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FOURTH QUARTERLY PROGRESS REPORT

JANUARY - MARCH, 1965

FOR THE

SUPERCritical TECHNOLOGY PROGRAM

AT(30-1)-3374-5

RESEARCH AND DEVELOPMENT REPORT

PREPARED FOR THE N.Y. OPERATIONS OFFICE
U.S. ATOMIC ENERGY COMMISSION

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ABSTRACT

This is the Fourth Quarterly Progress Report summarizing work performed under AEC Contract AT(30-1)-3374 for the period January through March 1965.

The objectives of this program are to:

1. Build and install a supercritical water-cooled, in-pile, fuel testing loop.
2. Demonstrate the feasibility of collapsed clad fuel elements in a reactor environment, cooled by supercritical water.
3. Evaluate the design of the fuel elements by post-irradiation examination.
4. Evaluate loop performance by analyzing operating data.

Two fuel assemblies manufactured by different methods (pellets and vibratory compaction) will be tested. Fuel rods containing pellets will be clad with Incoloy 800, while those which are vibratory compacted and swaged will be clad with 16 Cr - 20 Ni stainless steel.

An existing loop design and large number of loop components previously purchased by Westinghouse have been turned over to the AEC under the terms of the contract. The design of the loop is complete and the remainder of the components have been purchased under the contract. Fuel assembly and pressure tube designs have been completed. Two pressure tubes and the first fuel assembly have been fabricated. Loop construction is continuing.

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SUMMARY

This is the Fourth Quarterly Progress Report under AEC Contract AT(30-1)-3374 on a Supercritical Technology Program for the period from January through March 1965.

The design of an in-pile loop facility capable of operating at supercritical pressures and at temperatures of up to 1000°F is complete. Erection of the loop components in the vapor container of the Saxton Reactor, owned and operated by the Saxton Nuclear Experimental Corporation (SNEC), began October 15, 1964. Installation work was halted on October 30, 1964 when SNEC resumed scheduled reactor operation. Loop erection started again on January 25, 1965 and is essentially complete. Reactor operation will be resumed after loop shakedown is complete and the first fuel assembly is installed.

Two pressures tubes and the first fuel assembly have been fabricated. Fabrication of the second fuel assembly is nearly complete.

1.0 INTRODUCTION

This is the Fourth Quarterly Progress report on research and development work under AEC Contract AT(30-1)-3374 for the period from January through March 1965. The program consists of completing the design and fabrication of a supercritical water cooled, in-pile loop. Two fuel assemblies are to be tested in a pressure tube inserted into the Saxton reactor. The irradiated fuel will be examined at the Westinghouse Post Irradiation Facility, and the loop performance evaluated.

The designs were largely completed under a Westinghouse-funded program prior to the contract period. In addition, most of the loop components and several parts of the pressure tube and fuel assemblies were purchased under this program.

The following reports have been issued under the contract:

<u>WAPD Report No.</u>	<u>Title</u>
None Req'd.	Monthly Progress Letters for the months of April, May, July, August, October, November 1964; January, February 1965.
WCAP-2626	Work Programs for the period April 6, 1964 to September 30, 1964.
WCAP-3374-1	First Quarterly Progress Report, April to June 1964.
WCAP-3374-2	Second Quarterly Progress Report, July to September 1964.
WCAP-3374-3	Work Programs for the Period October 1, 1964 to March 31, 1965.
WCAP-3374-4	Third Quarterly Progress Report October to December 1964.
WCAP-3374-6	Work Progress for the Period April 1, 1965 to November 30, 1965.

The work is divided into the following tasks and sub-tasks:

<u>Task No.</u>	<u>Title</u>
1.0	Project Management
2.0	Loop Construction and Erection
2.1	Loop Design and Procurement
2.2	Loop Fabrication and Erection
2.3	Loop Shakedown
2.4	Pump Testing
2.5	Loop Removal
3.0	Transition Joint Evaluation
4.0	Pressure Tube Design and Fabrication
4.1	Pressure Tube Design
4.2	Pressure Tube Fabrication
5.0	Fuel Assembly Design and Fabrication
5.1	Fuel Assembly Design
5.2	Fuel Fabrication and Assembly
5.3	Shipping Container Design and Fabrication
5.4	Fuel Assembly Materials Consulting
6.0	Loop Operation
7.0	Post Irradiation Examination
7.1	Irradiated Fuel Shipping Container Design and Fabrication
7.2	Fuel Shipping Services
7.3	Fuel Examination Specifications
7.4	Hot Cell Services

Task No.

Title

8.0

Performance Analysis

8.1

Loop Performance Analysis

8.2

Fuel Performance Analysis

2.0 LOOP DESIGN, CONSTRUCTION AND ERECTION

The design of the supercritical water loop was initiated under a Westinghouse Division General Research Program which was closed out early in 1963. Under this program, the loop was partially designed and most of the loop components purchased.

Under the present contract, the design work and loop components have been turned over to the AEC. The loop has been essentially completed and installed in the Saxton reactor vapor container which is owned and operated by the Saxton Nuclear Experimental Corporation (SNEC).

The design of the loop and of the loop components will be fully described in a topical report, which will be issued after the shakedown of loop.

R. L. Whitney, Manager, Mechanical
Components

F. Ottenheimer

W. S. Boyd

STP-210 Loop Mechanical Design

The major effort during this period was expended on completion of design and procurement work and on construction assistance. Several test programs were consummated, some auxiliary systems experienced final design and layout changes, and the requirements of insurance and State regulatory authorities were resolved.

Final erection drawings were issued and necessary procurement was performed for piping and components to be installed in the various compartments of the containment vessel. The work was complicated somewhat by a number of late changes. Prominent among these were:

1. Modifications of the sampling system, compressed air system and safety injection backup.
2. Addition of a filter and several isolation, vent, and drain valves.
3. Relocation of the feed tank, the filters (with resultant shielding requirements), and the sampling ion exchange columns.

The major procurement items during the quarter were the added compressed air system components, the thermal insulation work and material, and mechanical spare parts.

Information was submitted to state authorities to satisfy the requirements for the Pennsylvania Special Number assigned to the loop. In addition, the insurance Code inspector was provided with chemical and physical test reports applying to all significant component and piping materials used in the loop.

Performance tests were carried out on three components. The Union Pump Company, supplier of Loop Pump No. 2, subjected the unit to a six-week test at design conditions of pressure and capacity, with special emphasis on mechanical seal performance. General pump operation was found to be quite satisfactory. High pressure seal leakage was negligible during the first five weeks (generally less than 30 ml/min per plunger). During

the last week of the test, leakage past one of the three plungers rose to 320 ml/min (approximately 5 gph), which was still well within allowable limits. The low pressure (back-up) seals were found to be generally ineffective, necessitating a re-evaluation of the present leak-off scheme to pump suction. The pump was shipped to the site along with replacement plungers and new seals.

The Standby Pump was subjected to a formal performance test at Westinghouse APD for two successive periods of 73 hours each, following previous intermittent operation in excess of 100 hours. Maximum packing leakage for any one plunger was measured as 10 and 100 ml/minute, respectively, during the two periods. The leakage, as well as pump performance in general, was considered satisfactory, especially in view of the limited service which this pump is expected to see on site. The back-up packing sections failed to perform satisfactorily (similar to Union Pump experience) and have been removed from the pump.

Two spring loaded check valves (1/2" CV-42) were subjected to a static back-pressure of 5000 psi for seven days as a test of their reliability. There was no measurable leakage during this period. Immediately following release of test pressure, water was introduced slowly in the normal flow direction. It was found that 6 to 8 psi of pressure was required to open the valve at this time. Test results were considered excellent.

A number of trips were made to the site for inspection of work and consultation with SNEC and construction personnel. Contributions were also made to the operator training program, Systems Description, and Operating Manual.

A. R. Collier, Manager, Fluid Systems
T. J. Mitlo
W. R. Snyder
R. S. McQueen
J. L. Gallagher

STP-211 Loop Fluid Design

Calculations were performed to assure that the equipment and piping layout provided adequate seal water flow to the vacuum pump.

Additional calculations were performed to determine that there was adequate component cooling water flow for the supercritical loop coolers under various component cooling system operating conditions, and to determine the back pressure on loop safety valves PSV-1 and 2.

A rough preliminary draft of the Loop Operations Manual was extensively revised and subsequently re-issued. The re-issued Loop Operations Manual is presently being reviewed by Westinghouse APD and SNEC and will have a final issue after loop shakedown has been completed.

Figure 1 presents the Loop Process Flow Diagram. Figure 2 is the complete Sampling Process Flow Diagram. Figure 3 is the Air Supply System Process Flow diagram.

NO.	DESCRIPTION	DATE	BY	CHKD.
1	ISSUED FOR CONSTRUCTION	10/1/54	D. M. PETERS	G. M. J. L.
2	REVISION	10/1/54	D. M. PETERS	G. M. J. L.
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9	REVISION	10/1/54	D. M. PETERS	G. M. J. L.
10	REVISION	10/1/54	D. M. PETERS	G. M. J. L.

Figure 1

Figure 3

STP-212 Loop Controls Design

R. Eastman, Manager, Control Systems
R. J. Cooney, Manager, Electrical Systems
E. G. Herrick

Purchase orders were issued for miscellaneous new control equipment.

Range changes were made to several instrument channels.

Purchase orders were issued for I & C spare parts.

All available instruction manuals were issued and missing manuals were placed on order.

Purchase orders were written for a two speed starter to supply a second main Loop Pump. The control circuits for the first main Loop Pump and the Standby Pump were revised to accommodate automatic starting of the second Loop Pump. New control switches and auxiliary relays were purchased for the revised circuits.

All instrumentation channel and remote operated valve design requirements were reviewed and compared to as-received equipment. Equipment was updated as-required. Failure mode of all valves was reviewed and several valves were revised to agree with it.

Purchase orders were issued for electrical system spare parts.

Assistance was provided for Control and Electrical Systems checkout at Saxton.

Many electrical construction drawings were revised to show as-built conditions.

STP-213 Supercritical Loop Safeguards Analysis

R. A. Wieseemann, Manager
Plant Safeguards & Licensing
R. C. Nichols

During the period, several additional changes to the Supercritical Loop Safeguards Report were prepared to reflect the latest design and operations. These changes were discussed with SNEC and a final format agreed to and the changes submitted to the AEC as Revision I to the loop Safeguards Report. In addition to the changed pages for the report, revised proposed Technical Specifications were submitted as part of Revision I.

STP-214 Vessel & Tool Design

L. R. Katz, Manager, Pressure Vessel &
C. Benton Tool Design
E. H. Frye

The following components have been shipped to the Saxton site:

1. Pressure Tube Handling Tool
2. Pressure Tube Lifting Bar
3. Failed Fuel Assembly Spacer
4. Pressure Tube Handling Tool Support Rack

In addition to the above components, the pressure tube storage rack has been installed in the Saxton spent fuel storage well.

G.R. Taylor, Manager
Chemistry Section

D.D. Whyte
D.G. Sammarone

STP-215 Loop Chemical System Design and Fabrication W.D. Fletcher

During the last quarter it was decided to add provisions in the loop design for continuous ammonia injection at the loop pump suction.

The purpose of adding ammonia to the system is to suppress radiolytic decomposition of the coolant thereby inhibiting corrosion of the fuel elements. Recent experience in out-of-pile corrosion work under Contract AT(30-1)-2948 has shown that oxygen at levels of 2 to 3 ppm will severely limit clad life. There is no data on radiolysis of water at the proposed operating conditions in-pile, hence ammonia will be used as a preventative measure.

The ammonia injection system design requirement have been established and construction has started. The system will be installed at Saxton during the next quarter.

S. N. Tower, Manager, Supercritical
Technology Program
W. S. Boyd

STP-220 Loop Fabrication Outside APD

No work was accomplished on this shop order during this reporting period.

D. C. Beatty, Manager, Nuclear Power
R. H. Baulig Service
R. E. Carr
D. D. Payne
W. H. Furfari

STP-221 Loop Erection

General

Installation of loop components was resumed on January 25, 1965, with Westinghouse supervisors and contractor's forces who, for the most part, had taken part in the 12 days installation work of the previous October. Work was continued on an accelerated schedule of generally ten (10) hours per day, six (6) days a week.

The work progressed somewhat slower than the schedules established prior to the beginning of the job, and construction forces were kept at a near maximum in order to try to meet the estimated 8 weeks schedule for this second phase of installation work. However, this phase actually required ten weeks.

At this writing (end of the report period) construction and installation are nearing completion and construction forces have been released. Remaining construction items are being completed by Westinghouse personnel.

Mechanical

The mechanical installation work was performed with a force which averaged six fitters and four welders. Other work which was included in Mechanical Contractor's scope was weld testing (radiograph and dye-check), rigging in of prefabricated packages and other large components (primarily pumps and compressors), installation of supports and pipe hangers, on-site fabrication of fittings not available commercially, and all construction janitorial work.

Wherever it was possible, piping sections were prefabricated in the on-site, temporary welding shop. Part of this prefab work had been completed prior to this installation phase. Approximately 3200 welds were required during installation. Of this total, approximately one-third

of the welds were made in the field welding shop, and the remaining two-thirds were made in the reactor vapor container.

The general sequence of installation was as follows: complete high pressure piping in primary compartment, high pressure piping in Storage Well, high pressure piping in Auxiliary Compartment, Auxiliary System piping in Primary Compartment, instrument air piping in all areas, auxiliary systems in the Auxiliary Compartment

A hydrostatic test to 6600 psi of the high pressure system was performed on March 16, with inspection and approval by the Code Inspector.

Electrical

The electrical forces averaged six men plus foreman (peak force - ten men plus foreman). Following was the general sequence of work completion:

- a. Completed yard conduit and cable work.
- b. Placed cables inside C&A Building.
- c. Placed cables inside Vapor Container (partial).
- d. Ran vapor container penetrating cables.
- e. Sealed and tested vapor container penetrations.
- f. Ran cables from vapor container junction boxes to control room
- g. Placed remaining cable inside vapor container (as devices mounted).
- h. Made terminal connections at Control Boards and at remote devices.
- i. Made preliminary check outs as circuits completed.

No major difficulties were encountered during installation. Following were the principal inconveniences:

- a. Decreases in worker efficiency necessitated by compliance with Health Physics requirements (i.e., lost time in clothes changing, working while wearing gloves, lost time in entering and leaving the vapor container for parts and material, etc.).
- b. The inefficiency of attempting to do electrical work before mechanical work was completed (i.e., running wire to a device before that device actually was mounted). This was necessary

in some cases to prevent the electrical work from falling too far behind.

Instrument Calibration

Initial calibrations were begun on a limited basis about February 20, 1965 in conjunction with checkouts of the control board sections. Calibrations were first completed on recorders, indicators, converters, and controllers in the control boards. Calibrations of remote detector and electrical loop checkouts were completed as external wiring was completed.

Since most of the instrumentation components were supplied by the Foxboro Company, the services of Foxboro field technicians were obtained for parts of the calibration work. Two Foxboro technicians were used from March 1st to March 10th, and one technician was recalled for four days additional work from March 15th to March 19th.

The Westinghouse loop operators were used for assistance in the final phases of the calibration work. It was felt that this would help to familiarize the operators with the loop and its instrumentation.

Radiation Protection

Because of the large number of contractor personnel inexperienced in radiation work and the small SNEC staff for radiation protection, Westinghouse provided additional field engineering services in the area of radiation protection.

During the quarter no serious injuries or accidents occurred. Working radiation exposure limits were set at 300 mrem per week and this limit was not exceeded. Maximum accumulated whole body radiation exposure was about 1200 mrem; average exposure was about 500 mrem per man. No instances of personnel contamination occurred of such a degree as to give rise to suspicion of significant inhalation, ingestion, or absorption of radioactive material.

Special arrangements were made with SNEC, Penelec, and NAVCO radiographers to insure that use of the radiographic source was in compliance with 10CFR Part 20, the regulations of the State of Pennsylvania; the SNEC operating license and the NAVCO by-product license without unduly impeding construction progress or interfering with SNEC and Penelec plant operations.

Protective clothing and equipment was supplied and administered as required without difficulty. Incidental tool reclamation was accomplished as necessary.

A. S. Kitzes, Manager Test
Engineering

D. Miner

T. D. Stormer

STP-222 Loop Fabrication - APD

Sample system components were completed and sent to Saxton for field installation. Comments were received on the first draft of the operating manual and incorporated in the latest issue (see STP-211 above).

A. S. Kitzes, Manager, Test Engineering
W. S. Boyd
D. Miner
R. Colombo

STP-230 Loop Shakedown

Shakedown of the supercritical loop started in the latter half of March. The shakedown crew consisted of six technicians and 3 engineers. The crew arrived on site one week before start of shakedown in order to receive health physics training and be qualified by SNEC personnel. Complete health physics qualification was required since loop shakedown would continue around the clock when only limited SNEC personnel are available.

The shakedown work during this quarter consisted mostly of:

- a. Preparing loop components for service.
- b. Checking component function and response, and adjusting set points.
- c. Completing two of the hydro tests of loop piping.

It was possible to perform these tasks while construction was being completed.

A replacement cylinder block was received from John Bean Div. in late January. Examination of the block at WAPD disclosed a number of unacceptable defects and the block was returned to John Bean Div. for repair. Following repair, the block was inspected in accordance with the requirements and acceptance standards for cast materials per Section III of the ASME Boiler and Pressure Vessel Code (Nuclear Vessels).

The repaired casting was installed and the pump reassembled in mid-March. The loop has been modified to provide a static head of 2 ft. of water on the seal gland. Because the pump suction head conditions are well below those that will exist in the supercritical loop, the pump tends to suck air which has a debilitating effect on performance. Use of the water seal eliminates air entry, resulting in smoother pump operation. Testing has been progressing since then with an interruption to replace a cylinder head gasket on No. 2 cylinder. The gaskets are spiral wound asbestos in stainless steel specially manufactured for John Bean by Flexitallic.

The pump has been in operation since March 15, with measured leakage holding in the range of 1000 ml/per 8-18 minutes with no upward trend indicated. Most of the leakage is believed to be seal water rather than pumped fluid since the effectiveness of the last stage seal is not near optimum with so small a pressure head acting across it.

STP-250 Loop Removal

W. H. Comtois, Manager, Supercritical
W. S. Boyd Technology Program

No work was accomplished on this task during the preceeding quarter.

3.0 ZIRCALOY-4 TO 316 STAINLESS STEEL TRANSITION JOINT EVALUATION

As part of an earlier Westinghouse funded program, six transition joints were purchased from Nuclear Metals Inc. These joints were manufactured by tandem extrusion using a process developed by NMI. One failed inspection after tube reduction, one was burst tested and a third was tension tested after being pressure and temperature cycled.

The other three were welded to Zircaloy tubes; two for fabrication into pressure tubes and the third for further burst testing after cold drawing. One joint was severely damaged while attempting to remove the mandrel after cold drawing. The two remaining transition joints developed small unbonded areas during the drawing operation. They are not considered acceptable for use in the supercritical program. An all stainless steel pressure tube without a transition joint will be used.

A topical report on these joints, WCAP-3374-7, has been written and it is nearly ready for publication.

4.0 PRESSURE TUBE

The pressure tube contains the test fuel assembly and is inserted into the Saxton reactor via port N-4. The design originally incorporated a bimetallic, metallurgically bonded, transition joint used to connect a Zircaloy-4 portion of the pressure tube in the active core region, to an upper stainless steel portion. This joint permits the elimination of complex mechanical devices which require large diametral clearances. Transition joints fabricated for use in the Saxton reactor were not satisfactory. An alternate, all-stainless steel, pressure tube without a transition joint has been designed and fabricated. It will be used to contain at least the first fuel assembly.

The progress reported in this area covers design, procurement and fabrication of the two pressure tubes. Most of the design was performed under a Westinghouse-funded program prior to the present contract.

N. J. Georges, Manager, Mechanical
Development

STP-410 Pressure Tube Design

J. R. Reavis

No work was accomplished on this shop order during this reporting period.

J. F. Chalupa, Manager
Manufacturing Engr

R. E. Eyre
R. E. Schwalm

STP-420 - Pressure Tubes

Two pressure tubes have been completed. One is located at Saxton and the other at Cheswick awaiting shipping instructions. Work on this task has now been completed.

5.0 TEST FUEL ASSEMBLIES

The design of the fuel assemblies, to be tested as part of the present program, was largely completed under the same Westinghouse funded program mentioned previously. The progress on completion of the design and on procurement and fabrication of the assemblies is reported below.

Two assemblies will be tested, one for twelve weeks, and the second one for six weeks. One assembly was fabricated by inserting pellets of 21% enriched UO_2 in Incoloy 800 tubes. After fuel loading and capping, the Incoloy 800 clad fuel rods were subjected to 3000 psi and 700°F to collapse the cladding onto the fuel.

The second assembly will have rods of 21% enriched UO_2 which will be vibratory compacted and swaged to 90-92% theoretical density. These will be clad with 16 Cr - 20 Ni stainless steel, a Westinghouse developed alloy.

The outer fuel rods of both assemblies will be wire-wrapped to maintain rod spacing (see Figures 4 and 5).

An assembly drawing for the pressure tube and fuel assembly is shown in Figure 6.

- L. Max. allowable tensile load in wire for wrapping purpose equals 25 tons. Tension must be maintained until final weld attaching wire to tube is made.
- M. Wire used gap of section A-B not to exceed .002 inches over 2 inches of wire length. Total of 6 inches of gap permitted per rod.
- N. Straightness allowance, .010 in. per foot of length, .03 length.
- O. Indentations in clad less than .003 deep are acceptable at final inspection.
- P. Inspect with three-point non destructive identification numbers on the surface. Record identification number, heat no., metal etc., feel gauge with final dimensions marked and final clad O.D., maximum and minimum, every two inches along length.

[illegible]

NOTES

- [illegible]

UNLESS OTHERWISE SPECIFIED THE FOLLOWING TOLERANCES APPLY

[illegible]

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1-5	WESTINGHOUSE ELECTRIC CORPORATION
2-6	ATOMIC POWER DIV. PITTSBURGH PA. U.S.A.
3-7	TITLE
4-8	502 BLUDD-12
5-9	BLUDD-12
6-10	SCALE 3:1
7-11	882D
8-12	DIMENSIONS IN INCHES
9-13	DO NOT SCALE
10-14	SUB E23

Figure 5

Fi

STP-510 Fuel Assembly Design

N. J. Georges, Manager, Mechanical
J. R. Reavis Development
E. Paxson, Manager, Mechanical Analysis
G. H. Eng

The final compilation of mechanical properties for clad materials are listed in Tables I and II.

Final heat treatments specified for the cladding are as follows:

Pelletized Incoloy 800 Rods

The tubing is annealed at 1800°F maximum and quenched before loading.

Vibratory Compacted and Swaged 16Cr-20N: Rods

The rods are annealed at 1950°F after swaging to ~ 0.460 inch diameter then swaged down to a final diameter of 0.450 inch.

Vibratory compacted and swaged fuel rods for the second fuel assembly will be subjected to 4000 psi external pressure at room temperature instead of 3000 psi at 700°F as originally specified. The room temperature test is more expeditious to run and is a more severe test for tendencies of clad wrinkles to form.

TABLE I
MECHANICAL PROPERTIES OF INCOLOY 800
(SUPERIOR TUBE CO., HEAT # NH256A)

A. CHEMISTRY

C	Mn	S	Si	Ni	Cr	Co	Ti	Ca	Fe
.05	.65	.012	.31	31.86	20.10	.24	.42	.21	Balance

B. TENSILE PROPERTIES

<u>Treatment</u>	<u>Temp. °F</u>	<u>0.2% Y. Strength, PSI</u>	<u>Ult. Strength PSI</u>	<u>% Uniform Elong. in 2 in.</u>
CW, As Rcvd.	70	79,400	96,300	26
CW, As Rcvd.	70	79,000	96,000	27
CW, As Rcvd.	800	66,450	84,150	15
CW, As Rcvd.	1,000	63,000	80,700	19
CW, As Rcvd.	1,000	66,300	80,950	-
CW, As Rcvd.	1,200	54,150	69,150	9.5
Swage to .453, 5 hrs. @ 1650°F, Swage to .450	70	69,050	75,200	-
Swage to .460, * 15 min. @ 1850°F, A/Q, Swage to .450	70	62,700	91,550	30.4
1 hr. @ 1550°F	70	57,400	90,850	37.0
15 min. @ 1800°F	70	55,600	90,850	37.0
15 min. @ 1950°F	70	28,700	81,400	43.1
Annld., As Rcvd.	70	30,800	80,500	49.0
Annld., As Rcvd.	70	30,500	80,900	50.0

*No distortion during air quench.

C. BURST PROPERTIES

<u>Treatment</u>	<u>Temp. °F</u>	<u>Burst Pres. PSI</u>	<u>% Increase in O.D.</u>
CW, As. Rcvd.	1,000	3,700	1.8
3 Days @ 1250°F	1,000	3,300	3.6
7 Days @ 1250°F	1,000	3,400	4.5
12 hrs. @ 1350°F	1,000	3,200	3.3
12 hrs. @ 1450°F	1,000	3,200	3.3
48 hrs. @ 1450°F	1,000	2,900	2.2

TABLE I (Cont'd.)

<u>Treatment</u>	<u>Temp. °F</u>	<u>Burst Pres. PSI</u>	<u>% Increase in O.D.</u>
1 hr. @ 1550°F	1,000	3,200	6.9
5 hrs. @ 1550°F	1,000	3,150	5.1
1 hr. @ 1650°F	1,000	3,200	5.8
5 hrs. @ 1650°F	1,000	3,000	8.9
15 min. @ 1950°F	1,000	2,700	17.7
Swage .493 to .450 O.D.	1,000	3,600	3.1
Swage .493 to .450 O.D.	1,000	3,500	2.4
Swage .493 to .460, 15 min. @ 1850°F, Swage .460 to .450	1,000	3,400	6.0
Swage .493 to .453, 5 hrs. @ 1650°F, Swage to .450	1,000	3,200	5.2

TABLE II

MECHANICAL PROPERTIES OF 16 Cr-20 Ni STAINLESS STEEL

(CARPENTER STEEL COMPANY, HEAT # V 90548)

A. CHEMISTRY

C	Mn	Si	P	S	Cr	Ni	Mo	N	Co
.009	.07	.06	.004	.002	16.55	20.55	.04	.009	.02

B. TENSILE PROPERTIES

<u>Treatment</u>	<u>Temp. °F</u>	<u>0.2% Y. Strength, PSI</u>	<u>Ult. Strength PSI</u>	<u>% Uniform Elong. in 2 in.</u>
CW, as Rcvd.	70	70,000	85,200	24.0
CW, As Rcvd.	70	73,500	84,800	28.0
CW, As Rcvd.	70	76,600	85,500	24.0
CW, As Rcvd.	800	62,350	65,150	1.5
CW, As Rcvd.	800	61,050	65,850	1.6
CW, As Rcvd.	1,000	57,500	60,300	1.7
CW, As Rcvd.	1,000	57,450	60,400	1.8
CW, As Rcvd.	1,200	44,050	47,850	3.7
CW, As Rcvd.	1,200	43,800	48,150	3.0
5 hrs. @ 1350°F	70	57,350	79,200	26.1
Swage .493 to .460, 6 hrs. @ 1950°F max., Swage .460 to .450	70	44,500	66,350	28.5
Annld., As Rcvd.	70	31,400	64,300	46.0
Annld., As Rcvd.	70	32,400	64,300	43.0

C. BURST PROPERTIES

<u>Treatment</u>	<u>Temp. °F</u>	<u>Burst Pres. PSI</u>	<u>% Increase in O.D.</u>
CW, As Rcvd.	70	4,100	1.1
CW, As Rcvd.	800	3,700	0.4
CW, As Rcvd.	800	3,400	0.4
CW, As Rcvd.	1,000	3,200	0.1
CW, As Rcvd.	1,000	2,900	0.4
CW, As Rcvd.	1,000	2,900	0.7
15 min. @ 1950°F	70	2,600	16.7
15 min. @ 1950°F	800	1,800	11.1

TABLE II (Cont'd.)

<u>Treatment</u>	<u>Temp. °F</u>	<u>Burst Pres. PSI</u>	<u>% Increase in O.D.</u>
15 min. @ 1950°F	1,000	1,700	10.0
15 min. @ 1950°F	1,000	1,900	12.2
5 min. @ 1850°F	800	2,000	16.7
5 min. @ 1850°F	800	2,100	14.4
5 min. @ 1700°F	800	2,100	13.3
8 min. @ 1650°F	800	2,200	12.2
5 min. @ 1600°F	800	2,500	5.1
1 hr. @ 1450°F	1,000	2,450	2.2
5 hr. @ 1450°F	1,000	2,100	10.5
12 hrs. @ 1450°F	1,000	1,900	11.5
1 hr. @ 1350°F	1,000	2,500	3.2
5 hrs. @ 1350°F	1,000	2,200	9.1
12 hrs. @ 1350°F	1,000	1,900	11.3
48 hrs. @ 1350°F	1,000	2,000	16.0
3 days @ 1250°F	1,000	2,300	1.8
3 days @ 1250°F	1,000	2,400	2.2
7 days @ 1250°F	1,000	2,300	1.6
7 days @ 1250°F	1,000	2,300	1.3
11 days @ 1250°F	1,000	2,200	2.2
11 days @ 1250°F	1,000	2,200	2.0
Swage .493 to .450	800	2,500	0.0
Swage .493 to .450	800	2,900	0.0
Swage .493 to .460, 6 hrs. @ 1950°F max., Swage .460 to .450	1,000	2,100	7.8

J. F. Chalupa, Manager
Manufacturing Engr.

R. E. Eyre
R. E. Schwalm

STP-520 Fuel Assembly Parts Procurement

All detail items have been manufactured. One fuel assembly is nearly completed. All the subassemblies have been completed for the second fuel assembly. The major subassembly will be sent to Thermoelectric for attachment of terminal connectors to the thermocouples. When this subassembly is received, final assembly will commence.

Completed fuel subassemblies are shown in Figure 7. Various operational steps during the insertion of the fuel assembly into the pressure tube are shown in Figure 8.

Figure 7

Completed Fuel Subassemblies

Figure 8

Insertion of Fuel Assembly
Into the Pressure Tube

R. W. Brown, Manager, Fuel
Fabrication Development

STP-521 Fuel Fabrication and Assembly

E. S. Foster

Fabrication process procedures were finalized for fabricating STP fuel rods for both the vibratory compacted-swaged, and pelleted types. Both procedures were distributed and approved by the design section and the project.

Vibratory Compacted and Swaged Fuel Rods

Release was given to fabricate enriched arc fused UO_2 vibratory compacted-swaged fuel rods clad with 16-20 (16% Cr - 20% Ni) material. Eight fuel rods of this type were vibratory compacted to 83.5% theoretical density, swaged from 0.494 inch diameter to 0.458 inch diameter, intermediate annealed at 1950°F for 15 minutes in hydrogen, and swaged to 0.450 inch final diameter. One of the eight fuel rods was processed further by machining off the temporary end plugs from both ends, machining the tube to length, fitting the permanent end plugs into the tube, welding on the permanent end plugs, heating the fuel rod to 730°F for 2 hours in vacuum, outgassing the fuel rod at room temperature in a vacuum weld box, back-filling the fuel rod with helium, and seal welding the vent hole in the upper end plug. The other seven 16-20 clad vibratory compacted-swaged enriched UO_2 fuel rods must be processed similarly at a later date.

Five Incoloy 800 clad enriched arc fused UO_2 fuel rods were vibratory compacted 83.5% theoretical density. All five Incoloy 800 vibratory compacted fuel rods were swaged from 0.494 inch diameter to 0.458 inch diameter in preparation for intermediate annealing. No further work performed after a decision was made to use only 16Cr - 20Ni clad rods for the second fuel assembly.

Pelleted Fuel Rods

The tubing to be used for the enriched pelleted Incoloy 800 fuel rods was sent back to the supplier for re-annealing. Previously, it was found the as-received tubing did not have sufficient ductility for use as fuel cladding. After re-annealing by the supplier and receipt of the tubing at WAPD, it was determined the tubing had become oval during heat treatment and could not be used for enriched pelleted fuel rods unless it could be re-sized on the I.D. Re-sizing was necessary to permit the passage of UO_2 pellets having a maximum of 0.001 inch diametral clearance. The tubing was re-sized at the supplier's plant to obtain the required I.D. for pellet loading. Completed fuel rods are shown in Figure 9.

Eight pelleted enriched fuel rods were fabricated according to the appropriate process procedure previously written. One major fabrication problem was encountered which caused additional fabrication work. By x-ray, it was found after autoclaving the fuel rods at 700°F and 3000 psi for 30 minutes, an excessive gap existed at the upper end plug and the top of the pellet column. The gap had to be removed, consequently, all seven fuel rods were reworked by machining off the upper end plug, machine the tube and end plug to eliminate the gap, fit the upper end plug into the tube, weld the upper end closure, heat treat at 730°F for 2 hours in vacuum, back-fill with helium in a vacuum weld box, and seal weld the vent hole in the upper end plug. Afterwards, the fuel rods were dye checked, x-rayed, helium leak tested, and wire wrapped. Each fuel rod was dimensionally checked.

Figure 9
Completed Fuel Rods

Fabrication operations on the first fuel assembly were completed during the period. The fuel rods were inserted into the hex baffle sub-assembly. The fit-up of the fuel rods was excellent in that there was some interference fit but not enough to prevent the hex baffle from sliding over the fuel rods. Stainless steel thermocouple lead wires were brazed to the ends of the thermocouples to enable threading the thermocouples through the hypodermic tubing attached into the hex baffle sub-assembly. All thermocouples were threaded through the hypodermic tubing. The baffles were welded to the upper grid which attached the fuel tube assembly to the upper baffle assembly previously fabricated. Thermocouples at the bottom of the fuel tube assembly were trimmed to length and gold brazed into position.

H. N. Andrews, Manager, Mechanical
Design & Development

STP-530 New Fuel Shipping Container

H. W. Keller

No effort was required under this shop order during this report period.

Pressure Bonded Fuel Rods

The feasibility of using high-temperature, gas-pressure bonding as a technique for fabricating UO_2 fuel elements for tests in a supercritical environment was evaluated. A total of four fuel rods were prepared by Westinghouse and shipped to Battelle Memorial Institute (BMI) for pressure bonding. Two of these fuel rods were prepared with a 70%, -100 to +200 mesh fused and 30% ceramic grade UO_2 mixture, vibratory compacted, and swaged. Two additional rods were prepared by vibratory compacting and swaging arc-fused UO_2 powder to 90-91% of theoretical density.

Details of the rods are given in the following tabulation:

<u>Rod No.</u>	<u>4 INCUDC</u>	<u>08-1-DBV</u>	<u>05-1-DBV</u>	<u>07-1-DBV</u>
Total Rod Length, in.	40.725	26.250	15.430	13.314
Total End Plug Length, in.	1.950	1.820	2.60	2.250
Total Fuel Length, in.	38.775	24.430	12.830	11.064
Average Rod Diameter, in.	.4502	.4506	.4681	.4672
Type of UO_2	100% fused	100% fused	70% fused 30% ceramic	70% fused 30% ceramic
Weight of UO_2 , gm	916.1	579.05	250.4	215.9
% of Theoretical Density	90.97	91.1	69.34	69.55
Cladding Material	Incoloy	16-20 SS	16-20 SS	16-20 SS
Approx. Clad Thickness, in.	.010	.010	.010	.010

All four rods were pressure checked in 200 psi helium and found to be leak-tight. A dimensional survey was run on each rod to determine variations in rod diameter and amount of camber and provide a comparison with corresponding data to be taken after pressure bonding. This information is included in Tables III, IV, V and VI where both prebonding and post-bonding data are listed. Only rod 05-1-DBV was found to show an excessive initial variation in diameter (0.4653 to 0.4716 in.).

TABLE III

DIMENSIONAL CHANGES (ROD 4 INC-DUDC)

Position, in. from Numbered End	Diameter, In.				Average Decrease Diam, In.(b)	Average Bonding Temp of (c)	Remarks
	Before Bonding		After Bonding				
	0°	90°	0°	90°			
1	.4495	.4495	.4456	.4455	.0035	1780	End plug area
2	.4499	.4497	.4465	.4467	.0032		
3	.4501	.4499	.4475	.4473	.0026	-	TC out
4	.4500	.4497	.4475	.4474	.0024	-	
5	.4500	.4498	.4475	.4475	.0024		
6	.4501	.4498	.4470	.4472	.0029	2020	
7	.4500	.4497	.4472	.4475	.0025		
8	.4499	.4497	.4474	.4475	.0023		
9	.4499	.4497	.4471	.4473	.0026	2000	
10	.4499	.4496	.4476	.4475	.0022		
11	.4499	.4497	.4478	.4476	.0021		
12	.4501	.4499	.4477	.4475	.0024	2030	
13	.4502	.4499	.4475	.4478	.0024		
14	.4499	.4499	.4476	.4474	.0024		
15	.4497	.4492	.4476	.4476	.0024	2040	
16	.4501	.4499	.4478	.4480	.0026		
17	.4497	.4498	.4475	.4475	.0027		
18	.4499	.4495	.4475	.4478	.0023	1980	
19	.4499	.4495	.4475	.4474	.0023		
20	.4499	.4495	.4472	.4471	.0025		
21	.4498	.4496	.4476	.4475	.0021	1950	
22	.4499	.4495	.4475	.4475	.0022		
23	.4501	.4497	.4475	.4478	.0023		
24	.4502	.4497	.4478	.4478	.0022	1950	
25	.4500	.4496	.4479	.4479	.0019		
26	.4503	.4496	.4478	.4479	.0021		
27	.4500	.4498	.4474	.4475	.0025	2020	
28	.4500	.4497	.4478	.4477	.0021		
29	.4501	.4496	.4475	.4475	.0024		
30	.4499	.4497	.4477	.4477	.0021	1860	
31	.4499	.4496	.4475	.4475	.0022		
32	.4497	.4495	.4480	.4479	.0017		
33	.4498	.4495	.4479	.4480	.0017	1575	
34	.4498	.4495	.4480	.4480	.0017		
35	.4498	.4494	.4480	.4478	.0017		
36	.4496	.4495	.4473	.4477	.0020	1350	
37	.4495	.4494	.4470	.4470	.0025		
38	.4499	.4464	.4458	.4448	.0029		Indent area
39						1050	

*Footnotes appear on following page

TABLE III. (CONT'D)

Footnotes to

DIMENSIONAL CHANGES (ROD 4 INC-INDC)

- (a) Specimen jugged in 304 SS rod assembly (.5 in. diam) and bonded for 3 hours at 10,000 psi and 2000F.
- (b) ΔD of 0.002 = 1% decrease in area/1% increase in e .
 ΔD of 0.003 = 1.5% decrease in area/1.5% increase in e .
- (c) Approximate average for 3 hr. run: thermocouples at given locations outside can assembly.

$$\Delta L = 40.725 \text{ in.} - 40.3125 \text{ in.} = 0.4125 \text{ in. decrease. (approximately 1\% increase in } e)$$

CAMBER MEASUREMENTS:

<u>Distance from Numbered End. in.</u>	<u>Before Bonding, in.</u>	<u>After Bonding, in.</u>	(1)
6	0.0185	0.0485	
14.5	0.0400	0.0330	
22	0.0452	0.0409	

- (1) Free path for rod in assembly would permit up to 0.050 in camber - this can be reduced with a redesigned assembly.

TABLE IV

DIMENSIONAL CHANGES (ROD 08-1-DBV)

Position, in. from Numbered End	Diameter, in.				Average Decrease in Diam, in. (b)	Average Bonding Temp, °F(c)	Remarks
	Before Bonding		After Bonding				
	0°	90°	0°	90°			
1	.4513	.4507	.4495	.4490	.0018	--	End plug area, TC out.
2	.4516	.4511	.4485	.4475	.0034		
3	.4520	.4514	.4485	.4485	.0032	2205	
4	.4516	.4514	.4475	.4478	.0036		
5	.4519	.4514	.4470	.4478	.0042		
6	.4522	.4515	.4485	.4480	.0036	2180	
7	.4519	.4517	.4485	.4480	.0036		
8	.4522	.4517	.4487	.4485	.0034		
9	.4517	.4510	.4475	.4475	.0038	2205	
10	.4514	.4515	.4474	.4473	.0041		
11	.4517	.4515	.4470	.4470	.0046		
12	.4517	.4516	.4478	.4475	.0040	2215	
13	.4516	.4512	.4480	.4480	.0034		
14	.4519	.4519	.4475	.4475	.0042		
15	.4513	.4514	.4480	.4475	.0036	2210	
16	.4515	.4514	.4479	.4430	.0035		
17	.4514	.4514	.4482	.4478	.0034		
18	.4515	.4515	.4483	.4475	.0036	2180	
19	.4524	.4513	.4490	.4475	.0036		
20	.4523	.4514	.4492	.4483	.0031		
21	.4516	.4515	.4482	.4484	.0032	2185	
22	.4516	.4513	.4485	.4478	.0033		
23	.4515	.4514	.4480	.4481	.0034		
24	.4513	.4515	.4482	.4478	.0034	2210	
25	.4503	.4501	.4471	.4465	.0035		
26	.4486	.4484	.4482	.4480	.0004	2190	End plug area

DIMENSIONAL CHANGES (ROD 08-1-DBV)

(a) Specimen jigged in Al_2O_3 tube and placed in can with 304 SS rods for bonding 3 hrs. at 2200F and 10,000 psi.

(b) ΔD of 0.003 = 1.3% decrease in area/1.3% increase in ρ .
 ΔD of 0.004 = 1.78% decrease in area/1.78% increase in ρ .

(c) Approximate average for 3 hr. run at location indicated.

$$\Delta L = 27.193 - 26.828 = 0.365 = 1.3\% \text{ decrease}/1.3\% \text{ increase in } \rho.$$

CAMBER MEASUREMENTS

Distance from Numbered End in.	Before Bonding in.	After Bonding in.
7	0.0055	0.027
13	0.0052	0.0556
19	0.0105	0.0287

TABLE V

DIMENSIONAL CHANGES (ROD 051DBV)

Position in. from Numbered End	Diameter, in.				Average Decrease in Diam, in.	Average B Bonding Temp, °F	Remarks
	Before Bonding		After Bonding				
	0°	90°	0°	90°			
1	.4676	.4700	.4760	.4742	+ .007	--	End plug, TC out
2	.4653	.4716	.4242	.4241	.0443		
3	.4657	.4702	.4321	.4305	.0366	2205	
4	.4673	.4692	.4355	.4361	.0325		
5	.4676	.4685	.4300	.4288	.0387		
6	.4638	.4711	.4192	.4212	.0472	2180	
7	.4654	.4693	.4184	.4188	.0487		
8	.4665	.4697	.4392	.4405	.0282		
9	.4677	.4703	.4355	.4465	.0280	2205	
10	.4683	.4698	.4370	.4255	.0378		
11	.4688	.4694	.4248	.4382	.0376		
12	.4692	.4692	.4420	.4451	.0257	2215	
13	.4685	.4686	.4375	.4365	.0315		
14	.4678	.4682	.4700	.4694	+ .0022		End Plug
15	.4650	.4645	--	--		2210	

(a) Pressure bonded 3 hrs. at 2200F and 10,000 psi

CAMBER MEASUREMENTS

Distance from Numbered End, in.	Before Bonding in.	After Bonding in.
4	--	0.1061
8	0.0064	0.0805
12	--	0.0320

$$\Delta L = 15,433 - 14,562 = 0.871 = 5.6\%$$

TABLE VI

DIMENSIONAL CHANGES (ROD 071DBV)

Position, in. from Numbered End	Diameter, in.				Average Decrease in Diam, in.	Average Bonding Temp, °F	Remarks
	Before Bonding		After Bonding				
	0°	90°	0°	90°			
1	.4702	.4700	0.4720	0.4725	+ .0021	1780	
2	.4693	.4697	0.4355	0.4340	- .0347		
3	.4690	.4694	0.4260	0.4278	- .0423	--	TC out
4	.4698	.4705	0.4152	.4198	- .0526		
5	.4690	.4685	.4795	.4798	+ .0109		Bulged area
6	.4688	.4688	.4322	.4358	- .0348	2020	
7	.4693	.4685	.4265	.4260	- .0226		
8	.4689	.4684	.4237	.4365	- .0385		
9	.4686	.4687	.4450	.4349	- .0287	2000	
10	.4692	.4684	.4442	.4365	- .0284		
11	.4685	.4686	.4425	.4315	- .0315		
12	.4694	.4690	.4648	.4646	- .0045	2030	

Pressure bonded 3 hr at 2000F and 10,000 psi

CAMBER MEASUREMENTS

0.0276 over length before bonding

After bonding:

numbered end 0.2208

center 0.0160

opposite end 0.1003

Camber was found to be the greatest on the longest rod of this group, (Rod No. 4 INCDUDC), in which case a camber of 0.0452 in. was recorded at a point 22 in. from the numbered end.

All rods were again pressure checked in helium and found to be leak-tight, thus indicating that the system pressure was effective throughout the bonding cycle. Radiographs were taken on all rods, and a core-clad void was noted only in Rod 071DBV, which corresponded to the area which buckled during pressure bonding. Since the rods were leak-tight, both before and after bonding, this void is believed due to a gas or moisture content of the oxide powder at this location. Its contribution to the buckling observed cannot be determined at this time.

A dimensional study was performed on each rod to compare with the initial data. Both sets of data are compared in Tables III, IV, V and VI, where diameter changes at each point, average bonding temperatures, and changes in camber are recorded. The fused oxide rods, (Tables III and IV) showed an average density increase of 2 to 2.5 percent and 2.6 to 3.1 percent at the 2000 and 2200F bonding temperatures respectively. Based on the initial density of approximately 91 percent of theoretical, the final densities of the fused rods are 93 and 94 percent of theoretical. It is interesting to note that in Rod 4 INCDUDC, which extended out of the autoclave furnace, a diameter shrinkage corresponding to a 1% decrease in area was noted at the cold end (approximately 1200F). This suggests that densification may be attained at temperatures well below the nominal bonding temperatures of these experiments. Dimensionally, the fused oxide rods appear excellent as diameter variations are held with $\pm .001$ in. excluding the end plug areas.

The camber in the fused oxide rods was retained within 0.056 in. This camber could be greatly reduced with a precision clamped plate device for bonding. Considering the free path permitted in the current tests, the rod cambers have been controlled within the intended limits.

The fuel rods containing mixed fused and ceramic oxides do not lend themselves as readily to comparison because of the irregularities observed. With both rods of this type, accurate densities cannot be determined, although estimates have placed both final densities above 90% of theoretical. It is believed that controlled deformation with such rods would require a more uniform distribution of the two oxides in the initial packing and more rigid containment and support of the cladding surfaces during bonding. Since considerably more deformation occurs in these rods as compared to fused oxide rods, fixtures of a completely different design should be employed during bonding to approach a $\pm .001$ tolerance on rod diameters.

The brief experiments described above show that pressure bonding in its present state of development cannot be used to fabricate satisfactory thin-walled clad supercritical fuel elements from mixtures of fused and ceramic oxides. The major problem areas are rough surfaces and poor dimensional control.

With fuel rods containing vibratory compacted and swaged-fused UO_2 , pressure bonding can be used to increase the fuel density from 91% to 93-94% of theoretical. Since a minimum deformation is involved, excellent surface finish and dimensional control can be obtained. Since these rods were subjected to temperatures and pressures which greatly exceed those in our supercritical environment, added confidence in our vibratory compacted and swaged fabrication process was obtained.

Unfortunately, the economic incentive of using pressure bonding to increase fuel density above 91% is small, thus no further work on pressure-bonded fuel elements is planned.

6.0 LOOP OPERATION

The operation of the Supercritical Loop will be coordinated through the WAPD engineers permanently on-site at Saxton. The loop will be operated by the SNEC reactor operators, because of reactor operating license commitments. WAPD will supply a "loop operator" to be on-site 24 hours per day when the loop is operating. These men will act as advisors to the SNEC reactor operators. Also, WAPD will supply a technician to take loop chemistry samples and analyze them. This technician will be available approximately 8 hours per day. Loop maintenance will be performed by the WAPD loop operators.

S. Bartnoff, Manager, Saxton
Experimental Program

R. Colombo

T. L. Erion

STP-600 Loop Operation

A training program was initiated for Westinghouse loop operators and SNEC personnel. The program includes familiarization with the program objectives and loop design, review of the Operating Manual and Health Physics indoctrination.

7.0 POST IRRADIATION ANALYSIS

The objective of this task is to obtain data from the irradiated fuel assemblies for use in later analysis and evaluation under Task 8.0.

A special failed fuel can will be designed to fit into the existing WTR shipping cask.

The services required to transport the two fuel assemblies from the Saxton Reactor Site to the Westinghouse Post-Irradiation Facility at Waltz Mill, Pa. will be made available. It will be assumed that the fuel has failed. A hazards analysis will be made of this shipment for the purpose of securing a shipping license. Detailed specifications will be written for the examination of the fuel assemblies.

The following hot cell examinations will be done on selected rods from each assembly:

- a) Visual and stereomicroscopy examination.
- b) Dimensional measurements.
- c) Gamma scan.
- d) Fission gas collection and analysis.
- e) Clad burst testing.
- f) Clad tensile testing.
- g) Metallography and microhardness tests.

STP-710 · Irradiated Fuel Shipping Container
Design and Fabrication

L. R. Katz, Manager
Pressure Vessel & Tool Design
C. Benton

The failed fuel assembly container did not pass the hydrotest due to the metallic O-ring seal at the lid. Silicon rubber O-ring seals have been ordered as a replacement and the hydrotest will continue upon receipt of these O-rings.

No work was accomplished on these shop orders during this reporting period:

STP-720	Fuel Shipping Services
STP-730	Fuel Examination Specifications
STP-740	Hot Cell Examinations

8.0 PERFORMANCE ANALYSIS

The objective of this task is to analyze, evaluate, and report upon the performance of both the loop facility and the fuel. Emphasis will be placed on the following aspects of loop performance analysis:

- a) Loop design vs. operating parameters.
- b) Radiolysis of water at supercritical conditions, considering quantity, effects of ammonia injection, and comparison with existing theories.
- c) The corrosion behavior of materials under supercritical conditions, with emphasis on the rate of metal attack (oxidation), the rate the oxidized metal is released to the coolant, and the subsequent behavior of the released metal.

The fuel performance will be analyzed by comparing the original design criteria to the data gathered by loop operation and post-irradiation examination.

A final report will be issued covering the post-irradiation analysis and performance analysis.

No work was accomplished on these shop orders during this reporting period:

STP-810	Loop Performance Analysis
STP-820	Fuel Performance Analysis
STP-821	Fuel Mechanical Analysis
STP-822	Nuclear Analysis