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Westinghouse Astronuclear Laboratory

**FIRST ARTICLE TEST REPORT
FOR**

FFTF HEATER SUPPORTS

P.O. No. 8776-M-161-BC

FAST FLUX TEST FACILITY

U.S. ATOMIC ENERGY COMMISSION

RICHLAND, WASHINGTON

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Job 5853

HWS 2160

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TABLE OF CONTENTS

	<u>Page</u>
1.0 SUMMARY	1-1
2.0 FIRST ARTICLE TESTING	2-1
2.1 28-in. PHS System	2-2
2.1.1 Test Set-Up Description	2-2
2.1.2 Test Chronology	2-3
2.1.3 Test Results	2-8
2.1.4 Conclusions	2-17
2.2 1-in. PHS System	
2.2.1 Test Set-Up	2-17
2.2.2 Test Chronology	2-20
2.2.3 Test Results	2-23
2.2.4 Conclusions	2-28
3.0 REFERENCES	3-1
4.0 APPENDICIES	
A. 28-in. FAT Procedure	A-1
B. 28-in. FAT Data	B-1
C. 1-in. FAT Procedure	C-1
D. 1-in. FAT Data	D-1

LIST OF ILLUSTRATIONS

<u>Figure No.</u>	<u>Title</u>
2-1	3/4-in. Strap with Crimp Connector
2-2	All-Metal Pipe Heater Support (PHS) (28-in.)
2-3	28-in. Test Set-Up
2-4	PHS Instrumentation - Band No. 1
2-5	PHS Instrumentation - Band No. 3
2-6	PHS Instrumentation - Band No. 4
2-7	PHS Instrumentation - Band No. 5
2-8	PHS Instrumentation - Band No. 2
2-9	PHS Instrumentation - Band No. 6
2-10	Typical Pipe T/C Installation
2-11	Typical PHS Band T/C Installation
2-12	Typical PHS Strain Gage Installation
2-13	Typical Block Lift-Off Devices
2-14	Band Tensioning Tool
2-15	Spot Welding Tool
2-16	Typical Band Spot Weld
2-17	Test Set-Up Inner Jacketing/Accessories Installed
2-18	Insulation and Outer-Jacket Installation
2-19	Test Set-Up - Outer-Jacket Installed
2-20	Pipe End Insulation Plug
2-21	HOB Installation
2-22	Trace Heater Data
2-23	Band No. 6 Tension Data
2-24	Pipe (T/C No. 3) Data During Heat-Up (Cycle No. 2)
2-25	Pipe (T/C No. 4) Data During Heat-Up (Cycle No. 2)

LIST OF ILLUSTRATIONS (Continued)

<u>Figure No.</u>	<u>Title</u>
2-26	Trace Heater/Pipe Temperature Data (Cycle No. 2)
2-27	PHS Band Temperature (Above Heater)
2-28	PHS Band Temperature (180° From Heater)
2-29	Pipe Temperature (Bottom)
2-30	T/C No. 3, Cycle No. 6 Temperatures
2-31	T/C No. 4, Cycle No. 6 Temperatures
2-32	T/C Assembly Temperatures, Cycle No. 6
2-33	T/C No. 4I Temperatures, Cycle No. 6
2-34	T/C No. 4B Temperatures, Cycle No. 6
2-35	T/C No. 6F Temperatures, Cycle No. 6
2-36	Outer-Jacket Temperatures, T/C No. 23, Cycle No. 7
2-37	Outer-Jacket Temperatures, T/C No. 24, Cycle No. 7
2-38	Outer-Jacket Temperatures, T/C No. 25, Cycle No. 7
2-39	Outer-Jacket Temperatures, T/C No. 26, Cycle No. 7
2-40	Inner-Jacket Temperatures, T/C No. 21, Cycle No. 7 (Bottom)
2-41	Inner-Jacket Temperatures, T/C No. 22, Cycle No. 7 (Top)
2-42	Post-Test End View of Insulation Layers
2-43	Inner Surface of Outer-Jacket Post-Test
2-44	Insulation Outer Layer Post-Test
2-45	Post-Test Outer and Layer No. 3 Insulation
2-46	Third Insulation Layer, Hot Spot
2-47	Test Set-Up, Second and Third Insulation Layers
2-48	Test Assembly, Insulation Removed
2-49	Inner-Jacket (Post-Test)
2-50	Pipe Surface

LIST OF ILLUSTRATIONS (Continued)

<u>Figure No.</u>	<u>Title</u>
2-51	PHS Bands/Lift-Off Blocks (Post-Test)
2-52	Assembly Drawing No. 712J342
2-53	Marimet PHS Drawing No. 800C951
2-54	Marimet PHS
2-55	Marimet PHS
2-56	Steel PHS
2-57	Steel PHS
2-58	Steel PHS Drawing No. 389D400
2-59	Instrumentation List
2-60	Inner-Jacketing
2-61	MF Insulation Assembly
2-62	MF Insulation Assembly
2-63	MF Insulation Assembly
2-64	MF Insulation Assembly
2-65	Complete Test Assembly
2-66	Post-Test Insulation Condition
2-67	Post-Test Inner-Jacket
2-68	Post-Test Pipe With Inner-Jacket Removed
2-69	Post-Test Marimet PHS
2-70	Post-Test Steel PHS

1.0 SUMMARY

A 1-in. and 28-in. diameter test article have been assembled, tested in accordance with HWS-2160 and the FAT Plan, Revision 1, and disassembled and evaluated in the presence of a Bechtel representative. The following mutual observations and conclusions were drawn:

- (1) Acceptability of the proposed marimet 28-in. PHS design has been proven.
- (2) Acceptability of the proposed all-steel 1-in. PHS design has been proven.
- (3) The functionality of the proposed marimet 1-in. PHS design was demonstrated, however, a reasonable percentage of pre-load was not retained.
- (4) Acceptability of the modifications to accessories for improvements of field installation has been proven.
- (5) Problem areas exist in the area of insulation thermal and installation performance.
- (6) Temperature differences between components within the pipe inner-jacket annulus were higher than anticipated.

2.0 FIRST ARTICLE TESTING

In response to the requirements of the FFTF Trace Heater Specification (Reference (1)), First Article Tests (FAT) were completed on pre-production Pipe Heater Support (PHS) System hardware. The Preliminary Design Report (Reference (2)), provided the analytical basis for the hardware to be tested. Pre-production test hardware incorporated the general configuration, material type/thickness, and assembly/installation techniques. Non-essentials, such as cleaning, were not included.

The primary objectives of the FAT Program are to:

- Demonstrate assembly feasibility
- Obtain functional verification of the heater support system, including accessories, at representative operating conditions, as defined by Bechtel (Reference (1))

As defined in the First Article Test Plan (Reference (3)), the test program included both 1-in. and 28-in. pre-production hardware operated in a system configuration. The system therefore included representative trace heaters, MF insulation and outer jacket, in addition to the WANL pre-production hardware. Therefore, in addition to providing performance data on the WANL hardware, the system test provides data applicable to the thermal performance of the trace heaters and MF insulation, as well as the general handling characteristics of the insulation. At the request of Bechtel, the 28-in. PHS FAT was expanded to include an additional run to further investigate apparent insulation performance.

Success criteria applicable to the FAT is proof through observation and test data that the heater support system, including accessories, can be assembled; will demonstrate its ability to apply unit loading, and will prevent metal contact with the pipe at elevated temperatures and during thermal cycling of the system. Concurrence in this evaluation; i.e., between Bechtel and WANL engineering, will constitute proof. As requested, Bechtel personnel witnessed assembly/disassembly operations for each test.

2.1 28-in. PHS SYSTEM

2.1.1 Test Set-Up Description

In comparison with the general 28-in. FAT set-up as described in References (1) and (2), the following changes were incorporated in the "as-run" test set-up:

- The addition of two 3/4-in. wide PHS assemblies incorporating a crimped connector (Figure 2-1).
- The addition of an "all-metal" PHS (Figure 2-2).
- The addition of an "inner-jacket mounted" T/C assembly.

Figure 2-3 shows the 28-in. test set-up prior to the installation of the inner-jacket. The 8-ft long pipe section incorporated seven (7) PHS's, four (4) of which included heater support clips. Figures 2-4 through 2-9 show the PHS's in order of placement from fixture reference end and summarize the instrumentation incorporated on the PHS's and pipe. Active instrumentation was not provided for the "all-metal" PHS.

Active instrumentation consisted of thermocouples, strain gages, and block lift-off devices; examples of which are shown in Figures 2-10, 2-11, 2-12 and 2-13, respectively. The four (4) main heater support bands containing the heater clips, were tensioned per the test procedure in Appendix A with the special tool shown in Figure 2-14. The band joint was made with a spot welding tool (per Figure 2-15) resulting in the joint shown in Figure 2-16. The addition of inner-jacketing and accessories resulted in the configuration shown in Figure 2-17. This figure also shows the inner-jacket mounted T/C assembly. The wires extending from the block lift-off device holes form part of the circuit which extinguished a light when the block was clear of the pipe body.

Insulation and outer-jacketing were applied (per Figure 2-18) and resulted in the assembly shown in Figure 2-19. Ends of the pipe were insulated with plugs of insulation placed inside the pipe shown on Figure 2-20, and held in place by the transite plates placed over the ends of the pipe. The door in the transite plate provided access to the pipe ID and provided a forced air cool-down capability when a blower was placed over one end of the pipe.

Attachment of outlet boxes and connection of the trace heaters completed the assembly.

Figure 2-21 shows the HOB assembly. The trace heaters were obtained from Sensor Dynamics to a specification consistent with the heater data specified in Reference (1).

In the best interests of delivery time, some concessions with respect to this specification were necessary. These concessions consisted of changes in dimensions and power ratings and resulted in acceptance of two different heaters to be used in the test.

Figure 2-22 shows the heaters as-ordered and as-received. Heaters placed on the ID wall of the pipe to simulate the sodium heating were procured from a local heater manufacturer to a standard catalog description.

2.1.2 Test Chronology

The most effective method of relating events through assembly and test is to review the test chronology as taken from the test record book. This technique will also establish a time line associated with the various tasks necessary to complete the assembly.

3 Oct 1974 Completed end-to-end check-out of all instrumentation and functional check of control system.

3 Oct 1974 The initial attempt to tension the bands resulted in strain gage values that could not be correlated with the tensioning tool value. A check of the tool calibration showed it to be accurate. An inspection of the band assembly during tensioning indicated that the marimet-45 blocks would lock-up at fairly low levels of band tension and prevent the load from distributing evenly around the circumference of the strap. A test to confirm this was conducted where layers of wax paper were placed under each block and then tension applied. A dramatic improvement in tension distribution and correlation of tool tension with strain gage data was noted, however, it was still not even.

8 Oct 1974

Bands were loaded and during loading block lift checks were made to confirm tension values and to check variations in tension around strap periphery. It was noticed that block lift-off action had a tendency to equalize band tension. Final tension values were established per procedure (Appendix A) and the strap over-laps spot welded in place.

9 Oct 1974

Final block lift-off values were taken and installation of inner-jacket started.

10 Oct 1974

Installation of inner-jacket continued and resulted in the following observations:

The marimet-45 block supporting the thermocouple fitting was broken at some point during fit-up and replaced. Placement of jacketing cut-outs and fit-up of jacketing was judged more difficult than originally anticipated.

Indications of metal contact were observed by the use of the continuity circuits. Investigation into this problem indicated contact between the jacket and the top corner of the heater support clip. Glass tape was put over the edges of the clip to prevent the metal-to-metal contact.

It was also necessary to cut one lower section of jacketing in half to avoid cutting excessively large holes to fit over the leak detector and the support strut for the HOB which were within one length of jacketing at different theta orientation.

Block lift loads were checked following the banding of the inner-jacket in place. During some of the readings, clicking sounds were heard which could be associated with local movement of the jacket or fracture of the marimet-45 block containing the lift-off device.

- 11 Oct 1974 An end section of jacketing had to be removed to correct a heater continuity problem. The source of this problem was the fact that the two trace heaters were of different lengths. The short heater made contact with the jacket banding strap in the area of the heater outlet box support. High temperature insulating tape and high temperature strain gage cement was used to isolate the heater. During this operation, a crack in the band 3-location 1 marimet-45 block containing a lift-off device was noticed.
- 12 Oct 1974 Start of insulation assembly.
- 14 Oct 1974 The final fit-up of insulation and outer-jacket was completed. MF insulation appears to contain small beads of glass-type material which are dislodged by handling. This material spreads over the work area and is a contaminate which must be dealt with in the plant.
- 16 Oct 1974 Power on at 1405-hrs to commence run No. 1 which is a ramp from 70°F to 400°F at 10°/hr.
- 17 Oct 1974 During ramp, strap lights would come on and could be extinguished by movement of the heater outer box or movement of a block lift-off device extension. The procedures used to interrupt the metal-to-metal contact suggested that the contact was due to movement of heater and jacketing rather than heater support strap contact with the pipe wall.
- Due to the uneven heating and the amount of heat that appeared to be escaping from the lift-off device holes, these holes were packed with additional insulation. The insulation packing around the accessories was checked and improved where required. At average pipe temperatures greater than 390°F, the trace heater duty cycle was approaching 100%.

18 Oct 1974 Power off normal cooldown ramp started and maintained until 200°F reached; at that point, interior of pipe exposed and blower turned on.

Second 80°F to 400°F cycle at 10°/hr initiated at 1826-hrs. At this point, Band 6 light came on and would not go out.

20 Oct 1974 0402-hrs -- Initiated 3-hr soak at 400°F.

0920-hrs -- Power off and forced air cool-down cycle initiated.

At 1400-hrs cooldown completed and 3rd 80°F to 400°F cycle at a 10°F/hr ramp rate was initiated.

22 Oct 1974 0910-hrs -- completion of 3rd 80°F -- 400°F cycle, start of cycle 4 first ramp from 400°F to 1050°F at 100°F/hr using internal pipe heaters.

1400-hrs -- excessive smoking noticed coming from ends of fixture through insulation not jacketed. Smoke also coming from holes in outer-jacketing cut-outs for accessories and lift-off devices. Power cut off following discovery that wooden portion of fixture stand was smoldering. Stand replaced with one of metal design, ends of fixture repacked with insulation. During the repacking operation, it was noticed that the insulation had undergone some deterioration; i.e., loss of binder, change in color and would pack much tighter than original material.

1610-hrs -- Power on and pipe temperature readjusted to 400°F.

1632-hrs -- Second attempt on the ramp to 1050°F initiated run designated 4A.

23 Oct 1974 0030-hrs -- Power turned off, natural cooling initiated.

0805-hrs -- Initiated forced cool-down of fixture.

During this cycle, at one point all band lights were on. Smoking of insulation also noticed during this cycle..

0900-hrs -- Initiation of second complete ramp to 1050°F at 100°F/hr designated cycle 5.

1535-hrs -- 1 hour soak at 1050°F started.

1545-hrs -- Outer-jacket temperature measurements taken with hand-hold thermocouple probe. Highest temperature noted (183°F) was on top of assembly 54-in. from the reference end.

1645-hrs -- Power off fixture cooled to 400°F over night.

24 Oct 1974 0920-hrs -- Initiation of cycle 6 from 400°F to 1050°F at 100°F/hr.

1600-hrs -- Block lift-off load measurements taken.

1615-hrs -- Outer-jacket temperatures were taken; hot spot still 54-in. from reference end on top = 218°F.

1850-hrs -- Following a 2-hr soak, outer-jacket temperatures taken again at same point was the hottest and measured 198°F. Power turned off and pipe allowed to cool to room temperature.

29 Oct 1974 1530-hrs -- Room temperature measurements of length and circumference of the fixture were made. Block lift-off loads were checked where ever possible.

30 Oct 1974 Four (4) additional thermocouples were fabricated and spot-welded to the outer-jacket to be monitored continuously during a long fixture soak at 1050°F.

0945-hrs -- Cycle 7 initiated ramp from 77°F to 1050° at 100°F/hr.

1945-hrs -- Fixture up to temperature.

31 Oct 1974

1000-hrs power off following 15-hr soak at 1050°F. Pipe was force-cooled to 200°F and disassembly initiated. During disassembly the following points were noted:

- (1) Deposits of material which had off-gassed from the insulation had deposited on the inside of the outer jacketing.
- (2) The fourth layer of insulation on the underside had changed its appearance to a white or light gray.
- (3) The third layer varied in appearance from white to black. The areas that were white were areas of high skin temperature. This insulation layer had bonded in some areas to the second layer and made removal difficult.
- (4) The second layer of insulation was bonded to the first layer and made removal of this layer in one piece impossible.
- (5) The first layer of insulation appeared to have remained in excellent condition.
- (6) The inner-jacket was covered with crud and was rusty in appearance.
- (7) The problem of intermittent metal-to-metal contact indications throughout the thermal cycles appeared to originate from the area of the heater support clip and the short heater in the area of the heater outlet box connection (contact with pipe inner-jacket).

2.1.3 Test Results

Installation of the stainless steel marimet pipe heater support assemblies with the aid of the tensioning tool, strain gages, and block lift-off devices, indicated that a non-uniform distribution of strap tension or block loading existed due to lock-up of the marimet blocks. For the 28-in. OD assembly, the block lift-off load and the strap tension are related by twice the cos of the block-strap angle, which is approximately 0.6 (see Reference (2)).

Therefore, strap tension as set by the tool, multiplied by 0.6, should be approximately equal the measured block lift-off load. The mechanical advantage of the assembly tool was measured to be approximately 3; so a tool setting multiplied by 3, equals the tension in the strap.

Figure 2-23 is a duplication of the band 6 instrumentation sheet and will be used as an aid to illustrate the values set by the tool and the values indicated by the instrumentation. The table on this figure shows results for a tool setting of 50-lb, which translates to a band tension of 150-lb. The readings were taken at initial band set-up, following spot welding of joint in band, prior to inner-jacket installation and following inner-jacket installation. The split reading in the block lift-off box are readings that represent one side of the block. Two points of contact were made with the pipe on the lift-off device; one at each end of the block. The lights could be connected so that a light extinguishing represented one end of the block lifting or both ends of the block lifting. The first set of readings represents each end; this value could represent one or both ends because it was not known what the other end was doing. To eliminate this problem, the light was connected so that both contact points had to be clear of the pipe in order for the light to go out. It is felt that this value is more representative of block lift-off load.

The data shows the initial tendency for the tension loads to be high in the area where tool tension was applied and to taper off toward the opposite side of the pipe. The loads also appear to taper off and even out following the welding and block lift load measurement. This is due to the fact that any disturbance of the band following initial placement will shift the blocks and thus change the load. This particular band was loaded to the highest tension but the trend of the results is relatively consistent from band to band.

The first set of thermal cycle tests consisted of elevation of the pipe average temperature to 400°F at a ramp rate of 10°F/hr using one of the two trace heaters supported by the band assemblies. The average pipe temperature being calculated as the average of two (2) top and one (1) bottom temperature.

Cycle No. 2 has been chosen as a representative cycle showing the ramp rate, conditions following a 3-hr soak at temperatures and cool-down with and without the forced-air cool-down system. Figures 2-24 through 2-29 are plots of selected temperatures throughout the cycle to allow comparison of the temperatures of one component relative to the other.

Figures 2-24 and 2-25 represent temperatures of the top and bottom of the pipe respectively, at approximately the same distance from the reference end. The ΔT between top and bottom of the pipe wall steadily increases with pipe temperature to a maximum value of 50 degrees just before the soak period. The Δ falls off to approximately 43 degrees during the soak period. This temperature difference is a function of natural convection and trace heater placement, and could be reduced if the position of the heater was located closer to the bottom of the pipe. Figure 2-26 shows heater temperature during the cycle. The plot shows that a heater temperature of approximately 750°F was necessary to maintain the pipe at an average temperature of 400°F. During this period, the duty cycle of the heater was 80% or better. This value is significant due to the fact that these heaters were rated at a watt density of approximately 1.6 times that specified for normal FFTF trace heaters. Another factor to be considered here is that the test fixture had more penetrations than the normal run of FFTF piping which would place more demand on the heater. In any event, the possibility of marginal heater capability exists based on the results of the test.

Figures 2-27 through 2-29 show PHS strap temperatures during the test at different points around the pipe. Figure 2-27 shows a point on the same side of the pipe above the heater. Figure 2-28 shows a point on the opposite side of the pipe 180° away from the heater. Figure 2-29 shows a point at the bottom of the pipe. As one would expect from their location, they are listed in order of decreasing temperature. The temperature difference between strap locations I and B increases to 63 degrees to soak point and then levels off at approximately 55° during soak. The temperature differences between strap locations I and F increases to 237°F up to soak point and then levels out at an average of 239°F during soak.

To make a fair comparison of the difference between pipe wall temperature and strap temperature, one must look at the data obtained from the T/C fitting and T/C-4B. Both of these instruments are in the same location sector on the same strap and can be no more than a maximum of 6-in. from each other. The plot of the thermocouple fixture out-put can be found on Figure 2-26. An examination of the differences between these values show the strap to be approximately 5 degrees hotter than the pipe up to the point before the 3-hr soak. At the soak point, the pipe becomes hotter than the strap and maintains a Δ of approximately 6 degrees.

The most significant result of this portion of the test is the fact that significant temperatures around the periphery of the pipe can exist and reach levels as high as 239°.

Data sheets containing reduced cycle information for all cycles are included in Appendix B. Data necessary to construct plots similar to those shown in this section can be read from these data sheets.

The second set of thermal cycle tests consisted of elevation of the pipe average temperature to 1050°F, at a ramp rate of 100°F/hr, using the internal pipe heaters.

Cycle No. 6 has been chosen as a representative cycle showing the ramp rate and conditions following a 3-hr soak at temperature. Figures 2-30 through 2-35 are plots of selected temperatures throughout the cycle to allow comparison of the temperatures of one component relative to the other. The order and designations of these thermocouples is the same as for Cycle No. 2 to allow the reader ease of comparison between the two temperature levels.

Figures 2-30 and 2-31 represent temperatures of the top and bottom of the pipe, respectively, at approximately the same distance from the reference end. The ΔT between top and bottom of the pipe wall steadily decreases with pipe temperature from a maximum of 58° to a minimum value of 9° during the soak period. The effect of the more uniform heating is evident when these values are compared to Cycle No. 2.

Figures 2-33 through 2-35 show PHS strap temperature during the test at different points around the pipe.

The ΔT between sectors I and B (reference instrumentation location sheets) decreases with temperature from a maximum value at start-up of 8° to a minimum value of 3° during the 3-hr soak. These points could be considered to be at the same temperature and is a dramatic improvement over the large Δ 's observed in Cycle No. 2.

The temperature differences between strap locations I and F decreases from a maximum value of 61° at start-of-cycle to a minimum of 22° during the 3-hr soak period. This Δ shows that natural convection in the pipe jacket annulus is still a strong parameter effecting local temperature. The improvement over Cycle No. 2 ΔT 's is greater than a factor of 10.

A look at Figures 2-32 and 2-34 show ΔT conditions between the strap and pipe wall. A small Δ of 5 degrees exists at start-of-cycle and increases rapidly to 77 degrees, then gradually decreases to a minimum value of 28 degrees during the soak period. At all times, this Δ indicates that the pipe wall is hotter than the strap which is reasonable due to the fact that the pipe heaters are located on the inside wall. Cycle No. 2 data shows a cross-over in this data indicating that heater position and convection are important considerations.

Overall results of the Cycle No. 6 data tend to show dramatic reduction in ΔT 's between points located around the circumference of the pipe. The ΔT between pipe and strap actually increased to a level higher than anticipated by early heat transfer estimates. Refer to Appendix B for tabulations of all high temperature cycle data.

Strain gage data was recorded during all hot cycles. Several factors effecting the data to unknown degrees make its interputation difficult and value questionable; these factors are listed as follows:

1. Reliability of high temperature strain gage
2. Low band tensions which resulted in very low out-puts close to the zero point of the gage.
3. Effectiveness of gages placed on the back-side of the band to compensate for the bending in the band.

4. The consideration that due to the low band tensions bending in the band provided a larger contribution to inherent strain than anticipated.
5. Uneven temperature distributions from strap to pipe in the circumferential direction causing uneven thermal compensation in the bridge circuit.
6. The unknown effect of zero shift due to the initial zero only at time of strap tensioning.

Due to the individual or combined action of one or all of these factors, the strain gage data has been judged inconclusive and will not be reported.

During the high temperature cycles, outer skin temperature seemed hotter to the touch than anticipated. Measurements of outer skin temperature with a hand-held probe made during cycle No. 5 indicated that the outer-jacket on the top of the pipe averaged 137°F and the outer-jacket on the bottom of the pipe averaged 117°F. One hot spot was located on the top of the assembly that had a maximum temperature of 183°. During Cycle No. 6 the same measurements across the top of the pipe were taken following a one hour soak and averaged 156°F with the hot spot reading 213°F. At the end of a 3-hr soak at 1050°F, the average changed to 152°F with the hot spot reading 198°F.

To further document the outer skin temperature, four (4) special thermocouples were made up and welded to the outer skin along the top of the pipe. These thermocouples were designated T/C-23, -24, -25 and -26, and were located 15-in., 34-in., 54-in., and 82-in., respectively, from the reference end of the fixture. Cycle No. 7 was run and the data recorded during the 100°/hr ramp and a 12-hr soak at a 1050°F pipe temperature. Figures 2-36 through 2-39 show plots of these temperatures with respect to time.

The average temperature of the outer-jacket during the soak period is approximately 179°F with the hot spot hitting a maximum of 255°F.

To obtain a feel for the change in outer-jacket temperature as one moves around the pipe, a hand-held probe was used to obtain the following data:

<u>Position on Jacket</u>	<u>Temperature - °F</u>
Top Center	152
45° CCW	141
90° CCW	145
135° CCW	148
180° CCW	133

To further aid in the data reduction and analysis of insulation performance, thermocouples designated T/C-21 and -22 were plotted and shown in Figures 2-40 and 2-41. These plots show inner-jacket temperature on the bottom of the assembly 48-in. from the reference end and inner-jacket temperature on the top of the assembly 66-in. from the reference end, respectively.

It is stressed that the original intent of this test was not an insulation test but a test of pipe heater support equipment and accessories. The insulation, although representative of the mineral fiber material specified for FFTF use included outer layers which were not sized by the manufacturer to fit an OD as large as the outer layers of the 28-in. fixture. As a result of this fit problem, radial spaces in the insulation existed as confirmed by Figure 2-42, which shows an end view of the fixture prior to insulation disassembly. These radial slots are the result of wrapping a large OD pipe with a section of MF pipe insulation designed for a smaller pipe. The "V" cuts do not close because the material is not on the proper radius. The insulation was also used in the as-received condition.

It should also be stressed that no attempt was made to keep the fixture clean through the use of alcohol wipes, rubber gloves or adherence to cleaning specifications.

Disassembly of the test fixture was essentially the reverse of the assembly process. The heaters were disconnected from the outlet boxes and one end cover removed prior to the removal of the outer-jacket. The inside surface of the jacket, where it contacted the insulation, was coated with

a dark amber colored foul smelling substance. Traces of this substance were also visible on the layer of insulation exposed when the jacket was removed. Figures 2-43 and 2-44 show the condition of the outer-jacket and insulation, respectively.

The substance coating the jacket and first layer of insulation has the appearance of insulation off-gas products which condensed on the cooler layers of material as the temperature ramp progressed. Other than for deposits of the off-gas products, the interior of the insulation appeared unchanged.

The layer under the outer layer showed definite changes in color. Color tones from dark gray to light gray to white were observed and appeared to be a function of temperature level white being the area that was hottest. Figure 2-45 shows the condition of the top of the third layer. Figure 2-46 shows the condition of the third layer of insulation in the area of the hot spot located along the top of the outer-jacket. The next layer exposed was almost completely white and was very difficult to remove in the sections as-assembled. Some bonding to the layer below it was also observed. Figure 2-47 shows the second layer of insulation in contrast to the third layer of insulation.

Figure 2-48 shows the first layer of insulation almost completely removed exposing the inner-jacket and end of the pipe. The jacket appeared excessively tarnished and had etched in its surface the pattern of the mesh used to give the insulation body. This stainless steel wire mesh was removed prior to installation of the initial layer of one inch thick MF blanket. This figure also shows the condition of the HOB support, T/C fitting attached to the jacket, lift-off devices and a portion of the leak detector and original T/C lifting design.

Figure 2-49 shows a close-up of the jacket outer surface following removal.

The surface of the pipe was found to be in about the same condition as the inner-jacket. Along with the normal oxide were dense patches of attack caused by hand prints left during the assembly and instrumentation operations. These patches were heaviest on the top section of the pipe. Figure 2-50 shows these areas along with the block fracture where the T/C fitting was located.

Figure 2-51 shows the PHS bands and lift-off devices. The assemblies were generally in good shape although dirty in some areas. Fracture of the lift-off device marimet-45 block is also shown in this figure. The failure occurred where additional cut-outs were made for pipe contact screws. It should be noted that the normal marimet blocks did not experience a failure. It is stressed again that a good portion of the crud visible in these figures resulted from contamination left during the assembly operation. The original ground rule established during the planning phase of the test stated that adherence to cleaning specifications was not a requirement.

To determine the condition of the PHS assemblies block, lift-off loads were taken prior to removal of the inner-jacket. The following table summarizes the results of these readings taken before and after test.

Table 2-1

PHS ASSEMBLY BLOCK LIFT-OFF LOAD CONDITION

LIFT-OFF DEVICE IDENTIFICATION			LIFT-OFF LOAD - lb	
Band	Sector	Device	Before	After
1	I	2Z	25	52
3	C	1Z	61	>50
3	I	2Z	50	28
3	A	3Z	16	35
4	C	1Z	65	50
4	I	2Z	45	50
4	A	3Z	>90	>50

The lift-off loads measured in the after test sequence were not taken any higher than 50-lb for fear of marimet-45 block damage. The table shows that lift load was maintained and agrees reasonably well with original values measured prior to test.

2.1.4 Conclusions

Based upon the observations made during the test and analysis of the reduced data, the following conclusions can be drawn.

1. Acceptability of the proposed pipe heater support design has been proven.
2. Acceptability of modifications to accessories for improvement of field installation has been proven.
3. Temperature data obtained during the test indicates that temperature differences around the pipe and from pipe to PHS strap, were higher than anticipated.
4. Duty cycle data obtained during the trace heater portion of the test indicates a possible problem obtaining desired temperature with specified heater rating.
5. Skin temperature measurements indicate thermal performance of the designated insulation is not as anticipated.
6. Assembly and disassembly of the insulation indicates that the material contains contaminants, out-gases, and cannot be reused once removed from the pipe.

2.2 1-in. PHS SYSTEM

2.2.1 Test Set-Up

The 1-in. dia. pipe first article test assembly conformed basically to the description detailed in Reference (3), except for the following areas:

- A new design marimet PHS was included in the test.
- A new design all steel PHS was included in the test.
- The accessories, including one heater outlet box, were of the advanced design which attaches directly to the inner-jacket.
- The method used to heat the pipe to the 1200°F level was by resistance heating rather than by the use of cartridge heaters.
- Control temperature measurements were reduced from 4 to 1 due to the change in method of heating.

Drawing No. 712J342 is the 1-in. FAT assembly drawing and is included in the report as Figure 2-52. This drawing shows the complete assembly including the placement of PHS's, accessories, instrumentation, pipe heaters, jacketing and insulation.

The assembly generally consists of two (2) 4-ft lengths of 1-in. Schedule 40 stainless steel pipe joined by a long radius elbow and mounted such that one leg is horizontal and one vertical. Marimet-45 PHS assemblies, described by Drawing 800C951 and shown in Figure 2-53, were mounted on the pipe, tensioned to 30-lb in the band, and fastened by the same method used on the major supports attached to the 28-in. pipe assembly. A block lift-off device consisting of a stainless steel shoe between the pipe and block was included on all marimet supports. A piece of all thread welded to the shoe and extending through the marimet block was included to provide for application of lift-off load. Figures 2-54 and 2-55 show these supports in place along the horizontal section of the pipe.

The all steel PHS assemblies, fabricated per Drawing 389D400, were attached on the vertical section of pipe. Figures 2-56 and 2-57 show the details of these supports in the as-assembled condition. The all steel support consists of a standard section of banding strap with a standard wing seal fastener welded to one end. Welded around the OD of this strap are inner-jacket spacers which are short sections of stainless steel tube of the proper diameter. Captured between one spacer and the strap is a formed sheet metal pipe support with a retaining finger that is bent over to retain the heater at installation. Figure 2-58 is a copy of the all steel support drawing. These supports are tensioned with a conventional strapping tool which was calibrated so that application of a known load at the tool handle resulted in a known tension. During the test assembly, this load was applied to the tool with a spring scale. A tool for field use would be modified so the capability to monitor or limit the strap tension would be built in. The advantages of a design of this type over the marimet-45 block are many, starting with fabrication improvements and extending through ease of assembly and performance in the field.

The distribution of heater supports on the pipe was governed by the space between the heater and the pipe center-line. The all steel support maintains the same heater center-to-center spacing as the marimets support but the heaters are much closer to the center-line of the pipe due to the design of the support. This made it impossible to stagger placement of the supports and have some of each design represented on each leg of the test fixture. Active instrumentation in this assembly consisted of thermocouples and block lift-off devices. Locations of these devices are shown on the assembly drawing, designations consistent with the data acquisition system are shown in Figure 2-59.

The inner-jacketing, including the elbow and accessories, as shown on Figure 2-60, was mounted on the pipe and fastened in position with conventional banding strap and wing seals. Banding strap tension of approximately 30-lb was established in all bands. Mineral fiber insulation was applied to the inner-jacketing in the sequence shown in Figures 2-60 through 2-63. Joints in the insulation were staggered to avoid any direct heat leak from the pipe. Spaces and voids, at joints and penetrations were packed with micro quartz insulation prior to the application of the next layer of insulation.

Applications of outer-jacketing and connection of the data acquisition system resulted in the completed test article shown in Figure 2-64.

Trace heaters held in position by the PHS assemblies were procured from a local heater manufacturer to a standard catalog description which matched as close as possible the Reference (1) requirements. It was necessary to procure heaters of this type due to the fact that Sensor Dynamics was not set up to produce 0.375-in. OD heaters at the time of the order. The heaters procured were 0.315-in. OD, 90-in. long units rated at 33 watts/in², which is considerably higher than the 13.5 watts/in² specified in Reference (1). The heater bend configuration necessary to fit the 1-in. assembly as shown on Drawing 101E712, was close to and in some cases, below the lower limit of bend radius allowed by the manufacturer. The units were checked electrically prior to and following the bend operation and found to be operational. This factor should be a consideration in the final heater configuration as it relates to acceptable bend radius.

2.2.2 Test Chronology

The following summary of major events follow the sequence of test program progression as recorded in the test record book.

2.2.2.1 1-in. Pipe FAT Chronology

30 Oct 1974 Build-up of 1-in. FAT article initiated.

1 Nov 1974 Installed marimet heater support assemblies on horizontal leg.

4 Nov 1974 Trace heaters were bent according to Drawing 101E712 and checked for electrical characteristics.

5 Nov 1974 Build-up interrupted due to design/fabrication activity for "all metal" PHS.
-thru-
3 Dec 1974

3 Dec 1974 Installed "all metal" PHS on vertical leg. Completed T/C installation and band continuity circuits. Checked out circuits as follows:

Band No. 1 - lift-off at 49-lb

Band No. 2 - no lift-off at 60-lb

Band No. 3 - no lift-off at 60-lb

Installed top inner-jacket for check fit and Band No. 1 light came on due to contact between heater outlet box strut and the inner-jacket. Used glass tape as insulation.

Installation of inner-jacket, including elbow and inner-jacket, completed.

4 Dec 1974 Completed insulation installation for the elbow area; the insulation was mitered at 45° angle. No breather springs.

- 5 Dec 1974 Installed outer-jacket after making necessary cut-outs, including breather springs in banding strap assemblies, and started H. O. B. installation.
- 6 Dec 1974 Completed H. O. B. installation. Completed checkout of all TC's. Measured breather spring lengths.
- Power on 1315 hours R. T. to 400°F to R. T.
- 7 Dec 1974 Power off at 1415. Started air flow through pipe for cooldown.
- Power on at 1805 hours - Cycle No. 2.
- 8 Dec 1974 Power off at 2000 hours - Cycle No. 2.
- 9 Dec 1974 Power on at 0810 hours - Cycle No. 3.
- 10 Dec 1974 Reached temperature at 1310 hours and completed a 1-hr soak. Temperature is an average between pipe T/C's on vertical and horizontal legs.
- Changed over controller to control welder for temperature run to 1200°F.
- Controller would not control on four (4) T/C's average due to current flow and voltage difference along pipe. A T/C was inserted into the pipe almost to elbow for use as control.
- Power on at 1434 hours.
- 2200 hours - a plate was placed over insulation on bottom of vertical run to minimize air flow through insulation.
- Power off at 2335 at temperature 1200°F avg.

11 Dec 1974 Start Cycle No. 2 - 400°F to 1200°F to 400°F at 0855 hours.
Power off at 1700 hours and switched controller over to trace heater to maintain approximately 400°F temperature overnight.

12 Dec 1974 Connected controller back to welder to start Cycle No. 3.
Power on at 0815 hours.
At temperature 1535 hours - A lift-off check was attempted but not successful.
Band No. 2 lift-off rod assembly was loose.
A 1200°F soak was run from 1535 hours to 2335 hours.
Power off at 2335 hours.

18 Dec 1974 Disassembly and evaluation of test article in the presence of Bechtel representatives.

2.2.2.2 Disassembly Item Notes

During disassembly, the following points were noted:

- (1) Deposits of material which had off-gassed from the insulation had deposited on the inside of the outer-jacket.
- (2) Outer layer of insulation normal color on OD turning dark on the ID.
- (3) Middle layer of insulation dark color on OD turning light color on ID.
- (4) Inside layer of insulation light color on both sides.
- (5) Body of insulation reduced as progressed toward pipe. Inner layer difficult to remove in one piece.
- (6) Inner-jacket, heater supports and pipe oxidized.

- (7) Marimet-45 PHS assemblies judged to have functioned but did not retain pre-load.
- (8) All steel PHS assembly design acceptability was proven by the test.
- (9) Overall observations typical to those of the 28-in. assembly but judged not as severe.

2.2.3 Test Results

Initial block lift-off data taken prior to the installation of the inner-jacket indicated the following:

Band No. 1 indicated lift-off at 49-lb, Bands No. 2 and 3 lift-off load was greater than 60-lb. With a setting of 30-lb tension in the PHS banding strap, one would expect the lift-off load to be approximately 60-lb.

An attempt to measure block lift-off load during the soak period of the third high temperature cycle was not successful due to a malfunction of the continuity circuits.

Block lift-off data was taken following disassembly with the following results. Band No. 1 - 5-lb, Band No. 2 - 25-lb, and Band No. 3 - 5-lb. These values are significantly reduced from the initial settings and it is evident from handling the assembly that a percentage of pre-load has been lost. The marimet PHS assemblies did retain the capability to support the heaters and did maintain their positions on the pipe. The condition of the all steel PHS assemblies was judged unchanged from the initial assembly condition.

The first set of thermal cycle tests consisted of elevation of the pipe average temperature to 400°F at a ramp rate of 10°F/hr using one of the two trace heaters supported by the band assemblies. The average pipe temperature being calculated as the average of two central horizontal leg couples and two central vertical leg couples.

Comparison of the temperature can be made by listing the temperature in order of placement on the pipe from inside out. See the following listing.

Horizontal Leg Temperature Low - Cycle No. 2

84°F . . .	OJT1= Outer-jacket temperature horizontal top	} Inactive HTR side
412°F . . .	IJT1 = Inner-jacket temperature horizontal top	
440°F . . .	BT1 = Bend temperature horizontal top	
444°F . . .	PT1 = Pipe temperature horizontal top	
-----Pipe center-----		
445°F . . .	PT2 = Pipe temperature horizontal bottom	} Active HTR side
456°F . . .	BT2 = Band temperature horizontal bottom	
437°F . . .	IJT2 = Inner-jacket temperature horizontal bottom	
80°F . . .	OJT2= Outer-jacket temperature horizontal bottom	
439°F . . .	Inactive heater $\theta = 90^\circ$	
536°F . . .	Active heater $\theta = 180^\circ$	

Vertical Leg Temperature Low - Cycle No. 2

73°F . . .	OJT3= Outer-jacket temperature vertical outside	} Inactive HTR side
293°F . . .	IJT3 = Inner-jacket temperature vertical outside	
334°F . . .	BT3 = Band temperature vertical outside	
344°F . . .	PT3 = Pipe temperature vertical outside	
-----Pipe center-----		
350°F . . .	PT4 = Pipe temperature vertical inside	} Active HTR side
342°F . . .	BT4 = Band temperature vertical inside	
302°F . . .	IJT4 = Inner-jacket temperature vertical inside	
74°F . . .	OJT4= Outer-jacket temperature vertical inside	

The horizontal leg data is typical of data for the marimet PHS. The active heater on this leg is on the bottom side of the pipe, as can be concluded by heater temperatures and component temperatures on that side. Maximum differential between pipe and band is 11° on the bottom side and a minimum of 4° on the top side. On the bottom the band is hotter than the pipe which is expected due again to placement of the active heater. Uniformity of temperatures on the top side of the pipe is due to natural convection in the annulus formed by the inner-jacket.

The vertical leg data is typical of data for the all steel PHS. The active heater on this leg is on the inside of the pipe bend and is consistent with the trend of the data which shows that side of the assembly to be hotter. Notice here that the ΔT across the pipe is 6 degrees as opposed to the horizontal case of 1 degree. The vertical case not getting the benefits of the natural convection.

It is interesting to note that with the all steel support, the pipe now becomes the hottest portion of the system with ΔT 's between pipe and band of approximately 9 degrees for both sides of the system.

Duty cycle of the trace heater at temperature conditions was well below 50% indicating ample capacity to heat the system.

The second set of thermal cycle tests consisted of elevation of the pipe average temperature to 1200°F at a ramp rate of 100°F/hr using the resistance heating capability of the pipe as the source. Electrical energy for this series was supplied by a DC welding machine, the contactor system of which was operated by the data system temperature controller.

Hot Cycle No. 3 data will be presented due to the fact that this was the only cycle where an extended soak at temperature was maintained. This soak lasted for approximately 8 hours and that the data shows that approximately 4 to 6-hr was necessary to allow stabilization of the outer-jacket temperatures.

Comparison of the temperatures can be made by listing as for the low temperature data.

Horizontal Leg Temperature - High Cycle No. 3

166°F . . . OJT1 = Outer-jacket temperature horizontal top
1074°F . . . IJT1 = Inner-jacket temperature horizontal top
1255°F . . . BT1 = Bending temperature horizontal top
1278°F . . . PT1 = Pipe temperature horizontal top
-----Pipe center-----
1278°F . . . PT2 = Pipe temperature horizontal bottom
1244°F . . . BT2 = Band temperature horizontal bottom
1200°F . . . IJT2 = Inner-jacket temperature horizontal bottom
139°F . . . OJT2 = Outer-jacket temperature horizontal bottom

Vertical Leg Temperature - High Cycle No. 3

143°F . . . OJT1 = Outer-jacket temperature vertical outside
1113°F . . . IJT3 = Inner-jacket temperature vertical outside
1181°F . . . BT3 = Band temperature vertical outside
Out . . . PT3 = Pipe temperature vertical outside
-----Pipe center-----
1214°F . . . PT4 = Pipe temperature vertical inside
1196°F . . . BT4 = Band temperature vertical inside
1105°F . . . IJT4 = Inner-jacket temperature vertical inside
142°F . . . OJT4 = Outer-jacket temperature vertical inside

The horizontal data is again typical for the marimet-45 PHS. As expected, the pipe temperatures are much more uniform than those obtained during the trace heater cycles. The ΔT between pipe and strap run from a minimum of 23° to a maximum of 34° from top to bottom of pipe, respectively, with the pipe being hotter in both cases. The 10° difference between these two numbers is mainly due to natural convection. The ΔT across the inner-jacket annulus is larger than expected, being 78° on the bottom side of the pipe. The inner-jacket temperature on the top side of the pipe is suspect due to an interruption in reading during this cycle. The significant change over the soak period was the outer-jacket temperature going from 104°F at start-of-soak and becoming stable at 166°F at end-of-soak.

The true temperature of this skin is the indicator for evaluation of insulation performance.

The vertical leg data is again typical for the all steel PHS design. Pipe temperature PT3 was lost during the first high temperature cycle. Prior to its loss, it had indicated that the two temperatures could be considered very close and for the purpose of comparison here will be considered equal.

The ΔT from band to pipe ranges from a minimum of 18° on the inside surface to 33° on the outside surface. The maximum value is larger than expected due to the close contact between the band and the pipe. Examination of the fixture after disassembly shows that PT3 and BT3 had broken away from the pipe and the BT3 reading would have been low. It is therefore concluded that the PT4 - BT4 ΔT of 18 degrees is typical for this design. Further analysis of the temperature data can be conducted by making reference to Appendix D.

During disassembly of the test article, the same general comments made concerning the 28-in. fixture apply here.

An amber colored deposit was noted on the ID of the outer-jacket and the OD of the outer layer of insulation. The deposits were not as heavy as the 28-in. fixture but they were present. Changes in insulation color and texture were noted as layers of the material were removed. The outer layer appeared relatively normal on its OD and was black on its ID. The middle layer was black on its OD and turning light tan on its ID. The inner layer was

white through its entire thickness. The outer layer appeared to have suffered no loss of body. The middle layer was relatively stiff but was noticeably different from the outer layer indicating loss of binder. The inner-layer was very soft and it was difficult to remove the sections in one piece.

Figure 2-65 shows a composite shot of all three layers of insulation in the area of the mitered 90 degree bend.

Figure 2-66 shows the condition of the inner-jacket and some accessories following removal of the inner layer of insulation.

Figure 2-67 shows condition of the test article following removal of the inner-jacketing.

Figures 2-68 and 2-69 show the condition of a marimet-45 and an all steel pipe support, respectively, following the disassembly sequence.

A study of these figures indicates that no dramatic changes took place in either design.

It should also be noted that although the intent of the program was not to test insulation or to follow or confirm cleaning techniques, a greater degree of care was taken during this assembly to plug leakage paths in the insulation and to remove finger marks. The results of this effort can be seen in the post-assembly figures which show uniform oxide coatings and the absence of the crud seen on the post-test inspection of the 28-in. test article.

2.2.4 Conclusions

Based upon the observations made during the test and analysis of the reduced data, the following conclusions can be drawn.

- (1) The functionality of the marimet-45 PHS was demonstrated, however, a reasonable percentage of pre-load was not retained.
- (2) Acceptability of the all steel PHS design has been proven.

- (3) Acceptability of the modifications to accessories for improvement of field installation has been proven.
- (4) Temperature data indicates that temperature differences between components in the system are sensitive to trace heater placement.
- (5) Temperature data indicates that temperature differences across the pipe inner-jacket annulus are larger than anticipated.
- (6) Assembly and disassembly of the insulation indicates that the material contains contaminants, out-gasses, and probably cannot be reused once removed from the pipe.

Figure 2-1. 3/4 in. Strap with Crimped Connector

Figure 2-2. All-Metal PHS (28 in.)

Figure 2-3. 28 in. Test Setup

LOOKING AT REFERENCE END

- Z = BLOCK LIFT OFF DEVICE
- X = ACCELEROMETER LOCATION
- O = STRAIN GAGE LOCATION (SINGLE) I
- ∞ = STRAIN GAGE LOCATION (DOUBLE) B, F
- T = T/C LOCATION, B, F, I
- BC = BAND CRIMP, C
- BS = BAND SPLICE, H

28-in. PIPE BAND No. 1
1-in. WIDE BAND
FIXTURE AND BANDS

LOCATION
17-1/2" FROM
REF. END

IDENT	CHANNEL
TC & SG No.	VIDAR & SR4
C-1B	007
C-1F	008
TC-1I	009
C-1	000
SG1B	1
SG1F	2
SG1I	3

Figure 2-4. PHS Instrumentation — Band 1

LOOKING AT REFERENCE END

- Z = BLOCK LIFT OFF DEVICE
- X = ACCELEROMETER LOCATION
- O = STRAIN GAGE LOCATION (SINGLE) I
- ∞ = STRAIN GAGE LOCATION (DOUBLE) B, F
- T = T/C LOCATION, B, F, I
- BC = BAND CRIMP, C
- BS = BAND SPLICE, H

28-in. PIPE BAND No. 3
1-in. WIDE BAND

LOCATION
39" FROM
REF. END

IDENT	CHANNEL
TC & SG No.	VIDAR & SR4
TC-3B	010
TC-3I	011
TC-2	001
SG3B	7
SG3I	5

Figure 2-5. PHS Instrumentation — Band 3

Figure 2-6. PHS Instrumentation — Band 4

LOOKING AT REFERENCE END

- Z = BLOCK LIFT OFF DEVICE
- X = ACCELEROMETER LOCATION
- O = STRAIN GAGE LOCATION (SINGLE) I
- ∞ = STRAIN GAGE LOCATION (DOUBLE) B, F
- T = T/C LOCATION, B, F, I
- BC = BAND CRIMP, C
- BS = BAND SPLICE, H

28-in. PIPE BAND No. 5
3/4-in. WIDE BAND

LOCATION
69" FROM
REF. END

IDENT	CHANNEL
TC & SG No.	VIDAR & SR4
TC-5B	014
TC-4	003
SG5B	---
SG5I	---

Figure 2.7. PHS Instrumentation — Band 5

LOOKING AT REFERENCE END

- Z = BLOCK LIFT OFF DEVICE
- X = ACCELEROMETER LOCATION
- O = STRAIN GAGE LOCATION (SINGLE) I
- ∞ = STRAIN GAGE LOCATION (DOUBLE) B, F
- T = T/C LOCATION, B, F, I
- BC = BAND CRIMP, C
- BS = BAND SPLICE, H

28-in. PIPE BAND No. 2
3/4-in. WIDE BAND

LOCATION
77" FROM
REF. END

IDENT CHANNEL

TC & SG No.	VIDAR & SR4
TC-2B	015
SG2B	4
SG2I	---

Figure 2-8. PHS Instrumentation — Band 2

LOOKING AT REFERENCE END

- Z = BLOCK LIFT OFF DEVICE
- X = ACCELEROMETER LOCATION
- O = STRAIN GAGE LOCATION (SINGLE) I
- ∞ = STRAIN GAGE LOCATION (DOUBLE) B, F
- T = T/C LOCATION, B, F, I
- BC = BAND CRIMP, C
- BS = BAND SPLICE, H

28-in. PIPE BAND No. 6
1-in. WIDE BAND
FIXTURE AND BANDS

LOCATION
82-3/4" FROM
REF. END

IDENT CHANNEL

TC & SG No.	VIDAR & SR4
TC-6B	016
TC-6F	017
TC-6I	018
TC-6	004
SG6B	10
SG6F	11
SG6I	12

Figure 2-9. PHS Instrumentation — Band 6

Figure 2-10. Typical Pipe T/C Installation

Figure 2-11. Typical PHS Band T/C Installation

Figure 2-12. Typical Strain Gage Installation

Figure 2-13. Typical Block Lift-Off Devices

Figure 2-14. Band Tensioning Tool

Figure 2-15. Spot Welding Tool

Figure 2-16. Typical Band Spot Weld

Figure 2-17. Test Setup — Inner Jacketing/Accessories Installed

LAYER	INSULATION IDENTIFICATION	DESCRIPTION
1	30-in. BLANKET	85-in. of 30-in. (ONE PIECE PER WRAP)
2	32- and 34-in. MF	34* MF (2 at 2 Lin. ft), 32 MF (1 at 13 Lin. in. and 1 at 2 Lin. ft)
3	34- and 36-in. MF	34 [□] MF (2 at 2 Lin. ft), 36 MF (1 at 13 Lin. in. and 1 at 2 Lin. ft)
4	24-in MF	3 at 2 Lin. ft, 1 at 13 Lin. in. 24 MF [□]

*MUST BE CUT TO FIT CIRCUMFERENCE
[□] MUST BE FILLED TO FIT CIRCUMFERENCE

Figure 2-18. Insulation and Outer Jacket Installation

Figure 2-19. Test Setup — Outer Jacket Installed

Figure 2-20. Pipe End Insulation Plug

Figure 2-21. HOB Installation

TYPE	A	B	C	D	E	F	W/in ²
ORDERED	94.25	72	11.125	0.5	76.5	9.5	13.5
(1) AS-RECEIVED	93.5	68.187	12.5	0.5	73.375	9.5	22
(2) AS-RECEIVED	94.187	69.125	12.5	0.5	74.125	9.5	22

Figure 2-22. Trace Heater Data

LOOKING AT REFERENCE END

- Z = BLOCK LIFT OFF DEVICE
- X = ACCELEROMETER LOCATION
- O = STRAIN GAGE LOCATION (SINGLE) I
- ∞ = STRAIN GAGE LOCATION (DOUBLE) B, F
- T = T/C LOCATION, B, F, I
- BC = BAND CRIMP, C
- BS = BAND SPLICE, H

28-in. PIPE BAND No. 6
1-in. WIDE BAND
FIXTURE AND BANDS

Instrument	Tool Load 50 lbs Band Tension 150 lbs	Same Tension Following Spot Weld	Final Reading Prior to I. J. Installation	Block Lift off Following I. J. Installation
SG-6B	118	78	68	—
SG-6F	38	29.2	64	—
SG-6I	56	29.2	0	—
Z 1	31.0 / 36.5	—	66.5	—
Z 2	27.0 / 85	—	25	> 80

Figure 2-23. Band 6 Tension Data

VIDAR 002 70°F to 400°F

TC-3 PIPE TOP 4' FROM REF END

CYCLE 2

10-18-74

°F

Figure 2-24. Pipe (T/C-3) Data During Heatup (Cycle 2)

VIDAR 003 70°F to 400°F
 TC4 - PIPE BOT. 4 FT. 6" FROM REF. END.

CYCLE 2 10-18-74

Figure 2-25. Pipe (T/C-4-Bottom) During Heatup (Cycle 2)

VIDAR 003

70°F to 400°F

TC4 - PIPE BOT. 4 FT. 6" FROM REF. END.

CYCLE 2

10-18-74

Figure 2-25. Pipe (T/C-4-Bottom) During Heatup (Cycle 2)

VIDAR 005 70°F to 400°F
008

TC HEATER ○
TC ASSEMBLY △

CYCLE 2 10-18-74

Figure 2-26. Trace Heater/Pipe Temp (Cycle 2)

Cycle 2 10-18-74

Figure 2-27. PHS Band Temperature (Above Heater)

VIDAR 012 70°F to 400°F

Tc-4B (SG4B)

Cycle 2 10-18-74

Figure 2-28 PHS Band Temperature (180° From Heater)

Figure 2-30. T/C-3 Cycle 6 Temperatures

Figure 2-31. T/C-4 Cycle 6 Temperatures

Figure 2-32. T/C Assembly Temperatures — Cycle 6

Figure 2-33. T/C-4I Temperatures — Cycle 6

Figure 2-34. T/C-4B Temperatures — Cycle 6

Figure 2-35. T/C-6 F temperatures — Cycle 6

Figure 2-36. Outer Jacket Temperatures — T/C-23 — Cycle 7

Figure 2-37. Outer Jacket Temperatures — T/C-24 — Cycle 7

Figure 2-38. Outer Jacket Temperatures — T/C-25 — Cycle 7

Figure 2-39. Outer Jacket Temperatures — T/C-26 — Cycle 7

10-30-74

Figure 2-41. Inner Jacket Temperature (Top) — T/C-22 — Cycle 7

Figure 2-42. Post Test End View of Insulation Layers

Figure 2-43. Inner Surface of Outer Jacket — Post Test

Figure 2-44. Insulation Outer Layer — Post Test

Figure 2-45. Post Test – Outer and Layer 3 Insulation

Figure 2-46. 3rd Insulation Layer — Hot Spot

Figure 2-47. Test Setup — 2nd & 3rd Insulation Layers

Figure 2-48. Test Assembly — Insulation Removed

Figure 2-49. Inner Jacket (Post Test)

Figure 2-50. Pipe Surface

Figure 2-51. PHS Bands/Lift-Off Blocks (Post Test)

Figure 2.52 Drawing 712J342
1 Inch Test Article Assembly

Figure 2.53 Drawing 800C951
Marimet-45 PHS Assembly

Figure 2.54 Marimet-45 PHS

Figure 2.55 Marimet-45 PHS

Figure 2.56 All Steel PHS

Figure 2.57 All Steel PHS

Vidar ch.	T/C No.	Reading		
000	0	Room Temp.		
001	PT 1	Pipe Temp	Horizontal	Top
002	BT 1	Bond Temp	"	"
003	IJT 1	Inner Jacket Temp	"	"
004	OJT 1	Outer Jacket Temp	"	"
005	HT 1	Heater Temp.	"	"
006	PT 2	Pipe Temp	Horizontal	Bottom
007	BT 2	Bond Temp	"	"
008	IJT 2	Inner Jacket Temp.	"	"
009	OJT 2	Outer Jacket Temp.	"	"
010	HT 2	Heater Temp.	"	"
011	PT 3	Pipe Temp.	Vert	Outside
012	BT 3	Bond Temp	"	"
013	IJT 3	Inner Jacket Temp	"	"
014	OJT 3	Outer Jacket Temp	"	"
015	PT 4	Pipe Temp	Vert	Inside
016	BT 4	Bond Temp	"	"
017	IJT 4	Inner Jacket Temp	"	"
018	OJT 4	Outer Jacket Temp	"	"
019	PT 5	Pipe Temp T/c fitting	"	outside
020	BT 6	Bond Temp.	Horizontal	Top
021	BT 7	Bond Temp.	Horizontal	Bottom

Central pipe
Section

Central pipe
Section

Floor end
Elbow end
Elbow end

Figure 2.59 Instrumentation Description and Location

Figure 2.60 Inner Jacketing

Figure 2.61 MF Insulation Assembly

Figure 2.62 MF Insulation Assembly

Figure 2.63 MF Insulation Assembly

Figure 2.64 MF Insulation Assembly

Figure 2.65 Completed Test Article

Figure 2.66 Post Test Insulation Condition

Figure 2.67 Post Test Inner Jacket Condition

Figure 2.68 Post Test Pipe Condition

Figure 2.69 Post Test Marimet-45 PHS Condition

Figure 2.70 Post Test Steel PHS Condition

3.0 REFERENCES

- (1) HWS No. 2160 Specification for FFTF Insulation and Trace Heaters
- (2) 71563-E-04 "Preliminary Design Report" - 19 August 1974
- (3) 71563-E-02, Rev. 1 "First Article Test Plan, Seismic Analysis and Test Plan for FFTF Heater Supports" - 29 July 1974.

Astronuclear
Laboratory

APPENDIX A

28-in. FIRST ARTICLE TEST PROCEDURE

TEST PROCEDURE FOR 28 INCH PIPE

FIRST ARTICLE TEST

1.0 INSTALLATION

<u>TEST ENG. R</u>	<u>DATE</u>		
ORAWIEC	10-8-74	1.1	Temporarily position PHS 1 through 6 on the pipe per Figure 1. Instrumentation locations on PHS's are shown on Figures 2 through 5.
ORAWIEC	10-8-74	1.2	Position trace heaters in PHS to maintain PHS alignment during tensioning; temporarily wire or tape in place. Do not bend tabs.
ORAWIEC	10-8-74	1.3	Complete wiring of strain gages or block lift-off circuits, if necessary.
		1.4	Using the prototype tensioning tool, incrementally tension PHS 1, 3, 4 and 6 to the specified tool tension. Apply tension in 10 lb. increments for 4 cycles, adjusting block position to minimize tension maldistribution (note that band tension is 3.0 times tool tension). For the fourth cycle, record data per Table 1, including block liftoff load at final tension values, Table 2. Following tensioning and recording of data, complete band welding per drawing and PS598009.
ORAWIEC	10-8-74	1.4.1	PHS 1-25 lbs. (75 lbs. in band)
ORAWIEC	10-8-74	1.4.2	PHS 3 - ^{40 lbs.} 25 lbs. (75 lbs. in band)
ORAWIEC	10-8-74	1.4.3	PHS 4 - ^{60 lbs.} 40 lbs. (120 lbs. in band)
ORAWIEC	10-8-74	1.4.4	PHS 6 - 50 lbs. (150 lbs. in band)
RJ Steffen	9 Oct 74	1.5	Bend tabs on PHS-1, 3, 4 and 6 and verify free axial motion of trace heater.
		1.6	Using banding tool, tension PHS-2 and 5 a total of 4 cycles adjusting block position to minimize tension maldistribution, to obtain the following band tension based on SG Position 1 for each band. Record data per Table 1 and 2. Crimp when tension is established.
ORAWIEC	10-8-74	1.6.1	PHS 2 - ^{30 lbs.} 25 lbs.
ORAWIEC	10-9-74	1.6.2	PHS 5 - ^{70 lbs.} 30 lbs. based on lift-off device
		1.7	Install HOB's on PHS-1 and 6 (Ref. Dwg. 577F755).
Steffen	9 Oct 74	1.7.1	Attach box-block assy. to heater clip.
ORAWIEC	10-10-74	1.7.2	Tack weld per drawing.

Problem with continuity between bands due to heaters and special band. When one band is in place, wrap heater with glass tape + paint with cement. Wrap special band with glass tape.

- DRAWIEC 10-10-74 1.8 Install L/D on PHS-4 per Drawing 389D325. *HA HA*
- DRAWIEC 1.9 Install T/C on PHS-4 per Drawing 577F756.
- DRAWIEC 10-10-74 1.10 Check operation of metal contactor circuit.
- DRAWIEC 10-10-74 1.11 Install pipe inner jacketing per Figure 6.
- 1.11.1 Field fit inner jacket, making necessary cutouts for L/D, T/C, block liftoff devices, heaters and HOB extension.
- DRAWIEC 10-10-74 1.11.2 Install inner jacket banding (1/2 in. SST).
- DRAWIEC 10-10-74 1.11.3 *MATCH MARK INNER JACKET*
Record block liftoff loads per Table 2. *STRAIN readings*
- DRAWIEC 10-15-74 1.13 Field fit 0.002 in. SST foil over jacketing cutouts at T/C, L/D, HOB's and trace heater penetrations.
- DRAWIEC 10-15-74 1.14 Install insulation per Figure 7 making necessary cutouts for accessories. Fill voids with bulk insulation. Install banding straps with breather springs per Figure 7 tensioning to obtain 1 to 2 in. extension of breather springs.
- DRAWIEC 10-16-74 1.15 Install outer jacket, making necessary cutouts for accessories. *MATCH MARK OUTER JACKET*
- DRAWIEC 10-15-74 1.16 Install outer jacket banding with breather springs (1/2 in. SST) per Figure 6, tensioning to obtain 1 to 2 in. extension of breather springs.

NO 1.17 Record block liftoff loads per Table 2.

1.18 Complete HOB installation.

- DRAWIEC 10-11-74 1.18.1 Prepare ext. rings for wiring (knockouts).
- DRAWIEC 10-15-74 1.18.2 Install ext. rings on HOB Box per Drawing 577F755.
- DRAWIEC 10-15-74 1.18.3 Wire heaters & c/o.
- DRAWIEC 10-16-74 1.18.4 Install covers.

2.0 THERMAL CYCLING TEST

During the Thermal Cycling Test the channels shown in Table 3 will be continuously recorded.

- DRAWIEC 10-16-74 2.1 Take complete data point.

- 2.2 Cycle trace heaters to obtain an average pipe temperature of 400°F at a ramp rate of 10°F/hour; ~~block lift-off data~~ system will automatically de-energize trace heaters to permit system cool-down. 70° - 400° - 70° cycle 1
- 2.3 Heat system to 400°F with trace heaters and allow system to cool down. cycle 2
- 2.4 ^{Third cycle} Repeat trace heater heatup cycle and when 400°F temperature level is attained, de-energize trace heaters and energize pipe heaters.
- 2.5 Using the pipe heaters raise the pipe temperature to 1050°F at a ramp rate of 100°F/hr.; ~~record block lift-off data~~; de-energize heaters and allow system to cool to 400°F. 1st cycle
- 2.6 ^{2nd} Heat system to 1050°F with pipe heaters and allow system to cool down. 2.6.1 - Third cycle
- 2.7 Repeat 2.6. ^{Positive pressure test}
- 2.8 Take complete data point, including block liftoff data.
- 2.9 Evaluate thermal cycling test results prior to proceeding with seismic test.

3.0 SEISMIC TEST

- 3.1 Remove outer jacket, insulation, and inner jacket.
- 3.2 Install accelerometers per Figures 8 through 13 and verify proper operation.
- 3.3 Re-install inner jacket, insulation and outer jacket per requirements of Section 1.0. Record block liftoff loads.
- 3.4 Mount assembled fixture to vibration table.
- 3.5 Perform resonance search in three principal directions at 0.1 g input over the range of 1 to 50 Hz. After completion of resonance search, analyze data and complete the following if required:
- 3.5.1 Modify any fixturing not meeting requirements.
- 3.5.2 Conduct a sine beat test at any resonant frequencies below 30 Hz. Analyze data.
- 3.6 Record block lift-off loads.

APPENDIX B

REDUCED TEMPERATURE DATA FOR
CYCLES NO. 1, 2, 4A, 5, 6 and 7

BECHTEL 28" PIPE

THERMOCOUPLE INFO.

Circle 1

VIDAR

CHANNEL	10-16-74	10-16-74	10-16-74	10-16-74	10-16-74	10-16-74	10-16-74	10-17-74	10-17-74	10-17-74	10-17-74	10-17-74	10-17-74	10-17-74	10-17-74	TC IDENT.
	1543HRS	1643HRS	1743HRS	1843HRS	1943HRS	2050HRS	2153HRS	2256HRS	2400HRS	0104HRS	0202HRS	0302HRS	0402HRS	0502HRS	0602HRS	
000	88°F	98°F	104°F	120°F	138°F	137°F	147°F	155°F	161°F	169°F	177°F	186°F	196°F	206°F	215°F	TC-1
001	82°	90°	96°	104°	111°	119°	127°	134°	139°	146°	153°	160°	169°	177°	186°	TC-2
002	92°	112°	118°	124°	122°	151°	162°	171°	176°	185°	194°	205°	216°	228°	238°	TC-3
003	50°	92°	97°	103°	111°	119°	127°	135°	141°	148°	155°	162°	171°	180°	188°	TC-4
004	88°	97°	108°	123°	132°	141°	152°	160°	166°	174°	182°	191°	201°	211°	219°	TC-5
005	350°	295°	205°	327°	357°	387°	383°	374°	411°	434°	475°	497°	528°	543°	545°	NEST FE
006	92°	102°	115°	124°	134°	142°	153°	161°	167°	175°	185°	193°	204°	215°	224°	TC-A50V
007	92°	100°	112°	125°	137°	134°	144°	156°	152°	164°	172°	180°	190°	199°	207°	TC-1B
008	80°	85°	86°	86°	89°	90°	93°	94°	96°	99°	101°	103°	106°	108°	111°	TC-1F
009	91°	97°	104°	124°	128°	137°	146°	153°	160°	167°	176°	184°	194°	205°	214°	TC-1T
010	95°	108°	102	130°	139°	147°	156°	161°	168°	176°	185°	194°	205°	219°	222°	TC-2B
011	120°	135°	140°	152°	168°	179°	186°	190°	202°	211°	224°	235°	249°	260°	267°	TC-3I
012	78°	112°	115°	122°	138°	147°	157°	162°	169°	178°	187°	197°	209°	219°	227°	TC-4B
013	125°	137°	148°	162°	173°	182°	189°	193°	202°	213°	225°	237°	252°	264°	270°	TC-4I
014	98°	110°	115°	127°	136°	140°	151°	157°	164°	172°	180°	188°	198°	208°	216°	TC-5B
015	95°	105°	109°	129°	132°	137°	148°	154°	160°	168°	176°	184°	195°	204°	212°	TC-6B
016	90°	96°	112°	119°	138°	131°	144°	156°	157°	164°	172°	180°	190°	199°	201°	TC-6B
017	75°	77°	78°	84°	86°	87°	91°	93°	96°	97°	100°	101°	104°	107°	109°	TC-6F
018	90°	100°	110°	124°	133°	141°	153°	163°	171°	183°	195°	208°	222°	238°	252°	TC-6I
019	110°	125°	130°	145°	155°	163°	174°	179°	186°	196°	206°	215°	230°	241°	249°	TC-2C
020	80°	85°	93°	101°	107°	114°	121°	127°	133°	139°	146°	152°	160°	168°	175°	TC-21
021	122°	135°	140°	155°	164°	170°	179°	183°	190°	200°	211°	221°	234°	245°	252°	TC-22
022	74°	75°	75°	76°	76°	75°	76°	76°	76°	76°	76°	76°	76°	76°	75°	Room Temp

B-1

BECHTEL 28" PIPE

THERMOCOUPLE INFO

VIDAR
CHANNEL 10-17-74TC
IDENT

	0702 HRS	0802 HRS	0902 HRS	1002 HRS	1102 HRS	1202 HRS	1302 HRS	1402 HRS	1502 HRS	1602 HRS	1702 HRS	1802 HRS	1902 HRS	2002 HRS	2102 HRS	
000	224°F	233°F	241°F	251°F	259°F	266°F	273°F	281°F	290°F	301°F	315°F	328°F	340°F	352°F	363°F	TC-1
001	193°	201°	208°	220°	229°	236°	243°	251°	260°	273°	292°	303°	316°	329°	341°	TC-2
002	246°	255°	264°	275°	284°	290°	297°	306°	316°	329°	344°	356°	368°	380°	391°	TC-3
003	196°	204°	212°	222°	231°	238°	245°	253°	262°	274°	292°	303°	316°	328°	340°	TC-4
004	231°	236°	244°	255°	263°	269°	277°	283°	294°	306°	319°	332°	344°	355°	365°	TC-5
005	574°	576°	602°	603°	592°	606°	621°	640°	679°	707°	714°	719°	738°	749°	755°	HEAT
006	232°	241°	249°	259°	268°	274°	281°	289°	299°	301°	324°	336°	348°	360°	371°	TC-ASSY
007	215°	223°	231°	240°	248°	255°	262°	268°	279°	292°	307°	319°	331°	344°	354°	TC-1C
008	114°	116°	128°	137°	141°	144°	148°	151°	157°	177°	198°	204°	215°	222°	229°	TC-1F
009	222°	230°	238°	248°	255°	262°	270°	277°	287°	297°	310°	323°	335°	346°	358°	TC-1I
010	230°	238°	247°	257°	263°	269°	276°	284°	294°	307°	321°	332°	344°	354°	365°	TC-3C
011	278°	286°	298°	309°	314°	321°	329°	339°	352°	365°	379°	390°	402°	413°	424°	TC-3I
012	235°	243°	253°	263°	269°	275°	282°	290°	302°	316°	329°	339°	351°	361°	371°	TC-4C
013	280°	290°	299°	310°	315°	321°	330°	339°	354°	370°	385°	396°	408°	419°	431°	TC-4I
014	224°	233°	240°	250°	257°	263°	270°	278°	287°	300°	315°	326°	337°	348°	358°	TC-5C
015	220°	229°	237°	246°	253°	259°	266°	274°	283°	294°	307°	320°	330°	341°	352°	TC-2C
016	216°	223°	232°	242°	249°	255°	262°	269°	278°	290°	303°	315°	326°	337°	347°	TC-6C
017	112°	114°	120°	129°	133°	137°	138°	142°	145°	171°	192°	201°	205°	210°	213°	TC-6F
018	258°	276°	278°	288°	294°	302°	311°	320°	332°	345°	360°	371°	383°	393°	403°	TC-6I
019	251°	268°	276°	287°	293°	298°	299°	315°	330°	348°	363°	375°	386°	397°	408°	TC-20
020	183°	190°	197°	207°	215°	222°	229°	237°	245°	257°	271°	285°	298°	310°	321°	TC-21
021	261°	270°	279°	290°	294°	299°	307°	316°	339°	341°	355°	366°	378°	387°	398°	TC-22
022	75°	75°	75°	75°	75°	76°	75°	75°	75°	77°	77°	77°	77°	77°	77°	Room Temp

BIN

BECHTEL 28" PIPE.

Thermocouple Info.

[illegible]

BECHTEL 28" PIPE

Thermocouple INFO.

BLAUER
ON 1515 Hrs

WDR CHANNEL	10-12-74	10-13-74	10-18-74	10-18-74	10-18-74	10-18-74											TC IDENT.
	1302 Hrs	1402 Hrs	1502 Hrs	1602 Hrs	1702 Hrs	1802 Hrs											
000	215°F	207°F	199°F	136°F	109°F	89°F											TC-1
001	126	179	172	120	93	83											TC-2
002	219	210	202	124	96	85											TC-3
003	190	183	176	112	87	80											TC-4
004	215	207	199	100	84	78											TC-5
005	194	186	180	127	98	87											HEATER
006	214	206	198	120	95	86											TC-ASSY
007	208	199	192	139	107	93											TC-1C
008	126	125	123	127	102	89											TC-1F
009	211	202	199	145	112	96											TC-1J
010	210	202	194	138	107	93											TC-3C
011	214	205	197	143	109	94											TC-3J
012	210	202	194	115	101	90											TC-4C
013	214	205	198	137	106	92											TC-4J
014	209	201	193	122	97	87											TC-5C
015	208	200	192	127	93	85											TC-2C
016	207	199	191	127	92	84											TC-6C
017	125	122	120	103	86	81											TC-6F
018	212	203	196	120	96	85											TC-6I
019	214	206	198	166	111	119											TC-20
020	166	160	156	131	104	91											TC-21
021	215	207	198	161	116	111											TC-22
022	76	76	77	77	77	77											Room Temp

B-4

BECHTEL 28" PIPE

Thermocouple INFO

Cycle 2

START
2nd Cycle

3 Hr Soak Period

COOL
DOWN
PERIOD

BLOWER
IN OPERATION
0920 Hrs.

VICAR
3A11111L

10-17-74

10-19-74

10-20-74

10-20-74

To Ident

B-5

	1802 Hrs	1902 Hrs	0002 Hrs	0502 Hrs	1002 Hrs	1502 Hrs	2002 Hrs	0102 Hrs	0402 Hrs	0502 Hrs	0602 Hrs	0902 Hrs	1102 Hrs	1402 Hrs	
000	72°F	95°	158°F	205°F	254°F	302°F	347°F	393°F	410°F	411°F	410°F	387°F	166°F	87°F	TC-1
001	83	86	140	183	230	277	323	371	386	396	384	354	131	81	TC-2
002	85	96	174	223	276	325	374	420	433	432	431	399	155	87	TC-3
003	80	83	140	183	220	278	324	372	389	389	388	361	113	78	TC-4
004	78	90	165	211	259	304	348	393	408	409	407	384	121	80	TC-5
005	87	397	389	421	589	664	749	789	756	755	706	594	149	87	TC-6
006	76	94	164	207	260	308	355	401	416	415	414	386	149	87	TC-7
007	93	110	158	200	247	293	336	383	397	398	397	375	170	92	TC-8
008	89	86	120	145	169	191	216	242	246	248	243	220	154	88	TC-9
009	96	105	158	201	250	297	343	389	405	406	406	383	185	97	TC-10
010	73	105	169	213	261	308	349	392	406	406	406	381	171	94	TC-11
011	74	141	198	251	308	360	409	452	460	460	454	415	187	97	TC-12
012	90	102	168	214	266	312	356	397	410	410	407	382	160	92	TC-13
013	72	136	207	258	312	362	414	460	468	467	460	414	174	95	TC-14
014	87	109	166	208	255	300	343	386	401	402	401	378	150	89	TC-15
015	85	102	161	203	249	293	337	382	397	398	397	375	148	87	TC-16
016	74	97	159	201	247	290	333	376	392	392	392	372	147	85	TC-17
017	86	85	113	134	155	181	204	223	228	225	223	203	106	80	TC-18
018	85	77	162	221	277	341	387	433	446	446	441	403	156	90	TC-19
019	114	172	191	240	290	342	390	435	445	445	440	404	237	125	TC-20
020	91	93	135	173	216	262	307	354	371	372	371	341	157	93	TC-21
021	111	143	195	237	288	334	380	423	434	433	428	395	227	121	TC-22
022	77	76	76	76	76	76	76	76	76	76	76	76	76	76	TC-23

10/20/74

BECHTEL 28" PIPE THERMOCOUPLE INFO

START
OF CYCLE
PA

1 H-
SOAK

POWER
OFF
COOL DOWN

VIOAR 900°F-1450°F

CHAPTER 1

	1730 HRS	1730 HRS	1730 HRS	1730 HRS	0030 HRS	0130 HRS	0230 HRS	2330 HRS	0030 HRS	0230 HRS	0430 HRS	0630 HRS	0830 HRS	0900 HRS	
000	412°F	553°F	657°F	755°F	849°F	942°F	1035°F	1115°F	1109°F	973°F	865°F	769°F	496°F	357°F	TC-1
001	330	522	637	744	844	942	1037	1117	1109°F	973°F	865°F	769°F	496°F	357°F	TC-2
002	430	559	660	756	849	945	1041	1128	1115	980	870	777	507	386	TC-3
003	338	523	637	737	833	933	1035	1116	1107	968	858	764	435	305	TC-4
004	387	541	646	746	841	936	1033	1115	1106	971	862	771	539	377	TC-5
005	316	507	623	727	828	928	1026	1113	1109	979	876	787	530	367	HEATER
006	650	613	713	804	892	988	1086	1148	1115	971	867	773	490	358	TC-15
007	401	533	636	734	831	928	1022	1103	1096	961	853	757	545	410	TC-1B
008	390	466	581	676	762	857	934	1056	1010	849	727	624	498	362	TC-F
009	417	548	647	743	835	928	1021	1104	1095	959	852	760	560	432	TC-12
010	411	538	644	741	838	931	1024	1115	1107	971	862	768	536	404	TC-3B
011	425	546	646	743	840	940	1036	1118	1111	977	867	772	557	425	TC-25
012	392	532	639	738	835	935	1032	1114	1108	977	867	770	511	377	TC-4B
013	422	552	653	746	846	938	1035	1118	1111	974	865	773	513	390	TC-47
014	374	536	644	743	846	934	1028	1111	1104	974	875	775	507	367	TC-5B
015	376	526	640	739	834	930	1026	1108	1101	970	864	768	510	349	TC-2B
016	379	517	626	725	821	919	1017	1100	1093	959	851	757	521	376	TC-62
017	363	479	603	717	833	928	1025	1112	1107	965	848	750	426	279	TC-61
018	411	534	637	733	829	926	1023	1105	1097	961	853	760	490	319	TC-6A
019	438	540	639	738	838	934	1026	1099	1096	969	869	776	593	475	TC-25
020	371	524	609	702	802	912	1009	1098	1094	960	850	756	556	392	TC-31
021	441	542	630	726	832	928	1028	1101	1097	968	861	766	578	448	TC-22
022	77	77	76	76	77	78	78	77	77	76	76	76	76	76	TC-22

Circle 5

[illegible]

10-24-74

400°F to 150°F 100°F/Hr

28" OD BENTON PIPE

THERMOCOUPLE INFO. CYCLE 6

	Power ON							START 3 HR SOAK	Power OFF START Cool Down					
VIDAR	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74	10-24-74			
Channel	0920 HRS	1020 HRS	1120 HRS	1220 HRS	1320 HRS	1420 HRS	1520 HRS	1550 HRS	1650 HRS	1750	1850	COOL DOWN WITH POWER OFF NO DATA RECORDED BUT DATA TYPED IN BOX NO THERMOCOUPLE RECORDS NORMAL CYCLE 6 TO BE TAKEN		
000														
001	364°F	517°F	621°F	734°F	832°F	931°F	1027°F	1053°F	1055°F	1056°F	1057°F			TC-2
002	441	545	646	747	842	942	1036	1062	1064	1064	1065			TC-3
003	383	517	626	730	828	928	1026	1052	1054	1055	1056			TC-4
004	435	537	636	736	832	930	1026	1052	1054	1055	1056			TC-5
005	326	513	620	724	823	923	1021	1049	1054	1055	1056			HEATER
006	433	607	705	798	892	987	1081	1093	1081	1084	1083			TC-ASSY
007	423	522	625	724	819	916	1012	1038	1041	1042	1043			TC-1B
008	290	410	519	601	691	783	881	918	926	929	930			TC-1F
009	428	525	625	725	820	917	1014	1040	1043	1044	1045			TC-1I
010	429	529	631	732	828	926	1022	1048	1052	1053	1051			TC-3B
011	415	531	632	733	830	928	1025	1051	1054	1055	1057			TC-3I
012	428	530	631	732	828	926	1024	1049	1053	1054	1055			TC-4B
013	436	534	635	736	832	930	1027	1053	1057	1057	1051			TC-4F
014	427	529	631	731	826	925	1021	1047	1051	1052	1053			TC-5B
015	425	528	628	727	822	921	1018	1043	1047	1048	1049			TC-2B
016	420	521	619	718	813	912	1010	1035	1040	1041	1042			TC-6B
017	375	481	586	693	796	900	1000	1028	1038	1035	1037			TC-6F
018	428	525	625	724	819	918	1015	1041	1045	1046	1047			TC-6I
019	430	507	601	702	799	899	997	1025	1032	1035	1036			TC-20
020	379	459	568	677	779	883	984	1012	1023	1026	1028			TC-21
021	430	508	602	702	799	899	997	1025	1032	1037	1037			TC-22
022	76	76	76	77	77	77	78	77	78	71	71			Room

Rm Temp to 1050°F

28" OD BECHTEL PIPE Tc INFO.

Cycle 7

10-30-74

		START POWER ON																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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● Inner skin
* outer skin

APPENDIX C

1 INCH FAT TEST PROCEDURE

TEST PROCEDURE FOR ONE INCH PIPE FIRST ARTICLE TEST

1.0 INSTALLATION (Ref. WANL Dwg. 712J342)

Operator

1.1 Install pipe T/Cs *Later*

1.2 Temporarily position PHS 1 through 6 on the pipe.

1.3 Position trace heaters in PHS to maintain PHS alignment during tensioning; temporarily wire or tape in place.

1.4 Relocate PHSs, as required, to maintain relative positions.

1.5 Using the prototype tensioning tool, tension PHSs to the specified tool tension.

1.5.1 PHS 1 - 10 lbs. (30 lbs. in band)

1.5.2 PHS 2 -

1.5.3 PHS 3 -

1.5.4 PHS 4 -

1.5.5 PHS 5 -

1.5.6 PHS 6 -

1.6 Bend tabs on PHSs and verify free axial motion of trace heater.

1.7 Install PHS T/Cs.

Date	Operator		
12/26	MB RS	1.8	Check operation of metal contactor circuit.
12/3	MB RS	1.9	Record block liftoff loads per Table 1.
1/3/74	MB RS	1.10	Install P1J, straight sections. <ul style="list-style-type: none"> 1.10.1 Field fit cutouts for heaters, T/C Assembly, L/D Assembly and lift-off measurement. 1.10.2 Install HOBs L/D and T/C on P1J. ✓ 1.10.3 Install P1J elbow. ✓ 1.10.4 Band P1J (30 lb. tension) using 1/2 in. SST banding. 1.10.5 Record block lift-off loads per Table 1.
1/3/74	MB RS	1.11	Install inner jacket T/Cs. IST I , IST II , IST III , IST IV
1/4/74	MB RS	1.12	Install insulation making necessary cutouts for accessories. Fill voids with bulk insulation. ^{after each layer is installed} Install banding straps with breather springs tensioning to obtain one to two inch extension of breather springs.
12-5	MB, HS, CS, & B	1.13	Install outer jacket making necessary cutouts for accessories.
12-5	HS, MB, RG, & B	1.14	Install outer jacket banding (1/2 in. SST) with breather springs per tensioning to obtain one to two inch extension of breather springs. <p>INSTALLED OUTER JACKET TC OTT1, OTT2, OTT3, OTT4</p>
		1.15	Record block liftoff loads per Table 1. Deleted JW 12/3/74
12-5	RG, MB	1.16	Complete HOB installation <ul style="list-style-type: none"> 1.16.1 Prepare ext. rings for wiring (knockouts). 1.16.2 Install ext. rings on HOB 1.16.3 Wire heaters & c/o. 1.16.4 Install covers.

2.0

THERMAL CYCLING TEST

Date Operator

During the Thermal Cycling Test the channels shown in Table 2 will be recorded once/hour.

2.1 Take complete data point.

2.2 Cycle trace heater to obtain an average pipe temperature of 400°F at a ramp rate of 10°F/hour; *file to file to file to* record block liftoff data at *file to file to* temperature; system will automatically de-energize trace heaters to permit system cool-down to <100°F.

2.3 Heat system to 400°F with trace heaters and allow system to cool down.

2.4 Repeat trace heater heatup cycle and when 400°F temperature level is attained, de-energize trace heaters and energize pipe heater (welder).

2.5 Using the pipe heater raise the pipe temperature to 1200°F at a ramp rate of 100°F/hr.; *DID NOT DO RT* (record block liftoff data at temperature;) de-energize heater and allow system to cool to 400°F.

2.6 Heat system to 1200°F with pipe heater and allow system to cool down to 400°F.

2.7 Repeat 2.6 except cool down to room temperature.

2.8 Take complete data point, including block liftoff data.

APPENDIX D

1 INCH FAT TEMPERATURE DATA

SHEET 1 OF 2

1" DIA. PIPE F.A.T. BECHTEL PIPE TEST

CYCLE 1

RHTEMP to 400°F. 105/14

12-6-74

POWER
ON

VIDAR TC NO.

CUMUL.

12-7-74

	1315HRS	1415HRS	1515HRS	1615HRS	1715HRS	1815HRS	1915HRS	2015HRS	2115HRS	2215HRS	2315HRS	0015HRS	0115HRS	0215HRS	0315HRS
000 R _h TEMP.	71°F	71°F	71°F				68°				70°F				70
001 * PT 1	72	135	133	154	170	185	199	213	228	243	252	272	286	301	315
002 BT 1	72	132	132				196				253				313
003 ITT 1	76	114	127				186				239				292
004 OTT 1	69	297?	71				73				72				76
005 HT 1	73	114	137				198				249				208
006 * PT 2	72	134	134	154	170	185	198	213	228	243	252	272	286	301	315
007 BT 2	73	132	142				205				263				324
008 ITT 2	74	118	131				198				253				311
009 OTT 2	67	69	69				70				75				74
010 HT 2	73	129	188				257				318				393
011 * PT 3	72	132	130	143	155	164	173	182	192	202	210	221	230	241	251
012 BT 3	72	115	117				169				312				243
013 ITT 3	73	439?	113				152				182				215
014 OTT 3	77	69	69				68				69				70
015 * PT 4	72	132	131	146	158	167	177	186	195	205	213	225	235	245	255
016 BT 4	72	130	130				174				209				249
017 ITT 4	74	115	112				156				186				209
018 OTT 4	77	78	69				68				68				70
019 PT 5	71	99	98				121				139				159
020 BT 6	74	136	139				202				252				304
021 BT 7	73	136	145				485?	221			260				315

* REDUCE TEMP CHARTS EVERY 4 HRS
ALL OTHER CHARTS EVERY 4 HRS

1" DIA PIPE FAT BECHTEL PIPE TEST Cycle #1 RH-TEMP TO 400°F 10/9/92

															POWER
															OFF
VICAR TC No	12-7-74														
CHANNEL	0415	0515	0615	0715	0815	0915	1015	1115	1215	1315	1415	1515	1615	1715	1815
000 RH TEMP				ALL				ALL			ALL				
* 001 PT-1	329	343	357	370	382	396	408	422		448	462				
002 BT-1				366				419			457				
003 ITT1				342				391			428				
004 OTT1				79				82			85				
005 HT1				363				417			457				
* 006 PT2	329	343	357	383	383	396	410	422	435	448	463				
007 BT2				379				515			467				
008 ITT2				363				414			451				
009 OTT2				76				80			81				
010 HT2				447				502			536				
* 011 PT3	259	268	277	286	294	304	313	323	333	344	353				
012 BT3				277				314			343				
013 ITT3				244				277			302				
014 OTT3				71				73			73				
* 015 PT4	264	273	282	290	300	310	320	329	339	350	360				
016 BT4				284				321			350				
017 ITT4				250				284			310				
018 OTT4				71				73			74				
019 PT5				177				196			216				
020 BT6				350				390			432				
021 BT7				364				411			448				

AVG PT. 409.5°F

1" DIA. PIPE F.A.T. BECHTEL PIPE TEST

CYCLE 2

R. TRAP TO 400°F 10°F/HR

VIDIP. TC NO. 12-8-74.

CHANNEL 0905HRS 1005HRS 1105HRS NO DATA PRINTER 1900HRS

TIME	TEMP.	0905HRS	1005HRS	1105HRS	1900HRS
000	R. TEMP.		69°F		69°F
001	* FT 1	317°F	330°F	343°F	444
002	BT 1		327		440
003	ITT 1		306		412
004	OJT 1		77		84
005	HT 1		322		439
006	* PT 2	317°F	330	343°F	445
007	BT 2		339		456
008	ITT 2		334		437
009	OJT 2		74		80
010	HT 2		209		536
011	* PT 3	252°F	262	271°F	344
012	BT 3		254		334
013	ITT 3		224		293
014	OJT 3		70		73
015	* PT 4	256°F	266	276°F	350
016	BT 4		252		342
017	ITT 4		230		302
018	OJT 4		70		74
019	PT 5		166		210
020	BT 6		317		418
021	BT 7		328		436

AVG PT 39575°F

1" DIA. PIPE F.A.T. BECHTEL PIPE TEST

CYCLE 2

Rm Temp to 400°F 10°F/HR.

POWER
ON

VIDAR TC NO 12-7-74

12-3-74

Channel		1805 HRS	1905 HRS	2005 HRS	2105 HRS	2205 HRS	2305 HRS	0005 HRS	0105 HRS	0205 HRS	0305 HRS	0405 HRS	0505 HRS	0605 HRS	0705 HRS	0805 HRS
000	Rm Temp	ALL				ALL				ALL				ALL		
001 *	PT 1	77	144°F	140°F	151°F	162	176°F	189°F	203°F	216	231°F	245°F	260°F	274	288°F	303°F
002	BT 1	84				162				215				272		
003	IJT 1	113				155				203				257		
004	OJT 1	75				69				116				74		
005	HT 1	99				161				212				267		
006 *	PT 2	77	144°F	140°F	151°F	163	176°F	189°F	203°F	216	231°F	245°F	260°F	270	288°F	303°F
007	BT 2	94				169				224				283		
008	IJT 2	108				164				215				271		
009	OJT 2	71				68				70				71		
010	HT 2	376				208				272				341		
011 *	PT 3	74	132°F	122°F	132°F	143	153°F	164°F	174°F	183	194°F	203°F	213°F	222	232°F	243°F
012	BT 3	7				140				178				283		
013	IJT 3	88				137				160				192		
014	OJT 3	68				66				70				68		
015 *	PT 4	82	132°F	125°F	135°F	145	156°F	166°F	177°F	186	196°F	206°F	216°F	227	237°F	247°F
016	BT 4	90				143				183				222		
017	IJT 4	93				130				164				197		
018	OJT 4	69				66				68				69		
019	PT 5	76				107				137				146		
020	BT 6	89				126				216				267		
021	BT 7	94				164				223				276		

* REDUCE TEMP CHARTS EVERY HOUR.
ALL OTHERS EVERY 4 HRS

1" DIA PIPE FAT. BECHTEL PIPE TEST CYCLE 3 Pn Temp - 900°F 10.5/hr

VIDAR	T/L NO	12-9-74	12-10-74														
			11L														
CHANNEL		2310 HRS	0010 HRS	0110 HRS	0210 HRS	0310 HRS	ALL 0410 HRS	0510 HRS	0610 HRS	0710 HRS	ALL 0810 HRS	0910 HRS	1010 HRS	1110 HRS	ALL 1210 HRS	1310 HRS	
000	Rn TEMP		66°F				66°F				66°F				67°F		
001*	PT-1	277°F	289°F	302°F	314°F	326°F	338	350°F	361	372	384	394	431°F	433	445	457°F	
002	BT-1		287				335				380				441		
003	ITT-1		268				315				356				412		
004	CJT-1		77				80				82				85		
005	HT-1		283				332				378				439		
006*	PT-2	277°F	290	302	314	326	338	350	361	373	384	394	432	433	446	457	
007	BT-2		297				348				393				455		
008	ITT-2		284				333				374				434		
009	OJT-2		72				74				77				77		
010	HT-2		355				416				461				530		
011*	PT-3	221°F	229	237	245	254	262	270	278	286	293	302	337	333	340	348	
012	BT-3		246				254				285				333		
013	ITT-3		196				224				250				204		
014	OJT-3		67				69				70				72		
015*	PT-4	284°F	232	241	357?	258	267	274	284	291	299	306	342	338	347	356	
016	ITT-4		227				260				291				338		
017	BT-4		201				229				334				298		
018	OJT-4		67				69				69				72		
019	PT-5		146				343?		172	176	179				206		
020	BT-6		279				322				362				418		
021	BT-7		288				334				375				434		

*NOTE REDUCE TEMP CHARTS EVERY HOUR
ALL OTHERS EVERY 4 HRS.

Power
on

Vidmar, TC NO 12, 9-74

WIND	TIME	0810 HRS	0910 HRS	1010 HRS	1110 HRS	1210 HRS	1310 HRS	1410 HRS	1510 HRS	1610 HRS	1710 HRS	1810 HRS	1910 HRS	2010 HRS	2110 HRS	2210 HRS
000	P-TLP	68°F				69°F				69°F				66°F		
001*	PT 1	64	130°F	135°F	145°F	151°	158°F	165°F	176°F	189°	202°F	214°F	227°F	239	252°F	264°F
002	BT 1	64				148				188				237		
003	ITT 1	65				144				177				202		
004	OST 1	65				69				71				74		
005	HT 1	65				155				186				232		
006*	PT 2	64	129°	136°	144°	150	158°	164°	176°F	189	202°F	214°F	227°F	239	252°F	264°F
007	BT 2	64				161				197				245		
008	ITT 2	65				150				189				235		
009	OST 2	64				68				69				70		
010	HT 2	64				188				249				296		
011*	PT 3	64	126°	131°	132°	136°	142°	144°	154°	164	171°F	183°F	188°F	196	204°F	212°F
012	BT 3	64				133				160				191		
013	ITT 3	64				121				144				179		
014	OST 3	64				67				67				66		
015*	PT 4	64	126°	129°	133°	138°	144°	146°	156°	167	175°F	180°F	191°F	199	208°F	216°F
016	BT 4	64				136				164				195		
017	ITT 4	64				125				147				173		
018	OST 4	64				67				67				65		
019	PT 5	64				103				118				130		
020	BT 6	64				156				192				234		
021	BT 7	64				161				197				240		

* Reduce Time CHARTS EVERY HOUR
ALL OTHERS EVERY 4 HRS.

1" DIA PIPE FAT. BECHTEL PIPE TEST

Cycle 1

400°F to 1200°F 100°F/HR

Power
ON
DC HEATER

Power
OFF

LOGIC TC NO 12-10-74

LOGIC	TC NO	12-10-74	1435HRS	1505HRS	1535HRS	1635HRS	1735HRS	1835HRS	1935HRS	2035HRS	2135HRS	2235HRS	2335HRS
000	Rm. Temp.	67°F	68°F	68°F	68°F	68°F	68°F	68°F	68°F	68°F	68°F	68°F	68°F
001 *	PT 1	429	445	550	644	750	870	967	1060	1158	1260	1303	
002	BT 1	415	461	512	604	718	846	925	1036	1133	1233	1287	
003	ITT 1	381	409	449	530	647	783	884	978	1085	1178	1250	
004	OTT 1	85	85	84	86		100	114	118	139	150	157	
005	HT 1	395	431	478	567	689	816	924	1004	1100	1198	1256	
006 *	PT 2	428	494	549	643	756	871	968	1060	1158	1257	1311	
007	BT 2	409	452	502	600	710	755	837	1027	1122	1221	1275	
008	ITT 2	373	393	433	504	633	790	897	977	1066	1167	1242	
009	OTT 2	80	81	80		86	96	122	143	148	155	155	
010	HT 2	389	416	462	551	671	821	918	1006	1099	1199	1255	
011 *	PT 3	294	339	386	468	543	618	675	781	902	1029		
012	BT 3	281	325	371	453	528	599	656	757	879	1012	1105	
013	ITT 3	238	707 ?	297	366	440	508	513	669	798	924	1030	
014	OTT 3	72	54 ?	71	68	73	77	80	87	98	107	115	
015 *	PT 4	293	224	385	467	554	616	682	771	767	1032	1131	
016	BT 4	283	301	373	455	538	600	663	755	877	1012	1115	
017	ITT 4	240	237	293	360	438	505	571	666	794	916	1023	
018	OTT 4	72	58 ?	72	73	75	77	81	88	100	107	117	
019	PT 5	197	255	312	396	475	528	579	653	772	955	1120	
020	BT 6	394	411	484	567	664	773	874	967	1094	1203	1316	
021	BT 7	394	414	487	571	672	797	882	988	1096	1205	1277	
		31.0°F	32.0°F	42.0°F	55.5°F	68.0°F	77.1°F	82.3°F	92.3°F	99.6°F	114.4°F	124.8°F	
		PIB	PIB	PIB	PIB	AVG	AVG	AVG	AVG	AVG	AVG	AVG	

SHIELD PUT ON BOTTOM
OF INSULATION @ 2200HRS

2315HRS

Power stays on for 7 seconds and
off for 10 seconds

12-11-74

1" DIA. PIPE FAT. BECHTEL PIPE TEST

CYCLE 2

400°F to 1200°F 100°F/hr

Power
ON
DeWitt

V. DNR TC NO 12-11-74

Channel		0755 HRS	0855 HRS	0955 HRS	1055 HRS	1155 HRS	1255 HRS	1355 HRS	1455 HRS	1555 HRS	1655 HRS	OFF 1700 HRS
P21		P21	P21	P21	P21	P21	P21	P21	P21	P21	P21	P21
000	Rm TEMP	67°F	68°F				68°F				68	
001*	PT1	322	442°F	530°F	619°F	727°F	825	926°F	1021°F	1120°F	1216	
002	BT1	306	414				792				1194	
003	IJT1	291	372				742				1144	
004	OJT1	83	80				99				94	
005	HT1	299	378				756				1162	
006*	PT2	322	440	539°	618°	725°	823	924	1018	1119°F	1213	
007	BT2	304	397				777				1176	
008	IJT2	288	367				733				1134	
009	OJT2	77	66?				93				127	
010	HT2	298	376				756				1161	
011*	PT3			505°	566°	671°	940?	819?			349?	
012	BT3	47?	327				686				1118	
013	IJT3	176	254				578				1047	
014	OJT3	72	71				81				119	
015*	PT4	216	359	460°	552°	640	731	831	939	1050°F	1164	
016	BT4	207	350				710				1147	
017	IJT4	179	251				576				1038	
018	OJT4	73	72				82				120	
019	PT5	140	264				600				1055	
020	BT6	283	396				791				1182	
021	BT7	284	381				779				1168	

* TC READINGS REQUIRED EVERY HOUR,
ALL OTHERS EVERY 4 HOURS

400°F to 1200°F, 100°F/24h

		Power ON DC Voltage	STRET SOAK																Power OFF
Vidur	Tc No.	12-12-74																	
Channel		0815HRS	0915HRS	1015HRS	1115HRS	1215HRS	1315HRS	1415HRS	1515HRS	1535HRS	1635HRS	1735	1835	1935	2035	2135	2235	2335	
000	Rm Temp	68°F	68°F			69°F				69°F								69	
001 *	PT 1	445	589	688°F	790°F	893	991	1091	1200°F	1238°F	*1274°F	1277°F	1277°F	1275	1274	1273	1274	1278	
002	BT 1	454	559			864				1216								1255	
003	IRT 1					810				1163								1074	
004	OJT 1	91	91			104				104	* 125°	127	127	112	169	170	163	166	
005	HT 1	465	523			828				1225								1207	
006 *	PT 2	445	588	688	788	891	990	1088	1197	1235	* 1272	1274	1274	1272	1273	1271	1272	1278	
007	BT 2	462	543			848				1197								1244	
008	IRT 2	451	505			803				1155								1200	
009	OJT 2	83	84			96				118	* 126	140	154	146	142	142	139	139	
010	HT 2	467	521			828				1182								1221	
011 *	PT 3																		
012	BT 3	352	453			751				1131								1181	
013	IRT 3	711	362			640				1145								1113	
014	OJT 3	74	74			82				114	* 123	145	150	148	147	145	145	143	
015 *	PT 4	368	494	591	688	738?	896	946	1120	1110	* 1222	1219	1156	1151	1155	1219	1219	1214	
016	BT 4	358	478			777				1150								1196	
017	IRT 4	320	361			634				1033								1105	
018	OJT 4	75	76			83				111	* 132	143	146	148	147	145	143	142	
019	PT 5	237	348			658				1064								1120	
020	BT 6	428	542			850				1204								1247	
021	BT 7	436	579			837				1191								1237	
* TC READINGS REDUCED EVERY HOUR ALL OTHERS EVERY 4 HRS																			
SLN CHARGE 8.2.14-18																			