52.0	659	60.6	659	60.4	659	56.2
658	51.0	658	52.5	658	63.9	658	59.6
657	56.9	657	55.7	657	68.9	657	66.8
656	67.1	656	65.0	656	79.1	656	77.4
655	61.4	655	67.1	655	60.6	655	54.7
654	54.0	654	54.6	654	65.1	654	59.4
653	57.7	653	55.8	653	68.8	653	65.8
652	65.0	652	62.2	652	76.7	652	74.8
651	73.2	651	81.5	651	62.5	651	58.2
650	56.6	650	57.9	650	67.9	650	61.9
649	61.8	649	60.4	649	73.3	649	69.8
648	74.4	648	72.2	648	86.4	648	84.3
647	73.6	647	81.4	647	61.4	647	57.4
646	55.3	646	56.8	646	66.2	646	60.0
645	59.8	645	58.4	645	70.8	645	67.6
644	69.5	644	67.4	644	81.3	644	79.2
643	53.8	643	54.0	643	65.7	643	60.1
642	55.4	642	62.0	642	61.4	642	54.1
641	58.3	641	56.2	641	69.9	641	67.0
640	64.6	640	62.1	640	76.7	640	74.8
639	59.8	639	67.6	639	61.4	639	55.4
638	56.0	638	57.4	638	67.9	638	61.9
637	63.2	637	61.6	637	75.0	637	71.6
636	74.4	636	72.1	636	86.6	636	84.4
635	61.4	635	67.4	635	60.8	635	55.1
634	55.1	634	56.4	634	66.1	634	59.9
633	60.6	633	59.1	633	71.7	633	68.6
632	70.6	632	68.5	632	82.3	632	80.3
631	50.5	631	55.5	631	61.0	631	54.2
630	51.0	630	51.5	630	63.0	630	58.6
629	56.8	629	54.9	629	68.3	629	66.4
628	64.7	628	62.1	628	76.6	628	75.1
627	53.8	627	60.2	627	62.2	627	56.1
626	53.7	626	54.8	626	66.1	626	61.2
625	62.2	625	60.4	625	74.2	625	72.1
624	73.9	624	71.7	624	86.1	624	84.3
623	53.9	623	60.6	623	61.8	623	56.0
622	53.1	622	53.8	622	65.1	622	60.8
621	58.7	621	57.3	621	70.5	621	68.3
620	69.2	620	67.2	620	81.2	620	79.4

TABLE E-23 CONCRETE SILO NO. 2 THERMOCOUPLE DATA, FUEL ASSEMBLY: B02

DATE: 3/31/82
TIME: 4:00 p.m.
OPERATING HRS: 29,041

T/C No.	Temp(°F)
683	100.5
682	103.3
681	123.5
680	120.6
679	122.0
678	123.0
677	118.1
676	117.5
675	109.5
674	107.3
673	68.9
672	68.8
671	77.6
670	77.7
669	73.8
668	71.2
667	58.8
666	55.3
665	59.7
664	69.2
663	61.2
662	57.7
661	64.0
660	78.3
659	61.3
658	55.6
657	60.8
656	70.7
655	61.8
654	57.0
653	60.6
652	68.5
651	66.8
650	59.5
649	64.5
648	77.9
647	65.9
646	57.8
645	62.1
644	72.4
643	56.9
642	59.9
641	61.4
640	68.4
639	61.9
638	59.0
637	65.8
636	77.9
635	61.7
634	57.3
633	62.6
632	73.5
631	57.4
630	55.0
629	60.5
628	68.7
627	60.2
626	57.8
625	65.8
624	77.9
623	60.2
622	56.6
621	62.1
620	72.6

APPENDIX F

FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST DATA

Test data are provided in this Appendix for the Fuel Assembly Internal Temperature Measurement Tests. Data from the test thermocouples are provided for the calibration heater and the two spent fuel assembly tests. Table F-1 provides the detailed identification and the location of the test thermocouples. Figure F-1 shows the location of the fifteen thermowell tubes containing thermocouples which measured fuel assembly internal temperatures. Test data are provided in Tables F-2 through F-54 for thermocouple readings at the times and for the test operating conditions shown below:

Table No.	Date	Test Operating Condition
Phase I: Electrical Tests		
F-2	6/5/79	Calibration Heater at 0.5 kW, No Band Heaters
F-2	6/4/79	Calibration Heater at 1.0 kW, No Band Heaters
F-3	6/26/79	Calibration Heater at 1.5 kW, No Band Heaters
F-3	6/27/79	Calibration Heater at 2.0 kW, No Band Heaters
F-4	6/28/79	Calibration Heater at 2.5 kW, No Band Heaters
F-4	6/29/79	Calibration Heater at 3.0 kW, No Band Heaters
Phase II: Fuel Assembly B43 Tests		
F-5	7/25/79	Band Heaters Off with Vacuum
F-6	8/5/79	Band Heaters Off with Helium
F-7	7/23/79	Band Heaters Off with Air
F-8	9/18/79	Band Heaters Off with Vacuum (Rerun)
F-9	9/11/79	Band Heaters Off with Helium (Rerun)
F-10	9/20/79	Band Heaters Off with Air (Rerun)
F-11	11/29/79	Elect. Heated Drywell Canister Profile with Vacuum
F-12	11/30/79	Elect. Heated Drywell Canister Profile with Helium
F-13	1/10/80	Elect. Heated Drywell Canister Profile with Air
F-14	6/25/80	Elect. Heated Drywell Canister Profile with Vacuum (Rerun)
F-15	6/17/80	Elect. Heated Drywell Canister Profile with Air (Rerun)

Table No.	Date	Test Operating Condition
F-16	11/28/79	Drywell Canister Profile with Vacuum
F-17	9/13/79	Drywell Canister Profile with Helium
F-18	11/14/79	Drywell Canister Profile with Air
F-19	11/27/79	Drywell Canister Profile with Helium (Rerun)
F-20	2/8/80	Uniform Canister Temperature at 250°F with Vacuum
F-21	12/6/79	Uniform Canister Temperature at 250°F with Helium
F-22	1/4/80	Uniform Canister Temperature at 250°F with Air
F-23	2/11/80	Uniform Canister Temperature at 300°F with Vacuum
F-24	12/7/79	Uniform Canister Temperature at 300°F with Helium
F-25	1/14/80	Uniform Canister Temperature at 300°F with Air
F-26	1/30/80	Uniform Canister Temperature at 400°F with Vacuum
F-27	12/11/79	Uniform Canister Temperature at 400°F with Helium
F-28	1/17/80	Uniform Canister Temperature at 400°F with Air
F-29	12/20/79	Uniform Canister Temperature at 500°F with Vacuum
F-30	12/17/79	Uniform Canister Temperature at 500°F with Helium
F-31	1/24/80	Uniform Canister Temperature at 500°F with Air

Phase III: Fuel Assembly D15 Tests

F-32	9/30/80	Band Heaters Off with Vacuum
F-33	10/3/80	Band Heaters Off with Helium
F-34	9/26/80	Band Heaters Off with Air
F-35	1/5/81	Band Heaters Off with Air (Rerun)
F-36	12/31/80	Elect. Heated Drywell Canister Profile with Vacuum
F-37	12/19/80	Elect. Heated Drywell Canister Profile with Helium
F-38	12/10/80	Drywell Canister Profile with Vacuum
F-39	12/14/80	Drywell Canister Profile with Helium
F-40	12/8/80	Drywell Canister Profile with Air
F-41	12/27/80	SFT-C Canister Profile with Vacuum
F-42	12/22/80	SFT-C Canister Profile with Helium
F-43	10/8/80	Uniform Canister Temperature at 350°F with Air
F-44	10/27/80	Uniform Canister Temperature at 400°F with Helium
F-45	10/10/80	Uniform Canister Temperature at 400°F with Air
F-46	11/5/80	Uniform Canister Temperature at 450°F with Helium

Table No.	Date	Test Operating Condition
F-47	11/7/80	Uniform Canister Temperature at 450°F with Air
F-48	10/20/80	Uniform Canister Temperature at 500°F with Vacuum
F-49	10/22/80	Uniform Canister Temperature at 500°F with Helium
F-50	10/17/80	Uniform Canister Temperature at 500°F with Air
F-51	11/14/80	Uniform Canister Temperature at 550°F with Vacuum
F-52	11/17/80	Uniform Canister Temperature at 550°F with Helium
F-53	11/12/80	Uniform Canister Temperature at 550°F with Air
F-54	11/20/80	Uniform Canister Temperature at 600°F with Helium

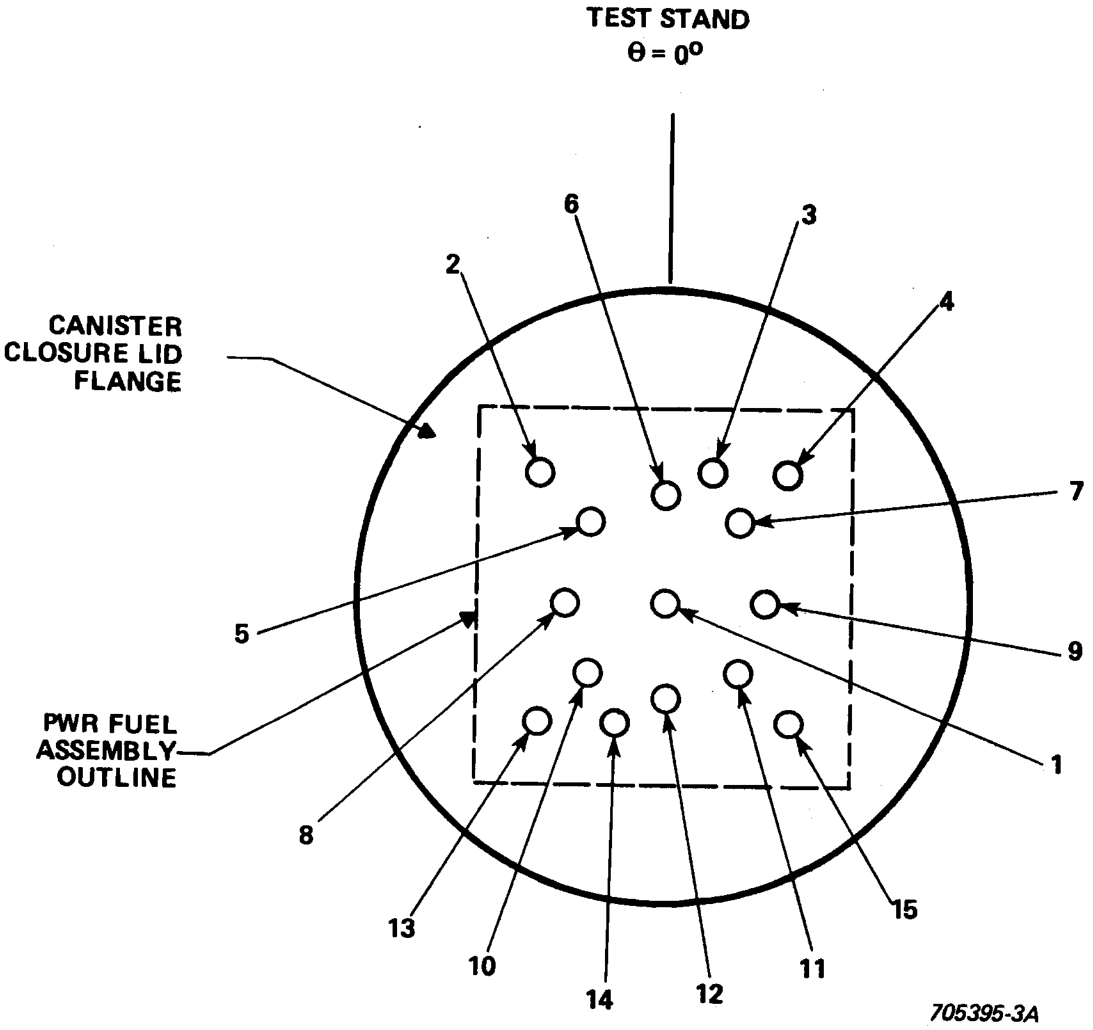

Figure F-1. Canister Lid Thermowell Tube Identification (Top View of Lid)

TABLE F-1

FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance Below Top of Canister (In.)	Radius (In.)	Orientation (Degrees)	Location
Data Thermocouples				
301	135.0	0	-	Canister Lid Thermowell No. 1*
302	113.0	0	-	Canister Lid Thermowell No. 1
303	86.8	0	-	Canister Lid Thermowell No. 1
304	73.0	0	-	Canister Lid Thermowell No. 1
305	53.0	0	-	Canister Lid Thermowell No. 1
306	37.0	0	-	Canister Lid Thermowell No. 1
307	25.0	0	-	Canister Lid Thermowell No. 1
308	135.0	3.97	315	Canister Lid Thermowell No. 2
309	113.0	3.97	315	Canister Lid Thermowell No. 2
310	86.8	3.97	315	Canister Lid Thermowell No. 2
311	73.0	3.97	315	Canister Lid Thermowell No. 2
312	53.0	3.97	315	Canister Lid Thermowell No. 2
313	37.0	3.97	315	Canister Lid Thermowell No. 2
314	25.0	3.97	315	Canister Lid Thermowell No. 2
315	135.0	3.03	22	Canister Lid Thermowell No. 3
316	113.0	3.03	22	Canister Lid Thermowell No. 3
317	86.8	3.03	22	Canister Lid Thermowell No. 3
318	73.0	3.03	22	Canister Lid Thermowell No. 3
319	53.0	3.03	22	Canister Lid Thermowell No. 3
320	37.0	3.03	22	Canister Lid Thermowell No. 3
321	25.0	3.03	22	Canister Lid Thermowell No. 3
322	135.0	3.97	45	Canister Lid Thermowell No. 4
323	113.0	3.97	45	Canister Lid Thermowell No. 4
324	86.8	3.97	45	Canister Lid Thermowell No. 4
325	73.0	3.97	45	Canister Lid Thermowell No. 4
326	53.0	3.97	45	Canister Lid Thermowell No. 4
327	37.0	3.97	45	Canister Lid Thermowell No. 4
328†	25.0	3.97	45	Canister Lid Thermowell No. 4
329	135.0	2.38	315	Canister Lid Thermowell No. 5
330	113.0	2.38	315	Canister Lid Thermowell No. 5
331	86.8	2.38	315	Canister Lid Thermowell No. 5
332	73.0	2.38	315	Canister Lid Thermowell No. 5
333**	53.0	2.38	315	Canister Lid Thermowell No. 5
334	37.0	2.38	315	Canister Lid Thermowell No. 5
335	25.0	2.38	315	Canister Lid Thermowell No. 5

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*See Figure F-1 for illustration of thermowell locations

**Connected to heater controller C21

†Electrical check showed low internal resistance - readings may be in error

TABLE F-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Top of Canister (In.)	Radius (In.)	Orientation (Degrees)	Location
336	135.0	2.25	0	Canister Lid Thermowell No. 6
337	113.0	2.25	0	Canister Lid Thermowell No. 6
338	86.8	2.25	0	Canister Lid Thermowell No. 6
339	73.0	2.25	0	Canister Lid Thermowell No. 6
340	53.0	2.25	0	Canister Lid Thermowell No. 6
341	37.0	2.25	0	Canister Lid Thermowell No. 6
342	25.0	2.25	0	Canister Lid Thermowell No. 6
343	135.0	2.38	45	Canister Lid Thermowell No. 7
344	113.0	2.38	45	Canister Lid Thermowell No. 7
345	86.8	2.38	45	Canister Lid Thermowell No. 7
346	73.0	2.38	45	Canister Lid Thermowell No. 7
347	53.0	2.38	45	Canister Lid Thermowell No. 7
348	37.0	2.38	45	Canister Lid Thermowell No. 7
349	25.0	2.38	45	Canister Lid Thermowell No. 7
350	135.0	2.25	270	Canister Lid Thermowell No. 8
351	113.0	2.25	270	Canister Lid Thermowell No. 8
352	86.8	2.25	270	Canister Lid Thermowell No. 8
353	73.0	2.25	270	Canister Lid Thermowell No. 8
354	53.0	2.25	270	Canister Lid Thermowell No. 8
355	37.0	2.25	270	Canister Lid Thermowell No. 8
356	25.0	2.25	270	Canister Lid Thermowell No. 8
357*	135.0	2.25	90	Canister Lid Thermowell No. 9
358	113.0	2.25	90	Canister Lid Thermowell No. 9
359	86.8	2.25	90	Canister Lid Thermowell No. 9
360	73.0	2.25	90	Canister Lid Thermowell No. 9
361	53.0	2.25	90	Canister Lid Thermowell No. 9
362	37.0	2.25	90	Canister Lid Thermowell No. 9
363	25.0	2.25	90	Canister Lid Thermowell No. 9
364	135.0	2.38	225	Canister Lid Thermowell No. 10
365	113.0	2.38	225	Canister Lid Thermowell No. 10
366	86.8	2.38	225	Canister Lid Thermowell No. 10
367	73.0	2.38	225	Canister Lid Thermowell No. 10
368	53.0	2.38	225	Canister Lid Thermowell No. 10
369	37.0	2.38	225	Canister Lid Thermowell No. 10
370	25.0	2.38	225	Canister Lid Thermowell No. 10
371	135.0	2.38	135	Canister Lid Thermowell No. 11
372	113.0	2.38	135	Canister Lid Thermowell No. 11
373	86.8	2.38	135	Canister Lid Thermowell No. 11
374	73.0	2.38	135	Canister Lid Thermowell No. 11
375	53.0	2.38	135	Canister Lid Thermowell No. 11
376	37.0	2.38	135	Canister Lid Thermowell No. 11
377	25.0	2.38	135	Canister Lid Thermowell No. 11

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*Electrical check showed low internal resistance - readings may be in error

TABLE F-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Top of Canister (In.)	Radius (In.)	Orientation (Degrees)	Location
378	135.0	2.25	180	Canister Lid Thermowell No. 12
379	113.0	2.25	180	Canister Lid Thermowell No. 12
380	86.8	2.25	180	Canister Lid Thermowell No. 12
381	73.0	2.25	180	Canister Lid Thermowell No. 12
382	53.0	2.25	180	Canister Lid Thermowell No. 12
383*	37.0	2.25	180	Canister Lid Thermowell No. 12
384	25.0	2.25	180	Canister Lid Thermowell No. 12
385	135.0	3.97	225	Canister Lid Thermowell No. 13
386	113.0	3.97	225	Canister Lid Thermowell No. 13
387*	86.8	3.97	225	Canister Lid Thermowell No. 13
388	73.0	3.97	225	Canister Lid Thermowell No. 13
389*	53.0	3.97	225	Canister Lid Thermowell No. 13
390	37.0	3.97	225	Canister Lid Thermowell No. 13
391	25.0	3.97	225	Canister Lid Thermowell No. 13
392	135.0	3.03	202	Canister Lid Thermowell No. 14
393	113.0	3.03	202	Canister Lid Thermowell No. 14
394	86.8	3.03	202	Canister Lid Thermowell No. 14
395	73.0	3.03	202	Canister Lid Thermowell No. 14
396	53.0	3.03	202	Canister Lid Thermowell No. 14
397	37.0	3.03	202	Canister Lid Thermowell No. 14
398	25.0	3.03	202	Canister Lid Thermowell No. 14
399	135.0	3.97	135	Canister Lid Thermowell No. 15
400	113.0	3.97	135	Canister Lid Thermowell No. 15
401	86.8	3.97	135	Canister Lid Thermowell No. 15
402	73.0	3.97	135	Canister Lid Thermowell No. 15
403	53.0	3.97	135	Canister Lid Thermowell No. 15
404	37.0	3.97	135	Canister Lid Thermowell No. 15
405	25.0	3.97	135	Canister Lid Thermowell No. 15
406	0	0.8	180	Canister Lid Top Plate
407	0	5.8	70	Canister Lid Top Plate
408	4.5	0.8	180	Canister Lid Top
409	4.5	5.8	70	Canister Lid Top
415	0.5	9.0	225	Canister Support Ring
416	2.5	8.0	135	Canister Upper Support Pipe
417	16.5	7.0	0	Canister Outside
418	16.5	7.0	180	Canister Outside
419	51.0	7.0	0	Canister Outside (Inside T/C Tube)
420	51.0	7.0	90	Canister Outside (Inside T/C Tube)

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*Electrical check showed low internal resistance - readings may be in error

TABLE F-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Top of Canister (In.)	Radius (In.)	Orientation (Degrees)	Location
421	51.0	7.0	180	Canister Outside
422	51.0	7.0	270	Canister Outside
423	85.5	7.0	0	Canister Outside
424	85.5	7.0	45	Canister Outside
425	85.5	7.0	90	Canister Outside
426	85.5	7.0	135	Canister Outside
427	85.5	7.0	180	Canister Outside
428**	85.5	7.0	225	Canister Outside
429	85.5	7.0	270	Canister Outside
430	85.5	7.0	315	Canister Outside
431	120.0	7.0	0	Canister Outside
432	120.0	7.0	90	Canister Outside
433	120.0	7.0	180	Canister Outside (Inside T/C Tube)
434	120.0	7.0	270	Canister Outside (Inside T/C Tube)
435	154.5	7.0	90	Canister Outside
436	154.5	7.0	270	Canister Outside
437	171.6	0.0	-	Canister Bottom
440	1.5	9.0	135	Outside of Liner Pipe
441	6.0	9.0	132	Outside of Liner Pipe
442	12.0	9.0	190	Outside of Liner Pipe
443	18.0	9.0	67	Outside of Liner Pipe
444	24.0	9.0	292	Outside of Liner Pipe
445	30.0	9.0	158	Outside of Liner Pipe
446	36.0	9.0	202	Outside of Liner Pipe
447	42.0	9.0	65	Outside of Liner Pipe
448	48.0	9.0	225	Outside of Liner Pipe
449	54.0	9.0	158	Outside of Liner Pipe
450	60.0	9.0	135	Outside of Liner Pipe
451	66.0	9.0	22	Outside of Liner Pipe
452*	72.0	9.0	245	Outside of Liner Pipe
453	78.0	9.0	68	Outside of Liner Pipe
454**	84.0	9.0	202	Outside of Liner Pipe
455	90.0	9.0	158	Outside of Liner Pipe
456	96.0	9.0	22	Outside of Liner Pipe
457	96.0	9.0	112	Outside of Liner Pipe
458	96.0	9.0	202	Outside of Liner Pipe
459	96.0	9.0	292	Outside of Liner Pipe
460†	102.0	9.0	112	Outside of Liner Pipe

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* Connected to heater control C9

** Electrical check showed low internal resistance - readings may be in error

† Connected to heater controller C11

TABLE F-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Top of Canister (In.)	Radius (In.)	Orientation (Degrees)	Location
461	108.0	9.0	135	Outside of Liner Pipe
462	114.0	9.0	22	Outside of Liner Pipe
463	120.0	9.0	248	Outside of Liner Pipe
464	126.0	9.0	68	Outside of Liner Pipe
465	132.0	9.0	202	Outside of Liner Pipe
466	138.0	9.0	158	Outside of Liner Pipe
467	144.0	9.0	292	Outside of Liner Pipe
468	150.0	9.0	112	Outside of Liner Pipe
469	156.0	9.0	135	Outside of Liner Pipe
470	162.0	9.0	22	Outside of Liner Pipe
471	168.0	9.0	248	Outside of Liner Pipe
472	174.0	9.0	68	Outside of Liner Pipe
473	180.0	9.0	202	Outside of Liner Pipe
474	186.0	9.0	158	Outside of Liner Pipe
475	192.0	9.0	292	Outside of Liner Pipe
476	196.2	9.0	90	Outside of Liner Pipe
477	196.2	9.0	180	Outside of Liner Pipe
478	0	10.1	315	On Insulation Sheath
479	65.0	10.1	315	On Insulation Sheath
480	65.0	10.1	135	On Insulation Sheath
481	130.0	10.1	315	On Insulation Sheath
482	130.0	10.1	135	On Insulation Sheath
483	195.0	10.1	315	On Insulation Sheath
484*	0	10.6	315	Outside Flexible Insulation
485	130.0	10.6	315	Outside Flexible Insulation
486	130.0	10.6	135	Outside Flexible Insulation
487	195.0	10.6	315	Outside Flexible Insulation
488	156.0	45.0	65	Ambient Temperature
489	52.0	45.0	65	Ambient Temperature
490	156.0	45.0	245	Ambient Temperature
491	52.0	45.0	245	Ambient Temperature
492	195.5	3.5	330	Top Plate of Insulation Plug

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*This thermocouple removed from insulation when insulation was removed

TABLE F-1 (Cont'd)

Data Channel (T/C) No.	Distance Below Top of Canister (In.)	Radius (In.)	Orientation (Degrees)	Location
Heater Controller Thermocouples				
TC-1	0	5.0	295	Canister Lid Cover
TC-2	0	7.7	295	Canister Support Ring
TC-3	6.0	9.0	312	Liner
TC-4	18.0	9.0	247	Liner
TC-5	30.0	9.0	338	Liner
TC-6	42.0	9.0	245	Liner
TC-7	54.0	9.0	338	Liner
TC-8	66.0	9.0	202	Liner
452	72.0	9.0	245	Liner
TC-10	90.0	9.0	338	Liner
460	102.0	9.0	112	Liner
TC-12	114.0	9.0	202	Liner
TC-13	126.0	9.0	248	Liner
TC-14	138.0	9.0	338	Liner
TC-15	150.0	9.0	292	Liner
TC-16	162.0	9.0	202	Liner
TC-17	174.0	9.0	248	Liner
TC-18	186.0	9.0	338	Liner
TC-19	196.2	9.0	292	Liner
TC-20	195.5	4.0	60	Top On Insulation Plug
333	53.0	2.38	315	Canister Lid Thermowell No. 5

TABLE F-2: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
CALIBRATION HEATER

DATE: 6/5/79 TIME: 8:00 a.m.
TEST CONDITIONS: Calibration Heater at 0.5 kW, No Band Heaters

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
442	136.0	472	88.3	492	83.3
441	135.8	471	91.3	491	80.7
440	137.8	470	96.3	490	79.9
437	107.7	469	100.9	489	80.8
436	127.6	468	105.5	488	80.0
435	126.5	467	110.0	487	79.6
434	158.9	466	114.1	486	86.9
433	160.8	465	118.3	485	86.5
432	162.1	464	121.2	484	81.1
431	160.4	463	125.9	483	79.7
430	172.7	462	128.7	482	94.7
429	171.8	461	130.2	481	94.9
428	171.7	460	131.4	480	99.9
427	173.0	459	133.2	479	97.9
426	173.7	458	133.5	478	108.7
425	173.0	457	133.5	477	80.9
424	171.8	456	133.8	476	81.4
423	171.7	455	134.5	475	81.7
422	177.1	454	133.3	474	83.6
421	178.3	453	53.4	473	85.0
420	174.6	452	133.3		
419	175.0	451	135.8		
418	174.6	450	138.7		
417	169.7	449	139.1		
416	143.4	448	138.3		
415	139.1	447	140.9		
409	150.1	446	139.3		
408	151.9	445	139.6		
407	133.4	444	137.1		
406	133.0	443	139.0		

DATE: 6/4/79 TIME: 8:00 a.m.
TEST CONDITIONS: Calibration Heater at 1.0 kW, No Band Heaters

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
442	171.9	472	93.4	492	85.3
441	170.6	471	98.3	491	80.7
440	173.8	470	107.1	490	79.9
437	126.5	469	114.6	489	30.9
436	161.9	468	122.7	488	80.0
435	163.8	467	130.5	487	79.4
434	213.2	466	137.5	486	91.5
433	215.9	465	144.3	485	91.8
432	218.4	464	148.8	484	80.6
431	215.8	463	156.8	483	79.6
430	233.3	462	161.5	482	103.2
429	231.3	461	163.9	481	103.3
428	231.9	460		480	113.5
427	234.0	459	168.6	479	109.4
426	235.6	458	169.1	478	129.6
425	233.7	457	169.2	477	81.4
424	231.6	456	169.3	476	82.4
423	231.2	455	171.0	475	82.5
422	239.1	454	168.3	474	35.6
421	241.2	453	85.0	473	87.8
420	235.1	452	167.3		
419	235.2	451	171.3		
418	234.3	450	176.3		
417	225.4	449	177.6		
416	182.9	448	176.1		
415	174.9	447	180.3		
409	193.7	446	178.0		
408	196.8	445	178.3		
407	167.0	444	173.4		
406	166.6	443	176.8		

TABLE F-3: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA CALIBRATION HEATER

DATE: 6/26/79 TIME: 8:00 a.m.

TEST CONDITIONS: Calibration Heater at 1.5 kW, No Band Heaters

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
442	212.5	472	100.7	492	86.5
441	209.6	471	108.4	491	32.7
440	213.4	470	122.0	490	82.4
437	159.2	469	133.3	489	82.3
436	207.9	468	145.7	488	81.1
435	211.2	467	158.0	487	30.2
434	277.8	466	168.1	486	97.2
433	281.9	465	178.4	485	97.5
432	285.7	464	184.3	484	82.5
431	282.2	463	196.5	483	80.5
430	300.9	462	202.8	482	114.9
429	299.6	461	206.1	481	115.6
428	299.8	460		480	129.6
427	304.3	459	211.8	479	123.2
426	305.8	458	212.3	478	151.6
425	303.3	457	213.3	477	83.2
424	299.2	456	212.6	476	84.2
423	298.6	455	215.8	475	84.6
422	307.2	454	212.1	474	89.0
421	311.4	453	123.3	473	92.4
420	302.0	452	209.2		
419	302.6	451	213.9		
418	298.8	450	222.1		
417	286.2	449	223.1		
416	225.8	448	220.6		
415	214.7	447	226.2		
409	240.8	446	222.7		
408	245.1	445	223.3		
407	205.0	444	215.9		
406	204.2	443	220.0		

DATE: 6/27/79 TIME: 8:00 a.m.

TEST CONDITIONS: Calibration Heater at 2.0 kW, No Band Heaters

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
442	241.9	472	106.6	492	91.3
441	237.4	471	116.2	491	83.6
440	241.6	470	133.3	490	83.4
437	172.2	469	147.5	489	83.2
436	241.0	468	163.0	488	82.0
435	244.9	467	178.6	487	81.0
434	321.7	466	191.1	486	101.8
433	326.2	465	203.4	485	102.0
432	331.0	464	210.2	484	83.4
431	327.1	463	225.0	483	81.3
430	340.6	462	232.8	482	124.2
429	344.7	461	236.3	481	125.1
428	345.6	460		480	142.4
427	351.2	459	243.0	479	133.5
426	353.2	458	244.5	478	168.6
425	349.8	457	244.8	477	84.7
424	344.7	456	243.7	476	85.9
423	343.7	455	247.9	475	86.3
422	354.0	454	243.3	474	91.9
421	359.0	453	150.3	473	95.9
420	347.6	452	238.9		
419	347.5	451	244.7		
418	342.2	450	254.6		
417	326.1	449	256.0		
416	256.2	448	252.5		
415	242.3	447	259.2		
409	273.4	446	254.8		
408	278.8	445	255.7		
407	231.9	444	246.9		
406	231.3	443	250.8		

TABLE F-4: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA CALIBRATION HEATER

DATE: 6/28/79 TIME: 8:00 a.m.
TEST CONDITIONS: Calibration Heater at 2.5 kW, No Band Heaters

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
442	272.6	472	113.1	492	94.2
441	266.3	471	125.2	491	84.5
440	270.1	470	146.5	490	84.2
437	194.2	469	163.9	489	84.2
436	278.1	468	183.3	488	82.8
435	283.2	467	202.3	487	81.7
434	368.5	466	217.2	486	106.9
433	373.9	465	232.2	485	107.4
432	379.6	464	239.5	484	84.3
431	375.1	463	256.9	483	82.1
430	394.3	462	266.1	482	135.1
429	392.9	461	269.9	481	136.4
428	393.6	460		480	156.5
427	400.8	459	277.3	479	145.0
426	403.2	458	279.1	478	186.1
425	399.1	457	279.3	477	86.2
424	392.7	456	277.6	476	87.6
423	391.4	455	283.2	475	88.1
422	402.4	454	277.4	474	94.9
421	408.5	453	179.8	473	99.9
420	394.8	452	271.1		
419	394.6	451	278.3		
418	387.0	450	290.0		
417	367.4	449	291.6		
416	287.1	448	286.6		
415	270.6	447	294.5		
409	306.5	446	289.1		
408	312.6	445	290.5		
407	259.4	444	279.9		
406	258.6	443	283.5		

DATE: 6/29/79 TIME: 8:00 a.m.
TEST CONDITIONS: Calibration Heater at 3.0 kW, No Band Heaters

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
442	295.7	472	117.8	492	95.8
441	287.6	471	113.8	491	84.6
440	291.5	470	156.6	490	84.0
437	210.9	469	176.5	489	84.2
436	305.9	468	198.8	488	82.6
435	311.7	467	220.6	487	81.5
434	402.5	466	237.2	486	110.2
433	408.3	465	253.9	485	111.0
432	414.7	464	261.6	484	84.3
431	409.7	463	281.1	483	81.8
430	428.8	462	291.2	482	143.1
429	427.5	461	295.2	481	145.0
428	428.5	460		480	168.2
427	436.2	459	303.2	479	153.3
426	438.6	458	304.5	478	198.5
425	434.5	457	305.2	477	86.5
424	427.0	456	302.9	476	88.0
423	425.8	455	309.4	475	88.7
422	436.8	454	302.9	474	96.6
421	444.1	453	202.3	473	102.2
420	428.7	452	295.2		
419	428.9	451	303.6		
418	419.0	450	316.1		
417	397.4	449	317.9		
416	310.0	448	312.1		
415	291.7	447	320.4		
409	330.7	446	314.6		
408	337.5	445	316.2		
407	280.6	444	304.5		
406	279.5	443	307.9		

TABLE F-5: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 7/25/79 TIME: 8:00 a.m.
TEST CONDITIONS: Band Heaters Off With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	336.0	428	239.2	492	89.7
361	372.9	427	242.0	491	85.8
360	387.3	426	243.8	490	84.9
359	388.9	425	241.5	489	85.3
358	383.5	424	239.8	488	84.4
357	363.6	423	239.2	487	84.2
356	267.8	422	235.1	486	96.5
355	335.9	421	236.4	485	97.0
354	373.0	420	230.5	484	95.9
353	385.0	419	229.7	483	84.4
352	385.7	418	189.2	482	109.1
351	379.6	417	188.3	481	109.2
350	360.0	416	155.3	480	119.1
349	275.1	415	152.0	479	113.6
348	336.1	409	157.7	478	124.5
347	374.0	408	157.8	477	85.9
346	388.0	407	142.9	476	86.3
345	388.8	406	142.6	475	87.1
344	383.5	405	261.9	474	90.2
343	365.2	404	313.0	473	92.7
342	278.3	403	345.6	472	98.4
341	339.6	402	356.4	471	104.1
340	375.0	401	358.0	470	112.8
339	387.4	400	351.0	469	121.6
338	387.7	399	332.3	468	129.6
337	381.6	398	271.6	467	137.4
336	364.0	397	325.8	466	145.4
335	276.3	396	358.4	465	152.8
334	336.5	395	369.0	464	156.7
332	386.1	394	370.5	463	165.1
331	385.6	393	365.0	462	169.0
330	379.0	392	342.6	461	172.6
329	361.4	391	262.5	460	93.2
328	261.9	390	315.2	459	175.5
327	316.0	389	345.1	458	177.3
326	347.0	388	356.0	457	176.0
325	359.8	387	357.0	456	173.8
324	361.3	386	350.2	455	178.8
323	354.1	385	326.9	454	171.4
322	335.2	384	275.9	453	168.3
321	268.9	383	334.2	451	174.7
320	327.0	382	371.9	450	175.0
319	361.4	381	384.9	449	178.1
318	374.2	380	385.6	448	174.5
317	375.4	379	379.6	447	176.7
316	369.3	378	360.4	446	172.3
315	351.1	377	270.3	445	170.8
314	261.3	376	332.0	444	166.1
313	313.2	375	371.6	443	165.8
312	345.1	374	384.7	442	159.4
311	355.1	373	385.5	441	155.5
310	356.2	372	380.6	440	153.7
309	348.2	371	362.5	437	136.2
308	331.9	370	276.4	436	170.2
307	283.2	369	335.1	435	171.8
306	347.2	368	372.4	434	225.4
305	389.9	367	384.9	433	226.7
304	404.7	366	384.8	432	228.9
303	404.4	365	377.7	431	229.1
302	399.3	364	358.6	430	239.6
301	382.1	363	271.5	429	238.4

TABLE F-6: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 8/5/79 TIME: 4:00 p.m.
TEST CONDITIONS: Band Heaters Off With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	297.3	428	234.9	492	87.8
361	318.6	427	235.9	491	84.7
360	328.2	426	239.5	490	83.9
359	326.9	425	233.7	489	84.3
358	320.8	424	234.3	488	83.6
357	292.6	423	231.4	487	83.1
356	256.8	422	232.6	486	94.5
355	305.4	421	232.1	485	94.8
354	324.4	420	222.0	484	92.3
353	330.8	419	221.8	483	83.3
352	329.3	418	202.4	482	105.9
351	319.9	417	192.9	481	105.9
350	290.9	416	164.4	480	117.0
349	254.9	415	161.1	479	112.1
348	295.8	409	169.6	478	124.7
347	317.7	408	174.7	477	84.4
346	327.2	407	149.2	476	85.0
345	326.5	406	149.7	475	85.4
344	320.4	405	247.8	474	88.2
343	293.2	404	281.3	473	90.2
342	259.7	403	300.1	472	95.2
341	300.9	402	306.1	471	99.9
340	319.4	401	306.5	470	108.0
339	327.8	400	299.0	469	116.1
338	326.4	399	271.5	468	124.3
337	319.6	398	264.8	467	131.9
336	292.5	397	300.0	466	140.0
335	262.1	396	315.4	465	147.2
334	303.6	395	321.1	464	152.1
332	328.9	394	319.9	463	160.3
331	326.9	393	311.0	462	164.6
330	316.1	392	279.1	461	167.9
329	290.5	391	257.2	460	91.4
328	240.0	390	292.2	459	171.2
327	276.3	389	306.2	458	172.7
326	294.0	388	311.9	457	171.4
325	304.5	387	311.1	456	189.9
324	305.5	386	300.6	455	174.1
323	298.8	385	268.3	454	167.4
322	271.3	384	265.7	453	162.9
321	250.2	383	303.7	451	170.0
320	288.7	382	323.8	450	171.4
319	308.3	381	330.7	449	175.3
318	317.6	380	329.1	448	172.8
317	317.2	379	320.1	447	172.1
316	310.6	378	291.2	446	171.8
315	283.8	377	256.9	445	169.2
314	249.4	376	297.4	444	167.8
313	283.4	375	320.4	443	163.9
312	299.7	374	327.6	442	162.4
311	306.1	373	326.3	441	158.4
310	305.5	372	319.6	440	159.5
309	296.8	371	292.3	437	125.3
308	270.2	370	266.9	436	161.5
307	267.3	369	305.5	435	162.4
306	309.6	368	324.6	434	221.0
305	334.5	367	331.2	433	221.7
304	342.6	366	329.2	432	224.4
303	340.4	365	318.8	431	224.9
302	332.6	364	289.6	430	235.3
301	306.2	363	254.7	429	232.6

TABLE F-7: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 7/23/79 TIME: 8:00 a.m.
TEST CONDITIONS: Band Heaters Off With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	352.6	428	228.0	492	87.4
361	346.2	427	229.8	491	85.1
360		426	229.7	490	84.3
359		425	228.9	489	84.5
358		424	228.1	488	83.7
357		423	229.5	487	83.4
356		422	236.5	486	93.5
355		421	231.9	485	93.8
354		420	227.8	484	93.2
353		419	232.2	483	83.5
352		418	212.7	482	103.4
351		417	221.3	481	103.5
350	181.7	416	173.0	480	115.5
349	184.5	415	167.8	479	111.5
348	354.9	409	324.9	478	128.2
347	353.1	408	187.1	477	84.6
346	356.2	407	156.9	476	85.0
345	355.5	406	157.4	475	85.4
344	336.7	405	295.4	474	87.8
343	289.2	404	320.5	473	89.5
342	328.7	403	317.0	472	93.8
341	359.3	402	321.1	471	98.0
340	359.4	401	321.1	470	104.9
339	360.3	400	307.1	469	112.3
338	359.1	399	266.7	468	119.3
337	337.6	398	312.5	467	126.1
336	288.5	397	339.7	466	133.2
335	326.6	396	328.3	465	140.4
334	358.7	395	333.2	464	144.7
332	357.7	394	335.6	463	152.9
331	356.3	393	320.3	462	157.4
330	334.3	392	272.7	461	161.3
329	286.8	391	300.7	460	
328	303.3	390	328.4	459	166.1
327	330.6	389	320.3	458	167.3
326	324.6	388	323.3	457	167.2
325	329.0	387	325.2	456	166.4
324	327.9	386	308.8	455	169.2
323	311.7	385	263.6	454	167.8
322	268.9	384	322.6	453	87.6
321	316.4	383	350.4	451	169.5
320	346.1	382	343.5	450	174.8
319	345.2	381	348.7	449	174.9
318		380	349.0	448	174.1
317		379	331.9	447	176.8
316	326.3	378	285.3	446	174.5
315	279.3	377	319.5	445	172.6
314	303.1	376	347.6	444	173.6
313	331.4	375	344.9	443	172.1
312	330.7	374	348.6	442	166.4
311	328.4	373	347.5	441	164.3
310	327.7	372	332.2	440	166.4
309	309.0	371	287.2	437	119.0
308	267.0	370	323.8	436	152.0
307	339.7	369	352.5	435	152.3
306	368.6	368	349.3	434	208.5
305	371.7	367	351.5	433	209.9
304	372.7	366	351.5	432	211.7
303	371.2	365	331.3	431	211.8
302	350.1	364	284.6	430	226.2
301	302.3	363	322.5	429	227.7

TABLE F-8: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 9/18/79 TIME: 12:00 noon
TEST CONDITIONS: Band Heaters Off With Vacuum (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	328.6	428	231.3	492	84.2
361	364.4	427	233.9	491	81.6
360	378.4	426	236.1	490	78.8
359	379.5	425	233.5	489	81.1
358	374.0	424	231.9	488	79.5
357	354.3	423	231.3	487	76.8
356	254.6	422	228.0	486	85.8
355	328.5	421	229.9	485	83.3
354	364.6	420	223.9	484	85.5
353	376.0	419	222.6	483	77.2
352	376.5	418	186.0	482	99.8
351	370.2	417	183.0	481	99.1
350	351.9	416	152.2	480	109.0
349	269.4	415	148.3	479	106.7
348	328.6	409	155.3	478	120.8
347	365.5	408	155.5	477	80.2
346	378.9	407	139.6	476	80.8
345	379.4	406	139.5	475	81.2
344	374.0	405	256.8	474	84.6
343	356.0	404	306.3	473	86.8
342	272.7	403	337.7	472	93.0
341	332.0	402	348.1	471	98.2
340	366.6	401	349.4	470	107.1
339	378.4	400	342.3	469	115.5
338	378.3	399	324.1	468	123.3
337	371.9	398	266.6	467	130.9
336	354.8	397	318.7	466	138.5
335	270.7	396	350.6	465	145.5
334	331.1	395	360.6	464	149.2
332	377.2	394	362.0	463	157.3
331	376.5	393	356.0	462	160.6
330	369.7	392	334.5	461	164.3
329	352.4	391	257.3	460	86.0
328	256.6	390	308.4	459	166.8
327	308.9	389	337.5	458	168.7
326	339.1	388	348.1	457	167.4
325	351.3	387	348.5	456	165.6
324	352.5	386	341.7	455	170.1
323	344.9	385	319.1	454	163.5
322	326.6	384	270.6	453	159.2
321	263.4	383	326.9	451	165.9
320	319.7	382	363.8	450	166.8
319	353.1	381	376.0	449	170.4
318	365.4	380	376.6	448	166.8
317	366.2	379	370.3	447	169.5
316	360.0	378	351.6	446	165.4
315	342.0	377	265.0	445	164.5
314	255.9	376	324.9	444	159.1
313	306.1	375	363.2	443	160.0
312	337.1	374	375.9	442	154.0
311	346.7	373	376.4	441	151.1
310	347.4	372	371.2	440	150.0
309	339.4	371	353.5	437	131.9
308	323.6	370	271.1	436	164.8
307	277.5	369	327.7	435	166.5
306	339.6	368	364.1	434	217.6
305	381.1	367	376.0	433	218.6
304	395.5	366	375.6	432	221.1
303	394.8	365	368.3	431	221.2
302	389.6	364	349.8	430	231.8
301	372.6	363	266.2	429	230.6

TABLE F-9: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 9/11/79 TIME: 11:50 a.m.
TEST CONDITIONS: Band Heaters Off With Helium (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	285.7	428	225.9	492	79.4
361	304.4	427	226.6	491	78.0
360	313.5	426	230.4	490	75.6
359	311.7	425	224.2	489	77.2
358	305.8	424	224.8	488	76.0
357	277.7	423	221.8	487	74.2
356	246.4	422	223.8	486	82.0
355	294.1	421	223.1	485	79.9
354	310.6	420	213.2	484	83.0
353	316.2	419	213.1	483	74.4
352	314.8	418	196.4	482	94.6
351	305.0	417	186.1	481	94.2
350	276.4	416	158.9	480	104.9
349	246.2	415	155.2	479	103.1
348	284.0	409	165.0	478	118.3
347	303.4	408	170.6	477	76.4
346	312.3	407	143.1	476	78.8
345	311.4	406	143.7	475	77.3
344	305.1	405	239.9	474	79.8
343	278.2	404	270.6	473	81.8
342	251.1	403	286.6	472	87.1
341	289.3	402	292.2	471	91.8
340	305.5	401	292.6	470	99.8
339	313.0	400	285.1	469	107.9
338	311.4	399	258.2	468	115.8
337	304.4	398	256.5	467	123.6
336	277.5	397	288.8	466	131.2
335	253.2	396	302.2	465	138.5
334	292.2	395	307.0	464	142.7
332	314.3	394	305.9	463	151.0
331	312.1	393	296.8	462	154.6
330	303.3	392	265.6	461	158.0
329	275.7	391	248.6	460	80.9
328	231.8	390	281.6	459	160.8
327	265.2	389	293.3	458	162.5
326	280.9	388	296.3	457	161.2
325	290.4	387	297.4	456	159.5
324	291.4	386	287.0	455	164.0
323	284.4	385	255.2	454	157.2
322	257.8	384	257.3	453	152.9
321	241.6	383	292.2	451	159.4
320	277.5	382	309.9	450	160.8
319	294.3	381	315.9	449	165.0
318	303.4	380	314.4	448	163.0
317	302.2	379	305.3	447	162.8
316	295.9	378	276.6	446	162.2
315	269.1	377	248.8	445	160.1
314	240.6	376	286.2	444	158.6
313	273.1	375	306.4	443	155.6
312	286.6	374	313.0	442	154.1
311	292.4	373	311.2	441	151.3
310	291.6	372	304.7	440	153.0
309	282.7	371	277.5	437	118.5
308	256.8	370	258.2	436	154.8
307	258.0	369	294.0	435	155.6
306	297.9	368	310.6	434	212.3
305	319.4	367	316.3	433	212.8
304	327.3	366	314.5	432	215.7
303	324.5	365	303.9	431	216.1
302	317.1	364	275.0	430	226.2
301	290.3	363	246.4	429	223.5

TABLE F-10: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 9/20/79 TIME: 4:00 p.m.
TEST CONDITIONS: Band Heaters Off With Air (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	347.5	428	217.7	492	78.3
361	347.5	427	220.0	491	77.8
360	350.1	426	221.1	490	76.2
359	348.0	425	220.7	489	77.2
358	325.2	424	217.9	488	75.7
357	276.2	423	217.7	487	73.4
356	307.5	422	222.2	486	81.6
355	341.7	421	227.1	485	79.8
354	335.4	420	222.1	484	83.6
353	339.8	419	218.3	483	73.7
352	341.2	418	210.9	482	92.2
351	322.6	417	206.3	481	91.6
350	275.3	416	166.6	480	104.3
349	316.4	415	159.4	479	101.3
348	345.1	409	177.3	478	120.0
347	343.4	408	179.1	477	76.2
346	347.0	407	148.7	476	76.4
345	345.7	406	149.1	475	78.6
344	324.9	405	293.3	474	78.9
343	278.4	404	320.7	473	80.4
342	316.8	403	321.0	472	84.9
341	345.3	402	318.8	471	89.0
340	337.7	401	317.1	470	95.8
339	343.1	400	298.4	469	103.0
338	342.1	399	256.8	468	109.8
337	322.8	398	304.5	467	116.7
336	276.7	397	332.6	466	123.6
335	314.1	396	329.8	465	130.6
334	343.2	395	329.0	464	134.5
332	340.8	394	329.0	463	142.7
331	340.9	393	311.2	462	146.5
330	321.8	392	262.9	461	150.5
329	276.4	391	291.8	460	72.5
328	294.1	390	318.2	459	154.7
327	320.8	389	311.3	458	156.2
326	314.2	388	314.8	457	155.0
325	319.7	387	316.1	456	153.8
324	318.1	386	299.2	455	158.2
323	300.0	385	254.1	454	153.6
322	258.6	384	315.2	453	149.6
321	304.9	383	344.2	451	157.3
320	332.2	382	345.2	450	160.4
319	324.3	381	344.5	449	164.8
318	330.7	380	342.6	448	162.8
317	328.8	379	322.6	447	166.8
316	310.4	378	275.2	446	164.5
315	267.5	377	314.0	445	165.0
314	287.4	376	344.0	444	160.2
313	311.9	375	347.6	443	163.4
312	306.7	374	346.2	442	158.6
311	311.8	373	343.6	441	157.8
310	312.3	372	323.4	440	159.9
309	296.9	371	277.0	437	111.4
308	257.1	370	314.8	436	143.8
307	331.0	369	342.4	435	144.3
306	358.7	368	339.9	434	199.0
305	362.2	367	342.1	433	200.0
304	363.0	366	341.6	432	201.6
303	360.9	365	321.5	431	201.9
302	339.0	364	274.6	430	216.7
301	291.7	363	316.3	429	217.6

TABLE F-11: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 11/29/79 TIME: 2:33 p.m.
TEST CONDITONS: Electrically Heated Drywell Test Canister Profile With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	336.3	428	274.3	492	100.1
361	378.1	427	278.2	491	78.5
360	392.1	426	280.6	490	77.6
359	398.9	425	278.5	489	79.2
358	396.7	424	276.8	488	78.9
357	381.7	423	275.3	487	77.5
356	262.2	422	251.8	486	103.3
355	336.7	421	253.4	485	101.2
354	373.7	420	248.1	484	92.6
353	390.8	419	246.5	483	78.4
352	396.1	418	203.5	482	138.9
351	393.5	417	203.0	481	137.3
350	379.8	416	168.5	480	133.4
349	279.8	415	164.3	479	116.8
348	336.5	409	109.8	478	136.4
347	374.3	408	170.9	477	87.3
346	393.2	407	155.1	476	88.9
345	398.8	406	154.6	475	92.5
344	383.3	405	268.3	474	106.2
343	363.3	404	316.0	473	114.4
342	282.7	403	349.0	472	135.3
341	339.8	402	365.7	471	169.4
340	375.2	401	372.3	470	206.9
339	392.9	400	368.3	469	208.7
338	397.5	399	355.4	468	193.8
337	395.2	398	277.4	467	191.4
336	382.0	397	327.8	466	197.5
335	281.3	396	360.9	465	208.3
334	339.0	395	376.9	464	214.8
332	391.5	394	343.1	463	216.5
331	396.0	393	381.0	462	214.5
330	392.8	392	364.1	461	216.0
329	380.1	391	289.5	460	103.4
328	263.0	390	318.4	459	233.9
327	318.6	389	349.0	458	236.2
326	349.8	388	365.3	457	237.6
325	368.4	387	371.6	456	232.2
324	374.7	386	368.1	455	253.2
323	371.4	385	350.9	454	232.3
322	357.5	384	280.9	453	202.0
321	274.4	383	335.1	451	203.2
320	328.2	382	372.8	450	203.9
319	363.0	381	390.9	449	202.3
318	380.4	380	396.0	448	192.4
317	387.0	379	393.5	447	196.7
316	383.9	378	379.2	446	188.8
315	371.1	377	275.7	445	188.2
314	267.6	376	332.7	444	180.6
313	316.1	375	372.3	443	181.8
312	342.1	374	390.4	442	173.9
311	363.9	373	395.9	441	170.0
310	370.0	372	394.2	440	167.5
309	366.5	371	381.1	437	184.5
308	354.9	370	281.4	436	231.1
307	287.6	369	335.8	435	233.6
306	346.4	368	373.1	434	265.3
305	389.2	367	390.6	433	266.9
304	407.9	366	395.0	432	269.4
303	412.4	365	391.7	431	269.4
302	410.2	364	377.6	430	274.1
301	398.0	363	276.5	429	272.7

TABLE F-12: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 11/30/79 TIME: 1:37 p.m.
TEST CONDITIONS: Electrically Heated Drywell Test Canister Profile with Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	308.0	428	274.1	492	99.7
361	332.5	427	276.2	491	80.6
360	349.2	426	281.3	490	79.2
359	353.7	425	277.9	489	81.4
358	349.9	424	278.5	488	80.0
357	331.1	423	275.0	487	79.2
356	248.9	422	252.0	486	107.4
355	308.9	421	254.1	485	107.9
354	333.5	420	249.9	484	91.3
353	348.9	419	247.9	483	79.8
352	352.4	418	208.4	482	140.8
351	348.1	417	207.3	481	139.9
350	330.0	416	174.3	480	135.3
349	262.8	415	170.4	479	122.7
348	307.8	409	118.3	478	134.5
347	332.9	408	179.2	477	87.3
346	349.3	407	159.7	476	88.8
345	353.3	406	159.4	475	92.1
344	349.4	405	253.1	474	104.4
343	331.9	404	292.7	473	112.9
342	265.9	403	315.0	472	134.5
341	311.0	402	329.2	471	168.1
340	333.7	401	335.0	470	206.1
339	349.4	400	330.1	469	205.9
338	352.5	399	313.7	468	193.1
337	348.9	398	262.6	467	190.8
336	331.1	397	303.9	466	196.7
335	264.7	396	325.2	465	206.8
334	310.2	395	340.2	464	213.2
332	348.5	394	344.0	463	215.7
331	351.4	393	340.7	462	214.4
330	346.9	392	320.0	461	216.2
329	329.5	391	254.9	460	109.4
328	253.4	390	296.2	459	234.3
327	294.5	389	316.3	458	236.1
326	314.1	388	331.4	457	237.1
325	330.8	387	336.0	456	230.8
324	336.0	386	331.6	455	252.2
323	331.1	385	310.6	454	232.8
322	313.6	384	264.4	453	203.4
321	259.6	383	307.9	451	202.6
320	302.8	382	333.3	450	204.3
319	325.2	381	349.0	449	203.8
318	341.2	380	352.2	448	195.5
317	345.3	379	348.3	447	198.6
316	341.1	378	329.9	446	192.2
315	324.1	377	259.1	445	190.6
314	254.2	376	305.2	444	184.3
313	292.6	375	332.2	443	184.1
312	313.7	374	347.6	442	177.6
311	328.3	373	351.6	441	173.3
310	332.9	372	348.1	440	171.7
309	328.7	371	331.0	437	180.8
308	312.4	370	264.4	436	227.8
307	268.1	369	308.3	435	230.3
306	314.8	368	332.9	434	265.6
305	344.2	367	348.5	433	266.7
304	360.4	366	351.7	432	270.0
303	363.0	365	346.8	431	270.3
302	359.2	364	328.3	430	275.5
301	342.4	363	260.2	429	271.4

TABLE F-13: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 1/10/80 TIME: 9:00 a.m.
TEST CONDITIONS: Electrically Heated Drywell Test Canister Profile With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	368.9	428	280.0	492	109.4
361	370.6	427	282.8	491	73.8
360	373.0	426	281.4	490	72.2
359	366.2	425	278.4	489	74.6
358	355.7	424	276.8	488	72.9
357	328.1	423	276.4	487	73.0
356	317.4	422	273.7	486	99.9
355	370.5	421	276.2	485	
354	378.3	420	264.3	484	88.3
353	382.0	419	262.5	483	75.4
352	381.5	418	247.5	482	133.8
351	366.8	417	238.8	481	131.3
350	329.8	416	195.9	480	137.1
349	334.6	415	190.6	479	125.3
348	367.7	409	206.0	478	140.4
347	368.8	408	211.0	477	93.0
346	371.4	407	176.0	476	95.8
345	367.3	406	176.6	475	104.4
344	357.2	405	318.5	474	129.9
343	329.5	404	344.6	473	131.6
342	338.5	403	350.4	472	143.7
341	371.8	402	351.4	471	164.2
340	369.1	401	347.3	470	195.8
339	371.6	400	334.9	469	195.2
338	367.3	399	310.1	468	183.4
337	357.1	398	329.8	467	180.0
336	327.8	397	359.9	466	186.1
335	338.4	396	366.8	465	195.7
334	372.3	395	371.8	464	202.0
332	376.0	394	371.4	463	203.4
331	373.2	393	357.0	462	202.3
330	359.9	392	317.2	461	204.8
329	328.4	391	320.4	460	97.1
328	311.9	390	350.9	459	219.7
327	342.0	389	356.8	458	222.3
326	342.2	388	362.1	457	223.0
325	347.8	387	361.8	456	219.2
324	343.6	386	345.7	455	240.9
323	334.6	385	307.5	454	250.4
322	310.7	384	336.4	453	245.0
321	325.6	383	368.4	451	225.7
320	356.9	382	377.0	450	228.1
319	354.9	381	381.6	449	227.7
318	359.4	380	380.2	448	217.6
317	354.0	379	365.9	447	213.4
316	344.8	378	329.0	446	209.5
315	318.5	377	333.3	445	206.0
314	320.6	376	366.3	444	200.5
313	346.2	375	374.1	443	198.5
312	347.8	374	375.4	442	193.8
311	350.6	373	370.6	441	189.2
310	346.9	372	359.6	440	189.9
309	335.2	371	329.7	437	177.7
308	309.1	370	337.3	436	213.8
307	348.7	369	369.3	435	215.5
306	382.3	368	378.8	434	251.0
305	391.4	367	383.4	433	252.4
304	393.0	366	382.1	432	254.9
303	389.1	365	366.1	431	253.8
302	375.8	364	328.4	430	276.5
301	343.9	363	334.2	429	278.8

TABLE F-14: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 6/25/80 TIME: 8:00 a.m.
TEST CONDITIONS: Electrically Heated Drywell Test Canister With Vacuum (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	350.2	428	270.5	492	95.6
361	377.8	427	272.4	491	83.1
360	387.7	426	274.2	490	82.1
359	384.9	425	272.3	489	83.4
358	372.3	424	271.8	488	82.3
357	351.5	423	270.6	487	81.7
356	288.3	422	275.6	486	103.1
355	350.1	421	276.6	485	103.2
354	378.0	420	271.7	484	95.7
353	385.3	419	270.0	483	82.5
352	382.4	418	244.6	482	127.1
351	369.4	417	240.5	481	126.1
350	349.9	416	222.8	480	137.7
349	303.7	415	220.8	479	128.6
348	350.0	409	224.7	478	162.5
347	378.3	408	225.9	477	87.6
346	387.9	407	230.7	476	88.7
345	384.5	406	237.1	475	90.7
344	372.4	405	294.3	474	99.1
343	352.9	404	332.3	473	103.8
342	306.2	403	356.4	472	116.6
341	352.9	402	363.8	471	134.1
340	379.0	401	360.2	470	155.6
339	387.4	400	345.6	469	160.3
338	385.6	399	326.8	468	159.6
337	371.0	398	302.7	467	164.1
336	352.7	397	342.6	466	174.9
335	305.4	396	367.0	465	191.3
334	352.6	395	373.5	464	202.9
332	386.3	394	370.1	463	204.2
331	382.2	393	357.7	462	199.2
330	368.8	392	336.2	461	198.4
329	350.4	391	296.0	460	89.0
328	293.5	390	335.2	459	201.8
327	334.3	389	356.7	458	204.3
326	356.8	388	363.3	457	203.7
325	365.9	387	359.8	456	202.3
324	362.7	386	345.8	455	214.3
323	347.8	385	323.6	454	223.8
322	328.9	384	305.6	453	227.2
321	298.8	383	349.0	451	219.3
320	342.7	382	377.3	450	222.4
319	368.0	381	385.7	449	228.4
318	376.8	380	382.3	448	232.1
317	373.8	379	369.4	447	240.0
316	360.4	378	349.4	446	235.5
315	341.9	377	300.7	445	228.4
314	294.0	376	346.8	444	223.8
313	332.3	375	377.1	443	224.8
312	355.6	374	385.8	442	221.3
311	362.0	373	382.4	441	218.5
310	358.6	372	370.0	440	220.9
309	344.3	371	351.1	437	157.5
308	326.7	370	306.0	436	194.2
307	311.0	369	349.5	435	195.7
306	358.8	368	377.8	434	246.7
305	392.3	367	385.7	433	247.6
304	402.1	366	381.5	432	250.2
303	397.8	365	367.8	431	250.1
302	385.6	364	348.6	430	270.3
301	367.5	363	301.2	429	269.1

TABLE F-15: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 6/17/80 TIME: 8:00 p.m.
TEST CONDITIONS: Electrically Heated Drywell Test Canister Profile With Air (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	358.0	428	274.3	492	94.9
361	358.6	427	276.7	491	81.1
360	359.1	426	275.8	490	79.9
359	351.4	425	273.6	489	81.4
358	339.5	424	272.3	488	80.1
357	307.0	423	271.9	487	80.2
356	314.9	422	272.8	486	102.5
355	359.9	421	274.2	485	102.7
354	366.4	420	264.4	484	94.4
353	368.3	419	263.2	483	81.0
352	365.7	418	248.2	482	128.2
351	347.1	417	240.9	481	127.4
350	306.6	416	199.5	480	141.5
349	326.7	415	194.7	479	136.3
348	356.8	409	209.4	478	146.0
347	356.8	408	213.9	477	86.5
346	357.6	407	180.8	476	87.5
345	352.7	406	181.1	475	89.6
344	341.2	405	312.6	474	98.5
343	308.5	404	330.4	473	104.4
342	330.6	403	340.9	472	119.4
341	360.6	402	340.2	471	141.2
340	356.9	401	335.1	470	167.2
339	357.7	400	321.1	469	169.9
338	352.9	399	290.6	468	164.7
337	341.0	398	322.9	467	166.7
336	307.1	397	350.4	466	176.0
335	330.9	396	356.5	465	191.5
334	361.7	395	359.6	464	202.6
332	362.2	394	356.8	463	203.5
331	358.1	393	338.0	462	198.9
330	342.5	392	296.2	461	199.3
329	306.7	391	314.4	460	87.7
328	305.8	390	342.4	459	207.1
327	333.1	389	347.6	458	209.9
326	332.7	388	351.1	457	209.4
325	336.9	387	348.3	456	207.5
324	332.3	386	327.9	455	225.4
323	321.1	385	287.9	454	246.2
322	292.2	384	329.1	453	259.3
321	318.5	383	358.3	451	239.8
320	346.8	382	365.6	450	233.8
319	344.0	381	368.1	449	228.6
318	346.8	380	364.8	448	222.5
317	341.4	379	346.7	447	222.8
316	330.6	378	306.4	446	218.6
315	299.3	377	325.8	445	212.5
314	315.0	376	355.9	444	206.8
313	337.9	375	362.2	443	203.6
312	338.3	374	361.5	442	196.3
311	339.4	373	355.7	441	193.2
310	334.7	372	342.4	440	193.6
309	321.1	371	307.9	437	154.8
308	290.3	370	329.9	436	193.6
307	339.9	369	359.1	435	194.7
306	370.5	368	367.4	434	243.0
305	378.1	367	370.1	433	244.4
304	377.7	366	366.6	432	247.4
303	372.4	365	346.4	431	246.3
302	356.8	364	305.9	430	271.5
301	320.2	363	326.5	429	273.4

TABLE F-16: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 11/28/79 TIME: 3:00 p.m.
TEST CONDITIONS: Drywell Canister Profile With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	329.5	428	245.5	492	124.8
361	363.6	427	243.1	491	76.2
360	378.4	426	252.2	490	75.6
359	382.6	425	249.8	489	77.0
358	385.6	424	248.5	488	76.4
357	373.7	423	247.0	487	77.1
356	262.1	422	238.3	486	100.6
355	329.5	421	240.3	485	100.8
354	353.9	420	235.4	484	87.1
353	376.4	419	233.3	483	78.9
352	379.5	418	199.9	482	132.2
351	382.5	417	197.0	481	130.6
350	371.9	416	167.5	480	126.0
349	274.1	415	163.9	479	112.4
348	329.5	409	167.9	478	128.0
347	364.7	408	169.3	477	93.0
346	379.1	407	152.7	476	95.4
345	382.4	406	152.6	475	100.1
344	385.5	405	262.7	474	116.8
343	375.2	404	303.9	473	119.9
342	276.8	403	336.8	472	128.5
341	332.8	402	350.3	471	147.5
340	365.3	401	354.2	470	169.4
339	378.7	400	356.7	469	179.7
338	381.1	399	347.3	468	177.0
337	384.1	398	271.7	467	150.4
336	374.0	397	320.7	466	203.6
335	275.2	396	350.8	465	203.3
334	331.7	395	362.1	464	204.2
332	377.3	394	365.9	463	207.4
331	379.4	393	362.8	462	234.7
330	381.6	392	356.2	461	203.6
329	372.1	391	263.4	460	87.0
328	262.2	390	311.0	459	207.1
327	311.3	389	328.8	458	209.5
326	339.7	388	342.9	457	210.5
325	353.4	387	353.6	456	205.7
324	357.1	386	356.6	455	225.9
323	359.4	385	342.9	454	202.8
322	349.3	384	375.2	453	174.4
321	258.5	383	326.2	451	191.0
320	321.2	382	353.0	450	189.4
319	353.1	381	376.6	449	185.1
318	366.2	380	379.6	448	160.8
317	370.2	379	382.4	447	187.2
316	372.5	378	371.3	446	182.3
315	363.1	377	270.2	445	183.1
314	261.4	376	325.0	444	177.4
313	308.7	375	362.7	443	180.1
312	337.8	374	376.2	442	172.4
311	348.7	373	379.4	441	167.5
310	351.9	372	363.2	440	185.9
309	354.5	371	372.1	437	165.3
308	346.9	370	275.6	436	207.1
307	281.8	369	328.7	435	208.6
306	339.5	368	363.2	434	252.8
305	379.8	367	376.3	433	254.6
304	394.5	366	378.5	432	255.9
303	395.9	365	380.7	431	256.1
302	399.5	364	369.4	430	246.2
301	390.2	363	271.0	429	244.2

TABLE F-17: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 9/13/79 TIME: 1:37 p.m.
TEST CONDITONS: Drywell Canister Profile With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	302.5	428	248.3	492	109.7
361	320.9	427	249.4	491	80.9
360	331.5	426	253.3	490	78.6
359	332.1	425	247.3	489	80.0
358	332.5	424	248.6	488	79.1
357	314.5	423	245.4	487	77.7
356	258.0	422	243.8	486	94.4
355	309.4	421	242.6	485	91.4
354	327.1	420	232.7	484	86.9
353	334.5	419	233.8	483	79.7
352	335.1	418	220.4	482	121.9
351	332.0	417	210.3	481	120.8
350	313.6	416	181.4	480	119.4
349	263.5	415	177.8	479	112.8
348	301.2	409	185.6	478	136.2
347	320.8	408	190.5	477	91.2
346	331.0	407	162.3	476	93.4
345	332.0	406	162.9	475	95.5
344	332.3	405	258.2	474	105.1
343	315.4	404	288.2	473	107.1
342	268.1	403	304.1	472	119.4
341	305.9	402	311.8	471	133.5
340	322.9	401	313.5	470	156.0
339	332.1	400	312.5	469	165.1
338	332.8	399	296.0	468	169.7
337	332.1	398	273.6	467	175.4
336	315.0	397	304.8	466	182.0
335	270.1	396	319.2	465	183.4
334	308.2	395	325.8	464	180.8
332	332.9	394	327.6	463	185.2
331	332.8	393	323.9	462	186.5
330	330.6	392	303.0	461	188.5
329	313.0	391	266.3	460	106.9
328	251.0	390	298.2	459	190.4
327	284.0	389	310.3	458	192.0
326	299.6	388	317.2	457	191.5
325	309.9	387	318.5	456	188.6
324	312.6	386	314.6	455	194.8
323	312.3	385	292.8	454	183.0
322	295.7	384	274.0	453	174.3
321	259.7	383	307.9	451	179.7
320	295.1	382	326.3	450	180.6
319	312.7	381	334.5	449	184.9
318	322.8	380	335.4	448	182.0
317	323.7	379	332.0	447	182.7
316	323.7	378	313.8	446	183.2
315	307.0	377	265.6	445	185.2
314	259.0	376	302.8	444	191.4
313	290.1	375	322.8	443	196.1
312	304.6	374	331.5	442	190.8
311	311.7	373	331.6	441	180.3
310	312.9	372	331.6	440	178.8
309	310.9	371	314.4	437	156.2
308	294.9	370	274.8	436	201.0
307	274.6	369	309.5	435	201.9
306	313.2	368	327.3	434	244.2
305	335.9	367	334.6	433	244.6
304	345.3	366	335.2	432	248.1
303	344.9	365	330.7	431	248.0
302	343.4	364	312.2	430	249.0
301	326.9	363	263.1	429	245.3

TABLE F-18: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 11/14/79 TIME: 8:00 a.m.
TEST CONDITIONS: Drywell Canister Profile With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	354.5	428	240.0	492	129.1
361	358.3	427	245.8	491	77.6
360	365.6	426	248.2	490	76.7
359	367.3	425	248.8	489	77.3
358	361.3	424	245.5	488	76.7
357	323.8	423	243.1	487	77.7
356	307.2	422	236.8	486	101.2
355	348.2	421	243.8	485	101.6
354	349.2	420	240.5	484	87.3
353	355.0	419	235.0	483	79.7
352	354.5	418	220.5	482	130.3
351	348.7	417	220.0	481	129.8
350	319.1	416	180.0	480	123.9
349	323.1	415	171.8	479	111.4
348	353.8	409	130.8	478	128.5
347	356.7	408	192.6	477	92.9
346	362.4	407	161.1	476	94.9
345	364.0	406	161.3	475	101.1
344	358.9	405	299.9	474	117.9
343	326.1	404	326.7	473	119.4
342	321.8	403	331.3	472	126.8
341	355.1	402	336.0	471	132.2
340	352.7	401	338.7	470	148.7
339	358.1	400	330.5	469	160.3
338	358.8	399	303.8	468	171.5
337	355.1	398	306.1	467	188.1
336	324.0	397	336.2	466	205.1
335	319.2	396	338.3	465	209.4
334	351.7	395	342.8	464	206.4
332	355.6	394	347.1	463	210.5
331	355.7	393	340.4	462	211.3
330	350.6	392	310.0	461	206.5
329	321.8	391	293.0	460	85.7
328	302.3	390	322.2	459	193.2
327	331.4	389	324.7	458	195.6
326	329.9	388	329.5	457	196.7
325	336.8	387	329.1	456	193.5
324	337.3	386	326.0	455	195.4
323	334.7	385	299.9	454	184.5
322	306.7	384	318.0	453	174.6
321	310.7	383	348.2	451	181.6
320	343.0	382	353.2	450	184.8
319	340.2	381	359.0	449	187.2
318	346.7	380	361.5	448	180.7
317	346.7	379	352.4	447	185.7
316	343.4	378	321.6	446	180.6
315	315.8	377	319.2	445	182.0
314	294.0	376	349.2	444	174.8
313	321.2	375	356.5	443	179.3
312	320.5	374	361.8	442	172.7
311	327.1	373	363.4	441	172.2
310	326.3	372	356.0	440	173.5
309	324.9	371	323.8	437	154.6
308	302.9	370	317.1	436	196.9
307	335.1	369	347.1	435	197.3
306	365.1	368	351.5	434	247.3
305	373.1	367	356.4	433	249.6
304	377.2	366	356.6	432	251.2
303	377.6	365	349.1	431	251.3
302	369.7	364	319.6	430	239.6
301	337.6	363	323.4	429	238.8

TABLE F-19: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 11/27/79 TIME: 9:14 a.m.

TEST CONDITIONS: Drywell Canister Profile With Helium (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	293.9	428	246.2	492	132.3
361	314.7	427	248.7	491	76.9
360	326.3	426	252.1	490	77.9
359	329.4	425	245.6	489	79.2
358	334.7	424	247.9	488	78.3
357	320.5	423	244.6	487	78.8
356	250.8	422	239.4	486	102.3
355	301.6	421	239.7	485	101.7
354	321.1	420	229.2	484	89.8
353	329.9	419	229.4	483	80.9
352	331.7	418	211.0	482	131.5
351	333.8	417	200.0	481	130.6
350	319.3	416	172.7	480	124.7
349	253.8	415	169.7	479	112.6
348	292.6	409	148.0	478	134.6
347	314.4	408	181.3	477	98.0
346	326.2	407	158.3	476	98.8
345	329.1	406	156.5	475	104.2
344	334.3	405	249.3	474	121.5
343	321.1	404	260.6	473	123.5
342	258.6	403	298.6	472	131.5
341	237.6	402	307.1	471	135.5
340	316.8	401	310.7	470	150.8
339	327.3	400	315.3	469	164.3
338	329.4	399	302.9	468	177.6
337	333.8	398	264.6	467	192.4
336	320.5	397	297.1	466	206.7
335	260.8	396	313.3	465	205.8
334	300.0	395	321.2	464	198.3
332	326.2	394	323.0	463	202.8
331	329.6	393	326.0	462	206.1
330	332.4	392	309.3	461	203.1
329	316.7	391	257.6	460	92.1
328	241.3	390	290.8	459	192.4
327	275.8	389	304.7	458	194.5
326	293.6	388	313.0	457	195.5
325	306.1	387	314.4	456	192.6
324	310.5	386	316.8	455	194.2
323	315.3	385	299.7	454	184.6
322	302.6	384	264.6	453	175.1
321	250.2	383	299.9	451	180.9
320	286.9	382	320.1	450	183.9
319	306.4	381	329.4	449	186.2
318	318.0	380	331.2	448	183.1
317	321.0	379	333.9	447	185.6
316	325.7	378	319.4	446	185.4
315	313.2	377	250.3	445	185.5
314	250.0	376	294.5	444	183.9
313	282.4	375	316.6	443	183.2
312	298.9	374	326.3	442	173.4
311	307.6	373	328.3	441	170.4
310	310.2	372	333.5	440	169.6
309	313.5	371	320.3	437	160.9
308	301.8	370	265.5	436	203.0
307	264.9	369	301.6	435	204.6
306	304.8	368	320.8	434	251.8
305	329.3	367	329.8	433	253.0
304	340.0	366	330.9	432	256.2
303	341.2	365	332.5	431	256.0
302	344.6	364	317.5	430	247.5
301	331.9	363	253.4	429	243.9

TABLE F-20: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D43

DATE: 2/8/80 TIME: 9:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 250°F With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	347.6	428	251.4	492	222.9
361	373.7	427	255.5	491	77.1
360	384.0	426	258.7	490	76.0
359	386.7	425	257.2	489	77.3
358	388.4	424	255.3	488	76.2
357	380.0	423	253.2	487	88.9
356	285.7	422	251.2	486	111.9
355	347.4	421	252.1	485	
354	373.6	420	247.1	484	89.6
353	382.1	419	246.2	483	115.3
352	384.1	418	244.2	482	160.4
351	385.5	417	242.7	481	146.6
350	378.5	416	236.6	480	128.7
349	303.3	415	237.5	479	114.5
348	347.6	409	234.3	478	160.7
347	373.9	408	233.9	477	232.8
346	384.5	407	215.1	476	249.5
345	386.4	406	214.6	475	227.8
344	388.6	405	292.3	474	253.4
343	381.5	404	326.7	473	228.9
342	305.9	403	348.8	472	221.7
341	350.6	402	356.8	471	190.0
340	374.9	401	359.1	470	199.9
339	384.1	400		469	204.6
338	385.3	399	354.3	468	206.0
337	387.2	398	300.8	467	196.6
336	381.2	397	338.1	466	205.9
335	304.7	396	360.8	465	206.0
334	349.9	395	368.5	464	208.0
332	383.0	394	370.5	463	204.2
331	383.7	393	372.9	462	207.2
330	385.0	392	364.4	461	206.9
329	378.6	391	293.5	460	94.2
328	292.3	390	329.6	459	197.8
327	329.8	389	348.9	458	199.2
326	349.7	388	356.8	457	204.0
325	359.1	387	358.5	456	201.3
324	361.8	386	359.9	455	201.3
323	362.5	385	350.9	454	190.8
322	356.3	384	304.3	453	180.3
321	298.2	383	345.7	451	188.1
320	339.7	382	372.4	450	193.5
319	362.4	381	382.2	449	195.7
318	371.9	380	383.8	448	191.4
317	374.0	379	385.2	447	198.3
316	375.9	378	377.8	446	200.6
315	369.4	377	299.9	445	210.3
314	292.3	376	344.0	444	221.3
313	327.3	375	372.5	443	234.7
312	348.0	374	382.1	442	224.7
311	354.9	373	383.6	441	217.3
310	357.0	372	385.9	440	228.0
309	358.4	371	379.3	437	236.8
308	354.1	370	304.9	436	239.8
307	310.8	369	346.3	435	244.3
306	357.7	368	373.0	434	255.9
305	389.4	367	382.2	433	257.7
304	400.5	366	383.0	432	261.8
303	400.6	365	383.6	431	261.4
302	402.2	364	377.1	430	252.0
301	396.1	363	300.6	429	250.2

TABLE F-21: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 12/6/79 TIME: 9:00 a.m.
TEST CONDITONS: Uniform Canister Temperature at 250°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	318.3	428	257.0	492	223.0
361	329.4	427	259.5	491	78.5
360	333.7	426	264.7	490	77.3
359	333.9	425	261.3	489	78.1
358	335.1	424	261.0	488	77.7
357	327.5	423	256.7	487	83.5
356	264.3	422	260.1	486	111.8
355	318.9	421	260.4	485	100.2
354	330.6	420	256.8	484	91.1
353	333.1	419	256.3	483	105.2
352	332.5	418	252.5	482	161.0
351	333.2	417	248.3	481	143.4
350	326.9	416	237.7	480	133.0
349	287.3	415	238.0	479	111.6
348	317.9	409	174.9	478	171.5
347	329.5	408	235.6	477	222.8
346	333.1	407	215.6	476	247.1
345	332.7	406	214.9	475	223.0
344	334.4	405	281.9	474	257.7
343	328.0	404	304.8	473	233.6
342	289.1	403	313.6	472	224.0
341	320.2	402	315.2	471	191.9
340	330.4	401	316.1	470	200.1
339	333.2	400	316.6	469	205.8
338	332.1	399	311.5	468	207.0
337	333.9	398	288.1	467	197.9
336	327.5	397	314.2	466	206.9
335	288.3	396	323.0	465	207.3
334	320.0	395	325.5	464	208.9
332	332.5	394	325.3	463	205.3
331	331.1	393	326.4	462	209.0
330	332.0	392	318.0	461	209.4
329	325.8	391	282.8	460	91.3
328	280.9	390	308.2	459	199.4
327	306.5	389	315.2	458	201.5
326	312.8	388	317.5	457	207.1
325	316.0	387	317.1	456	202.2
324	316.3	386	317.5	455	204.7
323	317.4	385	308.8	454	193.8
322	310.9	384	289.5	453	182.9
321	284.7	383	318.0	451	193.5
320	313.6	382	329.9	450	199.1
319	322.8	381	333.3	449	201.7
318	326.1	380	332.7	448	198.4
317	325.5	379	333.4	447	209.6
316	326.9	378	326.7	446	217.0
315	321.0	377	285.8	445	232.0
314	280.1	376	316.2	444	236.7
313	305.2	375	329.1	443	244.1
312	313.1	374	332.0	442	231.3
311	314.0	373	331.7	441	222.3
310	313.6	372	333.2	440	230.5
309	314.7	371	327.3	437	233.6
308	309.9	370	289.4	436	239.5
307	291.8	369	318.1	435	243.4
306	324.0	368	329.7	434	257.6
305	339.7	367	332.7	433	259.3
304	343.5	366	331.9	432	264.3
303	342.1	365	331.8	431	263.8
302	343.2	364	325.2	430	257.8
301	337.7	363	286.2	429	254.0

TABLE F-22: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 1/4/80 TIME: 1:00 p.m.
TEST CONDITIONS: Uniform Canister Temperature at 250°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	363.0	428	254.1	492	234.1
361	362.6	427	258.5	491	74.4
360	369.3	426	258.7	490	73.6
359	367.8	425	257.0	489	75.0
358	363.7	424	254.9	488	74.2
357	342.1	423	254.8	487	84.3
356	317.9	422	255.9	486	113.9
355	364.8	421	256.3	485	
354	366.8	420	250.3	484	86.7
353	369.9	419	250.3	483	109.1
352	373.4	418	254.3	482	166.1
351	368.9	417	253.1	481	147.8
350	343.8	416	240.7	480	134.1
349	334.4	415	240.2	479	110.4
348	363.7	409	182.3	478	159.5
347	364.2	408	243.7	477	245.9
346	369.7	407	217.3	476	261.9
345	370.0	406	217.4	475	236.8
344	365.9	405	314.6	474	273.1
343	344.7	404	337.4	473	244.1
342	337.7	403	338.3	472	234.4
341	367.6	402	342.6	471	199.1
340	365.6	401	343.5	470	210.7
339	370.3	400	339.4	469	215.0
338	370.6	399	322.9	468	213.3
337	366.4	398	327.3	467	199.8
336	343.9	397	352.7	466	209.6
335	336.9	396	351.5	465	208.6
334	367.1	395	355.8	464	210.3
332	370.0	394	360.4	463	205.3
331	371.4	393	357.4	462	208.5
330	366.5	392	330.5	461	209.3
329	343.7	391	317.0	460	90.7
328	315.3	390	342.6	459	198.8
327	341.4	389	341.0	458	200.6
326	338.6	388	344.9	457	206.6
325	344.9	387	348.4	456	202.6
324	344.1	386	345.0	455	203.7
323	340.8	385	320.9	454	194.3
322	324.0	384	335.0	453	182.9
321	326.7	383	362.2	451	191.0
320	355.2	382	363.7	450	197.4
319	352.1	381	369.2	449	197.8
318	358.5	380	372.1	448	192.0
317	357.5	379	367.8	447	198.0
316	353.3	378	342.4	446	196.3
315	333.4	377	331.6	445	202.3
314	317.5	376	360.0	444	210.3
313	341.4	375	363.2	443	223.1
312	339.8	374	367.8	442	217.4
311	343.0	373	368.1	441	215.5
310	344.4	372	365.3	440	229.3
309	341.3	371	343.5	437	239.7
308	323.2	370	335.7	436	237.7
307	347.6	369	362.7	435	242.3
306	376.9	368	365.8	434	255.2
305	383.3	367	369.9	433	257.0
304	387.3	366	372.4	432	260.0
303	387.8	365	367.3	431	259.4
302	382.5	364	342.6	430	252.9
301	359.5	363	332.5	429	253.6

TABLE F-23: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 2/11/80 TIME: 9:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 300°F With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	392.6	428	302.4	492	284.9
361	408.5	427	307.2	491	77.2
360	417.3	426	309.3	490	75.0
359	417.6	425	308.0	489	77.2
358	416.8	424	305.8	488	75.8
357	411.8	423	303.6	487	81.2
356	314.2	422	302.5	486	130.6
355	391.6	421	304.7	485	.
354	408.5	420	299.4	484	93.6
353	415.2	419	297.3	483	105.7
352	415.0	418	309.5	482	205.6
351	414.6	417	305.4	481	179.7
350	410.4	416	280.6	480	158.9
349	354.4	415	277.3	479	132.0
348	392.1	409	280.0	478	202.4
347	409.0	408	279.5	477	252.8
346	417.3	407	247.9	476	279.4
345	416.9	406	247.7	475	266.4
344	417.0	405	346.7	474	334.8
343	413.1	404	374.0	473	317.6
342	356.0	403	387.1	472	316.7
341	394.0	402	393.7	471	275.1
340	409.1	401	393.7	470	281.5
339	416.4	400		469	282.2
338	415.3	399	389.5	468	273.9
337	415.6	398	353.5	467	250.9
336	412.4	397	383.8	466	263.3
335	355.4	396	397.2	465	259.9
334	393.9	395	403.4	464	259.9
332	415.6	394	402.9	463	250.6
331	414.4	393	403.3	462	254.6
330	413.4	392	397.7	461	256.2
329	410.5	391	346.9	460	135.9
328	345.0	390	376.6	459	241.8
327	376.1	389	386.8	458	245.1
326	386.9	388	393.0	457	253.2
325	394.9	387	392.4	456	247.6
324	394.8	386	391.6	455	253.6
323	393.4	385	385.9	454	250.4
322	390.6	384	356.5	453	245.1
321	349.6	383	390.8	451	250.0
320	384.3	382	407.9	450	253.3
319	398.0	381	415.8	449	249.8
318	405.3	380	415.1	448	240.8
317	405.1	379	414.9	447	254.2
316	404.4	378	410.0	446	266.5
315	401.7	377	352.7	445	289.6
314	344.4	376	389.5	444	297.1
313	373.0	375	408.3	443	311.4
312	384.9	374	415.8	442	302.9
311	390.7	373	415.2	441	291.3
310	390.3	372	415.1	440	287.1
309	389.7	371	411.7	437	310.6
308	388.2	370	356.5	436	299.1
307	361.5	369	390.9	435	309.0
306	401.1	368	408.3	434	302.0
305	423.8	367	415.6	433	306.2
304	432.0	366	414.3	432	310.2
303	430.3	365	413.0	431	307.0
302	429.8	364	409.4	430	301.7
301	426.8	363	352.9	429	300.6

TABLE F-24: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 12/7/79 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 300°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	350.8	428	294.8	492	258.7
361	361.3	427	297.8	491	79.0
360	367.3	426	303.4	490	77.4
359	368.0	425	301.2	489	78.5
358	371.2	424	301.6	488	77.5
357	365.3	423	297.6	487	86.0
356	301.7	422	296.7	486	129.9
355	351.0	421	298.4	485	
354	362.5	420	294.2	484	92.8
353	366.3	419	292.6	483	106.3
352	366.3	418	297.7	482	195.6
351	369.4	417	295.5	481	175.8
350	364.9	416	273.2	480	160.3
349	324.9	415	270.8	479	132.3
348	350.7	409	209.5	478	190.5
347	361.4	408	270.8	477	215.8
346	366.8	407	242.4	476	234.9
345	367.0	406	242.0	475	240.4
344	370.7	405	319.8	474	309.7
343	366.1	404	337.4	473	299.4
342	326.6	403	346.9	472	302.8
341	352.7	402	350.3	471	260.4
340	362.2	401	351.0	470	264.9
339	366.6	400	353.3	469	263.8
338	366.4	399	350.5	468	257.8
337	370.2	398	324.7	467	241.1
336	365.4	397	346.1	466	251.9
335	325.8	396	355.4	465	250.4
334	352.3	395	359.2	464	252.9
332	365.8	394	359.1	463	249.1
331	365.2	393	362.7	462	257.6
330	368.3	392	356.5	461	261.3
329	363.8	391	320.4	460	142.1
328	319.5	390	340.8	459	249.4
327	339.9	389	348.1	458	249.8
326	345.6	388	351.7	457	257.4
325	351.0	387	351.3	456	250.8
324	351.9	386	354.6	455	248.3
323	355.0	385	347.7	454	234.3
322	349.9	384	326.1	453	221.8
321	322.8	383	349.9	451	249.4
320	346.6	382	362.0	450	252.1
319	355.0	381	366.8	449	246.2
318	360.0	380	366.4	448	236.6
317	360.3	379	369.4	447	246.4
316	363.7	378	364.7	446	252.8
315	359.3	377	323.0	445	271.0
314	318.9	376	348.4	444	284.9
313	338.3	375	361.1	443	304.8
312	345.6	374	365.7	442	296.4
311	348.5	373	365.6	441	283.4
310	348.5	372	369.3	440	279.3
309	352.7	371	365.5	437	292.7
308	348.6	370	326.0	436	287.9
307	328.7	369	350.0	435	295.8
306	356.0	368	361.7	434	298.8
305	371.1	367	366.0	433	300.9
304	376.3	366	365.6	432	305.7
303	375.5	365	367.8	431	305.3
302	378.4	364	363.2	430	296.9
301	375.1	363	323.4	429	292.6

TABLE F-25: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 1/14/80 TIME: 10:30 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 300°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	393.5	428	297.6	492	237.4
361	395.9	427	302.2	491	73.5
360	402.7	426	302.9	490	72.2
359	401.5	425	301.6	489	74.6
358	399.6	424	299.4	488	73.1
357	384.3	423	298.1	487	83.6
356	337.2	422	295.8	486	124.6
355	394.6	421	297.7	485	
354	398.4	420	291.7	484	86.9
353	403.2	419	290.0	483	108.5
352	405.4	418	309.8	482	195.4
351	402.0	417	303.6	481	177.9
350	384.7	416	276.6	480	156.3
349	362.4	415	272.8	479	130.4
348	392.6	409	277.5	478	186.1
347	396.3	408	279.3	477	241.5
346	402.4	407	242.4	476	256.1
345	402.1	406	242.7	475	222.0
344	400.0	405	350.0	474	257.8
343	385.2	404	371.8	473	267.4
342	365.3	403	374.4	472	300.0
341	395.4	402	379.4	471	276.1
340	396.4	401	379.5	470	280.9
339	402.3	400	376.0	469	276.5
338	401.6	399	364.8	468	264.4
337	399.1	398	361.2	467	247.6
336	383.4	397	384.8	466	259.6
335	365.6	396	386.0	465	255.3
334	396.1	395	391.4	464	250.5
332	402.5	394	393.7	463	244.1
331	402.9	393	391.6	462	244.9
330	399.2	392	372.4	461	247.7
329	383.5	391	353.0	460	125.5
328	347.1	390	376.4	459	236.4
327	372.6	389	375.8	458	239.9
326	372.9	388	381.0	457	246.3
325	379.9	387	382.8	456	240.3
324	378.9	386	379.6	455	248.6
323	376.0	385	362.2	454	251.3
322	364.5	384	366.3	453	246.2
321	355.8	383	393.2	451	236.3
320	383.2	382	397.2	450	241.3
319	384.1	381	403.5	449	239.3
318	390.9	380	404.7	448	230.5
317	389.6	379	401.8	447	240.6
316	386.5	378	384.0	446	246.0
315	372.8	377	361.8	445	263.4
314	350.4	376	391.0	444	281.8
313	372.2	375	396.8	443	306.9
312	372.7	374	402.2	442	299.4
311	377.5	373	401.5	441	285.2
310	377.6	372	400.4	440	281.5
309	374.7	371	385.5	437	286.6
308	363.2	370	366.7	436	287.5
307	374.3	369	393.5	435	294.7
306	405.0	368	398.2	434	294.8
305	413.7	367	403.7	433	298.1
304	419.0	366	404.9	432	300.2
303	418.0	365	400.9	431	297.7
302	415.3	364	383.8	430	296.4
301	400.0	363	361.3	429	296.9

TABLE F-26: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 1/30/80 TIME: 6:30 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 400°F With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	465.1	428	395.2	492	382.4
361	480.8	427	401.3	491	79.0
360	490.5	426	403.6	490	76.4
359	489.3	425	402.6	489	79.4
358	487.6	424	400.1	488	76.9
357	484.4	423	397.7	487	87.4
356	389.8	422	398.0	486	161.9
355	463.7	421	402.2	485	
354	480.9	420	397.2	484	103.0
353	487.6	419	394.0	483	117.5
352	485.8	418	400.9	482	275.9
351	484.9	417	398.9	481	246.4
350	483.2	416	402.1	480	219.4
349	433.3	415	399.0	479	175.6
348	465.1	409	394.9	478	271.3
347	481.3	408	393.7	477	324.5
346	490.6	407	364.9	476	342.4
345	483.5	406	366.0	475	322.2
344	488.0	405	426.3	474	401.3
343	486.0	404	449.0	473	386.3
342	434.8	403	464.1	472	396.7
341	466.5	402	471.8	471	357.1
340	481.5	401	469.4	470	366.8
339	489.5	400		469	375.5
338	487.0	399	466.5	468	369.2
337	486.8	398	431.3	467	348.4
336	485.3	397	456.8	466	369.5
335	434.1	396	471.6	465	368.6
334	466.3	395	478.5	464	368.1
332	488.3	394	476.0	463	360.6
331	485.8	393	475.6	462	368.5
330	484.6	392	472.7	461	359.5
329	483.3	391	426.6	460	220.4
328	426.1	390	451.5	459	331.3
327	452.2	389	463.1	458	335.0
326	463.4	388	469.9	457	343.1
325	472.9	387	467.0	456	336.4
324	470.6	386	465.7	455	348.9
323	468.8	385	462.8	454	360.7
322	467.7	384	433.9	453	360.1
321	429.7	383	462.8	451	354.0
320	458.7	382	480.4	450	359.5
319	472.3	381	488.7	449	358.7
318	480.8	380	486.6	448	352.3
317	478.9	379	485.0	447	369.1
316	477.8	378	482.9	446	366.4
315	476.7	377	431.1	445	374.3
314	425.5	376	461.8	444	375.4
313	448.5	375	480.7	443	395.0
312	461.4	374	489.1	442	391.2
311	468.0	373	486.9	441	392.3
310	465.8	372	485.8	440	402.4
309	464.9	371	484.6	437	392.6
308	465.1	370	434.1	436	386.1
307	438.8	369	462.9	435	398.4
306	471.6	368	480.6	434	394.9
305	493.4	367	488.1	433	400.6
304	502.1	366	485.4	432	405.7
303	499.3	365	483.4	431	402.3
302	497.6	364	482.2	430	393.5
301	498.9	363	431.4	429	392.6

TABLE F-27: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 12/11/79 TIME: 12:00 noon
TEST CONDITIONS: Uniform Canister Temperature at 400°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	454.2	428	407.9	492	
361	459.7	427	412.1	491	81.9
360	468.7	426	415.4	490	79.2
359	465.4	425	413.4	489	82.1
358	459.9	424	412.6	488	78.9
357	459.7	423	409.4	487	92.1
356	385.8	422	407.0	486	163.4
355	453.2	421	409.7	485	
354	460.2	420	406.5	484	107.3
353	466.5	419	404.0	483	126.6
352	462.3	418	415.4	482	283.3
351	457.6	417	413.0	481	254.9
350	459.3	416	417.1	480	222.1
349	433.7	415	417.0	479	183.4
348	454.0	409	347.7	478	286.2
347	459.8	408	408.2	477	334.0
346	468.4	407	379.8	476	354.0
345	463.8	406	380.1	475	338.5
344	459.4	405	429.6	474	414.3
343	460.6	404	442.6	473	402.4
342	434.9	403	448.5	472	414.5
341	455.3	402	456.6	471	377.6
340	460.2	401	451.6	470	388.2
339	467.5	400	444.7	469	392.1
338	462.6	399	448.5	468	380.4
337	458.6	398	433.0	467	357.0
336	459.6	397	449.0	466	378.4
335	434.4	396	454.3	465	374.6
334	455.1	395	461.8	464	370.9
332	466.5	394	456.9	463	365.5
331	461.7	393	452.6	462	373.7
330	456.6	392	452.7	461	367.1
329	458.3	391	429.6	460	223.8
328	429.4	390	445.5	459	342.4
327	445.6	389	448.3	458	345.1
326	446.7	388	455.7	457	353.5
325	456.3	387	450.7	456	280.6
324	451.7	386	445.4	455	362.2
323	446.1	385	445.3	454	380.8
322	447.1	384	434.4	453	383.1
321	431.9	383	452.5	451	360.1
320	450.6	382	460.1	450	361.4
319	454.0	381	468.3	449	361.3
318	462.3	380	463.5	448	361.6
317	458.0	379	458.4	447	386.8
316	452.9	378	459.6	446	382.9
315	454.4	377	432.4	445	390.1
314	428.5	376	451.5	444	391.4
313	442.6	375	459.8	443	411.7
312	446.0	374	467.8	442	408.7
311	452.0	373	463.6	441	409.6
310	448.0	372	458.5	440	419.9
309	442.6	371	460.5	437	406.2
308	445.6	370	434.2	436	397.0
307	437.0	369	452.4	435	410.1
306	457.8	368	459.6	434	400.2
305	467.7	367	467.0	433	405.3
304	475.7	366	462.3	432	409.8
303	470.8	365	456.7	431	406.1
302	465.8	364	458.0	430	407.1
301	468.1	363	432.7	429	405.0

TABLE F-28: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 1/17/80 TIME: 3:52 p.m.
TEST CONDITIONS: Uniform Canister Temperature at 400°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	472.3	428	392.8	492	392.6
361	477.4	427	399.0	491	77.2
360	482.7	426	400.3	490	75.3
359	481.0	425	399.7	489	78.2
358	480.1	424	396.8	488	75.1
357	472.8	423	394.7	487	88.3
356	398.0	422	397.5	486	156.5
355	470.7	421	400.4	485	
354	477.5	420	396.1	484	101.4
353	481.3	419	394.1	483	121.7
352	479.6	418	408.1	482	275.4
351	478.2	417	404.7	481	247.7
350	471.2	416	409.2	480	212.3
349	443.2	415	408.2	479	171.4
348	472.0	409	402.3	478	279.2
347	477.7	408	401.3	477	327.1
346	482.6	407	371.3	476	342.2
345	480.3	406	372.1	475	329.0
344	480.2	405	435.1	474	406.8
343	473.8	404	455.0	473	392.9
342	444.6	403	400.4	472	407.4
341	473.2	402	464.3	471	367.1
340	477.4	401	462.3	470	376.9
339	481.8	400	458.8	469	381.2
338	478.9	399	455.6	468	370.8
337	478.5	398	440.8	467	348.1
336	472.2	397	463.3	466	368.1
335	444.0	396	487.7	465	366.4
334	473.1	395	471.8	464	365.6
332	481.3	394	470.3	463	357.7
331	478.8	393	469.2	462	364.3
330	477.1	392	461.0	461	356.2
329	471.0	391	435.2	460	215.8
328	434.4	390	457.4	459	329.4
327	458.1	389	459.7	458	332.7
326	459.5	388	463.6	457	341.2
325	464.7	387	461.3	456	334.8
324	462.2	386	459.0	455	346.4
323	460.6	385	451.6	454	360.2
322	456.1	384	444.2	453	358.9
321	438.7	383	469.8	451	341.9
320	465.0	382	476.9	450	349.6
319	468.2	381	482.0	449	352.5
318	472.8	380	480.3	448	352.6
317	470.1	379	478.5	447	375.6
316	468.4	378	471.3	446	369.6
315	463.6	377	441.4	445	373.3
314	433.7	376	469.0	444	376.0
313	454.3	375	477.5	443	398.4
312	457.8	374	481.8	442	398.7
311	461.0	373	479.5	441	401.9
310	458.4	372	479.1	440	413.9
309	456.9	371	473.3	437	394.8
308	453.4	370	444.2	436	385.6
307	449.9	369	469.8	435	396.8
306	479.4	368	477.2	434	392.1
305	490.5	367	481.8	433	397.8
304	495.0	366	479.5	432	401.9
303	492.3	365	477.0	431	398.0
302	490.8	364	470.4	430	390.5
301	485.2	363	441.7	429	390.6

TABLE F-29: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 12/20/79 TIME: 2:38 p.m.
TEST CONDITIONS: Uniform Canister Temperature at 500°F With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	548.0	428	488.0	492	573.4
361	554.8	427	494.4	491	84.9
360	561.7	426	497.0	490	80.9
359	559.1	425	496.0	489	85.8
358	558.4	424	493.8	488	81.5
357	560.1	423	491.2	487	92.6
356	459.0	422	494.4	486	196.8
355	545.9	421	498.7	485	
354	554.5	420	494.8	484	115.2
353	558.4	419	492.3	483	126.6
352	555.3	418	503.8	482	355.8
351	556.0	417	500.8	481	328.4
350	558.8	416	501.5	480	272.9
349	524.0	415	497.2	479	228.8
348	547.7	409	432.1	478	351.4
347	555.0	408	493.4	477	347.6
346	561.5	407	471.0	476	373.5
345	558.0	406	476.9	475	375.4
344	558.9	405	519.4	474	466.8
343	561.3	404	535.1	473	461.2
342	525.2	403	542.2	472	486.5
341	548.8	402	547.8	471	456.5
340	555.1	401	543.5	470	466.8
339	560.1	400	541.0	469	486.5
338	556.3	399	546.9	468	486.2
337	557.7	398	522.8	467	461.0
336	560.3	397	540.9	466	477.1
335	524.4	396	547.5	465	479.0
334	548.6	395	552.3	464	477.5
332	559.0	394	548.2	463	464.1
331	555.2	393	549.3	462	465.3
330	555.8	392	551.1	461	461.1
329	558.6	391	519.1	460	325.7
328	519.0	390	537.3	459	435.1
327	538.1	389	540.9	458	435.3
326	540.9	388	545.6	457	444.5
325	547.9	387	540.8	456	428.9
324	544.0	386	541.3	455	443.2
323	543.6	385	543.2	454	464.2
322	547.1	384	524.6	453	466.1
321	521.5	383	545.5	451	447.8
320	543.1	382	554.5	450	457.3
319	547.8	381	560.4	449	463.6
318	554.0	380	556.8	448	460.0
317	550.3	379	556.4	447	482.1
316	550.7	378	558.9	446	476.8
315	553.9	377	522.6	445	483.7
314	518.2	376	544.9	444	480.3
313	534.4	375	554.8	443	500.9
312	539.3	374	560.7	442	499.6
311	542.9	373	557.1	441	502.3
310	539.2	372	557.1	440	511.8
309	539.8	371	560.4	437	483.2
308	544.5	370	524.4	436	486.9
307	527.9	369	545.3	435	500.7
306	552.5	368	554.4	434	491.5
305	564.3	367	559.3	433	497.9
304	570.3	366	555.3	432	503.0
303	566.1	365	555.0	431	498.5
302	566.1	364	558.2	430	486.4
301	569.5	363	522.7	429	485.1

TABLE F-30: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 12/17/79 TIME: 1:30 p.m.
TEST CONDITIONS: Uniform Canister Temperature at 500°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	535.5	428	485.6	492	
361	538.9	427	491.4	491	83.3
360	544.6	426	495.4	490	79.7
359	538.8	425	493.8	489	85.6
358	538.0	424	492.7	488	80.9
357	543.6	423	488.8	487	90.0
356	441.3	422	494.4	486	193.8
355	533.5	421	498.8	485	
354	538.7	420	495.9	484	120.9
353	541.2	419	493.3	483	122.2
352	534.8	418	499.7	482	353.7
351	535.8	417	496.8	481	325.6
350	542.5	416	495.5	480	275.0
349	515.9	415	491.9	479	224.7
348	535.3	409	426.3	478	348.4
347	538.9	408	487.8	477	343.0
346	544.1	407	464.1	476	374.4
345	537.1	406	469.4	475	371.0
344	538.1	405	512.8	474	462.7
343	544.2	404	525.1	473	454.0
342	516.7	403	529.6	472	477.3
341	536.0	402	534.1	471	450.3
340	539.0	401	526.6	470	463.9
339	542.7	400	524.3	469	484.0
338	535.6	399	534.1	468	483.6
337	537.4	398	515.1	467	462.4
336	543.4	397	530.0	466	481.6
335	516.0	396	533.7	465	480.3
334	535.9	395	537.4	464	474.9
332	541.4	394	530.0	463	464.2
331	534.5	393	531.4	462	469.8
330	535.4	392	537.2	461	455.4
329	542.0	391	511.9	460	304.1
328	512.4	390	527.3	459	423.4
327	528.1	389	528.7	458	425.3
326	527.9	388	531.9	457	434.5
325	533.7	387	524.1	456	412.2
324	526.4	386	524.9	455	442.3
323	526.5	385	530.8	454	461.5
322	533.1	384	516.5	453	460.2
321	514.2	383	533.3	451	449.8
320	532.1	382	538.8	450	459.6
319	533.8	381	543.5	449	465.5
318	538.4	380	536.6	448	458.7
317	531.8	379	536.5	447	482.3
316	532.2	378	543.0	446	476.7
315	539.0	377	514.8	445	485.7
314	510.9	376	532.7	444	478.7
313	524.6	375	539.0	443	498.1
312	526.5	374	543.6	442	493.9
311	528.7	373	537.0	441	495.9
310	522.0	372	536.9	440	505.0
309	523.1	371	544.1	437	477.8
308	530.9	370	516.1	436	485.4
307	519.0	369	533.0	435	497.9
306	538.0	368	538.4	434	489.6
305	546.1	367	541.9	433	496.6
304	550.4	366	535.0	432	502.0
303	543.4	365	535.0	431	497.7
302	542.9	364	542.0	430	484.4
301	550.6	363	515.0	429	482.0

TABLE F-31: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: B43

DATE: 1/24/80 TIME: 8:30 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 500°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	552.9	428	488.3	492	571.7
361	559.4	427	496.3	491	75.4
360	566.0	426	499.2	490	73.7
359	563.8	425	498.8	489	77.6
358	565.2	424	495.9	488	75.1
357	561.0	423	492.7	487	82.4
356	444.7	422	493.5	486	190.3
355	549.8	421	499.7	485	
354	558.5	420	496.2	484	116.8
353	562.5	419	492.2	483	112.5
352	560.2	418	503.2	482	352.0
351	562.4	417	499.3	481	324.0
350	558.9	416	498.8	480	278.5
349	527.3	415	493.9	479	223.6
348	552.3	409	492.7	478	356.4
347	559.5	408	491.9	477	335.0
346	565.7	407	467.6	476	361.5
345	562.8	406	472.9	475	358.3
344	565.3	405	522.5	474	455.1
343	562.2	404	539.2	473	449.2
342	527.9	403	546.0	472	474.9
341	552.8	402	551.4	471	446.8
340	559.3	401	548.1	470	459.5
339	564.1	400	547.4	469	483.1
338	560.9	399	547.4	468	487.8
337	563.6	398	525.7	467	465.2
336	561.1	397	544.7	466	480.3
335	527.0	396	551.1	465	483.1
334	552.5	395	555.6	464	482.9
332	563.1	394	552.5	463	472.0
331	560.1	393	555.4	462	477.2
330	562.0	392	551.1	461	469.3
329	559.4	391	521.0	460	332.0
328	521.2	390	540.2	459	437.8
327	541.4	389	543.9	458	439.5
326	544.9	388	548.4	457	449.5
325	551.4	387	544.8	456	439.5
324	548.1	386	546.8	455	448.8
323	549.4	385	543.1	454	463.8
322	548.0	384	528.2	453	459.5
321	523.8	383	550.2	451	455.9
320	546.3	382	558.7	450	464.5
319	551.7	381	564.4	449	466.6
318	557.1	380	561.5	448	455.6
317	554.1	379	563.1	447	479.3
316	555.5	378	559.7	446	472.5
315	554.3	377	526.3	445	483.4
314	519.0	376	549.8	444	475.7
313	536.5	375	559.4	443	499.6
312	542.1	374	564.9	442	496.4
311	546.0	373	561.9	441	500.2
310	543.1	372	564.1	440	509.3
309	545.6	371	561.5	437	473.7
308	544.9	370	527.5	436	485.1
307	532.1	369	549.6	435	496.6
306	557.6	368	558.5	434	495.6
305	569.8	367	563.4	433	502.9
304	575.1	366	560.2	432	507.5
303	571.7	365	561.5	431	503.5
302	573.2	364	558.6	430	485.7
301	571.0	363	526.4	429	485.0

TABLE F-32: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 9/30/80 TIME: 12:00 noon

TEST CONDITIONS: Band Heaters Off With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	442.5	428	305.0	492	91.9
361	480.2	427	309.1	491	85.2
360	493.3	426	311.8	490	84.5
359	493.0	425	308.8	489	85.5
358	485.2	424	306.6	488	84.8
357	459.2	423	305.8	487	84.6
356	351.3	422	300.2	486	99.3
355	441.5	421	302.3	485	98.1
354	481.8	420	293.9	484	101.9
353	492.0	419	292.8	483	085.0
352	492.5	418	237.2	482	119.4
351	483.6	417	235.1	481	118.4
350	459.6	416	186.9	480	132.2
349	364.2	415	180.9	479	123.8
348	443.5	409	191.6	478	136.0
347	481.6	408	191.8	477	87.2
346	494.7	407	169.1	476	87.6
345	493.7	406	168.7	475	88.5
344	486.2	405	341.7	474	92.7
343	461.2	404	407.8	473	96.0
342	367.6	403	443.9	472	104.0
341	447.3	402	454.1	471	112.6
340	483.3	401	454.6	470	125.1
339	494.3	400	445.5	469	138.1
338	493.5	399	422.6	468	150.2
337	485.4	398	356.0	467	161.8
336	463.4	397	426.2	466	173.8
335	365.0	396	461.7	465	184.6
334	446.7	395	471.4	464	189.5
332	493.8	394	471.5	463	201.0
331	492.2	393	464.9	462	206.8
330	483.4	392	437.6	461	212.0
329	460.5	391	342.6	460	128.7
328	343.6	390	412.2	459	213.5
327	413.9	389	444.7	458	217.3
326	446.0	388	455.7	457	216.7
325	459.4	387	456.5	456	214.3
324	459.8	386	447.7	455	219.8
323	449.7	385	419.5	454	210.4
322	426.3	384	363.2	453	201.9
321	355.2	383	438.4	451	212.4
320	430.7	382	478.9	450	216.5
319	465.1	381	389.0	449	218.2
318	478.0	380	489.0	448	211.9
317	478.2	379	481.2	447	216.8
316	469.8	378	456.8	446	209.3
315	445.2	377	355.9	445	208.5
314	342.8	376	436.5	444	198.9
313	410.9	375	478.9	443	201.1
312	445.2	374	490.2	442	191.0
311	455.9	373	488.8	441	186.6
310	457.0	372	482.1	440	184.2
309	447.3	371	458.9	437	159.1
308	425.3	370	363.7	436	213.0
307	375.9	369	440.0	435	215.7
306	458.9	368	481.0	434	288.7
305	503.7	367	491.0	433	289.8
304	516.6	366	490.0	432	293.7
303	513.6	365	480.4	431	294.3
302	505.5	364	458.4	430	305.4
301	483.0	363	358.3	429	303.7

TABLE F-33: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/3/80 TIME: 8:00 a.m.
TEST CONDITIONS: Band Heaters Off With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	393.5	428	304.0	492	91.6
361	418.4	427	305.6	491	86.3
360	430.6	426	312.3	490	85.2
359	427.1	425	307.0	489	86.3
358	416.5	424	308.4	488	85.3
357	381.1	423	304.1	487	85.0
356	319.0	422	298.8	486	101.6
355	392.9	421	301.1	485	101.5
354	420.5	420	294.2	484	99.0
353	430.2	419	292.4	483	85.3
352	428.1	418	243.3	482	119.1
351	416.0	417	238.8	481	118.7
350	381.6	416	194.2	480	133.8
349	330.6	415	188.0	479	127.2
348	393.3	409	201.1	478	136.6
347	418.7	408	202.5	477	87.2
346	430.6	407	175.4	476	87.8
345	427.2	406	175.3	475	88.5
344	416.6	405	313.9	474	92.1
343	381.8	404	368.2	473	95.1
342	334.2	403	391.1	472	102.2
341	397.2	402	398.8	471	109.8
340	420.3	401	397.2	470	121.8
339	430.9	400	386.1	469	134.2
338	427.8	399	354.4	468	146.4
337	417.0	398	328.7	467	158.2
336	384.0	397	384.4	466	170.3
335	331.2	396	407.1	465	181.6
334	396.5	395	416.1	464	187.2
332	430.6	394	413.4	463	199.3
331	426.7	393	403.2	462	205.3
330	415.1	392	366.2	461	210.5
329	381.6	391	315.5	460	126.8
328	314.6	390	372.6	459	213.9
327	370.9	389	393.7	458	216.9
326	390.4	388	404.1	457	215.9
325	402.6	387	402.0	456	214.0
324	401.0	386	389.9	455	219.5
323	388.7	385	351.5	454	212.0
322	356.3	384	332.4	453	203.4
321	325.2	383	392.1	451	213.5
320	384.9	382	419.0	450	218.5
319	406.7	381	428.0	449	220.8
318	419.7	380	425.0	448	215.5
317	416.9	379	413.8	447	219.0
316	405.8	378	379.7	446	213.2
315	371.0	377	324.6	445	211.0
314	313.5	376	389.0	444	202.7
313	368.9	375	418.0	443	203.3
312	391.5	374	427.2	442	195.5
311	401.5	373	423.7	441	190.6
310	400.2	372	413.6	440	189.5
309	388.6	371	380.9	437	148.7
308	356.0	370	331.4	436	205.5
307	339.1	369	392.4	435	207.4
306	404.6	368	419.8	434	286.5
305	436.2	367	429.0	433	287.1
304	447.7	366	426.1	432	291.9
303	442.5	365	413.1	431	292.9
302	431.5	364	380.2	430	306.6
301	398.9	363	326.8	429	300.7

TABLE F-34: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 9/26/80 TIME: 8:00 a.m.
TEST CONDITIONS: Band Heaters Off With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	459.9	428	293.2	492	90.5
361	451.0	427	295.9	491	86.2
360	458.7	426	295.6	490	85.2
359	456.7	425	294.7	489	85.9
358	440.8	424	293.8	488	85.1
357	383.3	423	296.3	487	84.7
356	406.7	422	303.1	486	99.3
355	462.5	421	296.1	485	99.3
354	463.7	420	290.0	484	99.3
353	462.1	419	297.3	483	85.0
352	465.0	418	266.3	482	114.6
351	443.9	417	280.1	481	114.4
350	385.0	416	210.2	480	129.9
349	421.5	415	202.9	479	125.2
348	462.8	409	227.2	478	141.7
347	458.9	408	231.5	477	86.7
346	463.7	407	189.4	476	87.2
345	464.1	406	190.4	475	87.7
344	446.1	405	380.2	474	90.9
343	387.2	404	415.7	473	93.5
342	425.8	403	411.8	472	99.6
341	467.7	402	417.5	471	106.2
340	467.0	401	417.1	470	116.2
339	468.9	400	404.0	469	127.6
338	469.0	399	357.2	468	138.4
337	449.1	398	403.3	467	148.9
336	389.5	397	441.5	466	160.1
335	422.5	396	428.9	465	171.1
334	467.7	395	434.7	464	176.7
332	466.8	394	437.2	463	188.8
331	467.0	393	423.7	462	194.9
330	445.9	392	366.7	461	200.8
329	387.4	391	387.4	460	118.5
328	392.1	390	426.8	459	205.5
327	429.3	389	418.0	458	208.1
326	422.0	388	421.6	457	206.4
325	428.8	387	425.0	456	205.0
324	428.5	386	409.6	455	210.7
323	411.4	385	354.8	454	204.3
322	359.8	384	416.8	453	198.0
321	409.7	383	455.7	451	208.1
320	450.4	382	448.5	450	212.7
319	447.7	381	452.7	449	216.1
318	452.9	380	454.4	448	214.8
317	453.1	379	438.4	447	218.7
316	433.7	378	382.7	446	214.9
315	375.2	377	412.5	445	211.6
314	391.4	376	453.2	444	212.7
313	430.6	375	449.2	443	210.9
312	430.5	374	454.2	442	202.0
311	429.5	373	452.4	441	198.7
310	431.4	372	438.8	440	201.1
309	412.1	371	384.9	437	137.6
308	359.0	370	418.3	436	190.5
307	439.5	369	458.8	435	191.5
306	480.5	368	456.6	434	271.7
305	483.2	367	457.8	433	274.0
304	485.1	366	459.4	432	276.5
303	483.9	365	440.0	431	276.8
302	464.1	364	384.5	430	294.5
301	406.0	363	416.6	429	293.6

TABLE F-35: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 1/5/81 TIME: 8:00 a.m.
TEST CONDITIONS: Band Heaters Off With Air (Rerun)

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	438.0	428	270.0	492	80.5
361	436.2	427	274.3	491	77.3
360	439.9	426	275.3	490	76.0
359	438.4	425	274.8	489	77.5
358	414.2	424	270.7	488	76.4
357	351.6	423	270.7	487	75.3
356	381.2	422	272.0	486	88.8
355	431.2	421	279.2	485	88.7
354	423.7	420	273.5	484	89.1
353	430.0	419	268.0	483	75.6
352	433.3	418	254.4	482	102.4
351	412.5	417	249.6	481	102.3
350	353.4	416	194.9	480	116.0
349	398.6	415	185.5	479	112.8
348	435.9	409	211.2	478	126.7
347	431.1	408	213.8	477	77.5
346	436.8	407	173.7	476	78.0
345	436.7	406	174.5	475	78.2
344	414.1	405	365.6	474	81.3
343	353.6	404	401.9	473	83.5
342	398.7	403	401.5	472	89.0
341	436.2	402	400.1	471	94.7
340	425.4	401	398.4	470	104.0
339	432.7	400	377.6	469	113.9
338	433.7	399	326.4	468	123.5
337	413.3	398	380.6	467	133.0
336	355.2	397	418.0	466	143.0
335	395.3	396	413.5	465	153.0
334	434.0	395	414.3	464	158.6
332	431.0	394	415.1	463	169.8
331	432.4	393	395.4	462	175.5
330	411.8	392	336.0	461	180.9
329	354.5	391	363.5	460	103.2
328	368.4	390	399.2	459	185.4
327	403.3	389	390.5	458	187.9
326	393.7	388	396.7	457	187.5
325	401.9	387	399.7	456	185.8
324	401.9	386	380.9	455	190.5
323	380.9	385	325.4	454	187.2
322	328.6	384	395.1	453	178.7
321	383.1	383	432.9	451	187.8
320	419.6	382	433.0	450	196.7
319	406.5	381	432.1	449	198.1
318	416.1	380	431.4	448	195.2
317	418.1	379	409.4	447	199.6
316	397.8	378	350.3	446	196.8
315	341.5	377	393.6	445	196.8
314	360.0	376	433.4	444	189.2
313	392.7	375	436.1	443	193.9
312	385.4	374	435.6	442	187.4
311	393.8	373	432.4	441	185.2
310	396.3	372	410.6	440	186.8
309	380.3	371	352.0	437	123.6
308	328.8	370	394.8	436	171.7
307	417.1	369	431.1	435	172.5
306	453.0	368	428.4	434	247.6
305	455.5	367	431.2	433	249.1
304	457.4	366	431.9	432	250.8
303	455.8	365	409.6	431	251.3
302	431.3	364	352.7	430	268.6
301	371.7	363	397.5	429	269.2

TABLE F-36: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/31/80 TIME: 4:00 p.m.
TEST CONDITIONS: Electrically Heated Drywell Test Canister Profile With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	464.0	428	345.5	492	101.5
361	494.2	427	352.3	491	80.1
360	505.7	426	356.1	490	78.0
359	508.3	425	354.9	489	80.0
358	503.7	424	352.2	488	78.0
357	477.7	423	349.8	487	77.0
356	374.0	422	341.1	486	114.3
355	463.5	421	344.5	485	114.3
354	496.5	420	336.1	484	98.6
353	505.0	419	334.0	483	78.1
352	507.4	418	300.9	482	159.2
351	502.3	417	291.3	481	159.6
350	478.1	416	238.1	480	160.0
349	396.2	415	232.3	479	136.9
348	464.4	409	242.2	478	162.6
347	495.4	408	242.5	477	86.9
346	506.8	407	216.2	476	87.6
345	508.6	406	215.5	475	91.2
344	504.3	405	380.0	474	104.1
343	478.9	404	434.9	473	115.8
342	398.5	403	463.2	472	146.6
341	467.2	402	471.6	471	194.7
340	496.7	401	474.5	470	248.6
339	506.5	400	469.2	469	246.9
338	508.0	399	445.6	468	230.2
337	503.5	398	392.5	467	225.7
336	480.9	397	451.2	466	231.7
335	396.7	396	478.9	465	240.3
334	467.0	395	486.9	464	247.2
332	506.1	394	489.3	463	270.7
331	506.9	393	485.9	462	288.7
330	501.9	392	458.9	461	287.5
329	478.6	391	381.1	460	188.3
328	379.3	390	439.0	459	280.6
327	438.7	389	464.4	458	283.3
326	464.1	388	473.0	457	286.5
325	475.6	387	476.0	456	281.7
324	478.9	386	471.4	455	292.2
323	472.5	385	443.5	454	273.5
322	448.8	384	397.6	453	243.0
321	387.8	383	461.7	451	254.5
320	452.5	382	494.1	450	269.3
319	480.3	381	503.0	449	273.4
318	491.6	380	504.3	448	264.2
317	494.6	379	500.0	447	268.8
316	489.9	378	475.4	446	275.6
315	465.2	377	390.6	445	289.2
314	378.1	376	459.4	444	284.5
313	435.6	375	493.8	443	287.1
312	463.5	374	503.6	442	266.3
311	472.0	373	504.2	441	244.7
310	475.6	372	500.5	440	236.9
309	471.1	371	476.7	437	217.3
308	448.2	370	397.7	436	286.9
307	406.8	369	462.4	435	290.4
306	478.0	368	495.7	434	339.0
305	515.3	367	504.3	433	340.9
304	526.7	366	505.1	432	343.8
303	526.0	365	499.2	431	344.2
302	520.8	364	476.9	430	346.2
301	498.3	363	391.8	429	343.2

TABLE F-37: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/19/80 TIME: 8:00 a.m.
TEST CONDITIONS: Electrically Heated Drywell Test Canister Profile With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	411.7	428	349.6	492	104.0
361	435.4	427	354.0	491	79.5
360	449.0	426	360.8	490	77.5
359	452.1	425	356.8	489	79.5
358	446.7	424	357.1	488	77.4
357	422.8	423	351.4	487	76.1
356	348.1	422	343.4	486	114.2
355	419.6	421	345.4	485	115.8
354	442.1	420	334.6	484	98.0
353	450.7	419	333.3	483	77.3
352	452.8	418	312.7	482	163.5
351	446.0	417	291.7	481	163.6
350	423.3	416	245.6	480	159.3
349	359.1	415	240.9	479	138.6
348	411.2	409	251.1	478	165.2
347	436.1	408	256.0	477	87.9
346	449.0	407	222.0	476	89.5
345	451.3	406	222.2	475	93.2
344	446.1	405	355.2	474	111.8
343	422.8	404	393.5	473	127.0
342	364.1	403	414.6	472	158.0
341	415.8	402	424.0	471	190.9
340	438.1	401	427.4	470	233.1
339	449.3	400	420.3	469	241.6
338	451.5	399	400.2	468	240.9
337	446.6	398	373.3	467	241.8
336	424.9	397	413.5	466	249.3
335	368.0	396	431.5	465	258.7
334	418.9	395	439.6	464	261.8
332	449.6	394	441.4	463	266.1
331	450.8	393	435.1	462	269.2
330	444.7	392	410.9	461	279.5
329	422.9	391	366.7	460	196.1
328	344.2	390	406.0	459	288.8
327	391.5	389	420.8	458	290.9
326	412.2	388	429.0	457	294.9
325	425.5	387	431.1	456	288.8
324	429.7	386	423.8	455	296.5
323	422.6	385	398.5	454	276.9
322	401.8	384	372.6	453	246.3
321	353.7	383	417.3	451	260.6
320	403.8	382	440.0	450	274.0
319	426.3	381	449.4	449	276.1
318	439.3	380	450.5	448	267.4
317	442.8	379	444.1	447	271.9
316	437.1	378	421.3	446	284.2
315	414.4	377	361.7	445	299.8
314	356.3	376	411.3	444	294.5
313	397.0	375	436.9	443	286.7
312	415.3	374	447.5	442	270.7
311	424.6	373	449.0	441	248.3
310	428.2	372	443.5	440	242.2
309	423.1	371	421.9	437	217.3
308	401.9	370	374.4	436	286.5
307	373.3	369	419.2	435	289.5
306	424.5	368	441.3	434	338.8
305	452.6	367	449.8	433	340.1
304	464.0	366	451.1	432	344.2
303	464.3	365	443.0	431	344.3
302	457.8	364	421.8	430	351.1
301	436.8	363	357.4	429	345.2

TABLE F-38: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/10/80 TIME: 8:00 a.m.
TEST CONDITIONS: Drywell Canister Profile With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	435.4	428	315.3	492	95.1
361	473.3	427	321.0	491	80.9
360	488.7	426	323.3	490	78.9
359	491.6	425	320.9	489	80.7
358	488.4	424	318.1	488	78.9
357	468.1	423	317.0	487	77.3
356	344.4	422	301.1	486	107.5
355	435.7	421	302.3	485	108.8
354	475.6	420	295.7	484	96.2
353	483.4	419	294.9	483	78.0
352	491.1	418	236.9	482	144.9
351	487.4	417	240.1	481	145.4
350	486.5	416	190.1	480	142.0
349	361.4	415	185.4	479	127.4
348	437.1	409	195.3	478	134.5
347	475.3	408	195.6	477	84.3
346	490.4	407	173.7	476	85.4
345	492.1	406	173.4	475	87.2
344	489.2	405	338.0	474	97.6
343	469.3	404	401.6	473	106.6
342	365.1	403	438.2	472	129.6
341	441.0	402	451.6	471	163.2
340	476.9	401	455.0	470	202.0
339	490.4	400	451.4	469	209.2
338	491.7	399	434.3	468	206.5
337	488.7	398	351.8	467	207.5
336	471.4	397	419.6	466	214.2
335	362.7	396	455.5	465	224.5
334	440.3	395	468.6	464	229.3
332	489.5	394	471.5	463	235.0
331	490.5	393	469.8	462	236.0
330	486.7	392	448.3	461	239.5
329	469.2	391	340.2	460	152.7
328	341.9	390	405.7	459	241.8
327	409.2	389	439.6	458	244.9
326	441.1	388	453.5	457	246.4
325	457.0	387	457.4	456	242.2
324	460.1	386	453.9	455	249.9
323	455.0	385	432.2	454	237.0
322	437.5	384	358.7	453	215.0
321	353.6	383	431.4	451	220.7
320	425.1	382	472.2	450	228.4
319	459.7	381	485.6	449	227.2
318	474.4	380	487.4	448	218.7
317	477.5	379	484.7	447	222.0
316	473.8	378	465.6	446	214.8
315	455.0	377	351.9	445	213.1
314	341.7	376	429.3	444	205.3
313	406.7	375	472.0	443	204.6
312	440.2	374	486.2	442	195.9
311	453.3	373	487.2	441	190.0
310	456.9	372	485.1	440	187.3
309	453.5	371	467.1	437	194.9
308	437.0	370	360.4	436	260.5
307	372.5	369	433.2	435	263.4
306	451.2	368	474.2	434	311.1
305	496.1	367	487.1	433	312.7
304	510.8	366	488.5	432	315.9
303	510.9	365	484.0	431	316.2
302	506.6	364	467.2	430	315.4
301	489.5	363	355.0	429	313.4

TABLE F-39: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/14/80 TIME: 4:00 a.m.

TEST CONDITIONS: Drywell Canister Profile With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	380.3	428	316.2	492	95.2
361	408.3	427	319.2	491	79.1
360	423.7	426	325.7	490	77.4
359	426.0	425	321.1	489	79.1
358	422.9	424	321.8	488	77.3
357	401.0	423	317.0	487	75.9
356	306.3	422	301.3	486	107.0
355	382.8	421	302.7	485	108.5
354	412.1	420	297.4	484	93.4
353	424.5	419	296.4	483	76.6
352	426.5	418	240.9	482	145.8
351	422.3	417	242.5	481	146.4
350	401.5	416	193.2	480	140.9
349	321.4	415	188.8	479	126.9
348	381.2	409	198.9	478	134.3
347	409.4	408	200.2	477	83.5
346	424.1	407	176.4	476	84.6
345	425.6	406	176.3	475	86.6
344	422.4	405	305.5	474	97.8
343	401.0	404	356.5	473	107.6
342	325.7	403	383.8	472	132.6
341	385.8	402	395.5	471	170.6
340	411.3	401	398.7	470	213.7
339	424.8	400	395.0	469	217.4
338	426.0	399	375.7	468	209.4
337	423.2	398	320.0	467	208.6
336	403.2	397	374.4	466	214.8
335	323.7	396	399.7	465	223.2
334	385.4	395	411.7	464	226.8
332	424.3	394	413.8	463	232.9
331	424.9	393	410.4	462	235.7
330	421.0	392	388.3	461	239.9
329	401.2	391	308.9	460	153.4
328	307.6	390	364.2	459	243.7
327	361.3	389	387.4	458	246.5
326	383.8	388	400.5	457	248.6
325	399.3	387	403.1	456	244.4
324	402.3	386	398.7	455	252.2
323	397.5	385	375.1	454	238.7
322	378.5	384	322.6	453	215.7
321	317.9	383	379.9	451	221.7
320	374.5	382	409.8	450	229.8
319	399.3	381	422.4	449	228.3
318	414.4	380	423.6	448	219.8
317	416.6	379	420.1	447	223.9
316	413.0	378	399.3	446	216.5
315	392.1	377	314.8	445	215.2
314	309.0	376	376.0	444	209.5
313	361.3	375	408.1	443	209.7
312	385.5	374	421.1	442	200.2
311	397.8	373	422.3	441	192.8
310	400.7	372	419.6	440	190.4
309	397.9	371	399.9	437	196.4
308	378.7	370	322.7	436	262.3
307	329.0	369	381.2	435	265.2
306	391.1	368	410.6	434	309.9
305	425.0	367	422.9	433	311.2
304	439.0	366	424.2	432	315.3
303	439.0	365	419.2	431	315.7
302	434.8	364	399.9	430	318.0
301	415.9	363	316.9	429	317.0

TABLE F-40: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/8/80 TIME: 8:00 a.m.
TEST CONDITIONS: Drywell Canister Profile With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	459.2	428	324.1	492	96.4
361	460.0	427	328.9	491	80.6
360	465.4	426	325.6	490	78.5
359	459.6	425	320.3	489	80.6
358	450.3	424	316.5	488	78.6
357	418.0	423	316.6	487	77.2
356	400.2	422	318.7	486	109.7
355	462.0	421	319.6	485	110.9
354	469.4	420	303.8	484	95.1
353	474.6	419	304.8	483	78.0
352	477.8	418	285.6	482	149.7
351	467.3	417	278.0	481	150.3
350	425.9	416	218.6	480	146.8
349	415.4	415	212.6	479	131.4
348	459.2	409	233.3	478	142.6
347	459.1	408	240.9	477	84.8
346	464.4	407	197.0	476	85.8
345	462.2	406	198.3	475	87.9
344	453.7	405	386.9	474	99.2
343	421.9	404	423.4	473	109.1
342	420.8	403	428.9	472	134.6
341	464.3	402	432.3	471	173.8
340	460.9	401	430.3	470	220.0
339	465.7	400	421.2	469	227.1
338	464.0	399	393.8	468	221.1
337	456.2	398	404.5	467	216.5
336	425.0	397	445.4	466	218.7
335	420.7	396	450.4	465	225.3
334	464.9	395	457.6	464	228.7
332	470.1	394	461.4	463	237.4
331	470.1	393	452.4	462	246.1
330	459.6	392	405.7	461	263.0
329	425.3	391	391.5	460	184.1
328	383.2	390	432.3	459	269.1
327	423.0	389	436.8	458	272.5
326	421.8	388	444.0	457	274.5
325	429.8	387	448.7	456	267.9
324	426.9	386	438.2	455	267.9
323	420.6	385	393.6	454	250.7
322	395.5	384	415.1	453	224.9
321	403.1	383	457.8	451	228.2
320	444.7	382	465.7	450	239.3
319	440.6	381	471.6	449	239.4
318	448.1	380	473.3	448	232.5
317	446.1	379	463.5	447	232.5
316	439.1	378	421.3	446	230.6
315	410.4	377	410.8	445	228.6
314	394.1	376	455.5	444	223.3
313	428.9	375	462.9	443	219.3
312	429.6	374	466.7	442	215.8
311	434.4	373	463.2	441	209.2
310	433.8	372	455.1	440	210.3
309	425.2	371	420.7	437	191.8
308	397.1	370	417.4	436	260.5
307	435.0	369	459.6	435	263.6
306	478.4	368	469.1	434	310.3
305	487.5	367	474.7	433	311.4
304	491.2	366	476.9	432	312.6
303	489.9	365	465.5	431	313.3
302	478.2	364	424.1	430	317.2
301	442.7	363	413.2	429	321.6

TABLE F-41: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/27/80 TIME: 8:00 a.m.
TEST CONDITIONS: SFT-C Canister Profile With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	481.6	428	388.1	492	141.8
361	516.6	427	396.0	491	79.5
360	531.6	426	398.8	490	77.2
359	536.0	425	397.1	489	79.2
358	533.9	424	393.9	488	76.8
357	508.1	423	391.3	487	77.6
356	385.6	422	375.9	486	125.6
355	480.7	421	379.4	485	126.4
354	518.5	420	373.2	484	102.8
353	530.6	419	371.3	483	83.6
352	535.2	418	314.7	482	193.6
351	532.5	417	316.9	481	191.9
350	508.5	416	255.1	480	186.7
349	413.2	415	249.8	479	155.5
348	482.8	409	260.5	478	172.2
347	518.3	408	260.5	477	120.9
346	532.8	407	234.6	476	110.5
345	536.4	406	233.6	475	142.6
344	534.3	405	395.7	474	160.6
343	509.2	404	453.5	473	168.8
342	416.1	403	487.6	472	195.3
341	485.8	402	499.9	471	229.5
340	519.5	401	504.7	470	281.0
339	532.5	400	501.8	469	285.7
338	535.7	399	479.2	468	277.6
337	533.9	398	407.8	467	280.1
336	511.2	397	469.1	466	294.6
335	413.3	396	502.0	465	307.3
334	484.9	395	513.6	464	313.5
332	531.6	394	518.2	463	325.6
331	534.6	393	517.3	462	337.3
330	532.0	392	490.9	461	341.7
329	509.0	391	396.7	460	245.4
328	397.4	390	457.1	459	338.9
327	458.8	389	488.1	458	342.4
326	489.0	388	500.5	457	346.3
325	503.9	387	505.7	456	338.9
324	508.5	386	503.9	455	347.0
323	504.7	385	477.0	454	323.0
322	481.8	384	412.8	453	284.8
321	406.5	383	478.9	451	312.9
320	472.0	382	516.4	450	328.0
319	504.3	381	528.9	449	327.4
318	518.4	380	532.4	448	306.8
317	523.2	379	530.4	447	303.7
316	520.8	378	505.9	446	298.0
315	496.7	377	405.9	445	303.5
314	395.7	376	476.7	444	299.1
313	455.1	375	516.0	443	303.9
312	487.6	374	529.5	442	281.7
311	499.9	373	532.2	441	261.6
310	504.9	372	530.9	440	253.9
309	503.8	371	507.4	437	255.6
308	481.2	370	412.9	436	325.6
307	422.7	369	479.5	435	329.9
306	494.8	368	517.8	434	385.7
305	536.9	367	529.8	433	387.7
304	551.1	366	533.0	432	390.9
303	552.9	365	529.6	431	391.2
302	549.5	364	507.4	430	386.5
301	527.4	363	407.5	429	384.4

TABLE F-42: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 12/22/80 TIME: 8:00 a.m.
TEST CONDITIONS: SFT-C Canister Profile With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	435.6	428	386.1	492	132.6
361	464.1	427	391.6	491	79.9
360	479.6	426	397.7	490	77.6
359	483.0	425	393.8	489	79.9
358	480.3	424	393.5	488	77.4
357	455.5	423	388.1	487	77.1
356	364.4	422	377.6	486	126.4
355	443.1	421	381.6	485	127.1
354	470.2	420	370.8	484	102.7
353	480.5	419	367.2	483	81.2
352	483.2	418	331.7	482	193.9
351	479.4	417	313.2	481	192.9
350	455.9	416	264.0	480	184.5
349	380.5	415	259.1	479	155.1
348	435.0	409	270.2	478	177.0
347	464.5	408	274.6	477	108.6
346	479.5	407	240.8	476	103.0
345	482.2	406	240.6	475	123.6
344	479.8	405	377.4	474	144.6
343	455.5	404	418.6	473	165.1
342	384.9	403	445.2	472	205.1
341	439.2	402	456.4	471	243.1
340	466.0	401	460.0	470	293.9
339	479.5	400	455.7	469	294.4
338	482.1	399	434.1	468	281.3
337	480.2	398	394.8	467	278.6
336	457.5	397	437.9	466	288.6
335	388.6	396	460.8	465	302.1
334	442.3	395	470.2	464	309.9
332	479.6	394	472.6	463	319.5
331	481.4	393	469.4	462	327.5
330	478.3	392	444.1	461	329.8
329	455.6	391	388.2	460	234.4
328	366.4	390	430.8	459	330.7
327	416.2	389	450.6	458	333.6
326	441.9	388	460.2	457	337.4
325	457.9	387	462.9	456	330.6
324	461.9	386	458.9	455	342.3
323	457.9	385	432.3	454	319.8
322	435.6	384	393.9	453	283.4
321	374.9	383	441.4	451	314.5
320	427.5	382	468.9	450	328.5
319	454.8	381	479.5	449	326.9
318	470.2	380	481.3	448	309.3
317	473.9	379	477.8	447	307.1
316	471.4	378	454.0	446	314.6
315	447.5	377	383.1	445	326.7
314	376.9	376	435.3	444	314.4
313	420.6	375	465.7	443	304.9
312	444.3	374	478.1	442	287.1
311	456.2	373	480.1	441	267.0
310	460.0	372	477.4	440	260.8
309	458.2	371	454.7	437	262.5
308	435.6	370	395.5	436	329.7
307	394.2	369	443.1	435	333.9
306	447.8	368	469.8	434	380.5
305	480.1	367	479.7	433	382.1
304	493.3	366	481.7	432	386.2
303	494.1	365	478.6	431	386.2
302	490.4	364	454.6	430	386.8
301	468.9	363	378.8	429	381.4

TABLE F-43: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/8/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 350°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	501.5	428	352.1	492	318.2
361	503.2	427	359.8	491	88.2
360	510.3	426	362.8	490	86.8
359	511.6	425	362.4	489	88.4
358	511.2	424	356.5	488	87.0
357	487.0	423	353.8	487	100.0
356	429.4	422	355.6	486	150.0
355	496.3	421	359.5	485	139.2
354	499.0	420	352.7	484	106.6
353	504.8	419	349.8	483	132.2
352	508.6	418	353.1	482	231.2
351	507.1	417	343.4	481	206.4
350	487.1	416	304.0	480	178.6
349	456.3	415	297.6	479	146.9
348	499.9	409	311.8	478	189.4
347	501.8	408	312.5	477	299.2
346	509.3	407	272.6	476	316.1
345	511.2	406	271.9	475	295.2
344	510.2	405	434.5	474	359.2
343	488.9	404	470.1	473	343.4
342	456.9	403	472.2	472	349.5
341	500.7	402	475.4	471	296.4
340	499.7	401	476.8	470	297.9
339	507.2	400	475.2	469	301.2
338	508.8	399	459.1	468	299.4
337	507.9	398	447.3	467	281.3
336	489.4	397	485.1	466	296.0
335	454.2	396	484.8	465	295.2
334	499.4	395	488.7	464	296.7
332	505.9	394	490.7	463	288.0
331	507.7	393	491.2	462	294.4
330	506.1	392	468.7	461	294.5
329	488.0	391	432.7	460	193.0
328	432.9	390	469.7	459	279.0
327	470.7	389	468.1	458	280.9
326	468.9	388	473.5	457	289.1
325	477.4	387	476.3	456	283.1
324	478.8	386	475.8	455	285.4
323	477.5	385	456.1	454	268.3
322	460.8	384	457.4	453	250.8
321	444.0	383	498.2	451	264.0
320	485.0	382	501.9	450	274.8
319	482.9	381	505.4	449	278.3
318	492.3	380	507.1	448	271.7
317	493.8	379	505.7	447	286.2
316	492.0	378	484.8	446	296.1
315	474.2	377	453.2	445	316.1
314	426.7	376	497.7	444	314.5
313	462.4	375	503.2	443	322.6
312	463.9	374	507.3	442	304.2
311	471.3	373	507.3	441	290.4
310	473.6	372	507.9	440	295.0
309	473.9	371	487.4	437	340.0
308	459.7	370	456.1	436	339.1
307	471.3	369	497.0	435	345.9
306	515.7	368	501.3	434	359.0
305	524.0	367	505.6	433	362.6
304	529.3	366	507.5	432	367.3
303	529.9	365	505.1	431	365.9
302	527.5	364	486.5	430	350.0
301	507.9	363	454.5	429	350.5

TABLE F-44: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/27/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 400°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	495.1	428	390.3	492	418.4
361	497.9	427	395.6	491	91.4
360	499.7	426	402.3	490	88.7
359	498.1	425	398.6	489	90.9
358	500.9	424	398.1	488	88.3
357	497.7	423	393.3	487	100.4
356	418.2	422	401.0	486	163.2
355	494.1	421	402.0	485	154.4
354	499.9	420	396.4	484	113.1
353	498.7	419	396.0	483	138.1
352	497.6	418	403.7	482	268.6
351	499.9	417	401.0	481	239.0
350	498.2	416	366.2	480	201.9
349	456.8	415	362.2	479	166.3
348	495.5	409	366.4	478	229.8
347	498.2	408	365.9	477	339.5
346	499.7	407	339.4	476	363.9
345	497.8	406	339.9	475	335.0
344	501.5	405	446.5	474	405.5
343	498.6	404	473.9	473	401.3
342	458.8	403	475.5	472	420.6
341	497.6	402	473.6	471	359.3
340	499.5	401	472.7	470	348.6
339	499.7	400	474.2	469	354.9
338	497.9	399	476.5	468	354.3
337	501.8	398	453.8	467	328.7
336	500.3	397	486.0	466	344.1
335	456.8	396	487.8	465	340.6
334	497.5	395	487.2	464	339.5
332	499.1	394	485.4	463	327.7
331	496.5	393	488.8	462	333.7
330	499.3	392	486.1	461	333.8
329	498.1	391	445.9	460	236.9
328	447.2	390	478.3	459	317.2
327	478.4	389	477.2	458	319.2
326	474.6	388	476.7	457	328.8
325	476.2	387	474.9	456	323.2
324	475.5	386	477.0	455	327.1
323	478.2	385	474.2	454	314.1
322	477.4	384	456.7	453	296.3
321	453.2	383	492.6	451	318.4
320	488.7	382	497.8	450	326.9
319	488.2	381	497.5	449	326.0
318	489.8	380	495.7	448	321.8
317	488.7	379	498.1	447	344.5
316	491.7	378	496.7	446	368.6
315	489.4	377	452.3	445	401.0
314	445.6	376	491.3	444	396.1
313	476.4	375	497.7	443	399.7
312	475.8	374	497.1	442	380.1
311	474.1	373	494.8	441	366.2
310	473.1	372	498.1	440	367.3
309	476.5	371	497.5	437	400.2
308	476.6	370	456.1	436	390.0
307	462.4	369	492.9	435	401.8
306	503.6	368	498.8	434	395.8
305	513.4	367	498.0	433	400.4
304	514.0	366	496.0	432	407.1
303	510.8	365	497.2	431	404.6
302	512.8	364	497.3	430	392.3
301	512.4	363	453.5	429	386.5

TABLE F-45: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/10/80 TIME: 4:00 p.m.
TEST CONDITIONS: Uniform Canister Temperature at 400°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	529.6	428	393.3	492	418.2
361	531.5	427	400.8	491	91.7
360	536.2	426	402.0	490	89.4
359	534.5	425	400.0	489	92.4
358	535.2	424	396.4	488	90.5
357	522.5	423	395.1	487	98.9
356	443.0	422	402.8	486	165.0
355	531.3	421	404.6	485	148.7
354	536.6	420	396.6	484	117.5
353	537.6	419	395.7	483	132.4
352	539.3	418	407.6	482	272.6
351	539.1	417	399.1	481	238.9
350	525.0	416	369.6	480	204.7
349	485.9	415	364.2	479	165.5
348	529.3	409	371.5	478	237.7
347	532.2	408	374.3	477	329.8
346	536.6	407	340.4	476	352.4
345	536.4	406	342.5	475	329.2
344	537.3	405	468.4	474	404.4
343	525.1	404	500.9	473	399.8
342	489.0	403	503.5	472	416.5
341	532.2	402	505.5	471	362.5
340	533.3	401	504.9	470	355.0
339	536.6	400	504.4	469	364.7
338	536.6	399	497.3	468	364.1
337	537.7	398	482.3	467	336.0
336	526.1	397	518.1	466	348.2
335	489.4	396	518.8	465	343.7
334	533.8	395	520.8	464	340.5
332	537.5	394	522.1	463	329.9
331	537.5	393	523.6	462	335.8
330	537.2	392	507.1	461	337.4
329	525.3	391	471.7	460	322.3
328	465.5	390	507.3	459	316.2
327	502.1	389	506.5	458	320.0
326	501.8	388	508.2	457	330.3
325	507.1	387	509.4	456	323.4
324	506.3	386	509.6	455	327.7
323	506.6	385	495.1	454	
322	498.2	384	489.3	453	303.1
321	477.1	383	529.0	451	323.2
320	516.9	382	533.6	450	334.6
319	517.0	381	535.7	449	332.3
318	522.1	380	536.5	448	322.8
317	522.3	379	536.7	447	340.3
316	522.3	378	522.4	446	351.8
315	511.5	377	483.5	445	375.3
314	469.4	376	526.7	444	375.0
313	503.1	375	532.7	443	386.3
312	503.4	374	535.1	442	376.3
311	505.4	373	533.4	441	368.2
310	506.2	372	535.5	440	370.9
309	506.3	371	524.1	437	398.8
308	497.7	370	490.0	436	390.6
307	500.5	369	530.2	435	401.0
306	545.5	368	536.2	434	398.9
305	554.7	367	537.5	433	403.8
304	557.4	366	537.9	432	408.3
303	556.3	365	536.9	431	404.5
302	555.9	364	524.2	430	391.6
301	544.0	363	483.4	429	392.1

TABLE F-46: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 11/5/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 450°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	525.9	428	437.6	492	519.1
361	528.5	427	444.2	491	90.9
360	530.2	426	451.6	490	87.8
359	531.2	425	448.4	489	90.4
358	534.3	424	447.5	488	87.2
357	533.1	423	442.1	487	99.3
356	446.0	422	445.1	486	178.3
355	525.0	421	446.8	485	169.6
354	530.3	420	442.4	484	118.1
353	528.9	419	440.9	483	137.7
352	529.9	418	453.0	482	309.9
351	533.0	417	450.7	481	276.4
350	533.6	416	443.0	480	232.7
349	492.9	415	440.3	479	186.6
348	526.1	409	440.3	478	268.1
347	528.7	408	440.0	477	363.5
346	530.1	407	431.3	476	384.6
345	530.4	406	436.3	475	373.1
344	534.6	405	483.9	474	466.4
343	533.8	404	506.8	473	456.0
342	494.5	403	509.1	472	471.2
341	527.9	402	507.6	471	402.9
340	529.7	401	509.0	470	391.4
339	529.6	400	510.5	469	409.0
338	530.3	399	514.8	468	416.0
337	534.6	398	490.3	467	384.8
336	535.1	397	517.5	466	398.5
335	493.0	396	519.7	465	398.6
334	527.9	395	519.0	464	401.5
332	528.9	394	519.5	463	385.4
331	528.7	393	523.3	462	389.8
330	532.2	392	523.0	461	388.7
329	533.1	391	484.0	460	279.1
328	484.7	390	510.9	459	376.9
327	511.1	389	510.4	458	378.8
326	507.9	388	509.5	457	389.6
325	509.4	387	509.8	456	382.5
324	511.2	386	512.7	455	393.6
323	514.2	385	512.3	454	376.9
322	515.4	384	492.9	453	348.0
321	489.6	383	523.5	451	367.5
320	520.1	382	528.6	450	377.7
319	519.8	381	528.3	449	376.5
318	521.0	380	528.7	448	380.1
317	522.4	379	531.5	447	411.0
316	525.9	378	532.3	446	414.5
315	525.8	377	489.3	445	427.4
314	483.2	376	522.3	444	426.8
313	508.8	375	528.5	443	445.3
312	508.7	374	528.0	442	436.8
311	506.5	373	528.1	441	434.3
310	508.2	372	531.7	440	445.4
309	512.1	371	533.0	437	451.9
308	514.3	370	492.7	436	438.3
307	498.2	369	523.7	435	451.3
306	533.1	368	529.3	434	443.7
305	542.0	367	528.2	433	449.4
304	542.5	366	528.5	432	456.3
303	541.6	365	530.4	431	452.5
302	544.2	364	532.6	430	439.3
301	545.9	363	490.2	429	433.1

TABLE F-47: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 11/7/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 450°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	562.2	428	436.8	492	517.4
361	564.8	427	446.6	491	90.6
360	566.1	426	449.9	490	87.6
359	568.1	425	449.4	489	90.1
358	571.2	424	444.8	488	87.0
357	559.5	423	441.8	487	99.0
356	473.6	422	447.8	486	179.7
355	558.9	421	450.1	485	171.0
354	564.8	420	444.2	484	116.8
353	565.8	419	443.0	483	137.2
352	568.3	418	453.7	482	312.1
351	569.1	417	451.4	481	278.8
350	559.0	416	447.1	480	230.6
349	519.9	415	443.6	479	183.2
348	562.5	409	445.5	478	266.6
347	565.6	408	445.5	477	360.0
346	567.6	407	431.6	476	380.1
345	569.0	406	436.9	475	369.6
344	571.9	405	503.5	474	462.8
343	561.2	404	535.2	473	452.7
342	521.9	403	538.4	472	469.2
341	563.9	402	537.4	471	410.5
340	566.1	401	539.6	470	405.4
339	567.8	400	540.9	469	417.4
338	568.1	399	535.3	468	414.6
337	570.6	398	512.8	467	383.5
336	561.8	397	547.5	466	399.9
335	519.9	396	549.3	465	401.0
334	563.0	395	550.2	464	404.1
332	567.0	394	551.9	463	387.1
331	567.5	393	555.1	462	391.0
330	568.7	392	543.5	461	392.1
329	559.8	391	502.8	460	284.2
328	504.3	390	536.8	459	383.2
327	540.1	389	537.5	458	386.3
326	538.6	388	538.2	457	397.3
325	540.6	387	540.2	456	389.2
324	542.4	386	541.7	455	401.3
323	544.6	385	531.9	454	374.6
322	536.9	384	519.4	453	335.3
321	512.9	383	557.9	451	361.0
320	551.9	382	563.1	450	380.7
319	552.1	381	564.3	449	388.1
318	555.0	380	565.7	448	384.9
317	555.9	379	567.6	447	405.5
316	557.5	378	557.5	446	402.5
315	548.7	377	515.4	445	411.6
314	502.7	376	557.6	444	412.1
313	535.2	375	564.4	443	433.6
312	537.1	374	564.5	442	433.6
311	537.7	373	564.9	441	438.6
310	538.9	372	568.8	440	451.1
309	541.0	371	559.6	437	451.7
308	535.0	370	519.1	436	437.2
307	529.9	369	558.0	435	449.7
306	573.7	368	564.4	434	444.0
305	583.4	367	565.4	433	449.9
304	585.1	366	566.4	432	456.4
303	585.2	365	566.7	431	452.5
302	586.1	364	558.5	430	435.3
301	577.2	363	516.9	429	433.6

TABLE F-48: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/20/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 500°F With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	546.2	428	495.5	492	614.1
361	609.2	427	503.2	491	94.6
360	617.3	426	505.1	490	90.8
359	615.3	425	503.9	489	94.0
358	610.2	424	500.8	488	90.1
357	606.0	423	499.2	487	101.9
356	496.9	422	496.3	486	202.5
355	594.5	421	499.8	485	188.9
354	610.0	420	493.9	484	127.9
353	614.9	419	491.2	483	140.1
352	613.3	418	501.7	482	352.0
351	609.1	417	499.3	481	316.8
350	606.4	416	495.8	480	270.4
349	553.1	415	490.9	479	223.0
348	596.9	409	493.5	478	301.2
347	609.9	408	493.8	477	369.7
346	618.0	407	496.3	476	394.1
345	615.2	406	505.2	475	389.1
344	611.4	405	541.1	474	486.9
343	607.9	404	573.2	473	480.8
342	554.8	403	585.2	472	506.3
341	598.4	402	591.6	471	471.9
340	610.5	401	589.2	470	481.9
339	616.8	400	582.5	469	480.9
338	614.3	399	583.5	468	454.2
337	610.6	398	548.4	467	416.9
336	608.9	397	584.1	466	441.6
335	553.5	396	595.7	465	451.6
334	598.4	395	601.7	464	459.9
332	616.1	394	599.2	463	442.4
331	613.2	393	596.1	462	436.9
330	608.8	392	592.1	461	434.2
329	606.8	391	541.1	460	319.3
328	541.7	390	576.2	459	419.6
327	577.5	389	584.6	458	423.2
326	584.8	388	590.7	457	432.0
325	593.8	387	588.3	456	421.0
324	591.4	386	583.9	455	444.6
323	585.6	385	580.5	454	449.5
322	584.5	384	552.8	453	436.4
321	547.8	383	593.0	451	438.2
320	587.7	382	608.3	450	438.9
319	597.3	381	614.5	449	433.7
318	605.2	380	612.2	448	435.0
317	603.5	379	607.8	447	467.1
316	598.6	378	605.1	446	465.1
315	596.3	377	548.8	445	473.6
314	540.6	376	592.2	444	471.0
313	574.2	375	608.8	443	492.3
312	583.7	374	615.4	442	488.8
311	589.4	373	612.3	441	490.3
310	587.7	372	608.6	440	501.6
309	582.9	371	606.8	437	500.7
308	583.0	370	552.9	436	488.0
307	560.5	369	593.7	435	507.2
306	606.8	368	609.6	434	493.0
305	626.3	367	615.0	433	499.6
304	633.1	366	612.1	432	503.5
303	629.6	365	607.0	431	498.5
302	624.6	364	606.0	430	493.7
301	623.7	363	549.5	429	492.2

TABLE F-49: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/22/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 500°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	570.3	428	482.4	492	615.9
361	572.9	427	489.5	491	95.2
360	575.1	426	495.1	490	91.5
359	574.2	425	492.3	489	94.9
358	574.6	424	490.9	488	90.8
357	573.5	423	486.2	487	102.6
356	481.4	422	490.3	486	196.7
355	568.9	421	492.7	485	188.9
354	574.1	420	488.3	484	131.2
353	573.0	419	486.5	483	141.9
352	572.4	418	500.1	482	348.0
351	573.2	417	497.7	481	314.5
350	573.9	416	495.5	480	261.1
349	537.8	415	491.2	479	214.7
348	570.6	409	492.7	478	298.9
347	573.0	408	492.8	477	373.9
346	574.9	407	496.0	476	399.0
345	573.5	406	504.8	475	393.7
344	575.1	405	528.8	474	491.2
343	574.5	404	551.7	473	485.0
342	539.3	403	554.1	472	508.6
341	572.2	402	553.4	471	467.6
340	573.8	401	552.8	470	471.4
339	574.2	400	551.5	469	474.9
338	573.0	399	555.7	468	453.2
337	575.0	398	534.9	467	418.2
336	575.5	397	561.6	466	439.8
335	538.0	396	563.5	465	444.9
334	572.1	395	563.5	464	450.3
332	573.3	394	562.3	463	434.6
331	571.6	393	563.8	462	437.2
330	572.6	392	563.3	461	431.5
329	573.7	391	528.6	460	316.3
328	529.4	390	555.3	459	415.9
327	555.9	389	554.6	458	418.1
326	552.6	388	554.3	457	427.9
325	554.9	387	552.9	456	419.5
324	554.4	386	553.3	455	437.9
323	554.8	385	552.9	454	431.0
322	556.0	384	537.8	453	408.1
321	534.4	383	567.7	451	415.9
320	564.4	382	572.6	450	425.1
319	563.9	381	573.0	449	428.1
318	565.6	380	571.8	448	432.5
317	565.1	379	572.2	447	465.4
316	566.0	378	573.0	446	463.4
315	566.0	377	534.3	445	472.3
314	528.0	376	566.7	444	470.1
313	553.2	375	572.8	443	491.7
312	552.9	374	573.0	442	488.2
311	551.3	373	571.3	441	489.8
310	551.1	372	572.5	440	501.3
309	552.4	371	573.8	437	498.2
308	554.7	370	537.5	436	484.2
307	543.2	369	568.0	435	499.7
306	577.6	368	573.3	434	485.7
305	586.2	367	572.8	433	492.1
304	587.1	366	571.4	432	498.5
303	584.7	365	571.0	431	493.8
302	585.0	364	573.2	430	482.9
301	586.7	363	535.2	429	477.8

TABLE F-50: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 10/17/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 500°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	600.9	428	492.5	492	610.4
361	606.8	427	500.3	491	93.9
360	612.7	426	501.7	490	90.5
359	609.0	425	500.6	489	93.7
358	607.8	424	496.6	488	89.8
357	601.5	423	495.0	487	101.8
356	505.0	422	498.1	486	202.1
355	599.2	421	501.6	485	191.9
354	603.1	420	495.2	484	126.6
353	611.4	419	492.6	483	139.8
352	608.9	418	505.5	482	355.1
351	607.0	417	500.5	481	322.4
350	601.4	416	497.1	480	272.2
349	559.9	415	491.9	479	224.6
348	601.1	409	496.0	478	303.1
347	607.2	408	496.9	477	366.6
346	612.7	407	496.9	476	390.1
345	609.0	406	506.1	475	385.9
344	608.9	405	546.4	474	483.6
343	603.0	404	576.7	473	478.2
342	561.6	403	583.2	472	503.7
341	602.5	402	587.5	471	472.2
340	607.6	401	583.9	470	483.5
339	611.6	400	580.1	469	482.3
338	608.0	399	579.7	468	455.6
337	607.8	398	555.2	467	425.6
336	603.3	397	588.5	466	451.8
335	560.6	396	593.7	465	461.2
334	602.8	395	598.2	464	467.8
332	611.7	394	595.1	463	447.2
331	607.9	393	593.8	462	444.7
330	606.4	392	587.2	461	436.6
329	601.8	391	546.7	460	320.3
328	546.2	390	579.7	459	413.5
327	580.2	389	582.9	458	415.8
326	581.9	388	587.5	457	424.8
325	588.4	387	584.2	456	411.8
324	584.5	386	581.6	455	432.3
323	583.0	385	576.3	454	442.6
322	580.1	384	560.5	453	437.9
321	553.3	383	597.8	451	437.9
320	591.0	382	606.4	450	439.7
319	594.0	381	610.9	449	435.1
318	599.6	380	607.8	448	436.2
317	596.4	379	605.5	447	467.5
316	595.0	378	600.4	446	460.6
315	590.8	377	556.3	445	465.5
314	545.5	376	597.0	444	465.8
313	577.1	375	607.0	443	491.4
312	581.3	374	611.3	442	489.7
311	585.0	373	606.9	441	491.2
310	581.9	372	606.4	440	502.4
309	580.0	371	602.4	437	498.1
308	578.5	370	560.4	436	489.3
307	569.1	369	598.3	435	503.6
306	612.2	368	508.0	434	495.0
305	624.6	367	611.6	433	502.1
304	629.0	366	608.0	432	508.3
303	624.6	365	605.0	431	502.5
302	622.7	364	601.2	430	489.7
301	618.5	363	557.1	429	489.5

TABLE F-51: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 11/14/80 TIME: 12:00 noon

TEST CONDITIONS: Uniform Canister Temperature at 550°F With Vacuum

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	637.8	428	537.9	492	590.4
361	643.7	427	548.0	491	87.2
360	649.3	426	551.0	490	82.0
359	647.9	425	550.3	489	87.9
358	643.9	424	546.7	488	84.2
357	646.5	423	544.0	487	86.9
356	509.7	422	543.0	486	204.1
355	635.7	421	547.6	485	183.9
354	644.2	420	543.5	484	126.4
353	646.5	419	541.1	483	117.2
352	645.1	418	552.9	482	386.7
351	642.5	417	549.9	481	354.9
350	646.3	416	539.6	480	292.3
349	598.7	415	531.8	479	234.3
348	638.2	409	537.8	478	349.2
347	644.3	408	538.0	477	342.2
346	649.7	407	536.7	476	363.0
345	647.3	406	546.4	475	366.7
344	645.0	405	589.0	474	467.3
343	647.6	404	617.3	473	464.0
342	600.1	403	622.3	472	490.8
341	639.3	402	626.5	471	476.8
340	644.5	401	624.1	470	497.0
339	648.3	400	617.9	469	517.4
338	645.9	399	627.1	468	516.7
337	644.3	398	594.8	467	502.7
336	648.3	397	626.6	466	527.3
335	598.6	396	631.0	465	529.3
334	639.3	395	634.9	464	519.6
332	647.4	394	632.5	463	491.9
331	644.9	393	630.4	462	488.3
330	642.3	392	634.3	461	481.6
329	646.7	391	588.3	460	368.4
328	589.2	390	619.8	459	470.3
327	621.5	389	621.2	458	471.0
326	621.7	388	624.6	457	480.8
325	628.1	387	622.3	456	473.6
324	625.6	386	619.0	455	491.9
323	621.6	385	624.2	454	502.1
322	627.5	384	598.5	453	488.6
321	594.1	383	634.5	451	479.1
320	630.0	382	642.5	450	485.1
319	632.5	381	646.8	449	488.7
318	637.7	380	644.5	448	490.9
317	636.3	379	641.1	447	531.2
316	633.4	378	645.4	446	530.1
315	637.4	377	595.0	445	543.4
314	587.4	376	634.0	444	527.5
313	617.7	375	643.5	443	546.2
312	620.4	374	647.7	442	538.0
311	622.8	373	645.0	441	539.5
310	621.7	372	642.0	440	548.4
309	618.6	371	646.8	437	506.5
308	625.3	370	598.3	436	533.2
307	604.9	369	634.7	435	547.7
306	646.8	368	643.6	434	538.5
305	659.1	367	646.7	433	547.1
304	663.6	366	644.0	432	554.4
303	660.2	365	640.3	431	549.6
302	656.9	364	646.1	430	536.1
301	660.9	363	595.8	429	534.0

TABLE F-52: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 11/17/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 550°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	614.7	428	544.3	492	606.0
361	618.5	427	551.6	491	94.5
360	626.4	426	555.7	490	90.3
359	623.7	425	553.4	489	93.7
358	617.6	424	551.9	488	88.0
357	625.5	423	548.3	487	97.2
356	515.5	422	544.7	486	213.6
355	613.3	421	548.8	485	211.4
354	619.8	420	544.6	484	131.1
353	624.3	419	542.2	483	133.0
352	621.0	418	554.0	482	392.9
351	616.4	417	551.3	481	368.2
350	625.3	416	546.9	480	296.4
349	585.2	415	539.5	479	249.6
348	615.0	409	544.1	478	332.1
347	618.9	408	544.3	477	359.9
346	626.5	407	544.6	476	385.5
345	622.2	406	554.7	475	380.5
344	618.3	405	577.3	474	479.1
343	625.9	404	597.8	473	473.5
342	586.5	403	602.2	472	501.5
341	616.4	402	608.4	471	472.6
340	619.5	401	604.6	470	491.2
339	625.4	400	595.7	469	518.4
338	621.5	399	610.1	468	529.6
337	618.2	398	582.4	467	508.9
336	626.8	397	606.5	466	523.5
335	585.2	396	610.4	465	531.7
334	616.3	395	616.2	464	532.6
332	624.4	394	612.2	463	500.7
331	620.2	393	607.5	462	487.2
330	615.9	392	616.5	461	475.6
329	625.0	391	576.9	460	361.1
328	577.9	390	601.0	459	469.7
327	601.8	389	602.2	458	470.5
326	600.6	388	608.0	457	478.6
325	609.4	387	603.6	456	472.2
324	605.6	386	597.7	455	497.8
323	599.3	385	607.5	454	512.6
322	610.2	384	585.0	453	498.8
321	582.1	383	612.1	451	479.7
320	609.3	382	618.6	450	489.2
319	610.4	381	624.8	449	494.6
318	618.0	380	620.7	448	494.5
317	614.6	379	615.2	447	523.6
316	609.7	378	624.6	446	518.1
315	618.4	377	582.1	445	526.7
314	576.3	376	611.4	444	523.2
313	598.7	375	618.7	443	548.6
312	600.5	374	624.9	442	545.3
311	605.1	373	621.0	441	546.7
310	602.2	372	615.5	440	556.6
309	596.8	371	625.5	437	507.3
308	608.7	370	584.9	436	534.2
307	590.0	369	612.2	435	547.1
306	621.0	368	618.9	434	541.2
305	630.6	367	624.2	433	549.3
304	636.8	366	620.0	432	556.6
303	632.1	365	614.1	431	551.1
302	626.8	364	624.8	430	543.5
301	636.4	363	582.9	429	539.3

TABLE F-53: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 11/12/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 550°F With Air

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	645.9	428	540.7	492	607.3
361	644.6	427	549.6	491	92.1
360	646.8	426	551.4	490	87.6
359	644.3	425	550.6	489	91.5
358	641.7	424	546.9	488	87.6
357	640.9	423	544.9	487	95.0
356	535.4	422	549.2	486	213.6
355	642.5	421	551.7	485	197.9
354	644.9	420	547.5	484	134.7
353	644.5	419	546.4	483	129.4
352	642.7	418	557.9	482	394.6
351	640.4	417	553.3	481	365.3
350	639.9	416	542.2	480	293.7
349	608.1	415	535.0	479	238.2
348	645.8	409	541.9	478	350.0
347	645.1	408	542.4	477	360.4
346	647.3	407	538.3	476	386.9
345	644.0	406	547.8	475	383.4
344	642.6	405	598.3	474	482.6
343	642.1	404	625.5	473	477.5
342	609.0	403	623.4	472	505.6
341	646.4	402	624.0	471	483.3
340	645.2	401	621.5	470	504.3
339	646.4	400	615.7	469	525.6
338	642.8	399	621.7	468	527.9
337	641.6	398	604.1	467	508.3
336	642.4	397	634.0	466	527.9
335	607.0	396	631.6	465	528.6
334	646.0	395	632.7	464	521.4
332	645.5	394	630.2	463	493.3
331	642.2	393	627.9	462	489.9
330	640.0	392	628.0	461	481.9
329	640.6	391	596.0	460	367.8
328	597.3	390	626.5	459	470.2
327	628.9	389	622.4	458	471.1
326	622.8	388	622.8	457	479.8
325	625.8	387	620.5	456	472.5
324	622.4	386	616.8	455	492.0
323	619.1	385	618.1	454	505.1
322	622.2	384	608.4	453	493.0
321	602.5	383	642.3	451	473.8
320	637.1	382	643.2	450	482.0
319	633.5	381	644.5	449	490.1
318	635.9	380	641.9	448	499.5
317	632.9	379	638.8	447	541.1
316	630.2	378	639.4	446	542.5
315	631.7	377	605.0	445	554.0
314	594.2	376	642.2	444	532.9
313	624.0	375	644.5	443	544.5
312	621.8	374	645.4	442	536.8
311	621.3	373	641.8	441	538.9
310	619.2	372	639.8	440	549.0
309	616.2	371	641.2	437	513.3
308	619.4	370	607.5	436	536.8
307	615.0	369	641.9	435	550.0
306	654.4	368	644.4	434	538.4
305	660.1	367	644.7	433	540.6
304	661.3	366	641.7	432	554.0
303	657.4	365	638.2	431	549.6
302	654.6	364	639.9	430	537.7
301	655.3	363	605.7	429	536.9

TABLE F-54: FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST THERMOCOUPLE DATA
FUEL ASSEMBLY: D15

DATE: 11/20/80 TIME: 8:00 a.m.
TEST CONDITIONS: Uniform Canister Temperature at 600°F With Helium

T/C No.	Temp(°F)	T/C No.	Temp(°F)	T/C No.	Temp(°F)
362	666.2	428	592.9	492	607.3
361	667.1	427	601.3	491	94.2
360	670.9	426	605.2	490	89.8
359	667.6	425	603.1	489	93.4
358	665.6	424	601.6	488	86.9
357	676.9	423	598.3	487	95.6
356	557.0	422	600.4	486	235.9
355	664.1	421	605.1	485	237.0
354	667.9	420	601.6	484	144.5
353	668.1	419	599.7	483	130.6
352	664.9	418	604.1	482	440.7
351	664.3	417	601.2	481	422.3
350	676.7	416	582.9	480	332.7
349	636.0	415	574.1	479	282.8
348	666.5	409	581.8	478	360.1
347	667.3	408	582.1	477	357.5
346	670.7	407	582.5	476	383.5
345	666.3	406	592.5	475	379.7
344	666.2	405	629.7	474	481.1
343	677.0	404	650.9	473	475.9
342	637.0	403	652.5	472	510.6
341	667.5	402	654.3	471	500.7
340	667.7	401	650.0	470	537.8
339	669.5	400	645.5	469	580.7
338	665.5	399	663.3	468	606.2
337	666.1	398	633.8	467	589.6
336	678.1	397	658.2	466	597.7
335	635.4	396	659.2	465	596.6
334	667.3	395	660.8	464	583.2
332	668.3	394	656.6	463	558.1
331	664.2	393	656.4	462	551.1
330	663.8	392	669.4	461	542.4
329	676.3	391	628.5	460	429.1
328	629.8	390	653.4	459	534.6
327	654.8	389	651.9	458	532.6
326	650.9	388	653.1	457	541.3
325	655.2	387	648.5	456	532.3
324	650.8	386	647.4	455	554.1
323	648.5	385	661.3	454	563.1
322	662.8	384	635.9	453	543,1
321	633.1	383	663.4	451	543.2
320	661.2	382	666.9	450	553.3
319	659.5	381	669.0	449	558.2
318	662.8	380	664.7	448	557.7
317	659.1	379	663.4	447	589.2
316	658.2	378	676.2	446	584.9
315	670.0	377	633.0	445	594.7
314	627.4	376	662.9	444	582.5
313	651.1	375	667.3	443	603.1
312	650.4	374	669.4	442	589.3
311	650.6	373	665.0	441	582.9
310	647.2	372	663.7	440	590.7
309	646.4	371	677.0	437	529.8
308	661.4	370	635.4	436	592.5
307	640.0	369	663.2	435	606.1
306	671.5	368	667.1	434	596.7
305	678.2	367	668.2	433	605.0
304	680.2	366	664.0	432	611.2
303	675.3	365	662.2	431	604.4
302	673.9	364	676.8	430	592.5
301	686.7	363	633.7	429	587.8

APPENDIX G

AIR-COOLED VAULT TEST DATA

Test data are provided in this appendix for the Air-Cooled Vault Test. Table G-1 provides the detailed identification and location of the test thermocouples. Tables G-2 through G-5 provides thermocouple readings at the times and for the operating conditions shown below:

OPERATING CONDITIONS

Table No.	Date	Time	Air Flow	F/A In Center Vault	Total No. of F/A in Vault
G-2	12/4/79	10:07 a.m.	Forced Ventilation	8	11
-2	12/5/79	9:24 a.m.	Partial Ventilation	8	11
-2	12/6/79	9:02 a.m.	Partial Ventilation	8	11
-2	12/7/79	7:55 a.m.	Natural Circulation	8	11
-2	12/15/79	8:00 a.m.	Forced Ventilation	8	13
-2	12/22/79	8:00 a.m.	Forced Ventilation	8	13
-2	1/1/80	8:00 a.m.	Forced Ventilation	8	13
-2	1/8/80	8:00 a.m.	Forced Ventilation	8	13
-2	1/15/80	8:00 a.m.	Forced Ventilation	8	13
-2	1/22/80	8:00 a.m.	Forced Ventilation	8	13
-2	2/1/80	8:00 a.m.	Forced Ventilation	8	13
-2	2/8/80	8:00 a.m.	Forced Ventilation	8	13
G-3	2/15/80	8:00 a.m.	Forced Ventilation	8	13
-3	2/22/80	8:00 a.m.	Forced Ventilation	8	13
-3	3/1/80	8:00 a.m.	Forced Ventilation	8	13
-3	3/8/80	8:00 a.m.	Forced Ventilation	8	13
-3	3/15/80	8:00 a.m.	Forced Ventilation	8	13
-3	3/22/80	8:00 a.m.	Forced Ventilation	8	13
-3	4/1/80	8:00 a.m.	Forced Ventilation	8	13
-3	4/8/80	8:00 a.m.	Forced Ventilation	8	13
-3	4/13/80	4:00 p.m.	Forced Ventilation	8	13
-3	4/14/80	4:00 p.m.	Forced Ventilation	7	12
-3	4/21/80	8:00 a.m.	Forced Ventilation	7	12
-3	4/22/80	8:00 a.m.	Forced Ventilation	6	11
G-4	4/24/80	8:00 a.m.	Forced Ventilation	6	11
-4	4/25/80	8:00 a.m.	Forced Ventilation	5	10
-4	4/28/80	12:00 midnight	Forced Ventilation	5	10
-4	4/29/80	12:00 midnight	Forced Ventilation	4	9
-4	4/29/80	11:30 a.m.	Forced Ventilation	4	9
-4	4/29/80	12:00 noon	Natural Circulation	4	9
-4	4/29/80	4:00 p.m.	Natural Circulation	4	9
-4	4/29/80	8:00 p.m.	Natural Circulation	4	9

OPERATING CONDITIONS

Table No.	Date	Time	Air Flow	F/A In Center Vault	Total No. of F/A in Vault
G-4	4/30/80	12:00 midnight	Natural Circulation	4	9
-4	4/30/80	5:42 a.m.	Natural Circulation	4	9
-4	4/30/80	8:00 a.m.	Natural Circulation	4	9
-4	5/1/80	8:00 a.m.	Natural Circulation	3	8
G-5	5/1/80	4:00 p.m.	Natural Circulation	3	8
-5	5/2/80	12:00 noon	Natural Circulation	3	8
-5	5/2/80	4:00 p.m.	Natural Circulation	3	8
-5	5/4/80	4:00 p.m.	Forced Ventilation	3	8
-5	5/9/80	4:00 p.m.	Natural Circulation	2	6
-5	5/19/80	8:00 a.m.	Forced Ventilation	2	4
-5	5/22/80	8:00 a.m.	Natural Circulation	1	2
-5	5/28/80	8:00 a.m.	Forced Ventilation	1	2
-5	6/4/80	12:00 noon	Forced Ventilation	1	2
-5	6/4/80	4:00 p.m.	Natural Circulation	2	2
-5	6/8/80	4:00 p.m.	Natural Circulation	2	2
-5	6/12/80	4:00 p.m.	Forced Ventilation	2	2
G-6	6/18/80	4:00 p.m.	Forced Ventilation	2	2
-6	6/19/80	4:00 p.m.	Natural Circulation	2	2
-6	6/22/80	4:00 p.m.	Natural Circulation	2	2

TABLE G-1

AIR-COOLED VAULT THERMOCOUPLE LOCATIONS

Data Channel (T/C) No.	Distance From Floor Level (In.)	Location
919	60 (above)	Outlet Pipe 9 (North End of Vault)
918	60 (above)	Outlet Pipe 8
917	60 (above)	Outlet Pipe 7
916	60 (above)	Outlet Pipe 6
915	60 (above)	Outlet Pipe 5
914	60 (above)	Outlet Pipe 4
913	60 (above)	Outlet Pipe 3
912	60 (above)	Outlet Pipe 2
911	60 (above)	Outlet Pipe 1 (South End of Vault)
909	129.85 (below)	Canister Body (East Side)
908	128.00 (below)	Canister Body (West Side)
901	--	Weld Pit Table (Near Window E-5)

TABLE G-2. AIR-COOLED VAULT TEST THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 12/4/79
TIME: 10:07 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 11

T/C No.	Temp(°F)
919	67.1
918	67.2
917	67.4
916	76.5
915	77.8
914	76.6
913	75.1
912	72.4
911	69.1
909	135.5
908	141.3
901	

DATE: 12/5/79
TIME: 9:24 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Partial Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 11

T/C No.	Temp(°F)
919	67.7
918	67.7
917	68.1
916	97.9
915	99.2
914	100.3
913	83.8
912	84.0
911	81.1
909	172.3
908	175.3
901	

DATE: 12/6/79
TIME: 7:55 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 11

T/C No.	Temp(°F)
919	65.9
918	65.8
917	68.9
916	101.3
915	103.0
914	103.4
913	86.2
912	86.2
911	83.3
909	176.8
908	181.0
901	

DATE: 12/7/79
TIME: 9:02 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Partial Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 11

T/C No.	Temp(°F)
919	68.2
918	68.4
917	68.6
916	83.6
915	83.6
914	79.3
913	77.4
912	70.6
911	70.3
909	150.1
908	143.7
901	

DATE: 12/15/79
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	67.3
918	67.5
917	67.7
916	76.9
915	78.2
914	77.3
913	78.0
912	76.0
911	70.3
909	146.3
908	139.7
901	

DATE: 12/22/79
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	67.8
918	68.1
917	68.2
916	77.4
915	78.9
914	77.9
913	78.9
912	76.5
911	71.1
909	147.3
908	140.5
901	71.3

DATE: 1/1/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	64.4
918	64.5
917	64.7
916	73.7
915	75.1
914	74.5
913	75.4
912	73.1
911	67.7
909	148.6
908	136.2
901	67.5

DATE: 1/8/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	64.6
918	64.7
917	64.7
916	73.6
915	75.1
914	74.4
913	75.3
912	73.0
911	67.5
909	148.5
908	135.9
901	67.9

DATE: 1/15/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	65.0
918	65.2
917	65.2
916	74.2
915	75.4
914	74.5
913	75.6
912	73.1
911	67.9
909	147.6
908	135.3
901	

DATE: 1/22/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	63.7
918	63.9
917	64.1
916	72.6
915	73.9
914	73.2
913	74.2
912	71.8
911	66.6
909	145.4
908	133.2
901	67.0

DATE: 2/1/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	64.0
918	64.3
917	64.3
916	73.0
915	74.3
914	73.5
913	74.5
912	72.3
911	67.1
909	144.4
908	132.5
901	67.4

DATE: 2/8/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	65.3
918	65.5
917	65.5
916	74.1
915	75.3
914	74.3
913	75.5
912	73.4
911	68.2
909	145.3
908	133.4
901	68.6

TABLE G-3. AIR-COOLED VAULT TEST THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 2/15/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	64.7
918	65.0
917	64.9
916	73.6
915	74.7
914	73.9
913	75.0
912	72.8
911	67.7
909	144.1
908	132.5
901	67.8

DATE: 2/22/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	64.6
918	64.9
917	64.8
916	73.2
915	74.3
914	73.9
913	74.7
912	72.7
911	67.3
909	142.7
908	131.5
901	67.9

DATE: 3/1/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	66.9
918	67.1
917	67.1
916	75.5
915	76.4
914	75.7
913	76.8
912	74.6
911	69.6
909	144.1
908	133.0
901	70.4

DATE: 3/8/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	65.4
918	65.7
917	65.6
916	73.9
915	75.0
914	74.5
913	75.4
912	73.4
911	68.2
909	142.2
908	131.2
901	68.6

DATE: 3/15/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	66.5
918	66.7
917	66.6
916	74.7
915	75.9
914	75.1
913	76.1
912	74.1
911	69.1
909	142.6
908	131.7
901	70.1

DATE: 3/22/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	66.6
918	66.8
917	66.8
916	75.1
915	76.2
914	75.5
913	76.5
912	74.4
911	69.4
909	142.5
908	131.7
901	70.1

DATE: 4/1/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	66.3
918	66.5
917	66.4
916	74.8
915	75.7
914	75.1
913	76.2
912	74.1
911	69.2
909	141.7
908	130.9
901	69.7

DATE: 4/8/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	68.0
918	68.3
917	68.2
916	76.2
915	77.2
914	76.6
913	77.5
912	75.3
911	70.4
909	141.4
908	130.9
901	71.7

DATE: 4/13/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 8
- TOTAL F/A'S IN VAULT: 13

T/C No.	Temp(°F)
919	70.1
918	70.4
917	70.2
916	77.9
915	79.0
914	78.7
913	79.3
912	77.4
911	72.4
909	150.2
908	134.1
901	73.9

DATE: 4/14/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 7
- TOTAL F/A'S IN VAULT: 12

T/C No.	Temp(°F)
919	72.0
918	72.4
917	72.0
916	77.7
915	80.6
914	80.5
913	81.2
912	79.2
911	74.2
909	151.1
908	135.5
901	76.4

DATE: 4/21/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 7
- TOTAL F/A'S IN VAULT: 12

T/C No.	Temp(°F)
919	74.6
918	74.9
917	74.5
916	80.2
915	83.1
914	82.9
913	83.7
912	81.4
911	76.9
909	153.0
908	137.0
901	78.4

DATE: 4/22/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 6
- TOTAL F/A'S IN VAULT: 11

T/C No.	Temp(°F)
919	74.7
918	75.1
917	74.7
916	80.3
915	82.4
914	81.8
913	83.8
912	81.9
911	77.2
909	151.7
908	135.8
901	78.7

TABLE G-4. AIR-COOLED VAULT TEST THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 4/24/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 6
- TOTAL F/A'S IN VAULT: 11

T/C No.	Temp(°F)
919	74.0
918	74.4
917	74.0
916	79.4
915	81.4
914	81.0
913	83.0
912	81.3
911	76.4
909	150.2
908	134.3
901	77.6

DATE: 4/25/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 5
- TOTAL F/A'S IN VAULT: 10

T/C No.	Temp(°F)
919	73.7
918	74.1
917	73.8
916	79.3
915	80.6
914	78.9
913	83.0
912	81.2
911	76.2
909	147.5
908	132.8
901	77.3

DATE: 4/28/80
TIME: 12:00 midnight
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 5
- TOTAL F/A'S IN VAULT: 10

T/C No.	Temp(°F)
919	74.2
918	74.5
917	74.1
916	79.5
915	80.7
914	78.9
913	82.9
912	81.2
911	76.4
909	147.3
908	132.5
901	77.5

DATE: 4/29/80
TIME: 12:00 midnight
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	74.5
918	74.8
917	74.4
916	77.9
915	80.2
914	79.1
913	83.4
912	81.5
911	76.7
909	147.1
908	133.0
901	77.9

DATE: 4/29/80
TIME: 11:30 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	73.6
918	74.0
917	73.7
916	77.2
915	79.5
914	78.5
913	83.0
912	81.0
911	76.1
909	147.0
908	132.6
901	76.7

DATE: 4/29/80
TIME: 12:00 noon
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	72.7
918	72.9
917	72.6
916	84.8
915	85.0
914	85.7
913	89.6
912	88.7
911	86.1
909	150.6
908	141.4
901	76.0

DATE: 4/29/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	72.5
918	72.8
917	72.4
916	87.7
915	87.6
914	89.1
913	92.8
912	91.9
911	89.9
909	163.9
908	156.6
901	76.0

DATE: 4/29/80
TIME: 8:00 p.m.
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	73.7
918	74.0
917	73.6
916	88.9
915	88.8
914	90.4
913	94.2
912	93.3
911	91.4
909	167.7
908	160.4
901	77.3

DATE: 4/30/80
TIME: 12:00 midnight
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	73.6
918	73.8
917	73.5
916	89.6
915	89.5
914	91.0
913	94.6
912	93.9
911	92.1
909	169.4
908	162.1
901	77.1

DATE: 4/30/70
TIME: 5;42 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	73.4
918	73.8
917	73.4
916	90.0
915	90.0
914	91.5
913	95.1
912	94.4
911	92.9
909	170.2
908	163.1
901	77.0

DATE: 4/30/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 4
- TOTAL F/A'S IN VAULT: 9

T/C No.	Temp(°F)
919	73.4
918	73.6
917	73.3
916	90.1
915	90.0
914	91.6
913	95.4
912	94.5
911	93.1
909	170.4
908	163.2
901	77.0

DATE: 5/1/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 3
- TOTAL F/A'S IN VAULT: 8

T/C No.	Temp(°F)
919	73.6
918	73.9
917	73.5
916	88.7
915	88.4
914	89.4
913	95.9
912	95.6
911	94.6
909	170.1
908	162.4
901	77.6

TABLE G-5. AIR-COOLED VAULT TEST THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 5/1/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 3
- TOTAL F/A'S IN VAULT: 8

T/C No.	Temp(°F)
919	72.6
918	72.9
917	72.5
916	88.3
915	88.1
914	89.3
913	96.2
912	95.7
911	94.9
909	170.1
908	162.2
901	75.6

DATE: 5/2/80
TIME: 12:00 noon
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 3
- TOTAL F/A'S IN VAULT: 8

T/C No.	Temp(°F)
919	73.8
918	74.0
917	73.6
916	89.0
915	88.7
914	90.0
913	96.9
912	96.7
911	95.7
909	170.2
908	162.3
901	77.4

DATE: 5/2/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 3
- TOTAL F/A'S IN VAULT: 8

T/C No.	Temp(°F)
919	74.3
918	74.7
917	74.5
916	80.1
915	82.0
914	82.4
913	89.3
912	87.1
911	81.7
909	168.5
908	156.3
901	78.9

DATE: 5/4/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 3
- TOTAL F/A'S IN VAULT: 8

T/C No.	Temp(°F)
919	74.2
918	74.5
917	74.2
916	77.0
915	78.4
914	78.8
913	83.6
912	81.7
911	77.0
909	145.8
908	131.5
901	77.6

DATE: 5/9/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 6

T/C No.	Temp(°F)
919	74.3
918	74.8
917	74.6
916	85.4
915	84.1
914	86.0
913	93.2
912	93.7
911	92.5
909	169.2
908	161.0
901	75.8

DATE: 5/19/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:

- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 4

T/C No.	Temp(°F)
919	75.3
918	75.6
917	75.2
916	76.4
915	77.6
914	79.0
913	79.8
912	78.1
911	76.0
909	144.4
908	130.3
901	78.6

DATE: 5/22/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 1
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	77.5
918	77.7
917	77.5
916	82.3
915	82.3
914	83.7
913	84.3
912	83.8
911	82.9
909	166.4
908	159.2
901	

DATE: 5/28/80
TIME: 8:00 a.m.
OPERATING CONDITIONS:

- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 1
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	75.9
918	76.3
917	75.9
916	76.5
915	76.4
914	78.8
913	78.9
912	76.9
911	76.3
909	142.7
908	128.9
901	79.7

DATE: 6/4/80
TIME: 12:00 noon
OPERATING CONDITIONS:

- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 1
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	76.9
918	77.2
917	76.8
916	77.4
915	77.6
914	80.4
913	77.6
912	77.3
911	76.8
909	142.2
908	129.1
901	80.1

DATE: 6/4/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	77.1
918	77.4
917	77.0
916	77.9
915	78.2
914	81.7
913	77.8
912	77.7
911	77.3
909	153.0
908	144.8
901	80.1

DATE: 6/8/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	76.8
918	77.1
917	76.7
916	86.6
915	86.2
914	85.8
913	77.7
912	77.6
911	76.9
909	166.0
908	160.5
901	78.9

DATE: 6/12/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	80.2
918	80.4
917	79.9
916	80.9
915	81.3
914	84.3
913	80.2
912	80.4
911	79.9
909	148.1
908	134.1
901	81.9

TABLE G-6. AIR-COOLED VAULT TEST THERMOCOUPLE DATA, FUEL ASSEMBLY: D22

DATE: 6/18/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Forced Vent
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	82.3
918	82.5
917	82.0
916	82.7
915	83.0
914	86.0
913	82.0
912	82.2
911	81.9
909	149.5
908	135.6
901	84.2

DATE: 6/19/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	83.9
918	84.0
917	83.8
916	89.0
915	88.6
914	89.4
913	82.6
912	83.4
911	83.1
909	165.7
908	160.0
901	84.3

DATE: 6/22/80
TIME: 4:00 p.m.
OPERATING CONDITIONS:

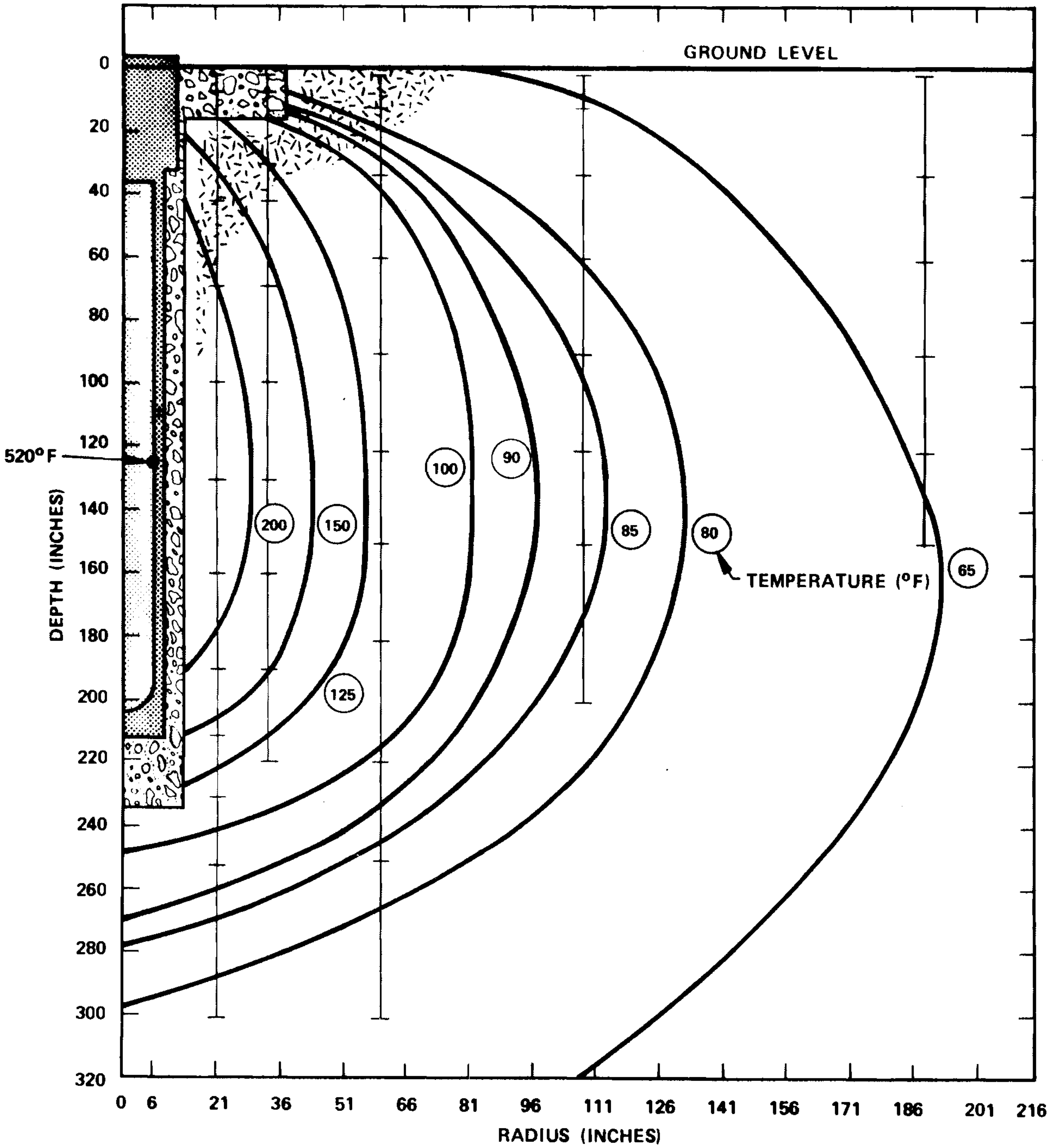
- AIR FLOW: Natural Circ.
- NO. OF F/A'S IN CENTER VAULT: 2
- TOTAL F/A'S IN VAULT: 2

T/C No.	Temp(°F)
919	81.5
918	81.8
917	81.4
916	90.8
915	90.3
914	90.0
913	81.5
912	81.8
911	81.4
909	168.9
908	162.7
901	83.4

APPENDIX H

ELECTRICALLY HEATED DRYWELL TEST DATA ILLUSTRATIONS

This appendix provides supplementary test data illustrations.



615576-2AA

Figure H-1. Soil Isotherms at End of Accelerated Heatup Period, May 1, 1978

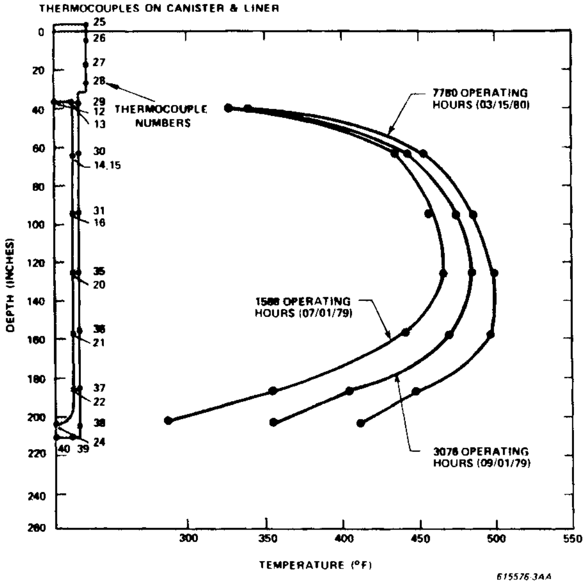


Figure H-2. Comparison of Canister Axial Temperature Profiles During 2 kW Operation

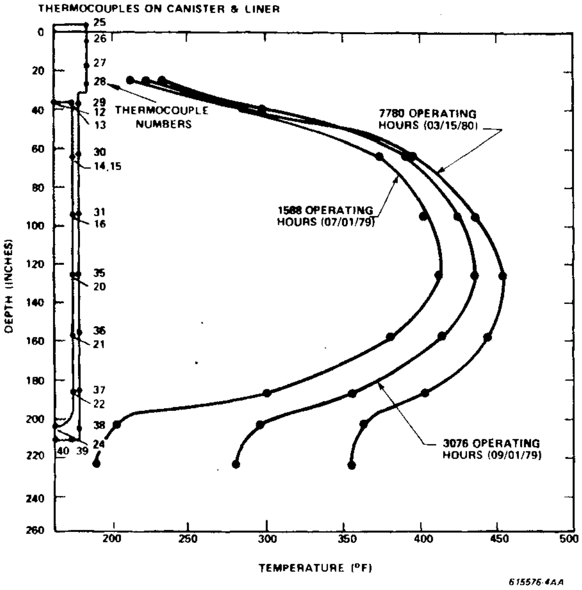


Figure H-3. Comparison of Liner Axial Temperature Profiles During 2 kW Operation

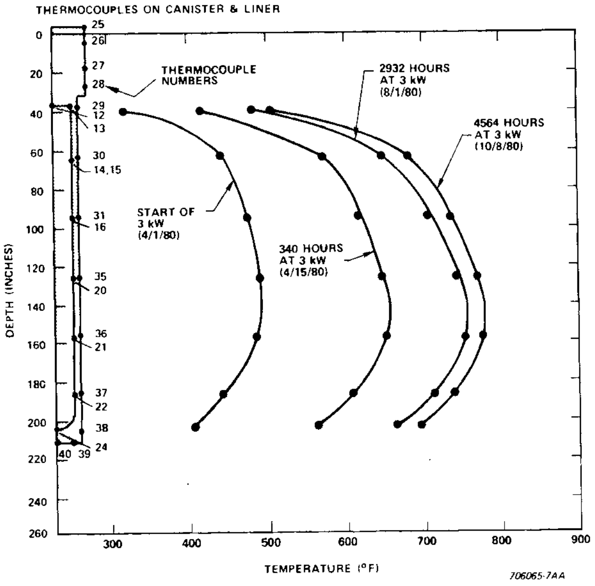


Figure H-4. Comparison of Canister Axial Temperature Profiles During 3 kW Operation

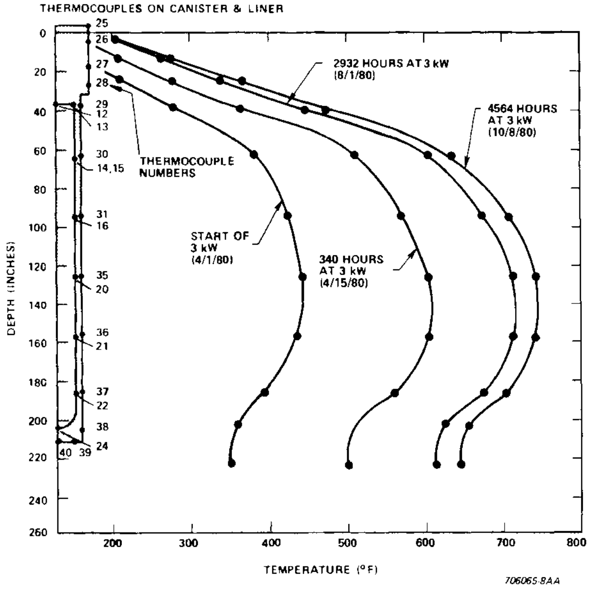


Figure H-5. Comparison of Liner Axial Temperature Profiles During 3 kW Operation

APPENDIX I

FUELED DRYWELL TEST DATA ILLUSTRATIONS

This appendix provides supplementary test data illustrations of canister, liner and soil temperature distributions for all four fueled drywells at various depths below ground level.

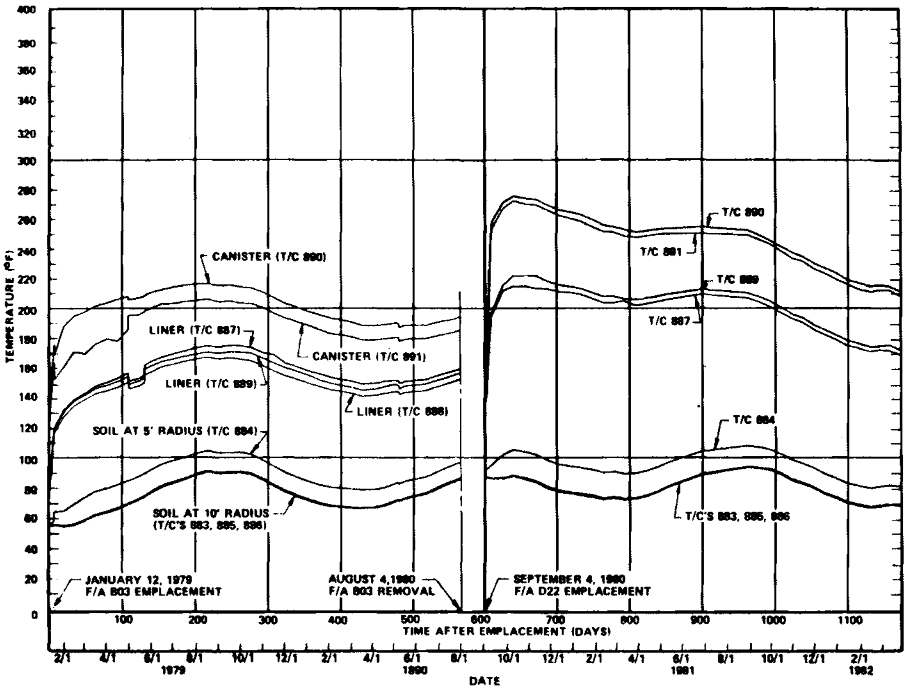


Figure I-1. Drywell 5 (F/A B03 and D22) Canister, Liner, and Soil Temperature Distributions at About 85 Inches Below Ground Level, January 12, 1979 to March 31, 1982

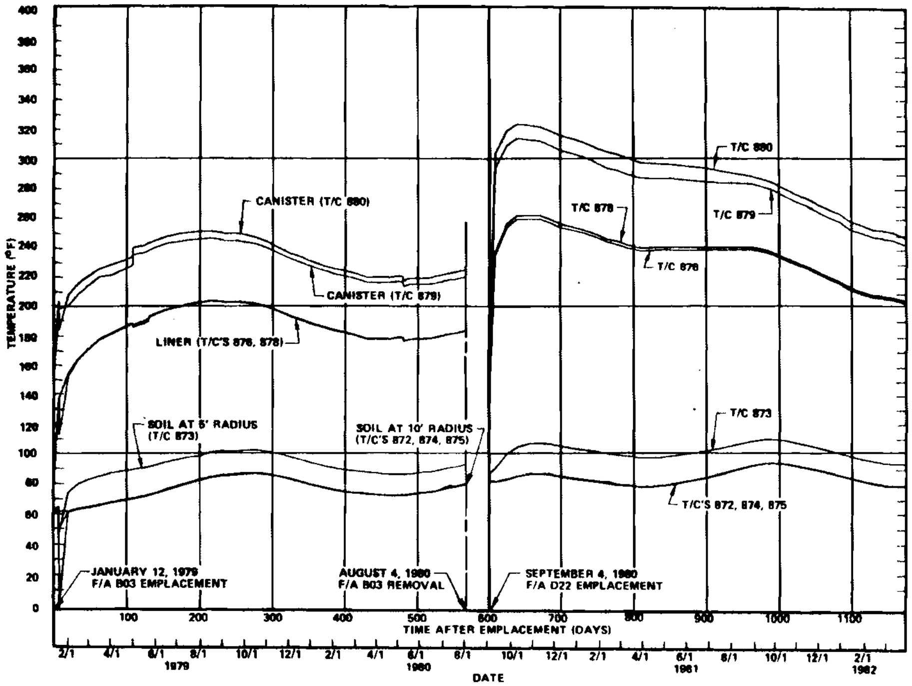


Figure I-2. Drywell 5 (F/A B03 and D22) Canister, Liner, and Soil Temperature Distributions at About 145 Inches Below Ground Level, January 12, 1979 to March 31, 1982

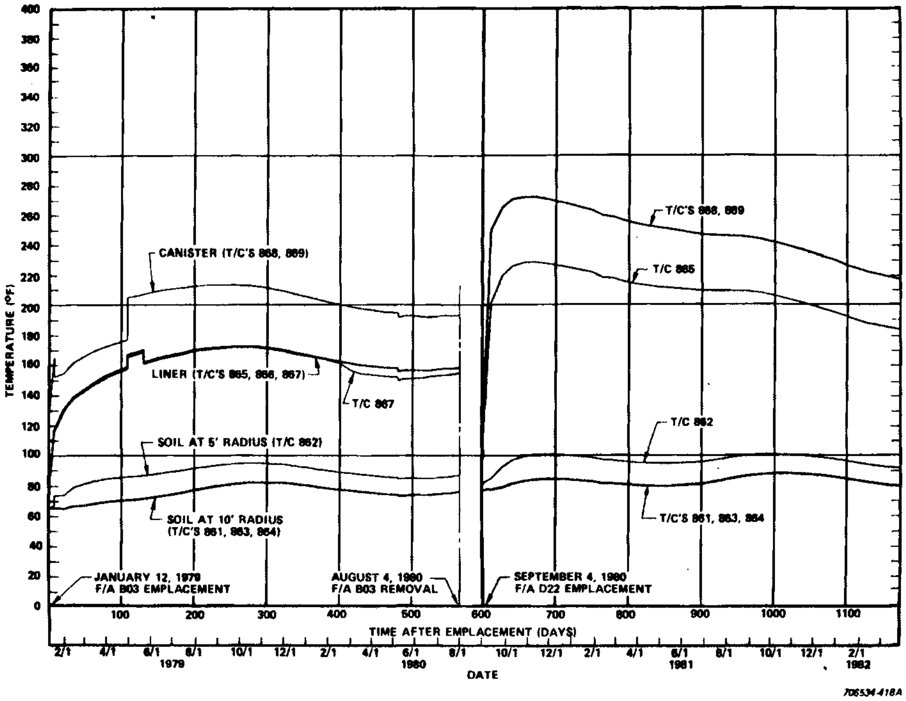


Figure I-3. Drywell 5 (F/A B03 and D22) Canister, Liner, and Soil Temperature Distributions at About 205 Inches Below Ground Level, January 12, 1979 to March 31, 1982

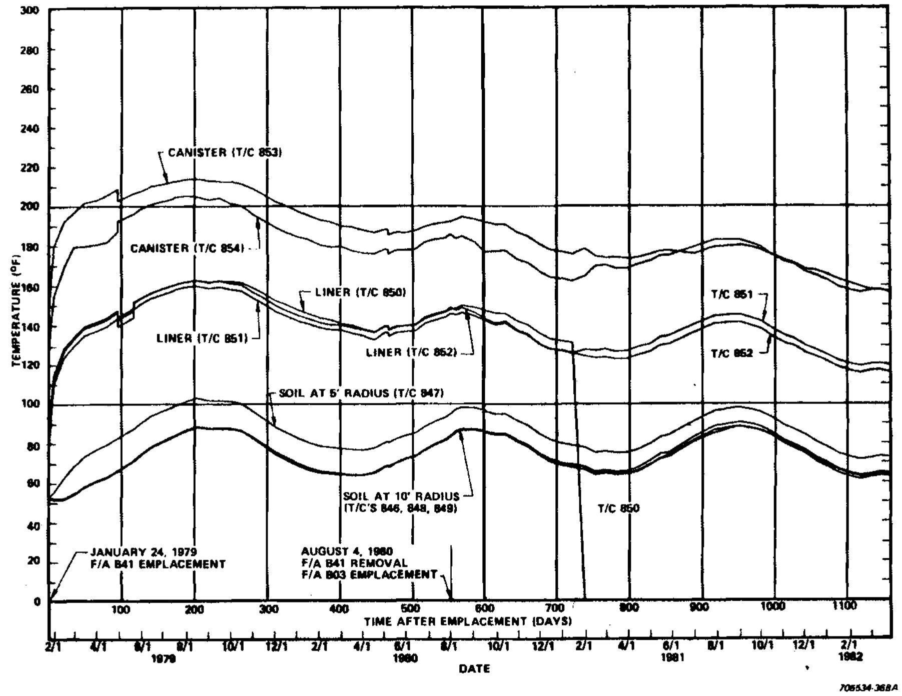
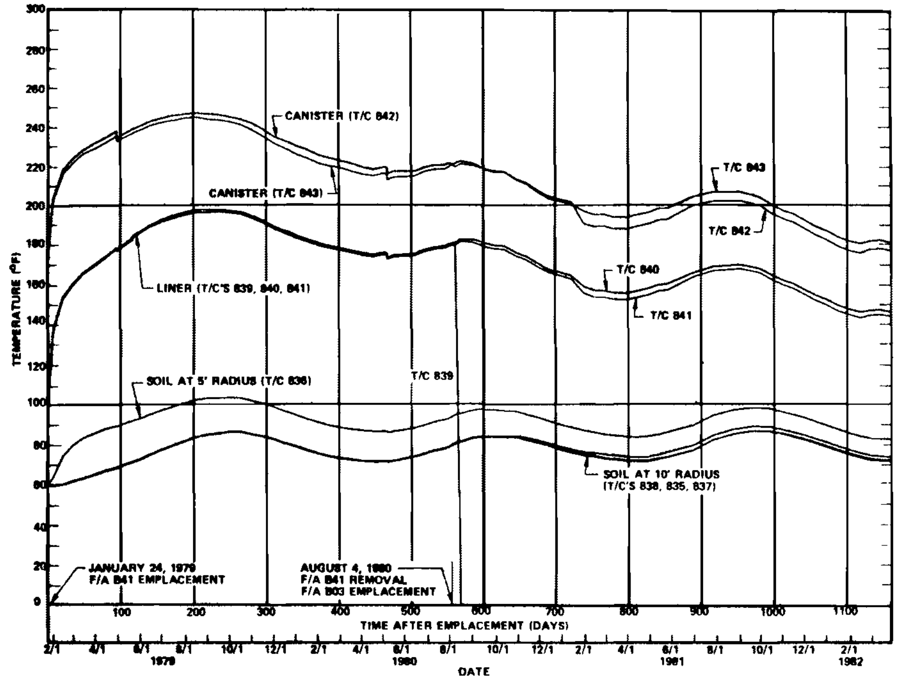
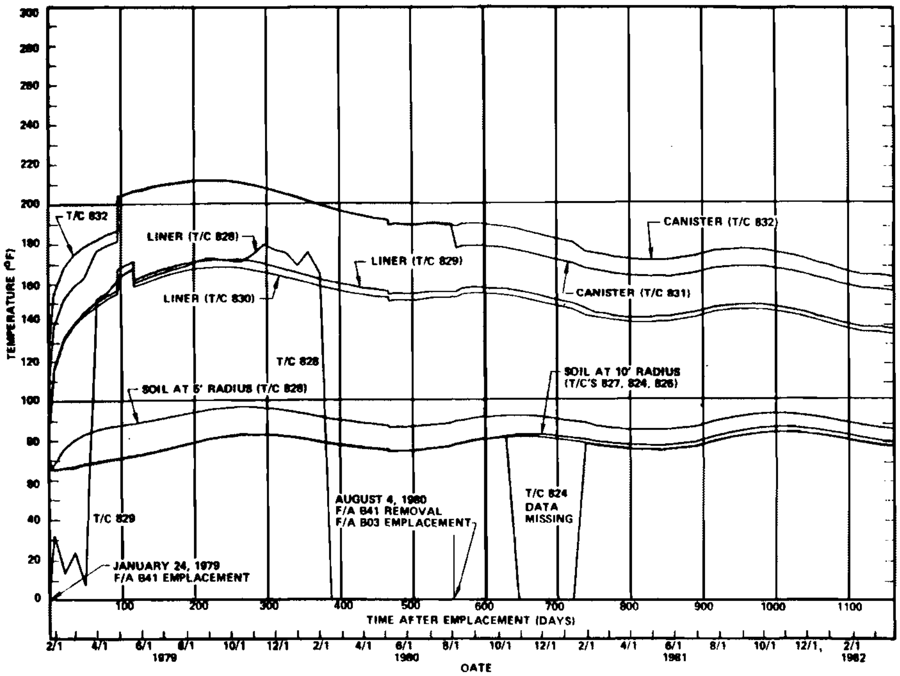


Figure I-4. Drywell 3 (F/A B41 and B03) Canister, Liner, and Soil Temperature Distributions at About 85 Inches Below Ground Level, January 24, 1979 to March 31, 1982



706534 378A

Figure I-5. Drywell 3 (F/A B41 and B03) Canister, Liner, and Soil Temperature Distributions at About 145 Inches Below Ground Level, January 24, 1979 to March 31, 1982



706534 388A

Figure I-6. Drywell 3 (F/A B41 and B03) Canister, Liner, and Soil Temperature Distributions at About 205 Inches Below Ground Level, January 24, 1979 to March 31, 1982

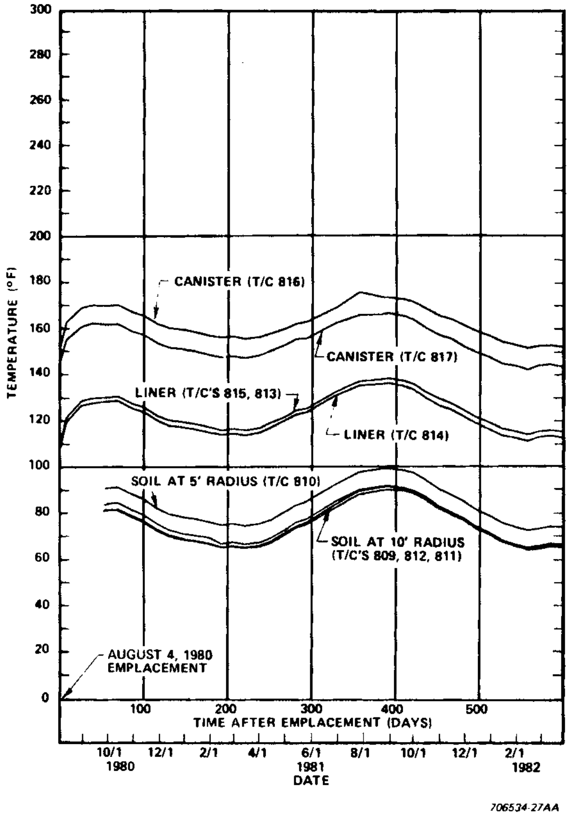


Figure I-7. Drywell 2 (F/A B41) Canister, Liner, and Soil Temperature Distributions at About 85 Inches Below Ground Level, August 4, 1980 to March 31, 1982

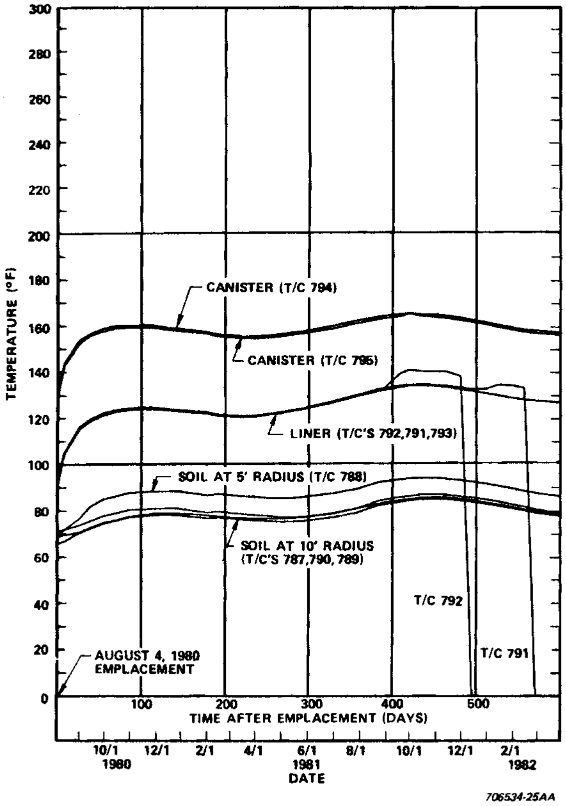


Figure I-8. Drywell 2 (F/A B41) Canister, Liner, and Soil Temperature Distributions at About 205 Inches Below Ground Level, August 4, 1980 to March 31, 1982

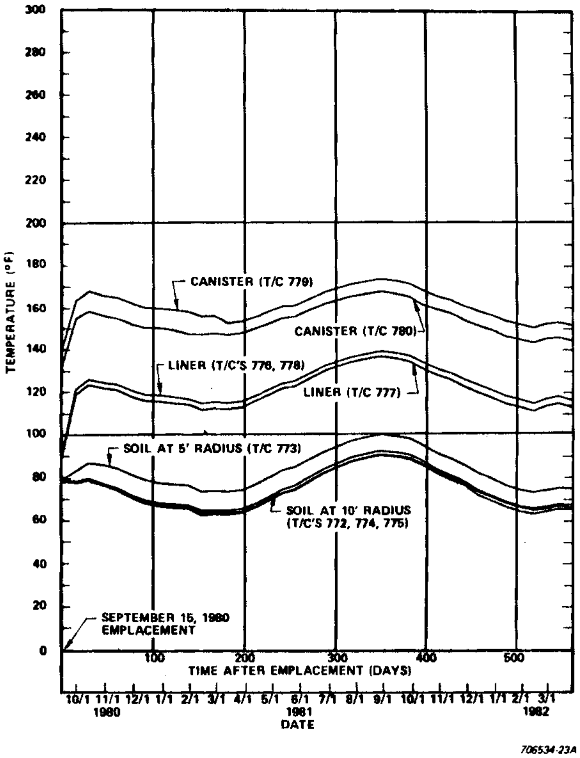


Figure I-9. Drywell 1 (F/A B43) Canister, Liner, and Soil Temperature Distributions at About 85 Inches Below Ground Level, September 15, 1980 to March 31, 1982.

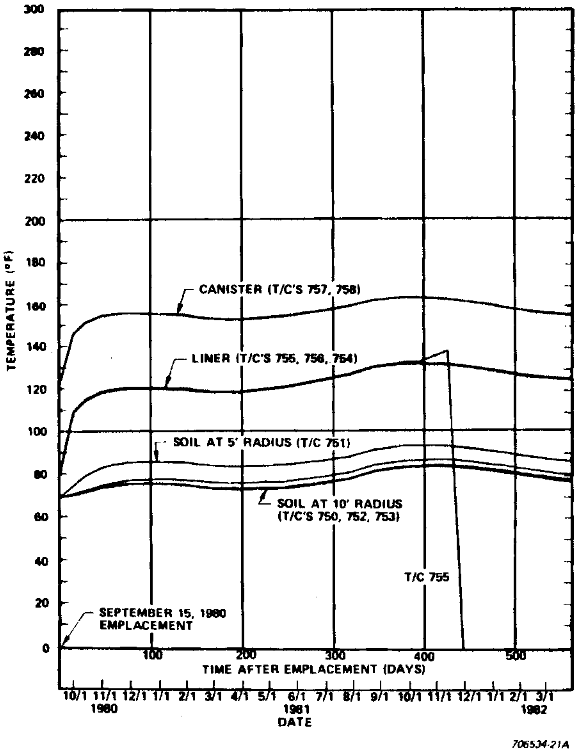
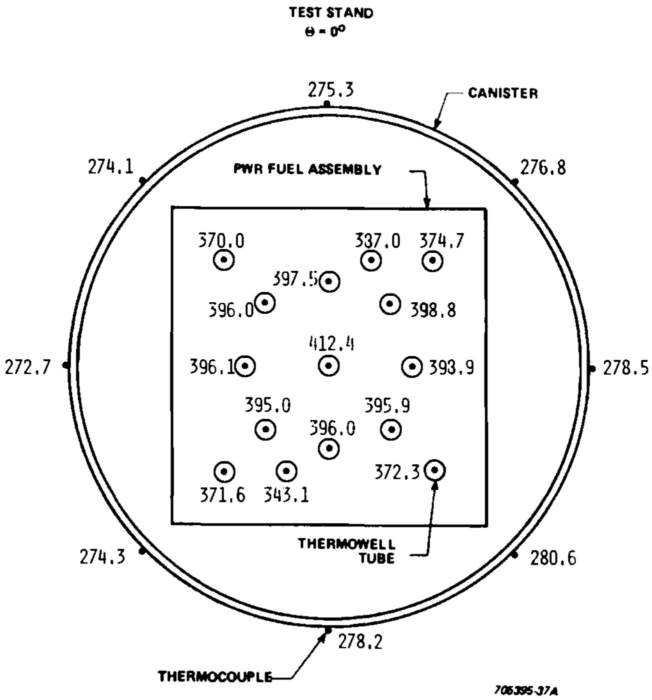


Figure I-10. Drywell 1 (F/A B43) Canister, Liner, and Soil Temperature Distributions at About 205 Inches Below Ground Level, September 15, 1980 to March 31, 1982

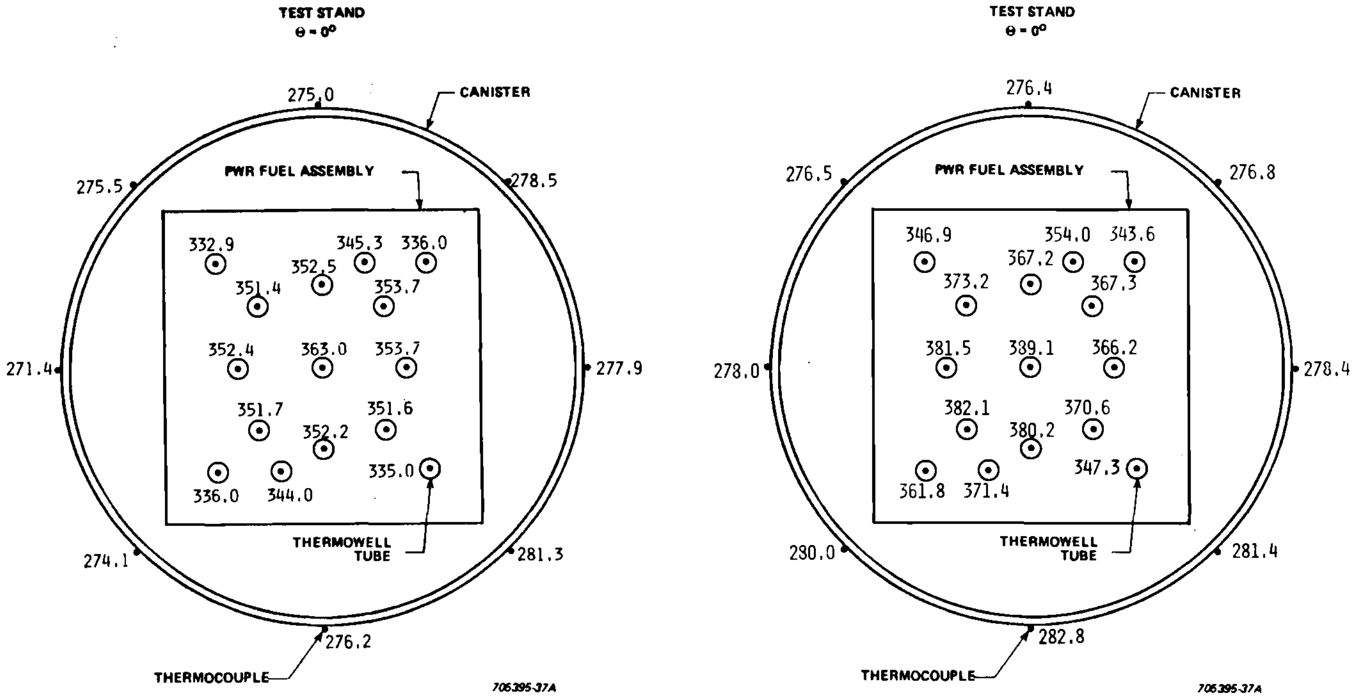
APPENDIX J

FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST DATA ILLUSTRATIONS

This appendix provides supplementary test data illustrations.



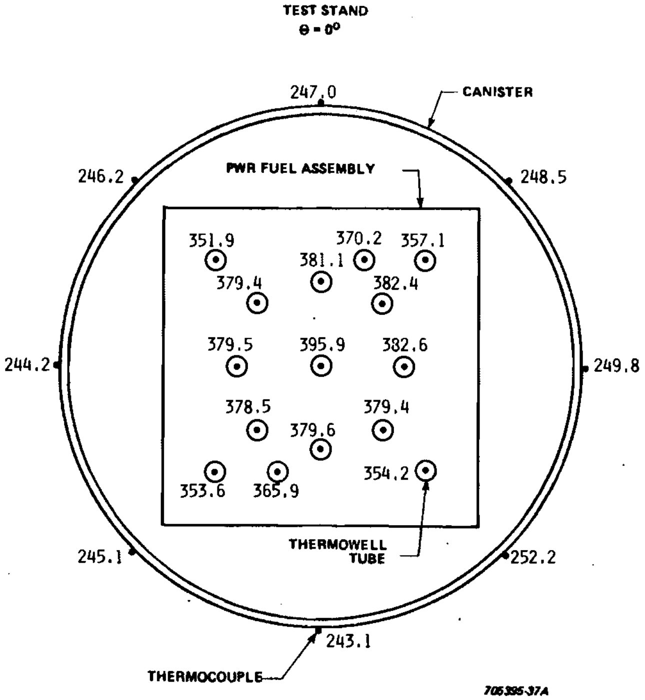
A. Vacuum Backfill (Reference: Table F-11)



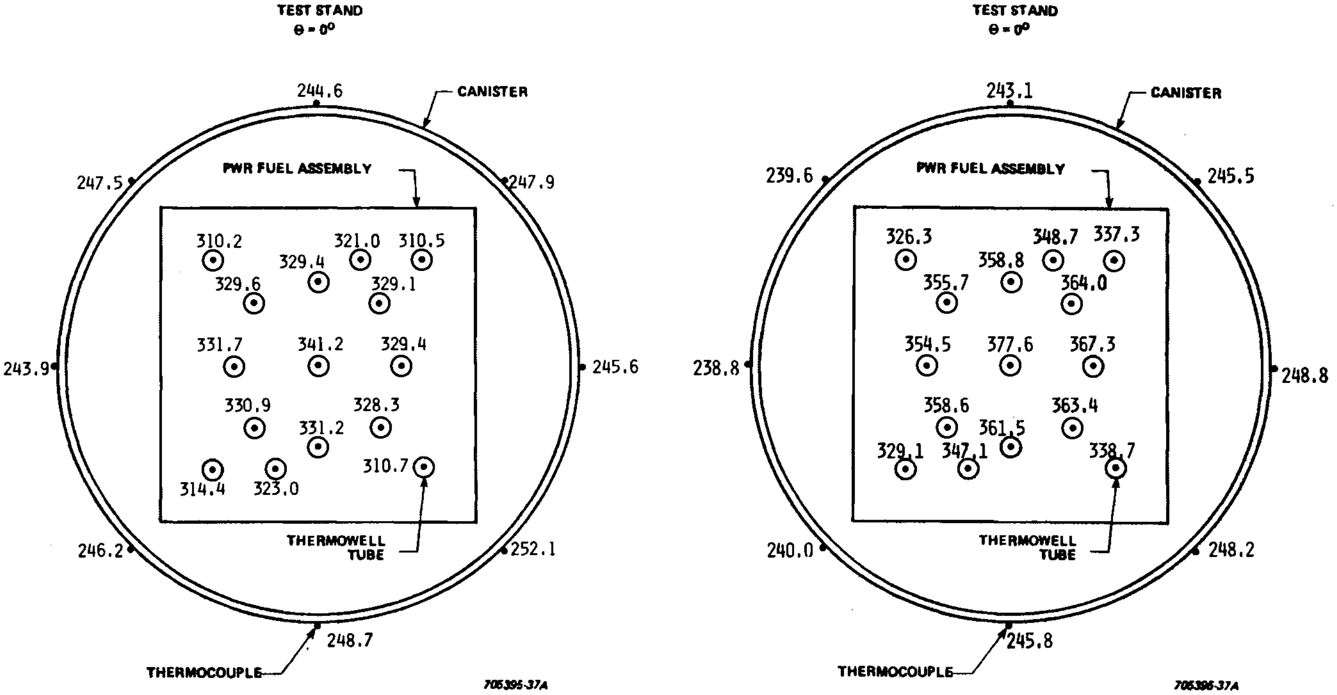
B. Helium Backfill (Reference: Table F-12)

C. Air Backfill (Reference: Table F-13)

Figure J-1. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the Electrically Heated Drywell Canister Profile Tests (F/A B43)



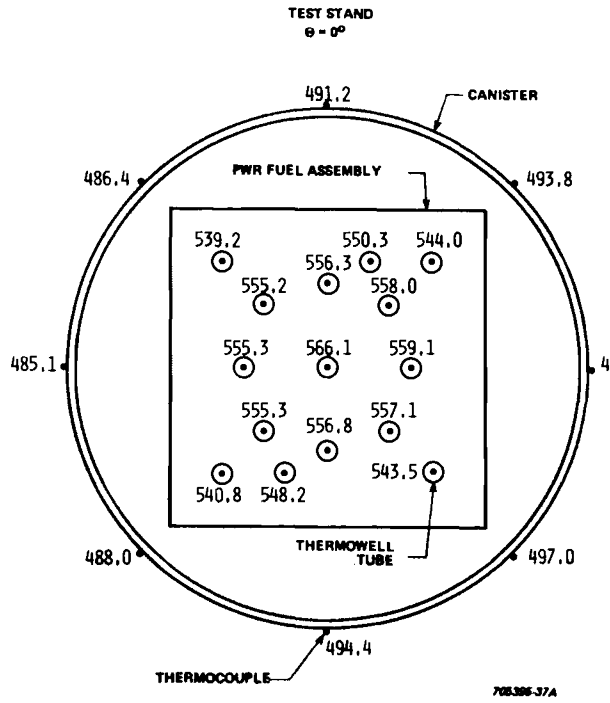
A. Vacuum Backfill (Reference: Table F-16)



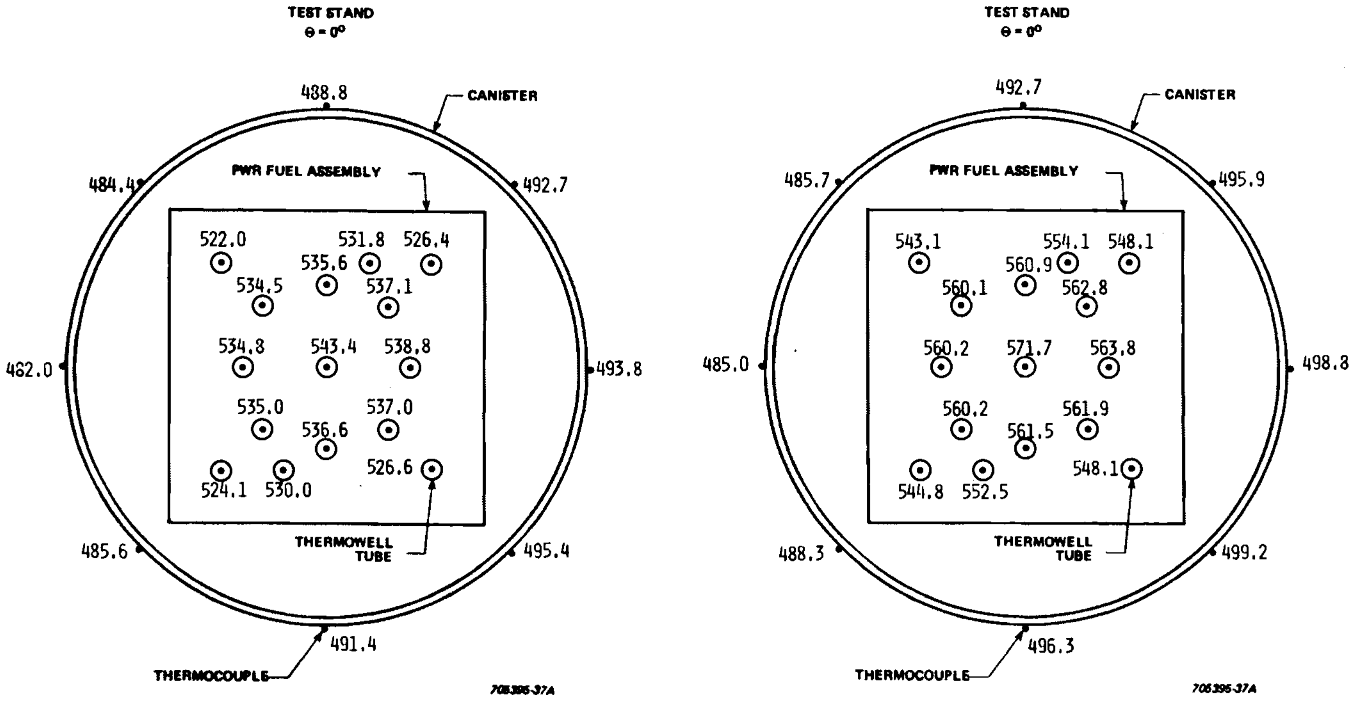
B. Helium Backfill (Reference: Table F-19)

C. Air Backfill (Reference: Table F-18)

Figure J-2. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the Drywell Canister Profile Tests (F/A B43)



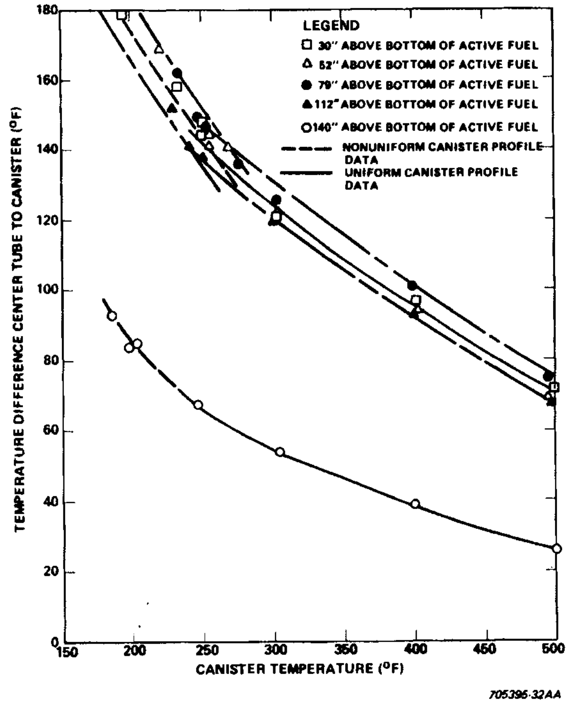
A. Vacuum Backfill (Reference: Table F-29)



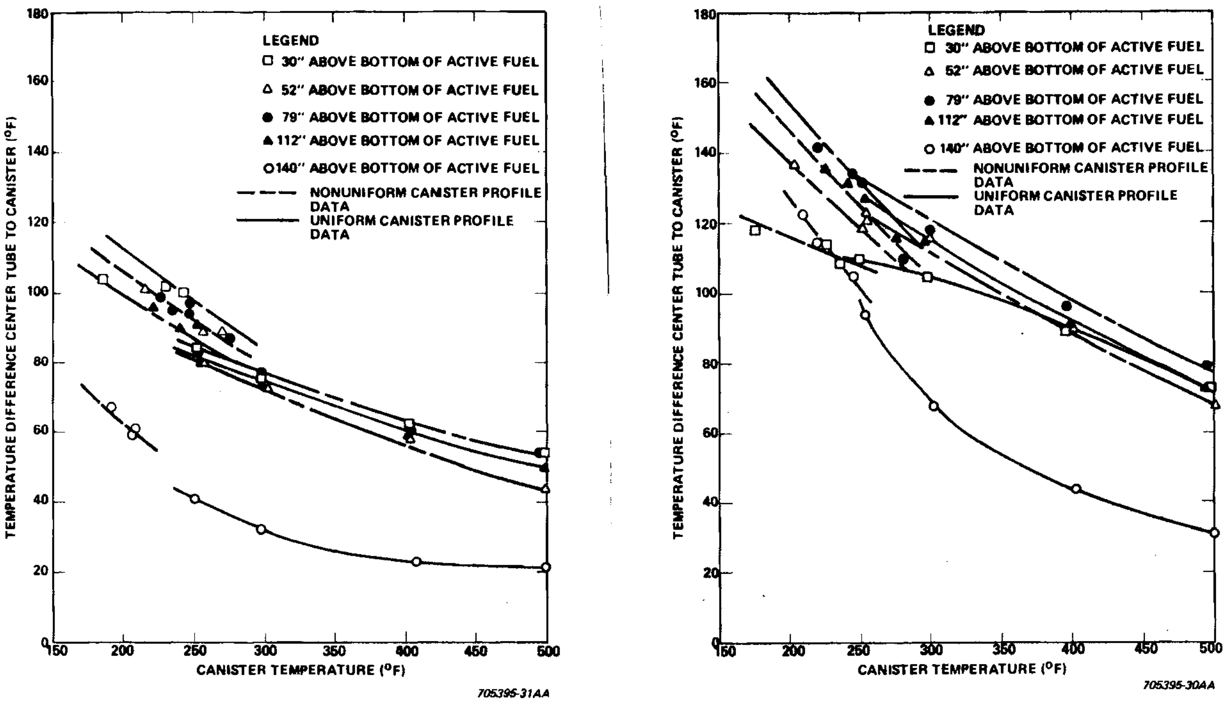
B. Helium Backfill (Reference: Table F-30)

C. Air Backfill (Reference: Table F-31)

Figure J-3. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the 500°F Uniform Canister Profile Tests (F/A B43)



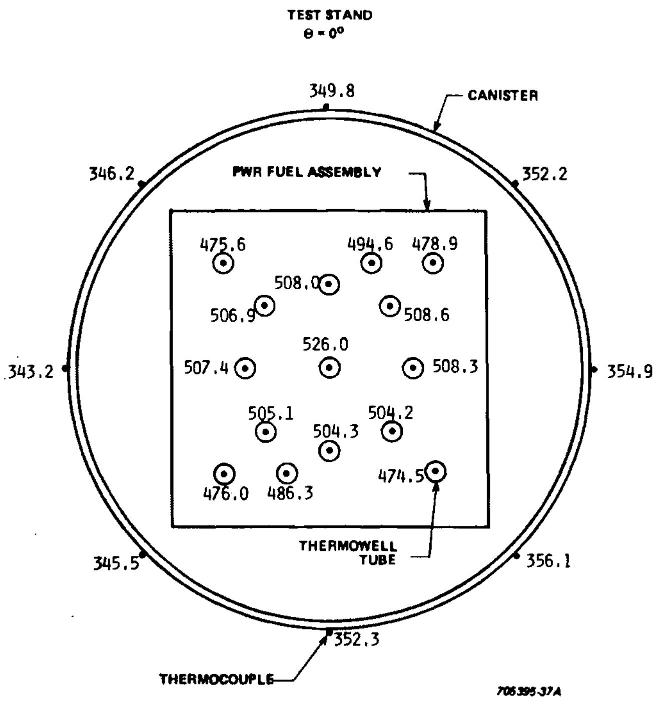
A. Vacuum Backfill



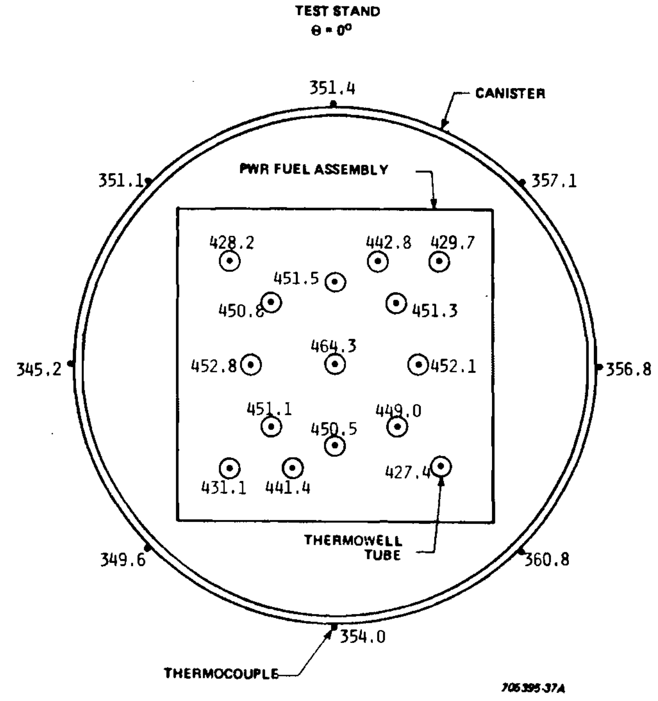
B. Helium Backfill

C. Air Backfill

Figure J-4. Center Thermowell/Canister Temperature Difference Versus Canister Temperature Profiles Developed From the F/A B43 Tests

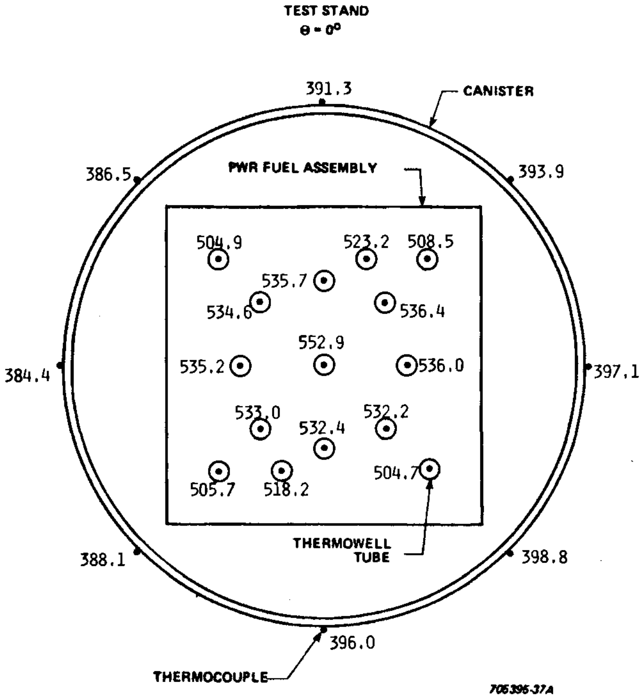


A. Vacuum Backfill (Reference: Table F-36)

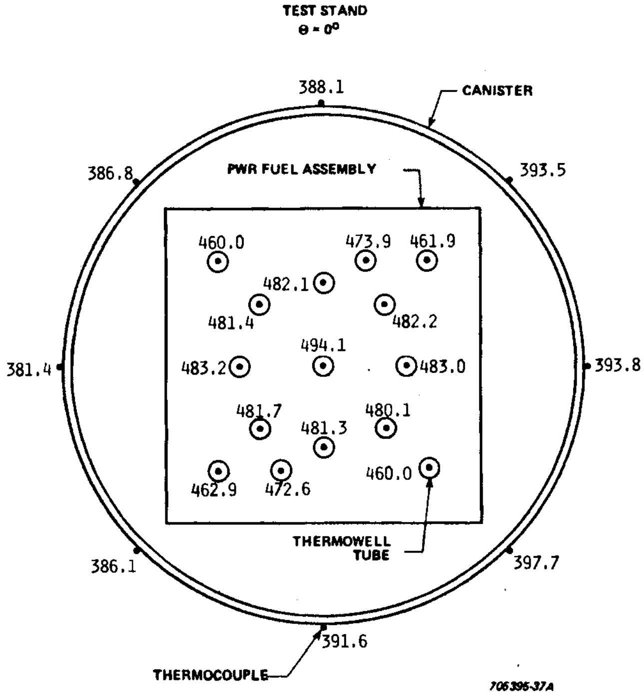


B. Helium Backfill (Reference: Table F-37)

Figure J-5. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the Electrically Heated Drywell Canister Profile Tests (F/A D15)

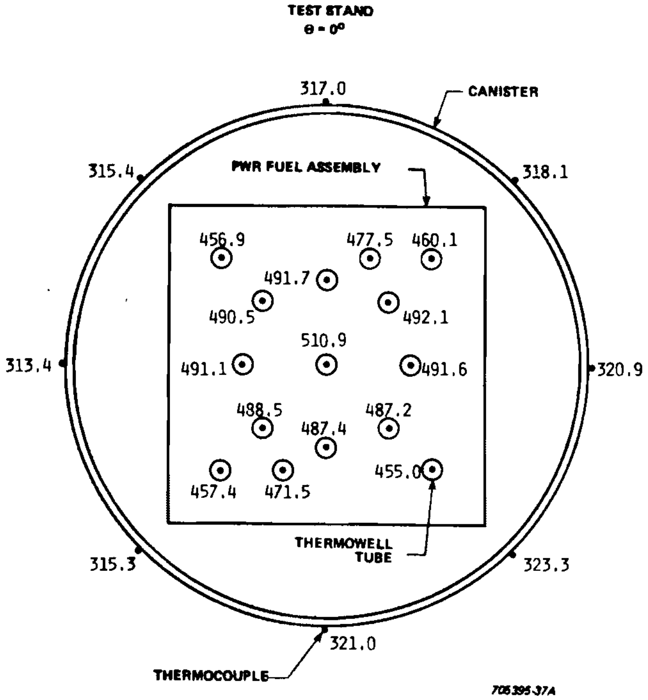


A. *Vacuum Backfill (Reference: Table F-41)*

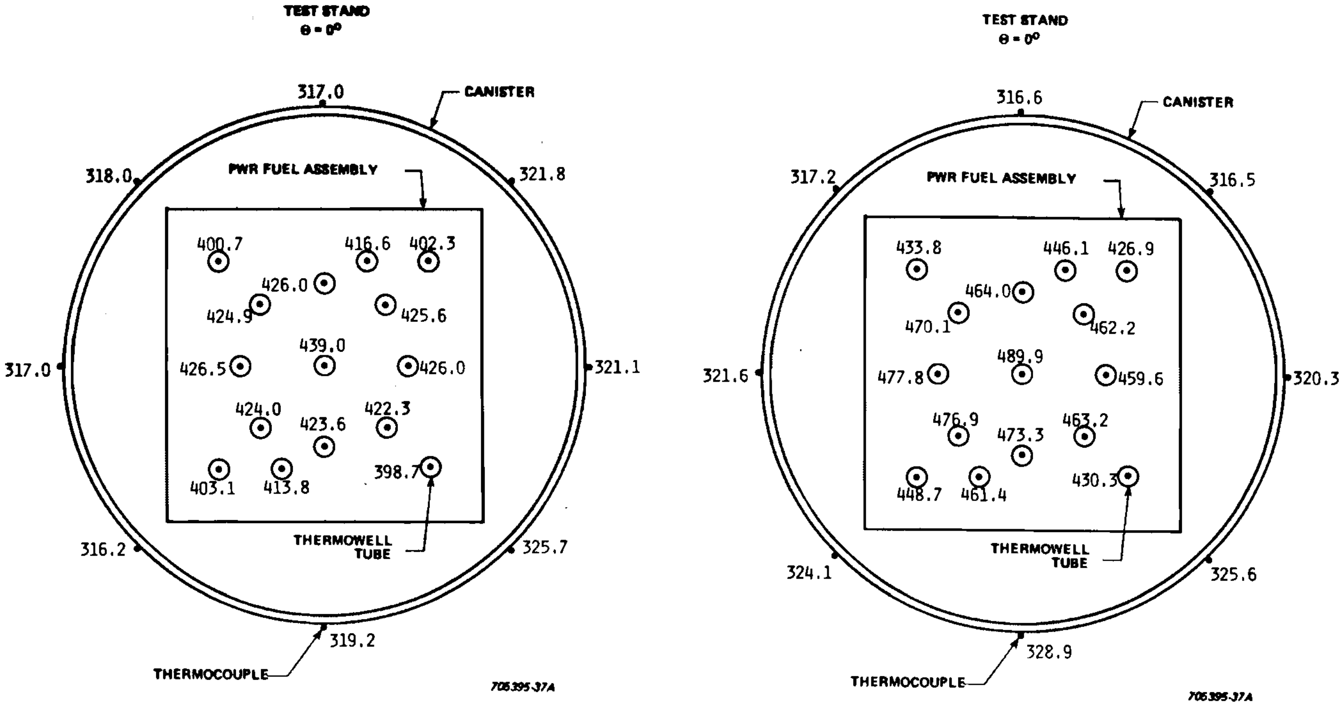


B. *Helium Backfill (Reference: Table F-42)*

Figure J-6. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the SFT-C Canister Profile Tests (F/A D15)



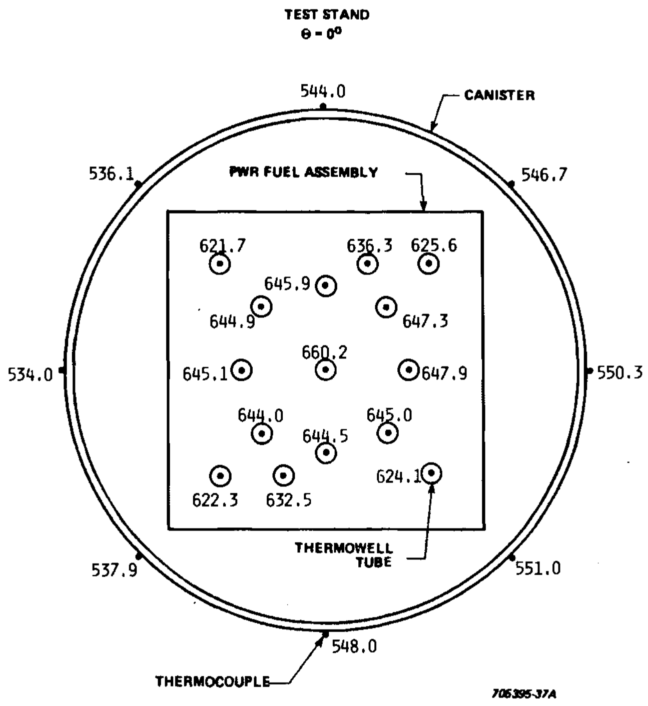
A. *Vacuum Backfill (Reference: Table F-38)*



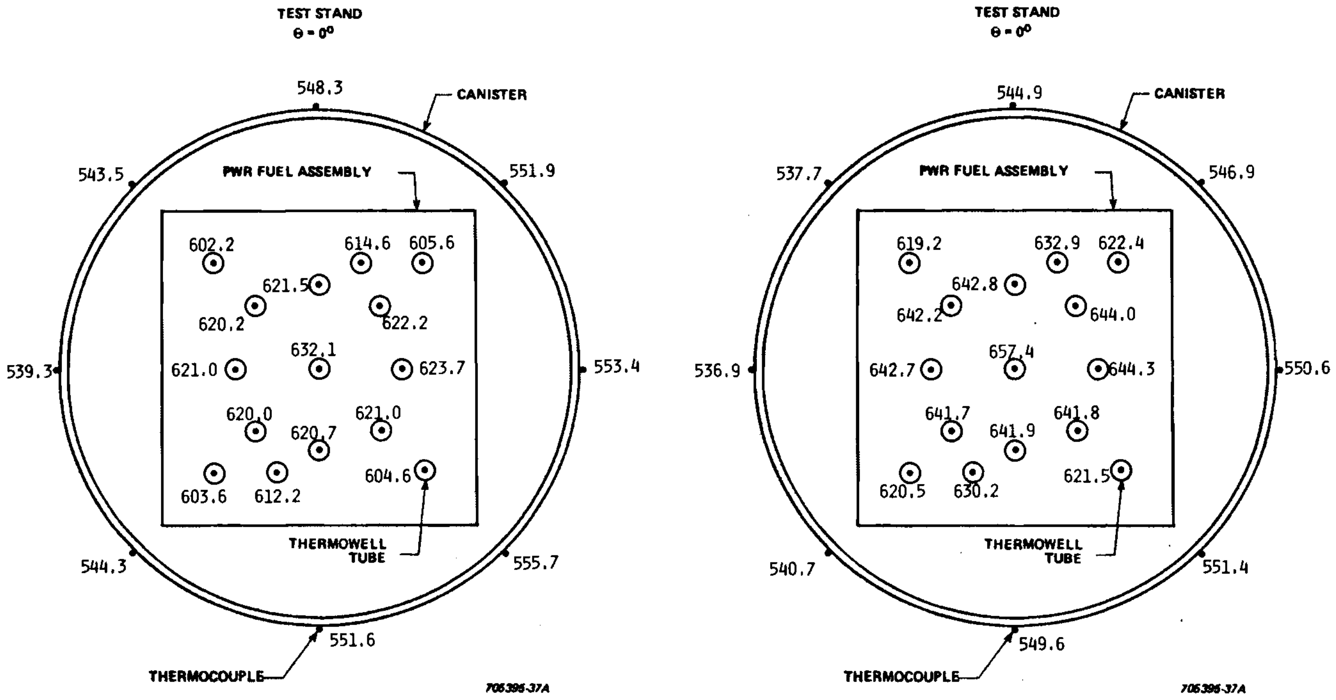
B. *Helium Backfill (Reference: Table F-39)*

C. *Air Backfill (Reference: Table F-40)*

Figure J-7. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the Drywell Canister Profile Tests (F/A D15)



A. Vacuum Backfill (Reference: Table F-51)



B. Helium Backfill (Reference: Table F-52)

C. Air Backfill (Reference: Table F-53)

Figure J-8. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the 550°F Uniform Canister Profile Tests (F/A D15)

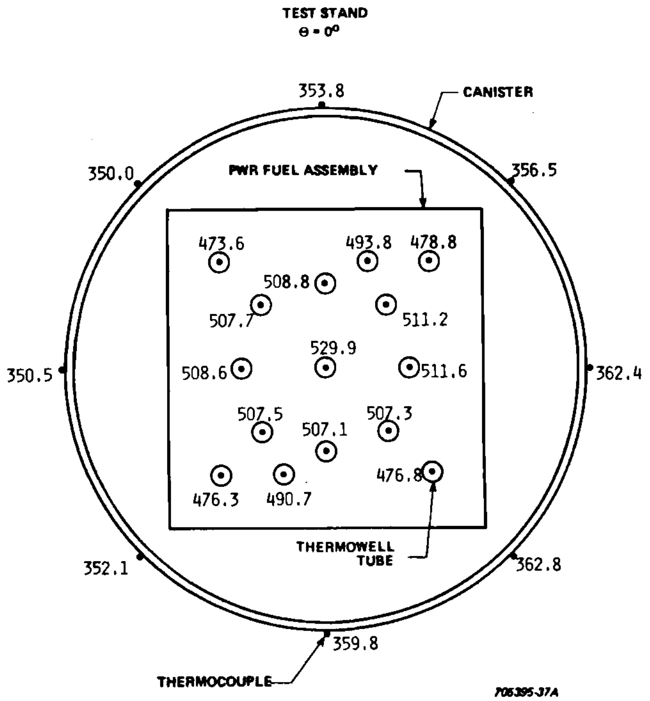


Figure J-9. Thermowell and Canister Temperature Maps Near Active Fuel Midplane Elevation From the Air Backfill 350°F Uniform Canister Profile Test (F/A D15)

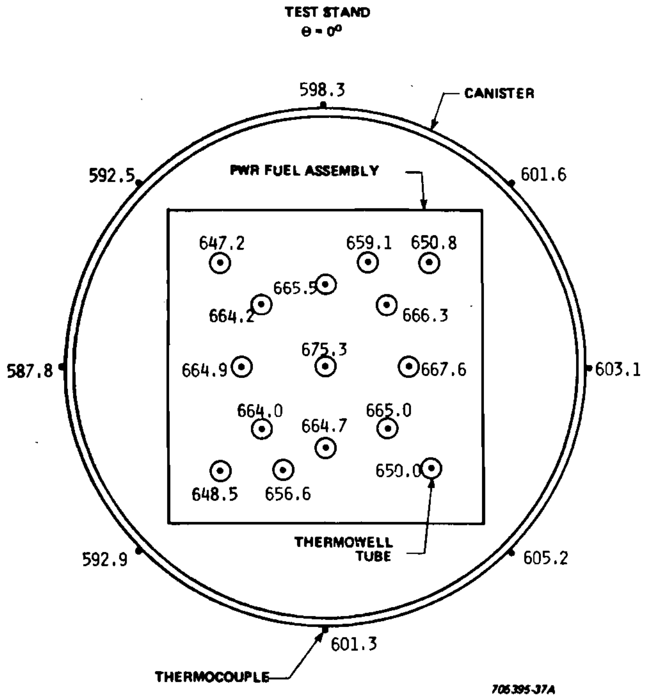
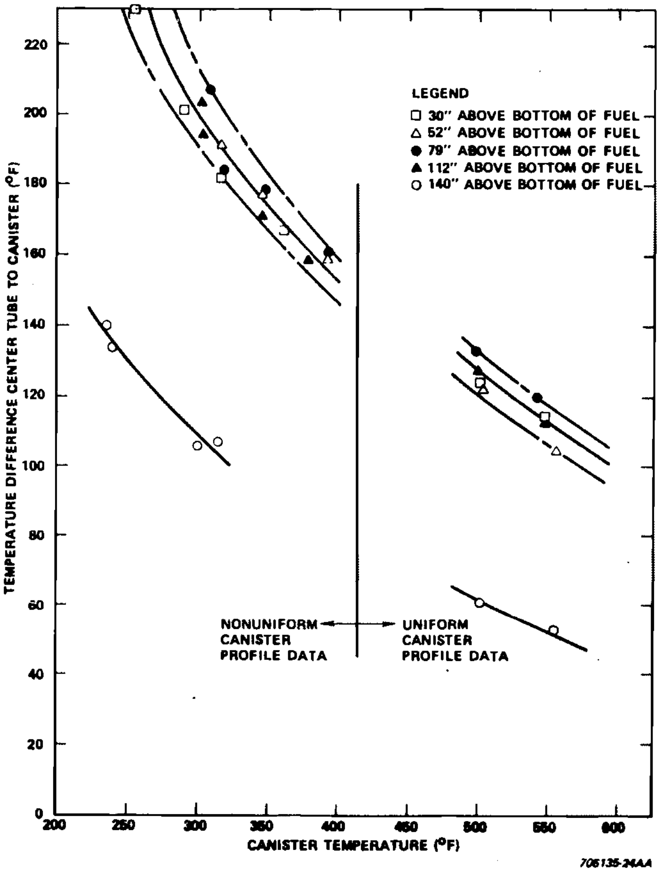
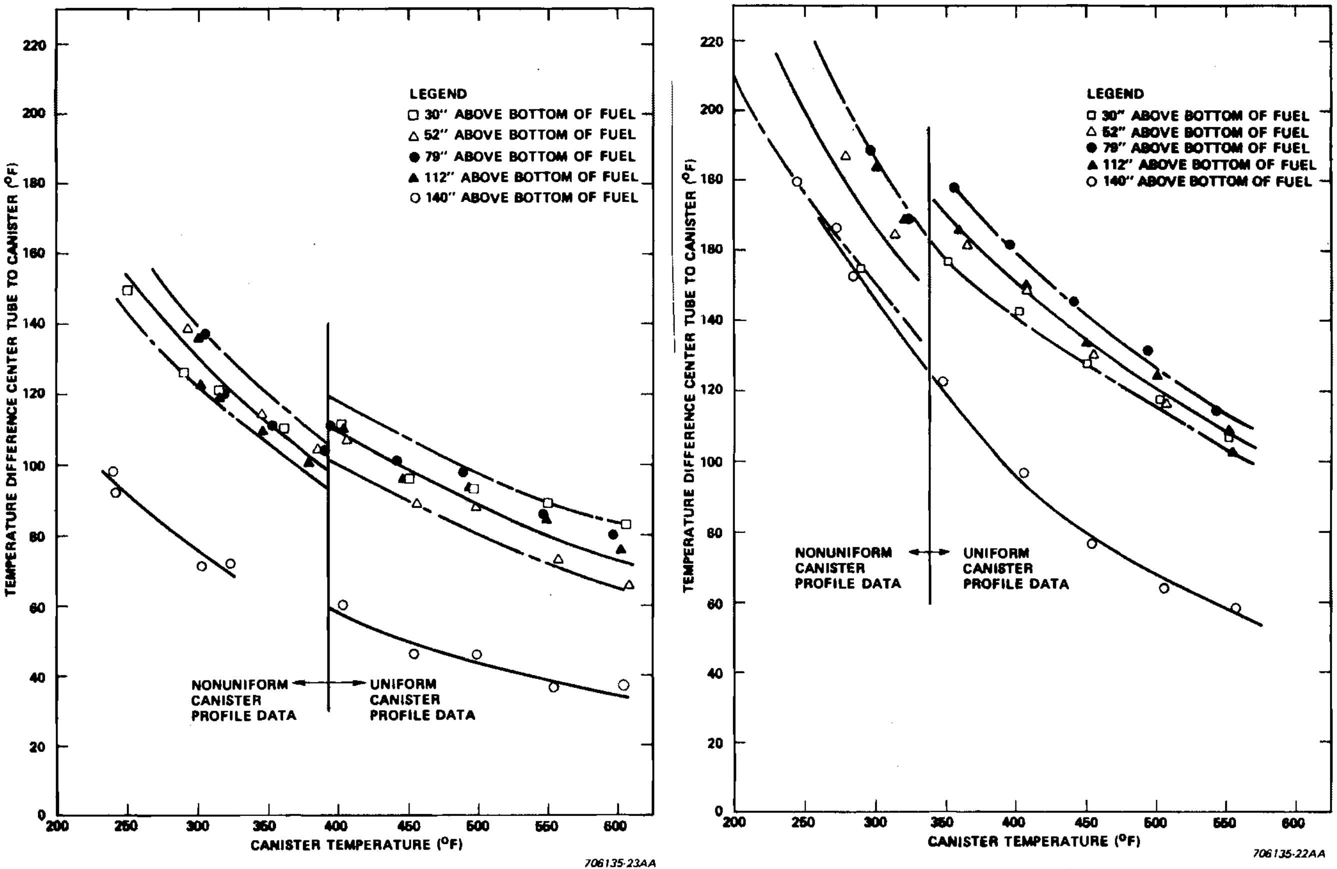


Figure J-10. Thermowell and Canister Temperature Map Near Active Fuel Midplane Elevation From the Helium Backfill 600°F Uniform Canister Profile Test (F/A D15)



A. Vacuum Backfill



B. Helium Backfill

C. Air Backfill

Figure J-11. Center Thermowell/Canister Temperature Difference Versus Canister Temperature Profiles Developed from the F/A D15 Tests

APPENDIX K

SPENT FUEL CALORIMETRY

K.1 OBJECTIVES

A boiling water calorimeter was designed by Battelle Pacific Northwest Laboratory to measure the decay heat generation rates of spent fuel assemblies prior to their encapsulation in the facility. The calorimeter was designed to measure single PWR or BWR fuel assembly decay heat rates in the range of 0.1 to 2.5 kW. The expected accuracy for assemblies with a total decay heat greater than 1.0 kW is ±5%; maximum decay heat measurement errors are estimated to be ±10% at 0.1 kW. The decay heat generation level was measured for five Turkey Point spent fuel assemblies. This appendix briefly discusses the spent fuel calorimeter, the procedures for its operation and results from its use. More detailed writeups can be found in References 30 and 31.

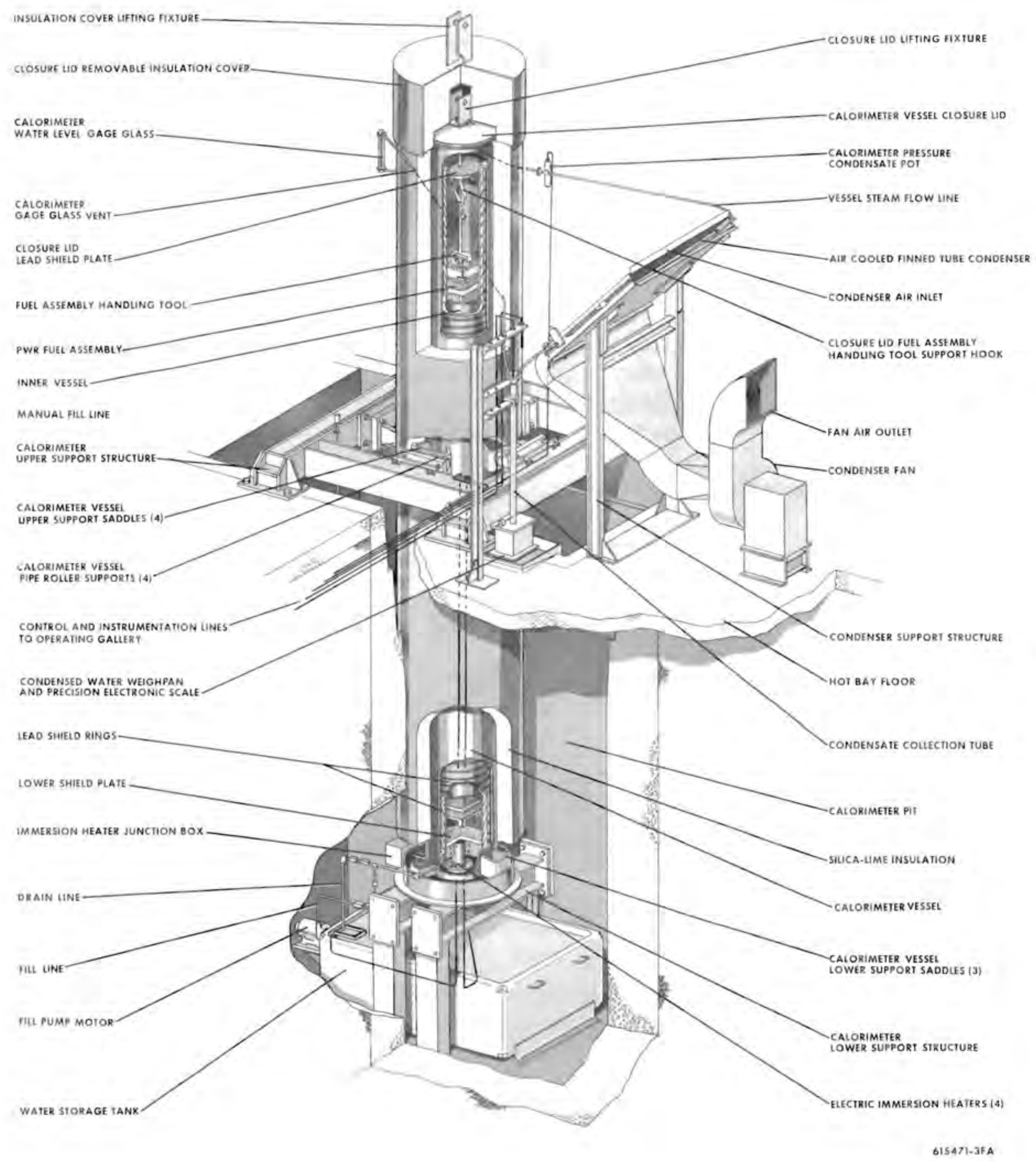
K.2 CALORIMETER DESCRIPTION

The design of the spent fuel calorimeter is illustrated in Figure K-1. The calorimeter system consists of five major subsystems. These subsystems are the calorimeter vessel and support structure, the water supply/storage tank and fill pump, the steam condenser, the condensate collection apparatus, and the control and data acquisition instrumentation. In addition, handling equipment unique to calorimeter operations is required to support the fuel assembly during testing. The 20 inch diameter by 18 foot long stainless steel calorimeter vessel contains an inner pipe which supports lead rings required to absorb radiated gamma energy. The vessel also contains four electric immersion heaters to boil water and a lid fitted with a hook to support spent fuel assemblies. The calorimeter weighs approximately five tons when filled with about 200 gallons of water. The water supply/storage tank is located directly below the vessel to provide make-up water and to permit the vessel to be completely drained. The condenser and condensate collection apparatus, located on the Hot Bay floor adjacent to the pit, condense steam generated in the calorimeter vessel, collect subcooled condensate over a recorded period of time, and measure both the volume and weight of the condensate. Instrumentation measures and records the steam pressure in the calorimeter vessel.

The calorimeter vessel and the water storage tank are installed in the calorimeter pit located on the east side of the E-MAD Hot Bay area as shown in Figure A-14.

K.3 PROCEDURES AND OPERATIONS

The calorimeter system uses a water boil-off principle to permit measurements of heat generation rates. Before a spent fuel assembly is inserted in the calorimeter, an internal reference heater is used to boil water and produce steam. The vaporization rate is determined by condensing the steam and measuring the condensate mass accumulation rate. The product of the mass accumulation rate and the latent heat of vaporization of the water is equal to the heat generated in the heater minus heat losses. This procedure is repeated at the same



615471-3FA

Figure K-1. Illustration of the Spent Fuel Calorimeter In the E-MAD Calorimeter Pit heater power with a spent fuel assembly inserted in the calorimeter. In this procedure, the product of the mass accumulated rate and latent heat is a measure of the unknown heat generated in the spent fuel assembly, plus the heat generated in the reference heater, minus system heat losses. The decay heat generation rate of spent fuel assemblies is determined by differencing the final and initial products of mass accumulation rates and latent heats.

To insert the fuel assembly into the calorimeter vessel a specially designed PWR fuel grapple, shown in Figure K-2, is engaged with the top nozzle of the fuel assembly. The calorimeter closure lid, suspended from the overhead crane, is moved into position over the weld pit and the lifting eye on the grapple is attached to the support hook below the closure lid using the master-slave manipulators.

Figure K-2. Fuel Assembly Being Removed From a Canister

Prior to moving the fuel assembly from the weld pit to the calorimeter, the insulation cap on the calorimeter vessel is removed using the Wall-Mounted Handling System and the temporary cover is prepared for removal. The water level in the calorimeter vessel is lowered to prevent the displaced volume of water from flooding the condensate collection system. The overhead crane then lifts the calorimeter closure lid and the attached fuel assembly and positions them over the calorimeter vessel. After removing the temporary cover, the closure lid is slowly lowered until it is seated on the upper vessel flange. The crane is then disengaged from the closure lid and the insulation cap replaced on the vessel.

The condensate collection system and the data acquisition system operate automatically. However, an operator monitors the system control panel whenever a fuel assembly is immersed in the calorimeter vessel. With a spent fuel assembly in the calorimeter vessel and the electric heater energized, the water in the vessel reaches an equilibrium boiling condition in which the rate of steam generation and condensation are steady, therefore, the interval of time required to collect a given quantity of condensate remains approximately constant during several collection cycles. A data scan is initiated each time the condensate level reaches the high limit in the collection tube. The measured parameters are processed by the data acquisition system and the data is printed out to provide a permanent record of each collection cycle. A data scan can be initiated and recorded without affecting the collection cycle in progress.

After termination of the test, the insulation cap is removed from the calorimeter vessel. The overhead crane is repositioned over the calorimeter vessel and the crane hook adapter is attached to the closure lid lifting fixture. Figure K-3 shows the crane removing the spent fuel assembly from the calorimeter. The closure lid and suspended fuel asembly are lifted and moved to the weld pit where the fuel assembly is lowered into a storage canister.

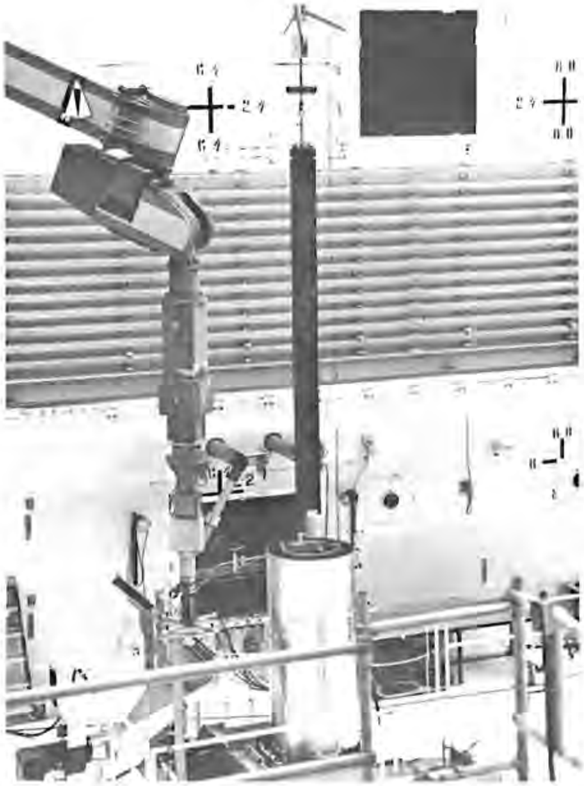


Figure K-3. Fuel Assembly Being Removed From the Boiling Water Calorimeter

The fuel grapple is then disengaged and the closure lid with the grapple removed to the closure lid support stand. The temporary cover must be replaced on the calorimeter vessel as soon as possible to minimize vapor escaping to the Hot Bay atmosphere. As the fuel assembly is lifted from the calorimeter vessel, the fill pump control circuit automatically restores the water level to the operating range.

K.4 RESULTS

Table K-1 presents the measured decay heat values for the five Turkey Point spent fuel assemblies D34, D04, D15, D22, and B43. Equilibrium was clearly established and cell ambient conditions were stable for assemblies D34, D15, B43, and D22. However, based on the analysis of later reference and measurement data, thermal equilibrium was not established during the measurement of fuel assembly D04.

TABLE K-1
MEASURED DECAY HEAT LEVELS FOR FIVE TURKEY POINT FUEL ASSEMBLIES

Fuel Assembly	Burnup (MWD/MTU)	Date of Measurement	Cooling Time (days)	Measured* Decay Heat (kW)
D34	27,863	April 1, 1980	864	1.550
D04	28,430	May 20, 1980	913	1.385**
D15	28,430	July 8, 1980	962	1.423
D22	26,485	July 9, 1980	963	1.284
B43	25,595	Sept. 10, 1980	1416	0.637
D15	28,430	Jan. 6, 1981	1143	1.125

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*Measurement uncertainty is 5%

**Low confidence (see text)

APPENDIX L

GAS SAMPLING OF SPENT FUEL CANISTERS

A test program was conducted at E-MAD to sample the gaseous media contained in selected spent fuel storage canisters and the Fuel Assembly Internal Temperature Measurement Test canister. The samples were analyzed by mass spectrographic and gamma scan techniques to detect the presence of gaseous fission products which could be indicative of fuel rod clad failure. This appendix describes the sampling equipment, sampling procedures, and presents the results of analyses performed on the gaseous samples. Table L-1 summarizes the pertinent data relevant to storage location, canister configuration, storage atmosphere, and storage initiation date for the canisters sampled.

L.1 SAMPLING EQUIPMENT AND PROCEDURES

L.1.1 UNWELDED CANISTERS

Four PWR spent fuel assemblies for the SFT-C Program (D34, D22, D15, and D04) were placed in stainless steel canisters without evacuation, helium backfill, or seal welding. The canisters are described in Section 3.2.2.3. The threaded canister lids were installed in the canister bodies, and the canister assemblies temporarily stored in the lag storage pit.

A mechanically sealed evacuation/backfill port is provided on each threaded canister lid (see Figure 3.2-19). This port is normally

TABLE L-1
GAS SAMPLED FUEL ASSEMBLY STORAGE SUMMARY

Fuel Assembly	Storage Location	Canister Configuration	Storage Atmosphere	Storage Initiated
D04	Lag Storage Pit	Unwelded	Air	12/11/79
D15	Lag Storage Pit	Unwelded	Air	11/27/79
D22	Lag Storage Pit	Unwelded	Air	11/12/79
D34	Lag Storage Pit	Unwelded	Air	11/1/79
B43	Transfer Pit	Unwelded	Air	2/6/79
	Test Stand	Sealed	Air, Helium & Vacuum	7/19/79*
B41	Drywell 3	Welded	Helium	1/24/79
B03	Drywell 5	Welded	Helium	1/12/79

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*Air, helium, and vacuum tests conducted from 7/23/79 to 2/11/80, test stand filled with air after 2/11/80 used for canister evacuation and helium backfill following the encapsulation seal weld. The port and the sealing cap are standard tube fittings. For canister gas sampling, the sealing cap was removed and a sampling tree, described below, was installed.

The sampling tree for each unwelding canister, illustrated in Figures L-1 and L-2, contained two 500 milliliter stainless steel sampling bottles with a shutoff valve welded to each bottle. The connecting manifold was assembled from standard tube fittings and furnished with a manifold isolation valve and a compound vacuum/pressure gauge to monitor the manifold pressure. The 500 milliliter sampling bottles were "baked out" at a temperature of 400°F during evacuation of the entire sampling tree. The tree and sample bottles were evacuated to approximately 10^7 torr and helium leak checked to ensure a vacuum until the gas samples were drawn.

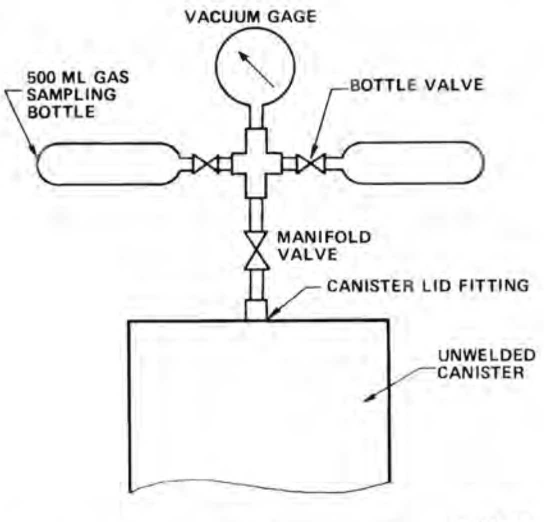

Figure L-1. Unwelded Canister Gas Sampling Test Arrangement

Figure L-2. Photograph of Unwelded Canister Gas Sampling Operation

To initiate the gas sampling procedure, the unwelded canister was moved from the lag storage pit to the weld pit, and the mechanical sealing cap removed from the evacuation/backfill port rapidly to minimize canister gas loss. With the manifold isolation valve closed, the shutoff valve on each sample bottle was opened independently (see Figure L-2) while observing the manifold gauge to verify the sample bottle vacuum. Following vacuum verification, both sample bottle shutoff valves were opened, and finally, the manifold shutoff valve was opened. This ensured the gas samples drawn into each sample cylinder were as identical as practicable. When the manifold gauge stabilized, the sample bottle valves were closed, the sample tree removed from the evacuation/backfill port, and the port resealed. The sample bottles were removed from the tree and forwarded to the analytical laboratories for mass spectrographic and gamma scan measurements.

L.1.2 FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST CANISTER

PWR spent fuel assembly B43 was installed in the Fuel Assembly Internal Temperature Measurement Test canister (described in Section 5.2). During the testing phase, the fuel assembly was subjected to several thermal cycles from ambient temperature to the test canister temperature profiles described in Section 5.3. The maximum fuel assembly temperature measured during fuel temperature testing was 572°F which occurred while the test canister was backfilled with air and with a uniform 500°F temperature profile imposed on the canister.

The Fuel Assembly Internal Temperature Measurement Test is located in the E-MAD West Process Cell. In order to draw samples from the test stand canister, tubing was extended from a fitting on the canister lid to a hot cell adjacent to the West Process Cell (see Figure 5.2-12). The sampling equipment consisted of a manifold to which four 500 milliliter sample bottles and two 1 gallon vacuum bottle were connected through appropriate isolation valves. It was estimated that each 1 gallon vacuum bottle would be sufficient to purge the sample line between the canister and hot cell. Two 1 gallon vacuum bottles and two independent sampling bottle sets were installed to ensure at least one sample set would be uncontaminated by residual gasses. A schematic diagram of this gas sampling system is shown in Figure L-3.

To initiate the sampling procedure, a uniform 500°F temperature profile was established on the test canister. The test canister heatup began on May 30, 1980 and continued through June 4, 1980 when the gas samples were taken. During the period May 31 to June 4, the canister temperatures ranged from 475 to 502°F, the thermowell temperatures ranged from 513 to 566°F, and the average thermowell temperature ranged from 529 to 545°F. The peak center thermowell temperatures ranged from 552 to 566°F. No attempt was made to evacuate or backfill the canister prior to initiating the sampling procedure. Therefore, the atmosphere within the canister was an unknown mixture of residual helium from the previous test run and air that may have leaked into the canister while the test stand was in the cold standby condition.

The vacuum in each sample bottle and the two purge bottles were verified prior to gas sample initiation. With the isolation valves closed on all sample bottles, the first purge bottle isolation valve was opened to draw the residual gasses from the sampling line into the bottle. When the pressure in the sampling manifold reached equilibrium, the purge bottle isolation valve was closed, and the isolation valves on the first pair of 500 milliliter sample bottles opened to draw gas samples. After isolating the first set of sample bottles, the purge and sampling procedure was repeated. The analysis results indicate that at the achievable levels of detectability, no difference could be found between the two sets.

L.1.3 DRYWELL CANISTERS

Two PWR spent fuel assemblies (B03 and B41), encapsulated in stainless steel canisters and placed drywells during January of 1979, were gas

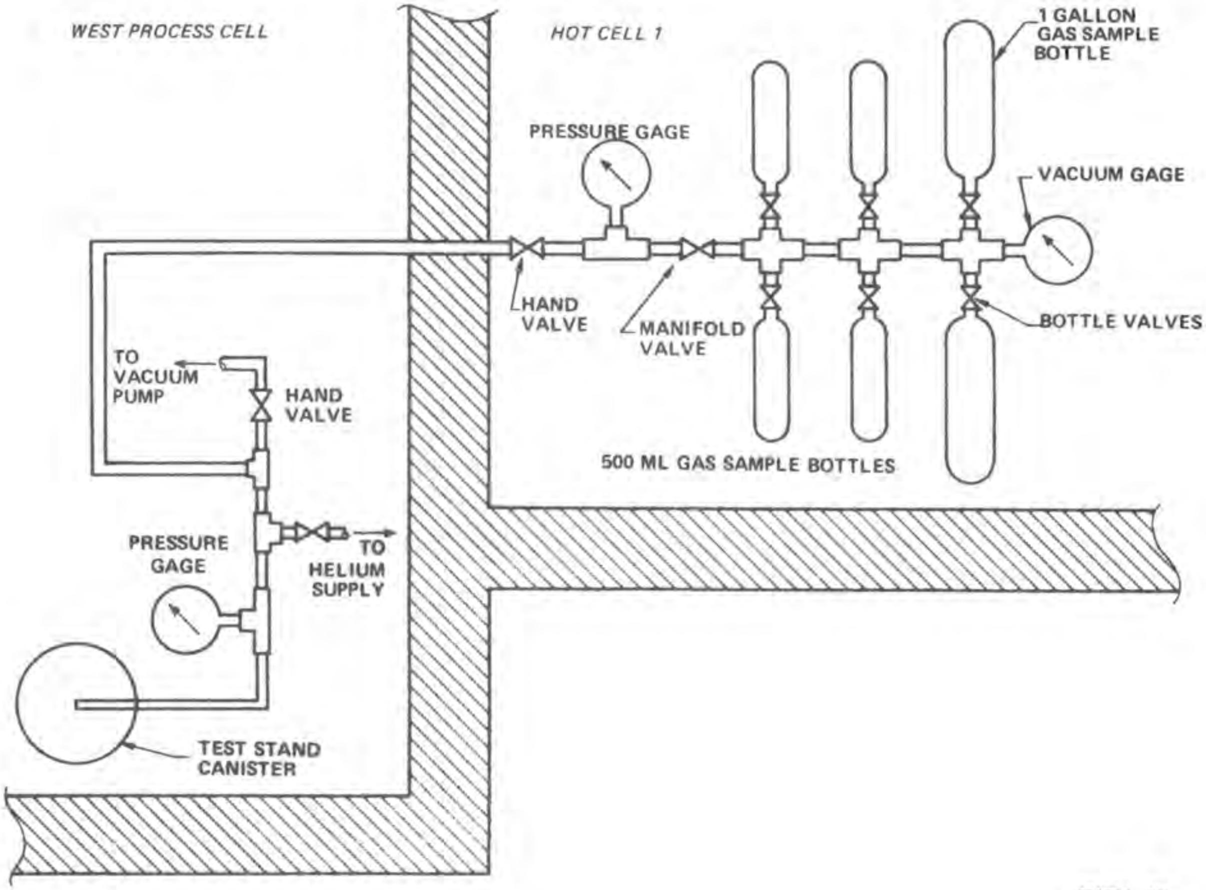

Figure L-3. Fuel Assembly Internal Temperature Measurement Test Canister Gas Sampling Test Arrangement

sampled. The encapsulation canisters were seal welded, evacuated, backfilled with helium, and leak checked prior to emplacement. The storage canister and drywell configurations are described in Section 3.2.2.

The equipment used for drawing gas samples from the drywell canisters is illustrated in Figure L-4. The sampling tree for each drywell canister consisted of two 500 milliliter stainless steel sampling bottles each with a welded shutoff valve. The manifold connecting the two sampling bottles was assembled from standard tube fittings and furnished with a manifold isolation valve and a compound vacuum/pressure gauge to monitor the manifold pressure. The sample bottles are "baked out" at a temperature of 400°F while maintaining a vacuum of approximately 10^{-7} torr on the sample tree assembly. The bottles and the manifold were helium leak checked to ensure a vacuum until samples were drawn. The sampling bottle vacuum was verified immediately before initiating gas sampling.

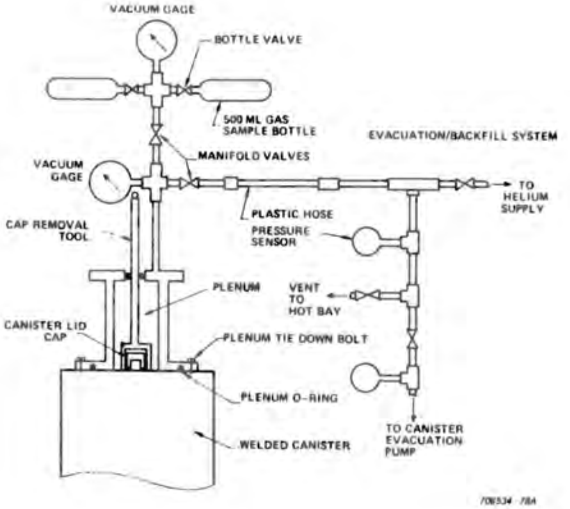

Figure L-4. Welded Drywell Canister Gas Sampling Test Arrangement

To perform gas sampling, the sample bottles and manifold were connected to an evacuation chamber mounted on the canister lid (see Figure L-5). An "O" ring was inserted between the evacuation chamber flange and the canister closure lid surface to provide a vacuum tight seal. The port connection on the canister closure lid was opened and closed by a shaft penetrating the evacuation chamber upper flange through a vacuum tight "O" ring gland. The shaft is equipped on one end with a socket to match the port connection nut and with a handle on the other that is turned by a master-slave manipulator. To complete the evacuation chamber assembly, a compound vacuum/pressure gauge and evacuation shutoff valve was installed on the nozzle to which the gas bottle sampling tree was connected. The evacuation chamber shutoff valve was connected with flexible tubing to the Evacuation/Backfill System (see Section A.5.3).

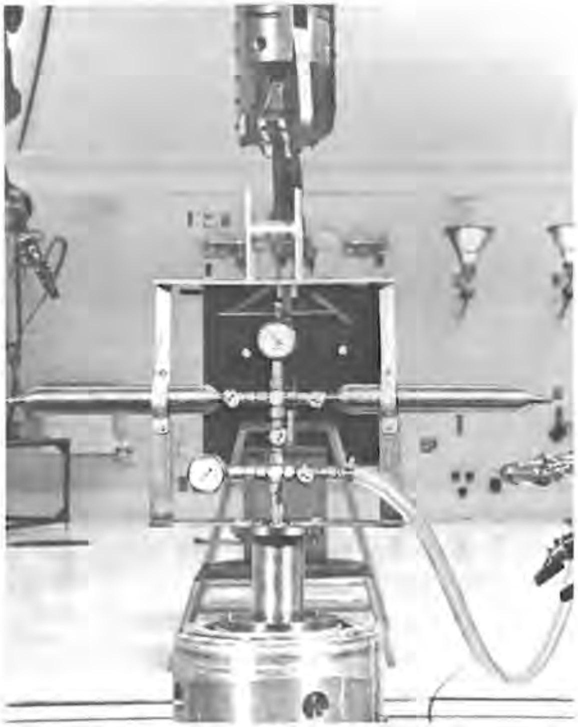

Figure L-5. Photograph of Welded Drywell Canister Gas Sampling Test

Prior to the initiating canister gas sampling, the evacuation chamber and sample tree manifold were purged by evacuating, charging with helium, and then re-evacuating to less than 1 millitorr. With the manifold and evacuation chamber isolation valves closed, the sample bottle shutoff valves and the mechanical seal cap on the canister lid port connection were opened to allow the canister backfill gas to flow into the evacuation chamber. The manifold isolation valve was then opened so gas samples could flow into the sample bottles. When the manifold pressure stabilized, the sample bottles were isolated by closing the manifold isolation valve and the bottle shutoff valves. The evacuation chamber was recharged with helium following gas sampling and before the canister lid port connection was resealed.

Leak checks were performed on the canister assembly both before and after sampling. The indicated leak rates were below specified standards. Measured backfill pressures in both canisters before gas sampling were above atmospheric.

L.2 GAS SAMPLE ANALYSIS

Gas samples obtained from all the storage canisters were analyzed for Krypton and Xenon by mass spectrographic and gamma spectrographic techniques at the Hanford Engineering Development Laboratory (HEDL). Gamma spectorgraph analyses were performed on duplicate gas samples at the Westinghouse Advanced Reactor Division (ARD) and in the case of the two drywell canister samples, mass spectrographics analyses were performed at the Oak Ridge National Laboratory (ORNL) following the ARD gamma analyses. In addition, mass spectrographic analyses of the gas samples from the two drywell canisters were performed by HEDL and ORNL. The results of the constituent analyses are given in Table L-2.

The detectable limits shown in Table L-3 for Krypton and Xenon using mass spectrograph techniques are affected by mass interference of other gas sample constituents directly related to the gaseous media in the storage canisters. The detectable limits for the samples from the unwelded air canisters were slightly higher than the samples from the Fuel Assembly Internal Temperature Measurement Test and helium drywell canisters. The varying detectable limits for gamma spectrographic analyses shown in Table L-3 are primarily a result of the counting statistics used for the individual analysis.

No specific analyses were made to detect the present of Cesium in the gas samples. It is expected that any Cesium produced directly by fission or from the Xenon decay condensed on the canister surfaces and therefore would not be detectable in the sampling bottles.

L.3 RESULTS

Results of all the mass spectrographic and all except one gamma spectrographic analysis performed indicated that fission product gases contained in the samples were below the detectable limits. One gamma spectrographic analysis performed by ARD on the drywell canister containing fuel assembly

TABLE L-2
GAS SAMPLING CONSTITUENT ANALYSIS

Fuel Assembly	Gas Constituents (Mole %)									Analytical Lab
	H_2	CH_4	H_2O	N + CO	O_2	Ar	CO_2	N_2	He	
B41	0.19	0.02	1.21	0.17	0.01	<0.01	0.27	-	98.1	ORNL
	0.12	-	-	-	<0.01	-	0.22	0.14	99.5	HEDL
B03	0.25	0.02	0.21	0.69	0.15	0.01	0.25	-	98.4	ORNL
	0.11	-	-	-	0.09	-	0.18	0.54	99.5	HEDL

TABLE L-3
SUMMARY OF GAS SAMPLING RESULTS

			Analysis Results					
				HEDL* Mass Spec.		ARD**	ORNL† Mass Spec.	
Fuel Assembly	Gas Sampling Date	Estimated Max. Fuel Clad Temp. (°F)	Gamma (μCi/cc)	Kr (ppm)	Xe (ppm)	Gamma (μCi/cc)	Kr (ppm)	Xe (ppm)
D04	4/9/80	520	$<3 \times 10^{-4}$	<5	<7	$<3 \times 10^{-5}$	-	-
D15	4/10/80	520	$<3 \times 10^{-4}$	<3	<6	$<3 \times 10^{-5}$	-	-
D22	6/25/80	520	$<3 \times 10^{-4}$	<4	<3	$<6 \times 10^{-6}$	-	-
D34	4/1/80	520	$<3 \times 10^{-4}$	<3	<6	$<3 \times 10^{-5}$	-	-
B43	6/4/80	350	$<3 \times 10^{-4}$	<2	<2	$<9 \times 10^{-6}$	-	-
		572††						
B41	8/5/80	350	$<3 \times 10^{-4}$	<1	<1	1.4×10^{-3}	<1	<1
B03	8/4/80	350	$<3 \times 10^{-4}$	<1	<1	$<6 \times 10^{-6}$	<1	<1

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*Hanford Engineering Development Laboratory

**Westinghouse Advanced Reactors Division

†Oak Ridge National Laboratory

††Measured in Test Stand for Short Term Test in Air

B41 detected the presence of Krypton. This indication was not supported by the mass spectrographic analyses performed by ORNL on the same gas sample or by the gamma and mass spectrographic analysis performed by HEDL on the duplicate gas sample drawn from the same canister. It may be noted that Cesium was detected in a water sample drawn from the shipping casks used to transport fuel assembly B41 from the Turkey Point Reactor storage pool to the Battelle Columbus Laboratory. Although never confirmed by visual examination at BCL, the fuel rod clad integrity of this assembly was considered suspect and identified as a "designated leaker" prior to encapsulation and storage, and this gas analysis reinforces this suspicion. Therefore, there appears to be no evidence to indicate that fuel assembly dry storage has caused any deterioration of fuel rod clad integrity.

APPENDIX M
TEST DATA UNCERTAINTY AND FUEL CLAD PREDICTION INACCURACY ANALYSES

Evaluations of test data uncertainty and fuel clad prediction inaccuracy are presented in this Appendix. The areas of test data evaluation included instrumentation measurement and position uncertainty, heat source position and power level uncertainty, variation in measured temperatures between correspondingly placed thermocouples, and differences between recorded temperatures included as test data and those not included. The effects of instrumentation measurement and position uncertainty and the calculational method inaccuracy were evaluated to determine overall fuel clad prediction inaccuracy.

M.1 INSTRUMENTATION AND HEAT SOURCE UNCERTAINTIES

M.1.1 INSTRUMENTATION

The typical measurement uncertainty for the Type K thermocouples used for all the tests is ±2°F for the range of temperatures measured. This is based on thermocouple calibration after fabrication.

An attempt was made to determine the effect of data logger calibration on test thermocouple readings; however, records of the recalibrations did not include pre- and post-calibration temperature readings for all calibrations. In addition, for those times when pre- and post-calibration readings were taken test data were still changing due to test transient thermal response which made evaluation of the data for calibration effects very difficult and possibly meaningless. It is expected that the recalibrations maintained thermocouple readings within measurement uncertainty noted above.

Thermocouple positional uncertainty for each of the different tests performed at E-MAD has been evaluated from the fabrication and installation tolerances on design drawings. Table M-1 presents the total position uncertainties for each group of test thermcouples. These uncertainties represent the summation of all the individual tolerances. In most cases, the positional variation is within ±1 inch except for the Reference Well thermocouples.

Most of the available tolerance data was for axial thermocouple position variations. Since the Electrically Heated Drywell Test, the Fuel Assembly Internal Temperature Measurement Test and the Concrete Silo Test have thermocouples attached to test hardware (liner, canister, concrete, etc.), radial position variations are of little concern. For the thermocouples buried in the soil, the effect of radial position variations (which were not readily available) is not expected to be significant since most of the temperature readings are low.

To access the effect of thermocouple axial position uncertainty on temperature data, the axial temperature profiles were used to determine the temperature variation with axial position near the test thermocouple locations. For all tests, the position uncertainty does not cause much inaccuracy in peak temperature reading since the axial profiles are relatively flat where peak temperatures occurred. Near the top and bottom of the

TABLE M-1
TEST THERMOCOUPLE POSITION UNCERTAINTY

Electrically Heated Drywell Test (Reference Elevation: Ground Level)

		Tolerance (In.)	
Thermocouple Location	Thermocouple No.	Axial	Other
Canister	14 to 24	+0.555 -0.705	
Liner	25 to 38	±0.23	
Liner Bottom Plate	39, 40	±0.43	
Shield Plug Inside	3 to 5	±0.35	
On Liner	6 to 9	+0.23 -0.29	
Outside of Plug	10, 11	+0.35 -0.41	
Grout	44 to 50	±0.23	±0.06 Radial(From Liner)
Canister Lid	12, 13	+0.63 -0.72	
Reference Well	101 to 109	±1.2	
Instrumentation Wells	51 to 99	±0.70	

Fueled Drywells (Reference Elevation: Top of Concrete Pad)

	Tolerance (In.)	
Thermocouple Location	Axial	Other
Canister	±0.37 +0.87 (Bottom of -0.89 T/C Tubes)	0.062 Dia. T/C in 0.75 x 0.75 Angle
Liner	±0.32	0.062 Dia. T/C in 0.083 I.D. Tube
Instrumentation Wells	±0.70	

Concrete Silo (Reference Elevation: Top of Liner)

	Tolerance (In.)	
Thermocouple Location	Axial	Other
Silo Concrete	Insufficient Data	
Silo Liner	±0.26	Same as fueled drywells
Canister	±0.37	Same as fueled drywells

TABLE M-1 (Continued)

Fuel Assembly Internal Temperature Measurement Test (Reference Elevation: Top of Canister)

Thermocouple Location	Tolerance (In.) Axial	Other
Canister	±0.26	
Liner	±0.27	
Thermowell	±0.20	0.062 Dia. T/C in 0.311 I.D. Tube
Canister Lid Top Plate	±0.43	
Canister Lid	±0.28	
Canister Bottom	+0.32 -0.38	
Insulation Sheath	±0.20	

Air-Cooled Vault (Reference Elevation: Hot Bay Floor)

Thermocouple Location	Tolerance (In.) Axial	Other
Canister	±0.37	Same as fueled drywells
Outlet Pipes	±0.50	

canister heated length, the profiles show slopes which result in larger temperature inaccuracies. Inaccuracies for all thermocouples were found to be less than ±2°F for all tests. Results of this evaluation have been included in the Test Data Accuracy section for each test.

For storage canisters in the drywells, concrete silo and lag storage pit, the canister thermocouples are inserted into 0.75 inch by 0.75 inch by 0.12 inch thick angles welded to the canister exterior. The resulting positional uncertainty is expected to create the largest error between measured and actual temperatures. For the canister thermocouple evaluation, data from the Fuel Assembly Internal Temperature Measurement Test and from the storage tests were evaluated. The Fuel Assembly Internal Temperature Measurement Test canister had thermocouples installed both in these tubes and attached to the canister at two elevations. Two pair of thermocouples placed on opposite sides of the canister at each elevation provided data from which the measurement error can be evaluated. The data from these thermocouples was adjusted to compensate for the measured variation around the canister (determined for each test by the eight thermocouples around the canister near the fuel assembly midplane). Table M-2 provides a summary of the comparison from the

TABLE M-2
FUEL ASSEMBLY INTERNAL TEMPERATURE MEASUREMENT TEST
CANISTER TEMPERATURE COMPARISON ATTACHED VERSUS IN INSTRUMENTATION TUBES

PHASE II TESTS - F/A B43

Distance Below Top of Canister (In.)	Direction of Comparison		Canister Temperature Range (°F) 220-230	250-280	300	400	500
53.0	0-180°	Max	6.2	10.9	5.6	4.6	3.2
		Min	0.6	1.3	3.6	2.0	2.9
		Ave	4.91	5.0	4.3	3.2	3.3
53.0	90-270°	Max	13.1	11.1	11.1	10.8	11.1
		Min	3.2	8.0	9.1	8.4	10.5
		Ave	7.53	9.05	10.23	9.9	10.76
113.0	0-180°	Max	8.5	7.8	4.6	5.3	4.2
		Min	2.2	4.3	3.5	3.5	3.7
		Ave	6.1	5.38	4.2	4.4	3.9
113.0	90-270°	Max	4.6	4.3	1.7	1.7	1.9
		Min	0.5	0.3	0.4	0.7	0.6
		Ave	2.86	2.07	2.9	1.06	1.03

PHASE III TESTS - F/A D15

			Canister Temperature Range (°F) 300-350	400	450	500	550	600
53.0	0-180°	Max	10.9	3.7	3.8	4.6	3.2	
		Min	0.8	3.2	2.3	2.9	0.6	
		Ave	5.64	3.45	3.05	3.73	2.0	2.4*
53.0	90-270°	Max	20.5	16.7	19.4	16.5	15.8	
		Min	4.1	14.1	18.1	14.0	14.2	
		Ave	13.47	15.4	13.75	14.87	15.23	14.1*
113.0	0-180°	Max	14.2	6.5	7.4	5.7	13.7	
		Min	2.4	6.4	5.2	2.9	5.1	
		Ave	7.47	6.45	6.3	4.5	8.43	2.4*
113.0	90-270°	Max	7.5	1.5	3.4	2.2	1.6	
		Min	0.1	0.8	2.9	1.2	0.4	
		Ave	3.8	1.15	3.15	5.1	1.06	0.8*

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*Only one value recorded

four thermocouple pairs for all the tests performed. In all cases, the temperatures measured in the tubes were lower than those on the canister. The peak differences at an elevation close to the fuel assembly midplane were 8.5°F for all the fuel assembly B43 tests and 14.2°F for all the fuel assembly D15 tests.

Since the recorded canister temperatures on canister opposite sides varied for each storage location, it was assumed that this difference was due to the thermocouple position variations within the instrumentation tubes. The differences between data from opposing canister thermocouples were calculated (see Tables M-3 and M-4) and the minimum values subtracted from the peak differences noted above to give a more representative estimate of the inaccuracy of the peak recorded canister temperatures. The resulting inaccuracies in canister temperatures (noted as maximum estimated difference between actual and measured temperature) were 8.5°F for the B series fuel assemblies in the drywells and concrete silo, 9.5°F for fuel assembly D22 in Drywell 5, and 7.0°F for fuel assembly D22 in the lag storage pit.

Combining the instrumentation position error induced inaccuracy and the thermocouple measurement uncertainties, the peak canister temperatures are estimated to be between 6.5 and 11.5°F higher than the peak measured canister temperatures for the helium filled canisters and between 5.0 and 9.0°F higher than the peak measured canister temperatures for an air filled canister.

For the Fuel Assembly Internal Temperature Measurement Test, the thermowell thermocouples are inserted into 0.375 inch diameter, 0.032 inch thick tubes which are inserted into control rod guide thimbles or the center instrumentation tube of a fuel assembly. A thermal analysis was performed to determine the difference between recorded thermowell temperature and the peak temperature of the adjacent fuel rod cladding. This analysis is detailed in Section M.4. The results indicated that the peak fuel clad temperatures were 1 to 2°F higher than those measured for a canister filled with helium and 5.0 to 6.5°F higher than those measured for a canister filled with air.

Combining the instrumentation position induced inaccuracy and the thermocouple measurement uncertainties, the peak fuel clad temperatures are estimated to be between 1.0°F lower and 4.0°F higher than the measured peak center thermowell temperatures for a helium backfill and between 3.0 and 8.5°F higher than the peak measured center thermowell temperatures for an air backfill.

M.1.2 HEAT SOURCE

The axial positional uncertainty of the heat sources (either electrical heaters or spent fuel assemblies) was determined from a summation of the component tolerances. Table M-3 presents the results of this summation. With the exception of the Fuel Assembly Internal Temperature Measurement Test, all of the test heat sources could vary by more than ±1 inch. Since the heated lengths are in excess of 140 inches and in all cases the heat is transferred to both radially and axially to a canister, this axial position uncertainty should have little effect on measured canister and other temperatures for each test.

The variations of the electrical power source for the Electrically Heated Drywell Test (resulting in a power level variation of ±1 percent) are expected to have had a significant effect on measured temperatures. The actual effect has not been evaluated since power level variations were only recorded twice a day during working hours and not on a continuous basis. During periods when test data was taken at one hour intervals, variations in temperatures were less than 5°F over the entire day (measured during 1 kW operation). During October 1980 at the 3 kW power level, the power level exceeded the ±1 percent and was nearly 3.3 kW when the power level was checked after a three day weekend

TABLE M-3
HEAT SOURCE AXIAL POSITION UNCERTAINTY

Test	Tolerance (In.)	Reference Elevation
Electrically Heated Drywell	±1.68	Ground Level
Fueled Drywell	+0.96 -1.00	Top of Concrete Pad
Concrete Silo	+1.08 -1.12	Top of Silo
Fuel Assembly Internal Temperature Measurement Test	+0.03 -0.09	Top of Canister
Air-Cooled Vault	+1.02 -1.06	E-MAD Hot Bay Floor

period. The peak canister temperatures were about 7 to 10°F higher prior to this power reading than they had been before the weekend started.

M.2 TEST TEMPERATURE READING VARIATIONS

The test data for the drywells (both electrically heated and fueled) and the concrete silo were examined for variations between thermocouples on opposite sides of canisters and liners. The variations were evaluated for the entire test period. Results of the comparison of thermocouples at three elevations for all four drywells are shown in Table M-4. The same results for the concrete silo are presented in Table M-5. The average variations in recorded data between thermocouples ranged from less than 1°F to more than 10°F for the drywell canisters and from less than 1°F to more than 8°F for the drywell liners. The average reading variations were greater for the highest and lowest thermocouple elevations. The average variations for the concrete silo were lower (less than 5°F) than those for the drywells.

The test data readings were evaluated for variations during the day to determine how representative test data readings included in this report are of temperatures for that day. The canister, liner and soil (or concrete surround the liner temperature reading variations for the Electrically Heated Drywell Test and the Concrete Silo Test were evaluated at three different axial thermocouple locations for three or more days of data taken at 1 hour intervals. The results of this evaluation are presented in Tables M-6 and M-7 for the Electrically Heated Drywell Test and Concrete Site Test, respectively. The overall variations for the drywell canister and liner were less than 5°F for any of the 24 hour periods investigated with the maximum deviation from the time of recorded test data presented in this report being between 1 and 5°F. Liner temperatures varied less than canister temperatures. For the concrete silo, canister and

TABLE M-4
FUELED DRYWELL MONTHLY CANISTER AND LINER TEMPERATURE READING VARIATIONS

		Temperature Difference Between Opposite Side Thermocouples (°F)													
		Drywell 1			Drywell 2			Drywell 3				Drywell 5			
Thermocouple Location	Depth Below Ground Level (In.)	Max	Min	Ave	Max	Min	Ave	F/A	Max	Min	Ave	F/A	Max	Min	Ave
Canister	86.0	10.5	5.3	7.3	9.3	6.5	8.5	B41	12.9	6.5	10.3	B03	11.5	8.7	9.9
								B03	4.7	0.3	2.54	D22	4.8	2.4	3.7
	146.0	1.9	0.0	0.57	3.3	1.1	2.6	B41	4.2	2.0	3.1	B03	5.3	3.5	4.3
								B03	6.5	3.6	4.8	D22	10.5	4.7	7.8
	206.0	0.3	0.0	0.1	1.2	0.7	1.1	B41	0.7	0.1	0.34	B03	2.3	1.4	1.76
								B03	8.6	6.9	8.0	D22	0.4	0.0	0.14
Liner	85.75	3.6	2.5	2.9	3.6	2.0	2.8	B41	5.3	3.0	3.9	B03	8.7	5.2	8.03
								B03	5.2	1.8	3.1	D22	7.3	3.0	3.9
	145.75	1.9	1.1	1.4	2.1	0.7	1.7	B41	1.5	0.5	1.2	B03	1.8	0.0	0.44
								B03	3.3	1.7	2.7	D22	2.3	1.5	1.84
	205.75	0.6	0.3	0.43	0.9	0.4	0.57	B41	7.7	3.0	4.2	B03	6.1	0.9	2.4
								B03	3.6	2.0	2.4	D22	NA	NA	NA

TABLE M-5
CONCRETE SILO MONTHLY CANISTER AND LINER TEMPERATURE READING VARIATIONS

		Temperature Difference Between Opposite Side Thermocouples (°F)		
Thermocouple Location	Distance Below Top of Silo (In.)	Max	Min	Ave
Canister	68	3.7	1.4	2.3
	128	2.3	0.5	1.1
	188	5.7	2.7	3.5
Liner	68	5.8	1.3	2.3
	128	1.7	0.1	0.95
	188	1.7	0.0	1.4

TABLE M-6
ELECTRICALLY HEATED DRYWELL TEST DAILY TEMPERATURE READING VARIATIONS

Thermocouple Location	T/C No.	Distance Below Ground Level (In.)	Maximum Variation (°F) Date 7/31/79	Maximum Variation (°F) Date 3/26/80	Maximum Variation (°F) Date 3/27/80	Max. Variation (°F) From Reading at: 4:00 p.m. Date 3/26/80	Max. Variation (°F) From Reading at: 4:00 p.m. Date 3/27/80	Max. Variation (°F) From Reading at: 3:00 p.m. Date 7/31/79	Max. Variation (°F) From Reading at: 11:00 a.m. Date 7/31/79
Canister	13	36.6	2.9	2.5	1.4	2.3	1.0	1.6	2.9
	16	96.6	4.1	4.9	3.3	4.9	1.7	2.1	4.1
	22	187.8	2.5	3.6	2.0	3.6	1.7	1.2	2.5
Liner	29	39.7	1.3	1.6	1.2	1.2	1.2	0.3	1.3
	31	96.3	2.2	2.7	1.3	2.7	1.2	0.8	2.2
	37	187.5	1.2	1.9	1.0	1.8	1.0	0.3	1.2
Instrumentation Well 2	51	1.0	28.0	21.5	19.4	21.5	19.4	24.5	20.8
	57	129.0	0.7	0.7	0.6	0.7	0.5	0.3	0.7
Instrumentation Well 6	93	1.5	24.9	27.9	24.0	27.9	24.0	21.8	6.5
	98	151.9	0.5	0.6	0.5	0.4	0.2	0.5	0.2

TABLE M-7
CONCRETE SILO DAILY TEMPERATURE READING VARIATIONS

Thermocouple Location	T/C No.	Distance Below Top of Silo (In.)	Maximum Variation (°F) Date 3/26/80	Maximum Variation (°F) Date 3/27/80	Maximum Variation (°F) Date 6/24/80	Maximum Variation (°F) Date 6/25/80	Max. Variation (°F) From 4:00 p.m. Reading Date 3/26/80	Max. Variation (°F) From 4:00 p.m. Reading Date 3/27/80	Max. Variation (°F) From 4:00 p.m. Reading Date 6/24/80	Max. Variation (°F) From 4:00 p.m. Reading Date 6/25/80
Canister	674	68	1.5	0.6	1.0	0.7	0.8	0.2	0.4	0.2
	678	128	1.1	0.9	0.3	0.6	0.9	0.6	0.5	0.6
	682	188	1.0	0.4	0.3	0.4	0.7	0.4	0.2	0.4
Liner	668	68	1.2	0.4	0.3	0.5	0.7	0.4	0.2	0.3
	670	128	1.1	0.4	0.4	0.7	0.7	0.1	0.3	0.5
	672	188	1.1	0.3	0.3	0.5	0.7	0.2	0.2	0.1
	660	128.5	0.9	0.3	0.2	0.6	0.7	0.2	0.2	0.6
23"R Concrete	661	128.5	1.0	4.3	0.8	0.8	1.0	0.3	0.5	0.6
37"R Concrete	662	128.5	2.9	2.8	3.9	3.2	2.5	2.4	3.9	3.2
50"R Concrete	663	128.5	12.8	12.1	16.6	17.9	0.8	0.8	6.9	7.3

liner temperatures varied by between 0.1 and 1.2°F. Variations in measured drywell soil temperatures (near heated length midplane) were less than 1°F as were the measured concrete temperatures at a 37 inch radius for the concrete silo. Daily variations in near-surface soil temperatures (drywell) and near-surface concrete temperatures (silo) were as high as 28°F (soil) and 18°F (concrete). These variations were caused by the day/night ambient air temperature variations and not measurement errors.

M.3 PEAK FUEL CLAD TEMPERATURE PREDICTION INACCURACY

The peak fuel clad temperature predictions were evaluated to determine the overall inaccuracy from the method of predictions and the effects of the uncertainties in the measured canister and center thermowell temperatures.

The peak center thermowell temperatures were calculated using the equations noted in Section 5.6.1 using the recorded canister temperatures and predicted decay heat levels from the Fuel Assembly Internal Temperature Measurement Tests. These predicted values were compared to the recorded values. The differences ranged from -4.5 to +6.3°F for the helium backfill tests and from -1.8 to +11.5°F for the air backfill tests for fuel assembly D15. The uncertainties in canister temperature measurements noted in Section M.1.1 were included in the evaluation of the predictions uncertainty. Predictions were made using the peak measured canister temperatures and compared to the predictions using the estimated actual canister temperatures (peak measured plus peak uncertainty).

The uncertainties from these two prediction comparisons were combined with the thermocouple measurement uncertainty, and the canister and center thermowell instrumentation position induced uncertainties to determine the overall prediction inaccuracy. The five maximum and minimum uncertainties were combined by taking the square root of the sum of the squares. The combinations of these uncertainties resulted in the following:

- Peak fuel clad temperatures for fuel assemblies in the drywells and concrete silo (canisters filled with helium) are estimated to be between 5.7°F lower and 14.0°F higher than the predicted values.

- Peak fuel clad temperatures for fuel assembly D22 in the lag storage pit (canister filled with air) are estimated to be between 3.4°F lower and 18.3°F higher than the predicted values.

M.4 ANALYSIS OF FUEL CLAD TEMPERATURE MEASUREMENT METHOD ACCURACY

The Fuel Assembly Internal Temperature Measurement Test attempted to measure fuel clad temperatures using thermocouples suspended in thermowells. The thermowells are attached to the canister lid and, when the lid is in place, a thermowell protrudes into each of fourteen control rod guide thimble tubes. The fifteenth thermowell is located in the instrument tube at the fuel assembly centerline. At any thermocouple location within the fuel assembly, the thermocouple hangs freely within the thermowell. A conservative approximation of the thermocouple and thermowell relative to the surrounding fuel rods is shown in Figure M-1. The temperature measured by the thermocouple positioned at the center of the thermowell would be an average of the surrounding fuel rods. In addition, the measured temperature could differ from the fuel rod clad temperature due to free convection effects outside the guide thimble tube, in the annulus between the thimble and thermowell, and inside the thermowell. The results of a three dimensional canister/fuel assembly analysis show fuel rod temperatures do not vary appreciably from row to row. However, free convection effects on the temperature measurements are less certain and an analysis estimated them.

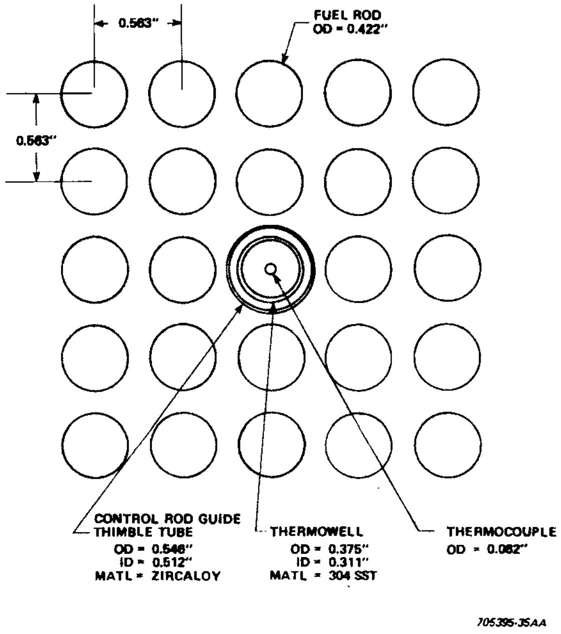

Figure M-1. Partial Fuel Assembly Cross-Section Showing Thermocouple, Thermowell, Control Rod Guide Thimble Tube and Fuel Rod Configuration for Fuel Assembly Internal Temperature Measurement Test

A complete analysis of the difference between the measured temperatures and actual fuel rod clad temperatures should consider natural circulation within the canister, the fuel assembly axial power distribution, all three heat transfer modes, and gas mixing between the fuel assembly and downcomer (the annular space between the fuel assembly and canister regions). This study would be complex and would require a computer code designed specifically for spent fuel storage analysis. A one-dimensional model has been developed to approximately analyze temperature differentials. The model and the analysis results are presented and discussed in this section.

The purpose of the analysis is to predict differences between thermocouple readings and actual fuel rod clad temperatures. The first step is to estimate the natural circulation flow rate and velocities in the fuel and downcomer regions. A key assumption is that the upward gas flow is restricted to the fuel region and that gas mixing between the fuel and downcomer does not occur. This conservative assumption leads to maximum gas velocities and maximum heat transfer coefficients at all elevations.

Once the gas flow rate is known, local gas temperatures can then be calculated. The radiation, conduction and convection heat transfer modes are considered in the region between the fuel rods and thermowell. The fuel rod temperature is assumed and the calculation predicts the temperature measured at each thermocouple location. That particular temperature, when compared with the fuel rod temperature, provides the desired estimate of the temperature difference.

Using this analysis method, temperature differences have been estimated for the air and helium backfill cases. The air backfill produces the largest differences since free convection effects are the strongest. The helium density is relatively small and even for large temperature differences, the natural circulation flow rates are low. The evacuated canister case was not analyzed since convection is nonexistent and the thermowell temperature measurement would be the closest to actual fuel rod clad temperatures.

FUEL ROD CLAD AND THERMOCOUPLE TEMPERATURE DIFFERENCE CALCULATIONS

The heat flow model used to estimate fuel rod and thermocouple temperature differences is depicted in Figure M-2. Heat flows between the fuel rod, gas, guide thimble and thermowell (as indicated in the detailed model) and the guide thimble, thermowell and thermocouple temperatures are calculated from the given gas and fuel rod temperatures. The convective heat flows q_2, q_4, q_5, q_{10}, and q_{11} are responsible for the difference between the measured temperature at the thermocouple, T_1, and the actual fuel temperature, T_F. If they are zero, T_1 and the guide thimble and thermowell temperatures would equal T_F.

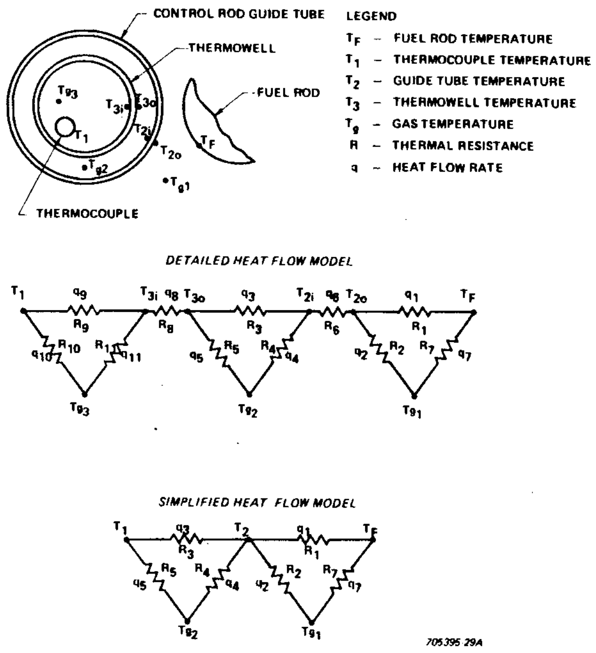

Figure M-2. Heat Flow Models

For less complicated calculations, a simplified version (also depicted in Figure M-2) can be applied. The simplification is possible, first, because the temperature differentials across the thermowell and guide thimble walls will be small compared to the other differentials. Therefore, $T_{2o} \sim T_{2i} = T_2$ and $T_{3o} \sim T_{3i} = T_3$. Second, because each thermowell is plugged at its lower end, convection currents due to net flow through the thermowell will not occur. Therefore, the temperatures T_1, T_3 and Tg_3 will be virtually equal.

The individual heat flow rates identified in the simplified model and which are pertinent to this analysis can be expressed as follows:*

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*Symbols are defined in Table M-8

$$q_1 = A_{2o}\, F_{2F}\, \sigma\, (T_F^{\,4} - T_2^{\,4}) + \frac{K_1 A_1}{X_1} (T_F - T_2)$$

$$q_2 = A_{2o}\, h_{2o}\, (T_2 - Tg_1)$$

$$q_3 = A_{1o}\, F_{12}\, s\, (T_2^{\,4} - T_1^{\,4}) + \frac{K_2 A_2}{X_2} (T_2 - T_1)$$

$$q_4 = A_{2i}\, h_{2i}\, (T_2 - Tg_2)$$

$$q_5 = A_{1o}\, h_{1o}\, (T_1 - Tg_2) \qquad \text{Eq. 1}$$

In equation form, and assuming a steady-state, these flow rates are related as follows:

$$q_1 = q_2 + q_3 + q_4 \qquad \text{Eq. 2}$$

$$q_3 = q_5 \qquad \text{Eq. 3}$$

Equations 4 and 5 can be solved simultaneously for T_1 and T_2 in terms of Tg_1, Tg_2 and T_F. Then, to evaluate T_1 and T_2, values for the gas temperatures were obtained from the gas flow analysis while T_F was assigned assumed values. Coefficient values used for calculating are identified in Table M-8.

Combining Equations 1, 2 and 3 yields

$$T_2^{\,4} (A_{2o}\, F_{2F}\, \sigma + A_{1o}\, F_{12}\, \sigma) + T_2 \left(\frac{K_1 A_1}{X_1} + A_{2o}\, h_{2o} + \frac{K_2 A_2}{X_2} + A_{2i}\, h_{2i} \right)$$

$$- A_{2o}\, F_{2F}\, \sigma\, T_F^{\,4} - \frac{K_1 A_1}{X_1} T_F - A_{2o}\, h_{2o}\, Tg_1 - \frac{K_2 A_2}{X_2} T_1$$

$$- A_{2i}\, h_{2i}\, Tg_2 - A_{1o}\, F_{12}\, \sigma\, T_1^{\,4} = 0 \qquad \text{Eq. 4}$$

and

$$A_{1o}\, F_{12}\, \sigma\, (T_2^{\,4} - T_1^{\,4}) + \frac{K_2 A_2}{X_2} T_2 - T_1 \left(\frac{K_2 A_2}{X_2} + A_{1o} h_{1o} \right) \qquad \text{Eq. 5}$$

$$+ A_{1o} h_{1o} Tg_2 = 0$$

TABLE M-8
SYMBOL DEFINITIONS & NUMERICAL INPUT* FOR TEMPERATURE DIFFERENCE CALCULATIONS

D_F - fuel pin outside diamter = 0.422 in

P - fuel pin pitch = 0.5629 in

D_o - guide thimble outside diameter = 0.546 in

D_i - guide thimble inside diameter = 0.512 in

D_t - thermowell outside diameter = 0.375 in

A_{2o} - guide thimble outside surface Area $= \pi D_o\ (1) = 1.7153\ in^2$

A_{1o} - thermowell outside surface area $= \pi D_t\ (1) = 1.781\ in^2$

A_{2i} - guide thimble inside surface area $= \pi (D_i)\ (1) = 1.6085\ in^2$

X_1 - conduction distance between fuel pin and guide thimble = $P - \frac{1}{2}(D_o + D_F) = 0.0789$ in

X_2 - conduction distance between guide thimble and thermowell = $\frac{1}{2}(D_i - D_t) = 0.685$ in

A_1 - conduction area between fuel pin and guide thimble = $\pi (D_o + X_1)(1) = 1.9632\ in^2$

A_2 - conduction area between guide thimble and thermowell = $\pi \left(\frac{D_t + D_i}{2}\right)(1) = 1.3933\ in^2$

h_{2o} - heat transfer coefficient on guide thimble outside surface ($Btu/hr\text{-}ft^2\text{-}F$) - variable**

h_{2i} - heat transfer coefficient on guide thimble inside surface = 0.0

h_{1o} - heat transfer coefficient on thermowell outside surface = 0.0

ε_F - fuel emissivity = 0.30†

ε_{2o} - guide thimble outside surface emissivity = 0.30†

ε_{1o} - guide thimble inside surface emissivity = 0.30†

ε_t - thermowell emissivity - variable

F_{2F} - guide thimble/fuel shape factor = $\dfrac{1}{\dfrac{1}{\varepsilon_t} + \dfrac{D_o}{2P}\left(\dfrac{1}{\varepsilon_F} - 1\right)}$

F_{12} - thermowell/guide thimble shape factor = $\dfrac{1}{\dfrac{1}{\varepsilon_t} + \dfrac{D_t}{D_i}\left(\dfrac{1}{\varepsilon_{1o}} - 1\right)}$

σ - Stefan-Boltzman constant = $0.1714 \times 10^{-8}\ Btu/hr\text{-}ft^2 - F^4$

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*Per unit length

**A function of fluid properties and the film temperature differential, Calculated based upon Equation 7-4a, Reference 15

†Conservatively low values

GAS FLOW RATE AND TEMPERATURE CALCULATIONS

Gas flow rates, heat transfer coefficients and local gas temperatures were estimated assuming known and uniformly distributed canister and fuel rod temperatures. It was also assumed that gas flowing upward was restricted to the channels between fuel assembly rods and mixing between the fuel and downcomer, which will occur in the actual canister since the fuel assembly is not shrouded, was not considered. Therefore, the analysis model consisted of a circulating gas stream warmed in the fuel assembly and cooled in the downcomer with the circulation driven by the difference in gas densities. Applying the model, the following expressions for local and average gas temperatures can be derived:

Gas Temperature at Fuel Exit

$$T_2 = \frac{T_F\,(1 - e^{-a_F L}) + T_{CAN}\, e^{-a_F L}\,(1 - e^{-a_c L})^*}{1 - e^{-L\,(a_c\ +\ a_F)}}$$

Gas Temperature at Fuel Inlet

$$T_1 = T_{CAN} + (T_2 - T_{CAN})\, e^{-a_c L}$$

Local Gas Temperature in Fuel Region

$$T_H = T_F - (T_F - T_1)\, e^{-a_F \ell}$$

Average Gas Temperature in Fuel Region

$$\overline{T}_H = T_F - \frac{1}{a_F L}\,(T_F - T_1)\,(1 - e^{-a_F L})$$

Average Gas Temperature in Downcomer Region

$$\overline{T}_c = T_{CAN} + \frac{1}{a_c L}\,(T_2 - T_{CAN})\,(1 - e^{-a_c L})$$

The natural circulation flow and pressure drop relationship is written as follows:

$$(\rho_c - \rho_H)\,\frac{g}{g_c}\,\frac{L}{144} = 0.0832 \times 10^{-10}\, W^2 \left[\, \frac{1}{\rho_H A_H^2}\,(K_H + f_H\,\frac{L}{D_H}) + \frac{1}{\rho_c A_c^2}\,(K_c + f_c\,\frac{L}{D_c})\right]$$

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*Symbols are defined in Table M-9

TABLE M-9
SYMBOL DEFINITIONS & NUMERICAL INPUT FOR GAS FLOW RATE AND TEMPERATURE CALCULATIONS

T_F - fuel temperature (°F) - variable

T_{CAN} - canister temperature (°F) - variable

T_1 - tas temperature at fuel inlet (°F) - variable

T_2 - gas temperature at fuel exit (°F) - variable

T_H - local gas temperature in fuel assembly (°F) - variable

$\bar{T}_H$ - average gas temperature in fuel region (°F) - variable

$\bar{T}_c$ - average gas temperature in downcomer (°F) - variable

L - fuel assembly length = 12.0 ft

ℓ - axial location referenced to fuel assembly inlet (ft)

a_c - $\frac{hC}{WC_p}$ in downcomer region - variable

a_F - $\frac{hC}{WC_p}$ in fuel assembly - variable

W - natural circulation flow rate (lb/hr) - variable

C_p - gas specific heat capacity = 0.24 Btu/lb-°F for air; 1.24 Btu/lb-°F for helium

C - heating or cooling perimeter = 3.56 ft in downcomer; 24.9 ft in fuel assembly

h - heat transfer coefficient (Btu/hr-ft^2-°F) - variable

ρ_c - gas density in downcomer (lb/ft^3) - variable

ρ_H - gas density in fuel assembly (lb/ft^3) - variable

A_c - downcomer flow area = 0.541 ft^2

A_H - fuel assembly flow area = 0.253 ft^2

D_c - downcomer hydraulic diameter = 0.607 ft

D_H - fuel assembly hydraulic diameter = 0.0407 ft

f_c - downcomer friction factor - variable

f_H - fuel assembly friction factor - variable

K_c - downcomer pressure drop coefficient = 0.0

K_H - fuel assembly pressure drop coefficient = 0.0*

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*Grids neglected - conservative assumption

It is noted that acceleration effects have been neglected and all fluid properties are evaluated at the average gas temperatures. Acceleration pressure drops can be ignored since they are small compared to the friction component.

The key assumption that the gas streams in the fuel assembly and downcomer are restricted to those regions makes this first approximation analysis possible. Without this assumption, mixing would have to be considered at all elevations and the calculations more complex. A more sophisticated analysis considering transverse mixing could establish local gas temperatures and velocities with better accuracy. However, it may be unnecessary since the present analysis is conservative and the resulting fuel and thermocouple temperature difference predictions are small enough to be acceptable. The analysis is conservative mainly due to the no mixing assumption. In the actual canister, transverse mixing would equalize the gas temperatures in the fuel assembly and downcomer regions. This would suppress the density differential and minimize natural circulation. By neglecting mixing, the analysis encourages the "chimney effect". This leads to maximum gas velocities and heat transfer coefficients and minimum gas temperatures in the fuel assembly zone. These conditions, of course, will all contribute to maximizing the temperature differential predictions.

In the Fuel Assembly Internal Temperature Measurement Test arrangement, the instrument tube is open at the top and bottom and could therefore support the net flow of gas past the thermowell. However, the tube rests directly on the canister cruciform plate which supports the fuel assembly when installed in the test canister. Therefore, gas flow between the thermowell and instrument tube is effectively blocked. This simplifies the calculations since convection effects in that annulus can be neglected and thermowell temperature T_1 (see Figure M-2) will be essentially equal to instrument tube temperature T_2.

Each guide thimble tube is capped at the lower end but has a set of four 0.097 inch diameter flow holes above the end. In the reactor, these flow holes relieve the pressure buildup occuring during control rod insertion and scram modes. The thimbles are open at their upper ends and a net gas flow through the thimble/thermowell annulus will occur, driven by the fuel assembly pressure differential. The flow resistance due to friction, however, is very high and calculations show the resulting gas velocities in the annulus will be small.

Therefore, as with the instrument tube, convection effects in the annulus will be small and can be neglected.

RESULTS

A variety of fuel and canister temperature combinations have been analyzed simulating 1.0 and 2.0 kW fuel assembly decay heat levels with an air backfill and a 1.0 kW level with helium. The various cases considered during the study are identified in Table M-10.

For the entire group, the maximum fuel clad and thermocouple temperature difference is 6.5°F and occurs for Case No. 7, with an air backfill at the lowermost thermocouple elevation. The temperature differences decrease at higher elevations as the gas temperature rises and, at midplane, none exceed 3°F. The analysis does not consider in detail the heat transfer processes and power shape effects at the fuel assembly ends. If considered, they could increase the temperature differences. However, due to the conservatism, it is not expected that the differences would exceed those calculated.

TABLE M-10

ANALYSIS CASES

Case No.	Fuel Temp (°F)	Canister Temp (°F)	Approximate Power Level (kW)	Backfill Medium	Temperature Difference (°F)*	Test Run Simulation
1	600	500	1.0	Air	5.0	500°F Uniform Canister Temp.
2	600	500	1.0	Helium	1.0	"
3	425	300	1.0	Air	5.0	300°F Uniform Canister Temp.
4	425	300	1.0	Helium	2.0	"
5	400	250	1.0	Air	5.0	Drywell No. 5 Canister Profile
6	400	250	1.0	Helium	2.0	"
7	700	450	2.0	Air	6.5	Postulated - No Test Run

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*Thermocouple elevation is 30 inches above the bottom of the active fuel