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HOT CORROSION/EROSION TESTING OF MATERIALS FOR APPLICATION TO ADVANCED POWER CONVERSION SYSTEMS USING COAL-DERIVED FUELS
TASK II - FLUIDIZED BED COMBUSTION

FINAL REPORT
For Period July 1, 1976-September 30, 1979

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I. ABSTRACT

The objective of this program was to provide an experimental basis for specifying materials for heat exchangers and gas turbines exposed to a pressurized fluidized bed combustor environment. A 1000 hour test was completed which:

- Exposed heat exchanger materials both within the fluidized bed and in the freeboard of a pressurized fluidized bed combustor at temperatures ranging from 1050°F to 1600°F for up to 1117 hours.

- Provided the first successful long term exposure of turbine blade materials subjected to PFBC flue gas where the particulates were removed solely by cyclones.

This report describes the operating conditions and major observations during this test period. Subsequent reports (1,2) will provide detailed metallurgical analysis of the test specimens to quantitatively determine the degree of hot gas corrosion and erosion present.

OPERATING CONDITIONS

Typical operating conditions for the PFBC miniplant combustor during this test period were 9 atm pressure, 915 to 950°C (1680-1740°F) bed temperature, 1.8 m/sec (6 ft/sec) fluidizing velocity, 15 to 25% excess air. Emission levels of SO_2 were 250 to 300 ppm and NO_x was approximately 100 ppm - both well below current EPA standards. Approximately 2 ppm of sodium and 0.5 ppm potassium was detected as alkali in the flue gas. Particulate concentration typically ranged from 0.025 to 0.07 gr/SCF.

RESULTS

Turbine Blade Section

During the 1000 hour test, operating conditions varied sufficiently to significantly alter the particulate loading and mean particle diameter of the particulate entering the turbine section. This permitted several observations to be made:

- Most of the turbine blade specimens visually appeared to be in satisfactory condition showing little, if any, erosion.

- Particulate loading and/or particle size had a profound effect on the degree of deposition and erosion on the turbine blades.

- In general, erosion was not visually apparent when 3 stages of conventional cyclones were used to clean the PFBC flue gas. However, upsets could cause marked erosion if the grain loading and particulate size increased only by small amounts.

Heat Exchanger Specimens

The heat exchanger specimens appeared to be in satisfactory condition both in bed and above the fluidized bed. However, several in-bed probes showed some visible signs of corrosion (one probe actually failed). The above-bed probes showed little, if any, visible corrosion or erosion.

CONCLUSIONS

- These tests indicated the possibility that conventional cyclones alone may be sufficient to protect gas turbine blade materials exposed to PFBC flue gas. This needs to be validated by further experimentation and metallurgical analysis of the test specimens.

- There seems to be satisfactory heat exchanger materials for above-bed use and probably in-bed use. Further experimentation and metallurgical analysis of the test specimens will better quantify the lifetime which can be expected.

II. SCOPE OF WORK

INTRODUCTION

Pressurized fluidized bed combustion offers the potential of an efficient and compact coal combustion technique also capable of providing pollution control. The technology involves the combustion of coal in a bed of particles maintained in a state of fluidization by the air required for combustion. The use of limestone or other suitable sorbent as the bed material permits the capture and removal of sulfur dioxide concurrently with the combustion process.

The objective of this program was to expose specimens of potential PFBCC fireside heat exchanger alloys (supplied by Westinghouse Research Center) and gas turbine materials (supplied by General Electric Company) to a pressurized fluidized bed coal combustion environment for 1100 hours. The Exxon Miniplant provided a test site for this test facility. The intent of the PFBCC exposure tests was to compile a sound engineering data base for the characterization of the corrosion/erosion behavior of a number of commercially available alloys when exposed to a pressurized fluidized bed combustion environment. These pressurized fluidized bed combustion exposures will provide corrosion/erosion data and comparisons of materials for application to advanced power systems using coal-derived fuels.

TEST PROGRAM AND OPERATING CONDITIONS

The initial 100 hours of testing represented the shakedown phase of the program. It was intended to assess the performance of the heat exchanger specimen probes and the turbine test section and to evaluate the compatibility of these components with the miniplant combustor operating conditions and controls. It also provided an early opportunity for General Electric and Westinghouse to evaluate materials after a short test run. The shakedown run was completed and the results were reported in the first task report, March 1978.

Following the shakedown run are the extended exposure tests of the heat exchanger materials supplied by Westinghouse Research and the gas turbine materials supplied by General Electric Company. Total exposure times were intended to be up to 1000 hours, with the tests interrupted at the 250, 500 and 700 accumulated hour intervals to allow removal, inspection and re-insertion of the material specimens.

The target Exxon FBC miniplant operating conditions for the extended hot corrosion/erosion run were - pressure: 8.7-9.1 atmospheres; combustor bed temperature: 1700-1750°F (925-950°C); superficial bed velocity: 6 ft/sec (1.8 m/sec); excess air: 15-20%. Illinois No. 6 coal and the sorbent Pfizer dolomite was used. GE turbine test section inlet conditions were 9 atmospheres pressure, 1550°F gas temperature and 0.72 to 0.92 lb/sec gas mass flow rate.

DESCRIPTION OF PFBCC MINIPLANT

The Exxon miniplant combustor is a 32 ft (10 m) tall vessel with a 24 inch (61 cm) pressure shell, refractory lined to a 13 inch (33 cm) inside diameter. It was modified by fabricating and inserting new sections to accommodate the 12 in-bed and 9 above-bed heat exchanger specimens (Figure 1).

Figure 2 is a flow schematic of the PFBC miniplant. Main fluidizing air for the combustor is supplied at pressures to 10 atmospheres and controlled flow rates of 600 to 1100 SCFM. Coal and dolomite (or limestone) are proportioned, premixed and continuously injected into the combustor at a port 11 inches (28 cm) above the distributor grid. The air passes up through the distributor grid where it fluidizes the bed material and provides the air required for combustion.

Heat extraction in the combustor is achieved by cooling coils through which water is circulated; they are mounted on flanges and immersed in the fluidized bed. The coils, fabricated from type 316 stainless steel 1/2 inch Sch. 40 pipe, are arranged in a serpentine, vertical orientation. Each coil covers a vertical distance of 18 inches and consists of 5.9 ft^2 (0.55 m^2) of surface area. Three coils were inserted in the combustor for the shakedown run - one below the new lower probe section and two above. This coil surface area was calculated to provide desired combustor temperatures for the shakedown run conditions. From the shakedown run it was ascertained that two coils would suffice and subsequently the uppermost one was removed.

Flue gas exits the combustor and flows through three stages of cyclones (Figure 2) for particulate removal. The solids collected by the first stage cyclone are returned to the combustor 20 inches above the grid. Solids, mainly flyash, collected by the second and third cyclones are collected by means of a lock hopper system. The expanded bed height is controlled by continuously rejecting solids at a controlled rate through a port at the 90 inch (2.3 m) elevation. Final particulate removal was achieved by passing the flue gases through three conventional cyclones. The first cyclone recycled material back to the combustor while the remaining two cyclones rejected the solids through lock hoppers.

Pressure control is accomplished by bleeding a small amount of flue gas through a by-pass line around the turbine test section (Figure 3). The by-pass stream is expanded through a choked nozzle with make up air supplying the back pressure control. A measuring orifice was installed downstream of the turbine test section. During a run, both turbine mass flow and inlet temperature are scanned once a minute and recorded on magnetic tape. Particulate and analytical sampling trains are also located downstream of the turbine section at 200 kPa pressure.

Figure 1

Combustor Corrosion Probe Location

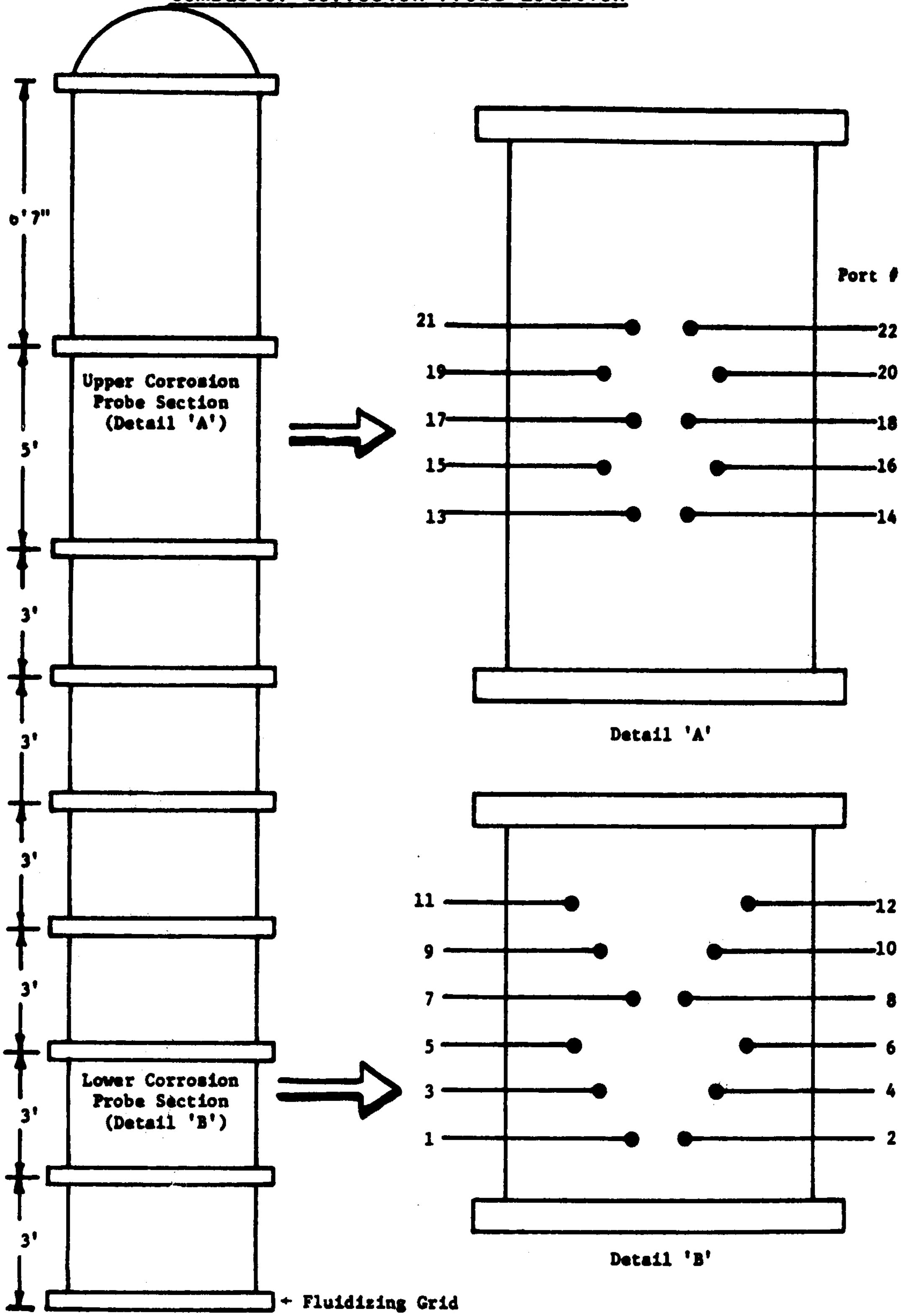
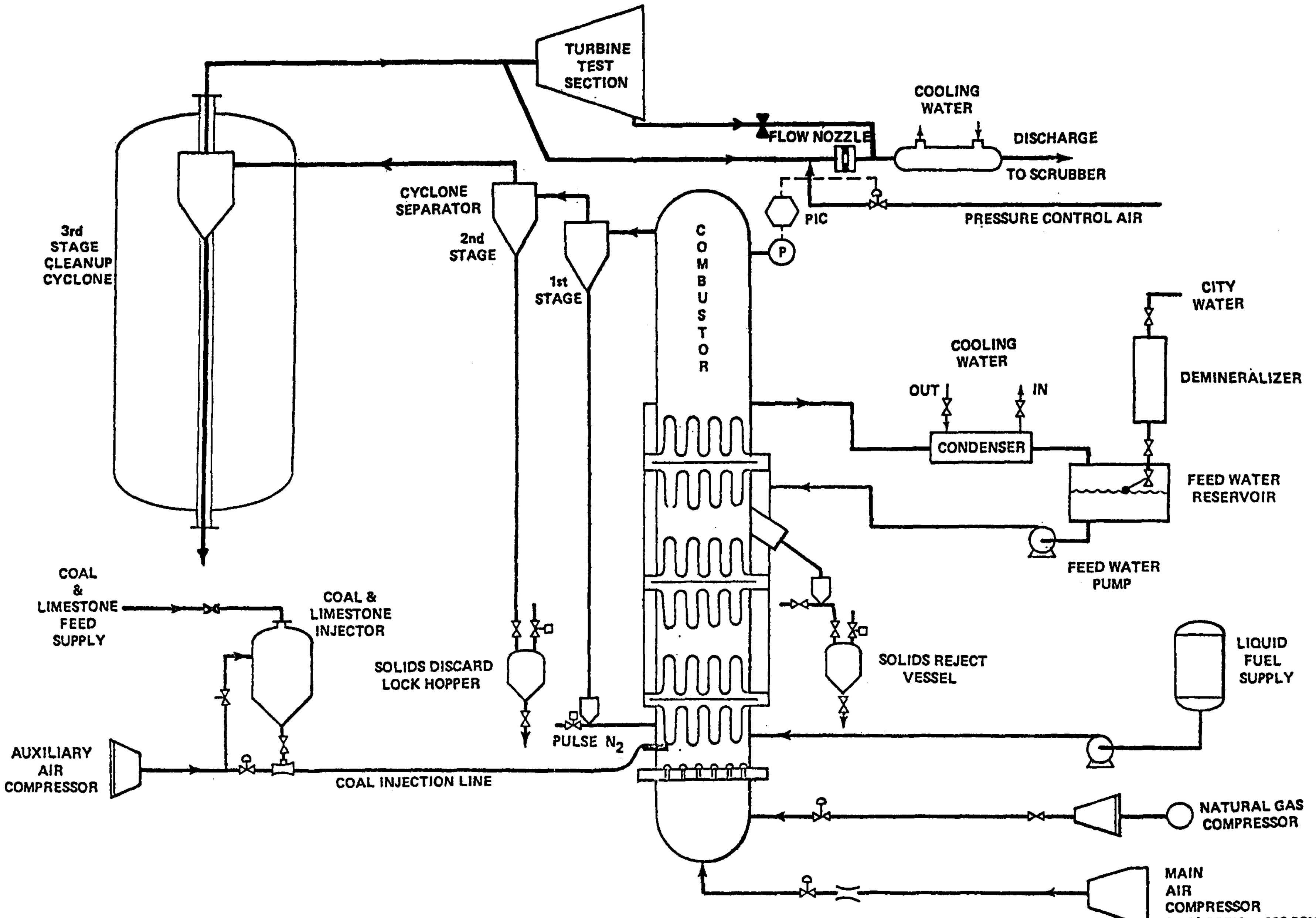


Figure 2

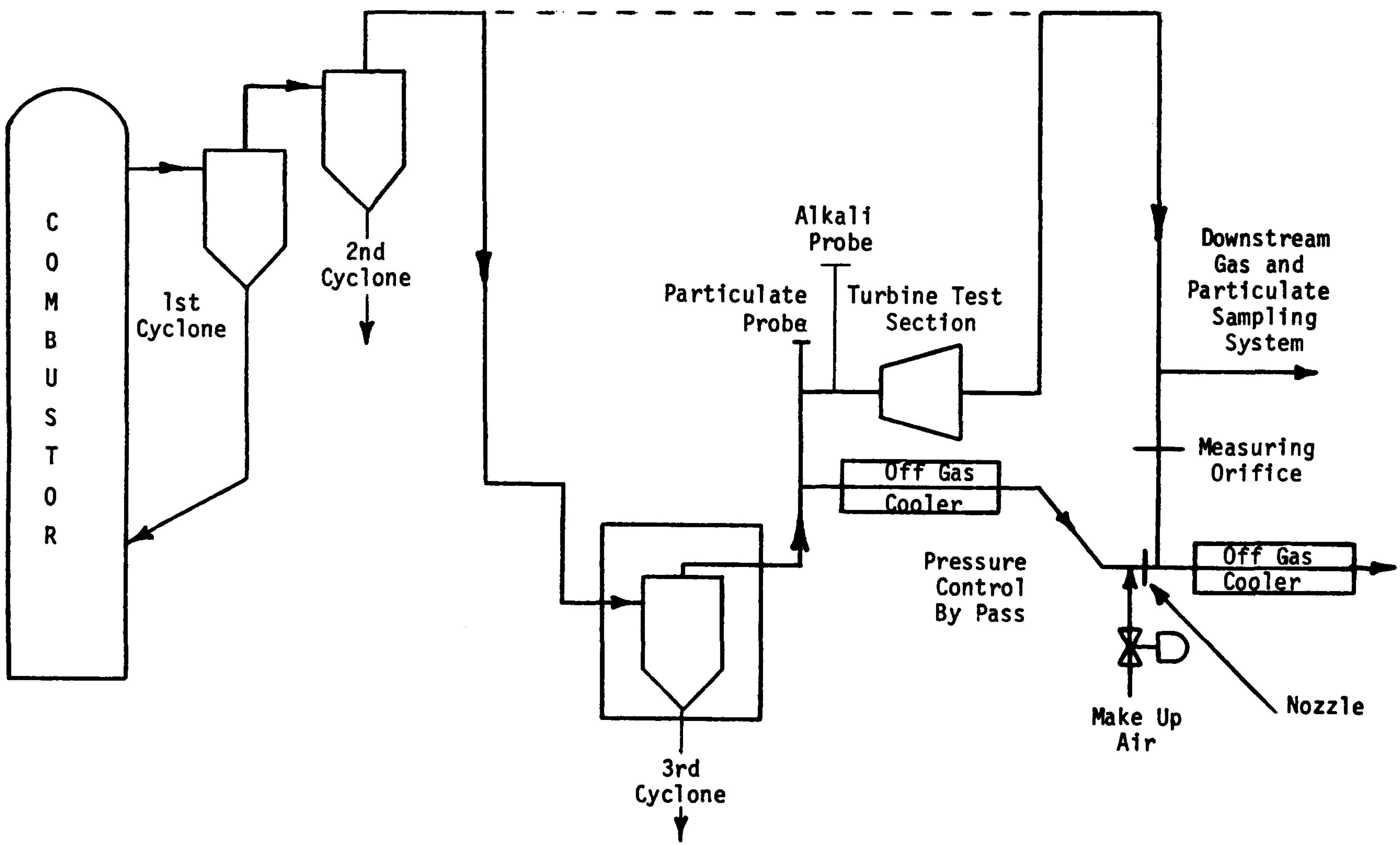
FLUIDIZED BED COMBUSTION MINIPLANT



FLOW SCHEMATIC

Figure 3

Miniplant Hot Gas Flow Schematic



III. EQUIPMENT AND TECHNIQUES

HEAT EXCHANGER SPECIMEN PROBES

The specimens prepared by Westinghouse for the PFBC combustor fireside corrosion/erosion exposures are 1.25 inch OD x 1.00 inch ID by 3 inch long cylinders with thermocouples inserted in the walls. Specimens of 2 different alloys selected for a given test matrix temperature are welded together, plugged at the end and welded to a tube section to form a bayonet probe. This specimen probe consists of a central cooling tube, thermocouple conduits, cooling air inlet and outlet and a flange for connection to the miniplant combustor port (Figure 4). The temperature of each specimen probe is controlled independently by regulating the flow rate of cooling air delivered to that probe. Each probe has a separate temperature control loop (Figure 4) consisting of a temperature controller, transducer (current-to-pneumatic) and control valve. Cooling air to the in-bed probes is supplied by an air compressor and a blower supplies air to the probes in the free board. This provides a reliable, independent and readily adjustable temperature control for the 21 specimens probes (each with 2 alloy specimens) inserted in the combustor. It permits control of 12 in-bed specimen probes at mean temperatures of 1050°F, 1200°F, 1400°F and 1600°F and 9 above-bed specimen probes at temperatures of 1200°F, 1400°F and 1600°F, with 3 specimen probes at each temperature.

The alloy-temperature matrix for in-bed and above-bed Exxon miniplant PFBCC exposure tests is shown in Table 1.

Table 1

Heat Exchanger Materials
Alloy-Temperature Matrix

	Specimen Temperature (°F)			
	In-Bed Only	In-Bed and Above-Bed		
Alloy	1050°	1200	1400	1600
2 1/4 Cr - 1 Mo	X			
9 Cr - 1 Mo	X			
304 Stainless Steel		X		
Incoloy 800		X	X	
Hastelloy X			X	X
Haynes 188				X

The heat exchanger specimen probes were installed in the combustor according to the location schedule presented in Table 2. Probes in ports #1 to 12 are immersed in the fluidized bed (i.e., "in-bed" probes). The nominal composition of the probe alloy specimens are listed in Table 3.

Individual heat exchanger specimen temperatures are recorded on a 100-point data logger - a Doric "Digitrend 210" with alarm capabilities. This unit provides a time-temperature record of the heat exchanger probe

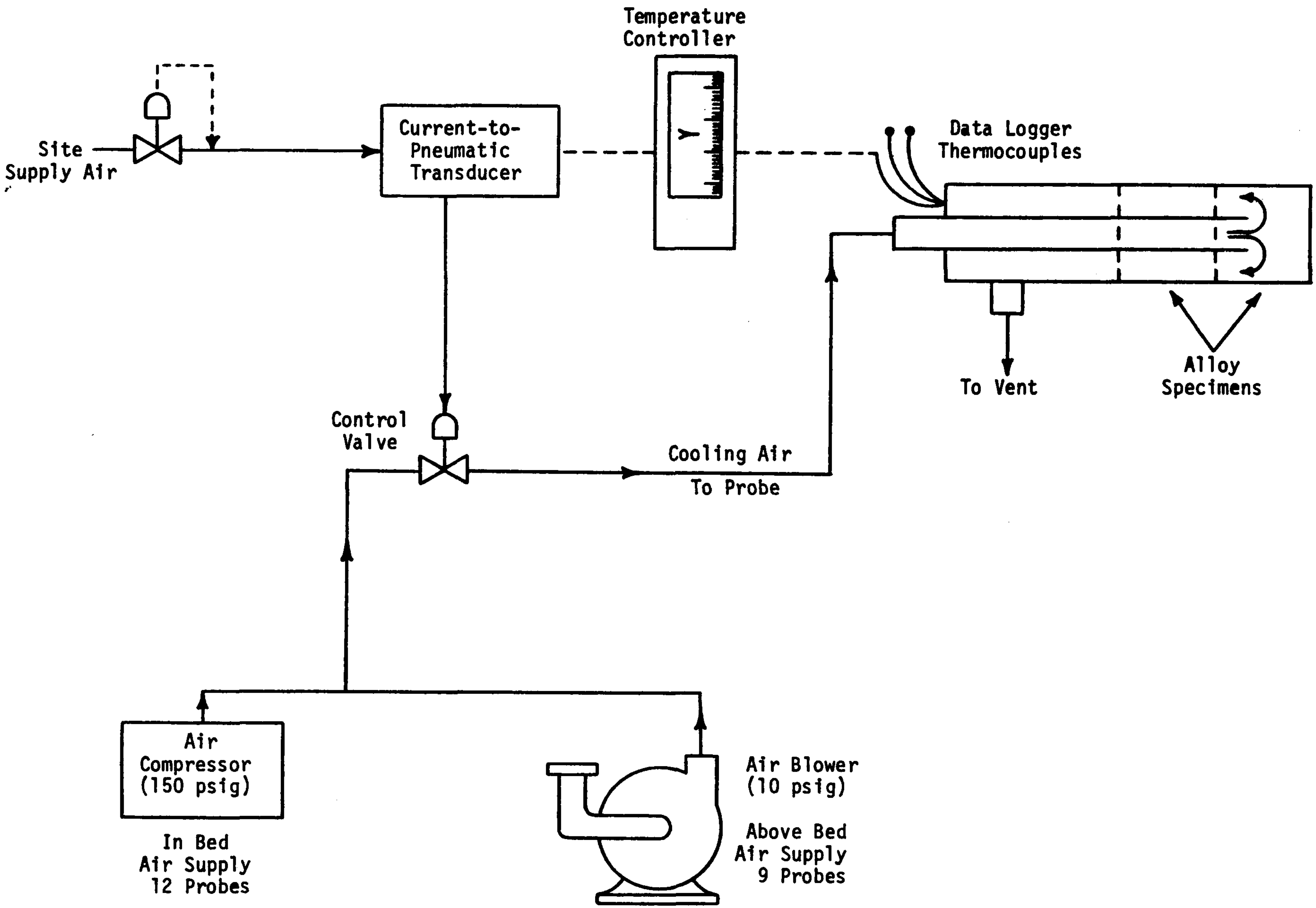


Figure 4

ER&E Miniplant PFBCC Hot Corrosion Specimen Probe Temperature Control System

Table 2

Material Description and Location

Combustor Port #	Specimen Material (Outer)*	Specimen Material (Inner)*	Target Operating Temperature °F	Target Operating Temperature °C
1	H	X	1600	871
2	X	8	1400	760
3	X	H	1600	871
4	8	X	1400	760
5	X	H	1600	871
6	8	X	1400	760
7	8	3	1200	649
8	9	2	1050	566
9	3	8	1200	649
10	2	9	1050	566
11	3	8	1200	649
12	2	9	1050	566
13	H	X	1600	871
14	8	X	1400	760
15	X	H	1600	871
16	8	X	1400	760
17	X	H	1600	871
18	X	8	1400	760
19	3	8	1200	649
20	8	3	1200	649
22	3	8	1200	649

Materials:		
	H - Haynes 188	1600
	X - Hastelloy X	1600 and 1400
	8 - Incoloy 800	1400 and 1200
	9 - 9 Cr - 1 Mo	1050
	2 - 2-1/4 Cr - 1 Mo	1050
	3 - 304 stainless steel	1200

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* Inner specimen is closest to center of combustor

* Outer specimen is closest to combustor wall

Table 3

Typical Composition of Alloys Tested in PFBC

	Composition (%)											
Heat Exchanger Probes	C	Cr	Ni	Fe	Co	Mo	W	Al	Ti	Mn	Si	Others
2 1/4 Cr - 1 Mo	0.1	2.2	--	Bal.	--	1	--	--	--	0.4	0.3	--
9 Cr - 1 Mo	0.1	9	--	Bal.	--	1	--	--	--	0.5	0.5	--
Type 304 SS	0.08	18	10	Bal.	--	--	--	--	--	1	0.5	--
Incoloy 800	0.04	20.5	32	46	--	--	--	0.4	0.4	0.7	0.4	0.3 Cu
Hastelloy X	0.1	21.5	Bal.	18.5	2.1	9	0.7	--	--	0.6	0.4	0.002 B
Haynes 188	0.08	22.2	22.3	1.8	Bal.	--	14	--	--	0.7	0.4	0.005 B
Turbine Blade Alloys												
U-700	0.07	15	55	0.1	17	5.0	--	4.0	3.5	<0.1	<0.1	<0.04 Zr, 0.15 B
IN-738	0.1	16	64	0.2	8.5	1.8	2.6	3.5	3.5	0.01	0.05	2.5 Nb, Ta
FSX-414	0.2	29	10.8	1.2	50	--	7	--	--	0.8	1.0	0.008 B
Blade Claddings												
IN-671	0.05	48	51	0.4	--	--	--	--	0.2	0.04	0.3	
S-57	0.1	25	10	0.5	Bal.	--	--	3	--	--	--	5 Ta, 0.15 Y
GE-2541	0.1	25	--	Bal.	--	--	--	4	--	--	--	1 Y

specimens at specified intervals. If the temperature of any specimen deviates from a pre-selected acceptable range, the data logger system will (1) alarm, (2) print out all specimen temperatures and the time once, and (3) continue to print the temperatures of the specimens outside of the control span until the proper specimen test temperature is restored.

GAS TURBINE TEST SECTION

The turbine test section is intended to provide a region with representative flow velocities to furnish engineering information on the possible corrosion/erosion deterioration of gas turbine materials exposed to the exhaust gas from a pressurized fluidized bed coal combustor. A photograph of the turbine test section components in their proper flow sequence is presented in Figure 5.

The General Electric test section for gas turbine materials corrosion/erosion evaluation incorporates both buckets and nozzle test specimens (Figures 6 and 7). The bucket (impulse profile) specimens are arranged in 3 cascades (6 specimens in each cascade) forming 3 right angle turns in the flow stream. A fourth cascade, which returns the flow to its original direction, consists of 6 nozzles (reaction profiles) which accelerate the exit flow to a 1.0 Mach number. The rectangular duct is 5/8 inch deep and 2-5/8 inch wide at the bucket cascade section. All profile chords are 1.0 inch.

GE supplied bare and clad alloy airfoil specimens. The bare, base alloy specimens were IN-738, U-700 and FSX-414. The IN-738 were clad with IN-671, S-57 and GE 2541, and the FSX-414 were clad with GE 2541. One blade with IN-738 as the base alloy was coated with RT-22 (platinum-aluminide). The nominal composition of the alloys and claddings is presented in Table 3.

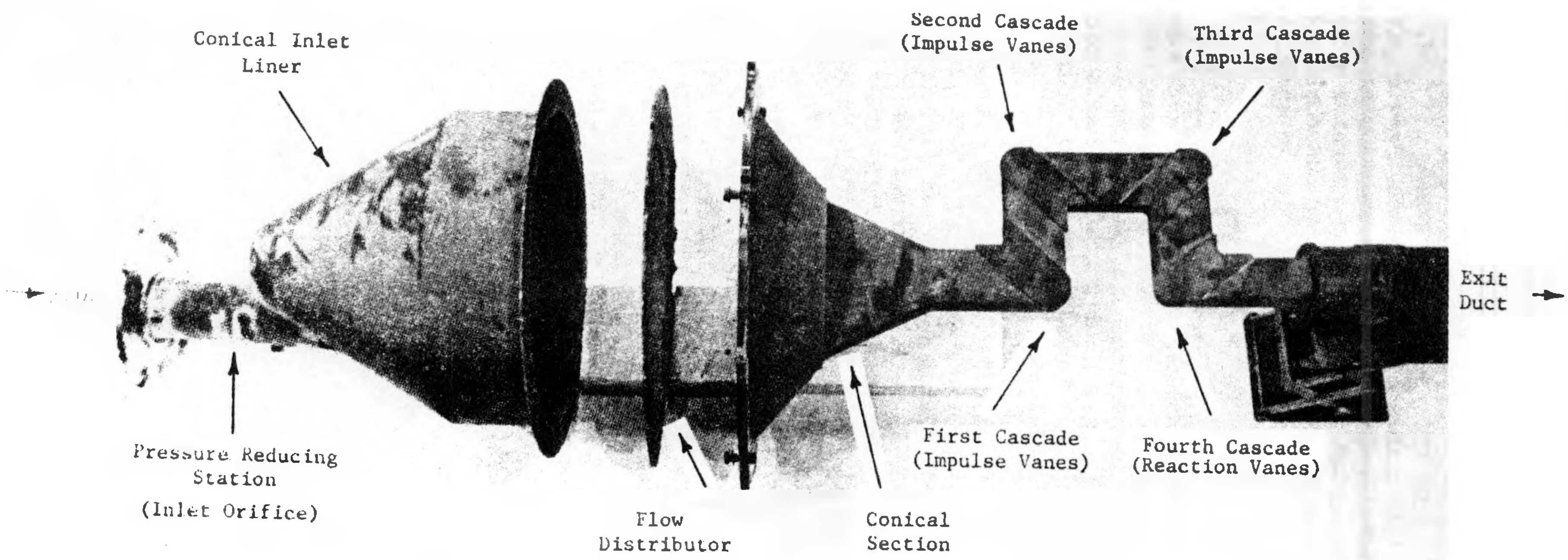
Enclosing the flow duct containing the airfoil specimens is a pressure shell which comprises the GE turbine test section. A pressure reducing section is an integral part of the turbine test section and located just upstream of the test passage. This is intended to adjust the turbine test section pressure so that proper blade velocities will be attained at miniplant test conditions.

The turbine test section was installed in the discharge line immediately downstream of the granular bed filter vessel (now housing the third stage cyclone). A new section of discharge pipe was fabricated and refractory lined to permit the insertion of the turbine test section.

Turbine test section flow control and combustor pressure control is accomplished by diverting a fraction of the flue gas through a by-pass loop around the turbine test section (Figure 3). The by-pass stream is expanded through a choked nozzle, with makeup air supplying the back pressure control. A measuring orifice was installed downstream of the turbine test section, so that turbine mass flow rate can be determined.

Figure 5

Turbine Test Section



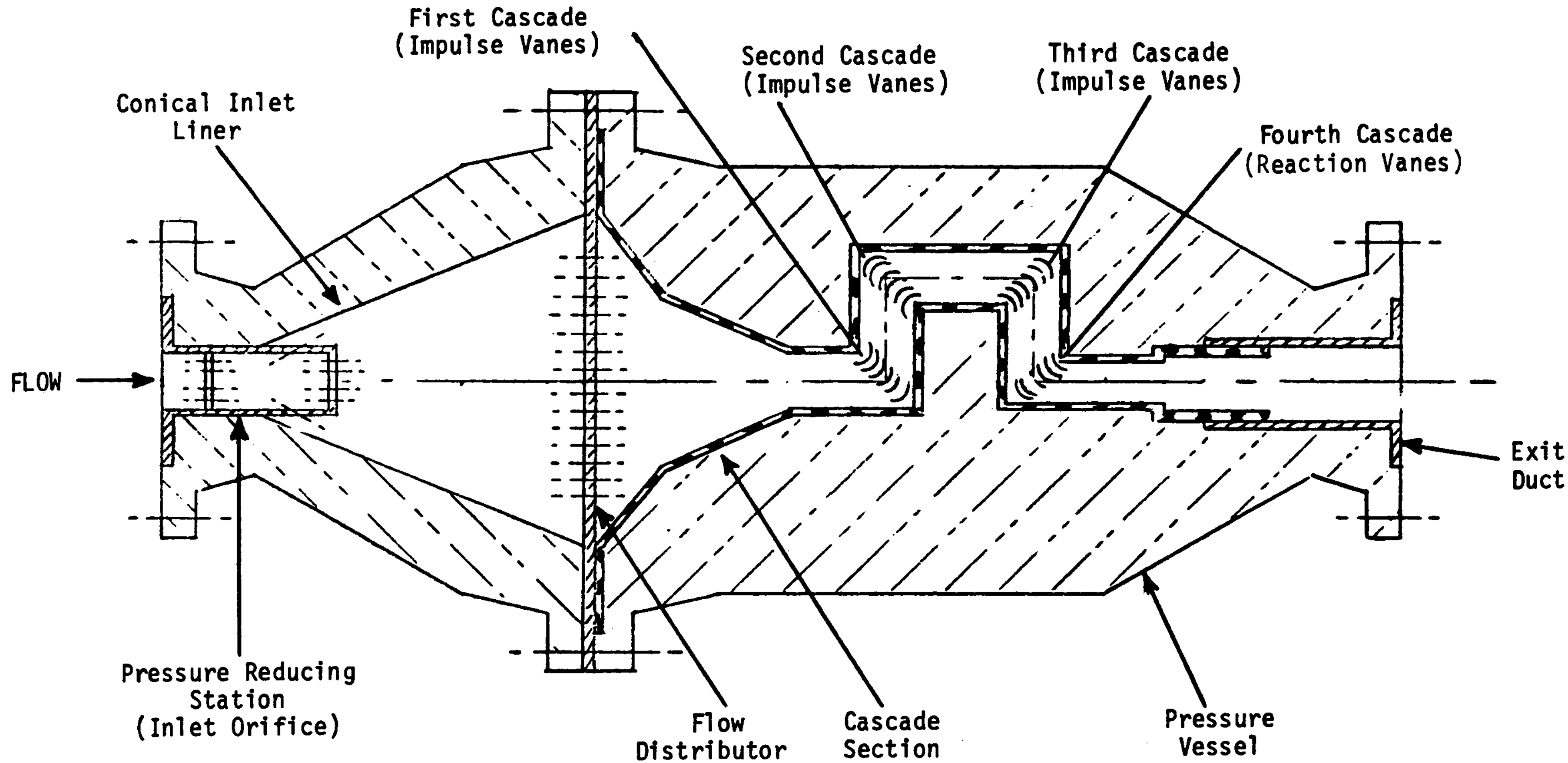


Figure 6

Turbine Test Section Schematic

FLOW CONDITIONS

Pressure - 9 atm

Temperature - 1550°F

Gas Flow Rate - 0.72-0.92 lb/sec
550-722 scfm

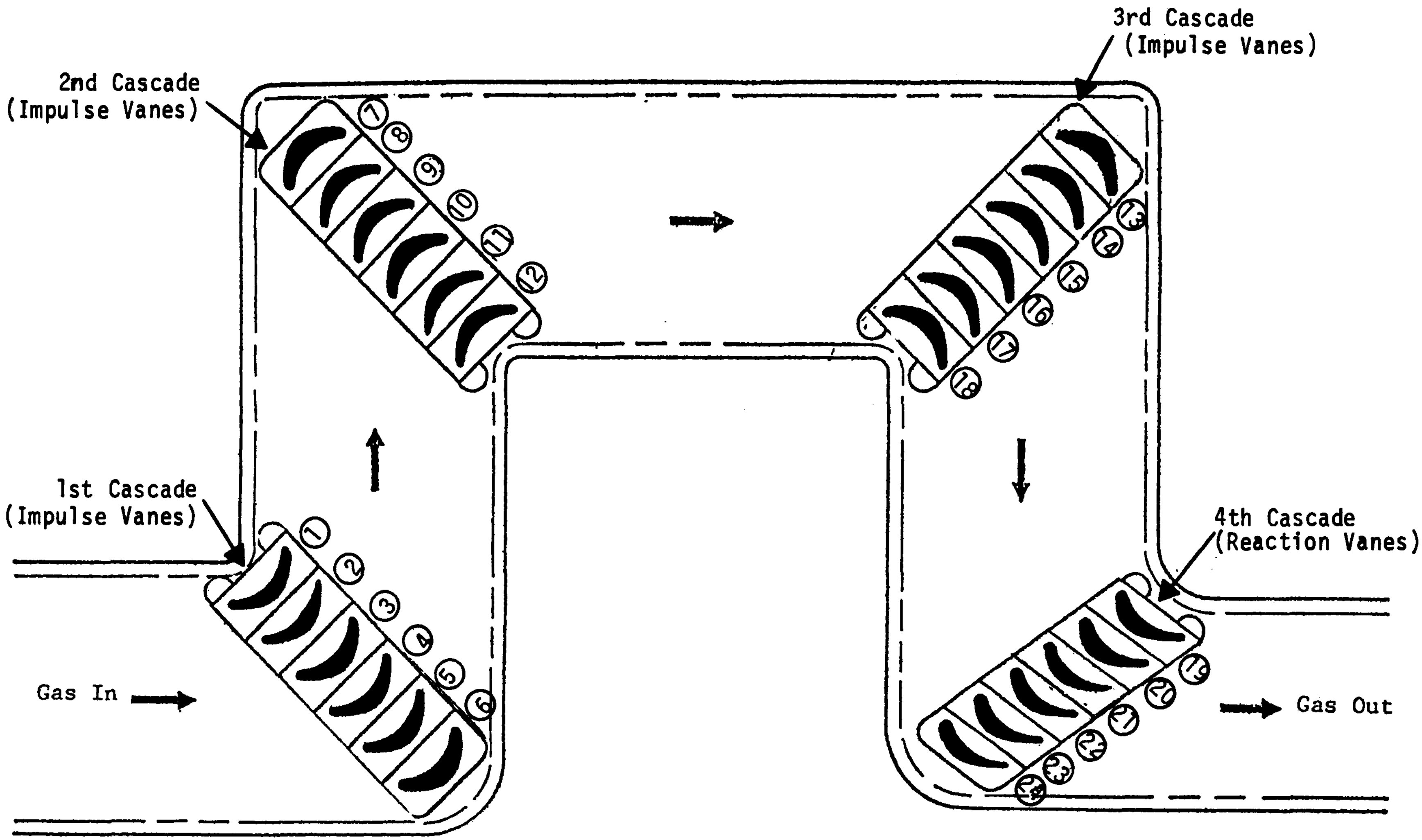


FIGURE 7 SCHEMATIC OF CASCADES IN TURBINE TEST SECTION

The study of turbine blade hot corrosion is deeply concerned with the possible attack of alkali salts on the blade materials. Since a commercial system would be designed to operate at high temperatures, the mini-plant system was modified to attempt to maintain the flue gas at a temperature of at least 1550°F at the turbine test section inlet. To satisfy these temperature conditions it was found necessary and practicable to combust some methane in the discharge piping. This compensates for the thermal losses in the pipe lines and the third cyclone vessel and assures that temperatures upstream of the turbine test section remain above 1550°F (see section on Methane Injection).

HOT GAS CLEANUP

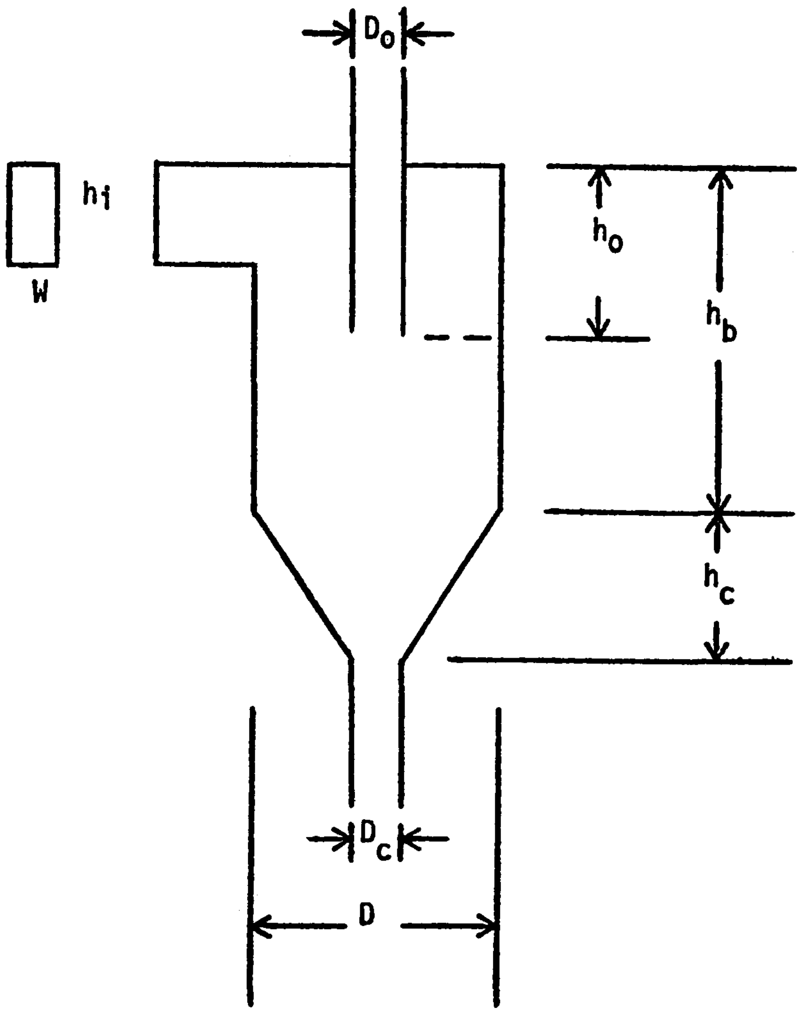
Estimates of the allowable particulate concentration in the flue gas entering the turbine range from 0.04 to 0.001 g/Nm^3 (0.02 to 0.0004 grains/SCF). To meet these estimated requirements, the flue gas leaving a pressurized combustor must first be precleaned in two stages of cyclones and then sent to a third stage high efficiency device for final cleaning. The efficiency of the third stage device must be in the range of 95 to 99.7% to be within the currently estimated particulate loading target range.

Initially, particulate removal was to be achieved by using two stages of conventional cyclones followed by a granular bed filter of a design developed by the Ducon Company. This granular bed was to have been tested at Exxon Research and Engineering Company under sponsorship to the U.S. Environmental Protection Agency (Contract 68-02-1312). However, during this test program of the granular bed filter a number of major operating difficulties were encountered which led to the abandonment of the device as a third stage cleanup device. These problems included (1) the formation of a hard filter cake particulate retaining screens of the granular bed filter reducing gas throughput rates; (2) the excessive loss of filter bed material after retaining screens had been removed and freeboard increased; (3) a retention of a significant amount of particulate in the filter bed which, then, uniformly distributed through the filter bed causing a decrease in collection efficiency with time; (4) an inability to achieve outlet concentrations less than 0.05 gr/SCF for a significant period and (5) high vulnerability to process upsets causing shutdown of the system. A detailed description of the granular bed filter test program is given elsewhere (3).

Because correction of the operating problems of the granular bed filter were beyond the scope of the EPA program, a third stage cyclone replaced the granular bed filter in order to provide the final particulate cleanup. Throughout some 2000 hours of testing under various conditions the third cyclone has averaged an efficiency of 90% ± 3%. This conventional cyclone was used in conjunction with the first two stages of cyclones to provide particulate cleanup of the PFBC flue gas for these hot gas corrosion turbine tests. The dimensions of the cyclone are shown in Figure 8. Normal operating conditions for the cyclone are listed in Table 4.

Figure 8

Miniplant Third Cyclone Dimensions



W	hi	h_o	h_b	h_c	D	D_o	D_c	
1.5	3.0	4.5	16	8	6.07	2.47	3.55	inches
3.81	7.6	11.4	41	20	15.4	6.27	9.02	cm

Table 4

Normal 3rd Cyclone
Operating Conditions

Pressure	900 kPa
Temperature	870°C
Inlet Velocity	50 m/sec
Inlet Loading	1.1 g/Nm^3
Inlet Average Particle Size	3-4 μm

METHANE INJECTION

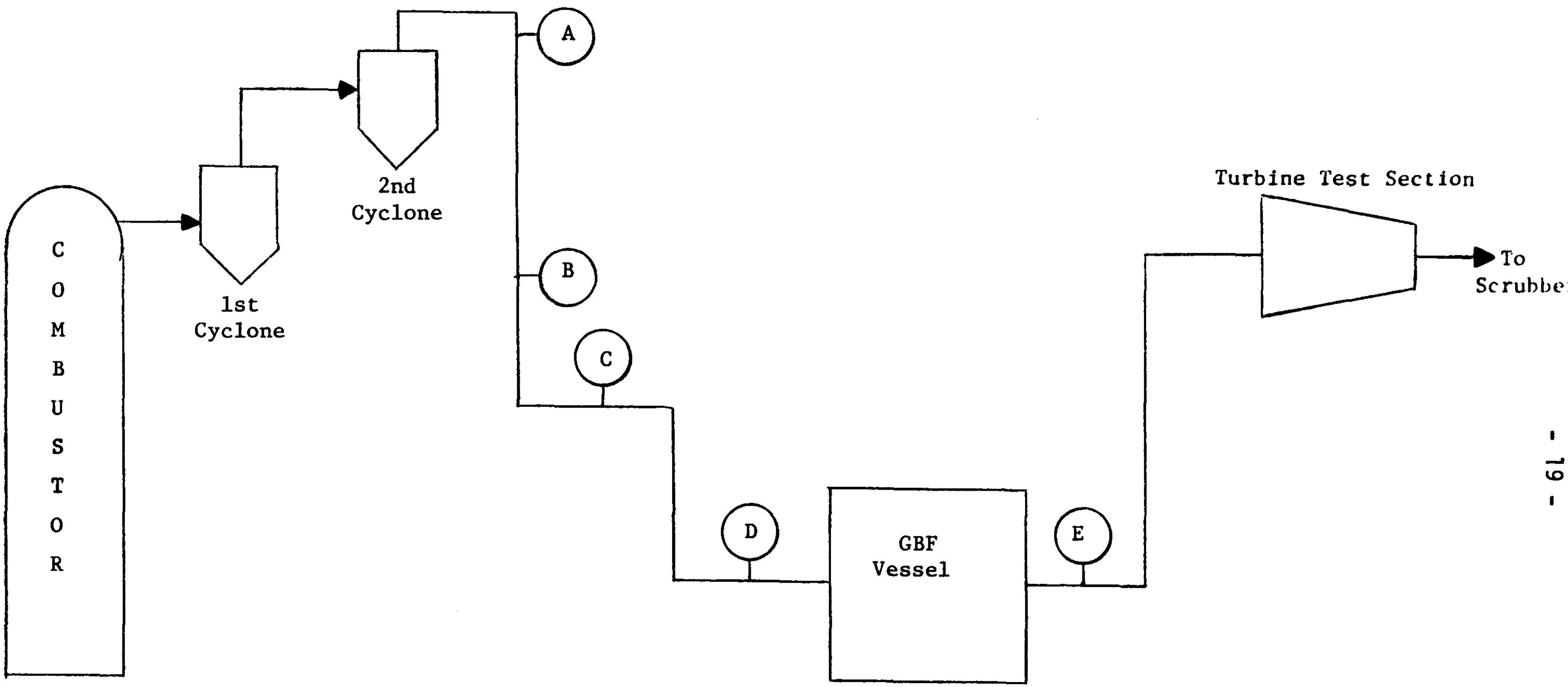
In order to simulate gas turbine operation, care must be taken to prevent the gas temperature from dropping below 843°C (1550°F). Below this temperature gas phase alkali will condense on duct walls or particulate matter. This would unrealistically reduce the gas phase alkali concentration to which the turbine blades are exposed. For this purpose a total of five (5) natural gas injection nozzles were installed in the flue gas line. Four (4) of the ports are located between the second and third cyclone and the fifth between the third cyclone (in the GBF vessel) and the turbine test section (Figure 9). The five ports are staggered to maintain gas temperatures between 1560°F and 1650°F (850°C and 900°C). The total amount of natural gas (typically 60 to 90 Ndm^3/min) is controlled to maintain a set third cyclone inlet temperature. The flow distribution between the five nozzles is manually controlled. The injection nozzle consists of a closed end 3/8 inch alonized tube projecting to the duct centerline with a 0.10 cm diameter hole facing downstream. The probes are purged with nitrogen when not in use.

Temperature measurements have revealed that the methane gas does not begin to burn until it is several inches downstream of the injection point. Combustion then occurs uniformly over the next 5 feet before it is complete as indicated by a temperature decline.

The only effect of natural gas injection that has been measured besides a 0.5 to 1% reduction in flue gas oxygen is a drastic reduction in CO. During run 81, CO emissions fell from 525 ppm 1-1/2 hours after coal injection was begun to 30 ppm after methane injection into the flue gas lines was started. Reduction in CO emissions was also observed in runs 79 and 80 with methane injection. CO emissions observed in the past for mini-plant runs without methane injection were in the range of 100 to 200 ppm. For the runs with methane injection, the residence time of the flue gas in the piping at the temperature range of 1500 to 1730°F (816 to 943°C) was about twice as long as for runs without methane injection. Thus, methane injection could provide increased opportunity for burnout of CO.

Figure 9

Location of Methane Injection Nozzles



Methane Injection Nozzle	Distance Downstream of 2nd Cyclone (ft)
A	7.5
B	22.0
C	32.0
D	47.0
E	60.0

PARTICULATE SAMPLING AND MEASUREMENT

Particulate Sampling

Since the start of the 1000 hour exposure test program, two particulate sampling systems have been used to measure flue gas particulate loadings into the turbine test section. The oldest system, also used during the shakedown run, is located downstream of the turbine test section. This is near the point where the gas is sampled for flue gas composition. The other measurement system is only several feet upstream of the turbine test section. This system was initially designed to be used with a Southern Research Institute 5-cyclone train or a University of Washington 7-stage impactor for high temperature and high pressure particulate sampling.

The particulate sampling system located downstream of the turbine test section consists of a 1/2 inch (0.035 in wall) 316 stainless steel tube facing into the flow. A high temperature valve provides shut off for the changing of the Balston total filter during a run. After the Balston filter there are various coolers and a water knockout followed by a manual flow control globe valve. After the expansion valve, the flow may either be sent to a wet test meter for direct measurement, or the flow rate may be measured through a rotameter and the total flow obtained by integration over the sampling time. This system is shown schematically in Figure 10. Note both the probe and the filter are purged when not in use.

The other system upstream of the turbine test section is referred to as the cyclone and impactor particulate sampling system (CIPSS). The CIPSS was initially intended to accommodate any sampling device. A Southern Research Institute 5-cyclone sampling train and a University of Washington 7-stage impactor have been used in this system to sample the flue gas for particulate. The use of both the SRI cyclone and the UoW impactor is still experimental, so none of the results obtained are reported here. With a minor piping change the pressure vessel used to house the other sampling systems was by-passed and a 7 inch Balston total filter was installed in its place. This filter made use of the remainder of the sampling train (cooler, knockout, flow control valve, etc.) as shown in Figure 11. The section of the CIPSS before the sampling device is similar to the other sampling system with two exceptions. First the probe is 3/8 inch (0.035 in wall) 316 stainless steel tubing. Second the line is fairly long and thereby necessitates electrical heating to prevent condensation.

The locations of these particulate sampling systems are shown in Figure 3. During the corrosion test program both the Balston filter and the CIPSS particulate sampling systems were used. The CIPSS system was used with one Balston total filter. Once the validity of the modified CIPSS system results were confirmed by comparing them to a Balston filter sampling system results taken concurrently, the CIPSS system was used preferentially. This was done primarily because the sample flow of the high pressure gas upstream of the turbine test section was easier to regulate than that of the lower pressure gas downstream.

Figure 10

BALSTON FILTER PARTICULATE SAMPLING SYSTEM

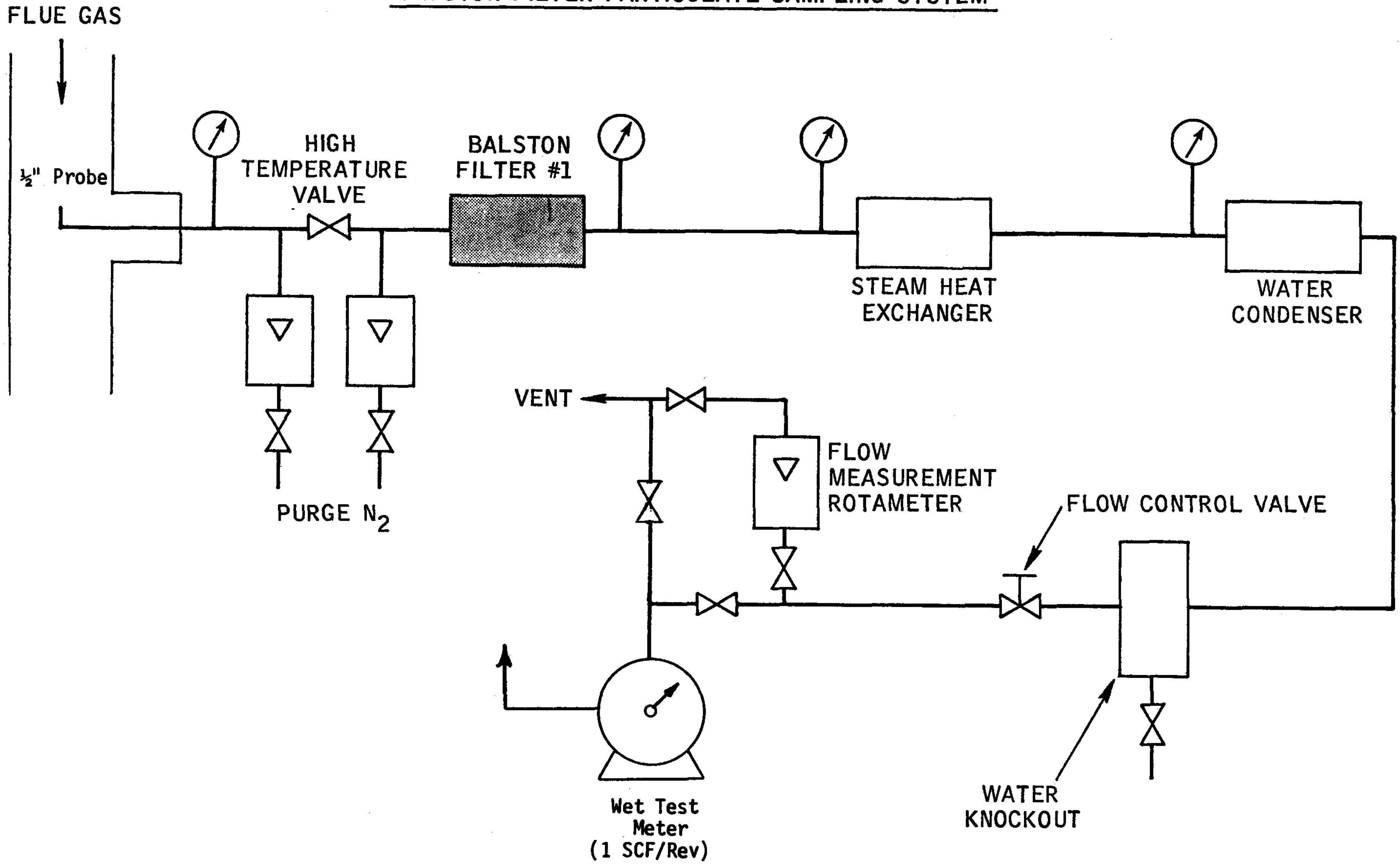
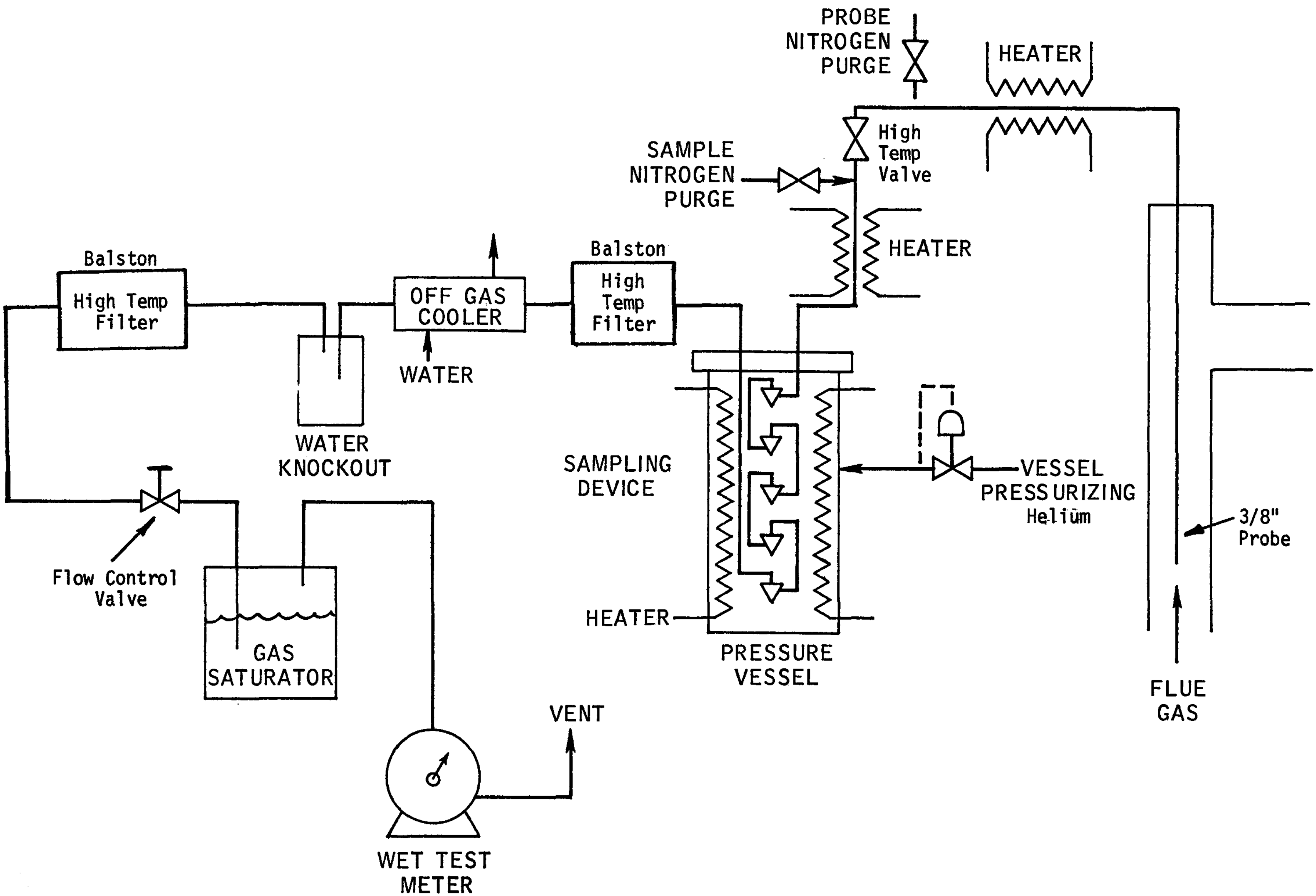


Figure 11

CYCLONE AND IMPACTOR PARTICULATE SAMPLING SYSTEM



Particulate Size Measurement

Particle size measurements for all of the 1000 hour exposure tests were done with a combination sonic sifter/Coulter Counter technique. Samples with significant concentrations of particles larger than 40 µm were first screened through a sonic sifter. The -325 US Mesh (44 µm) fraction from the sifter was analyzed with the Coulter Counter Model TA II with a 100 µm aperture. Material sized in this manner includes all second cyclone dump material, and some third cyclone dump material. Finer material, without significant material larger than 40 µm, is analyzed only with the Coulter Counter.

Balston filter particulates are carefully removed from the filter cake. Care must be taken to avoid mechanically brushing the filter cartridge material to prevent contamination. The particulate is redispersed in Isoton II with a dispersant in a sonic bath. This mixture is further diluted and analyzed with a 30 µm aperture probe on the Coulter Counter. If there is a reasonable amount of material larger than 12 µm, the sample is also analyzed with a 100 µm probe. The two size distributions are then combined with the dual aperture sizing technique developed by Coulter Counter Electronics, Inc.

Particle size distributions obtained with the above procedures for run 78 second and third cyclone dump material have been compared to distributions obtained with other size measurement equipment. Samples of the material were sent to General Electric who obtained size distributions with their Bahco particle size analyzer. The Bahco measures the aerodynamic equivalent diameter, whereas the Coulter Counter measures volumetric equivalent diameter. The size distributions for the second and third stage cyclone dump material are shown in Figures 12 and 13.

Continuous Particulate Monitor

A continuous, on-line particulate monitoring system was evaluated during run 80. The monitoring system (manufactured by IKOR, Inc., Gloucester, Massachusetts) makes use of the surface charge that particulates acquire during their flow through the combustion unit. The unit showed unexpected sensitivity to gas temperatures which made comparison of the signal amplitude with gravimetric sampling difficult. This indicated that while a gross change in particulate loading could be identified, the IKOR probe, in its present condition, could not be employed as a reliable device for controlling or monitoring particulate loading for the PFBC technology.

The IKOR system consists of two components. One of the components is a control and recording system; the other is a 1/4 inch diameter type 316 stainless steel rod which acts as the probe. The probe is inserted normal to the gas flow and acts as a site for particulate impaction. Each particle impacting on this probe transfers its accumulated charge to the probe. This

Figure 12

Comparison of Particle Size Distribution Via Bahco Vs. Coulter Counter of Secondary Cyclone Dump Material (Run #78)

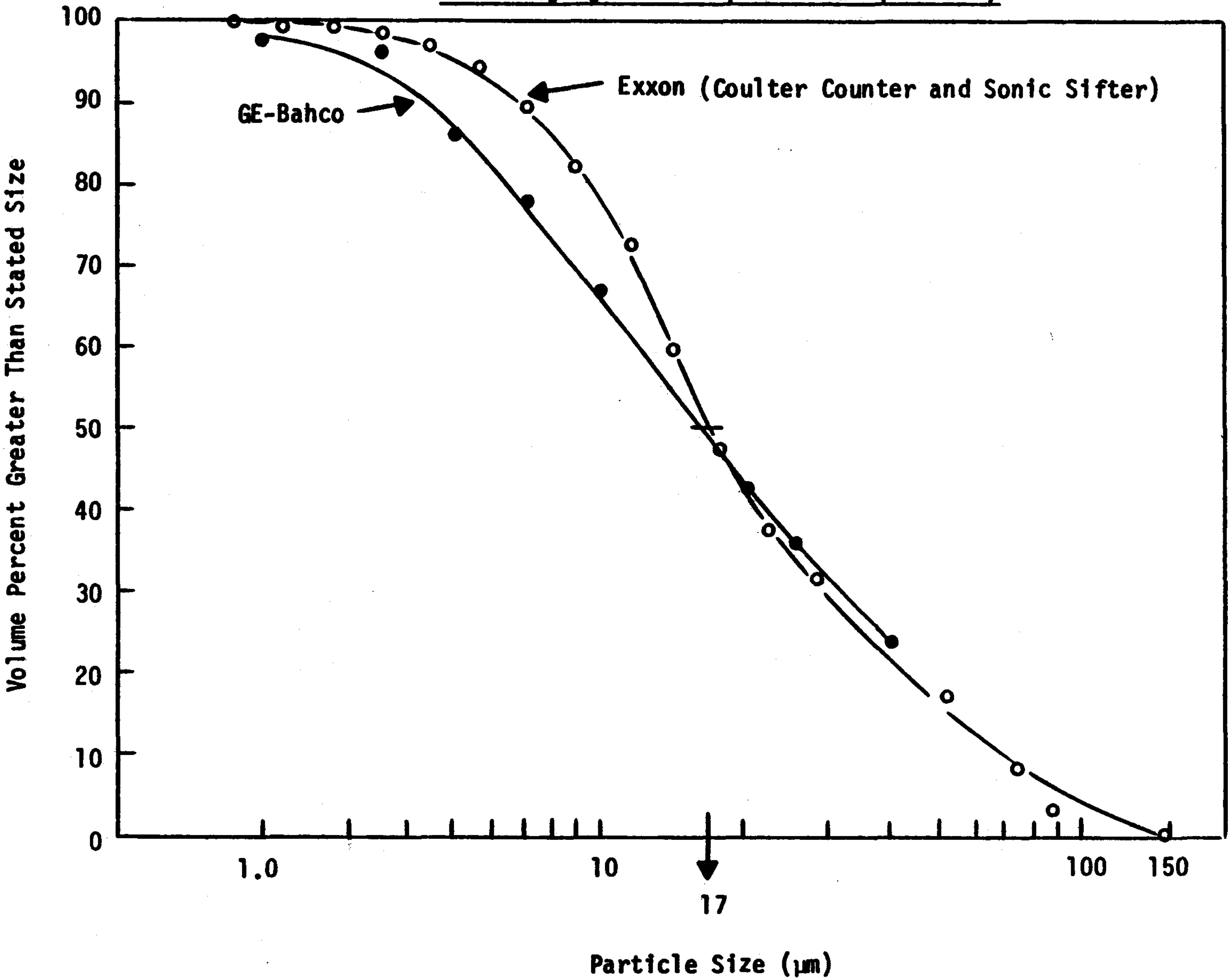
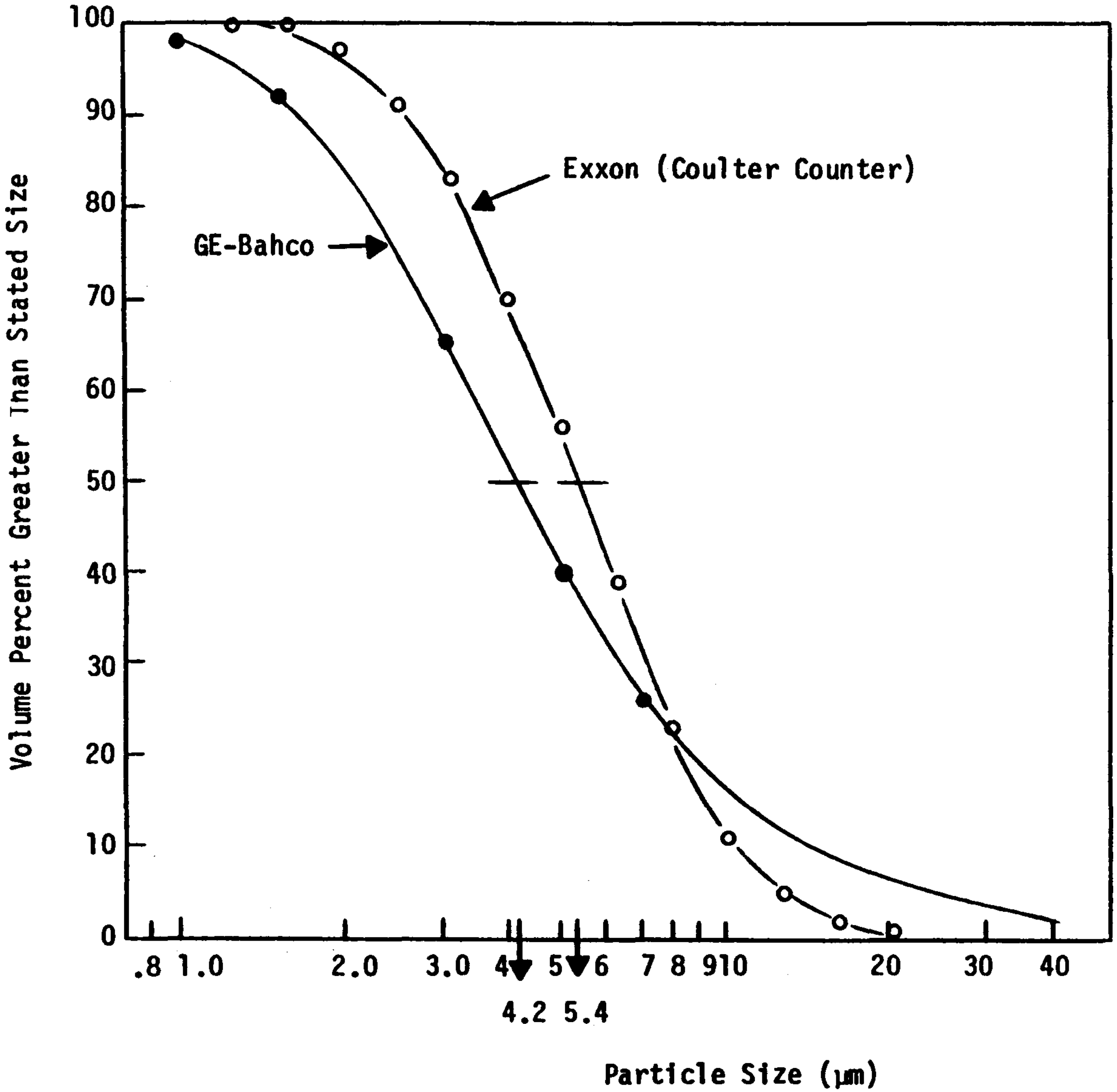


Figure 13

Comparison of Particle Size Distribution Via Bahco Vs. Coulter Counter of Tertiary Cyclone Dump Material (Run #78)



charge transfer effect generates an integrated output signal that is proportional to particulate mass flow in the gas stream. The magnitude of the integrated signal is correlated with a particulate loading measurement taken during the same time period. A strip chart is used to record and display the output.

The stainless steel probe, which was located in the off gas line about seven feet downstream of the GE turbine test section, survived the 215 hour test without noticeable damage. The gas temperature at the probe location was in the range of 1500-1525°F.

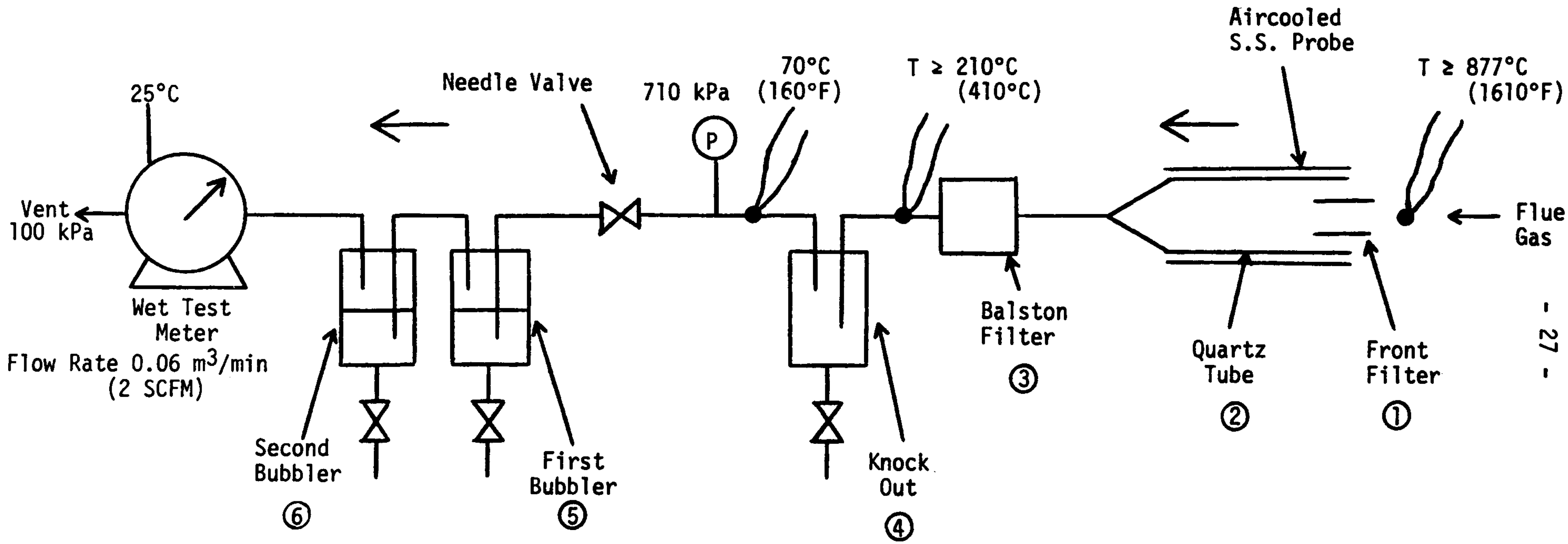
ALKALI PROBE TRAIN

An alkali probe train was designed and constructed by Exxon Research to enable acquisition of a hot pressurized flue gas sample before entering the turbine test section. The probe was designed to measure vapor phase Na and K concentrations of the flue gas at 1550°F and 9 atm pressure. Figure 14 is a schematic of the alkali probe train. The temperatures shown are those for test 4 of run 78, these are representative of normal operating conditions.

The hot pressurized flue gas enters the probe at system temperature and pressure and is prefiltered through three layers of astroquartz. Na and K vapors in the flue gas are then condensed on the walls of an air cooled quartz tube, which lowers the flue gas temperature from approximately 1550°F to 400°F. Alkali metals which condense on particulates in the flue gas are collected in a Balston filter after exiting the quartz tube. Flow is manually controlled by a needle valve and measured by a wet test meter.

Figure 14

Schematic of Alkali Probe Train
Alkali Test 4 During Run 78



① Front filter + particulates

② Quartz tube

③ Balston filter + particulates

④ Knock out solution

⑤ First distilled and deionized water bubbler

⑥ Second distilled and deionized water bubbler

IV. PRELIMINARY AND SHAKEDOWN TESTS

PREPARATION RUNS

A preliminary hot test was undertaken to test the temperature control for the Westinghouse Research specimen probes. The initial twenty-one (21) heat exchanger specimen probes supplied by Westinghouse Research were installed - twelve (12) in the bed region and 9 in the freeboard region (Figure 1). (Table 2 lists the 21 probe material specimens, their combustor location and intended operating temperature.) The turbine test section was not installed during these preliminary tests.

The test indicated that high pressure air was necessary to effectively cool all 21 probes. Control of the high temperature bed probes and all of the freeboard probes appeared feasible using air pressure at 10 psig but cooling the in-bed probes at the lower temperatures, namely 1050°F and 1200°F, required an alternate source of high pressure air (150 psig) since the large volume of air necessary for cooling at these lower temperatures resulted in high pressure drops across the control valves and test probe. By-pass loops around the control valves were not necessary when this high air pressure air (150 psig) was used. Stable control was maintained by throttling the cooling air upstream of the control valve. The above-bed probes were cooled by air from a blower operating at 10 psig. Tests had shown that temperature control at 1400°F and 1200°F was excellent in the freeboard region. When the probes were at 1600°F, smaller trims were installed in the control valves in order to achieve steady control at this temperature.

Natural gas, i.e., methane, injection into the flue gas line between the second stage cyclone and the granular bed filter was investigated as a means of maintaining the flue gas temperature above 1550°F before entering the turbine test section. Natural gas was injected 7.5 feet downstream of the second stage cyclone and the effect on the line temperature profile was observed. As seen in Figure 15, most of the natural gas appears to have burned within 5 feet of the injection point. Injection of 2.8 SCFM of natural gas into 620 SCFM of flue gas raised the line temperature from 1380°F to 1525°F 50 feet downstream of the injection point. The presence of "hot spots" near the injection nozzle caused by the instantaneous combustion of the natural gas was also investigated. Figure 16 shows that the gas does not begin to burn until it is several inches downstream of the injection point. Combustion then occurs uniformly over the next 5 feet before it is complete, as indicated by a temperature decline. As a result of these tests, a total of five (5) equally spaced injection nozzles were installed in the flue gas line between the second stage cyclone and the turbine test section (Figure 9). This enabled the flue gas to be maintained above 1550°F throughout the entire run of pipe without the occurrence of large temperature spikes.

Figure 15

Methane Injection - Temperature Profiles

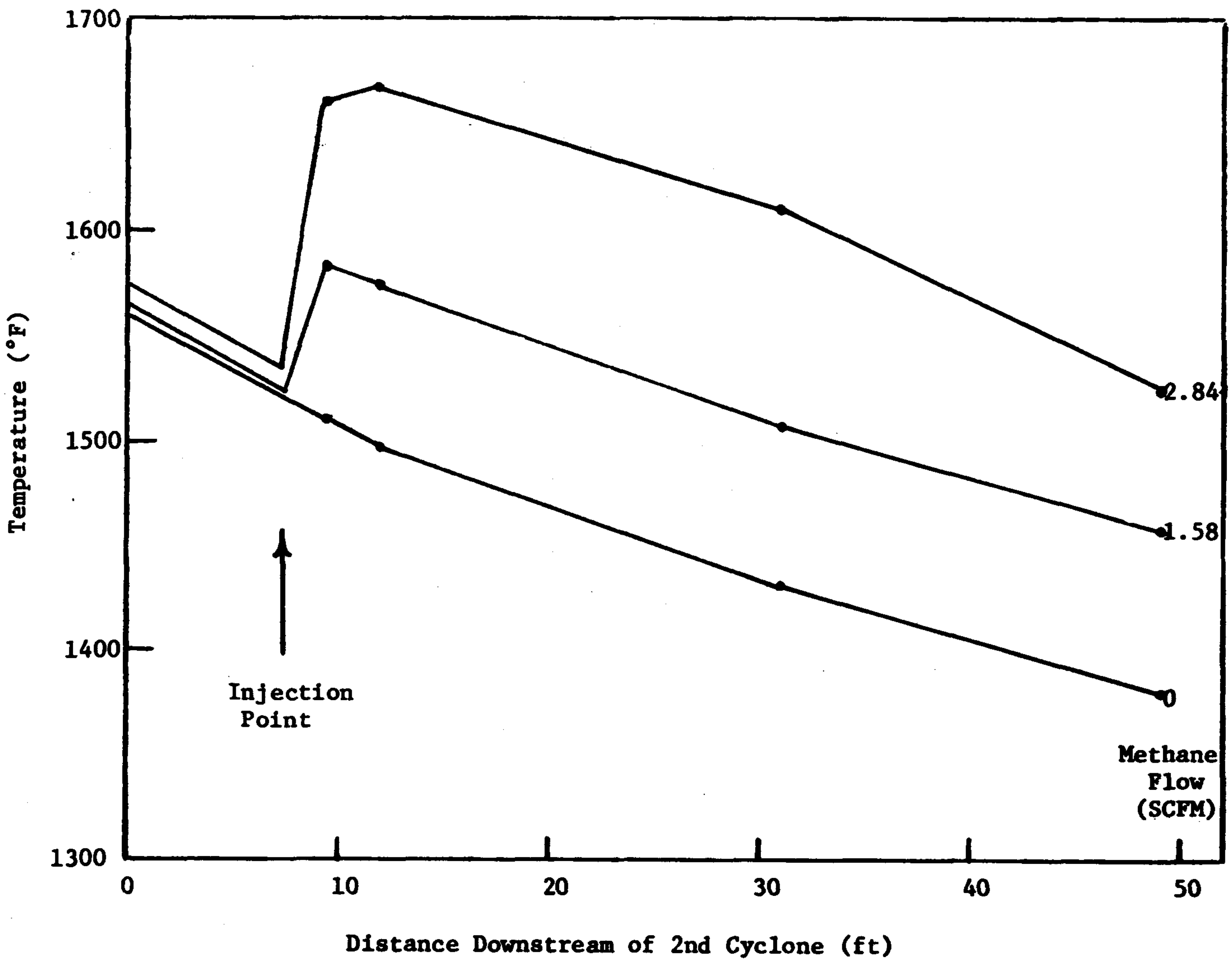
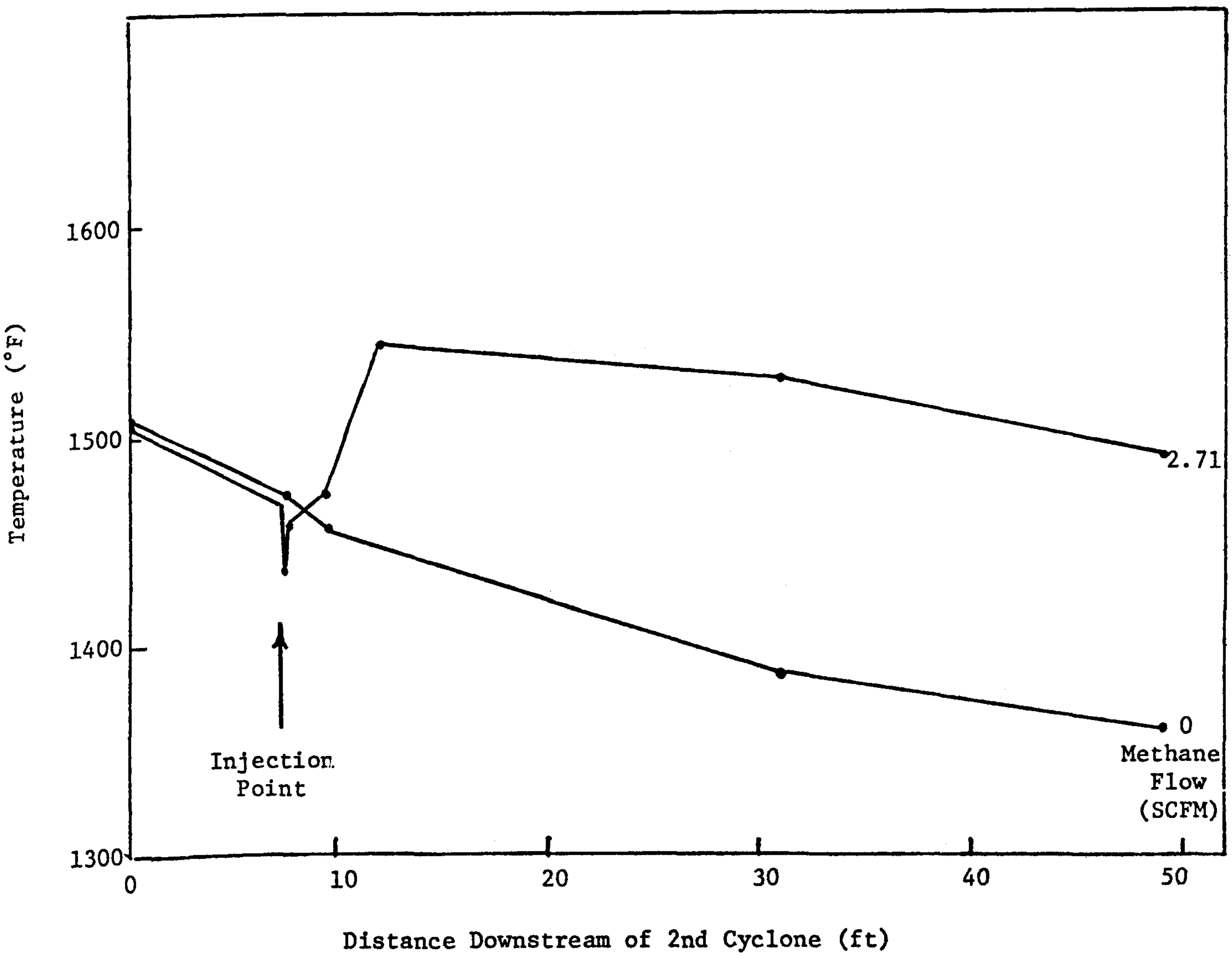


Figure 16

Methane Injection - Temperature Profiles



SHAKEDOWN TEST #1

Preparation for the 100 hour shakedown run included installation of the following major items: 21 heat exchanger specimen probes in the combustor, the turbine test section and associated discharge line modifications, a new pressure control system employing a by-pass loop around the turbine test section, and new combustor heat exchanger coils located above and below the in-bed heat exchanger specimen probes.

The turbine test section supplied by General Electric was installed in the discharge line immediately downstream of the granular bed filter (Figure 3). A new section of discharge pipe was fabricated and refractory lined to permit the insertion of the turbine test section. During a run both turbine mass flow and inlet temperature are scanned once a minute and recorded on magnetic tape. Particulate and analytical sampling trains were also located downstream of the turbine section at 200 kPa pressure.

Three (3) sets of granular bed filters, each containing 3 beds, were installed in the filter vessel downstream of a high efficiency cyclone (see Table 4 for dimensions). Improved blow back seals were adapated to each element, and methane addition and flow control capability was provided for each element. An oxygen sensor was interlocked with the methane addition system to alarm and shut off the methane injection if the oxygen level in the flue gas went below 1 percent. The cyclone, piping, and filter shrouds within the GBF vessel were wrapped with high temperature blanket insulation.

Preparations for the intended 100 hour shakedown run were completed on November 23, 1977 and test operations started on November 28th with the heat up of the granular bed filter vessel. The shakedown test (Miniplant Run 66) had to be terminated after 17 hours of operation due to excessive pressure drop across the granular bed filter. At one point, the filter pressure drop climbed as high as 207 kPa (30 psi). The blow back flow (cleaning cycle) was then increased in an attempt to lower the ΔP. A significant amount of filter media was lost because of the higher blow back velocity. However, the filter ΔP was lowered to approximately 7 kPa (10 psi) and remained constant until a fire in the coal feed injector vessel, caused by the pressure upsets during the high flow blow backs of the filter, forced the termination of the run.

Inspection of the filter elements after the run showed substantial plugging of the bottom support screen, the inlet retaining screens were relatively clean. This plugging caused the high pressure drop across the filter.

During the last 2 hours of the run the particulate concentration was measured at 0.06 gr/SCF. A summary of the operating conditions and emissions during the run is given in Table 5.

Table 5

Miniplant Operating Conditions and Emissions

Nominal Operating Conditions	Run 66	Run 67.1	Run 67.2	Run 67.3	Run 67.4
		Shakedown Runs			
Date 1977	11/29	12/12-12/13	12/13-12/14	12/15	12/15-12/16
Run Length (hrs)	17	28	25	10	37
Pressure (kPa)	930	930	930	930	930
Temperature (°C)	918	915	915	915-875	875
Superficial Velocity (m/sec)	1.6	1.7	1.7	1.6	1.6
Expanded Bed Height (m)	3.2	3.3	3.4	3.2	3.0
Excess Air % (Air/Fuel Ratio)	10	19	14	14	31
Coal Feed Rate (kg/hr)	130	118	130	125	115
Nominal Ca/S Molar Feed Ratio	1.25	1.25	1.25	1.25	1.25
Flue Gas Emissions					
SO_2 (ppm)	370	675	625	612	650
NO_x (ppm)	20	100	65	65	105
CO (ppm)	205	300	160	312	200
CO_2 (%)	12	14	15	12	12
O_2 (%)	1.9	3.0	2.5	2.5	~5

Note: Run 67.1 - From startup to shutdown when larger pressure control nozzle was installed

Run 67.2 - Steady state combustor operation at 915°C

Run 67.3 - Transition period when combustor temperature was lowered from 915°C to 875°C

Run 67.4 - Steady state combustor operation at 875°C maintained till shutdown

Eighteen of the 21 heat exchanger probes exhibited excellent temperature control throughout the run. However, control of the three in-bed probes intended for 1400°F conditions was somewhat erratic due to insufficient pressure of the air supply blower.

Temperature measurements of the probes controlled at the various temperatures showed the following gradients throughout the length of the probe, i.e., from "inner" to "outer" specimen.

1600°F	In-Bed	= 25°
	Above Bed	= 45°-60°
1400°F	In-Bed	= 200°
	Above Bed	= 40°-65°
1200°F	In-Bed	= 40°-140°
	Above Bed	= 225°-315°
1050°F	In-Bed	= 225°

Steady state was never established at the turbine test section inlet during this run, and the test was terminated before inlet temperature and pressure reached design specifications. Maximum inlet temperature was just under 1300°F (700°C) and maximum pressure just under 8.6 atm. Mass flow rate through the turbine test section started at 0.82 #/sec (650 SCFM), but continually decreased to 0.68 #/sec (540 SCFM) by the end of the run.

Examination of the turbine pressure reducing station following the run indicated that the orifice plate was partly plugged with small pieces of refractory which had broken off from the spool piece connecting the turbine test section. The obstruction of the flow area accounted for the declining flow rate through the turbine test section.

100 HOUR SHAKEDOWN TEST

Preparations for a second attempt at accomplishing the 100 hour shakedown test were completed in early December. The 100 hour shakedown test (Miniplant Run No. 67) commenced on December 12 and concluded at 11 P.M. on December 16, 1977.

Illinois No. 6 coal and Pfizer 1337 dolomite were fed to the combustor at a nominal calcium to sulfur molar ratio of 1.25. An analysis of the coal combusted is presented in Table 6.

The test was made using the third stage cyclone located in the GBF pressure vessel as the tertiary cleanup device. Because of the difficulties encountered in the previous test, the granular bed filters were eliminated. Methane was injected at 5 locations in the flue gas line between the second stage cyclone and the turbine test section. This enabled the flue gas to be maintained above 1550°F at the entrance to the turbine test section.

Table 6

Coal and Sorbent Analyses

(Used in Shakedown Runs #66 and 67; Nov-Dec, 1977)

Illinois No. 6 Analysis

Sample No. →	1		2		3		Avg.	
Basis →	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry	As Rec'd	Dry
Moisture (%)	2.00	-	2.00	-	2.05	-	2.02	-
Ash (%)	10.56	10.78	10.06	10.27	8.94	9.13	9.85	10.06
Sulfur (%)	4.14	4.22	4.12	4.20	3.95	4.03	4.06	4.15
Heating Value (BTU/#)	12,353	12,605	12,425	12,679	12,580	12,843	12,453	12,709

Pfizer 1337 Dolomite Calcined Analysis

	CaO	MgO	Cl	Na	K	Fe_2O_3	SiO_2	Al_2O_3	S
Weight Percent	56.6	42.69	0.25	1800 ppm	190 ppm	1.75	0.86	2.58	0.63

The combustor was operated at an average temperature of 1700°F for the first three days, but had to be lowered the last two days to maintain 9 atm pressure. Operations had to be interrupted for several hours because of a plugging problem in the turbine pressure reducing station. During the shut down, a larger pressure control nozzle was installed to allow for increased by-pass flow around the turbine test section without an increase in the combustor pressure.

A summary of the operating conditions and gaseous emissions during this test is given in Table 5. The run can be broken down into four parts with respect to operating conditions and turbine flow rates. The first 28 hours of the run (run 67.1) represents the time from initial heat up of the unit to the first shutdown when a larger pressure control nozzle was installed. During the next 25 hours (run 67.2) steady state combustor operations were maintained. Flow through the turbine continued to decline during this part of the run as seen in Figure 17. This was the result of plugging of the pressure reducing station. The temperature at the turbine test section had to be lowered during the run to maintain a 9 atm combustor pressure. This was accomplished by ceasing methane injection into the off gas piping, and later lowering the combustor operating temperature. During this transition period of approximately 10 hours (run 67.3) the combustor temperature was lowered from 1680°F to 1607°F. Flue gas temperatures show this effect, increasing initially with unit heat up and then decreasing to a constant level after 70 hours (Figure 18). Steady state operations were maintained for the remainder of the 100 hours (run 67.4).

Turbine Test Section

The gas flow rate through the turbine section was lower than General Electric specifications during most of the run. Figure 17 shows the turbine gas flow rate dropping off during the first 50 hours of the run. The flow rate was fairly stable at 300 SCFM for the remainder of the run. Inspection of the turbine pressure reducing station following the run revealed that the inlet orifice plate was partly plugged with small pieces of refractory which had broken off from the spool piece connecting the turbine test section. Flyash adhered to the refractory pieces caught in the inlet orifice plate and eventually obstructed approximately 75% of the flow area. About 35 gm of flyash and 15 gm of stone were removed from the pressure reducing section after the run. Significant amounts of flyash were also found on some internal surfaces of the turbine test section. Approximately 150 gram of flyash was found adhered to the downstream face of the flow distributor plate. The upstream face of the plate was very clean (Figure 19). Another 130 gm of the flyash was found impinged on the conical portion of the cascade section. The particle size analysis for these samples are presented in Table 7. The turbine blade specimens used for the shakedown phase were removed, photographed and returned to GE for metallurigcal analysis.

During the shakedown test there were several intervals where the particulate loading increased. Upon microscopic examination after the test some of the airfoil leading edges displayed a knife edge erosion configuration.

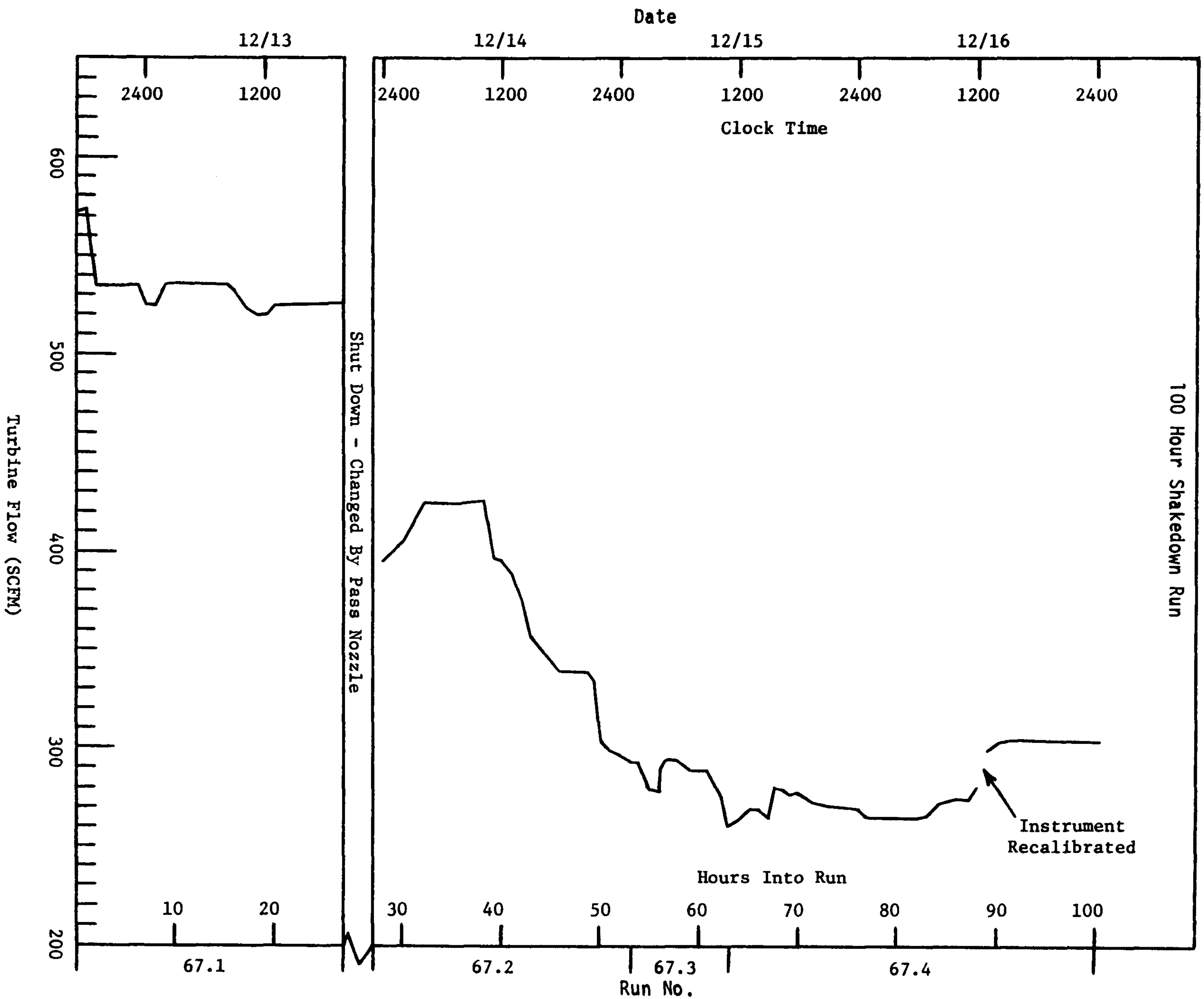


Figure 17

Turbine Test Section Gas Flow Rate

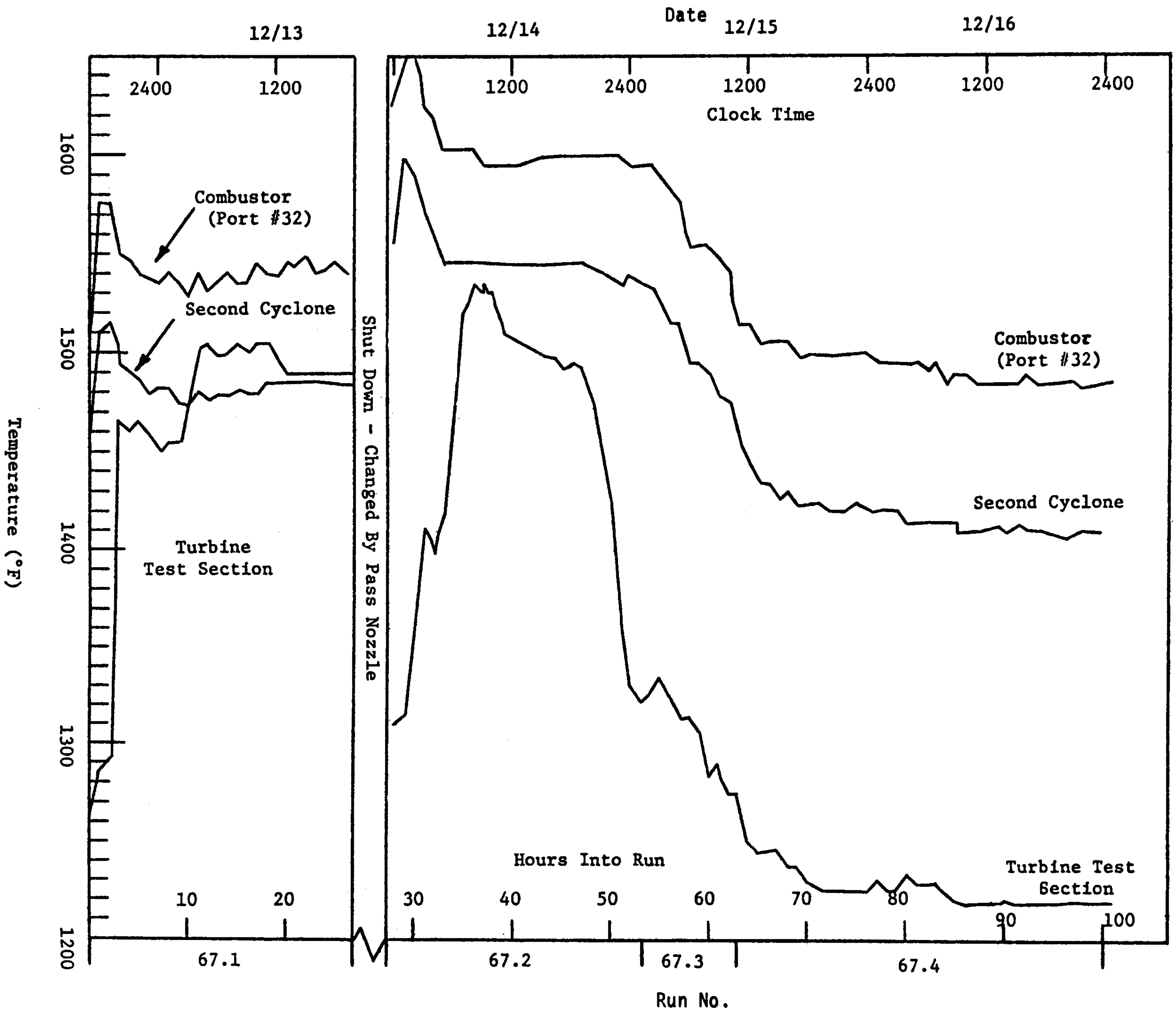


Figure 18

Flue Gas Temperature History

Shakedown

Figure 19

Turbine Test Section Flow Distributor
Plate and Conical Inlet After Shakedown (Upstream Face)

Table 7

Particulate Size Distribution

Shakedown Run

Sample	44	10	8	6	4	2	1 Microns
	Percent Finer Than						
TTS Pressure Reduction Section	85	75	67	56	36	14	5
TTS Rear of Flow Distributor	93	74	62	44	20	5	1
TTS Cascade Housing	89	69	59	46	27	7	2
Balston Filter #1 (61 Hours Into Run)	--	90	86	80	73	62	29
Cyclone #3 Dump #33	98	76	67	55	37	13	1

Views of the leading and trailing edges of the 4 turbine cascades after 100 hours of exposure appear in Appendix A, Figures A-1 to A-4. The deposition on the trailing edge can be clearly seen. Deposition was much heavier than after the first 17 hour shakedown tests.

Particulate Sampling

The flue gas particulate loading was measured throughout the run using 3 methods. As in prior runs, most of the samples were taken from an isokinetic slip stream using two Balston filters operating above the gas dew point. Three EPA Method V samples were taken from the cooled flue gas just upstream of the scrubber. Another sample was obtained using a set of 5 cyclones supplied by Southern Research Institute. All three methods consistently agreed with particulate concentrations ranging from 0.03 to 0.08 gr/SCF (Table 8). A similarly low particulate loading of 0.056 gr/SCF was measured using the Balston filters in run 66. Particle size analysis for the Balston filters collection of run 67 is presented in Table 7.

Chemical analysis of the flyash collected during the 100 hour shakedown run is listed in Table 9 according to collection point and run segment.

Table 8

Flue Gas Particulate Loading

Shakedown Run

Run #	Sampling Start Time (Hours Into Run)	Sampling Duration (hrs)	Sampling Method	Result (grains/SCF)		Result (g/m^3)
67.1	6	2	Balston Filters	0.057		0.13
	17	2	EPA Method V	0.07		0.16
	17	2	Balston Filters	0.053		0.12
67.2	30	2	Balston Filters	0.081		0.18
	41	2	Balston Filters	0.058		0.13
	43	2	EPA Method V	0.05		0.1
67.3	53	2	Balston Filters	--	(1)	--
	61	2	Balston Filters	0.066		0.15
67.4	72	13	Southern Research Cyclones	0.030	(2)	0.07
	87	3	EPA Method V	0.04		0.08

----

(1) Flue gas sample flow rate cannot be determined.
(2) Flue gas sample flow rate was lower than specified by the cyclone manufacturer.

Table 9

Run 67 - Fly Ash Chemical Analyses

Run 67.1 (Dumps)	Ca	S	SO_4	CO_3	C	Mg
2nd Cyclone (5-9)	7.3	5.39	14.01	0.45	4.69	3.1
2nd Cyclone (10-14)	7.1	5.03	16.4	0.51	4.2	3.4
3rd Cyclone (5-9)	6.7	6.05	19.85	0.03	1.26	3.9
3rd Cyclone (10-14)	6.8	6.90	20.61	0.01	1.23	4.1
Run 67.2						
2nd Cyclone (18-22)	8.4	5.26	16.37	0.84	3.43	4.3
2nd Cyclone (23-27)	8.4	5.44	17.68	0.49	3.66	4.2
3rd Cyclone (18-22)	6.9	8.02	23.29	0.13	2.26	3.5
3rd Cyclone (23-27)	6.8	6.19	18.64	0.08	1.16	3.4
Run 67.3						
2nd Cyclone (28-32)	7.3	4.99	15.34	0.51	4.01	3.6
3rd Cyclone (28-32)	6.1	8.02	21.53	0.21	0.40	3.6
Run 67.4						
2nd Cyclone (42-46)	4.3	5.17	15.66	0.49	4.78	2.1
2nd Cyclone (47-51)	6.9	5.78	16.19	0.48	4.53	3.4
3rd Cyclone (41-45)	6.7	9.3	28.78	0.09	1.06	5.0
3rd Cyclone (46-50)	6.9	8.78	28.29	0.04	1.15	4.9

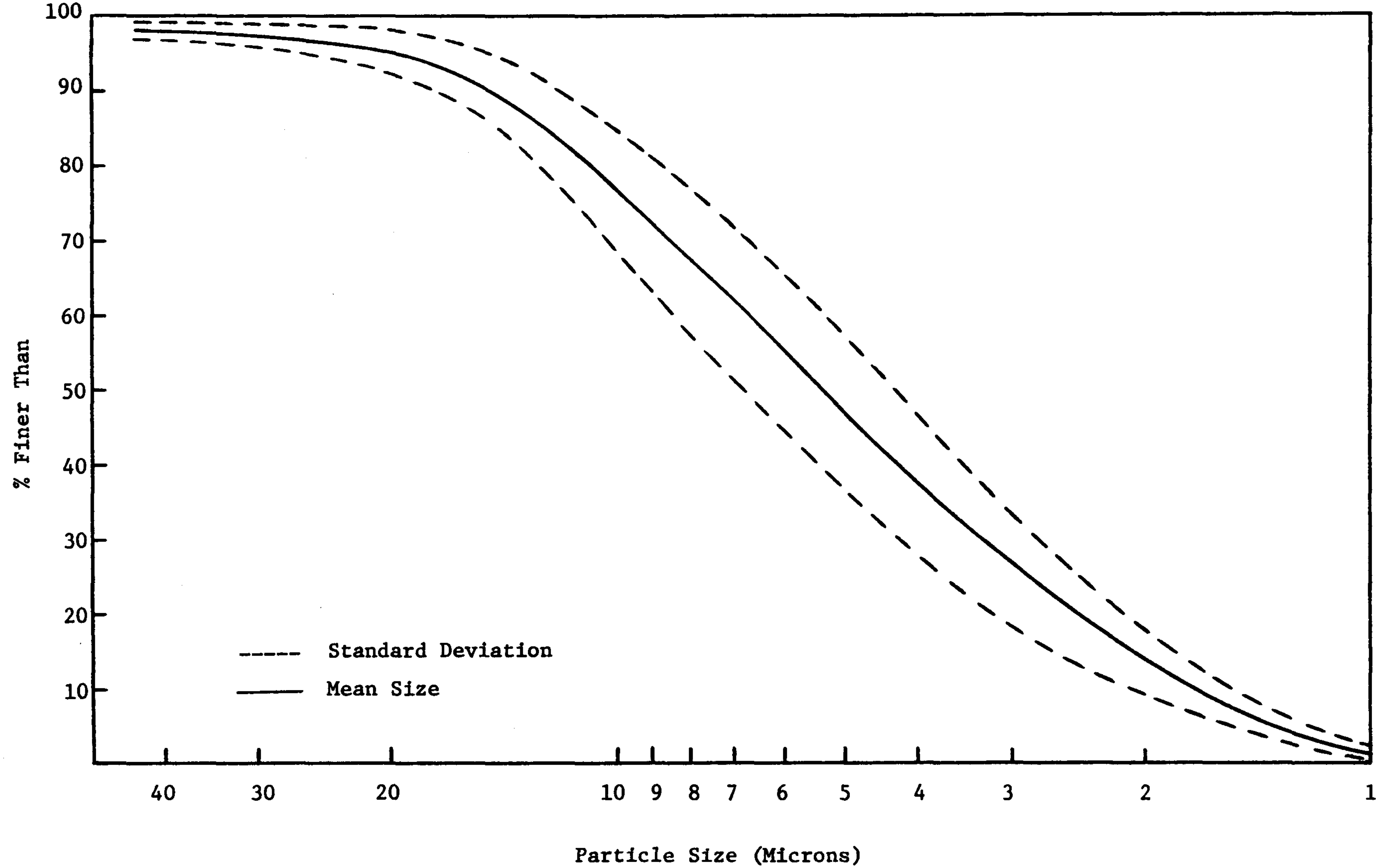
The particle size distribution of particulates captured by the third stage cyclone during the 100-hour shakedown run (run 67) is shown in Figure 20. The solid line represents the mean size distribution of 8 cyclone lock hopper dumps. The dashed line represents the standard deviation. The mean particle size distribution is consistent with calculated values for a conventional cyclone with those dimensions. The standard deviation is approximately ± 10%, and probably represents the limit of accuracy of the current particle size analysis technique; this consists of a wet sieving with a 325 US mesh (44 μm) screen. The minus 325 mesh is then used for Coulter Counter analysis.

Heat Exchanger Probes

All 21 heat exchanger probes exhibited excellent temperature control throughout the run. However, the above bed 1600°F probes were somewhat cooler than desired in the later part of the run because the combustor environment was at a slightly lower temperature than the control point.

Figure 20

Run 67 Tertiary Cyclone Captured Particulates
Mean Particle Size Distribution



Temperature data for the twenty-one (21) heat exchanger probes exposed during the 100 hour shakedown run are presented in Appendix Table A-1. Temperatures at two locations in each probe were recorded every 10 minutes for the first 25 hours; the time interval was increased to every 20 minutes for the remainder of the 100 hour run. In these tables the recorded temperatures have been averaged for five (5) hour segments of the run. Also listed are the standard deviations for that time period as well as the maximum and minimum temperatures experienced by the specimen material during those five (5) hours.

This collated temperature data of the heat exchanger probes generally reveals excellent temperature control of the individual specimens. Based on this data at steady combustor conditions 40% of the individual specimens would not experience a temperature span greater than 20°F; 70% not greater than a 30°F span, and 100% not greater than a 60°F span. During steady state periods more than 75 percent of the specimens were maintained within a 20°F temperature range.

Appendix figures A-5 through A-11 are typical time-temperature histories of the different specimen probes controlled at the four (4) specified temperatures. The figures are as follows:

Figure 5	Probe 1	1600°F	In Bed
Figure 6	Probe 13	1600°F	Above Bed
Figure 7	Probe 6	1400°F	In Bed
Figure 8	Probe 14	1400°F	Above Bed
Figure 9	Probe 11	1200°F	In Bed
Figure 10	Probe 20	1200°F	Above Bed
Figure 11	Probe 8	1050°F	In Bed

As seen in these figures, temperature gradients throughout the length of the probe, i.e., from "inner" to "outer" specimen, exist even after extended exposure times. ("Inner" refers to the tube specimen nearest the center of the combustor.) The mean temperature of two specimens on a probe characteristically differed by the an average of 20° to 180°F. In this run temperature control of the probe was maintained so as to prevent either of the two specimens from exceeding the designated temperature.

The heat exchanger probes have been photographed in groups of three (3) according to their operating temperatures and location in the combustor. These photographs are presented in the appendix, Figures A-12 through A-18.

V. PFBC EXPOSURE TEST RESULTS

TEST SUMMARY

The 1000 hour exposure test was completed in several segments between June 1978 and June 1979. The longest continuous run was 250 hours. Other runs were between 217 and 100 hours in duration. A chronological summary of the PFBC hot corrosion/erosion testing is presented in Table 10. During the 5 runs that comprise the 1000 hour test run conditions were acceptably steady. Many flue gas, particulate, coal and sorbent samples were taken. Most of these samples were analyzed and are included in the run summaries in Table 11.

Run 78 was the first run of the 1000 hour exposure test. This run marked the longest continuous operation of the miniplant - 250 hours. The combustor was operated at an average temperature of 1700°F throughout the 11 day period, and at a constant 9 atm pressure. Operations had to be interrupted several times due to coal feeding problems caused by line erosion. The total lost time after the unit was lined out was 6 hours. Run conditions were well controlled during the test with mass flow and temperature in the gas turbine test section reasonably steady. The turbine test section flow rate averaged 720 SCFM. Natural gas injection at 5 locations in the flue gas line between the second stage cyclone and the turbine test section maintained the flue gas above 1580°F before entering the test section. Flue gas temperature profiles at three times in the run are shown in Figure 21. Examination of the flue gas piping following the run revealed a large accumulation of flyash around thermocouple No. 5, resulting in an erroneous gas temperature reading. The thermocouple had become so inbedded in the deposits that it became isolated from the gas stream and was indicating a low temperature. Historical data indicated that the temperature drop across the 2nd cyclone is approximately 25°F. This temperature drop was used to correct the temperature profile. The corrected profile is shown in Figure 21. Correcting for this temperature measurement error, it would take approximately 40 hours before all points in the system were at a minimum of 1550°F. A graph of the combustor temperature at various times during the run is shown in Figure 22. The large temperature drop near the top of the combustor noticed during shakedown was eliminated with the removal of miniplant cooling coil 3B.

Run 78 was broken down into 10 parts to facilitate the data handling process. Illinois No. 6 coal and Pfizer No. 1337 dolomite were used in this run at a nominal calcium to sulfur molar feed ratio of 1.45. The SO_2 retention levels in the run averaged about 90%. This exceeds slightly the latest new source performance standard of 85% SO_2 removal specified by the EPA. During run 78, SO_2 emissions fluctuated more than expected. The variations in gas residence time and problems with the flue gas sampling system were responsible for most of the variations observed.

Table 10

PFBC Miniplant
Hot Corrosion/Erosion Testing Summary

Test Dates	Run No.	Run Length (Hours)	Cumulative Run Time (Hours)	Remarks
November 29, 1977	66	17	17	Shakedown - 1st Attempt
December 12-16, 1977	67	100	117	Shakedown Completed
June 19-30, 1978	78	250	250	Specimens Removed & Inspected
July 31 - August 5	79	100	350	
September 13-22	80	215	565	Specimens Removed & Inspected
October 9-16	81	170	735	Specimens Removed & Inspected No deposits on turbine blades
May 29 - June 10, 1979	106	265	1000	Five hour interval of high particulate loading (plugged cyclone) Exposure testing completed. All specimens removed for metallurgical analysis.

Table 11

Miniplant Operating Conditions and Emissions

Nominal Operating Conditions	Run 78.1	78.2	78.3	78.4	78.5	78.6	78.7	78.8	78.9	78.10
Date (1978)	6/19-6/20	6/21	6/22	6/23	6/24	6/25	6/26	6/27	6/28	6/29-6/30
Run Length (hrs)	25	25	25	25	25	25	25	25	25	25
Pressure (psig)	120	120	120	120	120	120	120	120	120	120
Temperature (°F)	1640	1660	1670	1680	1690	1710	1720	1720	1720	1720
Superficial Velocity (ft/sec)	5.9	6.0	6.0	6.0	6.1	6.1	5.8	6.2	5.8	5.9
Expanded Bed Height (ft)	12.4	11.6	9.4	11.2	10.2	10.9	10.7	9.4	9.5	12.4
Excess Air %	34	25	23	21	15	25	15	15	15	34
Coal Feed Rate (lb/hr)	224	266	261	270	245	290	292	288	288	288
Nominal Ca/S Molar Feed Ratio	1.25	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
<u>Flue Gas Emissions</u>										
SO_2 (ppm)	286	231	169	157	460	270	113	363	260	286
NO_x (ppm)	45	38	41	42	37	32	28	41	36	15
CO (ppm)*	679	679	613	655	644	667	590	724	596	679
CO_2 (%)	12.5	14.0	13.7	14.3	14.3	15.3	14.0	15.6	16.0	12.5
O_2 (%)	5.5	4.2	4.0	3.7	2.8	4.3	3.2	3.2	2.8	5.5
SO_3 (ppm by wet chemistry)	0.6	--	9.9	--	--	--	12.8	--	--	0.4

---

* CO analyzer appeared to be malfunctioning, reported levels may be high.

Table 11 (Cont'd)

Miniplant Operating Conditions and Emissions

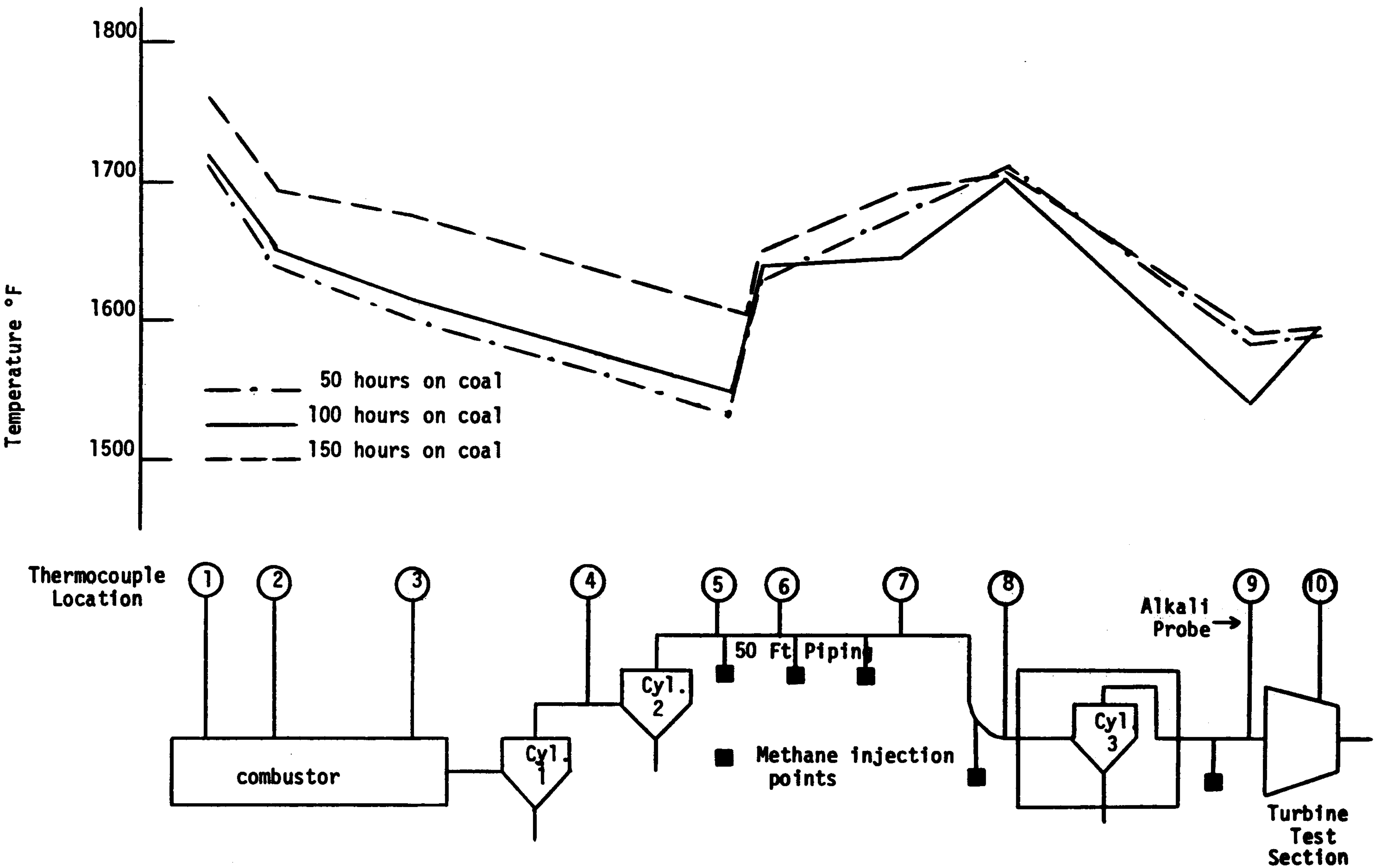
Nominal Operating Conditions	Run 79	80.1	80.2	81	106.1	106.2	106.3
Date	7/31-8/4/78	9/13-16/78	9/16-22/78	10/9-16/78	5/29/79	5/31	6/2-10/79
Run Length (hrs)	100	100	115	170	43	5	217
Pressure (psig)	120	119	119	119	116	116	117
Temperature (°F)	1717	1704	1670	1710	--	--	--
Superficial Velocity (ft/sec)	6.2	5.8	5.8	5.9	5.61	5.31	5.38
Expanded Bed Height (ft)	10.1	12.7	7.0	N.A.	7.90	10.66	10.00
Excess Air %	24	27	18	25-30	15.6	5.8	9.0
Coal Feed Rate (lb/hr)	290	359	370	250	306	318	316
Nominal Ca/S Molar Feed Ratio	1.45	1.41	1.41	1.45	1.45-1.20	1.20	1.25
Flue Gas Emissions							
SO_2 (ppm)	293	217	152	250-325	21.4	37.8	91.4
NO_x (ppm)	56	78	121	40-130	47.5	42.4	64.1
CO (ppm)*	--	--	--	--	332	507	540
CO_2 (%)	14.6	13.0	12.4	13	14.8	16.4	13.4
O_2 (%)	4.2	5.0	3.5	4.5-5.0	4.1	2.1	3.1
SO_2 (ppm by wet chemistry)							
SO_3 (average ppm)	~6.0	~3.0	~0.0				

N.A. = Data Not Available

* CO analyzer malfunctioned.

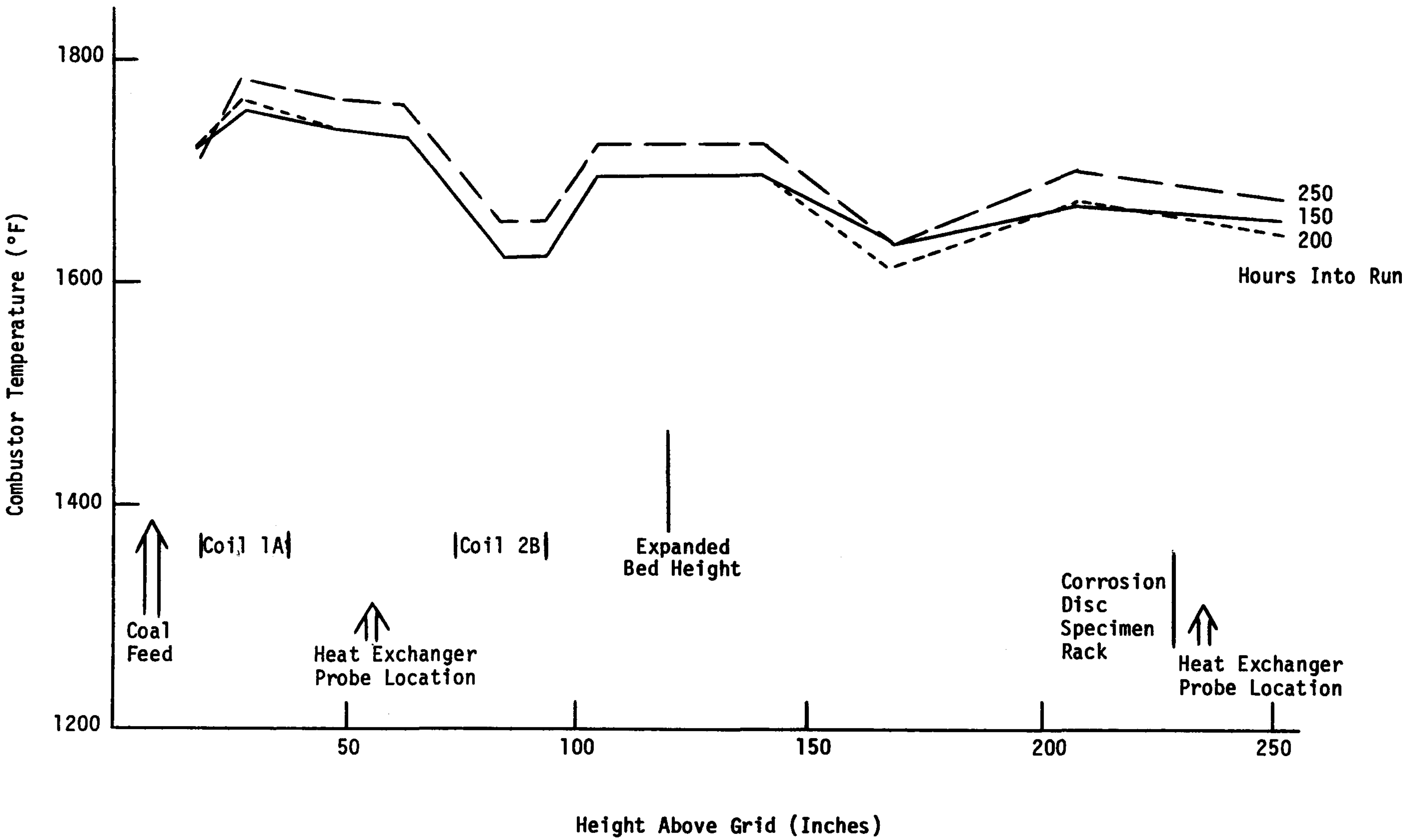
Figure 21

Flue Gas Temperature History - Run 78



<u>Figure 22</u>

<u>Miniplant Run 78: Combustor Temperature Profile</u>



The change in gas residence time resulted from a drift in bed height during the run. This accounted for many of the perturbations in SO_2 emissions. Operating problems with the flue gas sampling system accounted for the remaining variations. These operating problems were caused by gas dryer leakage and water condensation in the sampling line. When these problems occurred, SO_2 measurements were backed up with wet chemistry analysis which confirmed the steadier SO_2 emission measurements which were obtained during routine periods.

Several analyses of the coal combusted during run 78 showed an average moisture content of 13%. This was the first time that coal with such a high moisture content was fed into the combustor, and surprisingly, did not present any feeding problems. The coal had been screened to remove the -50 mesh fines and this undoubtedly helped avoid feeding problems. Chemical and particle size analyses of the coal and dolomite used in this and all subsequent runs is presented in Tables 12, 13 and 14.

General Electric and Westinghouse inspected their specimens after this run. As per the test plan, several turbine blade specimens and several boiler tube specimens were replaced at the conclusion of this run. All of the specimens removed appeared to be in good condition. No visible signs of corrosion or erosion were present.

Run 79 was the second segment of the materials corrosion test program. It commenced on July 31, 1978 and was terminated after 100 hours of operation because of a plug in the solids discharge line from the first (recycle) cyclone. The system was shut down in anticipation of an increased grain loading resulting from the plug which disabled the first cyclone. General Electric and Westinghouse did not inspect the specimens following this run.

Run conditions were well controlled during the test. Mass flow rate and temperature in the turbine test section were reasonably steady. Temperature at the turbine test section was maintained at approximately 1600°F throughout the run while the turbine flow rate averaged 685 SCFM. The combustor was operated at an average temperature of 1715°F throughout the 5 day period, and at a constant 9 atm pressure. Flue gas temperature profiles during this miniplant run are shown in Figure 23.

Illinois No. 6 coal and Pfizer No. 1337 dolomite were used in this run at a nominal calcium to sulfur molar feed ratio of 1.45; SO_2 retention levels averaged about 90%. Chemical analysis of the coal and dolomite used in this run is presented in Table 12.

The third segment of the test program, Miniplant run 80, was voluntarily terminated after 215 hours of successful operation. This brought the total exposure time for the gas turbine specimens to 565 hours. Superficial inspection of the turbine blade specimens again showed no signs of erosion or corrosion. All the heat exchanger probes looked satisfactory except for one in port no. 6 which showed signs of considerable wastage.

Table 12

Coal and Sorbent Analyses

Condition →	Illinois Coal No. 6 Analysis					
	78.1		78.2-78.10		79	
Basis →	As Received	Dry	As Received	Dry	As Received	Dry
Volatile Matter, %	39.95	41.25	37.57	43.04	37.71	43.10
Fixed Carbon, %	45.32	46.80	40.74	46.73	41.81	47.78
Moisture, %	3.16	--	12.82	--	12.5	--
Ash, %	11.57	11.95	8.88	10.19	7.98	9.12
Total Carbon, %	65.58	67.65	57.76	65.16	60.63	68.21
Hydrogen, %	5.63	5.81	5.02	5.66	5.48	6.17
Sulfur, %	4.17	4.31	3.52	4.04	3.33	3.81
Nitrogen, %	2.41	2.49	2.26	2.55	1.17	1.32
Oxygen, %	7.55	7.79	11.00	12.41	10.11	11.37
Heating Value, BTU/lb.	12,042	12,435	10,988	12,604	11,043	12,620

Table 12 (Cont'd)

Coal and Sorbent Analyses

	Illinois Coal No. 6 Analysis					
Condition →	80.1-80.2		81		106	
Basis →	As Received	Dry	As Received	Dry	As Received	Dry
Volatile Matter, %	38.72	42.44	36.98	42.46	37.10	41.85
Fixed Carbon, %	39.88	48.20	42.0	48.22	43.65	49.25
Moisture, %	12.86	--	12.9	--	11.36	--
Ash, %	8.54	9.36	8.12	9.33	7.89	8.90
Total Carbon, %	67.67	58.97	58.81	67.52	67.39	75.04
Hydrogen, %	5.81	5.06	4.78	5.49	5.10	5.68
Sulfur, %	3.53	3.87	3.37	3.87	3.52	3.97
Nitrogen, %	1.29	1.12	1.09	1.25	1.33	1.48
Oxygen, %	11.99	10.45	10.94	12.56	4.43	4.93
Heating Value, BTU/lb.	11,528	12,631	10,892	12,505	11,969	12,374

Table 13

Coal Particle Size Distribution

U.S. Sieve #	50	40	30	25	20	8
	% Finer Than					
Run 78.1	0.5	2.7	18.2	27.7	40.5	99.7
Run 106	0.5	2.8	10.1	13.5	20.5	99.7

Table 14

Pfizer 1337 Dolomite Calcined Analysis Run 79

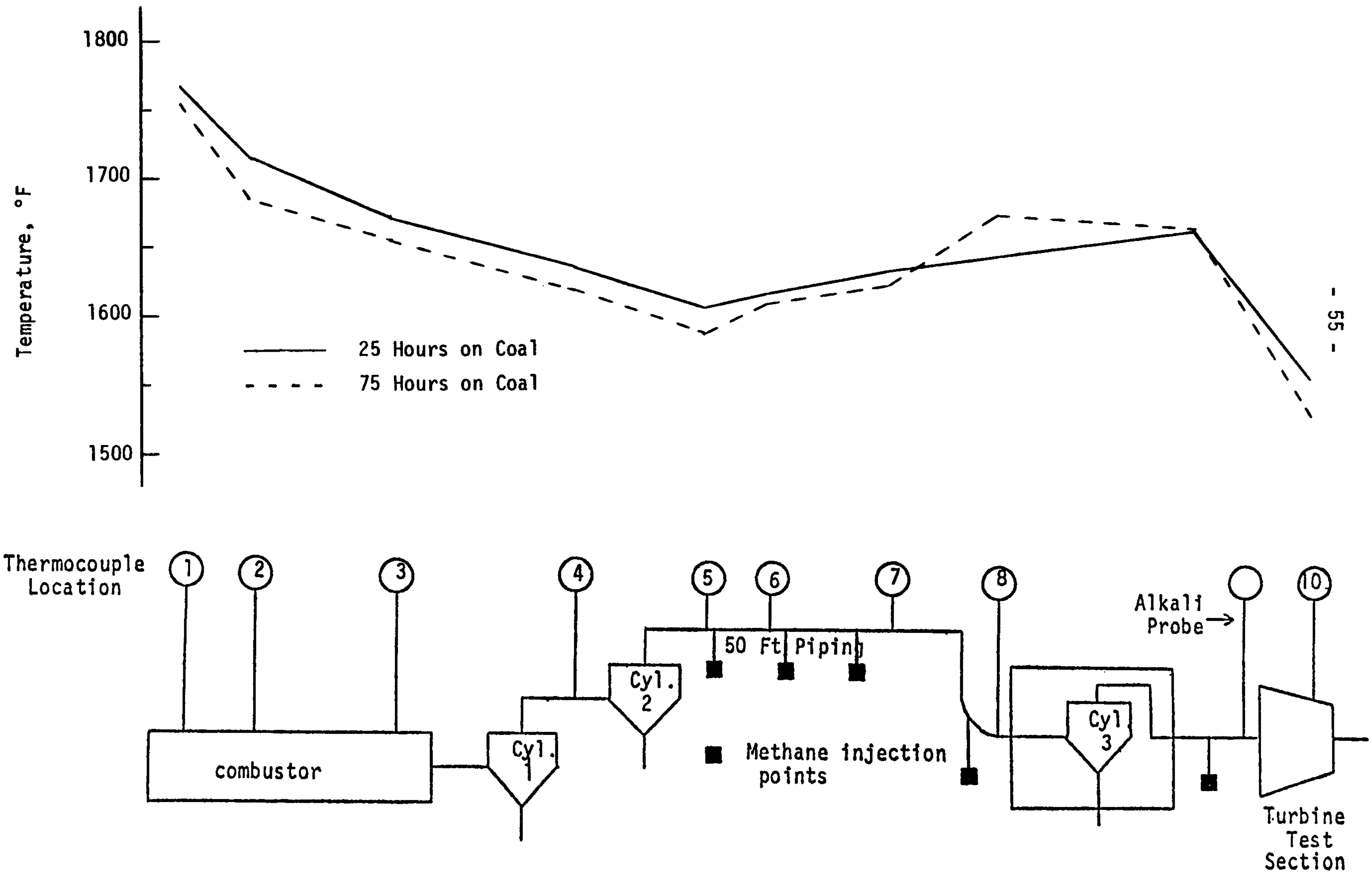
Run	CaO	MgO	Cl	Na	K	Fe_2O_3	SiO_2	Al_2O_3	S
				Weight %					
78.1-78.3	56.60	42.69	0.25	1800 ppm	190 ppm	1.75	0.86	2.58	0.63
78.4-79	55.31	44.10	0.09	325 ppm	439 ppm	0.23	0.82	0.32	0.17
80-81	61.33	37.96	0.09	1030 ppm	<400 ppm	0.27	0.36	0.21	0.12
106	55.78	37.04	0.09	300 ppm	100 ppm	0.23	0.59	0.45	0.003

Particle Size Distribution

U.S. Sieve #	25	20	18	16	12	8
	% Finer Than					
Run 78.4	0.5	0.7	1.5	21.5	38.2	92.2

Figure 23

Run 79: Flue Gas Temperature History



Temperatures at the turbine test section inlet ranged from 1570°F to 1620°F throughout the run. Flue gas temperature profiles for the miniplant are shown in Figure 24. The run had to be interrupted for 2 hours at the 82 hour mark to replace a leaking lock hopper valve. After the interruption, the turbine flow rate dropped by 12% from the previous level of 690 SCFM to 620 SCFM.

Examination of the flue gas piping following the run revealed a large accumulation of particulates at the entrance to the turbine test section, apparently caused by the formation of condensate during the shutdown and subsequent startup.

The fourth segment of the PFBC hot corrosion/erosion testing program terminated after 170 hours of successful operation. This run (#81) brought the total hours of miniplant exposure testing to 735 hours, exclusive of the shakedown runs. Run conditions were well controlled during the test with mass flow rate and temperature in the turbine test section reasonably steady. Temperature at the turbine test section (Figure 25) was maintained at approximately 1560°F throughout the run while the turbine flow averaged 700 SCFM. The turbine test inlet temperature was slightly lower than during prior tests. This is due mainly to the greater heat loss experienced in the cold weather (October). A longer time period was required to reach thermal equilibrium, however the gas was at or near 1550°F for most (60+%) of the run.

The final segment of the exposure tests (run 106) was completed on June 10, 1979. Run #106 started under operating conditions similar to those employed in the previous test (run #81). Combustor temperatures were approximately 1715°F and very uniform and the pressure was 9 atmospheres. What differed was that the elutriation rates and cyclone collections, both second and third, were unusually high at the start of the run. That may have been due to the old bed material used at the start of the run, which was more friable than new material. The particulate loadings a at the turbine test section were slightly higher than usual 0.03 to 0.08 gr/SCF, compared to the 0.025 to 0.035 values obtained in recent runs. After 41 hours of operation, the grain loading from the third stage cyclone increased to approximately 0.46 gr/SCF. Because of this, the run was terminated after 48 hours and the cyclones and turbine blades were examined. Based on cyclone lock hopper collections and particulate measurements, it was concluded that the turbine blade specimens were exposed to these high particulate concentrations for not longer than 7 hours, and most probably 5 to 6 hours. Inspection of the third stage cyclone found that it was almost fully blocked - both in the barrel and in the inlet transition piece - by caked, easily removed, flyash fines.

During the shutdown, the turbine test section was dismantled and inspected and two blades removed and replaced. The test section was reassembled. The run resumed and progressed smoothly until a voluntary

Figure 24

Run 80: Flue Gas Temperature History

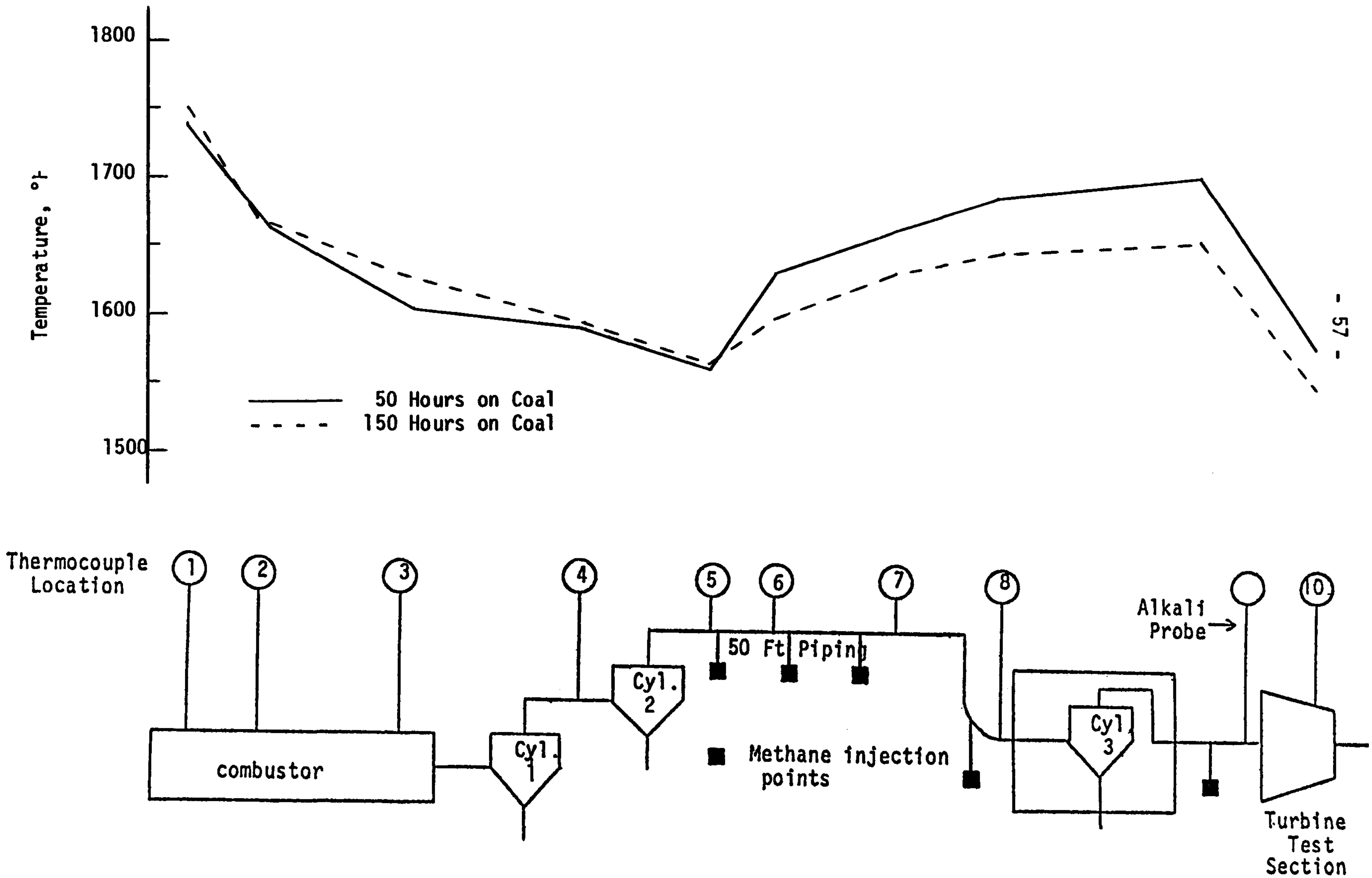
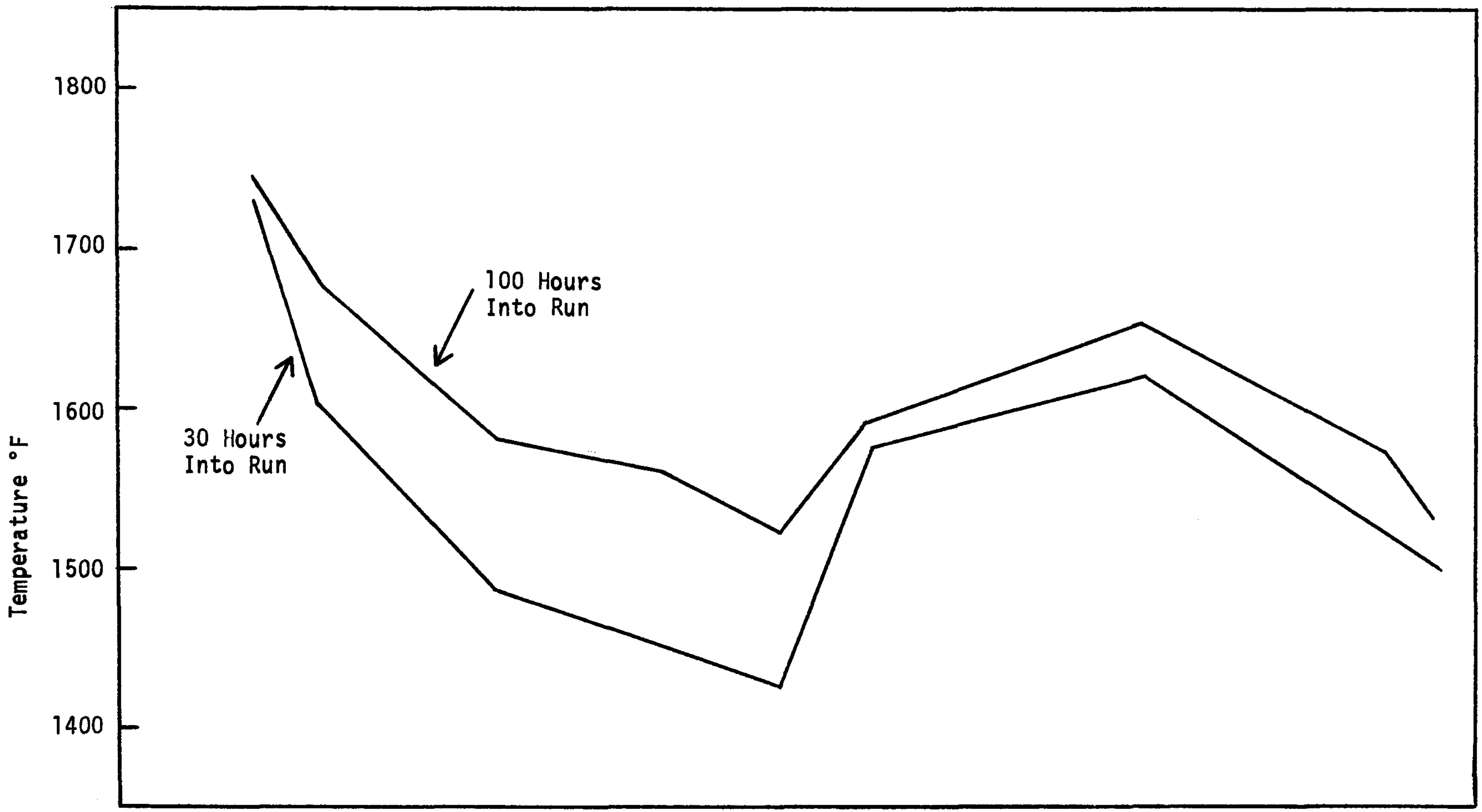
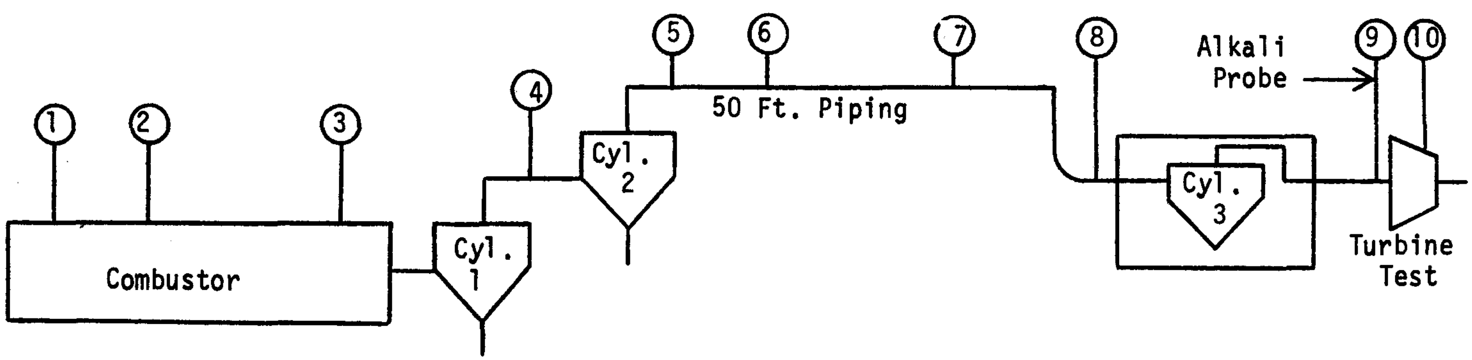


Figure 25

Run 81 Flue Gas Temperature History





shutdown after a total of 265 hours. Turbine flow remained the same throughout the run at ~630 SCFM. The temperature of the flue gas at various points also did not change (Figure 26).

One unusual aspect of this run was the much higher than expected SO_2 retention. The low SO_2 emissions (high retention) during the first segment of the run can be explained in part by the high elutriation rate. This would increase the gas residence time as well as the sorbent utilization. During the initial segment of the run the Ca/S was reduced from 1.45 to 1.25 to increase the SO_2 emissions. The feed was not changed during the shutdown. After the restart, when elutriation rates were normal, SO_2 emissions were still much lower than expected. The sulfur retention remained at or above 97% for the entire run. The reason for this is not known.

FLUE GAS EMISSIONS

The flue gas from the Miniplant is continuously analyzed for O_2, NO_x, CO, CO_2 and SO_2 with standard IR and UV gas analyzers. During long operations of the Miniplant, the analyzers are calibrated at least once per day. During the 1000 hour exposure tests, the on-line analyzers were also randomly compared to other analyzers normally used in the bench unit, as well as with gas chromatography or wet chemistry samples. The results of these various methods are shown in Table 15.

During the corrosion testing flue gas emissions were continuously monitored and averaged over periods reported in the prior section. In general the SO_2 emission of 260 ppm represented a very high reduction level comparable to the 90% reduction standard proposed by the EPA. During the last 265 hours of exposure retention levels were 98% (90 ppm SO_2 emission). The reason for this high retention is still unclear. The NO_x emission throughout the 1000 hours was 35-50 ppm. Mostly the flue gas consisted of 14% CO_2, and 5% O_2 throughout the series of tests.

Some components of the flue gas are only sampled in a batch wise manner. These include flue gas alkali as well as particulates. The alkali measurement train described in an earlier section has been used to take several samples just upstream of the turbine test section. The breakdown of where in the train the various amounts of alkali were detected is shown in Table 16. The test temperatures are shown in Figure 14.

The four good samples for Na, K, and Cl emissions were fairly consistent. During runs 78, 79 and 80, 1.8 to 3.2 ppmw Na, 0.3 to 0.5 ppmw K and 47 to 54 ppmw Cl were found in the flue gas. Most of the Na and K collected in the alkali probe train was found in particulates collected at low temperature (230°C) on the Balston filter. More K did condense on the front screen during runs 78 and 80 than during run 79. No difference was observed for the Na vapor. The Cl collected in the train was found only in the knock out condensate.

Figure 26

Run 106 Flue Gas Temperature History

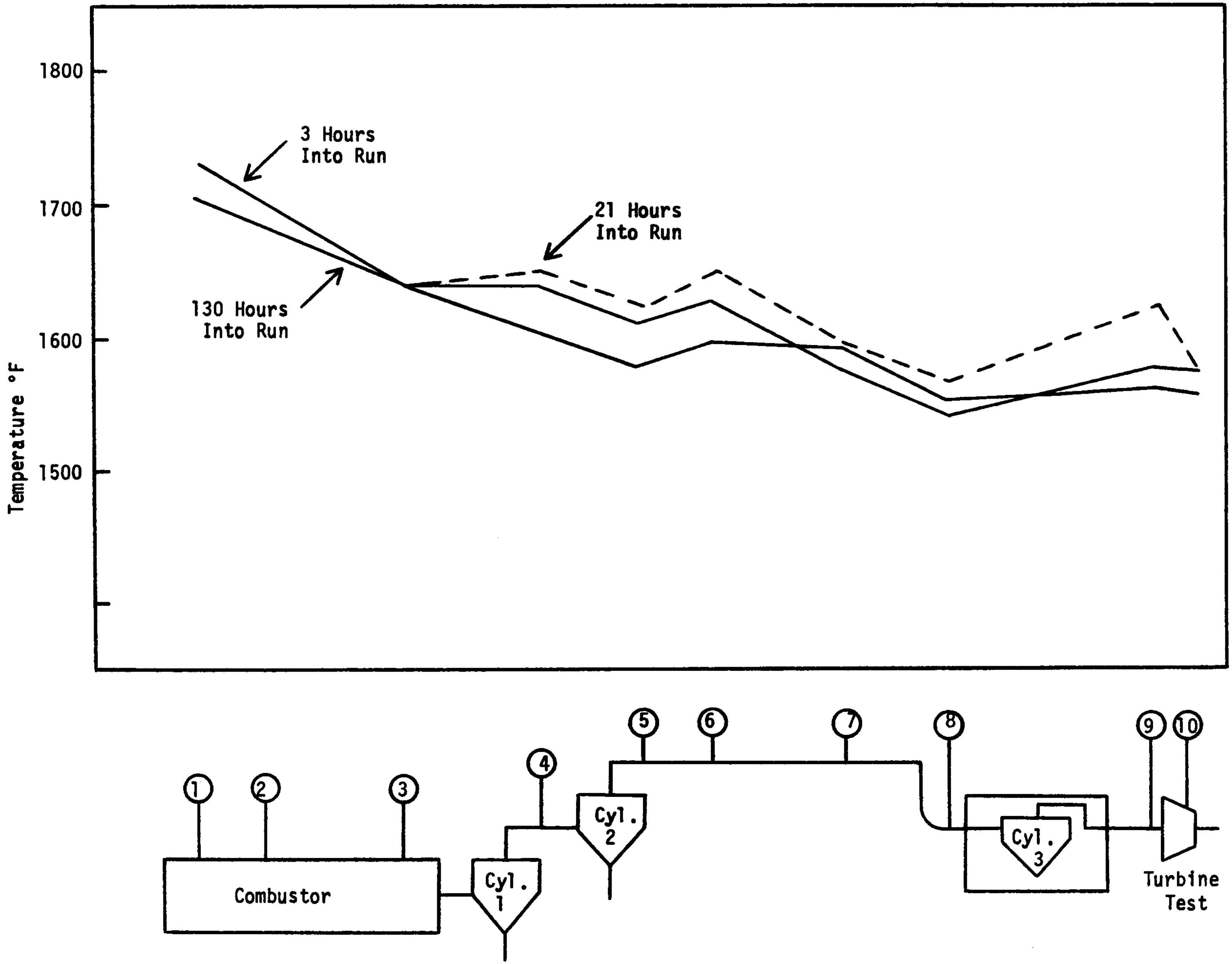


Table 15

Flue Gas Emissions During Run 81

Date (1978)	Time	Analysis	NO ppm	CO_2 %	CO ppm	O_2 Teledyne %	O_2 Beckman %	SO_2 ppm	SO_3 ppm
10-09	11:20-12:00	Miniplant	115	10	---	---	9	50-600+	---
		Bench Unit	120	13	525	6.5	---	80-400	---
10-09	13:00-13:30	Miniplant	---	11	---	---	7.7	240	---
		Bench Unit	140	13	30	5.2	---	240	---
10-12	09:20-10:20	Miniplant	---	--	---	---	---	322	---
		Wet Chem.(a)	---	--	---	---	---	324	7
10-12	11:30-12:00	Miniplant	120	13.5	---	5	5	270	---
		Bench Unit	138	13	30	5	---	280	---

Gas Chromatographic Analyses of Flue Gas During Run 78.3

Date (1978)	S Analyses of Dry Flue Gas				Hydrocarbon Analyses of Wet Flue Gas		
	SO_2 ppm	H_2S ppm	COS ppm	CS_2 ppm	CH_4 ppm	C_2H_6 ppm	C_3 to C_6 ppm
06-22	117	1	N.D.	N.D.	18	14	N.D.

(a) Controlled condensation method for SO_3; EPA method 8 for SO_2.

N.D. = Not Detected

Table 16

Na and K Emissions in Flue Gas
Alkali Probe Test - Runs 79 and 80

Alkali Train Location	Run 78		Run 79.1		Run 79.2		Run 80	
	Wt. % K Collected	Wt. % Na Collected	Wt. % K Collected	Wt. % Na Collected	Wt. % K Collected	Wt. % Na Collected	Wt. % K Collected	Wt. % Na Collected
Front Filter (Including Particulates)	36.8	6.8	5	1	6	1	13	1
Quartz Tube	3.2	0.7	14	2	8	2	30	2
Balston Filter Particulates	59.0	88.6	80	96	83	95	52	94
Knock Out Solution	1.0	3.9	1	1	3	2	5	3
ppmw in Flue Gas	0.54	2.06	0.28	1.84	0.38	3.23	0.32	2.88

PARTICULATE LOADING

Particulate loadings were carefully monitored throughout the 1000 hours of testing. Samples were taken with both particulate sampling systems described in an earlier section. A listing of all samples as well as all particle size distributions is in Appendix B. A summary of the particulate loadings is shown in Figure 27. Another summary of the size distribution limit (90% vol. finer than) is shown in Figure 28. Summaries of particulate in 5 principal size ranges at the outlet of the recycle cyclone and the two cleanup cyclones are shown in Tables 17, 18 and 19. The gas which exits the third cyclone is expanded through the turbine test section.

Particulate loadings for run 78 ranged from 0.014 to 0.056 gr/SCF (32 to 128 mg/m^3). Samples were taken both at high pressure upstream of the turbine test section and at low pressure downstream of the turbine test section. The samples from both locations were fairly well in agreement. The volume mean size of particulates captured by both sampling systems was 2 μ.

A routine cleaning and inspection of the third cyclone following run 78 revealed a thermal stress failure (hole) in the dipleg just before it exits the granular bed filter vessel. This failure was due to thermal stresses of expansion and contraction during the intermittent operations of the miniplant. The dipleg was repaired and a section of flexible tube was inserted in the system to allow for thermal expansion. The hole in the dipleg was small, but it may have allowed a very small stream of particulate rich gas to mix with the clean gas and thereby increased the loadings.

During run 79 only three particulate samples were taken. The loadings were unusually low, possibly due to the thorough cleaning and repair that the tertiary cyclone underwent just prior to the run. The average particle loading was 0.012 gr/SCF. This is the lowest sustained particulate loading average ever achieved in the miniplant. Near the end of the run particulate loadings increased. This was due to the plugging of the primary (recycle) cyclone. The run was terminated a few hours ahead of schedule to prevent possible damage to the turbine test section.

During run 80 particulate measurements were again taken with Balston total filters at the 2 sampling locations -- upstream and downstream of the GE turbine test section. Particulate loadings were consistently between 0.014 and 0.028 gr/SCF (33 and 55 mg/Nm^3) throughout the run. The material captured after the turbine had an average particle size of 0.92 μm whereas that captured before the turbine had an average size of 1.1 μm. The particulates collected during run 80 were generally finer than those collected during prior runs at similar conditions with the Illinois No. 6 coal. The reason for this discrepancy is not known.

Figure 27

Hot Corrosion Runs Particulate Loading Summary

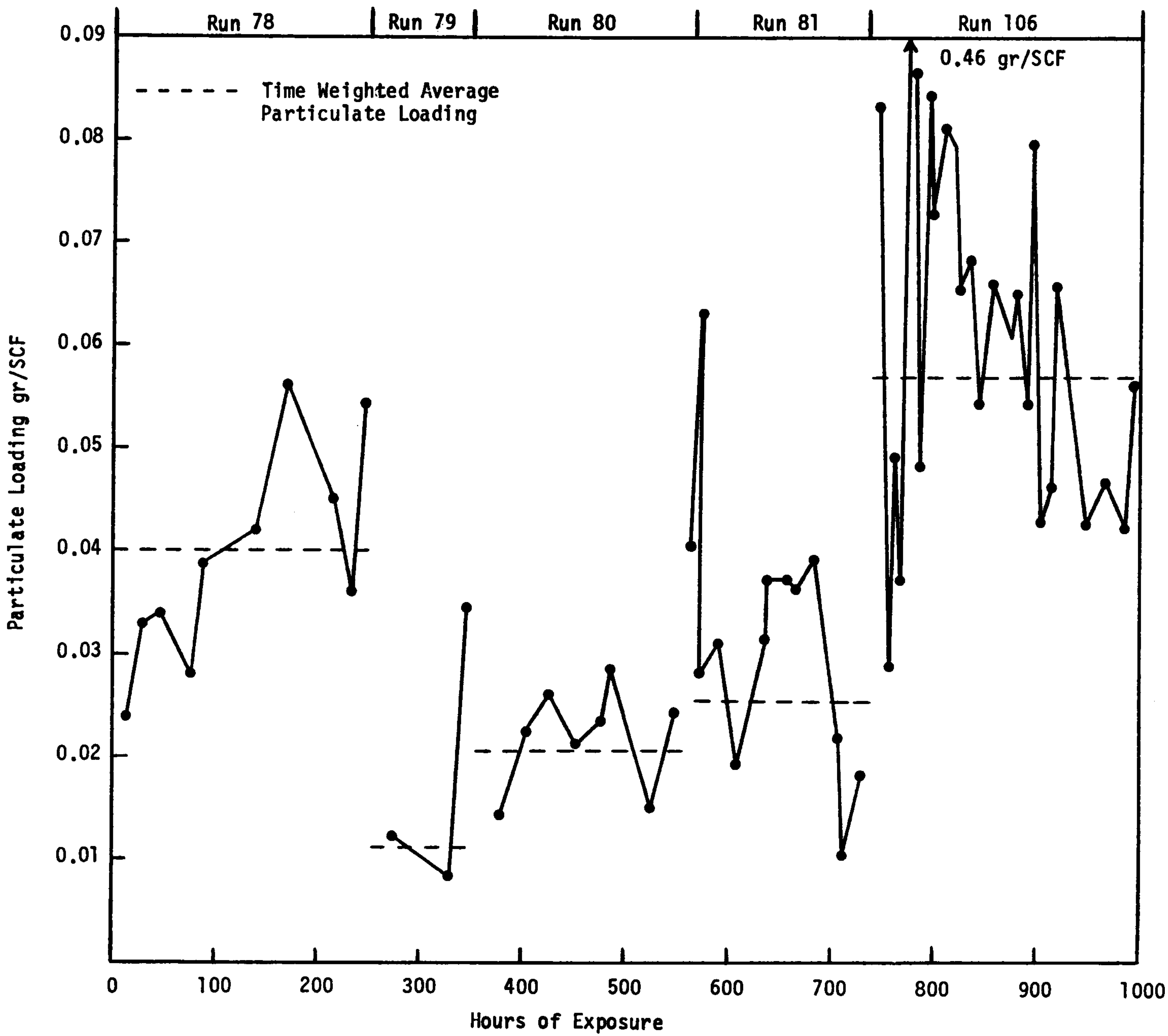


Figure 28

Particulate Size Limit Summary

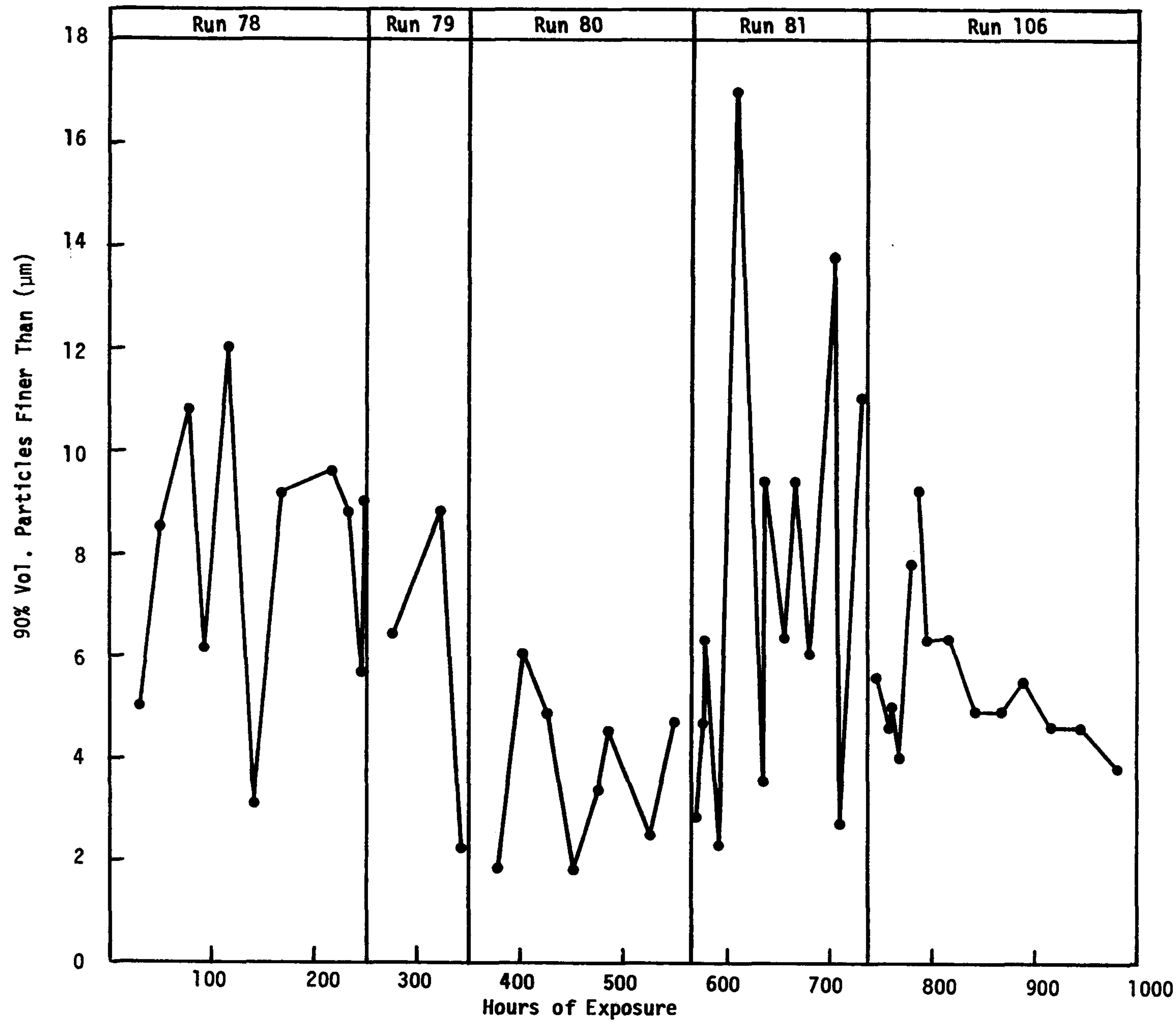


Table 17

First Cyclone Gas Outlet Particulate Concentration Summary

Run No.	0-5 µm gr/SCF	0-5 µm %	5-10 µm gr/SCF	5-10 µm %	10-20 µm gr/SCF	10-20 µm %	20-40 µm gr/SCF	20-40 µm %	> 40 µm gr/SCF	> 40 µm %	Total Loading gr/SCF
78.4	0.51	10.0	1.08	21.4	1.62	31.9	0.63	12.5	1.22	24.2	5.06
78.7	0.32	4.9	0.90	13.7	1.83	27.8	0.93	14.1	2.60	39.5	6.58
78.10	0.60	10.4	1.25	21.7	1.89	32.6	0.45	7.9	1.59	27.5	5.79
79	0.31	3.9	0.75	9.5	2.08	26.4	1.37	17.4	3.37	42.9	7.87
80.2	0.25	5.7	0.62	13.7	1.24	27.6	0.73	16.3	1.66	36.8	4.50
81	0.49	8.1	0.71	11.7	1.24	20.5	0.34	5.6	3.28	54.1	6.07
106.1	2.06	17.7	2.65	22.8	3.14	27.0	1.64	14.1	2.13	18.3	11.62
10.63	0.53	8.1	1.01	15.5	1.92	29.5	1.08	16.6	1.96	30.15	6.50

Table 18

Secondary Cyclone Gas Outlet Particulate Concentration Summary

Run No.	0-5 μm		5-10 μm		10-20 μm		20-40 μm		> 40 μm		Total Loading
	gr/SCF	%	gr/SCF	%	gr/SCF	%	gr/SCF	%	gr/SCF	%	gr/SCF
78.4	0.207	52.9	0.148	37.7	0.037	9.4	0.0	0.0	0.0	0.0	0.392
78.7	0.137	53.3	0.101	39.1	0.020	7.6	0.0	0.0	0.0	0.0	0.258
78.10	0.241	63.0	0.124	32.4	0.017	4.6	0.0	0.0	0.0	0.0	0.382
79	0.170	61.9	0.084	30.7	0.020	7.4	0.0	0.0	0.0	0.0	0.274
80.2	0.125	68.7	0.051	27.9	0.006	3.5	0.0	0.0	0.0	0.0	0.182
81	0.243	69.3	0.074	21.2	0.030	8.6	0.003	0.0	0.0	0.0	0.350
106.1	1.72	49.8	1.11	32.1	0.53	15.4	0.09	2.6	0.0	0.0	3.45
106.3	0.29	46.0	0.22	34.9	0.12	19.0	0.0	0.0	0.0	0.0	0.623

Table 19

Third Cyclone Gas Outlet Particulate Concentration Summary

Run No.	0-5 μm		5-10 μm		10-20 μm		20-40 μm		> 40 μm		Total Loading
	gr/SCF	%	gr/SCF	%	gr/SCF	%	gr/SCF	%	gr/SCF	%	gr/SCF
78.4	0.033	85.4	0.005	12.5	0.001	2.1	0.0	0.0	0.0	0.0	0.039
78.7	0.040	72.3	0.012	20.7	0.004	7.0	0.0	0.0	0.0	0.0	0.056
78.10	0.047	87.0	0.005	9.8	0.002	3.2	0.0	0.0	0.0	0.0	0.054
79	0.010	84.0	0.002	13.5	0.0	2.5	0.0	0.0	0.0	0.0	0.012
80.2	0.026	92.0	0.002	7.3	0.0	0.7	0.0	0.0	0.0	0.0	0.028
81	0.030	95.9	0.001	3.6	0.0	0.5	0.0	0.0	0.0	0.0	0.031
106.1	0.070	84.1	0.009	10.8	0.005	6.0	0.0	0.0	0.0	0.0	0.083
106.3	0.058	92.1	0.004	6.4	0.001	1.6	0.0	0.0	0.0	0.0	0.063

During run 81 twelve particulate measurements were taken with the Balston total filter sampling systems. The primary "recycle" cyclone dipleg plugged almost at the start of the run. This was the same problem that prematurely shutdown run 79. The run was continued to scheduled shutdown, when particulate measurements showed that the average loading (0.026 gr/SCF) was only slightly higher than during runs 79 and 80 (0.011 and 0.021 gr/SCF respectively). This average loading was significantly lower than during run 78 (0.04 gr/SCF). All of these runs were made under otherwise similar combustor operating conditions.

Particle size distributions obtained from the Balston filter particulates with the Coulter Counter revealed a similar average size (1.36 μm) to runs 78, 79 and 80 (1.9, 1.1 and 1.2 μm respectively). The difference was in the large end of the distribution. 5% of the particles were larger than 12 μm during run 81, whereas 5% were larger than 11, 10, and 5.4 μm respectively for the prior runs in the series. This can be seen in Figure 28 and Appendix B.

An important point to note is that after run 81 the turbine test blades and the miniplant ducting did not exhibit as much particulate deposition as during previous long runs. After runs 78, 79 and 80 the miniplant exhaust ducting had to be cleaned to remove particulate deposition. After run 81, the ducts were clean. This may be attributed to the abrasive action of the larger particles that resulted from the blockage of the primary cyclone dipleg.

At the start of run 106.1 particulate loadings from the combustor were extremely high. This was probably due to the use of an old starting bed. For several hours one order of magnitude higher than normal particulate concentrations into the tertiary cyclone deposited a layer of particulates on the flue gas ducts and the body of the cyclone. Later in the run, when cyclone inlet loadings were nearly normal, some of that coating must have dislodged and plugged the tertiary cyclone. The run was interrupted after 48 hours when tertiary cyclone outlet loadings (0.46 gr/SCF) were similar to the normal inlet loading (0.5-0.8 gr/SCF). This oulet loading during run 106.2 was no more than 7 hours and probably only 5 to 6 hours in duration.

Following the shutdown, the cyclone was inspected and the body, and dipleg were found almost completely plugged with caked -- but not fused -- particulates. Only a small hole was available for the flue gas to pass through the cyclone. This hole almost directly connected the inlet and the outlet of the cyclone. These particulates were easily removed and the system was put back together for a restart. The turbine test section was also disassembled and showed some erosion on many of the leading edges of the blades.

Following cleanout of the miniplant ducting, the run was resumed and designated 106.3. This time particulate loadings, though still higher than during prior tests, were within acceptable ranges. The average particle loadings for runs 106.1, 106.2 and 106.3 were 0.050, 0.46, and 0.068 gr/SCF respectively. The average particle sizes were 1.88, 3.5 and 1.76 μm respectively. During run 106.1 and 106.3 the particle size distribution was similar to that seen during run 80.

While three stages of cyclones seem to be sufficient to protect the gas turbine from massive erosion, the level of cleanup (0.035 gr/SCF) was not sufficient to meet the new source performance standard for particulates set by the EPA (approximately 0.015 gr/SCF). However, one could surmise that improvements or optimization of cyclone performance could be accomplished to meet both requirements i.e., protection of the gas turbine and environmental regulations. This may afford a major capital cost reduction in the PFBC process.

CYCLONE PERFORMANCE

During this hot gas corrosion/erosion study of turbine blade materials, high cyclone efficiencies allowed the use of two stages of cyclone cleanup before the turbine test section. Particulate loadings as low as 0.01 gr/SCF were achieved, which infers both cyclones operated at efficiencies in excess of 90%. These high efficiencies are not readily predicted and warrant further study.

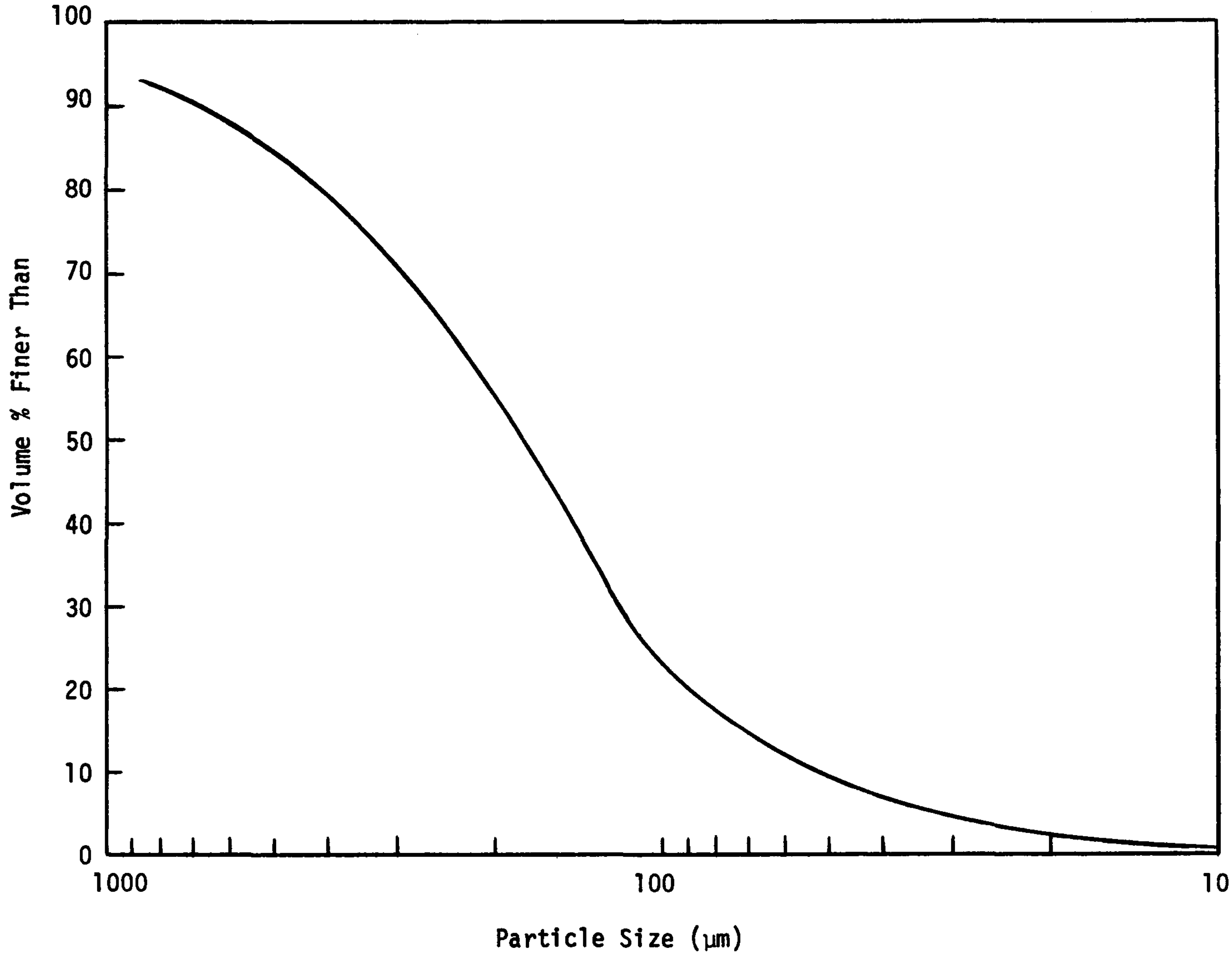
The efficiency of the primary "recycle" cyclone is intentionally low by design, so that larger particles can be recirculated to the fluidized bed combustor. There is no convenient way of measuring particulates in the gas entering or exiting the cyclone due to its location with respect to the combustor. During run 81, when the dipleg plugged, some of the material removed from the dipleg was subjected to particle size analysis. This is not representative of true recycle operation. A graph of the size distribution is shown in Figure 29.

The second cyclone in the series of three, captures material which is then collected in a lock hopper. This, plus knowledge of the outlet particulate concentration makes possible efficiency calculations based on a mass balance. Typically the cyclone is 90 to 95% efficient. This is with inlet loadings of 5 to 8 gr/SCF with an average particle diameter of 17 to 22 μ.

The third cyclone in the train receives an inlet loading of 0.5 to 0.7 gr/SCF with an average size of 3 to 4 μm. This cyclone is located in a large pressure vessel. The dimensions of this cyclone are shown in Figure 8. The cyclone normally operates at 880°C, 900 kPa pressure and inlet velocities of 50 m/s. Flue gas can be sampled for particulates both before and after the cyclone. During runs 78 through 81, isokinetic samples were taken with Balston total filters only on particulates in the gas exiting the cyclone. This sample gas was withdrawn through an isokinetic stationary probe. After the one to two hour sample was taken, the filter cartridge was weighed and particulates were removed from the filter cake for Coulter Counter size analysis.

Figure 29

Primary Cyclone Return Line
Particle Size Distribution (Run 81)



The size distribution of the material captured by the cyclone was analyzed with a combination of a sonic sieve and the Coulter Counter. A mass balance was completed around the cyclone to determine inlet size and concentration. In this way cyclone fractional (grade) efficiencies were obtained under the assumption that there was no accumulation or attrition in the cyclone. The validity of these calculations has been confirmed with concurrent inlet and outlet samples and mass balance calculations. Independent studies by other contractors have also confirmed the high cyclone efficiencies (4). A graph of the tertiary cyclone grade efficiency during run 79 and 80 is shown in Figure 30. The grade efficiency for all runs in this series is shown in Table 20.

The cyclone collection efficiency data confirm the ability of the miniplant cyclone train to very effectively capture particles greater than 10 microns. Particles in the 5-10 micron range are captured with a 95-99% efficiency, and particles in the 2-5 micron range with a 75 to 95% efficiency. This intimates that if a fourth cyclone were to be added, practically all particles larger than 10 microns could be captured and a substantial portion of the 5-10 µm population would also be removed. Since particles greater than 10 microns are prime suspects in causing turbine blade erosion, a four cyclone train could cleanup the flue gas to a suitable level for gas turbines.

HEAT EXCHANGER PROBES

Probes consisting of the alloy combinations listed in Table 1 were positioned in the combustor ports and exposed at the intended set point temperatures. A maximum of 21 probes were inserted in the combustor at a given time during the test program. At each temperature level, two probes were exposed for the entire 1000 hour test plus 117 shakedown hours. Thus, a total of 14 probes containing 28 specimens resided within the combustor for the duration of the test. Five of the seven probes which were inserted at the start of the test were exposed for 367 hours and then replaced with 7 new probes which remained in the combustor for 485 hours. The remaining probes were exposed for periods from 100 to 423 hours. A tabulation of the heat exchanger probe details and exposure times appears in Table 21. A probe test history is presented graphically in Figure 31.

Temperature data for the 31 different heat exchanger probes exposed during the PFBC hot corrosion/erosion program are presented in Appendix C Tables C-1 through C-5. Temperatures at two locations in each probe were recorded every 20 minutes during the run. In these tables the recorded temperatures have been averaged for five (5) hour segments of the run. Also listed are the standard deviations for that time period as well as the maximum and minimum temperatures experienced by the specimen material during those five (5) hours.

Figure 30

Particle Capture Efficiency of the Tertiary Miniplant Cyclone

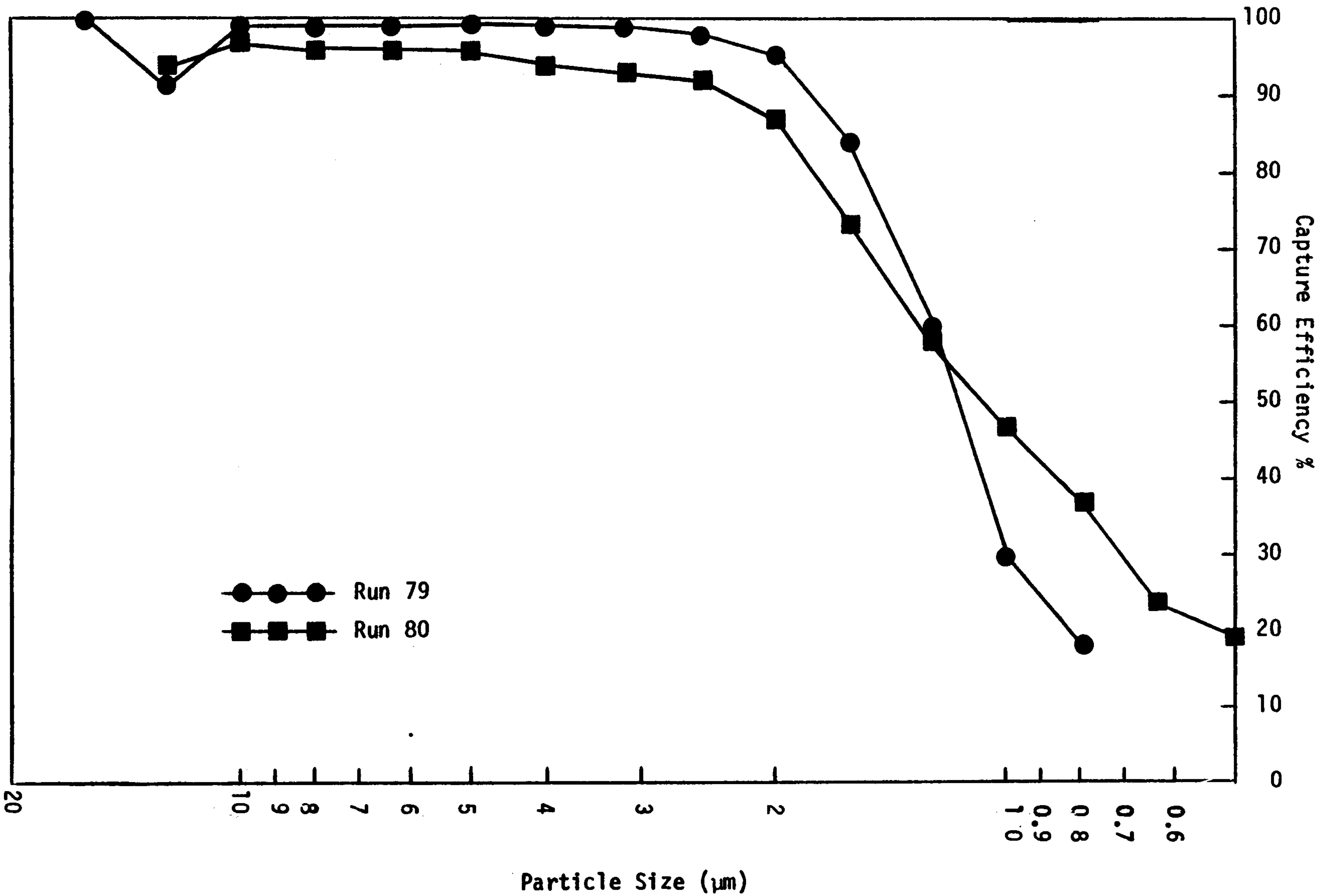


Table 20

Third Cyclone Grade Efficiency Summary

Run	Stated Particle Size (Microns) Collected with Efficiency (%)																
	0.5	0.63	0.794	1.0	1.26	1.59	2.0	2.52	3.17	4.0	5.04	6.35	8.00	10.08	12.7	16.0	20.2
78.2	40	39	45	61	78	87	94	95	95	95	95	95	95	95^{+}	99^{+}	99^{+}	99^{+}
78.4	5	10	22	41	69	86	93	95	96	97	96	97	96	96	99^{+}	99^{+}	99^{+}
78.10	37	30	53	58	78	86	90	93	94	94	94	94^{+}	94^{+}	94^{+}	99^{+}	99^{+}	99^{+}
79	0	0	32	48	81	94	98	99	99	99	99^{+}	99^{+}	99^{+}	99^{+}	99^{+}	99^{+}	99^{+}
79	0	0	5	13	39	74	93	97	99	99	99^{+}	99^{+}	99^{+}	99^{+}	99^{+}	99^{+}	99^{+}
80.2	20	24	37	47	58	74	87	92	93	94	96	96	97	99^{+}	99^{+}	99^{+}	99^{+}
81*	0	0	14.1	79.9	83	90	94	97	98	98	99	99	99	99^{+}	99^{+}	99^{+}	99^{+}
106.1	--	--	--	--	94	93	94	96	98	98	98	99	99	99^{+}	99^{+}	99^{+}	99^{+}
106.3	--	--	--	--	66	63	66	74	78	85	91	95	96	97	97	99^{+}	99^{+}
106.3	--	--	--	--	42	55	77	91	94	96	96	97	96	98	99^{+}	99^{+}	99^{+}

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* Primary cyclone disabled.

Table 21

Heat Exchanger Specimen Probe Summary

Port No.	Probe No.	Set Point Temp (°F)	Alloy Position: Near Wall	Alloy Position: Inner Bed	Run Exposed	Total Hours
			In-Bed Specimens			
1	27	1600	Haynes 188	Hastelloy X	66,67,78,79,80,81,106	1117
2	19	1400	Hastelloy X	Inconel 800	66,67,78,79,80,81,106	1117
3	21	1600	Hastelloy X	Haynes 188	66,67,78,79,80,81,106	1117
4	13	1400	Inconel 800	Hastelloy X	66,67,78	367
4	15	1400	Hastelloy X	Inconel 800	79,80,81	485
5	25	1600	Hastelloy X	Haynes 188	66,67,78,*	423
5	23	1600	Haynes 188	Hastelloy X	79,80,81	485
6	17	1400	Inconel 800	Hastelloy X	66,67,78,79,80,81,106	1117
7	11	1200	Inconel 800	SS 304	66,67,78,79,80,81,106	1117
8	4D	1050	9 Cr - 1 Mo	2-1/4 Cr - 1 Mo	66,67	117
8	4H	1050	9 Cr - 1 Mo	2-1/4 Cr - 1 Mo	78,79,80,81,106	1000
9	5	1200	SS 304	Inconel 800	66,67,78	367
9	7	1200	Inconel 800	SS 304	79,80,81	485
10	1A	1050	2-1/4 Cr - 1 Mo	9 Cr - 1 Mo	66,67	117
10	1F	1050	2-1/4 Cr - 1 Mo	9 Cr - 1 Mo	78	250
10	3	1050	9 Cr - 1 Mo	2-1/4 Cr - 1 Mo	79,80,81	485
11	9	1200	SS 304	Inconel 800	66,67,78,79,80,81,106	1117
12	2C	1050	2-1/4 Cr - 1 Mo	9 Cr - 1 Mo	66,67,*	123
12	2G	1050	2-1/4 Cr - 1 Mo	9 Cr - 1 Mo	78,79,80,81,106	1000
			Above-Bed Specimens			
13	28	1600	Haynes 188	Hastelloy X	66,67,78,79,80,81,106	1117
14	18	1400	Hastelloy X	Inconel 800	66,67,78,79,80,81,106	1117
15	26	1600	Hastelloy X	Haynes 188	66,67,78,79,80,81,106	1117
16	14	1400	Inconel 800	Hastelloy X	66,67,78	367
16	16	1400	Hastelloy X	Inconel 800	79,80,81	485
17	22	1600	Hastelloy X	Haynes 188	66,67,78	367
17	24	1600	Haynes 188	Hastelloy X	79,80,81	485
18	20	1400	Hastelloy X	Inconel 800	66,67,78,79,80,81,106*	1146
19	10	1200	SS 304	Inconel 800	66,67,78,79,80,81,106	1117
20	12	1200	Inconel 800	SS 304	66,67,78,79,80,81,106	1117
22	6	1200	SS 304	Inconel 800	66,67,78	367
22	8	1200	Inconel 800	SS 304	79,80,81	485

Figure 31

Westinghouse Heat Exchanger Probe Test History

Location/Temp.	Port No.	Exposure: Shake-Down 117	Run 78 250	Run 79 100	Run 80 215	Run 81 170	Run 106 265
In-Bed/1600	1	27-I-16-100-H-X-X					
	3	21-I-16-25-XA-HAX					
	5	25-I-16-100-XC-HC-H		23-I-16-50-HB-HB-X			
In-Bed/1400	2	19-I-14-100-XL-8L-8					
	4	13-I-14-25-8I-XI-X		15-I-14-50-XJ-8J-8			
	6	17-I-14-100-8K-XK-X					
In-Bed/1200	7	11-I-12-100-8D-3D-3					
	9	5-I-12-25-3A-8A-8		7-I-12-50-8B-3B-3			
	11	9-I-12-100-3C-8C-8					
In-Bed/1050	8	*	4-I-10-100-9H-2H-2				
	10	*	1-I-10-25-2F-9F-9	3-I-10-50-9B-2B-2			
	12	*	2-I-10-100-2G-9G-9				
Above Bed/1600	13	28-A-16-100-HH-XH-X					
	15	26-A-16-100-XG-XG-H					
	17	22-A-16-25-XE-HE-H		24-A-16-50-HF-XF-X			
Above Bed/1400	14	18-A-14-100-80-XO-X					
	16	14-A-14-25-8M-XM-X		16-A-14-50-XN-8N-8			
	18	20-A-14-100-XP-8P-8					
Above Bed/1200	19	10-A-12-100-3G-8G-9					
	20	12-A-12-100-8H-3H-3					
	22	6-A-12-25-3E-8E-8		8-A-12-50-8F-3F-3			

Hours Into Test: 100 200 300 400 500 600 700 800 900 1000 1100

* Exposed for shakedown only - see Table 21.

This collated temperature data generally reveals excellent temperature control of the individual specimens. At steady state condition 60% of the specimens had a temperature deviation from the mean less than 20°F, 90% less than 30°F, and all less than 50°F.

The probes were inspected following each run. All the specimens basically survived intact, except for the inner specimen on probe #6. This probe was comprised of Inconel 800 and Hastelloy X and controlled at 1400°F. The Hastelloy X showed considerable wastage near the capped end and developed a hole in that region after run 80 (at 565 hours). The remaining 2 in-bed probes of this type (materials and temperature) as well as the 3 above-bed probes appeared in good condition. A small portion of the probe around the perforation was removed for metallurgical analysis and the probe repaired for further testing. The probe completed the tests without further incident.

Photographs of the 14 heat exchanger probes that completed the 1000 hour testing (1117 hours total) are presented in Appendix C Figures C-1 through C-7. The photos are grouped according to probe operating temperature and bed location. For comparison, photographs taken of the probes after run 80 (682 hours for the original specimens) are presented in Appendix C Figures C-8 through C-14. Upon completion of the test program the heat exchanger probes were sent to Westinghouse R&D Center for complete metallurgical analysis. From a cursory observation of the probes it appears that the ferritic alloys and some Hastelloy X specimens experienced the most attack. Table 22 presents a brief summary of the probe specimen appearance at the conclusion of the testing. The 14 probes inspected were all exposed for 1117 hours. The above-bed probe specimens generally appeared in better condition than the in-bed probes.

TURBINE BLADE SPECIMENS

The turbine test section was positioned in the miniplant discharge piping for the entire PFBC hot corrosion/erosion testing program. The blades exposed during the initial 117 ("shakedown") hours were returned to GE for metallurgical analysis. The extended testing was started with an entirely new set of specimen blades, some bare and some clad.

Among the 24 airfoil specimens starting the test were 9 unclad base alloy specimens (4 of IN-738, 3 of U-700 and 2 of FSX-414). The other IN-738 blades were cald with either IN-671, S-57 or GE-2541. Blades of FSX-414 were clad with GE-2541. One blade with IN-738 as the base alloy was coated with RT-22 (platinum-aluminide).

Of the original airfoil specimens in the 24 cascade positions, 13 specimens were exposed for the full 1000 hours. Another 27 specimens were located in the remaining 11 positions for periods as short as 48 hours to as much as 750 hours. These blades were selectively replaced at various stages of the test. A tabulation of the specimen materials identification, cascade location, and exposure times is given in Table 23. Figure 7 (Section III) depicts the specimen location in the cascades and Figure 32 is a graph of the specimen location and exposure history.

Table 22

Heat Exchanger Probe Appearance at Test Conclusion

Specimen Alloy	Temp (°F)	
		In-Bed
2-1/4 Cr - 1 Mo/9 Cr - 1 Mo	1050	Thick, hard deposits and considerable oxide spalling
304 SS/Inconel 800	1200	Substantial oxidation of both specimens
Inconel 800/Hastelloy X	1400	Hastelloy X pitted and 1 Hastelloy X perforated
Hastelloy X/Haynes 188	1600	Hastelloy X oxidized slightly more than Haynes 188
		Above-Bed
304 SS/Inconel 800	1200	Smooth, deep reddish deposits
Inconel 800/Hastelloy X	1400	Some oxidation, especially on lower surfaces
Hastelloy X/Haynes 188	1600	Thin, brownish deposits

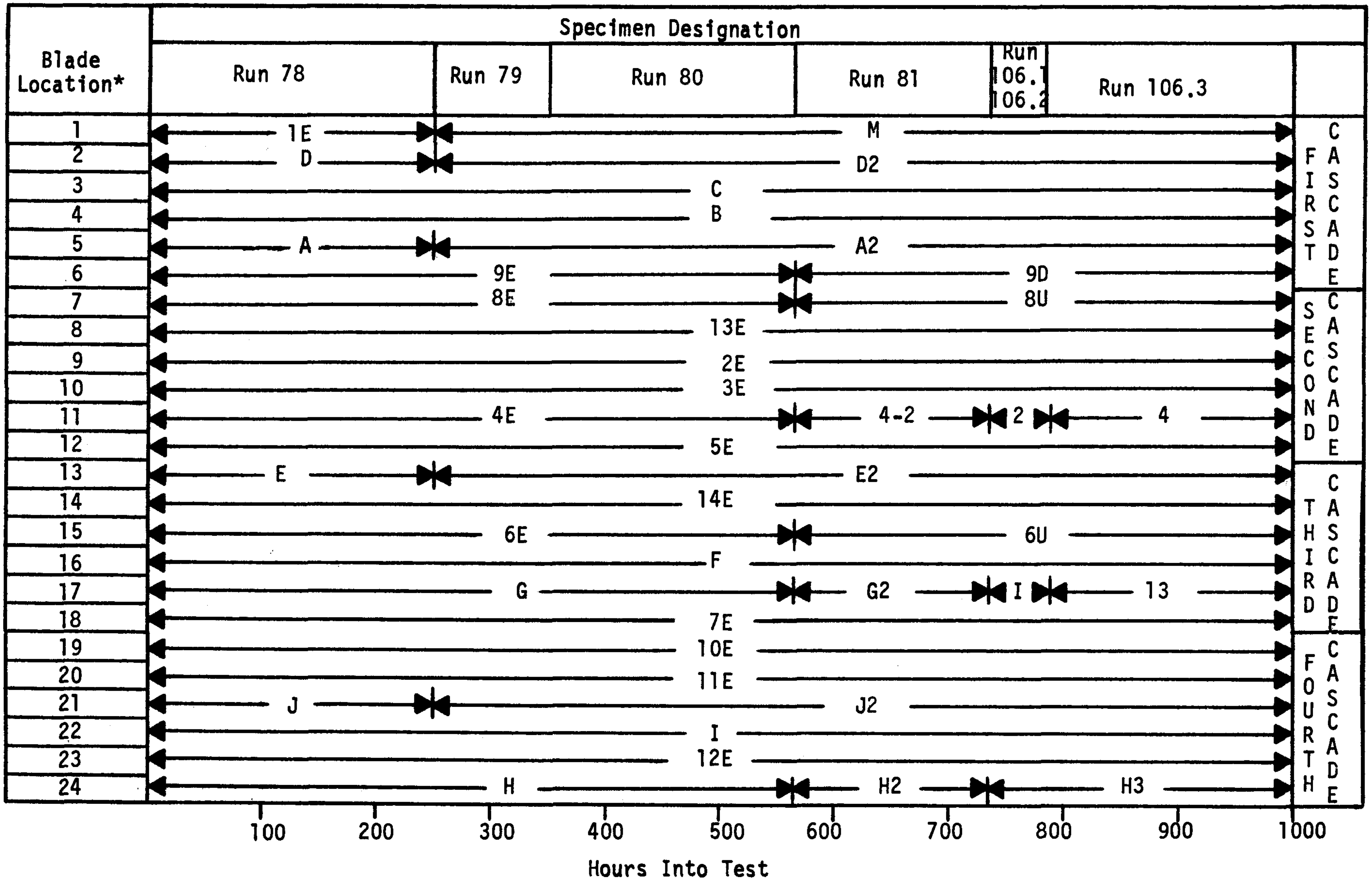
Table 23

GE Turbine Test Blade Specimens Exposed During the 1000 Hour Test

Location No.	Base Alloy	Cladding/Coating	Specimen No.	Runs Exposed	Hours Exposure
1	IN-738	IN-671	1E	78	250
2	IN-738	--	D	78	250
3	U-700	--	C	78-106	1000
4	IN-738	--	B	78-106	1000
5	FSX-414	--	A	78	250
6	IN-738	S51/Al	9E	78-80	565
7	IN-738	GE-2541 PM	8E	78-80	565
8	FSX-414	PFB-6PM/Al	13E	78-106	1000
9	IN-738	S57/Al	2E	78-106	1000
10	IN-738	GE-2541 PM	3E	78-106	1000
11	IN-738	IN-671	4E	78-80	565
12	IN-738	PFB-6Al	5E	78-106	1000
13	U-700	--	E	78	250
14	FSX-414	GE-2541 PM	14E	78-106	1000
15	IN-738	PFB-6/Al	6E	78-80	565
16	IN-738	RT-22	F	78-106	1000
17	IN-738	--	G	78-80	565
18	IN-738	PFB-6	7E	78-106	1000
19	IN-738	GE-2541 PM	10E	78-106	1000
20	IN-738	IN-671	11E	78-106	1000
21	IN-738	--	J	78	250
22	FSX-414	--	I	78-106	1000
23	FSX-414	PFB-6PM/Al	12E	78-106	1000
24	U-700	--	H	78-80	565
1	IN-738	--	M	79-106	750
2	IN-738	--	D2	79-106	750
5	FSX-414	--	A2	79-106	750
13	U-700	--	E2	79-106	750
21	IN-738	--	J2	79-106	750
6	IN-738	S57/Al	9D	81-106	435
7	IN-738	GE-2451	8U	81-106	435
11	IN-738	IN-671	4-2	81	170
15	IN-738	PFB-6/Al	6U	81-106	435
17	IN-738	--	G2	81	170
24	U-700	--	H2	81	170
11	IN-738	IN-671	2	106.1-106.2	48
17	IN-738	--	I	106.1-106.2	48
24	U-700	--	H3	106	265
11	IN-738	--	4	106.3	217
17	FSX-414	--	13	106.3	217

Figure 32

Turbine Test Section Sepcimen History



*See Figure 7

The turbine blade specimens were routinely brushed with a soft bristle brush and inspected after 250, 565, 735 and 783 hours of exposure. After 735 hours of PFBC exposure the turbine blade specimens revealed no obvious signs of attack. At the 250 and 565 hour inspections there was substantial deposition of flyash on the suction (i.e., convex) surface of the airfoils near the trailing edge. Figures 33, 34 and 35 show the second cascade specimens after 250, 565 and 735 hours exposure, respectively. Note that the particulate deposition present on the trailing edges of the blades in Figure 33 and 34 is not present in Figure 35. The photograph in Figure 35 was taken after run 81, during which the primary "recycle" cyclone plugged and increased the mean particle size and particulate loading at the turbine test section. This scouring effect did not cause visible erosion. However, it did act to remove or prevent the accumulation of deposits on the blades.

Run 106 started at the 735 hour mark but had to be interrupted after only 48 hours (at the 783 hour mark) because abnormally high particulate loadings were detected at the turbine test section. The high particulate loadings were found to be caused by blockage of the third stage cyclone. It is deduced that the turbine blade specimens were exposed to an order of magnitude increase in particulate concentration (Figure 27) for not longer than 7 hours and most probably 5 to 6 hours.

Examination of the turbine blades revealed that some specimens experienced noticeable erosion during this 48 hour interval, almost certainly mostly occurring in those final 5 to 6 hours. Practically no flyash deposits were found on the blade specimens. This corroborates previous experience, where the existence of higher particulate loading can scour the deposits from the blades. The blade specimens were gently cleaned and weighed. Many specimens experienced a weight loss of almost 0.10 grams. The erosion was most prominent on the leading edge of the airfoils. The blades with the most noticeable erosion wastage were in the following cascade sites (see Figure 7).

Cascade	Location
1st	3, 4, 5
2nd	9 (slight)
3rd	17, 16
4th	20, 21, 22, 23 (esp. 21)

The blades in the fourth cascade, which are the only reaction type airfoil profiles and where the flow velocities approach sonic, experienced the most prominent erosion. The most severely eroded specimen was in position 21 (Figure 7), which lost about 0.3 grams. All the reaction blades in the center of the 4th cascade also exhibited erosion on the pressure side - from the leading edge to about the center of the airfoil.

Figure 33

View of the Leading and Trailing Edges of the Second Cascade

(Run 78)

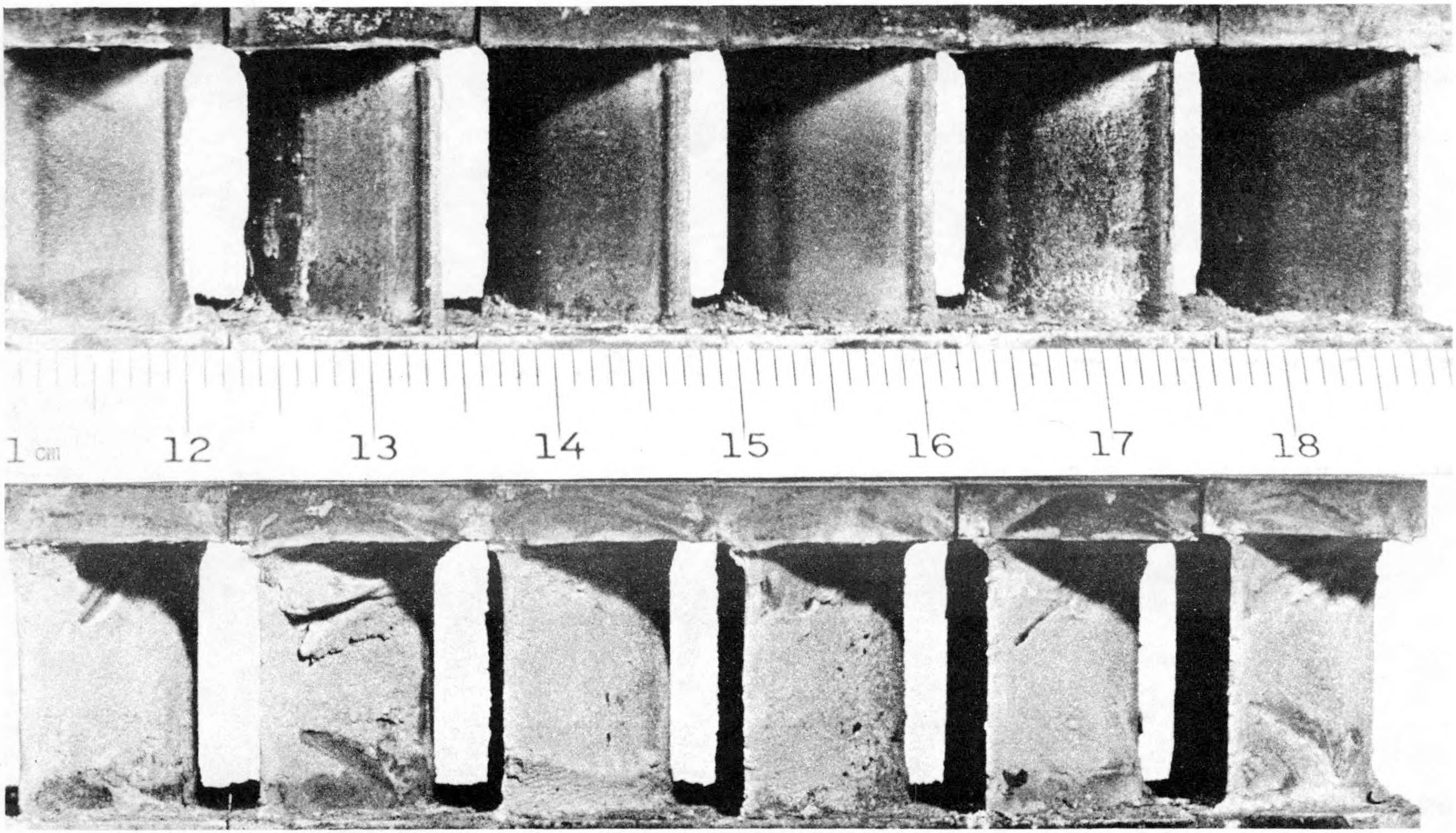


Figure 34

View of the Leading and Trailing Edges of the Second Cascade

(Run 80)

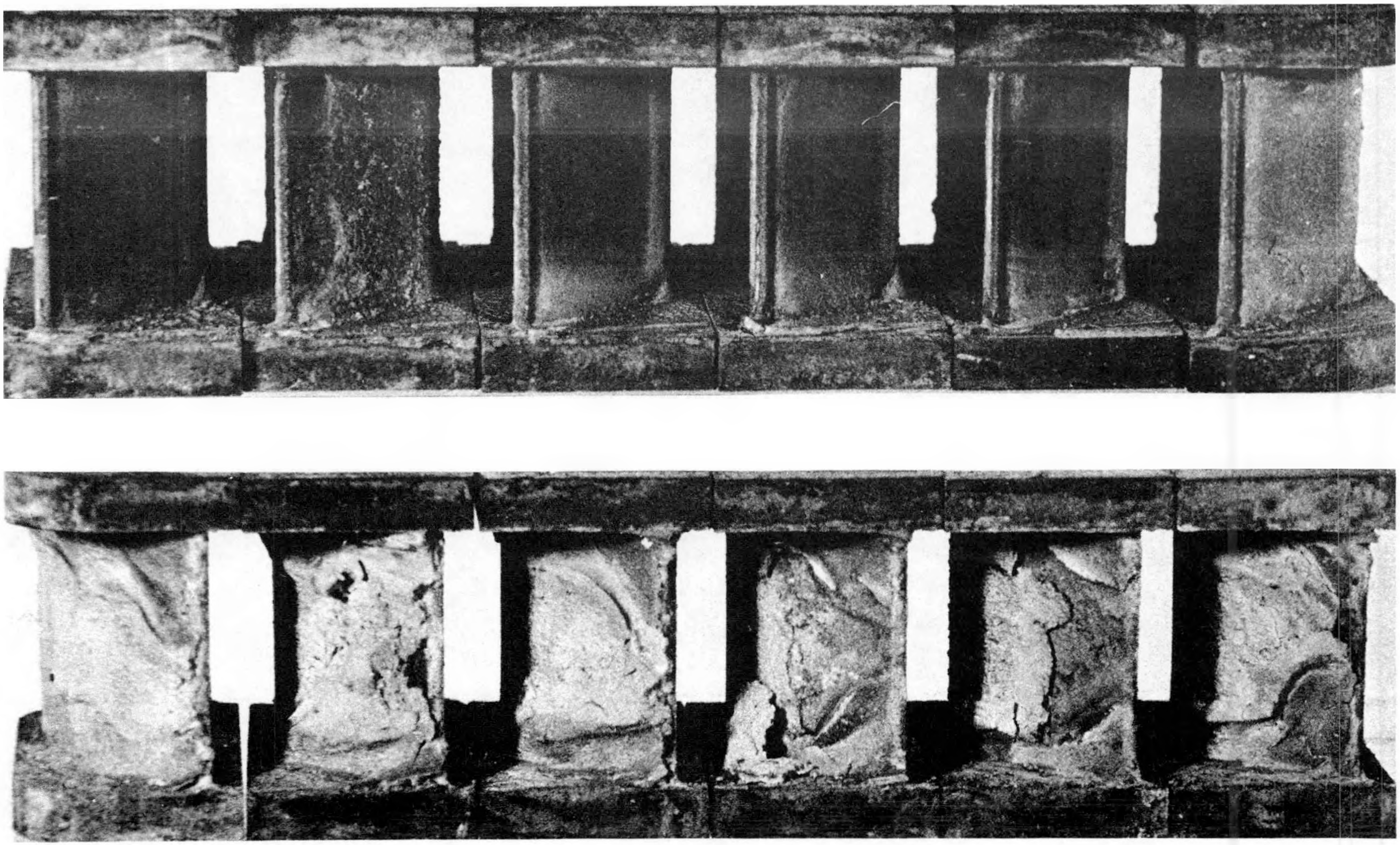
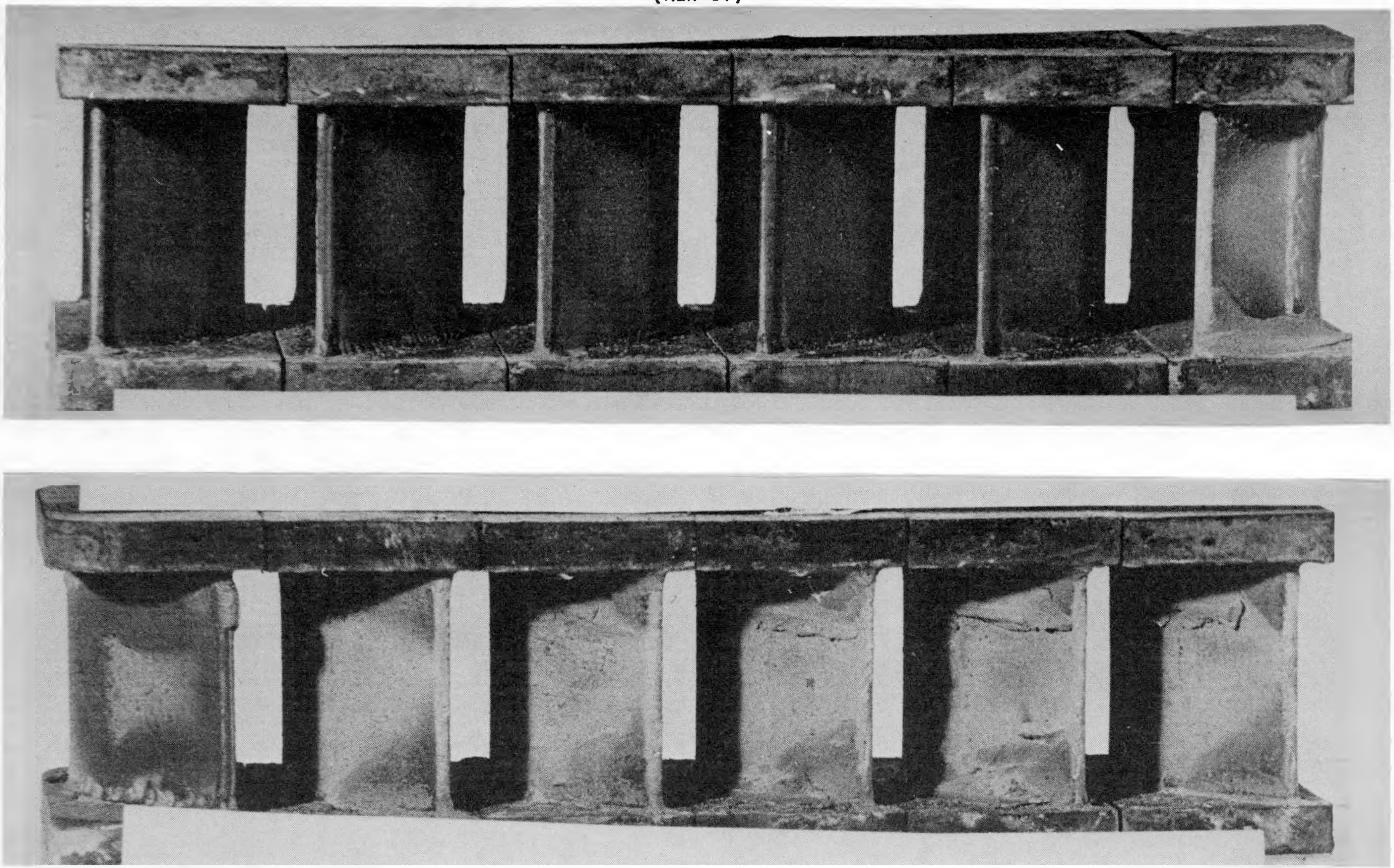


Figure 35

View of the Leading and Trailing Edges of the Second Cascade

(Run 81)



At the start of run 106, three new blade specimens had been inserted; one in the 2nd cascade (position 11), one in the 3rd cascade (position 17), and one in the 4th cascade (position 24). The airfoil at position 17 revealed considerable erosion at the leading edge, especially considering only 48 hours of exposure. To provide a guideline to help characterize the effects of this high particulate loading episode, it was decided to remove the specimens from positions 11 and 17 so that they could be available for metallographic examination. Replacement airfoils for these locations were obtained from GE and placed in the passage. Run 106 resumed and operated smoothly for the final 217 hours.

Figure 36 is a photograph of the two blades in position 17 during run 106 along side one another, revealing the erosion on the leading edge of the first specimen (I). Note that the other blade, which was exposed ~5 times longer to particulate concentrations ~5 times lower showed no signs of erosion.

At the conclusion of the 1000 hour PFBC exposure tests the turbine blade specimens were photographed and returned to General Electric for metallurgical examination. Flyash deposits from each blade cascade were collected for particle size analysis. From a cursory inspection, the airfoils generally appear satisfactory. The 4th cascade specimens in locations 20, 21, 22, and 23 (Figure 7) still exhibited the most noticeable erosion. Indeed, the most airfoil erosion during the 1000 hours of exposure appeared to occur during this run just concluded, and in particular during the 5 or 6 hours of this run, when the third staged cyclone plugged.

The photograph in Figure 37 is the leading edge of specimen J2 as it appeared at the completion of the test. This specimen in the fourth (reaction) cascade, position 21, experienced the most severe erosion. All of the noticeable metal wastage apparently occurred during the high particulate loading period. Visual inspections and weight comparisons of blade specimen J2 before and after the final 217 hours of exposure did not disclose signs of further erosion.

Figures 38 and 39 show a top and bottom view of all of the blade specimens exposed during the final 217 hours (run 106.3). Although some erosion is evident, it is not catastrophic and appears mostly to have occurred during run 106.2, the high particulate loading period.

Throughout the 1000 hour exposure test, gas flow through the turbine test section was within the required range (Figure 40). Although the flow rate varied somewhat from run to run, during a given test it was fairly steady. During most runs a slight decrease in flow with time was experienced. This is attributed to particulate deposition on the pressure reducing section or on the blades themselves. The most dramatic drop in flow occurred after a 2 hour shutdown during run 81. The flow went from 680 to 625 SCFM. The 1-1/2 day shutdown during run 106 did not cause such a sharp decrease in flow rate. This was probably due to the fact the flue gas line and the turbine test section were dismantled and cleaned prior to restarting.

Figure 36

Specimens Occupying Position No. 17 During Run 106

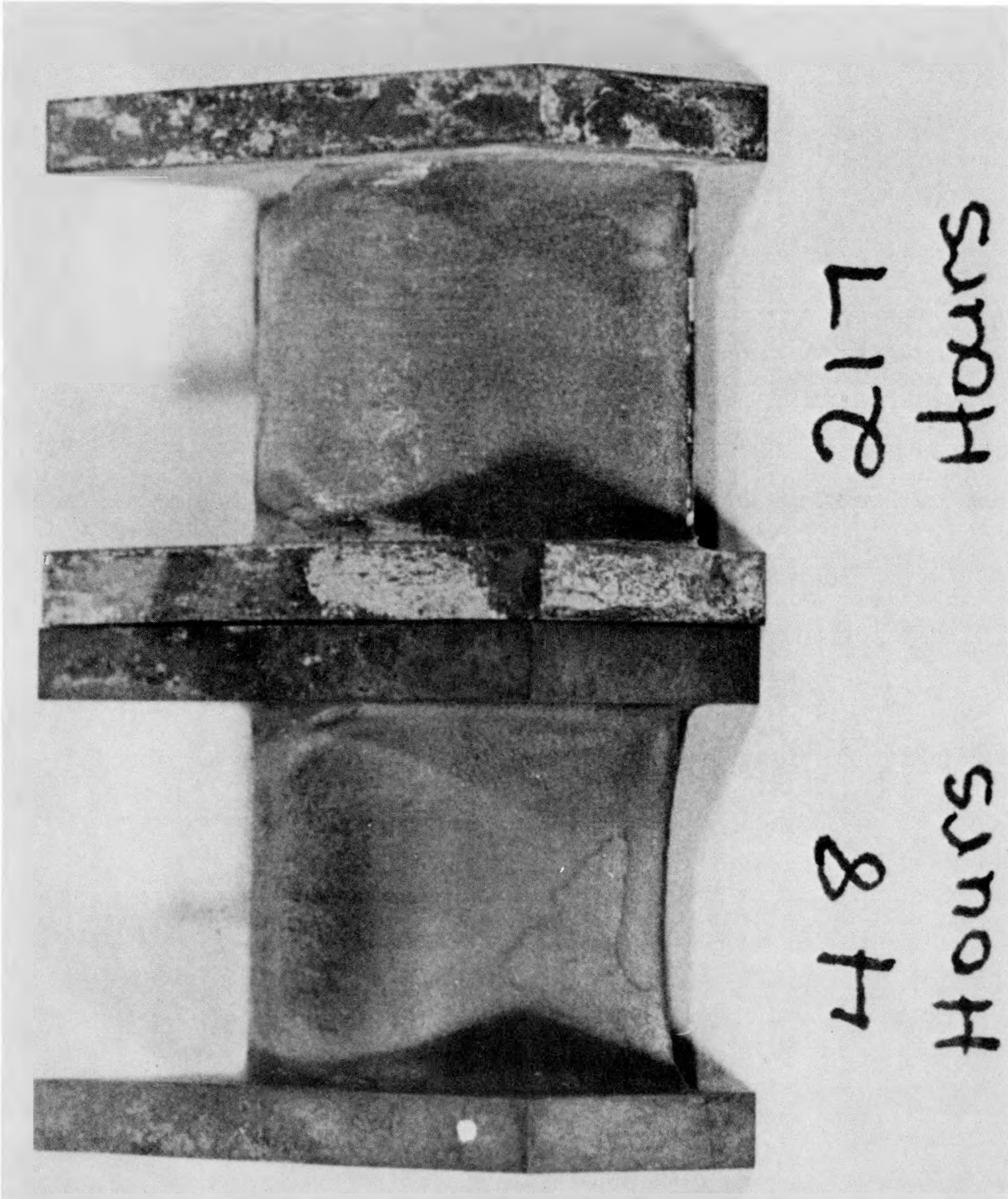


Figure 37

Blade Specimen J2 (21) After 1000 Hours

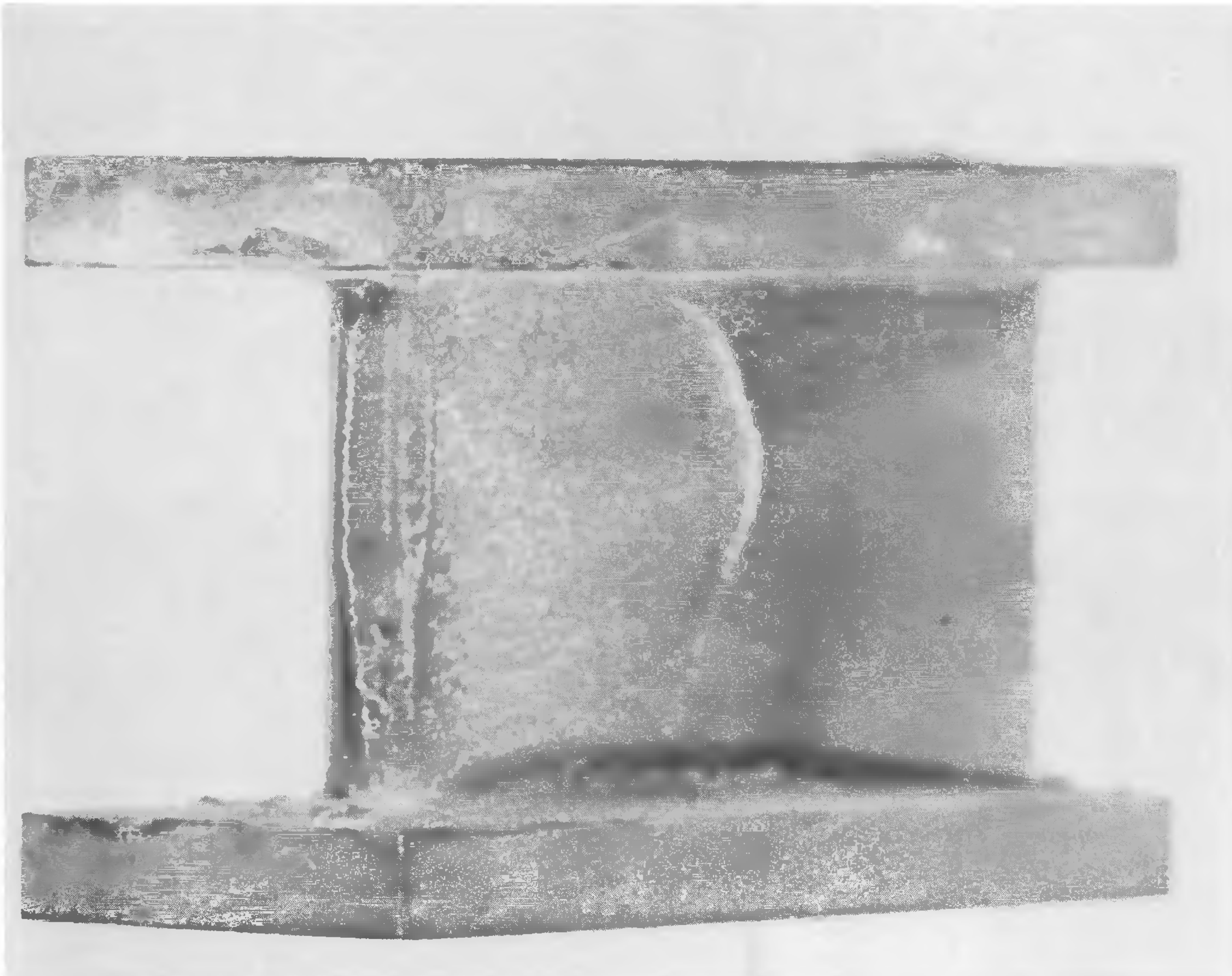


Figure 38

All Blade Specimens After 1000 Hour Tests (Convex Side)

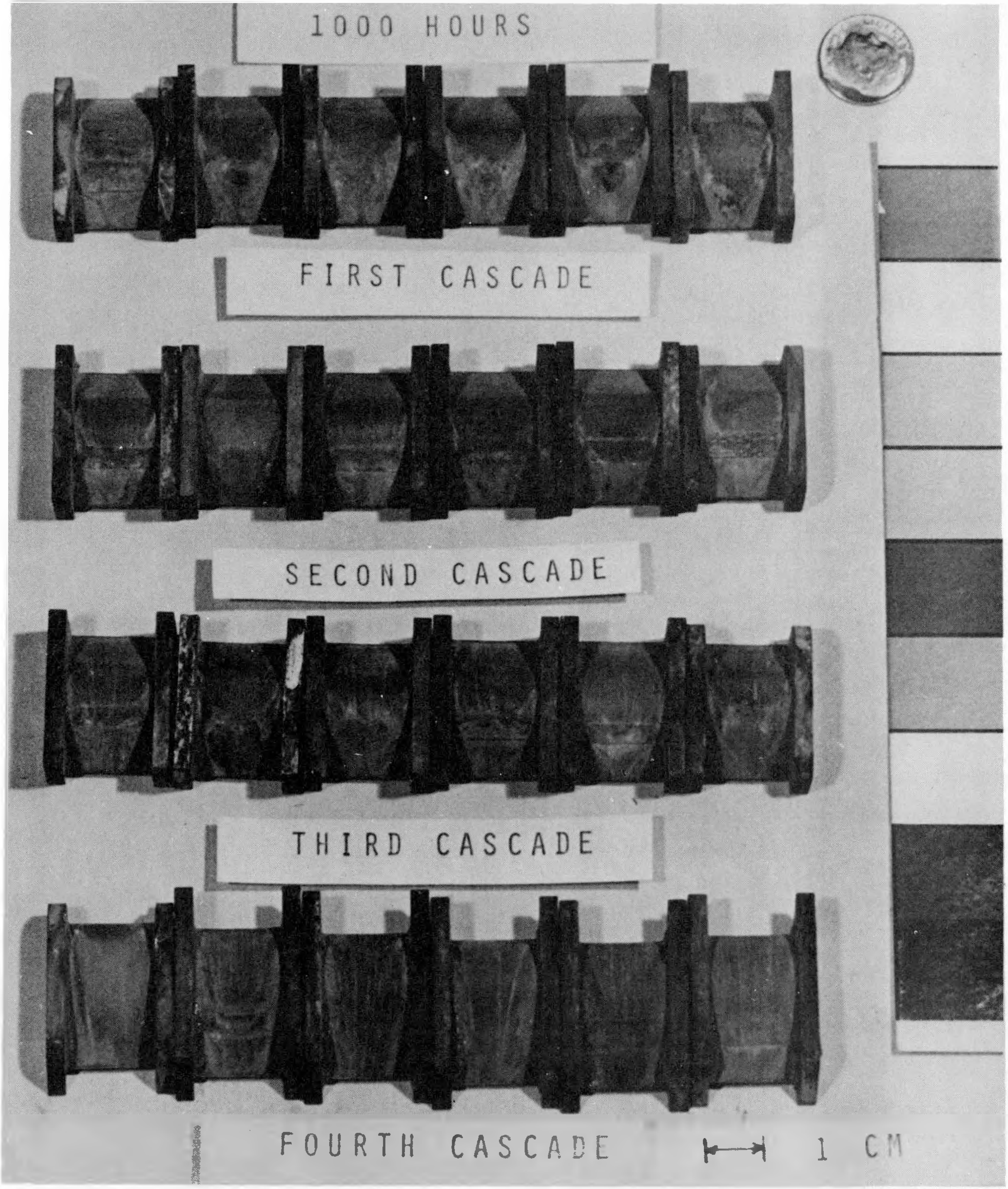


Figure 39

All Blade Specimens After 1000 Hour Tests (Concave Side)

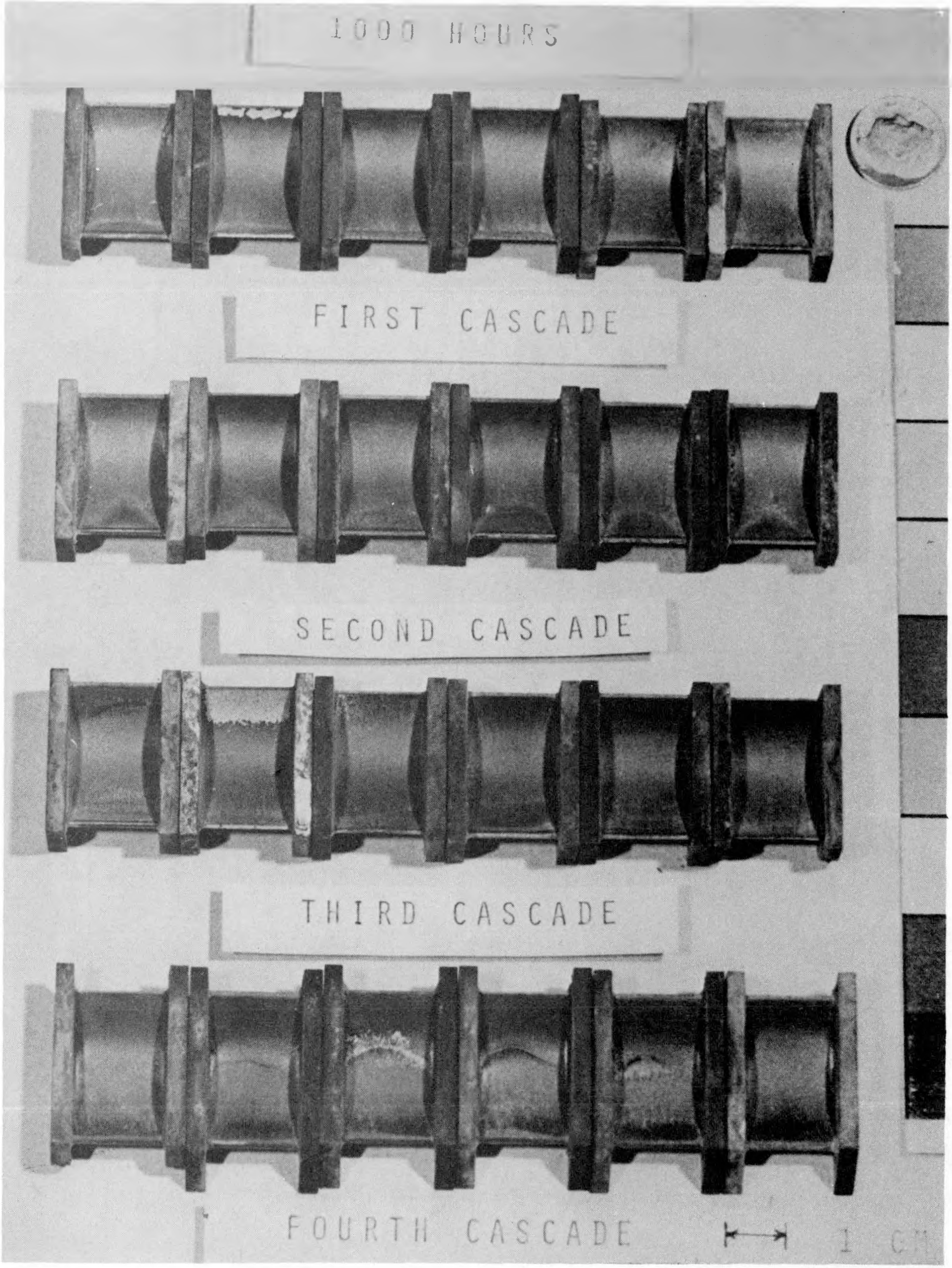
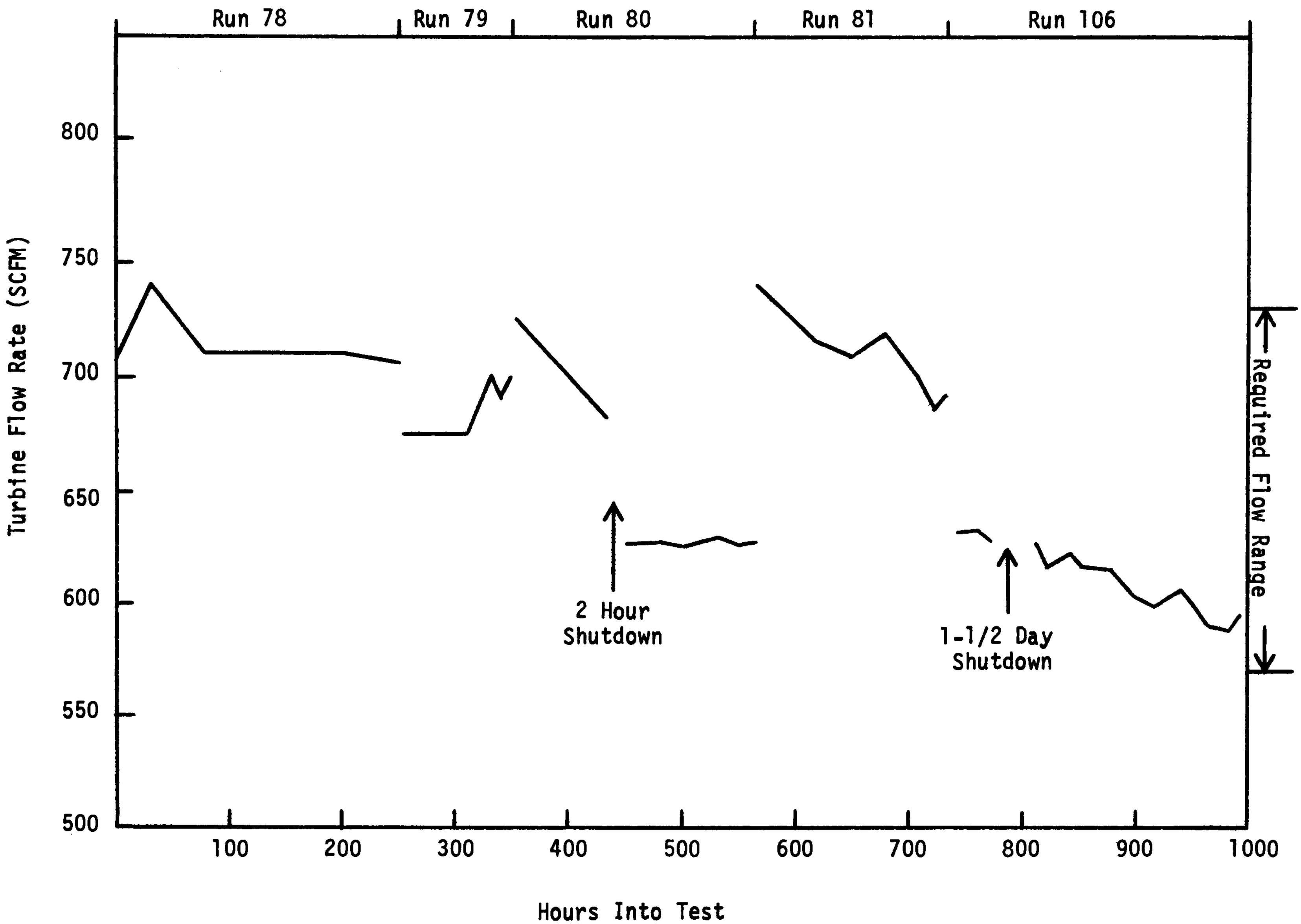


Figure 40

1000 Hour Turbine Flow Summary



CORROSION DISCS

During the 1000 hour hot corrosion exposure test, it was intended that combustor and discharge line conditions be constant. This provided an opportunity to obtain extended fireside corrosion data by also locating alloy specimens in the freeboard of the combustor. The same materials used for the turbine airfoil specimens were mounted on a support located inside the combustor. This permitted a comparison of the hot corrosion attack of the same material at two different regions within a PFBC.

Three sets of alloy discs (4 samples per set) were received from General Electric for exposure in the 1000 hour testing program. The alloys received were U-700, IN-738, and FSX-414. The first two are nickel based alloys similar to those tested in the turbine test section; the latter is a cobalt based alloy. The discs are approximately 1 inch in diameter by 1/16 inch thick. In the 250 hour run, two specimens from each alloy set were exposed in the combustor freeboard region in the vicinity of the heat exchanger probes. A plot of the combustor temperature profile at three times during the run is shown in Figure 22. This figure also shows the location of the corrosion discs and their approximate exposure temperatures. Visual examination of the discs after each run revealed no obvious signs of erosion or corrosion (Figure 41). Discs were periodically taken by General Electric for metallurgical analysis after various exposure times.

CONCLUSIONS

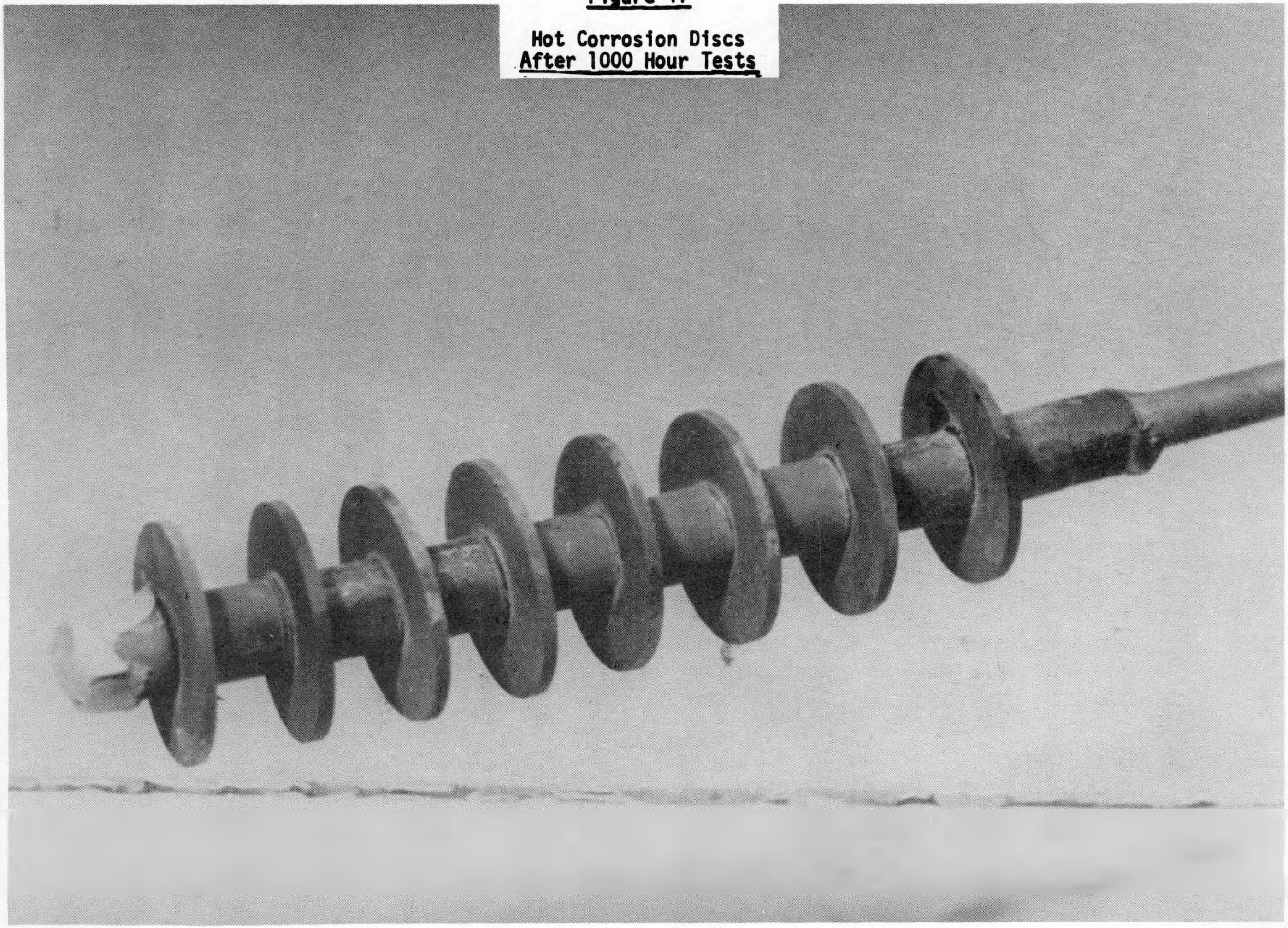
The 1100 hour test at the Exxon Miniplant facility has indicated that materials are available for use in the PFBC application as heat exchanger and turbine blades. This needs to be further substantiated by metallurgical testing which will be performed by Westinghouse Research and Development (1) and General Electric Company (2) on these specimens, as well as subsequent testing of materials in PFBC environments such as those presently being undertaken at the Coal Utilization Research Laboratory in England and by Curtiss-Wright. Furthermore, the indication is that particulate cleanup using conventional cyclones may be sufficient to provide adequate gas turbine protection for periods of time economically feasible in a PFBC application.

While cyclones seem to provide adequate protection for turbine blade materials, a number of significant problems may exist in terms of maintaining control. These are:

> Particle grain loading and particle size need to be controlled to relatively low concentrations (0.025 to 0.07 gr/SCF), and mean particle size of approximately 1-2 microns if significant erosion is to be avoided.

Figure 41

Hot Corrosion Discs
After 1000 Hour Tests



- Based on the Miniplant tests, there is a suspicion, that very fine particulate (less than 1.1 microns) and low grain loadings may induce particle deposition in the ducting prior to the gas turbine as well as on the gas turbine blades. Subsequent spalling of this material may cause severe erosion problems. There may be a lower limit to which cleanup might be feasible. This needs to be further explored in subsequent tests.

- High particulate loading or large mean particle size which could result from relatively minor process or equipment malfunctions e.g., cyclone plugging, can cause erosion rates that would very rapidly decrease the efficiency of the gas turbine. Therefore, reliable particulate control and measurement systems are necessary to protect the gas turbine.

Corrosion and erosion problems are not severe for heat exchanger materials in the freeboard of the combustor. However, the degree of in-bed corrosion/erosion in the fluidized bed needs to be further quantified by metallurgical analysis before definitive recommendations can be made for suitable heat exchanger materials.

VI. BIBLIOGRAPHY

1. Westinghouse Research report to be published under DOE Contract No. E(49-18)-2327.

2. General Electric CFCC project to be published under DOE Contract No. E(49-18)-2326.

3. Hoke, R. C., et al, "Miniplant Studies of Pressurized Fluidized-Bed Coal Combustion: Final Report," to be published under EPA Contract No. 68-02-1312.

4. "Evaluation of A Cyclonic Type Dust Collector for High Temperature High Pressure Particulate Control," M. Ernst, R. C. Hoke, V. J. Siminski, J. D. McCain, R. Parker, D. C. Drehmel, Presented for "The Second Symposium on the Transfer and Utilization of Particulate Control Technology," July 23-27, 1979 in Denver, Colorado.

APPENDIX A

TURBINE BLADES AND HEAT EXCHANGER PROBES AFTER SHAKEDOWN

Enclosed are photographs of the appearance of the turbine blade and heat exchanger probes after shakedown. The temperature history of the probes during shakedown are also included.

Figure A-1

View of the Leading and
Trailing Edges of the First Cascade

100 Hour Shakedown

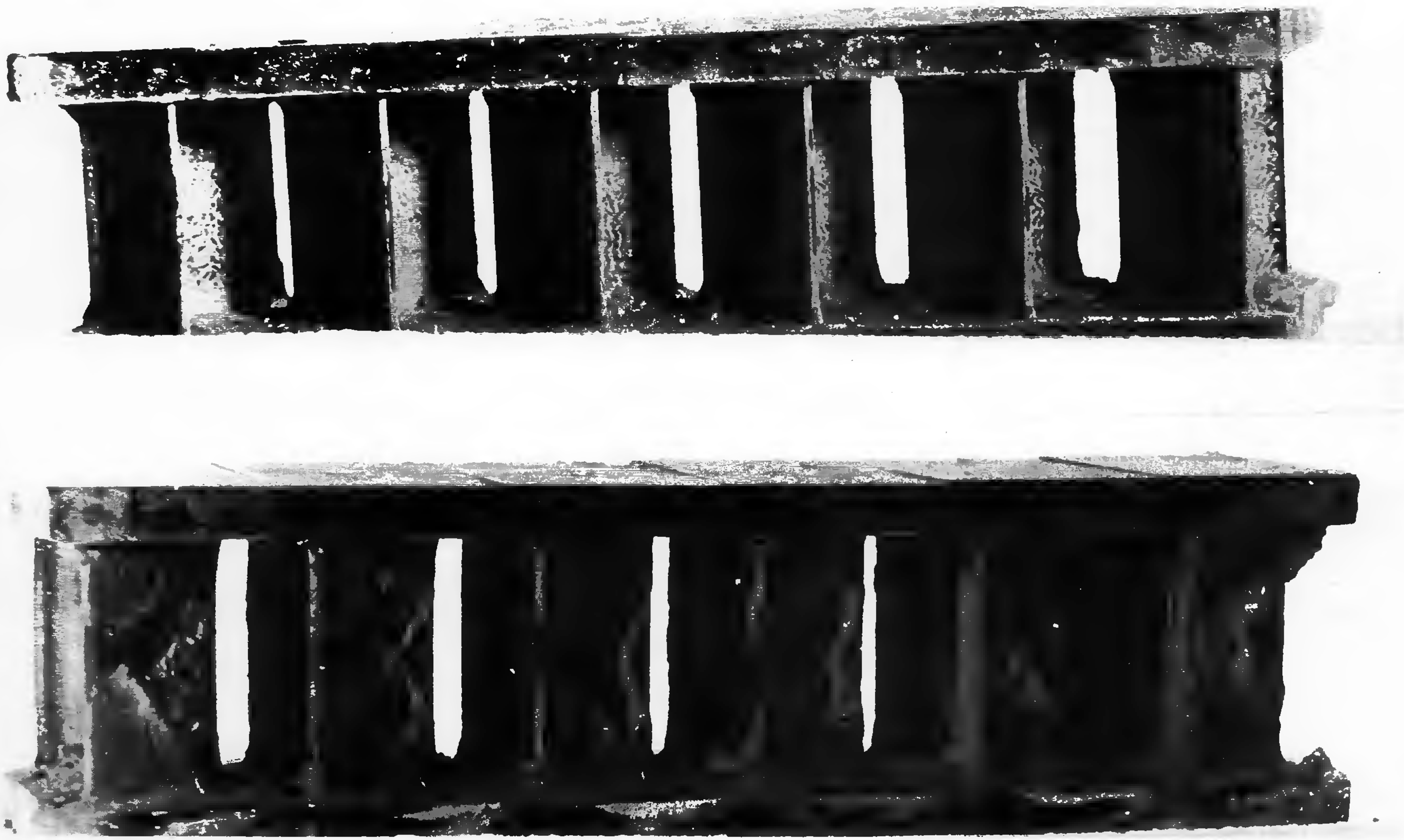


Figure A-2

View of the Leading and Trailing Edges of the Second Cascade

100 Hour Shakedown

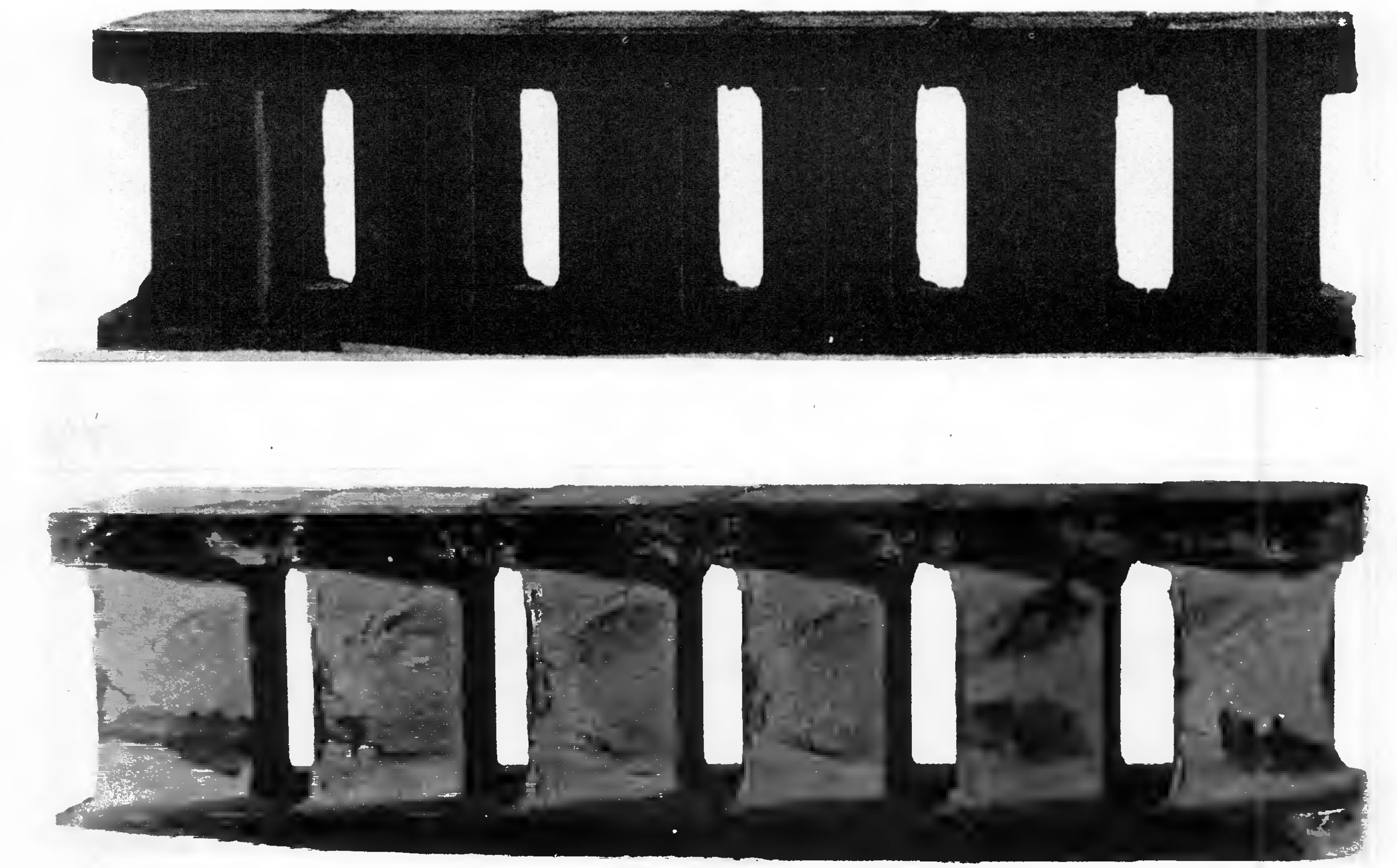


Figure A-3

View of the Leading and Trailing Edges of the Third Cascade

100 Hour Shakedown

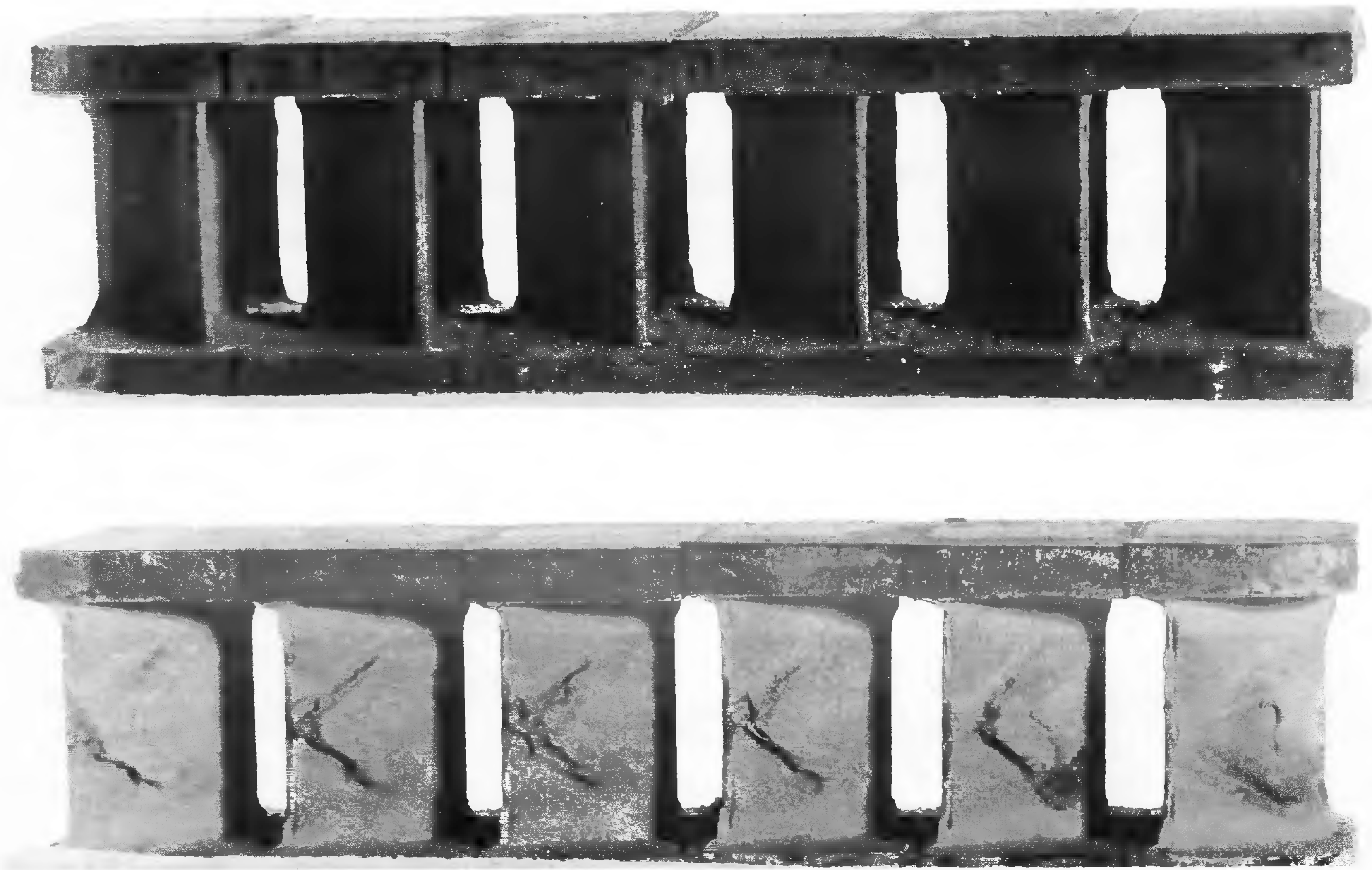
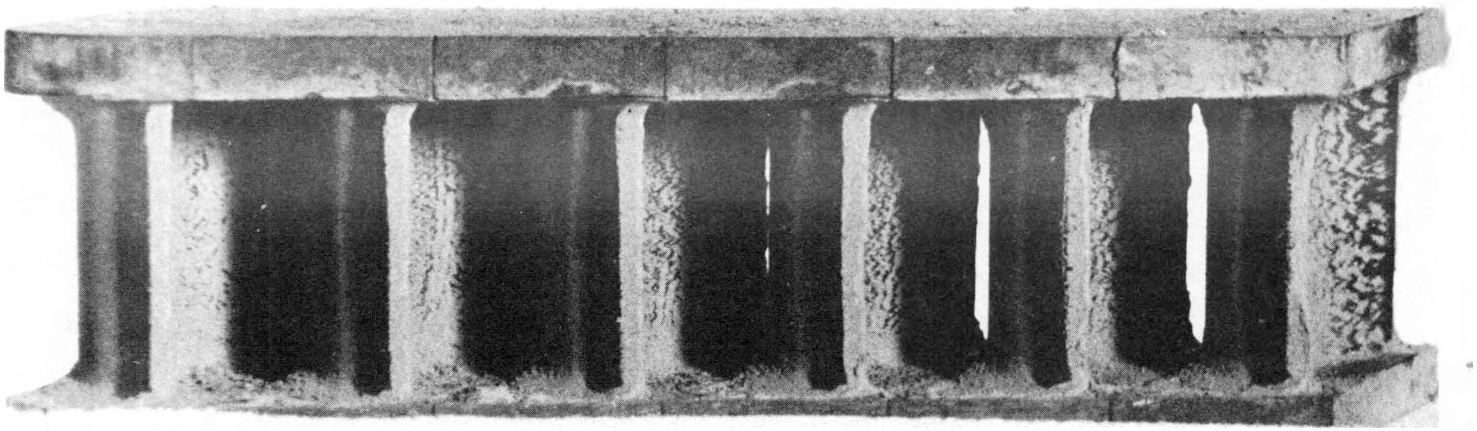


Figure A-4

View of the Leading and
Trailing Edges of the Fourth Cascade

100 Hour Shakedown



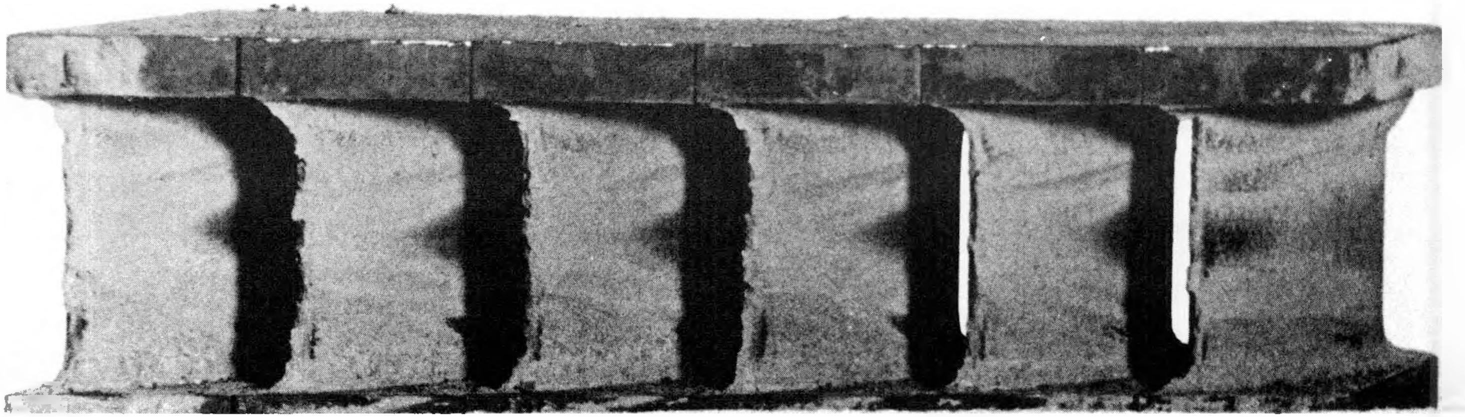


Figure A-5

Probe #1 1600°F In Bed (Shakedown Run 67)

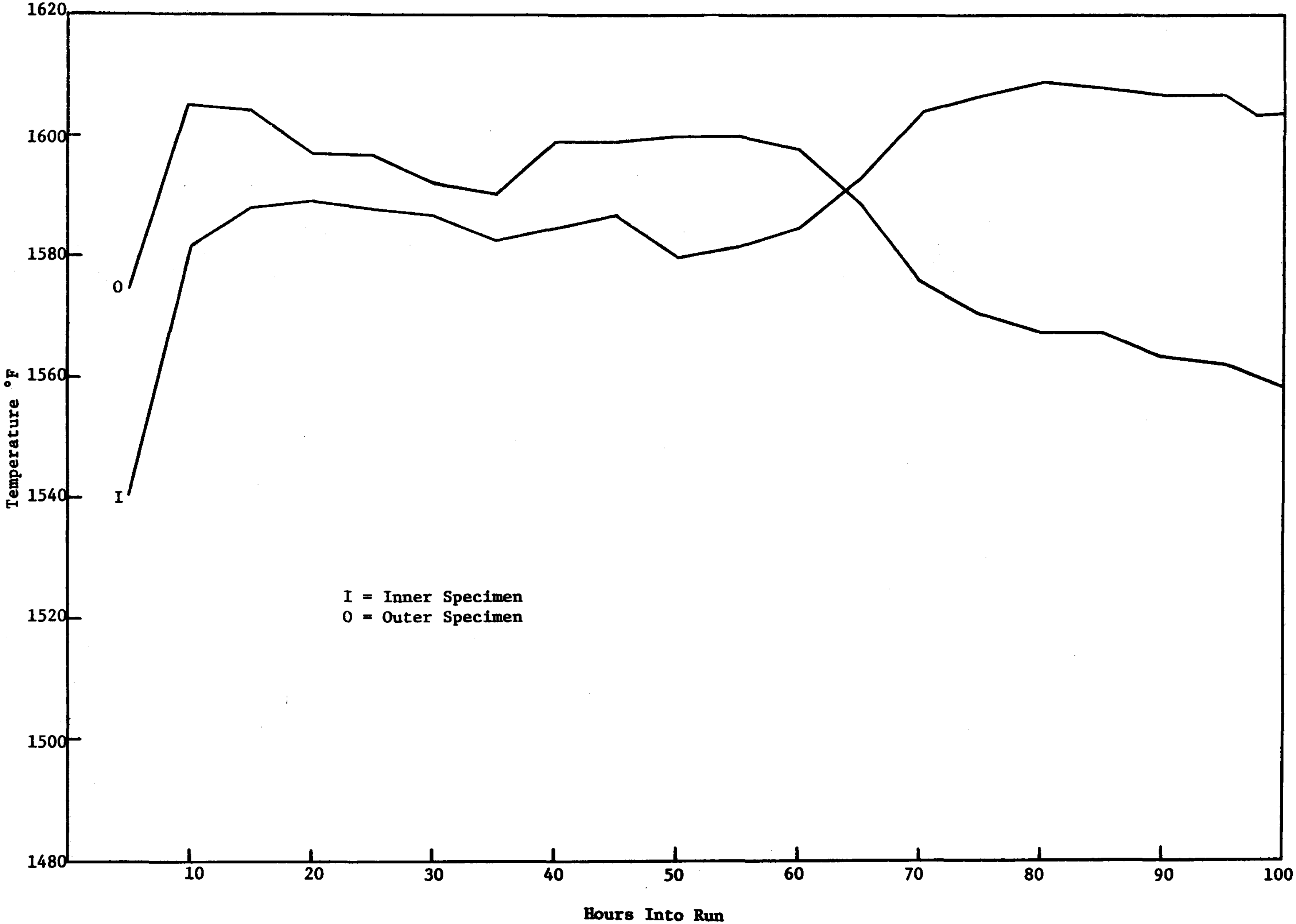


Figure A-6

Probe #13 1600°F Above Bed (Shakedown Run 67)

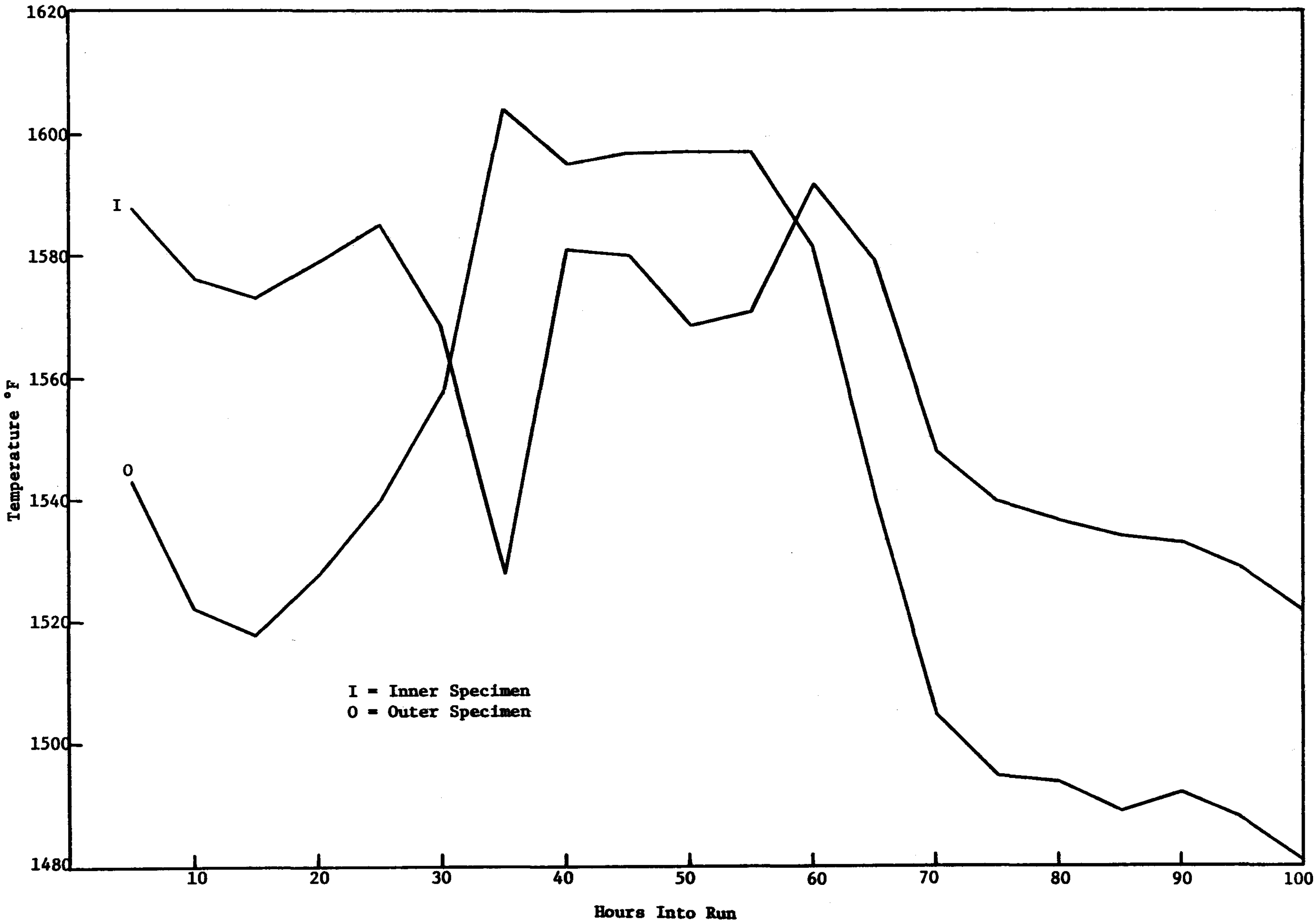


Figure A-7

Probe #6 1400°F In Bed (Shakedown Run 67)

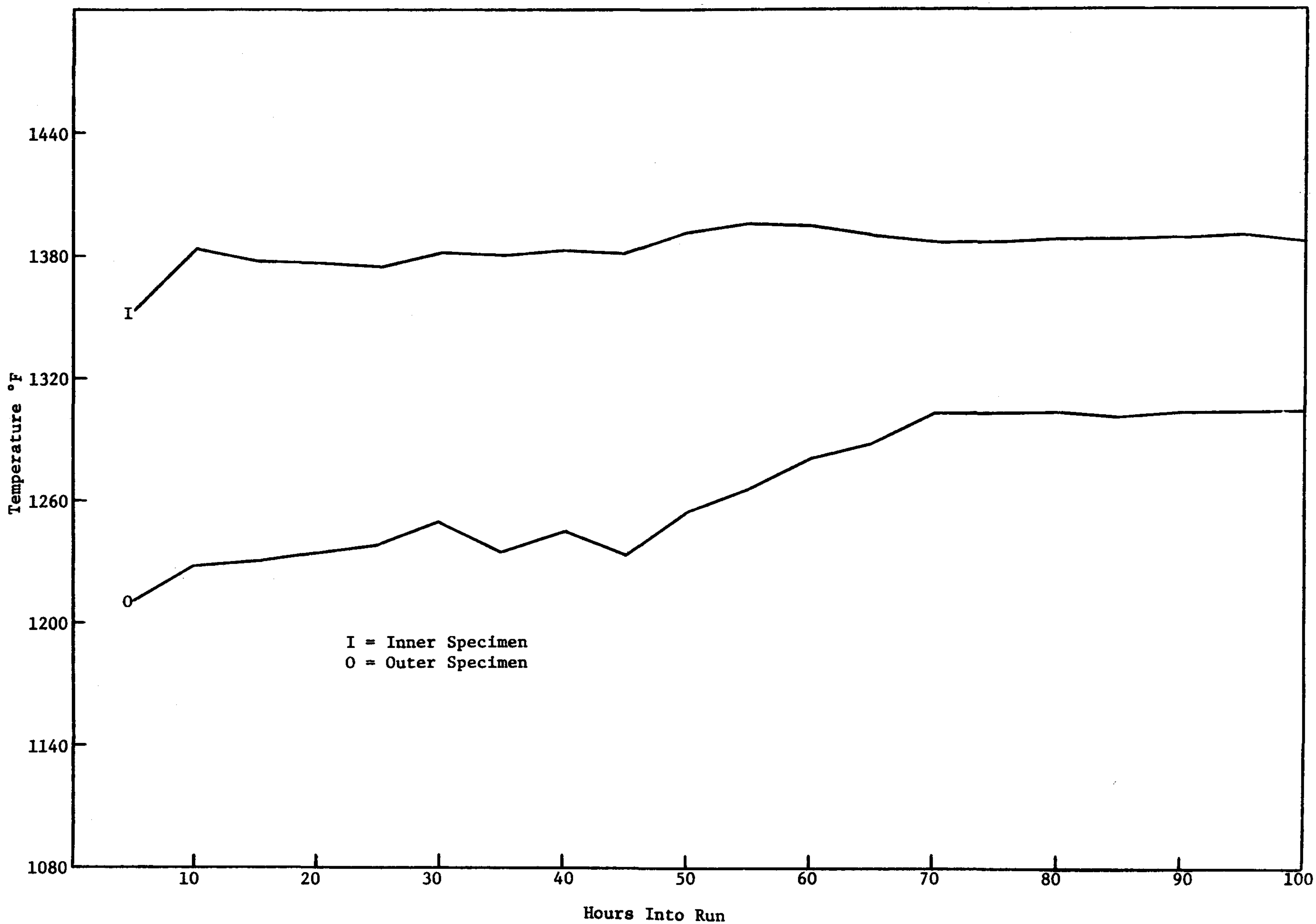


Figure A-8

Probe #14 1400°F Above Bed (Shakedown Run 67)

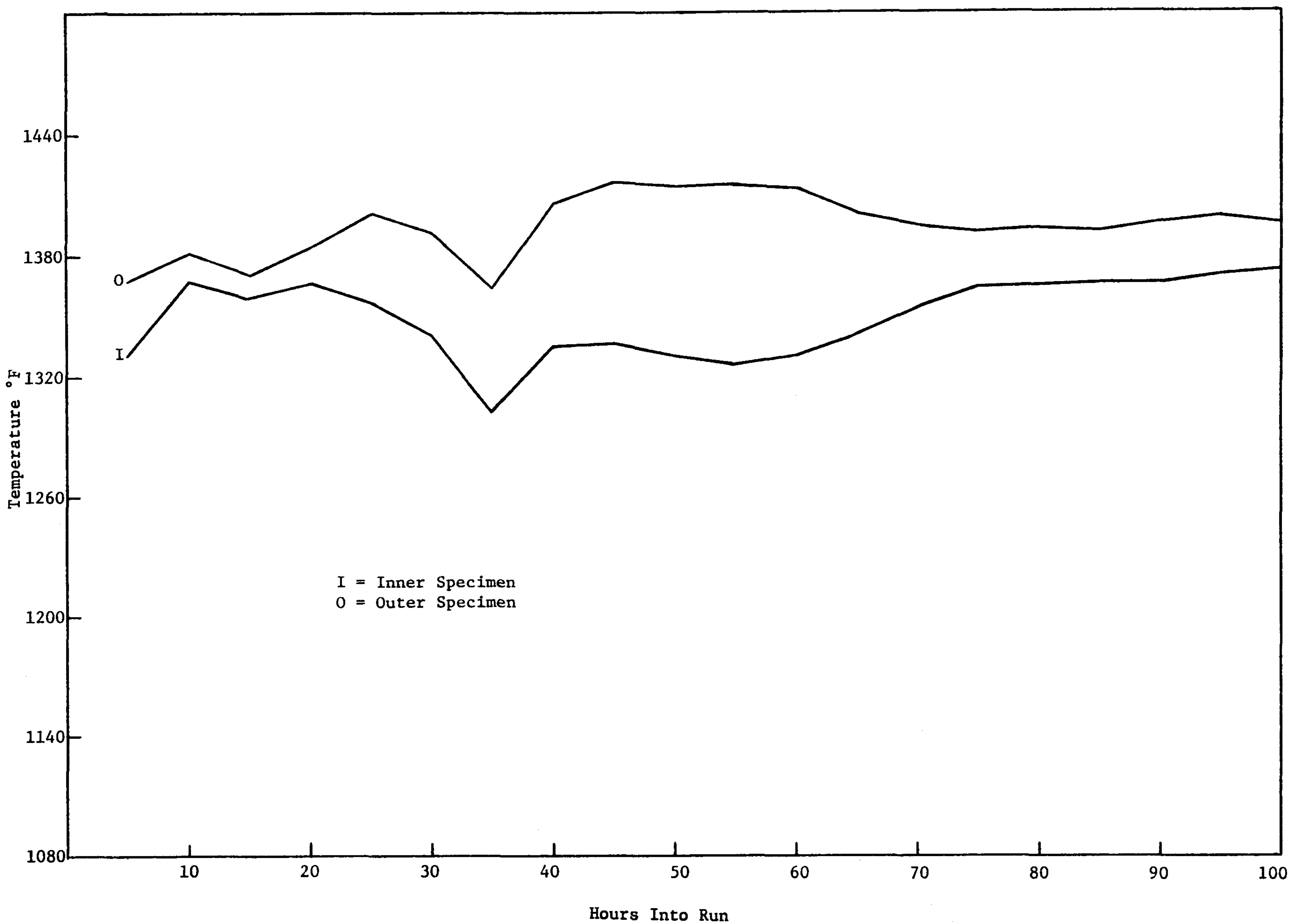


Figure A-9

Probe #11 1200°F In Bed (Shakedown Run 67)

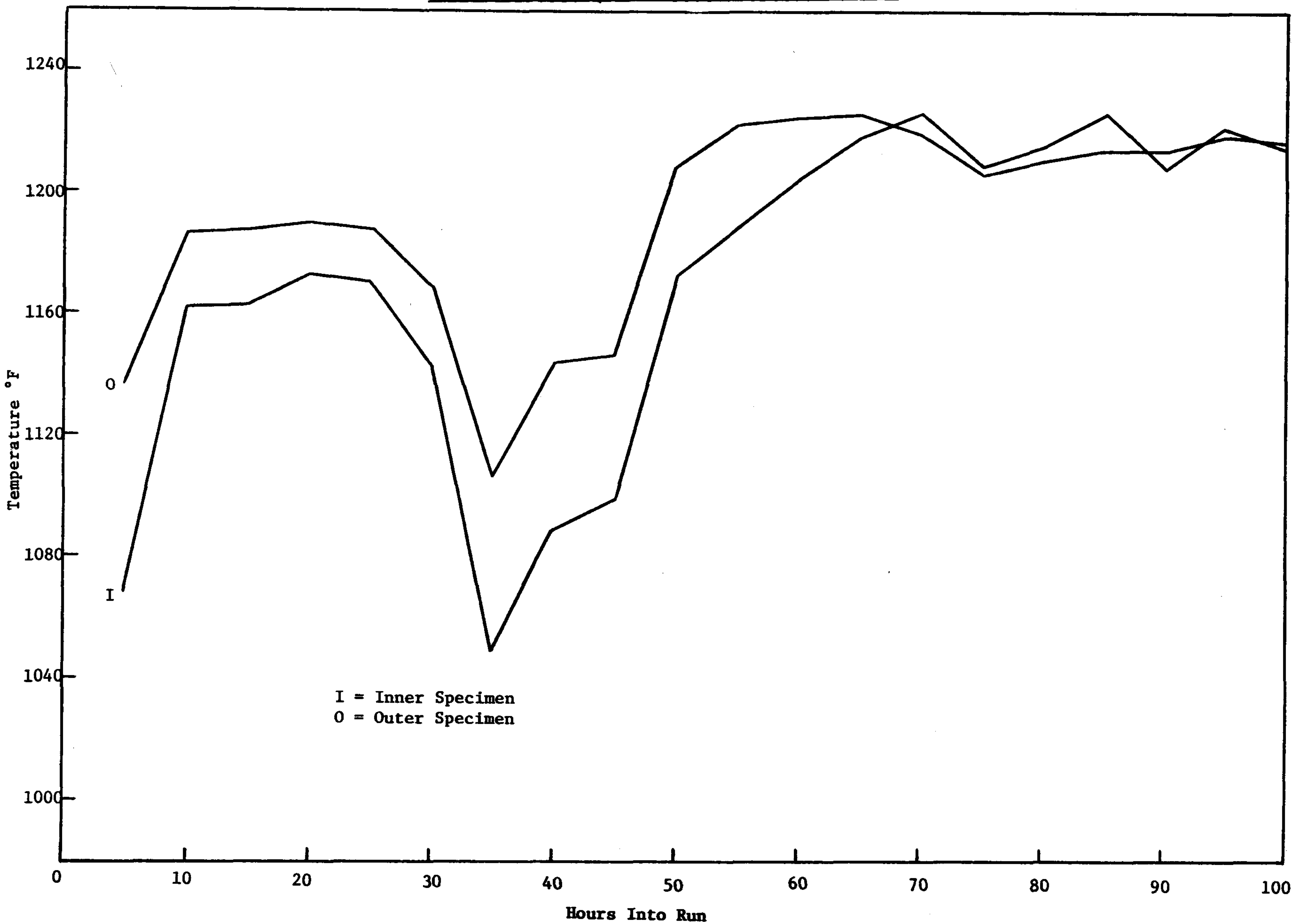


Figure A-10

Probe #20 1200°F Above Bed (Shakedown Run 67)

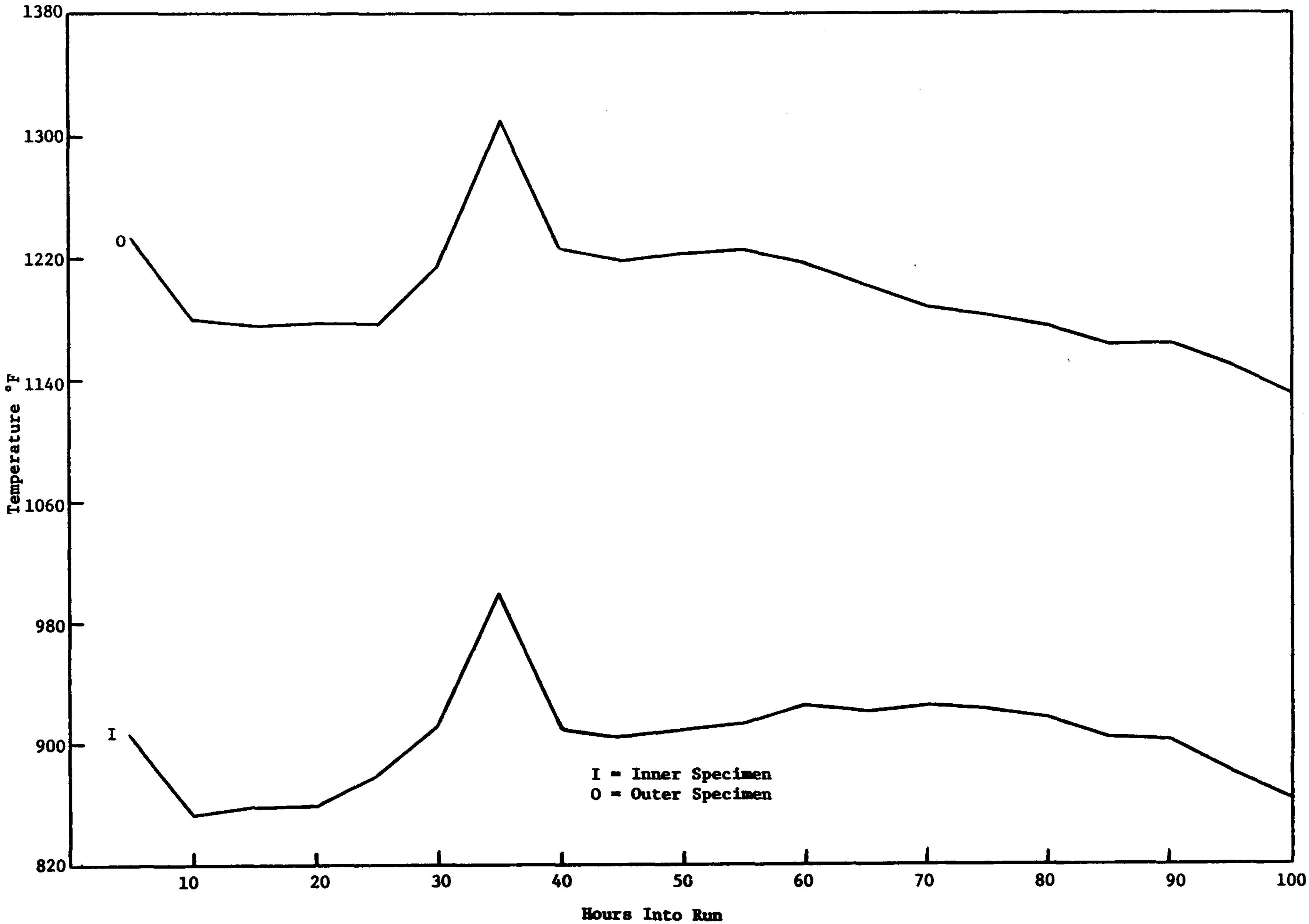


Figure A-11

Probe #8 1050°F In Bed (Shakedown Run 67)

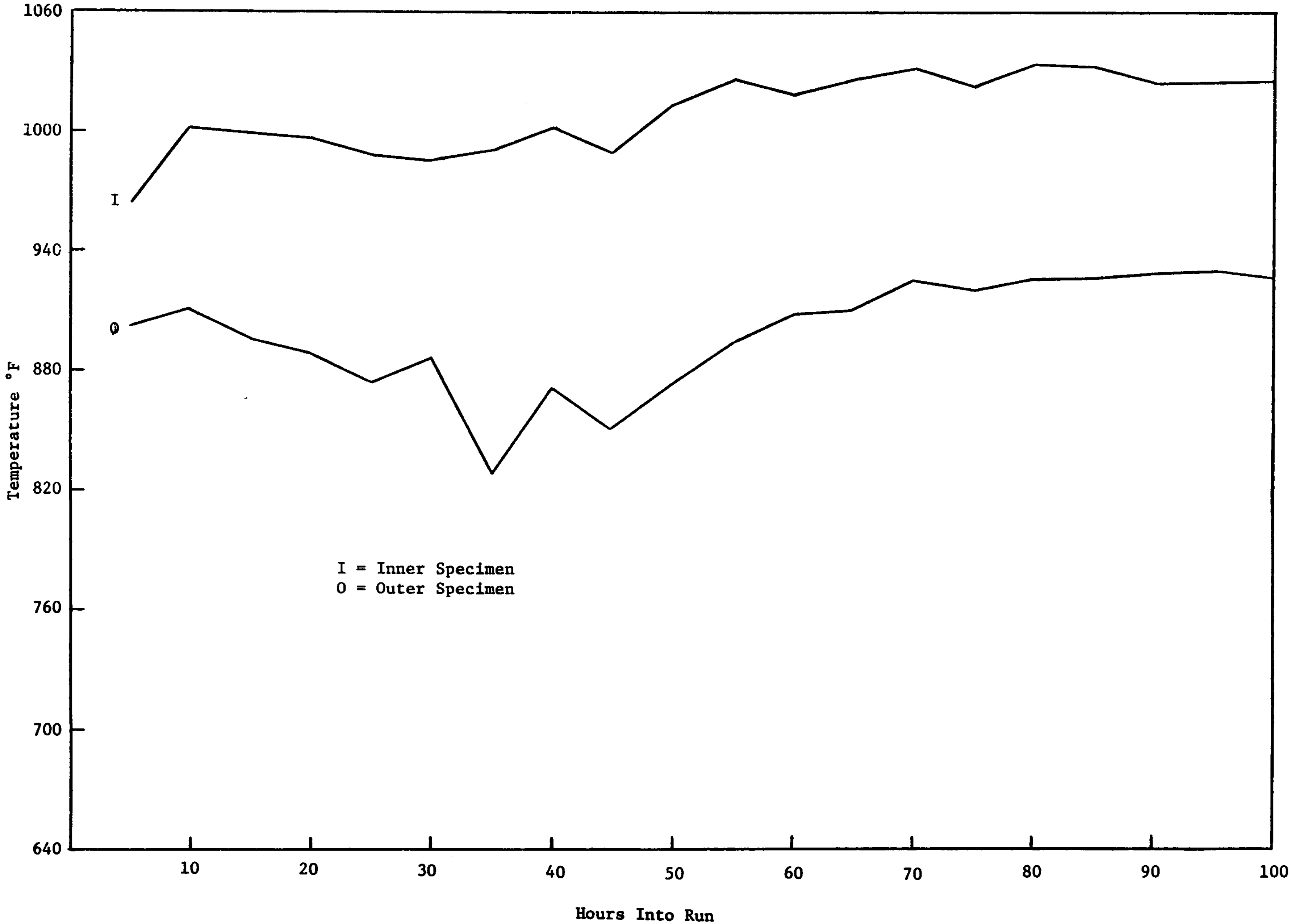


Figure A-12

1600°F In-Bed Probe (Top Side View)

After Shakedown

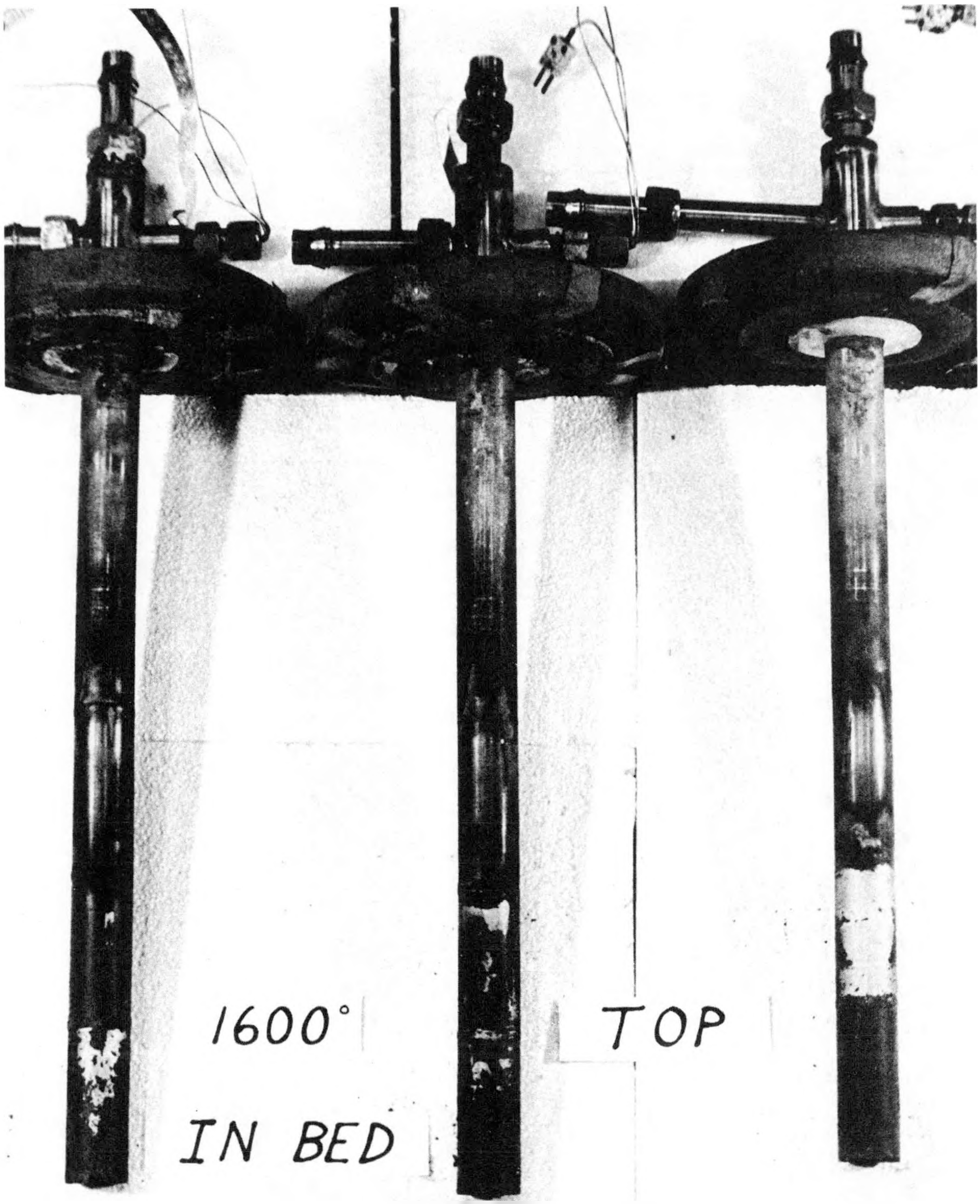


Figure A-13

1600°F Above-Bed Probe (Top Side View)

After Shakedown

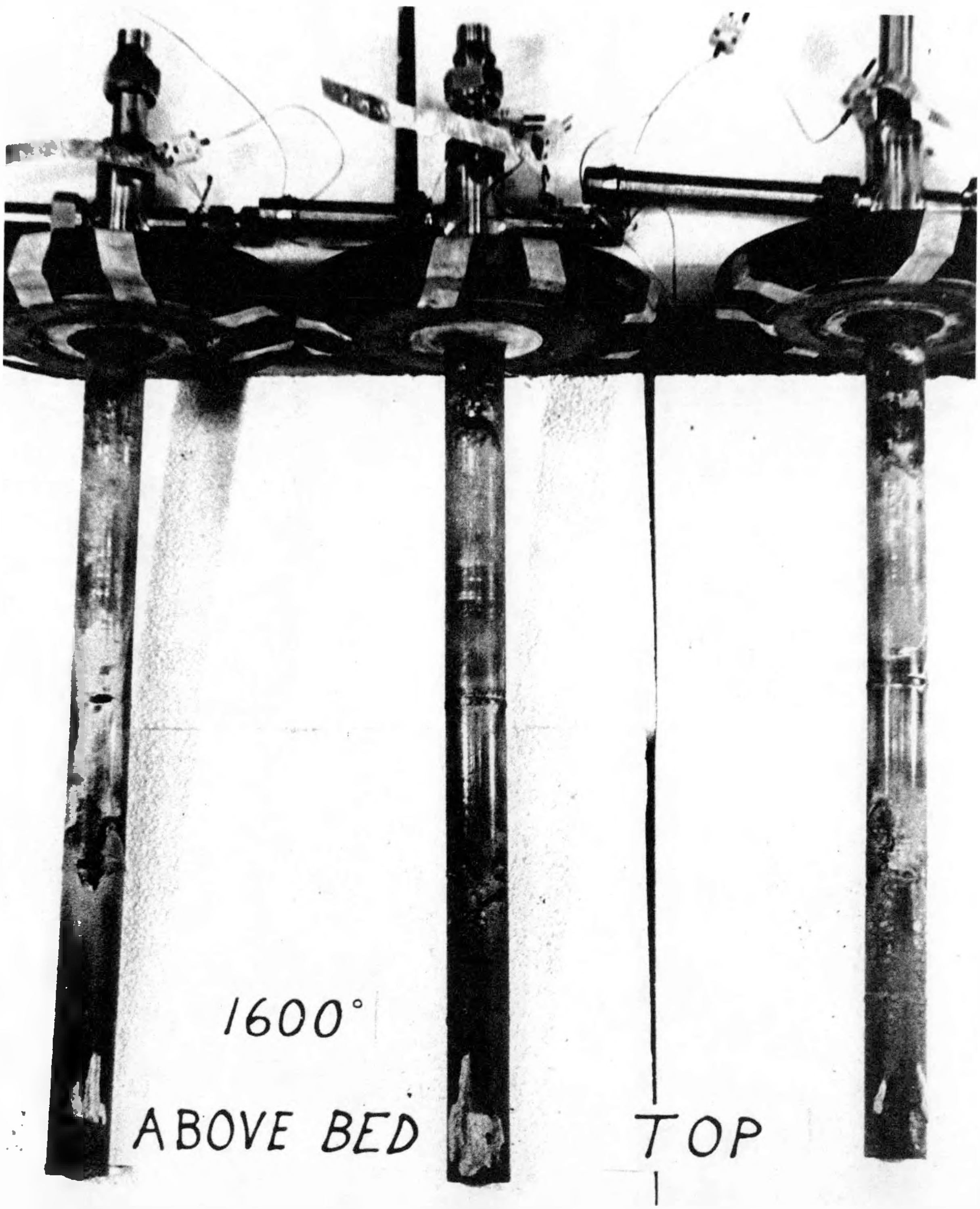


Figure A-14

1400°F In-Bed Probe (Bottom Side View)

After Shakedown

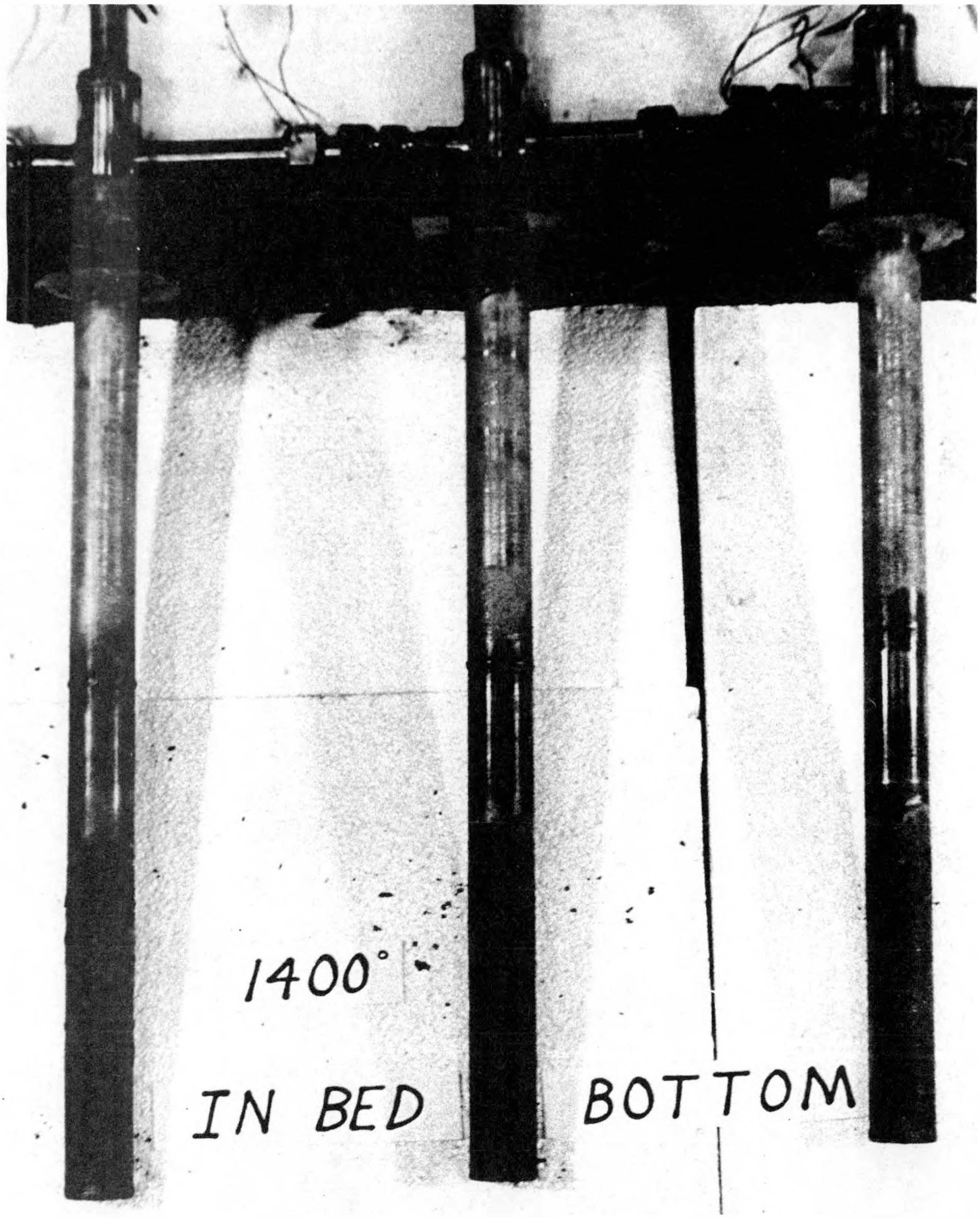


Figure A-15

1400°F Above Bed Probe (Top Side View)

After Shakedown

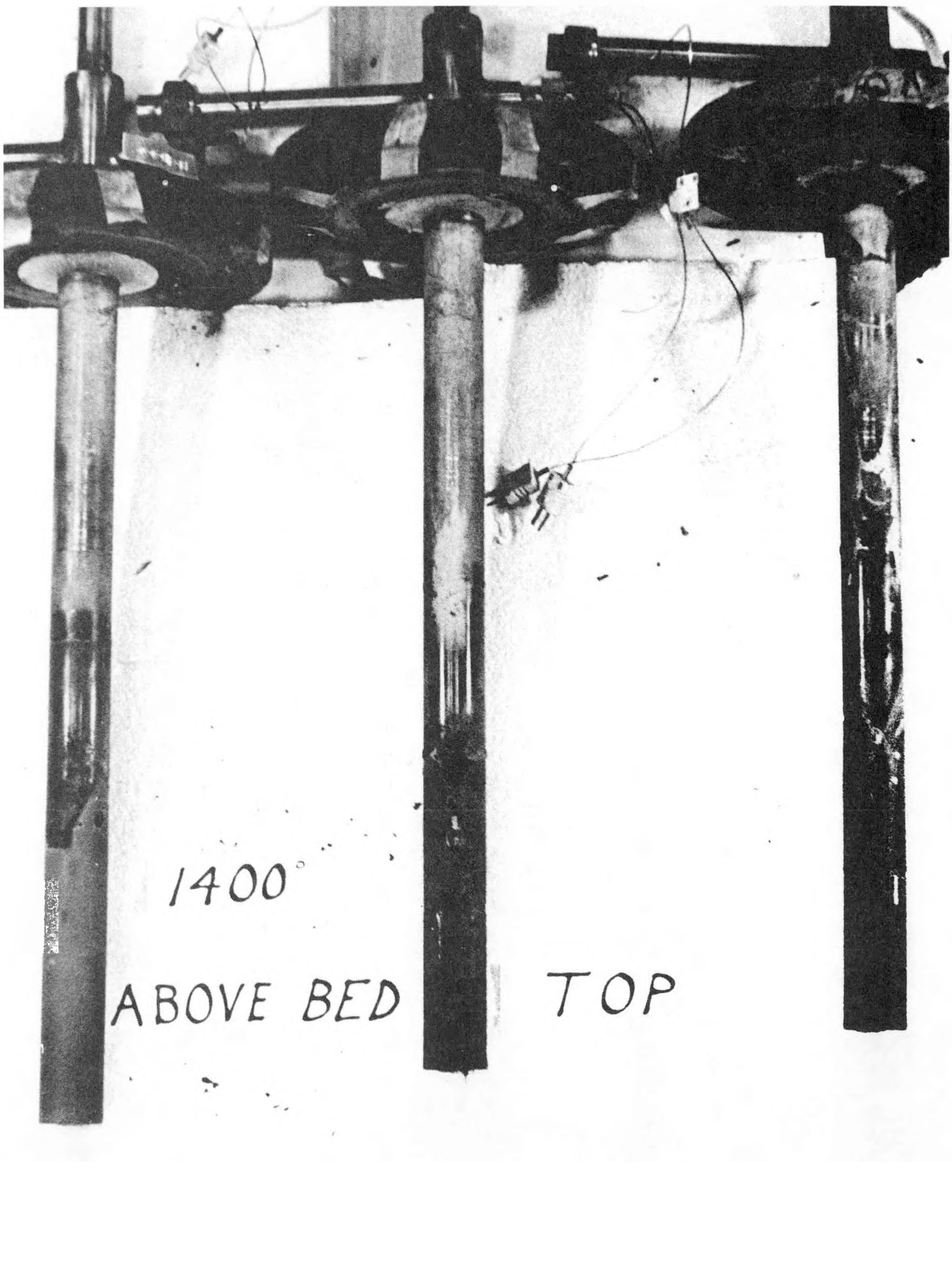


Figure A-16

1200°F In-Bed Probe (Bottom Side View)

After Shakedown

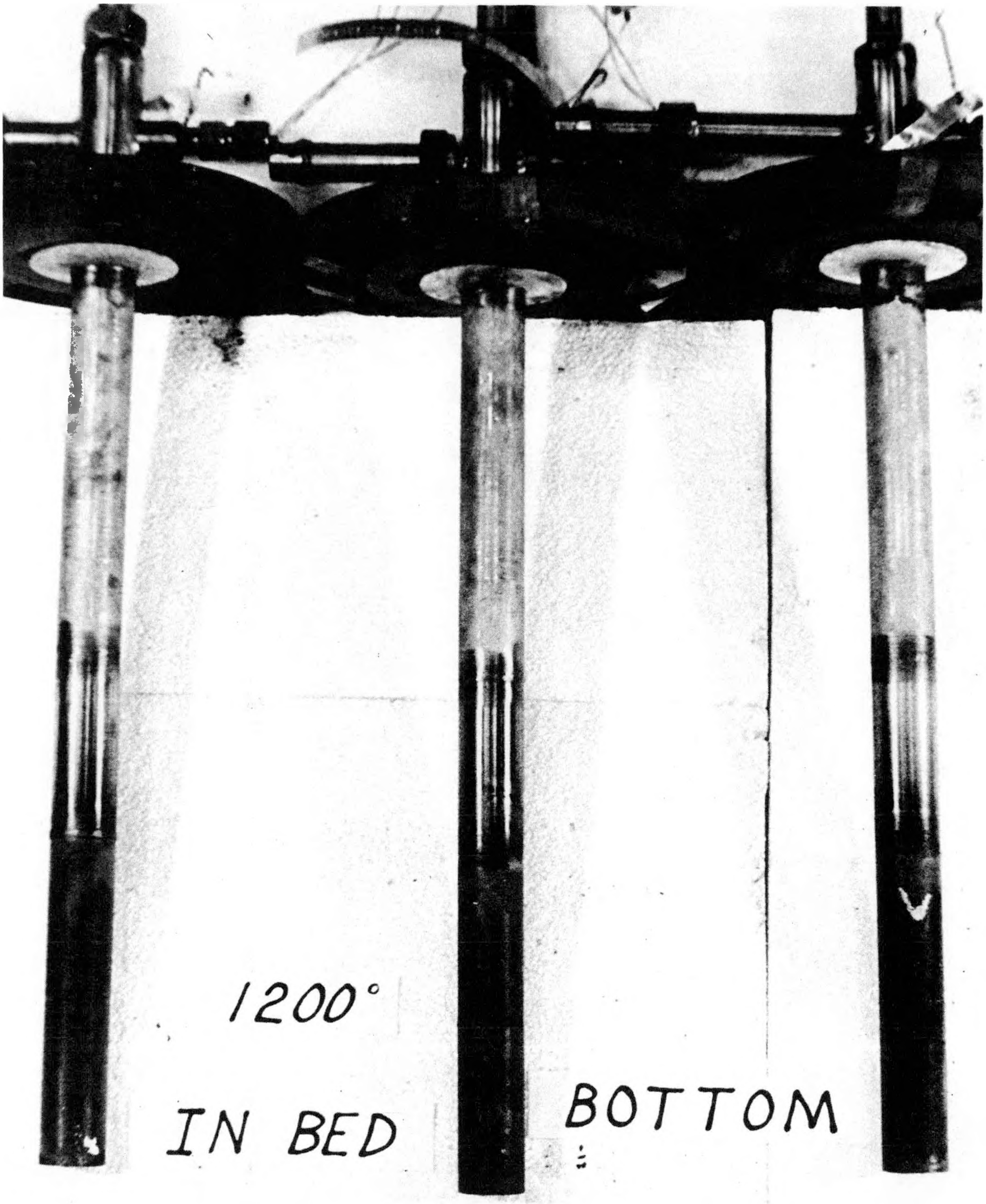


Figure A-17

1200°F Above-Bed Probe (Bottom Side View)

After Shakedown

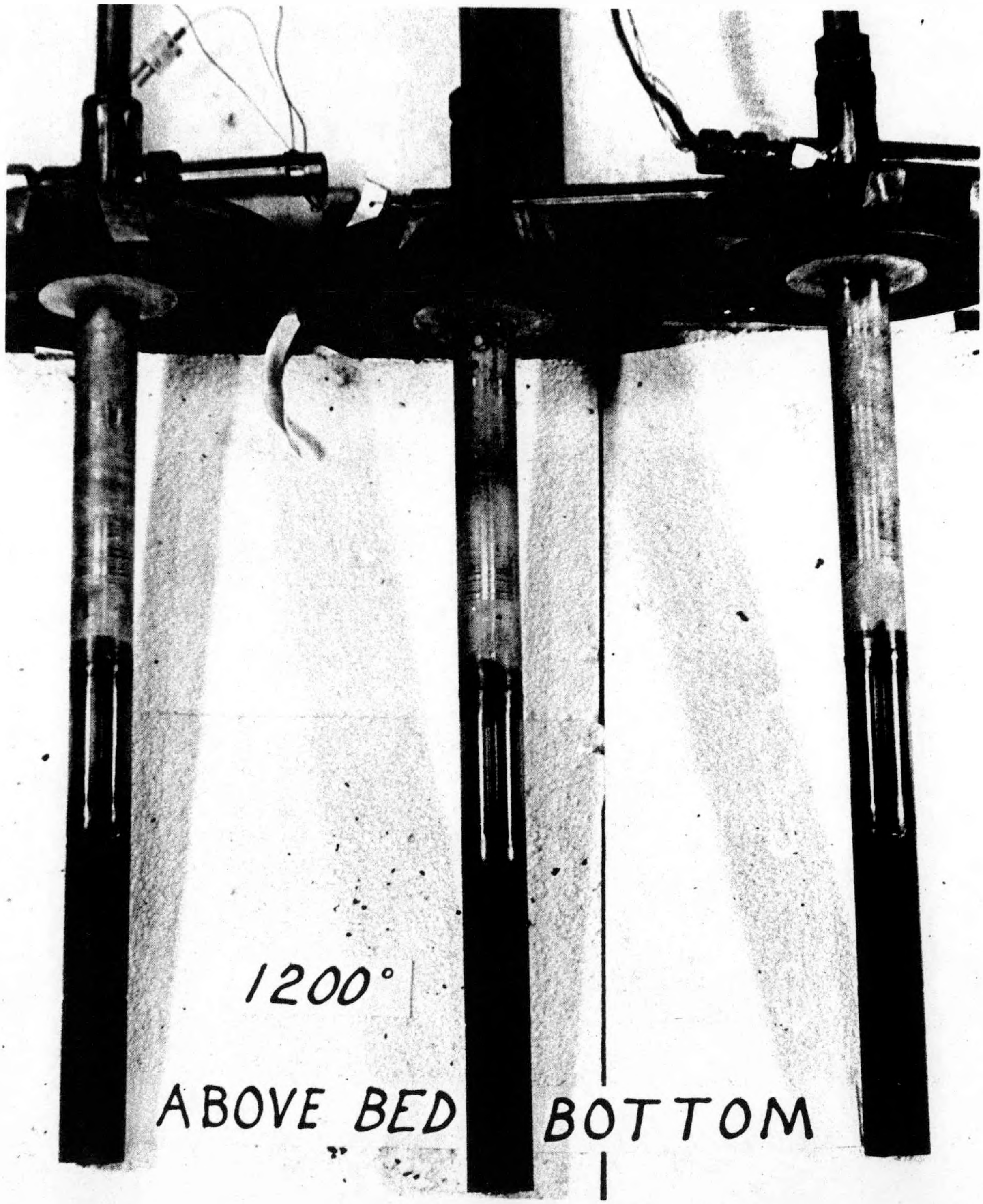


Figure A-18

1050°F In-Bed Probe (Bottom Side View)

After Shakedown

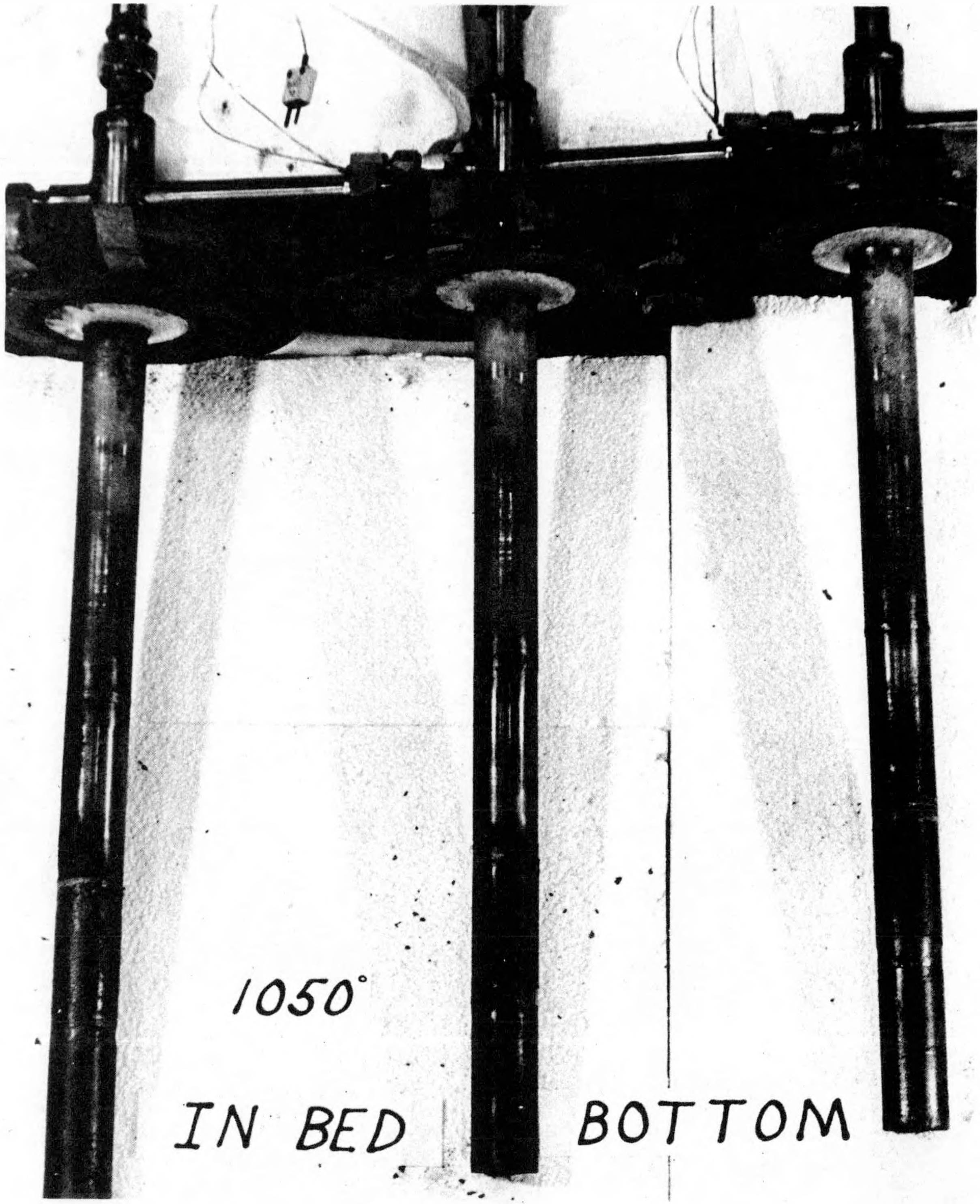


Table A-1

Heat Exchanger Probes Temperature History (Shakedown)

Control Temperature:	1600°F													1400°F												1200°F												1050°F				
Combustor Location:	In Bed						Above Bed						In Bed						Above Bed						In Bed						Above Bed						In Bed					
Port Number	1		3		5		13		15		17		2		4		6		14		16		18		7		9		11		19		20		22		8		10		12	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X	8	X	X	8	X	8	X	8	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9	9	2	9	2
5 Hour																																										
Avg. Temp. °F	1541	1575	1510	1568	1528	1575	1588	1543	1585	1531	1578	1518	1247	1383	1183	1386	1211	1353	1330	1368	1290	1413	1238	1436	1029	1162	1119	1057	1068	1138	954	1211	906	1233	855	1199	963	903	952		708	1045
Std. Dev.	54	44	58	39	55	32	12	13	13	13	14	12	22	15	21	22	20	59	35	22	14	8	39	29	38	42	75	81	73	49	18	21	49	24	28	26	11	18	7		13	14
Hi Temp. °F	1597	1609	1579	1598	1588	1601	1607	1560	1606	1552	1598	1538	1275	1405	1217	1393	1245	1410	1385	1395	1315	1428	1290	1473	1096	1225	1226	1165	1168	1205	978	1238	971	1263	945	1258	981	941	938		737	1075
Lo Temp. °F	1430	1496	1402	1502	1433	1522	1556	1508	1562	1499	1541	1499	1195	1353	1133	1326	1161	1241	1291	1340	1268	1402	1191	1395	966	1078	1010	956	986	1058	931	1179	849	1194	817	1147	927	848	965		680	1031
10 Hour																																										
Avg. Temp. °F	1581	1605	1551	1591	1574	1593	1576	1522	1569	1511	1561	1494	1269	1397	1194	1385	1229	1384	1368	1381	1294	1401	1195	1396	1086	1192	1195	1131	1162	1187	951	1164	853	1181	876	1112	1002	911	951		720	1032
Std. Dev.	11	3	16	5	13	3	11	10	10	10	10	10	12	5	19	5	19	14	11	4	11	4	4	6	14	28	15	13	19	8	8	7	7	6	6	11	22	34	7		11	5
Hi Temp. °F	1605	1613	1590	1607	1600	1599	1601	1547	1593	1536	1584	1518	1289	1407	1225	1395	1283	1407	1386	1383	1314	1407	1206	1409	1107	1229	1221	1159	1199	1201	970	1181	867	1197	886	1146	1090	996	970		745	1039
Lo Temp. °F	1565	1594	1519	1583	1551	1588	1555	1505	1550	1496	1543	1478	1253	1387	1154	1378	1193	1366	1345	1375	1272	1395	1188	1384	1057	1149	1163	1114	1123	1175	943	1151	840	1174	858	1100	979	872	942		697	1023
15 Hour																																										
Avg. Temp. °F	1588	1604	1557	1589	1576	1591	1573	1518	1566	1506	1558	1489	1274	1398	1198	1385	1235	1377	1367	1371	1298	1396	1193	1387	1092	1167	1200	1133	1163	1187	967	1151	859	1178	876	1105	999	896	953		726	1031
Std. Dev.	11	4	19	4	12	3	8	7	8	7	7	6	11	6	16	5	18	5	13	2	10	3	4	3	15	9	18	9	20	8	7	3	4	2	4	4	12	12	6		15	6
Hi Temp. °F	1607	1610	1599	1596	1606	1596	1590	1533	1582	1523	1573	1503	1301	1407	1227	1395	1288	1388	1384	1374	1313	1401	1203	1393	1120	1182	1219	1151	1202	1202	978	1156	865	1181	884	1119	1024	921	966		758	1043
Lo Temp. °F	1560	1587	1528	1576	1549	1587	1558	1505	1552	1494	1544	1477	1260	1387	1171	1375	1211	1367	1351	1366	1283	1392	1188	1381	1056	1150	1165	1120	1133	1173	955	1145	852	1173	869	1099	985	868	940		698	1020
20 Hour																																										
Avg. Temp. °F	1589	1597	1565	1591	1579	1590	1579	1528	1571	1515	1563	1497	1273	1398	1200	1385	1230	1377	1359	1385	1286	1395	1193	1387	1097	1172	1192	1138	1173	1190	959	1150	859	1178	878	1113	996	889	952		726	1032
Std. Dev.	9	3	15	3	10	3	7	7	7	7	7	6	10	6	15	11	17	4	12	9	10	2	4	3	11	10	15	9	16	8	7	3	6	4	19	5	14	11	7		11	7
Hi Temp. °F	1602	1601	1598	1598	1604	1594	1597	1541	1589	1528	1580	1510	1292	1409	1229	1395	1258	1383	1376	1400	1304	1401	1201	1391	1114	1192	1219	1154	1197	1208	976	1155	870	1181	975	1130	1024	907	969		742	1048
Lo Temp. °F	1573	1590	1536	1586	1560	1584	1565	1512	1557	1500	1550	1483	1254	1389	1174	1378	1205	1371	1351	1373	1270	1392	1183	1382	1079	1157	1156	1122	1144	1174	947	1144	849	1167	869	1105	976	862	941		697	1017
25 Hour																																										
Avg. Temp. °F	1588	1597	1555	1589	1578	1590	1585	1540	1577	1527	1568	1509	1272	1399	1206	1388	1238	1375	1357	1401	1278	1395	1194	1381	1095	1190	1204	1148	1171	1188	969	1169	880	1179	904	1135	988	874	954		726	1031
Std. Dev.	7	2	13	3	10	3	6	6	6	6	6	7	9	5	12	5	13	5	8	3	11	3	4	4	13	10	16	13	15	7	24	18	18	13	34	26	17	12	7		11	6
Hi Temp. °F	1598	1600	1576	1595	1592	1598	1598	1554	1590	1541	1581	1523	1288	1409	1226	1396	1259	1384	1370	1407	1295	1400	1201	1390	1117	1213	1233	1172	1195	1202	1014	1203	913	1204	968	1186	1022	900	966		742	1043
Lo Temp. °F	1576	1591	1529	1584	1552	1584	1575	1529	1567	1514	1558	1496	1256	1388	1188	1378	1207	1364	1341	1395	1250	1389	1188	1373	1066	1172	1168	1120	1139	1174	946	1147	864	1166	872	1112	960	855	940		697	1020
30 Hour																																										
Avg. Temp. °F	1587	1592	1561	1588	1583	1593	1568	1558	1577	1550	1565	1533	1272	1392	1201	1390	1250	1382	1341	1391	1235	1409	1198	1397	1085	1174	1179	1128	1143	1169	1000	1213	913	1215	967	1221	985	886	951		732	1028
Std. Dev.	10	8	19	4	18	6	45	25	11	31	17	34	17	12	29	5	24	10	31	22	37	17	15	21	30	58	43	53	67	45	17	36	13	30	20	59	20	21	13		27	19
Hi Temp. °F	1604	1600	1595	1594	1615	1601	1598	1606	1590	1610	1581	1603	1292	1406	1240	1396	1279	1402	1366	1411	1284	1446	1214	1439	1119	1223	1232	1169	1198	1210	1026	1299	950	1283	982	1344	1041	940	972		789	1055
Lo Temp. °F	1576	1578	1522	1583	1554	1582	1443	1535	1547	1524	1523	1506	1228	1357	1147	1378	1207	1366	1274	1352	1160	1392	1166	1376	1033	1050	1103	1023	1016	1086	954	1190	898	1195	923	1186	958	860	929		682	994
35 Hour																																										
Avg. Temp. °F	1583	1590	1545	1590	1564	1593	1528	1604	1578	1605	1549	1603	1189	1371	1162	1384	1235	1380	1303	1364	1197	1437	1164	1425	1042	1094	1149	1049	1049	1107	1075	1321	997	1312	1013	1371	990	829	934		688	1054
Std. Dev.	5	5	15	4	13	8	20	4	13	7	17	8	29	27	14	6	10	3	13	11	16	9	15	5	11	48	21	37	23	18	67	53	57	44	50	42	18	39	14		10	14
Hi Temp. °F	1593	1597	1565	1596	1582	1604	1564	1613	1599	1618	1577	1613	1235	1409	1186	1395	1260	1384	1327	1389	1221	1454	1190	1432	1074	1168	1183	1110	1076	1138	1173	1391	1084	1367	1093	1428	1033	906	956		709	1072
Lo Temp. °F	1576	1583	1521	1581	1546	1574	1505	1597	1555	1592	1518	1586	1136	1330	1144	1376	1224	1374	1279	1351	1164	1422	1143	1417	1031	1002	1116	994	1010	1080	957	1228	906	1237	948	1295	963	781	913		673	1030
40 Hour																																										
Avg. Temp. °F	1585	1599	1546	1595	1573	1603	1581	1595	1607	1589	1585	1578	1124	1339	1194	1396	1245	1383	1335	1406	1237	1416	1204	1398	1079	1192	1154	1105	1089	1144	972	1236	910	1227	933	1252	1003	872	957		714	1033
Std. Dev.	7	2	13	3	8	2	16	3	6	6	6	4	96	63	24	6	10	4	4	8	6	3	7	10	12	18	13	12	17	7	7	6	6	6	19	24	14	10	7		8	5
Hi Temp. °F	1595	1603	1566	1600	1586	1608	1604	1598	1619	1597	1597	1585	1273	1418	1234	1405	1259	1389	1344	1416	1247	1422	1219	1418	1103	1226	1178	1125	1112	1158	982	1245	918	1236	963	1283	1026	888	969		726	1040
Lo Temp. °F	1575	1596	1520	1590	1559	1599	1543	1587	1599	1576	1576	1571	1013	1254	1166	1383	1232	1375	1330	1394	1229	1411	1196	1387	1064	1167	1135	1084	1060	1135	957	1225	899	1219	911	1221	973	851	946		700	1023

Table A-1 (Cont'd)

Heat Exchanger Probes Temperature History (Shakedown)

Control Temperature:	1600°F												1400°F					
Combustor Location:	In Bed						Above Bed						In Bed					
Port Number	1		3		5		13		15		17		2		4		6	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X	8	X	X	8	X	8
45 Hour																		
Avg. Temp. °F	1587	1599	1545	1596	1575	1604	1580	1597	1606	1592	1586	1580	1101	1330	1195	1392	1233	1381
Std. Dev.	8	1	11	2	8	3	22	3	5	5	6	5	13	12	20	7	8	5
Hi Temp. °F	1599	1602	1566	1599	1587	1610	1602	1601	1615	1598	1597	1586	1124	1346	1232	1407	1246	1391
Lo Temp. °F	1566	1597	1523	1590	1563	1600	1539	1591	1597	1581	1577	1568	1082	1304	1160	1382	1221	1373
50 Hour																		
Avg. Temp. °F	1580	1600	1542	1597	1573	1605	1569	1597	1607	1594	1598	1582	1195	1391	1203	1395	1254	1391
Std. Dev.	7	2	12	3	8	2	22	3	6	4	7	5	118	114	17	9	16	7
Hi Temp. °F	1593	1603	1565	1603	1585	1608	1599	1602	1620	1600	1613	1590	1248	1435	1223	1408	1282	1400
Lo Temp. °F	1570	1596	1520	1593	1558	1601	1523	1592	1598	1588	1588	1574	785	996	1173	1379	1223	1377
55 Hour																		
Avg. Temp. °F	1582	1600	1543	1596	1572	1604	1571	1597	1607	1592	1592	1579	1228	1419	1208	1398	1266	1396
Std. Dev.	6	2	15	2	10	2	27	4	9	8	25	9	5	5	15	3	14	6
Hi Temp. °F	1594	1603	1567	1601	1586	1608	1609	1602	1622	1602	1615	1591	1239	1430	1234	1403	1296	1407
Lo Temp. °F	1574	1597	1522	1593	1557	1601	1528	1586	1590	1572	1582	1557	1218	1400	1188	1390	1247	1389
60 Hour																		
Avg. Temp. °F	1585	1598	1555	1598	1581	1603	1592	1581	1601	1569	1593	1555	1236	1413	1230	1401	1281	1395
Std. Dev.	8	3	12	3	11	2	20	14	9	18	9	19	10	5	22	4	16	4
Hi Temp. °F	1600	1601	1576	1603	1603	1607	1609	1599	1617	1595	1610	1583	1254	1420	1258	1407	1305	1400
Lo Temp. °F	1574	1592	1535	1593	1568	1600	1544	1558	1586	1544	1577	1529	1226	1404	1181	1395	1258	1388
65 Hour																		
Avg. Temp. °F	1593	1589	1567	1594	1593	1599	1579	1541	1572	1527	1563	1512	1245	1407	1243	1393	1289	1390
Std. Dev.	7	10	19	7	7	8	18	18	17	19	17	18	6	5	19	6	15	4
Hi Temp. °F	1602	1597	1600	1603	1606	1605	1597	1563	1590	1547	1581	1532	1254	1417	1281	1403	1314	1396
Lo Temp. °F	1579	1556	1526	1571	1582	1574	1531	1493	1525	1478	1516	1465	1231	1399	1221	1382	1270	1382
70 Hour																		
Avg. Temp. °F	1604	1576	1583	1583	1603	1588	1548	1505	1540	1487	1531	1475	1254	1407	1261	1392	1303	1388
Std. Dev.	6	7	9	6	7	6	8	8	8	9	8	8	8	4	22	5	25	5
Hi Temp. °F	1614	1587	1597	1588	1611	1595	1558	1518	1551	1500	1542	1487	1270	1411	1297	1398	1344	1395
Lo Temp. °F	1593	1559	1564	1567	1586	1574	1531	1488	1524	1470	1516	1458	1243	1399	1221	1380	1269	1381
75 Hour																		
Avg. Temp. °F	1607	1571	1580	1578	1605	1585	1540	1495	1533	1476	1524	1464	1255	1407	1258	1390	1303	1388
Std. Dev.	6	5	18	4	7	4	5	4	5	5	5	4	6	4	13	4	16	6
Hi Temp. °F	1620	1581	1600	1585	1616	1590	1551	1503	1544	1485	1535	1473	1263	1415	1274	1397	1337	1399
Lo Temp. °F	1599	1564	1541	1574	1592	1579	1532	1487	1524	1467	1515	1456	1245	1400	1239	1384	1276	1378
80 Hour																		
Avg. Temp. °F	1609	1568	1586	1575	1608	1582	1537	1494	1530	1475	1520	1463	1258	1407	1263	1391	1304	1389
Std. Dev.	7	6	15	6	6	7	6	6	6	6	6	6	4	4	13	3	18	3
Hi Temp. °F	1621	1579	1604	1582	1617	1592	1543	1501	1536	1482	1526	1468	1268	1414	1284	1397	1334	1393
Lo Temp. °F	1595	1557	1555	1563	1592	1569	1524	1480	1518	1462	1509	1449	1252	1401	1240	1386	1277	1385

Control Temperature:	1400°F						1200°F												1050°F					
Combustor Location:	Above Bed						In Bed						Above Bed						In Bed					
Port Number	14		16		18		7		9		11		19		20		22		8		10		12	
Hours Into Run \ Specimen	X	8	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9	9	2	9	2
45 Hour																								
Avg. Temp. °F	1336	1417	1234	1417	1199	1389	1077	1194	1162	1111	1100	1147	972	1218	905	1219	909	1225	989	852	957		714	1033
Std. Dev.	3	6	8	5	4	3	8	18	24	14	23	21	7	15	6	4	14	12	18	11	6		6	5
Hi Temp. °F	1340	1429	1249	1423	1210	1393	1089	1218	1193	1132	1144	1182	985	1244	914	1226	924	1246	1016	870	968		725	1045
Lo Temp. °F	1329	1408	1218	1407	1192	1385	1066	1149	1127	1092	1068	1134	961	1193	892	1214	883	1210	958	829	949		699	1026
50 Hour																								
Avg. Temp. °F	1330	1415	1232	1418	1207	1393	1122	1211	1204	1148	1173	1209	969	1208	909	1223	890	1216	1014	874	991		717	1030
Std. Dev.	7	5	8	4	6	4	35	25	21	17	34	22	4	4	5	5	6	12	17	14	24		11	4
Hi Temp. °F	1341	1425	1245	1425	1216	1400	1157	1245	1237	1167	1221	1234	977	1214	916	1230	899	1233	1040	892	1015		742	1036
Lo Temp. °F	1322	1404	1218	1412	1193	1386	1051	1150	1157	1112	1101	1156	963	1202	899	1215	882	1197	978	851	945		704	1022
55 Hour																								
Avg. Temp. °F	1326	1416	1229	1420	1197	1391	1136	1229	1213	1152	1189	1223	975	1186	913	1226	890	1225	1026	895	1006		720	1032
Std. Dev.	5	4	10	4	7	3	12	12	17	11	20	7	8	13	8	5	11	14	17	12	7		12	5
Hi Temp. °F	1331	1421	1244	1427	1213	1400	1159	1250	1232	1176	1222	1237	986	1217	923	1242	919	1257	1063	917	1015		740	1042
Lo Temp. °F	1315	1407	1208	1415	1188	1386	1117	1199	1173	1138	1161	1214	956	1173	897	1219	875	1203	1002	872	991		694	1022
60 Hour																								
Avg. Temp. °F	1330	1413	1243	1412	1208	1386	1141	1238	1214	1165	1205	1226	986	1176	924	1218	895	1204	1019	909	1006		719	1026
Std. Dev.	10	7	7	9	8	5	15	12	20	14	20	8	5	6	7	11	10	33	10	10	6		13	5
Hi Temp. °F	1342	1424	1252	1426	1217	1397	1174	1255	1241	1187	1240	1239	995	1186	932	1244	916	1277	1063	924	1016		748	1036
Lo Temp. °F	1322	1401	1229	1402	1193	1378	1119	1212	1186	1143	1172	1212	975	1168	909	1201	883	1174	1002	891	995		700	1018
65 Hour																								
Avg. Temp. °F	1341	1401	1256	1394	1223	1384	1161	1240	1213	1166	1219	1227	1000	1160	921	1202	897	1164	1026	912	1005		726	1019
Std. Dev.	9	4	13	7	11	2	18	12	20	11	22	7	11	6	8	7	4	8	16	11	6		11	5
Hi Temp. °F	1367	1407	1284	1403	1248	1387	1184	1255	1244	1183	1262	1238	1031	1172	933	1212	908	1175	1048	928	1015		741	1028
Lo Temp. °F	1330	1394	1240	1379	1210	1380	1135	1221	1187	1147	1184	1215	988	1151	913	1186	891	1147	1000	893	992		703	1012
70 Hour																								
Avg. Temp. °F	1355	1395	1286	1381	1238	1385	1156	1243	1218	1175	1227	1220	1022	1140	924	1189	905	1145	1032	926	1008		729	1023
Std. Dev.	10	3	11	4	6	2	16	11	19	9	20	10	9	6	4	4	4	6	20	11	7		12	6
Hi Temp. °F	1381	1399	1299	1389	1247	1388	1180	1261	1242	1187	1263	1234	1038	1150	932	1198	916	1157	1060	939	1018		744	1035
Lo Temp. °F	1342	1391	1255	1374	1230	1380	1122	1227	1191	1154	1193	1205	1003	1130	919	1183	901	1137	992	904	994		703	1016
75 Hour																								
Avg. Temp. °F	1364	1392	1295	1377	1239	1384	1145	1239	1221	1170	1209	1209	1034	1133	922	1183	911	1134	1023	922	1009		731	1024
Std. Dev.	7	2	8	2	5	2	13	12	19	11	16	8	11	3	2	4	4	3	13	11	6		10	7
Hi Temp. °F	1376	1397	1305	1379	1248	1387	1166	1255	1256	1186	1234	1220	1047	1139	927	1190	918	1142	1041	940	1021		751	1035
Lo Temp. °F	1355	1387	1281	1374	1233	1380	1125	1215	1199	1155	1187	1199	1017	1128	919	1179	905	1131	996	897	999		716	1012
80 Hour																								
Avg. Temp. °F	1365	1394	1294	1377	1244	1382	1154	1242	1213	1169	1215	1211	1032	1135	916	1175	915	1141	1034	927	1014		731	1029
Std. Dev.	6	3	7	2	7	3	13	9	18	8	17	6	13	3	11	9	5	4	17	14	7		9	7
Hi Temp. °F	1399	2376	1312	1382	1253	1386	1176	1257	1242	1185	1239	1223	1053	1141	932	1184	922	1151	1058	942	1024		750	1040
Lo Temp. °F	1389	1353	1285	1374	1231	1377	1134	1226	1184	1152	1186	1202	1015	1131	895	1157	906	1134	1003	898	1003		718	1019

Table A-1 (Cont'd)

Heat Exchanger Probes Temperature History (Shakedown)

Control Temperature: 1600°F													1400°F					
Combustor Location:	In Bed						Above Bed						In Bed					
Port Number	1		3		5		13		15		17		2		4		6	
Hours Into Run \ Specimen	X	N	N	X	N	X	X	N	N	X	N	X	8	X	X	8	X	8
85 Hour																		
Avg. Temp. °F	1608	1568	1588	1573	1604	1580	1534	1489	1527	1470	1518	1457	1256	1406	1265	1389	1302	1389
Std. Dev.	8	7	12	6	6	6	4	6	4	5	4	4	4	4	15	3	13	5
Hi Temp. °F	1622	1578	1600	1582	1615	1589	1545	1502	1538	1483	1528	1468	1261	1414	1284	1395	1328	1395
Lo Temp. °F	1592	1554	1561	1561	1593	1569	1528	1483	1522	1463	1513	1452	1249	1402	1239	1384	1286	1381
90 Hour																		
Avg. Temp. °F	1607	1564	1592	1571	1605	1578	1533	1492	1527	1474	1517	1461	1257	1406	1259	1390	1305	1390
Std. Dev.	6	5	15	4	6	6	6	5	6	5	5	5	5	4	14	5	16	5
Hi Temp. °F	1620	1571	1604	1576	1614	1587	1544	1500	1536	1481	1526	1469	1267	1396	1283	1403	1328	1398
Lo Temp. °F	1596	1554	1552	1560	1592	1565	1524	1483	1518	1466	1508	1453	1246	1412	1230	1382	1280	1381
95 Hour																		
Avg. Temp. °F	1607	1563	1588	1568	1606	1578	1529	1468	1522	1469	1512	1457	1258	1407	1263	1393	1305	1391
Std. Dev.	9	8	18	6	8	6	4	4	4	4	4	4	7	3	16	4	16	6
Hi Temp. °F	1627	1576	1608	1576	1619	1588	1534	1494	1527	1475	1518	1463	1270	1413	1285	1400	1336	1401
Lo Temp. °F	1594	1549	1543	1559	1589	1568	1522	1481	1515	1463	1506	1451	1243	1403	1234	1386	1286	1380
100 Hour																		
Avg. Temp. °F	1604	1559	1596	1565	1604	1571	1522	1480	1516	1462	1507	1449	1262	1408	1259	1388	1305	1388
Std. Dev.	6	6	7	5	4	5	7	6	7	5	7	5	13	7	17	4	15	3
Hi Temp. °F	1614	1568	1605	1571	1610	1577	1530	1486	1526	1469	1516	1456	1285	1421	1280	1397	1323	1395
Lo Temp. °F	1596	1548	1582	1556	1598	1557	1507	1467	1501	1450	1492	1438	1243	1391	1231	1380	1276	1385

Control Temperature:							1200°F												1050°F					
Combustor Location:	Above Bed						In Bed						Above Bed						In Bed					
Port Number	14		16		18		7		9		11		19		20		22		8		10		12	
Hours Into Run \ Specimen	X	8	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9	9	2	9	2
85 Hour																								
Avg. Temp. °F	1367	1392	1301	1376	1242	1381	1150	1239	1216	1174	1227	1215	1038	1134	902	1164	921	1135	1037	928	1014		731	1025
Std. Dev.	6	3	8	2	5	2	13	11	18	8	21	11	9	3	7	6	3	10	17	13	7		8	5
Hi Temp. °F	1375	1396	1311	1380	1249	1384	1173	1252	1248	1190	1248	1229	1053	1140	913	1175	926	1153	1059	945	1029		740	1033
Lo Temp. °F	1355	1388	1284	1373	1231	1378	1129	1222	1192	1163	1189	1195	1023	1130	890	1155	915	1131	1005	896	1002		712	1015
90 Hour																								
Avg. Temp. °F	1367	1397	1297	1377	1243	1382	1152	1240	1218	1173	1209	1214	1037	1139	902	1165	919	1150	1025	930	1018		734	1029
Std. Dev.	6	3	9	2	10	3	17	7	12	10	17	8	11	4	9	7	5	5	12	9	4		15	5
Hi Temp. °F	1377	1402	1315	1381	1253	1386	1174	1249	1239	1193	1246	1228	1059	1149	917	1174	929	1158	1044	949	1026		759	1040
Lo Temp. °F	1358	1392	1281	1374	1234	1378	1121	1222	1195	1161	1187	1202	1020	1134	881	1150	910	1141	1004	916	1011		699	1019
95 Hour																								
Avg. Temp. °F	1371	1399	1298	1377	1250	1382	1151	1240	1226	1169	1222	1220	1035	1141	881	1150	923	1147	1025	931	1019		728	1033
Std. Dev.	5	2	8	2	5	2	4	7	16	7	17	7	10	4	12	9	5	5	13	7	5		14	8
Hi Temp. °F	1379	1405	1311	1382	1257	1386	1171	1253	1248	1182	1244	1230	1052	1146	903	1166	929	1153	1051	940	1031		747	1050
Lo Temp. °F	1356	1396	1282	1373	1240	1377	1128	1228	1206	1159	1192	1211	1020	1132	862	1137	912	1140	1005	915	1012		704	1015
100 Hour																								
Avg. Temp. °F	1373	1396	1298	1375	1253	1382	1157	1240	1219	1168	1215	1216	1040	1142	863	1132	921	1147	1026	928	1016		738	1035
Std. Dev.	6	1	6	2	5	2	11	7	18	9	18	8	12	3	8	10	7	5	18	11	4		11	5
Hi Temp. °F	1385	1398	1307	1379	1264	1386	1179	1252	1250	1180	1244	1225	1061	1146	882	1144	933	1155	1049	952	1023		755	1042
Lo Temp. °F	1365	1394	1287	1373	1247	1380	1145	1228	1186	1150	1195	1195	1025	1138	854	1124	912	1136	996	911	1008		714	1028

APPENDIX B

PARTICULATE CAPTURE DATA

Table B-1

Second Cyclone Capture Size Distribution

Run/Dump No.		Vol. % Finer Than 5%	10%	25%	50%	75%	90%	95%
79	130	4.4	6.0	9.6	15.5	32.5	68.0	94.0
79	18	7.4	10.0	15.0	28.0	55.0	92.0	120.2
80	64	5.9	8.1	13.0	24.0	47.0	92.0	120.0
81	15	5.8	8.0	14.5	33.0	92.0	--	--
81	74	5.4	8.0	15.0	36.0	100.0	--	--
106.1	2	5.0	6.6	10.5	18.0	38.0	83.0	140.0
106.1	11	7.0	14.0	34.0	84.0	165.0	310.0	430.0
106.2	23	4.2	6.0	11.5	23.0	52.0	105.0	160.0
106.3	57	4.8	6.4	11.5	23.0	52.0	105.0	160.0

Table B-2

Third Cyclone Captured Material
Size Distribution

Run/Sample		Vol. % Finer Than 5%	10%	25%	50%	75%	90%	95%
78	31	1.4	1.75	2.5	3.55	5.2	8.4	11.0
78	52	1.8	2.3	3.5	5.1	7.6	10.0	12.5
78	85	2.1	2.5	3.4	4.8	6.6	8.8	10.0
78	120	1.65	2.2	3.1	4.5	6.6	10.0	13.0
79	1	1.75	2.15	2.7	3.4	4.5	8.0	11.8
79	18	1.6	2.1	2.9	4.4	6.4	9.6	10.25
79	42	2.4	2.9	4.2	5.9	8.9	12.5	16.0
79	50	2.2	2.9	4.3	6.1	8.8	11.5	12.0
80	64	1.35	1.70	2.5	3.90	6.0	8.6	9.8
81	15	1.2	1.4	1.95	3.35	6.20	10.0	12.7
81	74	1.8	2.2	3.1	4.80	7.80	12.0	14.3

Table B-3

Flue Gas Particulates Entering Turbine Test **Section** (Exiting 3rd Cyclone) Size Distribution and Concentration

Run/Sample		Particulate Concentration (gr/SCF)	Vol. % Finer Than						
			5%	10%	25%	50%	75%	90%	95%
78BB	2	0.033	0.48	0.56	0.74	1.0	1.4	5.0	8.7
78BA	3	0.034	0.60	0.75	1.10	2.0	4.8	8.5	9.8
78BA	4	0.028	0.62	0.78	1.10	3.1	5.8	10.8	12.5
78BB	5	0.039	0.46	0.54	0.74	1.1	2.9	6.1	8.4
78BA	6	N/A	0.48	0.55	0.79	2.1	5.9	12.0	14.0
78BA	7	0.042	0.48	0.58	0.74	1.0	1.5	3.1	5.0
78BA	8	0.056	0.79	1.0	1.49	2.5	5.5	9.2	11.5
78BA	9	0.045	0.74	0.97	1.47	2.5	5.7	9.6	11.5
78BA	10	0.056	0.60	0.76	1.3	3.0	5.7	8.8	11.0
78BA	11	0.054	0.79	1.1	1.75	2.5	3.7	5.7	8.0
Avg. of Test 2-11			0.58	0.66	0.98	1.9	4.6	8.5	11.0
79BA	1	0.012	0.54	0.68	1.0	1.8	3.7	6.4	8.8
79BA	2	0.009	0.47	0.53	0.69	1.0	2.4	8.8	13.5
79BA	3	0.034	0.47	0.56	0.75	1.1	1.8	2.2	8.0
80BB	1	0.014	0.52	0.60	0.69	0.9	1.2	1.8	2.3
80BA	2	0.023	0.55	0.61	0.76	1.0	1.9	6.0	9.0
80BA	3	0.026	0.54	0.61	0.78	1.1	2.0	4.9	9.0
80BB	4	0.021	0.53	0.59	0.70	0.9	1.3	1.8	2.5
80BA	5	0.023	0.56	0.64	0.91	1.3	2.0	3.4	4.9
80BB	6	0.021	0.46	0.53	0.70	1.0	1.4	2.2	5.0
80BA	7	0.028	0.58	0.71	1.05	1.5	2.4	4.5	6.4
80BB	8	0.015	0.47	0.54	0.73	1.1	1.6	2.5	4.0
80BA	9	0.024	0.96	1.18	1.45	1.9	2.9	4.7	6.0
80BB	10	0.023	0.47	0.56	0.76	1.1	1.6	2.5	5.0

Table B-3 (Cont'd)

Flue Gas Particulates Entering Turbine Test Section (Exiting 3rd Cyclone) Size Distribution and Concentration

Run/Sample		Particulate Concentration (gr/SCF)	Vol. % Finer Than						
			5%	10%	25%	50%	75%	90%	95%
81BA	4	0.063	0.50	0.60	0.79	1.2	2.8	7.5	11.5
81BA	10	0.031	0.56	0.60	0.76	1.1	1.7	6.35	13.0
81BB	11	0.037	0.63	0.80	1.2	1.7	3.4	6.0	8.0
81BA	13	0.037	0.56	0.62	0.77	1.25	3.2	9.0	14.0
81BA	16	0.039	0.58	0.70	1.0	1.45	3.1	9.4	16.0
81BB	18	0.021	0.52	0.59	0.72	1.6	5.8	11.5	16.0
81BB	20	0.018	0.58	0.63	0.80	1.25	2.9	5.8	8.0
106BA	1	0.083	0.79	1.05	1.45	2.1	3.3	5.6	7.4
106BA	3	0.029	0.74	0.93	1.25	1.7	2.4	4.6	7.0
106BA	5	0.049	0.64	0.84	1.15	1.7	2.8	5.0	8.0
106BA	6	0.037	0.79	1.05	1.45	2.0	2.8	4.0	5.0
106BA	7	0.460	1.10	1.40	2.20	3.5	5.6	7.8	9.8
106BA	8	0.048	1.70	2.20	3.10	4.9	6.9	9.2	10.0
106BA	9	0.094	0.79	1.15	1.65	3.1	4.5	6.3	8.0
106BA	13	0.089	0.79	1.10	1.70	2.8	4.3	6.3	9.2
106BA	17	0.055	0.56	0.62	0.80	1.2	2.4	4.9	8.0
106BA	20	0.063	0.64	0.79	1.20	1.7	2.7	4.9	7.2
106BA	24	0.054	0.56	0.65	0.90	1.3	2.7	5.5	8.0
106BA	28	0.047	0.58	0.65	0.85	1.2	1.9	4.6	8.0
106BA	32	0.043	0.59	0.68	0.90	1.3	2.1	4.6	7.0
106BA	34	0.043	0.60	0.70	1.00	1.4	2.1	3.8	6.35

N/A = Data Not Available

APPENDIX C

HEAT EXCHANGER PROBE HISTORY

Enclosed is temperature history data for the heat exchanger probes for runs 78 thru 81 and run 106. Also, included are photographs of the probes after 1117 hours and 682 hours of operation.

Table C-1

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature: 1600°F

Combustor Location:	In Bed						Above Bed					
Port Number	1		3		5		13		15		17	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X
5 Hour												
Avg. Temp. °F	1584	1555	1476	1531	1540		1575	1577	1593	1573	1589	1563
Std. Dev.	2	7	13	4	4		10	2	2	3	3	4
Hi Temp. °F	1587	1561	1487	1536	1545		1583	1576	1595	1578	1594	1569
Lo Temp. °F	1581	1544	1454	1526	1535		1563	1580	1590	1572	1587	1560
10 Hour												
Avg. Temp. °F	1584	1555	1518	1570	1573		1595	1573	1590	1565	1588	1557
Std. Dev.	4.51	5	17	6	3		12	17	11	19	17	21
Hi Temp. °F	1592	1563	1547	1576	1579		1613	1598	1613	1593	1613	1587
Lo Temp. °F	1579	1551	1451	1531	1537		1581	1564	1576	1546	1570	1534
15 Hour												
Avg. Temp. °F	1581	1552	1517	1568	1571		1591	1565	1587	1557	1581	1549
Std. Dev.	4	2	14	3	2		8	6	7	6	6	6
Hi Temp. °F	1586	1561	1549	1575	1574		1612	1585	1608	1576	1602	1572
Lo Temp. °F	1576	1549	1499	1561	1566		1584	1561	1579	1548	1572	1537
20 Hour												
Avg. Temp. °F	1522	1515	1495	1512	1522		1539	1511	1538	1504	1532	1500
Std. Dev.	130	97	82	122	113		130	136	131	133	129	131
Hi Temp. °F	1587	1567	1549	1576	1574		1610	1588	1615	1589	1618	1582
Lo Temp. °F	972	946	954	978	967		1153	1163	1158	1161	1165	1164
25 Hour												
Avg. Temp. °F	1585	1552	1513	1563	1574		1607	1590	1613	1584	1608	1574
Std. Dev.	2	5	11	2	1		12	3	4	5	5	4
Hi Temp. °F	1590	1559	1542	1566	1577		1616	1595	1618	1592	1618	1583
Lo Temp. °F	1583	1540	1495	1559	1511		1582	1573	1605	1577	1602	1569
30 Hour												
Avg. Temp. °F	1579	1553	1510	1557	1571		1586	1587	1595	1581	1593	1573
Std. Dev.	6	4	7	2	3		26	15	10	19	7	22
Hi Temp. °F	1584	1558	1513	1559	1575		1609	1602	1605	1603	1599	1597
Lo Temp. °F	1570	1547	1501	1555	1568		1546	1566	1585	1557	1581	1546
35 Hour												
Avg. Temp. °F	1582	1551	1521	1561	1574		1602	1567	1598	1559	1591	1550
Std. Dev.	4	7	15	4	3		23	23	23	22	22	21
Hi Temp. °F	1586	1560	1539	1565	1577		1615	1582	1611	1569	1604	1563
Lo Temp. °F	1575	1541	1504	1555	1569		1561	1527	1558	1521	1552	1515
40 Hour												
Avg. Temp. °F	1584	1546	1511	1558	1573		1589	1596	1603	1592	1604	1585
Std. Dev.	4	8	18	4	2		22	8	11	10	11	15
Hi Temp. °F	1589	1554	1528	1564	1576		1614	1605	1616	1605	1614	1603
Lo Temp. °F	1578	1533	1491	1553	1571		1565	1589	1587	1583	1587	1573

Control Temperature: 1400°F

Combustor Location:	In Bed						Above Bed					
Port Number	2		4		6		14		16		18	
Hours Into Run \ Specimen	8	X	X	8	X	8	X	8	X	8	8	X
5 Hour												
Avg. Temp. °F	1159	1373	1142	1300	1185	1186	1383	1302	1337	1357	1291	1333
Std. Dev.	66	56	101	45	67	66	55	54	83	38	57	53
Hi Temp. °F	1205	1410	1235	1337	1265	1240	1465	1355	1442	1394	1343	1379
Lo Temp. °F	1045	1274	975	1221	1079	1071	1304	1219	1214	1300	1200	1254
10 Hour												
Avg. Temp. °F	1226	1401	1289	1376	1342	1337	1304	1404	1297	1440	1283	1425
Std. Dev.	11	4	18	4	46	48	5	4	15	11	11	4
Hi Temp. °F	1244	1406	1333	1387	1393	1396	1318	1410	1318	1452	1299	1461
Lo Temp. °F	1218	1395	1266	1371	1274	1278	1297	1399	1281	1426	1264	1402
15 Hour												
Avg. Temp. °F	1230	1399	1302	1376	1378	1371	1306	1401	1305	1432	1292	1418
Std. Dev.	11	2	17	6	18	17	2	8	14	3	8	4
Hi Temp. °F	1240	1404	1324	1386	1407	1402	1311	1405	1324	1436	1309	1430
Lo Temp. °F	1215	1391	1280	1368	1364	1358	1302	1388	1281	1420	1284	1413
20 Hour												
Avg. Temp. °F	1256	1389	1312	1368	1382	1380	1309	1373	1303	1400	1290	1381
Std. Dev.	64	22	44	15	10	8	2	62	12	70	9	77
Hi Temp. °F	1370	1412	1371	1389	1410	1407	1311	1408	1308	1446	1308	1423
Lo Temp. °F	940	955	940	953	946	946	1138	1146	1151	1142	1149	1145
25 Hour												
Avg. Temp. °F	1213	1403	1267	1360	1358	1358	1303	1392	1274	1438	1294	1411
Std. Dev.	7	2	20	7	9	11	2	4	18	2	2	2
Hi Temp. °F	1221	1406	1295	1368	1369	1376	1306	1397	1297	1441	1295	1414
Lo Temp. °F	1203	1393	1247	1351	1348	1346	1301	1387	1254	1435	1291	1410
30 Hour												
Avg. Temp. °F	1199	1396	1274	1354	1363	1365	1295	1382	1262	1437	1289	1411
Std. Dev.	15	7	23	4	17	20	7	6	24	9	8	3
Hi Temp. °F	1222	1402	1305	1358	1383	1389	1304	1389	1302	1449	1298	1415
Lo Temp. °F	1195	1388	1241	1347	1346	1338	1286	1376	1244	1425	1279	1407
35 Hour												
Avg. Temp. °F	1203	1396	1267	1357	1367	1369	1300	1376	1269	1426	1299	1420
Std. Dev.	8	3	27	7	17	13	4	5	7	7	11	6
Hi Temp. °F	1211	1399	1306	1365	1381	1387	1304	1384	1281	1435	1318	1428
Lo Temp. °F	1194	1393	1243	1348	1342	1350	1294	1371	1264	1415	1288	1411
40 Hour												
Avg. Temp. °F	1192	1396	1273	1354	1365	1365	1296	1387	1250	1441	1280	1406
Std. Dev.	4	5	10	5	11	16	7	15	12	7	10	8
Hi Temp. °F	1197	1400	1285	1361	1377	1384	1304	1405	1263	1449	1293	1415
Lo Temp. °F	1187	1389	1259	1350	1351	1345	1289	1371	1232	1434	1269	1398

Control Temperature: 1200°F

Combustor Location:	In Bed						Above Bed					
Port Number	7		9		11		19		20		22	
Hours Into Run \ Specimen	3	8	8	3	8	3	8	3	3	8	8	3
5 Hour												
Avg. Temp. °F	1034	1160	1043	1046	997	1089	1166	1168	1100	1283	724	1295
Std. Dev.	7	19	12	12	51	14	34	33	116	75	156	76
Hi Temp. °F	1043	1171	1063	1060	1077	1104	1226	1227	1224	1365	893	1366
Lo Temp. °F	1023	1139	1032	1026	937	1073	1146	1147	911	1162	586	1168
10 Hour												
Avg. Temp. °F	1036	1180	1060	1064	957	1120	1124	1124	972	972	542	542
Std. Dev.	12	15	11	6	12	31	14	15	23	23	8	8
Hi Temp. °F	1055	1194	1072	1071	966	1148	1134	1133	1008	1006	550	550
Lo Temp. °F	1023	1162	1046	1056	938	1066	1099	1097	942	942	530	530
15 Hour												
Avg. Temp. °F	1029	1177	1054	1070	963	1125	1140	1140	929	929	541	541
Std. Dev.	11	13	8	6	10	9	7	7	27	27	4	5
Hi Temp. °F	1046	1189	1063	1077	972	1133	1151	1151	958	960	546	547
Lo Temp. °F	1020	1155	1044	1063	952	1109	1133	1134	886	886	536	535
20 Hour												
Avg. Temp. °F	1062	1186	1063	1065	978	1115	1171	1171	870	869	577	577
Std. Dev.	46	11	23	12	54	9	74	74	140	137	45	45
Hi Temp. °F	1138	1202	1098	1081	1074	1124	1302	1303	950	950	656	656
Lo Temp. °F	1019	1175	1042	1050	951	1104	1129	1128	626	626	552	551
25 Hour												
Avg. Temp. °F	1027	1143	1052	1022	937	1087	1131	1130	965	965	551	551
Std. Dev.	16	23	21	12	8	7	8	8	14	15	3	3
Hi Temp. °F	1050	1164	1077	1041	945	1095	1140	1140	988	989	555	555
Lo Temp. °F	1010	1107	1034	1011	927	1080	1122	1122	951	950	546	546
30 Hour												
Avg. Temp. °F	1027	1120	1057	1020	933	1071	1109	1108	964	963	543	543
Std. Dev.	12	41	22	16	13	10	8	8	18	18	3	3
Hi Temp. °F	1036	1152	1084	1035	947	1087	1122	1121	984	983	547	547
Lo Temp. °F	1007	1050	1031	998	915	1062	1103	1102	936	936	540	539
35 Hour												
Avg. Temp. °F	1080	1177	1097	1072	1002	1127	1174	1174	912	912	658	658
Std. Dev.	46	34	54	63	60	47	45	45	48	48	107	106
Hi Temp. °F	1043	1216	1148	1125	1069	1163	1212	1213	966	966	765	764
Lo Temp. °F	1107	1142	1029	1001	937	1071	1118	1118	848	848	543	543
40 Hour												
Avg. Temp. °F	1087	1190	1140	1105	1025	1160	1005	1246	962	1241	546	1295
Std. Dev.	16	23	11	16	9	7	29	32	43	46	10	51
Hi Temp. °F	1101	1211	1153	1123	1038	1167	1050	1291	1010	1298	557	1361
Lo Temp. °F	1069	1159	1123	1079	1017	1149	981	1221	914	1193	536	1246

Control Temperature: 1050°F

Combustor Location:	In Bed					
Port Number	8		12		10	
Hours Into Run \ Specimen	2	9	9		9	
5 Hour						
Avg. Temp. °F	628	745	687		687	
Std. Dev.	25	55	8		7	
Hi Temp. °F	665	835	698		696	
Lo Temp. °F	597	698	676		678	
10 Hour						
Avg. Temp. °F	802	889	836		835	
Std. Dev.	88	90	57		60	
Hi Temp. °F	893	978	887		889	
Lo Temp. °F	672	762	768		764	
15 Hour						
Avg. Temp. °F	821	925	886		887	
Std. Dev.	28	35	5		7	
Hi Temp. °F	866	984	895		897	
Lo Temp. °F	800	895	881		878	
20 Hour						
Avg. Temp. °F	831	958	913		913	
Std. Dev.	50	47	36		36	
Hi Temp. °F	919	1025	976		977	
Lo Temp. °F	802	920	891		892	
25 Hour						
Avg. Temp. °F	790	924	892		895	
Std. Dev.	41	34	15		15	
Hi Temp. °F	861	982	908		914	
Lo Temp. °F	759	893	874		876	
30 Hour						
Avg. Temp. °F	748	913	909		908	
Std. Dev.	14	21	18		18	
Hi Temp. °F	767	944	932		929	
Lo Temp. °F	732	892	887		883	
35 Hour						
Avg. Temp. °F	825	996	983		984	
Std. Dev.	57	83	97		97	
Hi Temp. °F	890	1075	1069		1069	
Lo Temp. °F	750	888	865		864	
40 Hour						
Avg. Temp. °F	853	1017	1013		1013	
Std. Dev.	36	47	34		32	
Hi Temp. °F	909	1098	1057		1052	
Lo Temp. °F	808	975	983		985	

Table C-1 (Cont'd)

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature: 1600°F

Combustor Location	In Bed						Above Bed					
Port Number	1		3		5		13		15		17	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X
45 Hour												
Avg. Temp. °F	1578	1547	1513	1554	1570		1563	1603	1594	1605	1591	1601
Std. Dev.	2	2	13	6	3		18	2	4	2	4	4
Hi Temp. °F	1580	1549	1525	1560	1575		1583	1606	1598	1608	1596	1606
Lo Temp. °F	1576	1545	1492	1546	1567		1539	1601	1590	1603	1587	1596
50 Hour												
Avg. Temp. °F	1578	1551	1510	1552	1569		1561	1597	1594	1598	1600	1590
Std. Dev.	1	5	18	3	4		15	3	6	4	13	6
Hi Temp. °F	1579	1557	1525	1556	1574		1573	1600	1602	1602	1619	1597
Lo Temp. °F	1576	1546	1486	1550	1564		1543	1593	1588	1593	1489	1583
55 Hour												
Avg. Temp. °F	1576	1549	1509	1551	1569		1598	1585	1611	1581	1610	1568
Std. Dev.	3	10	21	3	1		9	6	3	9	8	8
Hi Temp. °F	1578	1558	1537	1554	1569		1610	1590	1614	1586	1615	1574
Lo Temp. °F	1572	1540	1485	1547	1566		1589	1517	1607	1568	1599	1556
60 Hour												
Avg. Temp. °F	1578	1551	1512	1553	1569		1589	1587	1611	1584	1611	1572
Std. Dev.	4	5	14	3	3		17	2	7	5	3	5
Hi Temp. °F	1582	1554	1535	1558	1572		1610	1590	1620	1589	1615	1578
Lo Temp. °F	1574	1544	1495	1549	1564		1565	1584	1603	1677	1606	1565
65 Hour												
Avg. Temp. °F	1577	1546	1503	1552	1568		1585	1587	1611	1584	1611	1711
Std. Dev.	3	4	7	3	3		14	3	7	6	3	7
Hi Temp. °F	1581	1551	1510	1556	1511		1599	1591	1619	1591	1615	1578
Lo Temp. °F	1574	1541	1495	1547	1564		1562	1583	1603	1576	1609	1563
70 Hour												
Avg. Temp. °F	1576	1552	1494	1545	1566		1565	1599	1590	1601	1593	1592
Std. Dev.	4	5	5	4	2		16	2	3	2	3	2
Hi Temp. °F	1580	1560	1503	1550	1568		1582	1600	1595	1602	1598	1594
Lo Temp. °F	1570	1547	1491	1539	1563		1547	1596	1587	1598	1589	1589
75 Hour												
Avg. Temp. °F	1572	1555	1504	1547	1565		1562	1597	1596	1599	1596	1590
Std. Dev.	5	6	10	8	2		17	4	6	5	7	6
Hi Temp. °F	1579	1566	1511	1558	1569		1585	1604	1604	1608	1606	1600
Lo Temp. °F	1567	1550	1487	1539	1563		1542	1592	1589	1593	1586	1582
80 Hour												
Avg. Temp. °F	1572	1545	1506	1547	1563		1573	1583	1593	1583	1590	1571
Std. Dev.	5	3	8	4	6		13	27	20	30	26	30
Hi Temp. °F	1578	1548	1520	1551	1569		1586	1599	1613	1603	1613	1595
Lo Temp. °F	1565	1541	1499	1543	1554		1554	1535	1561	1529	1547	1519

Control Temperature: 1400°F

Combustor Location	In Bed						Above Bed					
Port Number	2		4		6		14		16		18	
Hours Into Run \ Specimen	8	X	X	8	X	8	X	8	X	8	8	X
45 Hour												
Avg. Temp. °F	1196	1395	1250	1354	1358	1360	1293	1394	1248	1448	1268	1404
Std. Dev.	11	4	26	7	8	10	9	10	5	5	15	6
Hi Temp. °F	1213	1399	1281	1362	1368	1368	1307	1404	1254	1456	1290	1410
Lo Temp. °F	1186	1388	1226	1348	1348	1346	1284	1378	1241	1442	1249	1396
50 Hour												
Avg. Temp. °F	1185	1393	1268	1353	1354	1352	1287	1371	1239	1440	1282	1422
Std. Dev.	6	3	17	6	10	6	3	7	4	3	5	7
Hi Temp. °F	1193	1395	1278	1359	1365	1359	1291	1382	1244	1443	1288	1431
Lo Temp. °F	1178	1388	1242	1346	1343	1344	1285	1367	1234	1437	1278	1413
55 Hour												
Avg. Temp. °F	1189	1388	1274	1346	1370	1368	1293	1370	1254	1433	1281	1426
Std. Dev.	3	9	35	7	19	15	7	3	11	3	3	3
Hi Temp. °F	1192	1398	1297	1355	1390	1385	1297	1371	1261	1436	1284	1429
Lo Temp. °F	1185	1377	1222	1338	1348	1354	1282	1366	1239	1429	1278	1421
60 Hour												
Avg. Temp. °F	1183	1390	1274	1341	1356	1361	1297	1374	1239	1430	1279	1431
Std. Dev.	6	6	29	8	9	9	2	1	7	2	9	2
Hi Temp. °F	1189	1397	1301	1352	1366	1370	1298	1375	1247	1432	1292	1434
Lo Temp. °F	1174	1382	1231	1332	1346	1351	1294	1373	1229	1428	1269	1430
65 Hour												
Avg. Temp. °F	1185	1391	1239	1338	1370	1371	1297	1374	1231	1428	1286	1435
Std. Dev.	5	4	12	4	11	12	3	1	2	3	6	4
Hi Temp. °F	1191	1396	1257	1340	1384	1381	1300	1376	1234	1432	1291	1439
Lo Temp. °F	1178	1384	1225	1333	1358	1352	1293	1372	1228	1424	1279	1428
70 Hour												
Avg. Temp. °F	1185	1388	1258	1345	1360	1356	1291	1372	1225	1432	1278	1425
Std. Dev.	2	6	25	6	11	12	5	5	7	1	3	3
Hi Temp. °F	1188	1397	1287	1353	1373	1372	1295	1379	1234	1433	1282	1428
Lo Temp. °F	1182	1382	1229	1337	1344	1340	1285	1368	1216	1430	1274	1421
75 Hour												
Avg. Temp. °F	1187	1387	1248	1341	1355	1356	1295	1374	1228	1432	1277	1426
Std. Dev.	2	3	31	7	17	17	4	1	3	3	5	1
Hi Temp. °F	1189	1392	1291	1353	1370	1379	1300	1375	1231	1437	1285	1428
Lo Temp. °F	1183	1383	1217	1334	1329	1337	1291	1373	1225	1429	1271	1425
80 Hour												
Avg. Temp. °F	1191	1388	1259	1344	1365	1362	1310	1384	1232	1427	1280	1423
Std. Dev.	17	6	18	5	11	9	14	12	15	7	7	3
Hi Temp. °F	1221	1393	1281	1349	1377	1375	1324	1400	1247	1432	1287	1427
Lo Temp. °F	1179	1377	1235	1338	1350	1353	1296	1372	1208	1414	1272	1420

Control Temperature: 1200°F

Combustor Location	In Bed						Above Bed					
Port Number	7		9		11		19		20		22	
Hours Into Run \ Specimen	3	8	8	3	8	3	8	3	3	8	8	3
45 Hour												
Avg. Temp. °F	1073	1175	1157	1103	1027	1168	1032	1267	989	1275	554	1331
Std. Dev.	20	13	12	8	8	7	50	24	35	32	11	35
Hi Temp. °F	1102	1189	1169	1113	1037	1175	1107	1299	1043	1321	571	1371
Lo Temp. °F	1050	1158	1140	1094	1019	1158	972	1232	946	1232	541	1284
50 Hour												
Avg. Temp. °F	1072	1127	1159	1098	1019	1153	972	1233	957	1234	538	1276
Std. Dev.	7	26	14	19	5	11	16	8	5	7	3	5
Hi Temp. °F	1077	1160	1174	1125	1025	1167	983	1239	963	1245	541	1282
Lo Temp. °F	1062	1097	1140	1082	1014	1142	948	1222	952	1230	535	1272
55 Hour												
Avg. Temp. °F	1091	1163	1145	1093	1042	1146	972	1222	915	1199	545	1254
Std. Dev.	17	28	21	13	13	11	5	5	17	14	9	14
Hi Temp. °F	1096	1186	1175	1106	1055	1155	978	1226	934	1212	542	1270
Lo Temp. °F	1106	1122	1128	1078	1029	1131	968	1215	893	1180	525	1237
60 Hour												
Avg. Temp. °F	1073	1151	1166	1124	1072	1176	976	1226	909	1192	524	1238
Std. Dev.	8	14	16	11	14	8	5	1	8	6	1	3
Hi Temp. °F	1081	1171	1185	1139	1086	1187	984	1227	916	1200	524	1241
Lo Temp. °F	1063	1133	1149	1112	1053	1166	972	1224	896	1186	523	1234
65 Hour												
Avg. Temp. °F	1072	1149	1174	1116	1062	1180	978	1229	915	1199	529	1243
Std. Dev.	11	20	18	14	26	8	4	6	8	7	4	5
Hi Temp. °F	1083	1174	1195	1133	1093	1187	983	1237	924	1207	534	1250
Lo Temp. °F	1057	1124	1149	1098	1028	1168	972	1221	902	1188	524	1236
70 Hour												
Avg. Temp. °F	1071	1160	1170	1109	1052	1174	972	1235	949	1230	522	1262
Std. Dev.	13	9	14	14	18	8	6	6	7	4	8	13
Hi Temp. °F	1085	1167	1188	1132	1067	1181	982	1244	957	1236	533	1273
Lo Temp. °F	1057	1149	1157	1096	1023	1163	967	1229	942	1225	511	1242
75 Hour												
Avg. Temp. °F	1075	1156	1152	1102	1049	1154	978	1240	954	1233	522	1270
Std. Dev.	20	24	9	11	19	49	17	18	14	12	10	21
Hi Temp. °F	1106	1188	1162	1117	1074	1190	1005	1269	976	1253	541	1306
Lo Temp. °F	1054	1130	1142	1088	1023	1069	959	1223	938	1219	516	1252
80 Hour												
Avg. Temp. °F	1072	1157	1174	1105	1055	1165	969	1232	917	1199	511	1250
Std. Dev.	12	22	20	16	20	7	5	9	41	41	4	24
Hi Temp. °F	1085	1189	1200	1124	1080	1173	978	1243	948	1226	513	1216
Lo Temp. °F	1056	1134	1146	1084	1037	1159	964	1221	847	1127	504	1212

Control Temperature: 1050°F

Combustor Location	In Bed					
Port Number	8		12		10	
Hours Into Run \ Specimen	2	9	9		9	
45 Hour						
Avg. Temp. °F	784	972	997		994	
Std. Dev.	3	12	9		10	
Hi Temp. °F	787	984	1005		1005	
Lo Temp. °F						
50 Hour						
Avg. Temp. °F	788	977	994		997	
Std. Dev.	21	12	16		17	
Hi Temp. °F	819	995	1016		1019	
Lo Temp. °F	775	969	978		984	
55 Hour						
Avg. Temp. °F	780	999	1020		1024	
Std. Dev.	14	15	20		17	
Hi Temp. °F	818	1019	1032		1035	
Lo Temp. °F	785	986	990		998	
60 Hour						
Avg. Temp. °F	799	993	1014		1016	
Std. Dev.	21	29	17		16	
Hi Temp. °F	817	1018	1042		1041	
Lo Temp. °F	769	948	999		1002	
65 Hour						
Avg. Temp. °F	799	997	1018		1019	
Std. Dev.	19	23	23		27	
Hi Temp. °F	828	1023	1048		1056	
Lo Temp. °F	785	972	999		998	
70 Hour						
Avg. Temp. °F	790	1001	1008		1009	
Std. Dev.	9	19	29		28	
Hi Temp. °F	798	1024	1043		1044	
Lo Temp. °F	780	982	977		979	
75 Hour						
Avg. Temp. °F	789	1010	1013		1010	
Std. Dev.	12	15	16		17	
Hi Temp. °F	805	1029	1032		1036	
Lo Temp. °F	776	990	977		996	
80 Hour						
Avg. Temp. °F	795	1014	1013		1012	
Std. Dev.	18	26	21		21	
Hi Temp. °F	820	1053	1041		1042	
Lo Temp. °F	769	991	987		986	

Table C-1 (Cont'd)

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature:	1600°F												1400°F												1200°F												1050°F					
Combustor Location:	In Bed						Above Bed						In Bed						Above Bed						In Bed						Above Bed						In Bed					
Port Number	1		3		5		13		15		17		2		4		6		14		16		18		7		9		11		19		20		22		8		12		10	
Hours Into Run \ Specimen	X	N	N	X	N	X	X	N	N	X	N	X	8	X	X	8	X	8	X	8	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9	9		9	
85 Hour																																										
Avg. Temp. °F	1575	1549	1509	1548	1565		1565	1598	1593	1601	1590	1591	1190	1390	1270	1342	1358	1358	1319	1392	1219	[illegible]	1275	1423	1077	1146	1185	1096	1047	1160	970	1233	920	1207	515	1243	773	1006	1018		1017	
Std. Dev.	4	7	20	2	3		22	3	4	4	5	5	8	4	28	8	14	16	7	3	8	2	6	2	23	31	21	16	11	9	6	5	15	12	8	8	9	6	13		13	
Hi Temp. °F	1580	1558	1542	1551	1569		1592	1602	1596	1606	1595	1598	1201	1394	1287	1355	1371	1371	1328	1395	1226	1433	1280	1427	1102	1176	1214	1116	1063	1172	978	1241	938	1223	525	1254	785	1014	1032		1030	
Lo Temp. °F	1569	1544	1493	1546	1560		1541	1595	1587	1597	1583	1586	1181	1384	1221	1336	1334	1330	1308	1388	1206	1428	1265	1421	1048	1110	1166	1076	1034	1151	965	1228	904	1197	507	1235	761	1000	999		997	
90 Hour																																										
Avg. Temp. °F	1568	1549	1503	1541	1552		1555	1602	1588	1605	1583	1599	1183	1375	1266	1347	1363	1358	1305	1376	1220	1432	1271	1425	1060	1121	1181	1093	1033	1167	1093	1255	940	1227	525	1269	779	1020	1027		1021	
Std. Dev.	2	9	17	7	12		18	2	8	2	7	3	11	3	40	10	15	15	46	35	5	3	4	4	10	18	20	32	12	2	24	20	19	16	12	17	29	26	8		9	
Hi Temp. °F	1570	1557	1520	1547	1561		1579	1603	1598	1607	1591	1601	1198	1379	1297	1353	1385	1381	1373	1429	1224	1437	1275	1430	1071	1143	1209	1125	1046	1169	1016	1271	956	1239	536	1286	816	1057	1036		1039	
Lo Temp. °F	1566	1538	1480	1532	1535		1539	1600	1581	1604	1577	1594	1173	1372	1208	1333	1354	1349	1278	1355	1215	1430	1267	1421	1047	1100	1164	1065	1021	1165	962	1227	912	1204	512	1245	746	996	1019		1020	
95 Hour																																										
Avg. Temp. °F	1564	1550	1512	1542	1560		1545	1602	1585	1606	1581	1600	1186	1385	1244	1341	1352	1355	1283	1361	1213	1430	1265	1420	1071	1113	1162	1089	1045	1161	987	1252	942	1230	525	1269	775	1037	1023		1024	
Std. Dev.	6	10	16	6	2		21	1	3	1	3	1	5	5	27	4	14	14	3	3	5	3	3	4	17	14	10	17	12	5	33	3	2	2	12	4	20	23	10		10	
Hi Temp. °F	1569	1561	1525	1549	1563		1567	1604	1589	1608	1585	1602	1191	1392	1282	1347	1375	1373	1284	1363	1221	1434	1269	1424	1092	1134	1171	1105	1061	1169	991	1258	945	1232	531	1272	810	1076	1031		1034	
Lo Temp. °F	1558	1539	1489	1535	1558		1518	1601	1582	1605	1576	1598	1181	1381	1211	1334	1337	1334	1278	1356	1208	1428	1261	1415	1051	1096	1148	1066	1027	1158	983	1249	940	1227	523	1263	760	1017	1011		1012	
100 Hour																																										
Avg. Temp. °F	1564	1544	1504	1544	1561		1580	1595	1599	1598	1596	1588	1191	1381	1254	1342	1348	1352	1290	1365	1226	1428	1272	1421	1071	1120	1180	1095	1054	1161	967	1236	922	1205	514	1252	785	1044	1030		1029	
Std. Dev.	8	4	20	5	4		7	2	5	3	6	4	4	10	29	6	14	14	7	[illegible]	5	2	5	3	18	18	12	19	17	4	9	4	5	7	5	8	13	28	16		16	
Hi Temp. °F	1572	1550	1528	1549	1565		1588	1598	1605	1600	1606	1592	1197	1391	1299	1348	1363	1372	1300	1373	1232	1430	1280	1425	1097	1142	1197	1114	1078	1167	982	1241	928	1214	519	1260	800	1073	1047		1050	
Lo Temp. °F	1554	1539	1488	1539	1554		1570	1592	1592	1593	1590	1581	1187	1365	1219	1334	1333	1337	1281	1359	1217	1426	1266	1418	1055	1103	1166	1074	1029	1157	959	1231	916	1198	508	1243	772	998	1012		1010	
105 Hour																																										
Avg. Temp. °F	1567	1550	1506	1537	1561		1548	1601	1591	1605	1585	1597	1183	1378	1244	1341	1354	1357	1281	1361	1210	1430	1262	1421	1076	1139	1174	1083	1034	1162	970	1242	916	1206	494	1254	778	1030	1029		1031	
Std. Dev.	4	5	14	4	4		25	3	8	4	9	5	12	3	30	10	15	12	11	4	10	2	6	3	17	16	18	13	8	7	9	6	7	8	4	9	36	28	11		11	
Hi Temp. °F	1570	1554	1525	1543	1566		1582	1603	1603	1608	1600	1601	1200	1380	1288	1352	1366	1370	1292	1366	1223	1432	1270	1424	1094	1166	1197	1095	1040	1170	981	1251	922	1216	499	1265	835	1075	1038		1039	
Lo Temp. °F	1562	1542	1489	1533	1555		1513	1597	1584	1598	1578	1588	1174	1374	1219	1332	1330	1337	1266	1356	1198	1427	1256	1417	1052	1124	1167	1061	1020	1155	962	1237	904	1193	489	1241	741	1006	1016		1015	
110 Hour																																										
Avg. Temp. °F	1566	1547	1515	1541	1559		1554	1600	1599	1605	1589	1596	1187	1376	1273	1347	1344	1346	1285	1364	1220	1430	1267	1420	1057	1129	1178	1090	1043	1156	963	1238	918	1204	493	1252	769	1036	1036		1037	
Std. Dev.	5	9	13	2	5		26	3	9	4	9	5	7	9	21	7	13	12	5	2	7	3	4	3	5	14	22	10	8	8	13	9	12	14	10	12	11	8	21		19	
Hi Temp. °F	1574	1555	1526	1544	1566		1584	1604	1611	1610	1602	1602	1198	1387	1295	1353	1361	1361	1288	1367	1232	1434	1271	1424	1062	1153	1206	1101	1055	1168	975	1247	933	1220	503	1262	783	1049	1053		1057	
Lo Temp. °F	1560	1533	1497	1538	1552		1524	1595	1587	1598	1579	1587	1180	1368	1240	1338	1327	1330	1276	1361	1215	1428	1262	1418	1050	1117	1147	1076	1034	1148	941	1223	900	1183	481	1234	758	1029	1011		1013	
115 Hour																																										
Avg. Temp. °F	1571	1551	1514	1546	1564		1579	1595	1609	1594	1599	1582	1199	1384	1271	1342	1349	1350	1294	1370	1222	1424	1271	1422	1070	1136	1178	1102	1048	1159	968	1236	894	1180	488	1234	794	1030	1022		1024	
Std. Dev.	4	8	12	3	3		11	2	6	4	7	5	6	6	26	9	9	9	8	3	8	2	5	3	23	20	10	11	14	4	9	4	4	4	13	8	31	37	16		14	
Hi Temp. °F	1575	1558	1528	1551	1568		1592	1597	1615	1598	1608	1587	1204	1391	1292	1351	1364	1361	1306	1373	1230	1426	1278	1428	1098	1166	1190	1114	1059	1162	975	1241	899	1184	510	1242	848	1096	1043		1041	
Lo Temp. °F	1566	1540	1499	1543	1560		1566	1593	1600	1590	1591	1577	1191	1375	1238	1329	1341	1340	1287	1367	1213	1420	1266	1420	1045	1117	1164	1090	1023	1154	952	1231	890	1174	476	1223	771	1007	1007		1008	
120 Hour																																										
Avg. Temp. °F	1577	1561	1532	1556	1564		1554	1605	1590	1611	1575	1603	1189	1382	1249	1340	1344	1347	1277	1358	1213	1433	1266	1422	1080	1147	1177	1087	1048	1167	1002	1264	941	1230	533	1281	759	1034	1056		1061	
Std. Dev.	9	14	26	14	6		38	4	13	7	15	10	3	13	13	6	17	18	10	[illegible]	11	4	4	4	15	28	15	10	8	12	32	24	24	23	12	36	9	19	33		40	
Hi Temp. °F	1586	1573	1565	1568	1573		1595	1610	1603	1621	1590	1618	1192	1390	1263	1346	1364	1363	1293	1367	1228	1439	1270	1428	1090	1185	1197	1096	1056	1181	970	1299	974	1265	553	1331	769	1062	1112		1127	
Lo Temp. °F	1567	1540	1502	1539	1559		1493	1601	1568	1604	1550	1593	1185	1360	1230	1334	1319	1317	1267	1347	1199	1429	1261	1417	1061	1114	1162	1074	1036	1150	1054	1238	909	1203	520	1240	754	1013	1035		1034	

Table C-1 (Cont'd)

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature: 1600°F

Combustor Location:	In Bed						Above Bed					
Port Number	1		3		5		13		15		17	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X
125 Hour												
Avg. Temp. °F	1576	1564	1551	1564	1575		1510	1610	1564	1620	1551	1618
Std. Dev.	7	9	9	2	4		15	1	7	2	5	3
Hi Temp. °F	1583	1579	1562	1566	1579		1522	1611	1580	1622	1559	1620
Lo Temp. °F	1567	1557	1539	1561	1569		1489	1609	1564	1618	1545	1613
130 Hour												
Avg. Temp. °F	1571	1563	1552	1565	1577		1478	1610	1559	1625	1538	1625
Std. Dev.	7	3	14	13	4		15	2	12	3	13	6
Hi Temp. °F	1580	1566	1572	1580	1584		1491	1612	1570	1629	1551	1632
Lo Temp. °F	1563	1558	1538	1553	1674		1455	1608	1546	1621	1521	1618
135 Hour												
Avg. Temp. °F	1572	1567	1564	1565	1578		1489	1609	1514	1601	1489	1604
Std. Dev.	5	10	18	7	8		61	5	36	15	35	16
Hi Temp. °F	1579	1581	1592	1573	1589		1592	1613	1556	1627	1538	1630
Lo Temp. °F	1566	1559	1549	1555	1567		1441	1600	1484	1588	1457	1585
140 Hour												
Avg. Temp. °F	1572	1572	1551	1561	1580		1485	1611	1505	1600	1473	1601
Std. Dev.	5	7	14	7	5		29	2	9	2	9	2
Hi Temp. °F	1577	1580	1568	1573	1585		1534	1613	1521	1602	1488	1604
Lo Temp. °F	1567	1562	1531	1555	1571		1460	1609	1497	1598	1465	1598
145 Hour												
Avg. Temp. °F	1575	1564	1542	1563	1579		1482	1603	1502	1598	1456	1600
Std. Dev.	8	7	10	5	3		8	5	7	2	28	2
Hi Temp. °F	1586	1571	1549	1569	1582		1489	1613	1508	1600	1478	1603
Lo Temp. °F	1566	1556	1524	1557	1574		1469	1607	1492	1595	1462	1597
150 Hour												
Avg. Temp. °F	1573	1575	1553	1567	1578		1477	1610	1520	1606	1456	1602
Std. Dev.	4	17	10	5	7		9	1	40	16	28	1
Hi Temp. °F	1578	1595	1561	1575	1584		1486	1611	1584	1631	1474	1603
Lo Temp. °F	1569	1554	1536	1562	1566		1465	1609	1478	1588	1462	1600
155 Hour												
Avg. Temp. °F	1571	1571	1542	1570	1581		1477	1609	1476	1585	1468	1601
Std. Dev.	4	8	18	5	4		10	2	6	1	8	2
Hi Temp. °F	1578	1581	1566	1576	1586		1490	1611	1485	1586	1480	1602
Lo Temp. °F	1568	1561	1521	1564	1577		1467	1606	1469	1584	1459	1598
160 Hour												
Avg. Temp. °F	1566	1574	1543	1571	1586		1466	1610	1472	1586	1463	1602
Std. Dev.	2	7	16	7	4		10	2	3	2	4	2
Hi Temp. °F	1569	1582	1561	1579	1589		1477	1613	1476	1588	1470	1605
Lo Temp. °F	1563	1566	1528	1565	1581		1454	1608	1468	1584	1458	1600

Control Temperature: 1400°F

Combustor Location:	In Bed						Above Bed					
Port Number	2		4		6		14		16		18	
Hours Into Run \ Specimen	8	X	X	8	X	8	X	8	X	8	8	X
125 Hour												
Avg. Temp. °F	1174	1377	1252	1349	1329	1329	1269	1349	1191	1439	1255	1416
Std. Dev.	4	7	15	6	9	10	15	11	7	2	2	3
Hi Temp. °F	1179	1386	1278	1357	1338	1337	1287	1364	1202	1441	1257	1420
Lo Temp. °F	1167	1368	1239	1341	1316	1315	1254	1340	1184	1436	1252	1412
130 Hour												
Avg. Temp. °F	1168	1374	1270	1362	1324	1325	1285	1357	1181	1440	1245	1416
Std. Dev.	11	5	35	8	15	15	6	5	8	3	13	2
Hi Temp. °F	1179	1380	1304	1367	1341	1337	1292	1362	1191	1443	1259	1419
Lo Temp. °F	1166	1368	1230	1349	1300	1298	1278	1350	1173	1436	1229	1413
135 Hour												
Avg. Temp. °F	1181	1382	1271	1369	1330	1314	1280	1355	1179	1435	1296	1386
Std. Dev.	21	8	26	6	36	16	16	3	13	11	35	25
Hi Temp. °F	1216	1391	1314	1368	1391	1339	1307	1361	1198	1443	1238	1410
Lo Temp. °F	1164	1370	1252	1352	1299	1298	1266	1353	1164	1416	1144	1347
140 Hour												
Avg. Temp. °F	1185	1380	1267	1360	1319	1318	1287	1357	1183	1438	1207	1396
Std. Dev.	13	8	41	8	9	10	9	3	11	3	7	7
Hi Temp. °F	1195	1393	1318	1370	1331	1332	1299	1360	1194	1441	1212	1404
Lo Temp. °F	1167	1375	1229	1350	1306	1305	1274	1353	1169	1433	1195	1386
145 Hour												
Avg. Temp. °F	1182	1380	1266	1363	1312	1313	1274	1350	1179	1440	1212	1398
Std. Dev.	6	6	28	13	10	8	11	5	6	2	15	11
Hi Temp. °F	1189	1388	1298	1377	1326	1324	1289	1358	1184	1442	1220	1408
Lo Temp. °F	1175	1372	1242	1346	1302	1304	1262	1345	1172	1438	1186	1380
150 Hour												
Avg. Temp. °F	1194	1378	1272	1355	1314	1313	1283	1352	1184	1441	1219	1403
Std. Dev.	6	7	31	6	15	15	7	6	5	3	9	4
Hi Temp. °F	1203	1389	1321	1362	1335	1333	1292	1359	1190	1444	1234	1407
Lo Temp. °F	1188	1372	1247	1347	1297	1297	1272	1346	1178	1438	1209	1397
155 Hour												
Avg. Temp. °F	1198	1383	1259	1354	1327	1326	1293	1352	1186	1440	1223	1403
Std. Dev.	5	6	24	11	16	14	6	4	8	2	11	5
Hi Temp. °F	1204	1388	1296	1370	1344	1340	1301	1357	1198	1443	1230	1408
Lo Temp. °F	1193	1374	1238	1346	1304	1304	1287	1348	1179	1437	1205	1397
160 Hour												
Avg. Temp. °F	1192	1377	1383	1363	1308	1309	1285	1350	1183	1442	1230	1411
Std. Dev.	8	7	43	9	6	7	7	4	6	4	7	6
Hi Temp. °F	1203	1384	1316	1373	1313	1316	1296	1355	1192	1445	1238	1421
Lo Temp. °F	1183	1366	1226	1350	1299	1298	1279	1346	1175	1434	1221	1406

Control Temperature: 1200°F

Combustor Location:	In Bed						Above Bed					
Port Number	7		9		11		19		20		22	
Hours Into Run \ Specimen	3	8	8	3	8	3	8	3	3	8	8	3
125 Hour												
Avg. Temp. °F	1095	1191	1180	1095	1040	1177	1065	1305	986	1270	551	1345
Std. Dev.	9	44	31	12	14	12	9	6	6	6	6	8
Hi Temp. °F	1104	1253	1227	1109	1059	1190	1074	1311	994	1276	557	1351
Lo Temp. °F	1085	1131	1144	1083	1026	1159	1052	1295	977	1261	544	1331
130 Hour												
Avg. Temp. °F	1087	1227	1178	1091	1027	1158	1106	1332	1017	1299	557	1371
Std. Dev.	20	25	20	14	8	8	31	18	24	20	9	17
Hi Temp. °F	1121	1264	1200	1111	1034	1168	1150	1355	1049	1325	569	1397
Lo Temp. °F	1076	1206	1146	1079	1014	1148	1069	1313	991	1276	547	1355
135 Hour												
Avg. Temp. °F	1090	1199	1175	1081	1032	1159	1113	1328	1025	1300	561	1375
Std. Dev.	13	10	12	6	11	12	54	40	47	40	18	38
Hi Temp. °F	1097	1214	1191	1086	1047	1170	1156	1357	1062	1333	579	1406
Lo Temp. °F	1067	1185	1161	1074	1016	1142	1024	1260	949	1235	551	1314
140 Hour												
Avg. Temp. °F	1084	1193	1171	1083	1033	1170	1124	1339	1033	1310	568	1389
Std. Dev.	9	24	15	9	19	13	16	12	18	11	5	12
Hi Temp. °F	1100	1215	1192	1091	1057	1183	1144	1354	1053	1322	576	1402
Lo Temp. °F	1078	1153	1151	1067	1013	1148	1103	1320	1005	1292	561	1369
145 Hour												
Avg. Temp. °F	1079	1218	1169	1081	1042	1172	1110	1334	1031	1307	575	1381
Std. Dev.	8	17	19	13	2	13	17	10	14	10	16	9
Hi Temp. °F	1088	1244	1192	1097	1045	1182	1132	1342	1050	1317	599	1392
Lo Temp. °F	1069	1195	1146	1065	1039	1151	1088	1321	1016	1297	561	1368
150 Hour												
Avg. Temp. °F												
Std. Dev.	1100	1195	1178	1082	1034	1160	1109	1331	1027	1309	595	1386
Hi Temp. °F	12	44	21	13	11	12	13	8	11	8	4	10
Lo Temp. °F	1116	1256	1202	1098	1047	1170	1122	1341	1041	1318	599	1399
155 Hour												
Avg. Temp. °F	1094	1226	1179	1084	1037	1161	1111	1332	1030	1307	585	1385
Std. Dev.	7	45	15	4	9	6	9	11	12	12	7	15
Hi Temp. °F	1100	1282	1195	1091	1046	1168	1117	1340	1039	1317	593	1398
Lo Temp. °F	1083	1170	1158	1081	1024	1152	1095	1315	1011	1288	576	1360
160 Hour												
Avg. Temp. °F	1093	1261	1168	1082	1037	1159	1127	1340	1044	1315	584	1398
Std. Dev.	19	26	16	11	9	5	22	10	17	13	7	15
Hi Temp. °F	1116	1301	1188	1095	1049	1163	1163	1355	1071	1333	594	1415
Lo Temp. °F	1068	1231	1154	1066	1023	1151	1105	1331	1027	1302	577	1379

Control Temperature: 1050°F

Combustor Location:	In Bed					
Port Number	8		12		10	
Hours Into Run \ Specimen	2	9	9		9	
125 Hour						
Avg. Temp. °F	783	1059	1038		1040	
Std. Dev.	9	17	12		13	
Hi Temp. °F	792	1074	1050		1053	
Lo Temp. °F	772	1036	1020		1031	
130 Hour						
Avg. Temp. °F	1023	1023	1088		1029	
Std. Dev.	36	37	7		7	
Hi Temp. °F	786	1081	1034		1036	
Lo Temp. °F	701	990	1020		1021	
135 Hour						
Avg. Temp. °F	707	1014	1033		1025	
Std. Dev.	11	19	18		20	
Hi Temp. °F	722	1029	1053		1055	
Lo Temp. °F	693	984	1024		1023	
140 Hour						
Avg. Temp. °F	719	1027	1049		1050	
Std. Dev.	10	21	13		13	
Hi Temp. °F	735	1054	1064		1067	
Lo Temp. °F	707	998	1036		1034	
145 Hour						
Avg. Temp. °F	710	1015	1047		1047	
Std. Dev.	7	8	17		16	
Hi Temp. °F	719	1025	1069		1069	
Lo Temp. °F	702	1004	1027		1027	
150 Hour						
Avg. Temp. °F	721	1005	1006		1008	
Std. Dev.	24	25	13		12	
Hi Temp. °F	758	1044	1017		1017	
Lo Temp. °F	693	979	985		989	
155 Hour						
Avg. Temp. °F	711	1011	1007		1007	
Std. Dev.	17	30	39		38	
Hi Temp. °F	738	1052	1065		1064	
Lo Temp. °F	694	984	964		961	
160 Hour						
Avg. Temp. °F	716	1018	977		976	
Std. Dev.	13	20	11		14	
Hi Temp. °F	729	1044	986		988	
Lo Temp. °F	698	995	958		953	

Table C-1 (Cont'd)

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature:	1600°F												1400°F												1200°F												1050°F					
Combustor Location:	In Bed						Above Bed						In Bed						Above Bed						In Bed						Above Bed						In Bed					
Port Number	1		3		5		13		15		17		2		4		6		14		16		18		7		9		11		19		20		22		8		12		10	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X	8	X	X	8	X	8	X	8	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9	9		9	
165 Hour																																										
Avg. Temp. °F	1569	1571	1543	1568	1583		1473	1608	1475	1585	1456	1602	1194	1375	1255	1366	1317	1321	1285	1353	1180	1442	1220	1406	1086	1249	1180	1084	1032	1154	1115	1339	1034	1311	581	1393	710	993	973		972	
Std. Dev.	3	14	22	8	3		28	2	7	2	29	3	6	10	46	6	17	15	10	7	15	3	18	13	20	20	12	5	13	10	23	19	26	21	11	20	15	22	11		10	
Hi Temp. °F	1572	1582	1575	1577	1585		1502	1610	1482	1587	1475	1605	1200	1386	1307	1374	1347	1344	1297	1361	1205	1447	1237	1416	1120	1267	1200	1090	1043	1163	1137	1359	1060	1336	593	1423	725	1017	986		982	
Lo Temp. °F	1566	1547	1522	1558	1579		1442	1606	1466	1583	1455	1598	1184	1362	1237	1358	1301	1508	1272	1343	1169	1439	1190	1383	1072	1221	1170	1077	1011	1143	1080	1314	1001	1283	566	1383	694	972	960		959	
170 Hour																																										
Avg. Temp. °F	1524	1549	1557	1531	1548		1525	1559	1511	1542	1505	1544	1229	1372	1297	1354	1360	1359	1328	1367	1251	1417	1129	1323	1138	1212	1189	1106	1064	1152	1033	1257	899	1185	578	1327	747	1024	1041		1040	
Std. Dev.	54	48	48	53	50		57	58	37	53	38	63	46	11	67	9	45	44	56	21	62	24	84	79	29	36	11	25	44	9	59	62	119	112	10	48	68	50	100		102	
Hi Temp. °F	1565	1594	1613	1563	1584		1607	1608	1552	1586	1544	1601	1310	1382	1389	1368	1416	1415	1413	1388	1334	1441	1217	1411	1171	1258	1204	1143	1140	1161	1103	1336	1025	1308	592	1391	865	1112	1213		1217	
Lo Temp. °F	1441	1468	1480	1447	1465		1454	1475	1470	1464	1458	1454	1201	1353	1237	1343	1314	1313	1278	1346	1170	1386	1013	1220	1100	1165	1180	1082	1033	1141	959	1206	730	1037	566	1271	692	1001	969		969	
175 Hour																																										
Avg. Temp. °F	1568	1567	1557	1572	1572		1461	1608	1473	1587	1466	1603	1196	1386	1266	1356	1339	1337	1293	1359	1190	1444	1212	1399	1093	1164	1175	1091	1024	1151	1105	1331	1021	1302	580	1383	703	1001	973		974	
Std. Dev.	3	13	8	5	5		9	2	2	1	4	1	4	9	35	9	25	24	9	4	10	4	7	3	13	15	12	11	13	8	10	6	11	7	5	6	15	19	26		28	
Hi Temp. °F	1572	1578	1564	1575	1576		1471	1610	1475	1588	1470	1604	1199	1394	1312	1367	1368	1369	1303	1365	1203	1447	1218	1403	1113	1185	1187	1105	1043	1161	1120	1338	1035	1312	587	1390	727	1031	1005		1012	
Lo Temp. °F	1565	1548	1543	1564	1563		1448	1606	1470	1586	1461	1603	1191	1372	1226	1344	1301	1303	1285	1355	1177	1438	1201	1396	1079	1151	1155	1076	1011	1142	1092	1322	1006	1294	574	1375	689	978	934		935	
180 Hour																																										
Avg. Temp. °F	1567	1557	1542	1571	1574		1450	1610	1468	1587	1460	1604	1196	1386	1264	1352	1347	1344	1289	1359	1191	1446	1209	1405	1092	1139	1171	1084	1029	1154	1117	1340	1031	1037	585	1391	729	1025	964		965	
Std. Dev.	2	8	11	7	7		7	1	1	4	2	1	8	7	29	9	12	13	8	4	12	4	3	1	16	16	15	10	8	7	9	3	8	6	2	6	26	30	14		16	
Hi Temp. °F	1570	1570	1553	1580	1577		1460	1611	1470	1590	1462	1605	1209	1393	1300	1363	1362	1361	1297	1364	1202	1450	1213	1406	1117	1157	1186	1098	1040	1163	1129	1345	1042	1317	587	1401	760	1063	982		988	
Lo Temp. °F	1565	1547	1527	1563	1561		1443	1608	1467	1585	1457	1602	1189	1375	1230	1340	1328	1325	1276	1354	1175	1440	1204	1404	1074	1114	1152	1072	1018	1144	1106	1337	1023	1303	583	1387	708	990	947		946	
185 Hour																																										
Avg. Temp. °F	1560	1567	1551	1566	1573		1510	1594	1499	1574	1492	1583	1209	1385	1285	1356	1361	1359	1298	1361	1215	1437	1154	1360	1110	1183	1186	1094	1047	1152	1058	1292	969	1251	575	1357	718	1008	998		997	
Std. Dev.	15	15	28	11	3		47	28	42	23	41	33	25	5	22	8	21	25	14	16	19	18	70	62	29	34	18	10	14	8	41	42	77	75	11	33	29	19	18		20	
Hi Temp. °F	1568	1589	1598	1575	1575		1572	1610	1572	1588	1562	1604	1251	1391	1302	1365	1396	1402	1324	1388	1249	1451	1206	1408	1155	1234	1203	1106	1066	1159	1104	1331	1025	1304	589	1384	765	1036	1028		1030	
Lo Temp. °F	1533	1550	1528	1549	1567		1460	1544	1470	1533	1460	1525	1190	1378	1249	1346	1345	1342	1291	1345	1203	1407	1037	1254	1080	1147	1165	1079	1028	1141	994	1226	835	1120	560	1301	692	987	980		983	
190 Hour																																										
Avg. Temp. °F	1564	1562	1534	1571	1580		1500	1608	1484	1586	1477	1600	1195	1378	1272	1356	1368	1368	1304	1364	1200	1442	1176	1379	1104	1190	1168	1094	1028	1153	1064	1292	996	1280	570	1357	707	1009	1005		1008	
Std. Dev.	2	10	27	5	7		8	2	2	2	5	2	6	5	37	9	20	20	12	13	10	3	12	5	19	17	22	5	13	15	14	17	9	8	8	13	4	16	24		21	
Hi Temp. °F	1567	1580	1572	1576	1586		1514	1610	1486	1588	1483	1604	1203	1384	1313	1362	1396	1392	1319	1380	1217	1446	1190	1385	1126	1218	1199	1100	1048	1169	1081	1307	1006	1289	579	1371	713	1029	1023		1022	
Lo Temp. °F	1562	1555	1518	1563	1570		1494	1606	1482	1584	1470	1598	1189	1372	1228	1340	1341	1337	1291	1352	1190	1439	1167	1374	1081	1174	1146	1086	1015	1134	1047	1265	988	1273	561	1343	702	995	964		971	
195 Hour																																										
Avg. Temp. °F	1565	1563	1522	1572	1569		1462	1610	1472	1589	1463	1604	1193	1380	1283	1372	1359	1361	1312	1376	1188	1446	1180	1391	1088	1163	1176	1072	1048	1160	1093	1320	1025	1302	577	1388	708	1020	998		999	
Std. Dev.	3	18	15	15	7		38	3	12	3	13	5	11	78	36	11	17	19	10	6	17	6	15	17	15	39	9	16	12	7	38	29	40	34	16	31	15	16	10		11	
Hi Temp. °F	1568	1582	1546	1592	1578		1510	1614	1484	1593	1473	1611	1207	1391	1329	1384	1385	1393	1323	1384	1209	1454	1205	1417	1107	1226	1190	1096	1056	1166	1150	1366	1084	1354	601	1438	729	1038	1006		1008	
Lo Temp. °F	1561	1542	1509	1555	1559		1415	1608	1457	1587	1447	1600	1178	1372	1238	1358	1343	1344	1301	1371	1163	1439	1163	1371	1068	1126	1168	1058	1027	1148	1058	1298	984	1268	560	1366	694	1001	982		980	
200 Hour																																										
Avg. Temp. °F	1563	1565	1524	1579	1571		1491	1609	1470	1587	1473	1601	1199	1375	1296	1372	1379	1375	1320	1379	1201	1444	1171	1377	1101	1141	1187	1086	1030	1157	1155	1293	989	1277	558	1361	703	1010	991		991	
Std. Dev.	2	14	10	20	6		9	1	1	3	2	2	8	9	32	6	8	7	8	5	6	2	6	3	19	25	18	24	7	5	2	4	6	4	5	7	21	26	15		12	
Hi Temp. °F	1565	1579	1533	1603	1579		1500	1610	1480	1590	1475	1603	1210	1388	1336	1381	1390	1384	1333	1386	1209	1447	1176	1380	1114	1173	1206	1111	1037	1165	1057	1299	994	1282	564	1373	2727	1039	1008		1007	
Lo Temp. °F	1561	1543	1511	1560	1564		1479	1608	1477	1583	1470	1598	1191	1366	1258	1364	1368	1364	1313	1374	1195	1442	1162	1372	1068	1111	1166	1055	1022	1151	1053	1288	982	1271	551	1353	677	984	974		980	

Table C-1 (Cont'd)

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature: 1600°F

Hours Into Run	In Bed: Port 1, X	Port 1, H	Port 3, H	Port 3, X	Port 5, H	Port 5, X	Above Bed: Port 13, X	Port 13, H	Port 15, H	Port 15, X	Port 17, H	Port 17, X
205 Hour												
Avg. Temp. °F	1562	1562	1527	1578	1577		1461	1610	1472	1586	1463	1603
Std. Dev.	1	14	22	14	6		14	2	3	1	5	32
Hi Temp. °F	1563	1578	1559	1596	1584		1478	1613	1475	1587	1470	1606
Lo Temp. °F	1560	1543	1505	1567	1567		1444	1608	1464	1584	1457	1602
210 Hour												
Avg. Temp. °F	1565	1560	1534	1566	1582		1460	1610	1468	1587	1460	1605
Std. Dev.	2	11	14	6	5		17	2	5	3	4	3
Hi Temp. °F	1566	1579	1555	1573	1590		1473	1612	1473	1591	1463	1608
Lo Temp. °F	1562	1554	1520	1557	1578		1431	1606	1462	1584	1453	1602
215 Hour												
Avg. Temp. °F	1563	1560	1532	1565	1581		1448	1609	1465	1587	1459	1605
Std. Dev.	4	12	17	6	7		24	2	8	2	5	3
Hi Temp. °F	1567	1573	1560	1574	1591		1484	1612	1476	1588	1467	1609
Lo Temp. °F	1558	1545	1517	1558	1571		1422	1608	1456	1584	1454	1600
220 Hour												
Avg. Temp. °F	1571	1569	1560	1591	1585		1465	1608	1477	1591	1467	1604
Std. Dev.	4	20	25	9	11		26	1	9	4	7	4
Hi Temp. °F	1577	1590	1580	1601	1595		1490	1610	1488	1596	1475	1611
Lo Temp. °F	1566	1542	1527	1578	1569		1423	1607	1466	1585	1453	1600
225 Hour												
Avg. Temp. °F	1570	1576	1555	1585	1597		1470	1609	1478	1591	1463	1603
Std. Dev.	2	12	14	4	4		10	1	4	1	5	1
Hi Temp. °F	1572	1588	1579	1591	1603		1481	1611	1484	1591	1469	1604
Lo Temp. °F	1568	1555	1544	1582	1593		1458	1608	1475	1590	1457	1602
230 Hour												
Avg. Temp. °F	1570	1575	1559	1584	1593		1447	1608	1473	1590	1458	1605
Std. Dev.	4	18	12	10	1		24	1	6	1	6	3
Hi Temp. °F	1573	1595	1572	1597	1594		1471	1609	1478	1591	1453	1602
Lo Temp. °F	1566	1553	1541	1572	1592		1415	1607	1464	1589	1453	1602
235 Hour												
Avg. Temp. °F	1569	1571	1555	1588	1594		1454	1608	1476	1592	1460	1605
Std. Dev.	2	11	17	3	8		9	2	3	2	3	2
Hi Temp. °F	1571	1579	1581	1592	1598		1462	1611	1480	1594	1465	1607
Lo Temp. °F	1568	1552	1540	1585	1579		1441	1607	1473	1590	1457	1603
240 Hour												
Avg. Temp. °F	1569	1571	1563	1591	1590		1459	1608	1475	1592	1460	1605
Std. Dev.	4	20	13	7	7		23	2	7	1	7	2
Hi Temp. °F	1575	1592	1574	1598	1598		1478	1610	1481	1593	1467	1608
Lo Temp. °F	1565	1539	1544	1580	1582		1422	1606	1467	1591	1451	1603

Control Temperature: 1400°F

Hours Into Run	In Bed: Port 2, 8	Port 2, X	Port 4, X	Port 4, 8	Port 6, X	Port 6, 8	Above Bed: Port 14, X	Port 14, 8	Port 16, X	Port 16, 8	Port 18, 8	Port 18, X
205 Hour												
Avg. Temp. °F	1204	1383	1305	1375	1377	1376	1311	1376	1198	1452	1191	1392
Std. Dev.	8	8	28	11	8	11	13	6	12	2	10	10
Hi Temp. °F	1215	1391	1332	1386	1390	1390	1327	1386	1214	1455	1207	1408
Lo Temp. °F	1193	1371	1261	1359	1370	1366	1297	1369	1184	1450	1181	1383
210 Hour												
Avg. Temp. °F	1198	1377	1312	1369	1372	1372	1301	1368	1186	1450	1190	1396
Std. Dev.	9	5	11	5	9	7	6	3	7	2	7	4
Hi Temp. °F	1211	1383	1323	1376	1382	1382	1310	1371	1194	1453	1196	1400
Lo Temp. °F	1189	1371	1301	1364	1360	1364	1293	1364	1178	1449	1181	1392
215 Hour												
Avg. Temp. °F	1199	1382	1287	1370	1375	1377	1300	1372	1182	1452	1186	1397
Std. Dev.	7	8	24	8	17	14	3	4	6	2	12	6
Hi Temp. °F	1207	1388	1318	1379	1389	1391	1303	1377	1191	1455	1200	1404
Lo Temp. °F	1189	1370	1254	1361	1347	1353	1297	1368	1175	1450	1169	1388
220 Hour												
Avg. Temp. °F	1207	1392	1292	1405	1370	1369	1324	1387	1164	1431	1175	1386
Std. Dev.	10	10	31	30	15	15	12	8	28	9	15	13
Hi Temp. °F	1217	1402	1347	1432	1385	1382	1339	1396	1207	1455	1191	1399
Lo Temp. °F	1194	1378	1270	1361	1346	1346	1310	1375	1141	1422	1154	1366
225 Hour												
Avg. Temp. °F	1206	1380	1267	1416	1391	1392	1322	1388	1140	1423	1175	1385
Std. Dev.	12	6	8	7	13	12	8	5	5	2	6	5
Hi Temp. °F	1223	1387	1278	1425	1405	1407	1330	1395	1146	1426	1184	1393
Lo Temp. °F	1194	1371	1258	1409	1374	1377	1313	1382	1132	1420	1169	1381
230 Hour												
Avg. Temp. °F	1208	1385	1274	1416	1382	1377	1323	1382	1138	1426	1181	1390
Std. Dev.	3	5	8	5	16	15	7	4	9	3	12	8
Hi Temp. °F	1210	1390	1281	1423	1398	1391	1330	1387	1147	1428	1194	1400
Lo Temp. °F	1203	1378	1261	1411	1364	1360	1315	1377	1127	1422	1168	1382
235 Hour												
Avg. Temp. °F	1207	1387	1264	1417	1373	1376	1322	1383	1153	1432	1182	1391
Std. Dev.	6	5	7	4	6	9	7	2	6	3	4	2
Hi Temp. °F	1216	1393	1270	1420	1381	1390	1330	1386	1159	1436	1185	1394
Lo Temp. °F	1200	1380	1253	1411	1365	1368	1313	1381	1144	1427	1178	1388
240 Hour												
Avg. Temp. °F	1202	1380	1258	1414	1384	1383	1326	1387	1147	1430	1178	1388
Std. Dev.	8	6	11	6	12	12	5	2	11	6	16	11
Hi Temp. °F	1212	1391	1271	1422	1397	1394	1331	1391	1165	1437	1199	1405
Lo Temp. °F	1191	1378	1243	1407	1366	1362	1318	1385	1137	1422	1163	1378

Control Temperature: 1200°F

Hours Into Run	In Bed: Port 7, 3	Port 7, 8	Port 9, 8	Port 9, 3	Port 11, 8	Port 11, 3	Above Bed: Port 19, 8	Port 19, 3	Port 20, 3	Port 20, 8	Port 22, 8	Port 22, 3
205 Hour												
Avg. Temp. °F	1096	1189	1179	1086	1039	1160	1093	1316	1024	1302	568	1381
Std. Dev.	8	20	30	13	15	7	19	13	15	12	9	6
Hi Temp. °F	1107	1217	1212	1105	1054	1168	1118	1335	1041	1318	582	1387
Lo Temp. °F	1088	1163	1138	1074	1019	1154	1075	1300	1003	1284	558	1373
210 Hour												
Avg. Temp. °F	1109	1221	1190	1085	1034	1154	1106	1329	1032	1311	545	1391
Std. Dev.	18	22	14	7	9	5	16	10	11	8	15	9
Hi Temp. °F	1124	1249	1206	1091	1044	1160	1123	1336	1041	1320	566	1400
Lo Temp. °F	1079	1194	1173	1073	1025	1147	1087	1312	1013	1303	525	1380
215 Hour												
Avg. Temp. °F	1096	1223	1196	1091	1049	1157	1096	1328	1024	1307	528	1386
Std. Dev.	9	27	13	6	10	5	17	12	21	11	9	13
Hi Temp. °F	1107	1256	1214	1097	1058	1162	1117	1344	1056	1323	538	1405
Lo Temp. °F	1081	1182	1182	1082	1037	1149	1074	1311	1003	1293	520	1373
220 Hour												
Avg. Temp. °F	1118	1180	1188	1078	1060	1167	1084	1313	1014	1294	533	1376
Std. Dev.	19	26	19	9	7	13	30	20	31	22	18	23
Hi Temp. °F	1133	1209	1211	1092	1069	1186	1127	1343	1062	1327	560	1410
Lo Temp. °F	1087	1155	1164	1070	1052	1152	1044	1284	979	1265	513	1349
225 Hour												
Avg. Temp. °F	1116	1225	1193	1091	1063	1182	1082	1305	1002	1288	536	1373
Std. Dev.	13	40	17	11	14	5	6	5	8	5	7	7
Hi Temp. °F	1134	1269	1219	1105	1076	1186	1090	1310	1013	1292	545	1382
Lo Temp. °F	1101	1177	1173	1079	1043	1174	1075	1298	993	1281	528	1364
230 Hour												
Avg. Temp. °F	1120	1201	1188	1080	1065	1180	1086	1312	1014	1296	529	1376
Std. Dev.	14	29	19	15	8	4	11	10	7	8	13	13
Hi Temp. °F	1137	1235	1218	1094	1073	1186	1103	1323	1021	1306	545	1393
Lo Temp. °F	1105	1168	1170	1063	1053	1176	1076	1301	1006	1287	517	1359
235 Hour												
Avg. Temp. °F	1115	1218	1191	1075	1053	1174	1078	1309	1017	1294	542	1374
Std. Dev.	4	20	17	16	7	9	11	4	5	4	5	4
Hi Temp. °F	1120	1235	1205	1098	1060	1183	1090	1313	1023	1299	550	1380
Lo Temp. °F	1110	1195	1165	1057	1043	1161	1065	1304	1010	1288	536	1370
240 Hour												
Avg. Temp. °F	1118	1205	1195	1077	1064	1176	1085	1311	1012	1293	537	1375
Std. Dev.	16	25	17	11	10	8	20	16	22	16	17	17
Hi Temp. °F	1134	1242	1216	1088	1074	1185	1117	1335	1047	1317	556	1400
Lo Temp. °F	1094	1181	1178	1064	1053	1164	1068	1299	990	1281	513	1354

Control Temperature: 1050°F

Hours Into Run	In Bed: Port 8, 2	Port 8, 9	Port 12, 9	Port 12	Port 10, 9	Port 10
205 Hour						
Avg. Temp. °F	709	1014	998		998	
Std. Dev.	9	17	16		16	
Hi Temp. °F	721	1004	1013		1014	
Lo Temp. °F	698	1001	973		973	
210 Hour						
Avg. Temp. °F	719	1010	1017		1017	
Std. Dev.	16	16	31		24	
Hi Temp. °F	738	1034	1067		1055	
Lo Temp. °F	696	996	984		990	
215 Hour						
Avg. Temp. °F	718	1019	1011		1014	
Std. Dev.	9	4	8		9	
Hi Temp. °F	725	1024	1023		1027	
Lo Temp. °F	711	1014	1002		1003	
220 Hour						
Avg. Temp. °F	724	1038	1024		1024	
Std. Dev.	22	25	24		25	
Hi Temp. °F	777	1075	1048		1043	
Lo Temp. °F	713	1016	990		989	
225 Hour						
Avg. Temp. °F	740	1051	1031		1030	
Std. Dev.	19	28	38		38	
Hi Temp. °F	764	1070	1092		1093	
Lo Temp. °F	713	1003	988		999	
230 Hour						
Avg. Temp. °F	722	1033	1021		1021	
Std. Dev.	18	17	13		17	
Hi Temp. °F	755	1051	1033		1036	
Lo Temp. °F	712	1007	1006		1003	
235 Hour						
Avg. Temp. °F	715	1025	1018		1016	
Std. Dev.	19	23	12		11	
Hi Temp. °F	746	1059	1031		1030	
Lo Temp. °F	694	1003	1000		1000	
240 Hour						
Avg. Temp. °F	717	1031	1024		1028	
Std. Dev.	12	23	16		20	
Hi Temp. °F	730	1058	1044		1049	
Lo Temp. °F	701	998	1006		1002	

Table C-1 (Cont'd)

Heat Exchanger Probes Temperature History (Run 78)

Control Temperature: 1600°F

Combustor Location:	In Bed						Above Bed					
Port Number	1		3		5		13		15		17	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	H	X
245 Hour												
Avg. Temp. °F	1569	1572	1557	1586	1596		1451	1608	1473	1592	1458	1605
Std. Dev.	2	15	17	8	2		23	1	8	2	7	2
Hi Temp. °F	1571	1585	1577	1594	1599		1465	1604	1481	1594	1466	1608
Lo Temp. °F	1566	1547	1538	1575	1593		1411	1607	1459	1590	1448	1603
250 Hour												
Avg. Temp. °F	1558	1572	1556	1577	1582		1514	1590	1508	1574	1495	1581
Std. Dev.	26	9	26	29	17		61	33	39	30	40	39
Hi Temp. °F	1571	1584	1584	1597	1595		1597	1609	1557	1592	1549	1607
Lo Temp. °F	1512	1561	1521	1528	1553		1459	1532	1477	1522	1463	1515
255 Hour												
Avg. Temp. °F	1568	1580	1561	1586	1596		1436	1609	1466	1593	1451	1605
Std. Dev.	2	14	16	8	6		9	1	4	1	5	3
Hi Temp. °F	1570	1593	1574	1600	1602		1444	1611	1473	1594	1458	1603
Lo Temp. °F												

Control Temperature: 1400°F

Combustor Location:	In Bed						Above Bed					
Port Number	2		4		6		14		16		18	
Hours Into Run \ Specimen	8	X	X	8	X	8	X	8	X	8	8	X
245 Hour												
Avg. Temp. °F	1200	1380	1265	1415	1377	1380	1322	1384	1150	1430	1184	1394
Std. Dev.	10	16	11	2	16	15	3	3	8	5	11	10
Hi Temp. °F	1214	1396	1282	1418	1393	1396	1326	1387	1158	1438	1203	1411
Lo Temp. °F	1188	1362	1257	1413	1353	1363	1319	1380	1140	1424	1178	1387
250 Hour												
Avg. Temp. °F	1220	1388	1295	1418	1406	1403	1348	1398	1176	1414	1124	1357
Std. Dev.	16	5	25	5	41	41	34	17	32	21	74	66
Hi Temp. °F	1241	1392	1329	1426	1465	1458	1402	1425	1221	1430	1191	1398
Lo Temp. °F	1208	1380	1271	1413	1376	1371	1322	1384	1142	1381	1014	1241
255 Hour												
Avg. Temp. °F	1204	1376	1266	1414	1379	1382	1310	1376	1139	1430	1176	1393
Std. Dev.	6	13	2	2	13	15	5	3	6	2	7	5
Hi Temp. °F	1210	1394	1268	1417	1391	1397	1318	1379	1147	1432	1186	1398
Lo Temp. °F	1198	1359	1264	1412	1361	1358	1305	1373	1133	1428	1169	1386

Control Temperature: 1200°F

Combustor Location:	In Bed						Above Bed					
Port Number	7		9		11		19		20		22	
Hours Into Run \ Specimen	3	8	8	3	8	3	8	3	3	8	8	3
245 Hour												
Avg. Temp. °F	1126	1179	1179	1082	1066	1175	1084	1316	1127	1302	553	1381
Std. Dev.	6	7	18	14	10	6	27	19	25	20	10	19
Hi Temp. °F	1133	1187	1202	1100	1077	1183	1123	1348	1071	1337	570	1414
Lo Temp. °F	1118	1168	1157	1061	1055	1166	1067	1299	1011	1289	544	1369
250 Hour												
Avg. Temp. °F	1134	1192	1189	1090	1068	1164	1021	1259	947	1224	539	1324
Std. Dev.	13	13	18	22	15	8	64	57	83	84	7	36
Hi Temp. °F	1152	1206	1215	1117	1086	1173	1076	1308	1013	1291	547	1374
Lo Temp. °F	1117	1187	1164	1064	1051	1155	950	1187	822	1098	528	1291
255 Hour												
Avg. Temp. °F	1121	1193	1178	1084	1071	1182	1090	1322	1024	1305	536	1387
Std. Dev.	8	34	15	12	11	7	21	11	8	9	12	11
Hi Temp. °F	1132	1232	1204	1102	1077	1188	1110	1331	1030	1313	545	1398
Lo Temp. °F	1112	1138	1165	1074	1052	1171	1066	1308	1015	1295	517	1373

Control Temperature: 1050°F

Combustor Location:	In Bed					
Port Number	8		12		10	
Hours Into Run \ Specimen	2	9	9		9	
245 Hour						
Avg. Temp. °F	730	1045	1031		1033	
Std. Dev.	17	20	9		9	
Hi Temp. °F	746	1065	1041		1043	
Lo Temp. °F	701	1024	1016		1022	
250 Hour						
Avg. Temp. °F	738	1055	1058		1058	
Std. Dev.	37	20	44		43	
Hi Temp. °F	781	1080	1121		1123	
Lo Temp. °F	707	1032	1016		1017	
255 Hour						
Avg. Temp. °F	715	1036	1045		1046	
Std. Dev.	13	21	10		8	
Hi Temp. °F	727	1068	1055		1054	
Lo Temp. °F	693	1006	1026		1033	

Table C-2

Heat Exchanger Probes Temperature History (Run 79)

Control Temperature:	1600												1400												1200												1050					
Combustor Location:	In Bed						Above Bed						In Bed						Above Bed						In Bed						Above Bed						In Bed					
Port Number	1		3		5		13		15		17		2		4		6		14		16		18		7		9		11		19		20		22		8		12		10	
Specimen	X	H	H	X	H	X	X	H	H	X	H	X	8	X	X	8	X	8	X	8	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9			9	2
Hours Into Run	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
5 Hour																																										
Avg. Temp. °F	1443	1487	1417	1501	1287	1507	1293	1489	1357	1502	1267	1506	1055	1299	754	1410	1317	1325	1163	1286	915	1325	979	1262	971	1032	1076	1103	915	1071	826	1140	803	1092	739	1133	594	807	893		933	940
Std. Dev.	73	56	92	69	101	58	87	73	80	71	77	55	78	62	14	54	64	65	84	72	79	56	41	32	75	81	66	74	65	67	104	92	95	87	96	112	67	85	67		115	103
Hi Temp. °F	1537	1567	1549	1590	1425	1588	1426	1588	1476	1595	1391	1582	1158	1384	774	1485	1411	1419	1279	1383	1028	1399	1018	1291	1067	1134	1155	1201	1006	1174	994	1273	963	993	911	1300	682	903	998		1115	1098
Lo Temp. °F	1360	1433	1315	1419	1185	1448	1207	1411	1283	1428	1183	1430	964	1230	742	1354	1234	1244	1075	1206	836	1263	920	1210	889	920	1012	1025	841	1008	712	1018	712	1231	711	990	522	714	824		801	814
10 Hour																																										
Avg. Temp. °F	1022	1045	1015	1043	988	1038	1043	1097	1052	1095	1015	1092	849	959	553	994	947	950	976	1015	884	1013	591	783	774	823	817	850	753	892	629	796	719	880	757	951	553	649	715		722	704
Std. Dev.	674	664	667	665	641	673	545	545	557	549	524	549	517	590	365	621	603	606	489	460	425	480	417	517	451	474	490	499	435	487	408	502	384	445	303	415	218	343	401		381	391
Hi Temp. °F	1567	1594	1548	1596	1528	1588	1468	1468	1496	1588	1411	1581	1311	1391	858	1478	1415	1416	1345	1394	1328	1395	989	1255	1142	1227	1190	1230	1145	1196	984	1243	1050	1216	934	1288	711	922	1069		1009	995
Lo Temp. °F	152	172	152	171	156	164	257	257	253	336	252	328	157	168	105	171	156	156	252	347	249	315	115	155	157	164	155	167	174	174	133	177	179	240	256	332	191	154	155		173	154
15 Hour																																										
Avg. Temp. °F	1553	1580	1532	1589	1468	1590	1446	1588	1489	1593	1397	1584	1160	1384	909	1476	1371	1373	1296	1395	1078	1397	999	1263	1070	1104	1176	1190	1019	1174	966	1242	954	1221	926	1290	657	876	945		967	976
Std. Dev.	16	3	15	3	40	2	9	2	2	1	4	1	5	4	7	5	18	27	5	2	4	1	3	4	19	17	15	14	10	6	8	5	1	5	3	3	34	37	21		8	11
Hi Temp. °F	1568	1582	1538	1593	1514	1593	1451	1589	1492	1595	1402	1585	1167	1388	191	1483	1388	1396	1301	1398	1083	1398	1005	1268	1094	1134	1191	1207	1028	1179	980	1251	956	1226	929	1294	708	925	974		979	993
Lo Temp. °F	1530	1575	1515	1586	1425	1588	1436	1585	1487	1592	1393	1583	1155	1377	902	1469	1345	1339	1287	1393	1074	1396	996	1257	1051	1090	1156	1171	1005	1165	959	1237	952	1216	920	1286	616	827	921		959	961
20 Hour																																										
Avg. Temp. °F	1544	1574	1539	1590	1470	1588	1461	1589	1493	1592	1403	1582	1171	1377	910	1472	1396	1399	1298	1394	1072	1395	1001	1267	1077	1095	1154	1181	1020	1172	964	1242	952	1225	931	1289	659	896	947		959	979
Std. Dev.	10	7	19	5	31	6	14	2	9	4	11	2	10	5	6	5	31	26	8	6	10	3	16	15	5	12	22	10	18	9	4	6	4	5	3	6	31	40	13		14	9
Hi Temp. °F	1558	1579	1569	1598	1413	1592	1478	1590	1505	1596	1417	1585	1180	1382	916	1475	1425	1429	1309	1403	1086	1399	1015	1283	1084	1107	1188	1191	1044	1180	970	1249	956	1230	936	1297	691	928	963		974	987
Lo Temp. °F	1532	1562	1522	1587	1431	1578	1439	1586	1481	1585	1388	1579	1158	1369	902	1464	1357	1364	1288	1386	1061	1392	977	1244	1071	1081	1134	1164	1002	1163	960	1234	945	1217	927	1280	617	834	928		946	964
25 Hour																																										
Avg. Temp. °F	1555	1575	1539	1586	1462	1591	1438	1591	1482	1597	1389	1585	1165	1376	902	1470	1371	1379	1295	1391	1063	1396	1169	1378	1074	1097	1142	1170	1021	1170	955	1242	949	1227	928	1298	653	893	955		962	984
Std. Dev.	12	7	8	4	18	2	14	1	6	2	8	2	10	7	4	7	20	21	3	3	3	2	135	85	13	14	17	13	8	4	3	6	2	2	3	5	35	34	11		9	11
Hi Temp. °F	1571	1581	1549	1589	1483	1594	1453	1592	1490	1600	1399	1587	1175	1384	908	1477	1402	1411	1299	1395	1067	1398	1276	1445	1091	1120	1166	1188	1032	1175	958	1251	952	1229	931	1304	692	937	967		971	1001
Lo Temp. °F	1539	1565	1530	1579	1441	1589	1421	1590	1476	1595	1379	1584	1149	1367	898	1458	1352	1360	1291	1387	1059	1394	1013	1278	1062	1083	1125	1152	1015	1165	951	1235	947	1225	924	1292	616	862	939		949	974
30 Hour																																										
Avg. Temp. °F	1576	1599	1568	1610	1466	1609	1472	1609	1508	1615	1416	1604	1189	1393	908	1469	1349	1347	1320	1417	1096	1415	1158	1372	1099	1116	1185	1192	1050	1188	958	1246	948	1227	926	1295	699	938	975		980	996
Std. Dev.	16	7	17	4	15	3	20	1	7	3	9	3	6	5	5	3	11	9	7	4	6	2	66	43	8	7	21	7	17	9	4	3	3	2	4	4	37	36	11		7	21
Hi Temp. °F	1596	1611	1588	1615	1483	1615	1492	1610	1514	1619	1424	1609	1195	1398	913	1474	1359	1355	1329	1423	1100	1417	1201	1399	1109	1125	1214	1199	1062	1198	963	1248	953	1229	932	1300	746	980	993		987	1031
Lo Temp. °F	1558	1594	1544	1603	1445	1606	1439	1608	1497	1612	1400	1601	1179	1384	903	1467	1333	1332	1310	1413	1087	1414	1041	1295	1089	1109	1167	1181	1021	1176	954	1241	946	1224	920	1291	665	900	965		969	980
35 Hour																																										
Avg. Temp. °F	1569	1596	1559	1608	1498	1611	1467	1608	1506	1615	1414	1603	1192	1394	911	1467	1350	1351	1325	1420	1100	1413	1184	1387	1086	1108	1184	1198	1042	1185	962	1243	945	1227	923	1288	679	910	970		985	993
Std. Dev.	14	3	16	4	18	1	16	1	5	1	5	2	5	6	4	6	12	12	6	3	6	1	6	4	16	11	34	15	11	6	7	5	2	1	4	2	18	14	12		5	17
Hi Temp. °F	1593	1599	1577	1614	1513	1613	1479	1609	1511	1616	1420	1606	1197	1399	915	1475	1367	1365	1331	1424	1110	1415	1194	1393	1106	1122	1215	1212	1054	1192	968	1248	947	1229	926	1292	704	922	986		989	1019
Lo Temp. °F	1559	1592	1545	1605	1471	1610	1441	1607	1499	1614	1406	1601	1184	1385	907	1459	1336	1340	1316	1418	1094	1412	1178	1384	1064	1092	1133	1181	1026	1178	951	1235	942	1226	917	1287	656	887	957		977	973
40 Hour																																										
Avg. Temp. °F	1575	1588	1565	1600	1477	1610	1450	1609	1501	1615	1402	1604	1188	1395	917	1473	1336	1334	1316	1405	1075	1408	1193	1406	1106	1115	1183	1185	1053	1186	949	1251	937	1235	918	1311	665	929	979		969	984
Std. Dev.	16	7	14	7	16	3	7	1	5	1	6	1	7	6	6	10	12	11	7	9	17	3	13	14	18	12	27	14	12	6	13	8	1	7	1	15	38	30	21		16	17
Hi Temp. °F	1592	1597	1516	1606	1501	1614	1461	1611	1505	1616	1412	1605	1195	1405	924	1483	1351	1346	1327	1419	1095	1412	1210	1423	1130	1136	1226	1206	1072	1195	968	1259	939	1245	919	1331	707	969	1011		989	1009
Lo Temp. °F	1553	1580	1546	1588	1455	1607	1443	1608	1493	1614	1396	1603	1180	1391	909	1460	1323	1320	1309	1396	1053	1403	1179	1389	1083	1103	1160	1173	1044	1179	933	1240	935	1225	916	1295	610	892	954		950	965

Table C-2 (Cont'd)

Heat Exchanger Probes Temperature History (Run 79)

Hours Into Run \ Specimen	1	2	3	4	5	6	7	8	9	10	11	12
Control Temperature:	1600											
Combustor Location:	In Bed						Above Bed					
Port Number	1		3		5		13		15		17	
Specimen	X	H	H	X	H	X	X	H	H	X	H	X
45 Hour												
Avg. Temp. °F	1569	1582	1566	1604	1483	1605	1449	1609	1500	1614	1402	1603
Std. Dev.	10	10	15	4	26	6	12	0	5	1	8	1
Hi Temp. °F	1580	1593	1580	1609	1527	1609	1464	1610	1504	1614	1411	1603
Lo Temp. °F	1556	1572	1542	1600	1462	1595	1439	1609	1495	1613	1393	1602
50 Hour												
Avg. Temp. °F	1567	1572	1565	1594	1465	1607	1432	1607	1490	1610	1387	1601
Std. Dev.	6	4	18	7	26	3	4	1	4	1	8	3
Hi Temp. °F	1574	1576	1582	1604	1505	1611	1436	1608	1494	1612	1397	1604
Lo Temp. °F	1562	1567	1537	1586	1441	1604	1425	1606	1484	1609	1379	1597
55 Hour												
Avg. Temp. °F	1580	1558	1568	1583	1504	1605	1450	1598	1500	1600	1411	1590
Std. Dev.	19	6	22	17	54	20	71	24	40	26	85	23
Hi Temp. °F	1597	1563	1598	1594	1499	1617	1573	1609	1571	1612	1562	1602
Lo Temp. °F	1551	1549	1537	1586	1447	1570	1401	1555	1475	1553	1359	1549
60 Hour												
Avg. Temp. °F	1562	1563	1563	1588	1463	1612	1441	1608	1496	1610	1392	1599
Std. Dev.	11	3	19	3	12	3	7	2	4	1	4	1
Hi Temp. °F	1578	1565	1583	1592	1475	1615	1451	1610	1499	1611	1397	1600
Lo Temp. °F	1552	1559	1542	1585	1443	1608	1432	1604	1491	1609	1386	1597
65 Hour												
Avg. Temp. °F	1574	1564	1565	1590	1495	1613	1430	1607	1488	1609	1382	1597
Std. Dev.	21	7	12	4	26	3	23	3	15	2	21	1
Hi Temp. °F	1593	1573	1581	1595	1531	1609	1455	1611	1505	1612	1405	1598
Lo Temp. °F	1549	1556	1548	1585	1460	1616	1397	1604	1465	1606	1349	1595
70 Hour												
Avg. Temp. °F	1180	1194	1192	1213	1141	1216	1154	1260	1177	1259	1120	1253
Std. Dev.	590	581	599	596	555	608	496	531	514	531	471	527
Hi Temp. °F	1569	1573	1585	1606	1514	1620	1482	1610	1508	1608	1421	1597
Lo Temp. °F	214	246	213	246	221	232	326	407	325	406	323	403
75 Hour												
Avg. Temp. °F	1353	1350	1365	1362	1327	1367	1345	1380	1358	1373	1318	1370
Std. Dev.	207	225	216	238	172	228	185	254	196	257	168	254
Hi Temp. °F	1570	1577	1586	1604	1512	1599	1480	1605	1511	1603	1428	1593
Lo Temp. °F	1131	1119	1136	1118	1135	1130	1115	1094	1114	1086	1112	1087
80 Hour												
Avg. Temp. °F	1573	1579	1569	1598	1477	1592	1489	1608	1511	1604	1421	1594
Std. Dev.	16	3	13	2	20	2	5	3	5	2	9	1
Hi Temp. °F	1591	1583	1585	1600	1495	1595	1497	1613	1514	1606	1427	1595
Lo Temp. °F	1557	1576	1552	1596	1446	1590	1485	1606	1502	1602	1405	1593

Hours Into Run \ Specimen	13	14	15	16	17	18	19	20	21	22	23	24
Control Temperature:	1400											
Combustor Location:	In Bed						Above Bed					
Port Number	2		4		6		14		16		18	
Specimen	8	X	X	8	X	8	X	8	X	8	8	X
45 Hour												
Avg. Temp. °F	1191	1396	915	1469	1338	1336	1314	1400	1077	1407	1201	1410
Std. Dev.	3	4	4	5	16	16	11	7	13	3	13	11
Hi Temp. °F	1195	1402	919	1474	1363	1363	1326	1410	1093	1411	1217	1421
Lo Temp. °F	1186	1391	911	1461	1321	1321	1298	1393	1063	1403	1186	1396
50 Hour												
Avg. Temp. °F	1196	1403	916	1467	1362	1364	1315	1390	1045	1396	1230	1434
Std. Dev.	9	7	3	4	21	24	6	5	5	2	6	4
Hi Temp. °F	1206	1413	921	1472	1381	1386	1322	1395	1053	1399	1235	1438
Lo Temp. °F	1186	1395	912	1461	1332	1337	1308	1384	1038	1394	1220	1428
55 Hour												
Avg. Temp. °F	1197	1396	909	1459	1390	1392	1324	1392	1066	1392	1207	1413
Std. Dev.	27	10	6	10	17	19	22	14	47	8	67	59
Hi Temp. °F	1245	1410	918	1472	1419	1422	1361	1418	1148	1397	1249	1455
Lo Temp. °F	1180	1381	903	1449	1375	1369	1308	1384	1031	1378	1089	1309
60 Hour												
Avg. Temp. °F	1187	1399	917	1471	1385	1382	1314	1383	1048	1391	1229	1426
Std. Dev.	7	4	3	5	10	14	5	4	10	4	2	4
Hi Temp. °F	1198	1404	920	1479	1396	1402	1319	1388	1059	1395	1231	1429
Lo Temp. °F	1179	1393	913	1466	1373	1367	1309	1377	1035	1387	1226	1421
65 Hour												
Avg. Temp. °F	1197	1402	904	1469	1395	1397	1313	1384	1052	1395	1231	1429
Std. Dev.	9	9	14	17	10	13	15	3	16	7	20	16
Hi Temp. °F	1208	1414	915	1483	1410	1410	1325	1387	1080	1403	1257	1449
Lo Temp. °F	1185	1391	881	1439	1382	1382	1287	1380	1038	1387	1202	1405
70 Hour												
Avg. Temp. °F	966	1092	674	1135	1079	1081	1070	1130	916	1127	885	1064
Std. Dev.	425	507	342	538	506	508	435	424	332	437	473	523
Hi Temp. °F	1209	1410	907	1476	1395	1405	1329	1396	1085	1400	1214	1418
Lo Temp. °F	221	237	128	240	221	220	321	417	322	392	171	239
75 Hour												
Avg. Temp. °F	1191	1268	810	1296	1282	1281	1276	1263	1159	1267	950	1167
Std. Dev.	58	133	150	175	127	126	109	155	98	148	238	235
Hi Temp. °F	1284	1410	947	1481	1411	1406	1390	1393	1320	1398	1188	1395
Lo Temp. °F	1124	1119	624	1105	1123	1122	1111	1080	1090	1084	696	905
80 Hour												
Avg. Temp. °F	1194	1403	954	1469	1399	1397	1326	1389	1090	1400	1183	1394
Std. Dev.	13	3	23	4	13	13	12	3	10	3	12	9
Hi Temp. °F	1213	1407	982	1473	1418	1414	1342	1393	1098	1403	1201	1406
Lo Temp. °F	1181	1398	922	1463	1382	1382	1309	1385	1074	1395	1169	1381

Hours Into Run \ Specimen	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Control Temperature:	1200												1050					
Combustor Location:	In Bed						Above Bed						In Bed					
Port Number	7		9		11		19		20		22		8		12		10	
Specimen	3	8	8	3	8	3	8	3	3	8	8	3	2	9			9	2
45 Hour																		
Avg. Temp. °F	1119	1136	1179	1188	1037	1180	942	1249	940	1237	921	1309	694	960	974		962	998
Std. Dev.	10	12	23	11	18	6	4	8	3	4	4	12	24	29	17		15	13
Hi Temp. °F	1128	1154	1203	1203	1064	1188	947	1259	943	1242	927	1319	720	990	996		978	1012
Lo Temp. °F	1105	1121	1157	1174	1015	1174	937	1240	938	1232	916	1295	665	914	959		944	977
50 Hour																		
Avg. Temp. °F	1117	1172	1205	1179	1049	1200	927	1247	938	1247	904	1321	649	940	976		947	998
Std. Dev.	11	24	38	11	12	8	10	9	3	4	25	20	28	42	12		8	8
Hi Temp. °F	1129	1192	1260	1195	1067	1207	944	1259	942	1254	934	1351	689	994	994		957	1007
Lo Temp. °F	1101	1138	1167	1169	1038	1186	916	1236	934	1244	876	1303	620	894	965		937	989
55 Hour																		
Avg. Temp. °F	1133	1193	1206	1191	1054	1200	919	1233	943	1243	873	1297	644	930	975		949	987
Std. Dev.	14	20	26	12	22	12	30	36	12	14	17	35	38	26	22		18	19
Hi Temp. °F	1150	1218	1229	1208	1089	1215	939	1258	962	1251	885	1317	707	974	1013		971	1014
Lo Temp. °F	1120	1164	1176	1178	1034	1185	866	1170	933	1218	843	1235	613	904	956		923	962
60 Hour																		
Avg. Temp. °F	1127	1214	1218	1212	1045	1199	939	1243	943	1248	880	1302	644	931	988		971	985
Std. Dev.	11	7	10	10	11	10	7	4	5	2	5	2	32	31	15		6	7
Hi Temp. °F	1140	1224	1228	1219	1062	1206	949	1247	950	1251	887	1305	699	981	1009		979	994
Lo Temp. °F	1112	1207	1202	1195	1033	1183	928	1236	938	1246	874	1300	624	898	966		964	974
65 Hour																		
Avg. Temp. °F	1116	1204	1215	1217	1067	1205	930	1244	937	1244	877	1301	649	923	983		967	991
Std. Dev.	5	23	17	9	6	13	11	11	3	3	5	7	21	35	18		13	19
Hi Temp. °F	1123	1215	2141	1223	1073	1218	947	1263	940	1249	882	1309	682	946	1006		977	1007
Lo Temp. °F	1111	1163	1196	1205	1060	1183	919	1235	933	1240	871	1292	633	883	969		944	965
70 Hour																		
Avg. Temp. °F	922	981	963	987	880	978	669	917	721	953	651	970	646	647	882		838	838
Std. Dev.	396	423	426	431	371	413	364	476	347	453	333	499	249	249	339		330	348
Hi Temp. °F	1132	1223	1247	1237	1073	1217	932	1240	948	1248	881	1306	973	973	1006		995	1004
Lo Temp. °F	220	243	218	236	218	258	132	175	162	216	143	182	274	274	218		248	216
75 Hour																		
Avg. Temp. °F	1147	1170	1180	1182	1122	1164	746	999	835	1078	712	1064	834	837	1083		1030	1027
Std. Dev.	70	59	68	60	74	62	201	223	138	180	163	225	156	154	116		37	39
Hi Temp. °F	1261	1215	1273	1233	1221	1226	954	1220	953	1238	879	1284	989	989	1211		1078	1065
Lo Temp. °F	1089	1095	1089	1096	1051	1084	533	758	657	862	536	822	643	637	960		985	977
80 Hour																		
Avg. Temp. °F	1093	1208	1188	1224	1068	1215	934	1222	949	1238	882	1288	691	693	988		988	990
Std. Dev.	37	4	37	23	11	18	6	3	2	2	6	5	32	29	12		15	10
Hi Temp. °F	1120	1215	1227	1263	1071	1236	942	1226	952	1240	887	1294	746	728	1008		1008	1002
Lo Temp. °F	1028	1204	1136	1204	1057	1193	926	1219	947	1235	872	1282	668	663	977		967	975

Table C-2 (Cont'd)

Heat Exchanger Probes Temperature History (Run 79)

Control Temperature:	1600												1400							
Combustor Location:	In Bed						Above Bed						In Bed						Above Bed	
Port Number	1		3		5		13		15		17		2		4		6		14	
Hours Into Run \ Specimen	X	H	H	X	H	X	X	H	H	X	X	H	8	X	X	8	X	8	X	8
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
85 Hour																				
Avg. Temp. °F	1578	1580	1566	1599	1474	1592	1504	1606	1523	1601	1439	1592	1200	1406	903	1475	1398	1392	1330	1390
Std. Dev.	15	5	11	5	14	3	18	1	10	3	12	2	11	6	9	11	9	6	5	5
Hi Temp. °F	1591	1587	1578	1605	1486	1595	1527	1607	1536	1604	1457	1595	1211	1415	944	1493	1412	1403	1337	1399
Lo Temp. °F	1554	1573	1551	1595	1454	1589	1487	1605	1511	1597	1427	1590	1182	1402	922	1465	1388	1388	1326	1387
90 Hour																				
Avg. Temp. °F	1580	1579	1558	1593	1497	1587	1539	1604	1538	1597	1459	1589	1200	1400	931	1468	1423	1423	1337	1400
Std. Dev.	15	5	24	4	11	6	14	2	9	3	10	3	9	5	7	13	17	13	9	6
Hi Temp. °F	1595	1583	1598	1599	1515	1594	1555	1605	1552	1601	1473	1593	1211	1407	937	1479	1444	1438	1348	1409
Lo Temp. °F	1557	1573	1544	1590	1487	1579	1525	1600	1529	1595	1449	1585	1189	1395	920	1449	1400	1410	1325	1396
95 Hour																				
Avg. Temp. °F	1587	1581	1556	1607	1488	1593	1553	1599	1551	1593	1477	1585	1201	1400	929	1461	1408	1410	1344	1413
Std. Dev.	16	4	22	15	13	3	18	4	12	4	15	4	5	5	8	5	20	14	3	4
Hi Temp. °F	1595	1586	1590	1627	1510	1595	1576	1603	1570	1596	1501	1589	1205	1406	936	1468	1437	1433	1347	1418
Lo Temp. °F	1553	1577	1531	1589	1476	1590	1528	1593	1539	1587	1462	1578	1194	1395	916	1456	1389	1395	1340	1408
100 Hour																				
Avg. Temp. °F	1577	1582	1566	1604	1517	1599	1559	1588	1554	1581	1495	1575	1207	1391	947	1459	1411	1418	1346	1422
Std. Dev.	13	5	9	13	18	5	42	26	30	27	54	25	8	4	27	6	24	21	15	7
Hi Temp. °F	1592	1589	1574	1624	1536	1604	1607	1605	1586	1598	1577	1592	1215	1396	991	1466	1445	1445	1368	1430
Lo Temp. °F	1556	1576	1550	1589	1492	1593	1514	1542	1520	1534	1446	1532	1195	1386	920	1450	1388	1397	1328	1412

Control Temperature:	1400				1200												1050				
Combustor Location:	Above Bed				In Bed						Above Bed						In Bed				
Port Number	16		18		7		9		11		19		20		22		8		12		10
Hours Into Run \ Specimen	X	8	8	X	3	8	8	3	8	3	8	3	3	8	8	3	2	9			9	2
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
85 Hour																						
Avg. Temp. °F	1096	1395	1178	1385	1110	1217	1178	1228	1061	1214	936	1215	952	1235	886	1283	663	660	970		1000	997
Std. Dev.	6	3	13	13	12	3	15	8	10	8	9	8	7	3	3	7	38	46	24		8	6
Hi Temp. °F	1106	1398	1191	1399	1120	1220	1194	1237	1070	1227	950	1222	962	1238	890	1292	710	728	997		1013	1005
Lo Temp. °F	1091	1392	1159	1368	1093	1212	1157	1219	1045	1206	925	1207	946	1231	881	1273	628	622	944		994	992
90 Hour																						
Avg. Temp. °F	1105	1390	1154	1366	1109	1211	1142	1202	1066	1207	926	1201	958	1231	887	1277	661	666	955		996	995
Std. Dev.	9	2	8	6	6	9	6	9	15	11	9	7	4	2	4	11	35	38	9		14	8
Hi Temp. °F	1121	1392	1164	1375	1116	1219	1147	1213	1081	1224	939	1210	962	1233	892	1292	687	701	970		1007	1006
Lo Temp. °F	1099	1388	1145	1361	1099	1201	1132	1188	1047	1196	917	1194	952	1228	880	1264	602	606	947		973	985
95 Hour																						
Avg. Temp. °F	1125	1390	1138	1352	1125	1201	1175	1217	1085	1210	909	1193	956	1224	876	1263	647	646	978		991	993
Std. Dev.	7	2	12	9	10	15	18	9	9	7	15	13	2	4	12	13	37	30	13		13	10
Hi Temp. °F	1134	1393	1150	1360	1138	1219	1192	1225	1096	1221	928	1214	959	1228	886	1280	706	689	990		1010	1008
Lo Temp. °F	1118	1388	1118	1337	1114	1178	1145	1202	1071	1202	888	1177	954	1218	856	1244	616	615	959		978	979
100 Hour																						
Avg. Temp. °F	1147	1393	1133	1345	1130	1166	1151	1197	1085	1197	867	1131	954	1212	861	1206	657	665	971		985	1006
Std. Dev.	24	12	89	77	23	23	11	31	18	9	75	110	18	19	48	100	49	57	24		22	13
Hi Temp. °F	1187	1409	1256	1448	1165	1189	1164	1241	1115	1205	917	1191	973	1223	896	1260	740	755	1010		1015	1027
Lo Temp. °F	1125	1378	1008	1234	1104	1135	1137	1155	1067	1186	735	934	927	1178	778	1027	617	612	946		963	994

Table C-3

Heat Exchanger Probes Temperature History (Run 80)

LOCATION	IN BED						ABOVE BED					
PORT NO.	1	1	3	3	5	5	13	13	15	15	17	17
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	1	2	3	4	5	6	7	8	9	10	11	12
	DEGREES FAHRENHEIT											
5 HOUR												
AVG. TEMP.	1582	1576	1566	1598	1510	1586	1572	1590	1602	1585	1498	1574
STD. DEV.	22	8	15	5	24	3	27	4	22	8	17	5
HI TEMP.	1648	1594	1590	1607	1542	1591	1615	1596	1642	1595	1531	1581
LO TEMP.	1557	1561	1543	1588	1443	1591	1537	1582	1570	1567	1470	1564
10 HOUR												
AVG. TEMP.	1585	1578	1563	1604	1517	1587	1607	1572	1593	1562	1559	1557
STD. DEV.	15	4	17	8	27	5	7	9	7	9	33	8
HI TEMP.	1604	1587	1589	1629	1555	1595	1617	1582	1603	1572	1603	1565
LO TEMP.	1558	1572	1535	1593	1462	1581	1595	1556	1579	1544	1519	1541
15 HOUR												
AVG. TEMP.	1589	1582	1554	1592	1513	1593	1600	1563	1596	1553	1598	1548
STD. DEV.	14	3	16	12	27	2	13	7	7	7	7	6
HI TEMP.	1611	1588	1577	1620	1553	1596	1613	1576	1602	1566	1613	1561
LO TEMP.	1566	1577	1529	1568	1466	1589	1558	1550	1574	1539	1585	1536
20 HOUR												
AVG. TEMP.	1589	1583	1560	1580	1529	1591	1591	1587	1566	1579	1586	1578
STD. DEV.	14	3	15	4	28	2	17	7	13	7	16	10
HI TEMP.	1611	1589	1581	1586	1570	1593	1615	1592	1591	1585	1609	1588
LO TEMP.	1567	1579	1540	1574	1483	1588	1548	1571	1546	1563	1557	1555
25 HOUR												
AVG. TEMP.	1591	1584	1558	1574	1514	1592	1575	1594	1549	1585	1561	1588
STD. DEV.	16	2	14	8	27	2	15	3	8	3	11	3
HI TEMP.	1616	1587	1582	1584	1567	1595	1595	1597	1570	1588	1587	1592
LO TEMP.	1564	1579	1535	1563	1479	1589	1544	1586	1539	1577	1547	1579
30 HOUR												
AVG. TEMP.	1593	1586	1559	1565	1495	1596	1562	1595	1546	1586	1563	1590
STD. DEV.	13	3	6	4	17	1	28	4	14	2	16	4
HI TEMP.	1602	1588	1563	1567	1507	1596	1582	1597	1556	1587	1574	1592
LO TEMP.	1583	1584	1555	1562	1483	1595	1542	1592	1536	1584	1551	1587
35 HOUR												
AVG. TEMP.	1599	1585	1565	1569	1546	1594	1577	1596	1543	1587	1556	1591
STD. DEV.	12	3	18	6	12	1	10	1	7	1	8	2
HI TEMP.	1613	1589	1587	1575	1566	1595	1591	1597	1552	1588	1566	1593
LO TEMP.	1589	1582	1538	1559	1532	1592	1562	1595	1536	1586	1549	1589
40 HOUR												
AVG. TEMP.	1592	1584	1571	1567	1529	1594	1567	1597	1543	1587	1559	1591
STD. DEV.	22	4	17	3	20	2	23	3	9	2	12	4
HI TEMP.	1616	1589	1583	1572	1549	1595	1596	1600	1552	1590	1571	1596
LO TEMP.	1569	1581	1541	1565	1499	1592	1536	1592	1530	1584	1541	1587
45 HOUR												
AVG. TEMP.	1595	1586	1562	1566	1509	1594	1541	1598	1535	1589	1550	1594
STD. DEV.	7	3	24	5	28	4	15	1	7	2	9	3
HI TEMP.	1605	1588	1589	1571	1535	1596	1565	1599	1542	1591	1557	1598
LO TEMP.	1587	1581	1535	1561	1477	1591	1524	1596	1526	1587	1538	1592
50 HOUR												
AVG. TEMP.	1595	1586	1579	1570	1537	1595	1537	1601	1524	1591	1533	1599
STD. DEV.	21	4	9	4	26	3	12	1	5	1	7	2
HI TEMP.	1611	1590	1587	1574	1577	1597	1553	1601	1529	1592	1539	1601
LO TEMP.	1567	1580	1563	1564	1507	1590	1522	1600	1519	1590	1524	1597
55 HOUR												
AVG. TEMP.	1581	1583	1565	1567	1513	1595	1522	1602	1519	1593	1527	1601
STD. DEV.	13	1	20	5	25	2	9	1	5	2	7	2
HI TEMP.	1600	1585	1586	1572	1549	1597	1532	1603	1527	1595	1538	1604
LO TEMP.	1568	1582	1542	1559	1483	1593	1513	1601	1514	1591	1521	1598
60 HOUR												
AVG. TEMP.	1600	1586	1548	1574	1532	1597	1549	1597	1541	1587	1556	1591
STD. DEV.	11	3	18	6	19	4	23	1	4	1	6	1
HI TEMP.	1610	1590	1575	1584	1557	1602	1582	1598	1548	1588	1566	1593
LO TEMP.	1584	1582	1524	1569	1510	1592	1526	1596	1538	1585	1551	1590
65 HOUR												
AVG. TEMP.	1588	1584	1571	1572	1542	1587	1539	1596	1515	1582	1549	1592
STD. DEV.	17	3	11	6	11	11	26	2	13	3	4	1
HI TEMP.	1608	1588	1581	1578	1552	1600	1567	1598	1538	1587	1555	1593
LO TEMP.	1565	1580	1553	1563	1525	1578	1510	1594	1507	1580	1545	1591
70 HOUR												
AVG. TEMP.	1591	1583	1560	1568	1526	1578	1547	1597	1510	1580	1549	1592
STD. DEV.	8	2	17	5	28	5	14	2	9	2	17	3
HI TEMP.	1598	1585	1580	1576	1557	1583	1565	1600	1516	1582	1565	1596
LO TEMP.	1579	1581	1539	1564	1487	1572	1526	1595	1496	1579	1523	1588

LOCATION	IN BED						ABOVE BED					
PORT NO.	2	2	4	4	6	6	14	14	16	16	18	18
SPEC. MAT.	8	X	X	8	X	8	X	8	X	8	8	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	13	14	15	16	17	18	19	20	21	22	23	24
5 HOUR												
AVG. TEMP.	1193	1373	959	1500	1391	1389	1345	1396	1171	1393	1249	1445
STD. DEV.	6	5	7	99	20	24	7	6	8	4	4	3
HI TEMP.	1201	1381	970	1856	1425	1430	1357	1408	1183	1400	1281	1450
LO TEMP.	1190	1365	948	1445	1367	1363	1334	1386	1157	1387	1244	1441
10 HOUR												
AVG. TEMP.	1206	1378	947	1480	1393	1392	1357	1404	1184	1389	1277	1447
STD. DEV.	17	10	11	7	23	18	10	3	13	5	5	2
HI TEMP.	1231	1394	959	1493	1427	1422	1370	1409	1200	1396	1286	1451
LO TEMP.	1184	1366	927	1468	1365	1367	1337	1395	1160	1385	1278	1443
15 HOUR												
AVG. TEMP.	1222	1389	934	1476	1405	1406	1355	1404	1195	1393	1281	1450
STD. DEV.	4	3	8	4	25	26	9	3	7	2	7	3
HI TEMP.	1229	1396	944	1483	1435	1439	1379	1409	1214	1397	1290	1455
LO TEMP.	1215	1385	912	1467	1369	1363	1342	1396	1183	1391	1270	1447
20 HOUR												
AVG. TEMP.	1216	1387	951	1461	1402	1404	1344	1396	1183	1395	1270	1445
STD. DEV.	5	4	10	7	17	22	6	4	6	3	6	4
HI TEMP.	1225	1392	968	1470	1428	1435	1353	1404	1190	1401	1285	1452
LO TEMP.	1207	1381	936	1446	1379	1372	1334	1390	1170	1391	1264	1439
25 HOUR												
AVG. TEMP.	1215	1388	964	1468	1395	1393	1339	1389	1174	1398	1269	1446
STD. DEV.	9	5	9	4	15	17	7	4	7	2	3	3
HI TEMP.	1229	1398	976	1475	1425	1427	1351	1396	1185	1403	1272	1451
LO TEMP.	1199	1380	944	1457	1370	1374	1328	1384	1163	1395	1264	1440
30 HOUR												
AVG. TEMP.	1211	1383	964	1463	1413	1418	1342	1392	1179	1400	1267	1445
STD. DEV.	1	9	8	1	10	4	3	1	5	2	2	1
HI TEMP.	1212	1389	969	1463	1428	1421	1344	1393	1182	1401	1268	1445
LO TEMP.	1210	1376	958	1462	1406	1415	1340	1391	1175	1398	1265	1444
35 HOUR												
AVG. TEMP.	1219	1389	971	1465	1401	1395	1340	1391	1175	1400	1268	1445
STD. DEV.	7	2	8	4	16	17	9	5	3	2	4	3
HI TEMP.	1224	1392	985	1476	1417	1425	1349	1397	1179	1403	1274	1449
LO TEMP.	1209	1386	967	1459	1375	1383	1327	1386	1172	1397	1265	1442
40 HOUR												
AVG. TEMP.	1215	1387	972	1469	1398	1392	1343	1391	1174	1398	1266	1444
STD. DEV.	10	5	8	3	29	27	5	7	6	3	2	3
HI TEMP.	1227	1395	981	1474	1438	1437	1346	1396	1180	1402	1269	1448
LO TEMP.	1202	1380	961	1466	1367	1364	1335	1380	1163	1395	1264	1441
45 HOUR												
AVG. TEMP.	1212	1387	980	1468	1396	1391	1341	1388	1175	1400	1264	1445
STD. DEV.	6	6	7	1	18	22	5	3	10	2	2	2
HI TEMP.	1219	1393	989	1470	1411	1417	1347	1391	1185	1403	1266	1447
LO TEMP.	1204	1379	970	1467	1367	1357	1332	1384	1162	1398	1261	1442
50 HOUR												
AVG. TEMP.	1216	1386	975	1468	1389	1390	1339	1388	1172	1403	1268	1447
STD. DEV.	6	4	12	9	27	30	4	2	2	1	3	1
HI TEMP.	1224	1391	982	1476	1431	1438	1343	1390	1175	1405	1272	1449
LO TEMP.	1210	1382	954	1453	1364	1368	1333	1384	1170	1401	1264	1446
55 HOUR												
AVG. TEMP.	1217	1389	980	1469	1385	1389	1335	1386	1167	1402	1269	1447
STD. DEV.	3	5	11	4	29	23	6	6	5	2	2	2
HI TEMP.	1221	1394	991	1474	1419	1426	1344	1392	1173	1404	1271	1450
LO TEMP.	1213	1384	962	1464	1370	1371	1329	1376	1160	1398	1266	1444
60 HOUR												
AVG. TEMP.	1221	1389	987	1468	1407	1402	1344	1398	1184	1402	1270	1444
STD. DEV.	6	4	8	4	7	12	4	2	5	3	5	2
HI TEMP.	1225	1394	1000	1474	1417	1415	1350	1400	1191	1407	1275	1446
LO TEMP.	1211	1385	981	1464	1401	1385	1339	1396	1177	1399	1263	1442
65 HOUR												
AVG. TEMP.	1217	1384	988	1470	1382	1384	1342	1397	1178	1402	1269	1444
STD. DEV.	6	3	3	3	18	21	4	1	4	2	3	2
HI TEMP.	1224	1387	992	1475	1411	1420	1347	1398	1183	1403	1273	1447
LO TEMP.	1211	1380	983	1467	1367	1368	1337	1395	1173	1399	1266	1442
70 HOUR												
AVG. TEMP.	1214	1382	969	1471	1400	1401	1337	1394	1173	1400	1271	1446
STD. DEV.	3	5	4	4	29	25	2	3	10	4	3	2
HI TEMP.	1218	1386	993	1477	1430	1431	1340	1398	1186	1407	1275	1447
LO TEMP.	1211	1374	982	1466	1372	1371	1335	1392	1163	1395	1269	1443

LOCATION	IN BED						ABOVE BED					
PORT NO.	7	7	9	9	11	11	19	19	20	20	22	22
SPEC. MAT.	3	8	8	3	8	3	8	3	3	8	8	3
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	25	26	27	28	29	30	31	32	33	34	35	36
	DEGREES FAHRENHEIT											
5 HOUR												
AVG. TEMP.	1104	1198	1096	1189	1080	1202	919	1149	901	1222	901	1261
STD. DEV.	11	17	24	19	14	8	9	9	5	2	8	9
HI TEMP.	1126	1219	1157	1218	1108	1214	943	1208	989	1225	923	1285
LO TEMP.	1090	1165	1068	1146	1059	1187	909	1175	973	1217	892	1252
10 HOUR												
AVG. TEMP.	1100	1214	1082	1212	1094	1226	923	1181	906	1219	890	1244
STD. DEV.	8	4	14	10	23	10	31	22	5	2	21	7
HI TEMP.	1114	1221	1110	1237	1139	1242	968	1224	996	1222	945	1257
LO TEMP.	1089	1207	1064	1197	1055	1205	893	1159	977	1215	871	1234
15 HOUR												
AVG. TEMP.	1098	1216	1082	1221	1116	1229	973	1213	990	1210	934	1251
STD. DEV.	11	4	11	9	20	7	9	6	5	3	15	7
HI TEMP.	1118	1227	1101	1234	1145	1244	986	1223	999	1223	956	1264
LO TEMP.	1082	1212	1065	1204	1090	1218	954	1202	982	1212	908	1239
20 HOUR												
AVG. TEMP.	1106	1202	1096	1201	1095	1211	966	1214	983	1222	925	1262
STD. DEV.	11	8	13	7	27	10	8	6	5	2	14	6
HI TEMP.	1119	1217	1119	1212	1165	1233	976	1225	993	1225	952	1273
LO TEMP.	1085	1187	1074	1187	1070	1199	944	1203	975	1210	905	1253
25 HOUR												
AVG. TEMP.	1104	1203	1097	1204	1089	1215	955	1211	980	1225	920	1265
STD. DEV.	7	6	13	8	14	8	9	9	5	2	16	7
HI TEMP.	1115	1213	1124	1219	1122	1232	971	1224	989	1227	949	1275
LO TEMP.	1091	1189	1077	1191	1074	1204	942	1195	974	1222	902	1254
30 HOUR												
AVG. TEMP.	1116	1196	1089	1199	1108	1211	960	1215	977	1226	926	1267
STD. DEV.	6	4	2	13	45	15	0	2	4	1	11	1
HI TEMP.	1120	1198	1090	1208	1139	1221	960	1216	980	1226	933	1268
LO TEMP.	1111	1193	1087	1190	1076	1200	960	1213	974	1225	918	1266
35 HOUR												
AVG. TEMP.	1104	1199	1103	1202	1118	1214	956	1214	981	1227	925	1264
STD. DEV.	5	9	8	2	17	8	6	4	6	2	16	3
HI TEMP.	1115	1211	1109	1204	1137	1226	962	1219	989	1229	952	1272
LO TEMP.	1097	1189	1090	1198	1094	1205	947	1209	975	1226	911	1264
40 HOUR												
AVG. TEMP.	1107	1197	1098	1201	1136	1222	955	1215	980	1227	925	1268
STD. DEV.	10	4	20	9	23	6	3	3	6	1	14	3
HI TEMP.	1117	1202	1131	1216	1159	1232	958	1219	987	1229	939	1272
LO TEMP.	1096	1193	1081	1194	1105	1216	950	1211	973	1226	908	1265
45 HOUR												
AVG. TEMP.	1109	1196	1102	1197	1126	1223	953	1211	978	1229	926	1266
STD. DEV.	7	5	13	6	12	9	7	5	4	1	8	5
HI TEMP.	1116	1201	1124	1202	1139	1233	964	1218	984	1230	931	1272
LO TEMP.	1101	1189	1069	1189	1107	1215	946	1204	972	1227	911	1261
50 HOUR												
AVG. TEMP.	1113	1195	1101	1195	1102	1224	949	1214	979	1231	924	1272
STD. DEV.	8	7	9	9	9	5	5	5	4	2	10	5
HI TEMP.	1125	1203	1112	1208	1117	1230	955	1219	986	1233	937	1279
LO TEMP.	1104	1185	1088	1184	1095	1217	944	1206	974	1229	912	1266
55 HOUR												
AVG. TEMP.	1117	1195	1099	1194	1134	1232	946	1213	974	1231	920	1271
STD. DEV.	3	7	15	4	24	9	8	6	3	1	12	5
HI TEMP.	1121	1203	1123	1199	1175	1247	958	1221	978	1232	934	1276
LO TEMP.	1113	1183	1085	1189	1115	1222	935	1207	970	1230	911	1267
60 HOUR												
AVG. TEMP.	1105	1168	1101	1179	1152	1241	956	1212	941	1200	931	1263
STD. DEV.	12	5	13	11	17	5	6	7	84	62	13	5
HI TEMP.	1120	1177	1116	1189	1180	1247	962	1218	981	1229	947	1270
LO TEMP.	1092	1164	1083	1161	1137	1233	944	1203	791	1088	916	1257
65 HOUR												
AVG. TEMP.	1114	1180	1103	1184	1171	1248	955	1213	941	1201	936	1263
STD. DEV.	10	13	14	6	20	2	6	2	81	63	14	6
HI TEMP.	1125	1201	1123	1198	1194	1250	959	1215	984	1232	950	1268
LO TEMP.	1104	1166	1087	1175	1150	1246	945	1211	797	1089	918	1255
70 HOUR												
AVG. TEMP.	1107	1195	1094	1194	1159	1254	954	1212	976	1230	931	1264
STD. DEV.	4	17	17	13	15	5	12	8	4	3	15	4
HI TEMP.	1113	1208	1107	1205	1192	1259	967	1217	981	1233	953	1268
LO TEMP.	1101	1167	1065	1173	1144	1247	936	1198	972	1227	912	1258

LOCATION	IN BED					
PORT NO.	8	8	12	12	10	10
SPEC. MAT.	2	9			9	2
SPEC. LOC.	I	O	I	O	I	O
DATA LOG NO.	37	38	39	40	41	42
5 HOUR						
AVG. TEMP.	0	745	0	1183	995	991
STD. DEV.	0	48	0	40	14	13
HI TEMP.	0	779	0	1204	1014	1000
LO TEMP.	0	644	0	1152	966	961
10 HOUR						
AVG. TEMP.	0	803	0	1140	1020	985
STD. DEV.	0	48	0	28	9	13
HI TEMP.	0	909	0	1166	1032	1006
LO TEMP.	0	751	0	1097	1003	950
15 HOUR						
AVG. TEMP.	0	890	0	1099	1024	986
STD. DEV.	0	10	0	4	6	10
HI TEMP.	0	916	0	1104	1038	1003
LO TEMP.	0	846	0	1091	1015	971
20 HOUR						
AVG. TEMP.	0	889	0	1097	1004	997
STD. DEV.	0	6	0	4	8	10
HI TEMP.	0	902	0	1102	1016	1015
LO TEMP.	0	878	0	1090	990	981
25 HOUR						
AVG. TEMP.	0	887	0	1103	1007	1000
STD. DEV.	0	6	0	4	6	10
HI TEMP.	0	895	0	1108	1016	1011
LO TEMP.	0	877	0	1090	996	984
30 HOUR						
AVG. TEMP.	0	893	0	1104	997	998
STD. DEV.	0	1	0	3	8	6
HI TEMP.	0	893	0	1106	1002	1002
LO TEMP.	0	892	0	1102	991	993
35 HOUR						
AVG. TEMP.	0	902	0	1107	996	1005
STD. DEV.	0	10	0	3	6	10
HI TEMP.	0	915	0	1110	1002	1014
LO TEMP.	0	890	0	1102	994	996
40 HOUR						
AVG. TEMP.	0	908	0	1109	996	999
STD. DEV.	0	11	0	4	4	26
HI TEMP.	0	925	0	1113	1001	1025
LO TEMP.	0	890	0	1104	969	977
45 HOUR						
AVG. TEMP.	0	898	0	1110	997	993
STD. DEV.	0	4	0	5	6	7
HI TEMP.	0	904	0	1116	1008	1002
LO TEMP.	0	893	0	1104	987	983
50 HOUR						
AVG. TEMP.	0	910	0	1112	997	1009
STD. DEV.	0	9	0	3	10	10
HI TEMP.	0	921	0	1117	1010	1020
LO TEMP.	0	896	0	1109	984	996
55 HOUR						
AVG. TEMP.	0	918	0	1110	985	1006
STD. DEV.	0	11	0	2	6	13
HI TEMP.	0	935	0	1112	991	1020
LO TEMP.	0	907	0	1107	976	987
60 HOUR						
AVG. TEMP.	0	912	0	1111	977	1013
STD. DEV.	0	11	0	2	5	9
HI TEMP.	0	922	0	1113	986	1021
LO TEMP.	0	895	0	1107	972	1000
65 HOUR						
AVG. TEMP.	0	894	0	1114	980	1005
STD. DEV.	0	8	0	4	10	13
HI TEMP.	0	906	0	1119	989	1017
LO TEMP.	0	885	0	1108	966	998
70 HOUR						
AVG. TEMP.	0	912	0	1108	994	1004
STD. DEV.	0	8	0	3	12	14
HI TEMP.	0	924	0	1112	1007	1025
LO TEMP.	0	903	0	1105	976	989

Table C-3 (Cont'd)

Heat Exchanger Probes Temperature History (Run 80)

LOCATION	IN BED						ABOVE BED					
PORT NO.	1	1	3	3	5	5	13	13	15	15	17	17
SPEC. MAT.	X	M	M	X	M	X	X	M	M	X	M	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	1	2	3	4	5	6	7	8	9	10	11	12
DEGREES FAHRENHEIT												
75 HOUR												
AVG. TEMP.	1281	1278	1269	1286	1249	1292	1328	1339	1297	1327	1318	1331
STD. DEV.	443	425	395	403	362	396	325	355	300	348	323	355
HI TEMP.	1412	1587	1572	1584	1529	1584	1578	1596	1514	1578	1559	1591
LO TEMP.	657	715	727	781	759	797	885	862	885	858	885	859
80 HOUR												
AVG. TEMP.	1581	1582	1555	1579	1537	1583	1558	1598	1511	1580	1552	1592
STD. DEV.	13	3	14	7	23	3	18	1	5	1	10	2
HI TEMP.	1604	1585	1570	1587	1554	1586	1582	1600	1515	1582	1564	1595
LO TEMP.	1569	1579	1538	1571	1497	1579	1541	1596	1502	1579	1537	1590
85 HOUR												
AVG. TEMP.	1573	1582	1562	1578	1499	1583	1543	1598	1507	1580	1540	1591
STD. DEV.	20	2	5	4	19	1	47	2	11	3	27	5
HI TEMP.	1595	1584	1568	1581	1520	1584	1585	1599	1514	1583	1556	1597
LO TEMP.	1555	1580	1559	1574	1487	1582	1492	1596	1494	1578	1508	1587
90 HOUR												
AVG. TEMP.	1590	1585	1560	1577	1518	1584	1562	1596	1519	1578	1562	1588
STD. DEV.	15	2	12	4	17	1	17	1	10	2	17	3
HI TEMP.	1612	1588	1573	1582	1543	1585	1587	1598	1527	1580	1579	1593
LO TEMP.	1576	1582	1544	1571	1495	1583	1541	1594	1503	1576	1537	1585
95 HOUR												
AVG. TEMP.	1606	1584	1556	1580	1518	1584	1569	1595	1519	1578	1567	1587
STD. DEV.	8	1	12	7	17	3	14	2	5	2	12	3
HI TEMP.	1612	1584	1572	1590	1547	1588	1584	1598	1527	1580	1586	1592
LO TEMP.	1593	1582	1539	1573	1501	1581	1552	1593	1512	1576	1555	1583
100 HOUR												
AVG. TEMP.	1603	1586	1561	1578	1530	1580	1578	1588	1531	1573	1573	1579
STD. DEV.	14	2	10	11	34	5	21	10	25	9	19	14
HI TEMP.	1613	1589	1578	1596	1567	1587	1604	1594	1573	1579	1597	1587
LO TEMP.	1580	1584	1555	1569	1490	1575	1558	1570	1515	1558	1556	1555
105 HOUR												
AVG. TEMP.	1592	1574	1561	1561	1531	1568	1548	1575	1521	1561	1556	1564
STD. DEV.	21	30	18	29	27	22	14	38	8	34	19	40
HI TEMP.	1611	1589	1584	1576	1546	1580	1563	1593	1530	1579	1577	1590
LO TEMP.	1561	1521	1541	1510	1511	1529	1531	1508	1510	1501	1526	1495
110 HOUR												
AVG. TEMP.	1525	1515	1506	1502	1479	1509	1522	1541	1480	1528	1514	1534
STD. DEV.	157	155	146	151	132	149	105	122	77	116	97	120
HI TEMP.	1607	1587	1580	1573	1568	1580	1594	1598	1527	1581	1570	1593
LO TEMP.	1245	1239	1246	1232	1246	1243	1341	1323	1343	1321	1342	1319
115 HOUR												
AVG. TEMP.	1588	1584	1561	1567	1533	1575	1531	1602	1500	1584	1536	1598
STD. DEV.	12	3	14	4	16	3	12	2	3	2	8	2
HI TEMP.	1607	1588	1582	1572	1546	1578	1550	1604	1503	1586	1546	1600
LO TEMP.	1577	1581	1543	1563	1515	1572	1520	1600	1495	1582	1524	1595
120 HOUR												
AVG. TEMP.	1592	1586	1562	1566	1553	1585	1521	1602	1498	1585	1526	1599
STD. DEV.	16	4	20	2	15	5	18	1	4	2	10	3
HI TEMP.	1606	1590	1580	1568	1568	1589	1544	1603	1501	1587	1535	1602
LO TEMP.	1571	1581	1535	1563	1534	1576	1501	1600	1493	1584	1514	1596
125 HOUR												
AVG. TEMP.	1586	1580	1562	1574	1531	1586	1542	1597	1509	1580	1545	1591
STD. DEV.	17	3	19	14	31	3	42	11	25	10	35	18
HI TEMP.	1610	1584	1586	1598	1568	1591	1613	1603	1553	1586	1606	1601
LO TEMP.	1566	1577	1541	1565	1497	1583	1513	1577	1490	1562	1522	1558
130 HOUR												
AVG. TEMP.	1591	1585	1552	1584	1553	1587	1549	1596	1513	1578	1555	1586
STD. DEV.	12	3	10	14	20	3	11	4	7	3	15	6
HI TEMP.	1604	1588	1565	1607	1577	1590	1559	1601	1519	1582	1571	1595
LO TEMP.	1572	1582	1544	1572	1535	1582	1533	1592	1501	1575	1531	1580
135 HOUR												
AVG. TEMP.	1590	1583	1553	1587	1553	1588	1525	1598	1507	1580	1546	1592
STD. DEV.	18	2	23	9	15	3	15	2	9	2	18	5
HI TEMP.	1614	1586	1580	1602	1573	1592	1550	1601	1522	1583	1575	1597
LO TEMP.	1570	1580	1531	1581	1537	1585	1513	1595	1496	1577	1527	1585
140 HOUR												
AVG. TEMP.	1575	1579	1547	1576	1534	1589	1546	1600	1502	1581	1541	1594
STD. DEV.	11	3	9	6	25	2	16	1	5	2	10	3
HI TEMP.	1592	1583	1563	1582	1570	1591	1564	1601	1506	1583	1552	1597
LO TEMP.	1565	1576	1541	1567	1503	1587	1520	1598	1495	1579	1530	1590

LOCATION	IN BED						ABOVE BED					
PORT NO.	2	2	4	4	6	6	14	14	16	16	18	18
SPEC. MAT.	8	X	X	8	X	A	X	8	X	8	8	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	13	14	15	16	17	18	19	20	21	22	23	24
75 HOUR												
AVG. TEMP.	1068	1169	908	1231	1170	1174	1198	1204	1081	1209	1153	1242
STD. DEV.	247	326	223	359	292	297	208	246	117	251	181	295
HI TEMP.	1235	1411	992	1500	1394	1402	1351	1390	1176	1397	1290	1452
LO TEMP.	677	707	473	743	753	753	891	856	886	861	843	857
80 HOUR												
AVG. TEMP.	1229	1399	948	1495	1401	1401	1342	1384	1156	1388	1269	1442
STD. DEV.	5	5	9	7	22	22	2	2	11	5	3	2
HI TEMP.	1234	1403	962	1505	1417	1416	1344	1386	1168	1393	1273	1446
LO TEMP.	1220	1392	940	1486	1362	1363	1340	1381	1141	1381	1266	1440
85 HOUR												
AVG. TEMP.	1222	1396	948	1472	1376	1377	1334	1383	1158	1390	1275	1446
STD. DEV.	7	4	3	5	29	18	6	6	7	1	5	5
HI TEMP.	1230	1400	950	1476	1409	1397	1338	1388	1164	1391	1280	1452
LO TEMP.	1218	1392	944	1467	1353	1362	1328	1376	1150	1389	1271	1442
90 HOUR												
AVG. TEMP.	1224	1393	940	1464	1392	1394	1345	1385	1168	1387	1271	1442
STD. DEV.	6	4	7	4	16	22	9	2	5	2	6	3
HI TEMP.	1227	1397	947	1468	1410	1417	1354	1388	1176	1390	1277	1446
LO TEMP.	1214	1386	929	1460	1369	1366	1333	1383	1162	1384	1264	1439
95 HOUR												
AVG. TEMP.	1225	1394	954	1467	1403	1400	1346	1386	1167	1388	1271	1440
STD. DEV.	3	4	14	3	13	17	2	4	5	2	3	1
HI TEMP.	1228	1398	967	1471	1412	1413	1348	1391	1173	1390	1275	1442
LO TEMP.	1221	1389	933	1463	1380	1372	1343	1382	1162	1384	1267	1439
100 HOUR												
AVG. TEMP.	1220	1387	970	1459	1405	1408	1346	1400	1191	1400	1273	1445
STD. DEV.	11	4	16	8	24	23	11	12	9	7	7	3
HI TEMP.	1237	1390	988	1469	1439	1445	1366	1414	1201	1407	1284	1449
LO TEMP.	1209	1379	947	1447	1376	1384	1339	1382	1176	1390	1267	1443
105 HOUR												
AVG. TEMP.	1234	1388	991	1449	1400	1400	1358	1403	1200	1400	1287	1444
STD. DEV.	15	9	17	19	31	34	34	8	39	5	24	13
HI TEMP.	1263	1401	1006	1460	1452	1455	1419	1417	1270	1404	1330	1453
LO TEMP.	1218	1377	967	1416	1374	1369	1337	1398	1172	1391	1273	1422
110 HOUR												
AVG. TEMP.	1227	1361	934	1415	1368	1363	1339	1377	1215	1386	1285	1420
STD. DEV.	12	65	57	98	71	67	8	37	70	41	32	57
HI TEMP.	1248	1393	963	1462	1427	1418	1351	1400	1341	1407	1341	1449
LO TEMP.	1218	1245	832	1240	1252	1252	1328	1312	1181	1314	1267	1318
115 HOUR												
AVG. TEMP.	1226	1397	980	1465	1392	1399	1337	1367	1172	1402	1270	1444
STD. DEV.	5	2	10	5	22	22	4	[illegible]	6	3	2	2
HI TEMP.	1233	1399	991	1470	1415	1422	1344	1391	1181	1406	1272	1446
LO TEMP.	1220	1394	964	1458	1368	1372	1333	1382	1165	1400	1268	1441
120 HOUR												
AVG. TEMP.	1229	1396	972	1461	1391	1399	1337	1388	1164	1401	1268	1445
STD. DEV.	5	4	11	2	19	20	8	5	12	2	3	3
HI TEMP.	1233	1401	982	1463	1409	1417	1345	1393	1173	1404	1271	1449
LO TEMP.	1221	1391	955	1457	1367	1373	1329	1380	1144	1399	1264	1442
125 HOUR												
AVG. TEMP.	1230	1395	961	1457	1384	1391	1340	1390	1170	1400	1273	1444
STD. DEV.	11	2	19	7	14	14	12	8	19	3	8	4
HI TEMP.	1245	1398	986	1464	1403	1410	1358	1404	1200	1404	1286	1449
LO TEMP.	1219	1392	938	1447	1367	1372	1325	1383	1156	1396	1265	1439
130 HOUR												
AVG. TEMP.	1232	1393	975	1461	1385	1385	1341	1394	1175	1399	1274	1446
STD. DEV.	5	4	9	6	19	17	6	8	13	4	3	3
HI TEMP.	1238	1399	987	1471	1410	1405	1348	1403	1192	1403	1277	1450
LO TEMP.	1226	1388	963	1456	1363	1365	1333	1386	1157	1394	1270	1442
135 HOUR												
AVG. TEMP.	1236	1397	952	1464	1388	1393	1339	1385	1167	1394	1268	1442
STD. DEV.	4	3	8	3	22	23	5	4	9	2	3	2
HI TEMP.	1241	1400	966	1469	1412	1419	1347	1390	1177	1397	1272	1446
LO TEMP.	1232	1393	946	1460	1370	1369	1333	1382	1154	1391	1265	1440
140 HOUR												
AVG. TEMP.	1232	1398	954	1465	1404	1395	1339	1386	1166	1394	1267	1442
STD. DEV.	2	2	9	8	21	17	11	5	8	2	2	3
HI TEMP.	1235	1399	964	1472	1426	1418	1356	1394	1175	1396	1269	1447
LO TEMP.	1229	1395	942	1452	1373	1382	1331	1381	1154	1391	1264	1438

LOCATION	IN BED						ABOVE BED					
PORT NO.	7	7	9	9	11	11	19	19	20	20	22	22
SPEC. MAT.	3	8	8	3	8	3	8	3	3	8	8	3
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	25	26	27	28	29	30	31	32	33	34	35	36
DEGREES FAHRENHEIT												
75 HOUR												
AVG. TEMP.	1008	1062	987	1061	1025	1101	835	1031	758	976	819	1089
STD. DEV.	149	204	130	200	165	233	150	241	295	358	137	251
HI TEMP.	1111	1212	1093	1206	1141	1284	952	1216	973	1235	924	1282
LO TEMP.	767	772	770	775	771	785	643	751	380	515	664	812
80 HOUR												
AVG. TEMP.	1107	1196	1056	1218	1171	1281	952	1215	979	1235	925	1272
STD. DEV.	8	4	5	6	10	6	7	7	3	2	10	2
HI TEMP.	1118	1202	1062	1225	1187	1289	965	1221	982	1238	936	1274
LO TEMP.	1099	1193	1049	1210	1164	1272	947	1203	975	1232	914	1269
85 HOUR												
AVG. TEMP.	1104	1189	1058	1232	1148	1284	961	1208	980	1236	924	1272
STD. DEV.	13	8	2	10	29	14	10	13	7	2	12	2
HI TEMP.	1117	1198	1060	1240	1182	1299	958	1223	985	1237	933	1274
LO TEMP.	1091	1184	1056	1221	1130	1273	939	1198	972	1234	911	1270
90 HOUR												
AVG. TEMP.	1104	1191	1057	1217	1099	1243	950	1204	982	1234	887	1249
STD. DEV.	10	6	10	12	43	31	11	10	3	2	12	10
HI TEMP.	1120	1198	1075	1227	1173	1296	961	1217	986	1237	908	1265
LO TEMP.	1095	1182	1050	1199	1067	1220	934	1194	979	1232	878	1241
95 HOUR												
AVG. TEMP.	1105	1188	1076	1217	1059	1204	951	1206	976	1232	884	1245
STD. DEV.	9	1	10	3	44	35	6	5	3	3	5	7
HI TEMP.	1115	1190	1093	1221	1116	1241	956	1212	980	1235	890	1257
LO TEMP.	1091	1187	1067	1214	1012	1163	943	1200	973	1227	878	1240
100 HOUR												
AVG. TEMP.	1114	1183	1103	1212	1007	1146	954	1208	981	1228	891	1234
STD. DEV.	10	6	17	16	6	12	12	9	10	5	17	11
HI TEMP.	1126	1191	1132	1230	1015	1161	965	1220	992	1234	921	1253
LO TEMP.	1101	1176	1090	1198	999	1131	938	1198	971	1221	879	1224
105 HOUR												
AVG. TEMP.	1125	1187	1099	1198	1018	1141	957	1202	981	1223	888	1226
STD. DEV.	30	10	19	13	20	12	14	10	3	16	9	17
HI TEMP.	1177	1209	1121	1207	1053	1153	982	1211	984	1233	898	1237
LO TEMP.	1105	1174	1074	1176	1002	1123	946	1186	977	1195	878	1197
110 HOUR												
AVG. TEMP.	1145	1193	1120	1194	1036	1146	976	1205	961	1191	893	1215
STD. DEV.	47	11	58	14	71	10	41	18	74	86	19	45
HI TEMP.	1229	1209	1224	1216	1163	1154	1050	1216	979	1234	926	1237
LO TEMP.	1121	1180	1069	1178	995	1131	952	1173	809	1038	877	1135
115 HOUR												
AVG. TEMP.	1112	1196	1089	1213	1007	1149	951	1215	978	1236	881	1246
STD. DEV.	10	9	17	9	7	8	13	6	5	1	5	6
HI TEMP.	1127	1209	1114	1226	1015	1161	960	1219	985	1237	887	1252
LO TEMP.	1101	1186	1066	1201	1002	1140	934	1204	972	1235	874	1237
120 HOUR												
AVG. TEMP.	1113	1198	1096	1207	1007	1149	944	1213	971	1236	881	1253
STD. DEV.	6	4	11	6	11	5	9	4	2	2	6	4
HI TEMP.	1119	1204	1110	1214	1018	1157	954	1219	974	1238	890	1257
LO TEMP.	1104	1192	1082	1199	994	1146	935	1209	969	1234	873	1247
125 HOUR												
AVG. TEMP.	1118	1193	1099	1206	1009	1145	954	1214	978	1235	882	1244
STD. DEV.	14	7	17	8	11	5	5	6	5	7	9	8
HI TEMP.	1139	1205	1118	1213	1020	1149	959	1221	983	1241	897	1253
LO TEMP.	1101	1189	1074	1193	993	1136	948	1204	972	1223	872	1231
130 HOUR												
AVG. TEMP.	1120	1190	1101	1208	1016	1149	949	1208	977	1233	884	1244
STD. DEV.	9	14	15	11	10	13	11	6	5	3	8	11
HI TEMP.	1127	1202	1118	1225	1026	1166	959	1216	983	1237	895	1259
LO TEMP.	1108	1171	1088	1197	1004	1133	935	1204	970	1230	874	1231
135 HOUR												
AVG. TEMP.	1115	1201	1079	1218	1013	1163	947	1210	971	1236	874	1250
STD. DEV.	10	4	10	8	9	11	9	8	6	3	8	6
HI TEMP.	1145	1211	1089	1226	1021	1175	961	1223	980	1239	888	1258
LO TEMP.	1101	1196	1068	1204	1002	1149	940	1203	965	1233	868	1244
140 HOUR												
AVG. TEMP.	1109	1202	1068	1225	1043	1196	909	1180	973	1236	876	1251
STD. DEV.	6	3	15	3	17	7	19	15	5	3	9	6
HI TEMP.	1112	1206	1084	1228	1066	1206	935	1204	979	1239	883	1260
LO TEMP.	1097	1198	1046	1221	1020	1169	884	1163	965	1232	862	1246

LOCATION	IN BED					
PORT NO.	8	8	12	12	10	10
SPEC. MAT.	2	9			9	2
SPEC. LOC.	I	O	I	O	I	O
DATA LOG NO.	37	38	39	40	41	42
75 HOUR						
AVG. TEMP.	0	876	0	997	951	937
STD. DEV.	0	71	0	155	118	98
HI TEMP.	0	926	0	1108	1041	1014
LO TEMP.	0	752	0	772	758	766
80 HOUR						
AVG. TEMP.	0	920	0	1109	1034	979
STD. DEV.	0	10	0	5	2	15
HI TEMP.	0	931	0	1115	1037	995
LO TEMP.	0	907	0	1103	1031	962
85 HOUR						
AVG. TEMP.	0	925	0	1106	1041	974
STD. DEV.	0	11	0	6	1	9
HI TEMP.	0	933	0	1110	1042	984
LO TEMP.	0	913	0	1100	1041	966
90 HOUR						
AVG. TEMP.	0	991	0	1084	1040	979
STD. DEV.	0	31	0	109	2	14
HI TEMP.	0	1008	0	1278	1042	995
LO TEMP.	0	936	0	1023	1036	959
95 HOUR						
AVG. TEMP.	0	1010	0	1054	1037	994
STD. DEV.	0	3	0	5	2	6
HI TEMP.	0	1015	0	1060	1039	1002
LO TEMP.	0	1007	0	1050	1034	986
100 HOUR						
AVG. TEMP.	0	1037	0	1051	1015	1010
STD. DEV.	0	23	0	7	9	14
HI TEMP.	0	1076	0	1059	1029	1027
LO TEMP.	0	1019	0	1041	1006	998
105 HOUR						
AVG. TEMP.	0	1072	0	1049	1010	1014
STD. DEV.	0	62	0	19	11	25
HI TEMP.	0	1191	0	1063	1024	1041
LO TEMP.	0	1037	0	1015	997	981
110 HOUR						
AVG. TEMP.	0	1069	0	996	1025	1025
STD. DEV.	0	74	0	43	27	32
HI TEMP.	0	1198	0	1021	1072	1080
LO TEMP.	0	1026	0	920	1001	1092
115 HOUR						
AVG. TEMP.	0	1046	0	1019	1025	1006
STD. DEV.	0	13	0	5	7	13
HI TEMP.	0	1062	0	1027	1033	1026
LO TEMP.	0	1031	0	1015	1015	996
120 HOUR						
AVG. TEMP.	0	1049	0	1016	1025	1015
STD. DEV.	0	3	0	4	6	11
HI TEMP.	0	1053	0	1025	1034	1030
LO TEMP.	0	1045	0	1010	1019	1001
125 HOUR						
AVG. TEMP.	0	1056	0	1013	1012	1008
STD. DEV.	0	26	0	6	10	11
HI TEMP.	0	1095	0	1020	1024	1018
LO TEMP.	0	1036	0	1005	997	989
130 HOUR						
AVG. TEMP.	0	1064	0	1015	998	1006
STD. DEV.	0	7	0	3	17	9
HI TEMP.	0	1072	0	1020	1013	1021
LO TEMP.	0	1056	0	1012	979	998
135 HOUR						
AVG. TEMP.	0	1059	0	1017	1017	994
STD. DEV.	0	12	0	4	5	8
HI TEMP.	0	1074	0	1022	1022	1004
LO TEMP.	0	1042	0	1011	1008	983
140 HOUR						
AVG. TEMP.	0	1044	0	1020	1023	999
STD. DEV.	0	19	0	6	4	6
HI TEMP.	0	1066	0	1036	1028	999
LO TEMP.	0	1021	0	1020	1019	983

Table C-3 (Cont'd)

Heat Exchanger Probes Temperature History (Run 80)

LOCATION	IN BED						ABOVE BED					
PORT NO.	1	1	3	3	5	5	13	13	15	15	17	17
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	1	2	3	4	5	6	7	8	9	10	11	12
	DEGREES FAHRENHEIT											
145 HOUR												
AVG. TEMP.	1594	1578	1552	1570	1529	1586	1536	1600	1502	1582	1536	1594
STD. DEV.	11	2	18	4	27	2	31	5	17	4	28	8
HI TEMP.	1605	1581	1572	1575	1571	1588	1586	1604	1532	1585	1585	1600
LO TEMP.	1581	1577	1530	1566	1506	1583	1505	1592	1489	1575	1515	1580
150 HOUR												
AVG. TEMP.	1578	1575	1546	1560	1546	1582	1519	1602	1495	1584	1522	1600
STD. DEV.	21	2	16	7	11	3	27	2	10	3	23	5
HI TEMP.	1599	1578	1573	1569	1563	1585	1552	1604	1510	1588	1558	1605
LO TEMP.	1550	1573	1533	1551	1535	1579	1480	1600	1486	1581	1495	1593
155 HOUR												
AVG. TEMP.	1575	1568	1548	1562	1523	1586	1486	1603	1486	1587	1501	1603
STD. DEV.	20	5	23	8	19	3	16	3	7	4	14	5
HI TEMP.	1599	1576	1575	1571	1547	1590	1502	1608	1494	1593	1516	1610
LO TEMP.	1558	1564	1520	1551	1496	1583	1461	1600	1476	1583	1481	1597
160 HOUR												
AVG. TEMP.	1577	1569	1556	1571	1528	1583	1521	1602	1497	1584	1525	1598
STD. DEV.	15	6	23	18	31	3	29	2	6	1	12	4
HI TEMP.	1600	1574	1582	1600	1572	1586	1559	1604	1503	1585	1538	1602
LO TEMP.	1561	1559	1532	1555	1500	1580	1490	1600	1491	1583	1515	1594
165 HOUR												
AVG. TEMP.	1589	1573	1556	1569	1559	1584	1534	1588	1524	1572	1550	1579
STD. DEV.	16	2	12	8	27	5	38	22	46	19	33	27
HI TEMP.	1601	1575	1571	1575	1578	1590	1590	1601	1577	1583	1588	1596
LO TEMP.	1566	1570	1541	1557	1528	1578	1510	1563	1495	1550	1530	1548
170 HOUR												
AVG. TEMP.	1586	1571	1550	1578	1541	1582	1556	1596	1517	1579	1559	1585
STD. DEV.	11	3	11	13	31	3	25	2	17	2	19	4
HI TEMP.	1603	1574	1560	1596	1558	1587	1599	1598	1543	1581	1593	1589
LO TEMP.	1579	1568	1534	1568	1495	1578	1539	1592	1507	1577	1547	1579
175 HOUR												
AVG. TEMP.	1588	1570	1545	1569	1547	1583	1566	1593	1518	1577	1567	1581
STD. DEV.	13	4	13	12	22	1	21	4	7	4	12	7
HI TEMP.	1602	1574	1557	1586	1568	1585	1597	1598	1527	1581	1581	1590
LO TEMP.	1569	1563	1523	1556	1518	1581	1550	1589	1508	1571	1549	1571
180 HOUR												
AVG. TEMP.	1587	1570	1547	1568	1512	1583	1527	1597	1505	1581	1545	1589
STD. DEV.	17	3	19	5	23	2	13	2	4	2	9	2
HI TEMP.	1601	1573	1570	1575	1544	1585	1550	1600	1510	1583	1555	1592
LO TEMP.	1560	1566	1526	1562	1490	1581	1518	1596	1500	1579	1533	1586
185 HOUR												
AVG. TEMP.	1590	1572	1544	1570	1538	1584	1548	1597	1508	1580	1550	1588
STD. DEV.	10	2	9	4	21	2	28	4	10	3	18	5
HI TEMP.	1601	1575	1556	1576	1566	1586	1590	1602	1520	1583	1572	1592
LO TEMP.	1579	1571	1533	1545	1518	1583	1516	1593	1497	1577	1527	1582
190 HOUR												
AVG. TEMP.	1606	1583	1554	1593	1543	1584	1558	1596	1513	1579	1557	1587
STD. DEV.	14	2	19	11	25	1	34	4	19	3	28	7
HI TEMP.	1615	1586	1578	1610	1573	1585	1608	1602	1545	1582	1603	1594
LO TEMP.	1584	1580	1532	1583	1507	1584	1515	1592	1498	1575	1534	1577
195 HOUR												
AVG. TEMP.	1591	1581	1553	1583	1521	1583	1526	1598	1499	1583	1528	1592
STD. DEV.	12	5	21	13	27	4	67	1	18	6	43	8
HI TEMP.	1606	1585	1587	1600	1557	1585	1585	1600	1512	1592	1555	1606
LO TEMP.	1576	1572	1534	1568	1494	1576	1413	1597	1466	1578	1454	1586
200 HOUR												
AVG. TEMP.	1583	1580	1572	1576	1536	1583	1542	1598	1505	1580	1545	1589
STD. DEV.	4	1	14	4	34	1	14	1	3	1	6	2
HI TEMP.	1598	1581	1588	1580	1569	1584	1562	1599	1510	1581	1552	1590
LO TEMP.	1579	1578	1555	1569	1497	1582	1522	1596	1502	1579	1539	1586
205 HOUR												
AVG. TEMP.	1605	1582	1561	1577	1527	1583	1555	1599	1508	1581	1550	1590
STD. DEV.	7	1	15	6	27	1	20	2	3	2	6	2
HI TEMP.	1615	1584	1581	1584	1562	1585	1579	1602	1513	1583	1558	1593
LO TEMP.	1597	1581	1545	1569	1503	1582	1530	1597	1505	1579	1543	1587
210 HOUR												
AVG. TEMP.	1600	1580	1571	1582	1526	1584	1538	1601	1505	1583	1543	1592
STD. DEV.	15	3	9	5	42	2	19	1	6	2	11	3
HI TEMP.	1617	1585	1578	1589	1592	1586	1559	1603	1513	1586	1559	1597
LO TEMP.	1594	1577	1556	1575	1492	1582	1518	1600	1497	1581	1528	1590

LOCATION	IN BED						ABOVE BED					
PORT NO.	2	2	4	4	6	6	14	14	16	16	18	18
SPEC. MAT.	8	X	X	8	X	8	X	8	X	8	8	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	13	14	15	16	17	18	19	20	21	22	23	24
	DEGREES FAHRENHEIT											
145 HOUR												
AVG. TEMP.	1221	1392	945	1465	1398	1398	1332	1381	1169	1394	1269	1441
STD. DEV.	7	5	10	8	30	25	6	8	14	5	3	4
HI TEMP.	1231	1397	956	1478	1427	1425	1343	1393	1186	1403	1272	1446
LO TEMP.	1214	1385	934	1458	1359	1369	1328	1370	1152	1390	1265	1435
150 HOUR												
AVG. TEMP.	1215	1387	944	1461	1392	1387	1330	1376	1166	1399	1272	1443
STD. DEV.	9	4	13	5	20	24	5	2	9	4	5	5
HI TEMP.	1222	1390	959	1467	1409	1415	1335	1378	1175	1405	1276	1450
LO TEMP.	1290	1381	925	1457	1361	1361	1322	1372	1157	1395	1267	1437
155 HOUR												
AVG. TEMP.	1217	1388	951	1468	1382	1381	1295	1344	1164	1399	1275	1448
STD. DEV.	7	2	12	8	24	29	7	6	9	3	7	3
HI TEMP.	1226	1392	967	1479	1405	1408	1302	1351	1174	1404	1286	1452
LO TEMP.	1210	1386	935	1460	1355	1347	1288	1337	1154	1396	1268	1444
160 HOUR												
AVG. TEMP.	1221	1387	970	1462	1372	1377	1306	1355	1172	1397	1271	1442
STD. DEV.	2	5	2	7	24	25	10	5	12	2	4	4
HI TEMP.	1223	1392	973	1469	1413	1420	1318	1362	1187	1400	1276	1447
LO TEMP.	1219	1382	967	1455	1356	1358	1296	1350	1156	1395	1267	1439
165 HOUR												
AVG. TEMP.	1229	1383	996	1458	1405	1397	1327	1367	1184	1402	1272	1447
STD. DEV.	4	4	25	9	42	43	27	13	12	4	4	4
HI TEMP.	1233	1386	1024	1467	1446	1434	1359	1381	1202	1406	1276	1450
LO TEMP.	1225	1379	978	1449	1362	1350	1310	1356	1176	1396	1267	1441
170 HOUR												
AVG. TEMP.	1230	1391	982	1460	1375	1379	1313	1364	1184	1402	1274	1446
STD. DEV.	4	2	13	9	14	15	15	6	3	4	4	6
HI TEMP.	1236	1393	998	1466	1391	1399	1336	1373	1187	1406	1278	1450
LO TEMP.	1224	1388	964	1445	1359	1364	1295	1357	1180	1395	1270	1435
175 HOUR												
AVG. TEMP.	1222	1385	982	1456	1396	1393	1315	1364	1186	1404	1274	1448
STD. DEV.	6	1	9	6	22	24	6	4	8	2	5	4
HI TEMP.	1228	1386	994	1461	1414	1422	1323	1370	1200	1407	1280	1452
LO TEMP.	1215	1384	974	1448	1359	1362	1309	1358	1180	1401	1269	1443
180 HOUR												
AVG. TEMP.	1227	1389	990	1464	1362	1361	1322	1375	1179	1404	1275	1447
STD. DEV.	6	1	5	7	7	3	8	5	6	2	3	2
HI TEMP.	1236	1391	998	1475	1375	1365	1329	1378	1196	1407	1280	1449
LO TEMP.	1221	1388	986	1459	1356	1358	1309	1366	1171	1401	1271	1445
185 HOUR												
AVG. TEMP.	1230	1390	984	1457	1390	1388	1324	1372	1187	1404	1273	1448
STD. DEV.	3	3	3	3	9	18	6	5	3	2	3	4
HI TEMP.	1235	1394	987	1460	1403	1411	1333	1377	1190	1405	1276	1453
LO TEMP.	1226	1385	980	1454	1380	1365	1317	1364	1183	1401	1269	1443
190 HOUR												
AVG. TEMP.	1231	1391	990	1459	1402	1399	1331	1379	1186	1403	1273	1447
STD. DEV.	5	3	9	2	12	17	12	6	14	4	2	4
HI TEMP.	1237	1395	1004	1461	1418	1418	1343	1386	1206	1410	1277	1450
LO TEMP.	1225	1388	982	1455	1389	1373	1312	1372	1174	1399	1272	1440
195 HOUR												
AVG. TEMP.	1224	1390	976	1460	1380	1387	1320	1377	1183	1411	1277	1455
STD. DEV.	9	3	17	3	16	17	13	7	20	4	7	10
HI TEMP.	1236	1394	994	1463	1396	1404	1332	1384	1195	1417	1289	1473
LO TEMP.	1212	1388	949	1456	1360	1365	1299	1366	1148	1406	1273	1449
200 HOUR												
AVG. TEMP.	1229	1389	989	1462	1377	1376	1331	1387	1190	1407	1275	1450
STD. DEV.	4	2	9	6	24	23	3	2	5	3	2	2
HI TEMP.	1234	1392	1001	1468	1408	1415	1335	1390	1196	1411	1278	1453
LO TEMP.	1225	1386	977	1454	1357	1361	1328	1383	1183	1404	1274	1447
205 HOUR												
AVG. TEMP.	1235	1392	983	1458	1392	1387	1328	1379	1190	1405	1271	1446
STD. DEV.	3	3	5	5	19	20	5	4	6	3	2	3
HI TEMP.	1237	1395	989	1465	1420	1408	1333	1385	1198	1409	1273	1448
LO TEMP.	1230	1388	977	1453	1371	1366	1321	1373	1183	1401	1269	1441
210 HOUR												
AVG. TEMP.	1232	1391	985	1455	1384	1381	1330	1379	1193	1405	1269	1444
STD. DEV.	6	3	8	5	23	23	5	5	7	2	5	4
HI TEMP.	1237	1394	999	1458	1409	1410	1335	1384	1202	1407	1274	1448
LO TEMP.	1223	1387	979	1447	1353	1353	1323	1373	1188	1401	1261	1437

LOCATION	IN BED						ABOVE BED						IN BED					
PORT NO.	7	7	9	9	11	11	19	19	20	20	22	22	8	8	12	12	10	10
SPEC. MAT.	3	8	8	3	8	3	8	3	3	8	8	3	2	9			9	2
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	DEGREES FAHRENHEIT												DEGREES FAHRENHEIT					
145 HOUR																		
AVG. TEMP.	1108	1196	1077	1217	1075	1216	968	1223	969	1234	877	1247	0	1022	0	1028	1023	993
STD. DEV.	12	8	10	11	35	10	13	8	3	4	12	4	0	17	0	5	3	8
HI TEMP.	1119	1208	1091	1232	1137	1229	989	1232	973	1238	899	1251	0	1037	0	1032	1027	1006
LO TEMP.	1094	1187	1068	1205	1053	1203	958	1210	964	1228	870	1241	0	994	0	1021	1020	985
150 HOUR																		
AVG. TEMP.	1111	1189	1087	1209	1059	1206	968	1222	972	1237	880	1249	0	1015	0	1028	1008	989
STD. DEV.	8	7	16	9	8	7	5	6	7	3	4	6	0	4	0	8	10	9
HI TEMP.	1120	1199	1109	1221	1067	1215	973	1229	978	1240	886	1259	0	1019	0	1041	1019	1003
LO TEMP.	1103	1184	1070	1197	1046	1196	962	1213	962	1232	876	1246	0	1009	0	1020	994	981
155 HOUR																		
AVG. TEMP.	1102	1184	1080	1214	1074	1212	968	1226	965	1239	886	1255	0	1006	0	1019	1024	1002
STD. DEV.	9	4	15	11	15	16	13	8	4	3	10	8	0	6	0	6	12	20
HI TEMP.	1113	1191	1098	1224	1100	1239	987	1236	969	1242	901	1269	0	1016	0	1026	1035	1033
LO TEMP.	1091	1180	1060	1199	1064	1198	951	1215	958	1235	877	1249	0	1000	0	1012	1006	980
160 HOUR																		
AVG. TEMP.	1113	1184	1096	1217	1109	1235	967	1222	966	1236	881	1237	0	1032	0	1012	1021	998
STD. DEV.	11	4	17	7	52	31	4	3	2	3	3	7	0	6	0	5	7	17
HI TEMP.	1129	1189	1116	1227	1173	1271	972	1225	969	1239	885	1245	0	1039	0	1018	1029	1016
LO TEMP.	1100	1180	1078	1208	1061	1211	962	1219	963	1232	878	1228	0	1025	0	1007	1011	979
165 HOUR																		
AVG. TEMP.	1113	1174	1104	1207	1122	1249	975	1225	965	1230	880	1225	0	1047	0	1004	1011	993
STD. DEV.	8	11	21	7	22	12	9	4	3	1	3	4	0	43	0	4	13	15
HI TEMP.	1118	1190	1129	1216	1151	1257	983	1230	968	1231	883	1230	0	1123	0	1008	1026	1014
LO TEMP.	1102	1164	1085	1202	1098	1231	963	1221	962	1229	876	1221	0	1018	0	998	996	980
170 HOUR																		
AVG. TEMP.	1107	1188	1100	1218	1172	1270	977	1222	870	1152	884	1220	0	1045	0	1001	1023	995
STD. DEV.	13	5	18	6	29	19	5	6	92	74	2	3	0	5	0	5	1	2
HI TEMP.	1124	1196	1122	1222	1208	1297	980	1232	974	1233	886	1223	0	1051	0	1005	1024	996
LO TEMP.	1089	1183	1079	1207	1147	1243	969	1217	794	1089	881	1218	0	1041	0	996	1023	993
175 HOUR																		
AVG. TEMP.	1109	1189	1096	1207	1043	1188	973	1216	969	1224	885	1214	0	1040	0	999	1015	1001
STD. DEV.	7	4	11	8	10	9	11	7	4	2	7	2	0	18	0	4	12	12
HI TEMP.	1118	1194	1111	1215	1055	1196	984	1225	976	1227	894	1216	0	1055	0	1004	1024	1014
LO TEMP.	1101	1183	1082	1195	1029	1174	958	1207	965	1221	878	1210	0	1013	0	994	998	993
180 HOUR																		
AVG. TEMP.	1112	1189	1102	1215	1051	1187	970	1216	963	1224	885	1215	0	1040	0	999	1019	1003
STD. DEV.	8	4	9	8	12	10	8	4	3	2	5	2	0	5	0	4	3	13
HI TEMP.	1126	1193	1113	1226	1065	1203	983	1221	968	1227	892	1217	0	1046	0	1004	1023	1021
LO TEMP.	1106	1184	1089	1207	1041	1176	962	1211	959	1222	880	1212	0	1034	0	993	1015	989
185 HOUR																		
AVG. TEMP.	1117	1191	1100	1215	1065	1199	971	1224	964	1224	885	1215	0	1051	0	999	1018	996
STD. DEV.	15	5	17	4	9	7	10	7	3	2	10	4	0	4	0	4	4	7
HI TEMP.	1132	1197	1118	1221	1078	1209	980	1233	967	1226	900	1220	0	1055	0	1005	1023	1002
LO TEMP.	1096	1185	1081	1211	1054	1191	954	1214	961	1221	874	1210	0	1046	0	995	1012	984
190 HOUR																		
AVG. TEMP.	1108	1186	1101	1208	1071	1197	971	1219	897	1174	878	1212	0	1060	0	1000	1014	1003
STD. DEV.	9	6	12	5	19	7	6	5	89	70	5	4	0	11	0	5	3	11
HI TEMP.	1124	1194	1116	1213	1097	1204	982	1225	967	1226	883	1218	0	1072	0	1005	1018	1012
LO TEMP.	1101	1179	1084	1201	1047	1185	967	1213	784	1083	873	1209	0	1051	0	992	1011	986
195 HOUR																		
AVG. TEMP.	1112	1185	1103	1212	1061	1191	972	1225	962	1225	889	1210	0	1057	0	1000	1010	1011
STD. DEV.	12	7	11	7	19	13	6	9	5	4	10	12	0	11	0	5	2	6
HI TEMP.	1128	1196	1121	1221	1077	1208	979	1236	968	1232	907	1231	0	1071	0	1008	1013	1019
LO TEMP.	1100	1179	1093	1203	1035	1178	966	1215	956	1221	882	1203	0	1045	0	995	1008	1006
200 HOUR																		
AVG. TEMP.	1112	1186	1109	1211	1050	1184	973	1221	964	1226	886	1205	0	1057	0	1000	1008	1003
STD. DEV.	11	6	9	6	6	6	3	5	4	2	5	6	0	6	0	5	4	6
HI TEMP.	1126	1193	1120	1220	1056	1190	976	1227	969	1229	894	1215	0	1066	0	1005	1012	1011
LO TEMP.	1103	1180	1096	1206	1041	1175	969	1214	959	1223	879	1201	0	1051	0	992	1002	995
205 HOUR																		
AVG. TEMP.	1120	1183	1112	1209	1054	1186	963	1214	865	1150	891	1210	0	1055	0	997	1010	1013
STD. DEV.	17	5	10	3	11	5	9	6	68	54	4	2	0	6	0	5	8	11
HI TEMP.	1135	1189	1124	1212	1068	1192	973	1220	962	1223	894	1212	0	1062	0	1001	1021	1024
LO TEMP.	1093	1177	1098	1206	1040	1180	949	1208	804	1100	883	1206	0	1046	0	989	1001	998
210 HOUR																		
AVG. TEMP.	1119	1182	1110	1203	1089	1201	975	1223	934	1202	889	1209	0	1060	0	995	1009	1002
STD. DEV.	4	6	14	10	19	10	8	6	67	53	5	3	0	15	0	2	3	8
HI TEMP.	1124	1192	1126	1213	1106	1212	988	1231	966	1230	896	1213	0	1078	0	997	1013	1015
LO TEMP.	1114	1176	1093	1188	1058	1189	966	1216	814	1107	882	1206	0	1039	0	992	1005	993

Table C-4

Heat Exchanger Temperature Probes (Run 81)

LOCATION	IN BED						ABOVE BED					
PORT NO.	1	1	3	3	5	5	13	13	15	15	17	17
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	1	2	3	4	5	6	7	8	9	10	11	12
	DEGREES FAHRENHEIT											
5 HOUR												
AVG. TEMP.	1590	1589	1554	1587	1516	1599	1564	1478	1562	1478	1551	1473
STD. DEV.	12	13	8	7	41	7	45	57	46	52	39	52
HI TEMP.	1599	1600	1565	1593	1586	1605	1609	1540	1605	1534	1587	1532
LO TEMP.	1569	1568	1547	1575	1483	1589	1494	1394	1489	1400	1486	1398
10 HOUR												
AVG. TEMP.	1590	1603	1557	1600	1537	1603	1550	1483	1546	1482	1537	1480
STD. DEV.	7	6	13	5	30	3	73	73	72	72	65	71
HI TEMP.	1596	1611	1575	1609	1588	1607	1605	1544	1601	1545	1589	1541
LO TEMP.	1581	1595	1543	1596	1509	1599	1450	1380	1449	1379	1446	1378
15 HOUR												
AVG. TEMP.	1593	1603	1557	1607	1574	1590	1455	1368	1455	1369	1452	1358
STD. DEV.	15	2	18	5	17	5	10	6	10	7	11	2
HI TEMP.	1609	1606	1589	1611	1603	1593	1468	1374	1467	1378	1464	1361
LO TEMP.	1569	1600	1544	1598	1558	1582	1443	1361	1442	1360	1439	1356
20 HOUR												
AVG. TEMP.	1585	1604	1545	1609	1566	1592	1459	1367	1458	1369	1456	1351
STD. DEV.	13	1	6	2	17	1	6	6	6	6	5	6
HI TEMP.	1602	1605	1551	1611	1577	1593	1465	1376	1465	1377	1462	1360
LO TEMP.	1571	1603	1535	1607	1536	1591	1452	1362	1451	1363	1449	1345
25 HOUR												
AVG. TEMP.	913	954	911	972	929	964	1031	977	1033	980	1033	973
STD. DEV.	611	604	592	594	599	588	404	367	401	366	400	357
HI TEMP.	1570	1602	1544	1610	1568	1595	1470	1373	1469	1374	1467	1356
LO TEMP.	274	317	272	345	285	342	598	580	605	582	603	587
30 HOUR												
AVG. TEMP.	1579	1597	1552	1594	1534	1595	1432	1332	1435	1333	1434	1315
STD. DEV.	16	17	31	34	40	21	59	64	60	67	60	63
HI TEMP.	1600	1611	1595	1624	1596	1606	1530	1425	1534	1431	1532	1406
LO TEMP.	1561	1567	1518	1540	1497	1558	1371	1245	1375	1242	1371	1230
35 HOUR												
AVG. TEMP.	1564	1601	1548	1593	1520	1603	1480	1381	1482	1383	1482	1364
STD. DEV.	7	3	9	5	12	2	44	40	44	40	44	41
HI TEMP.	1571	1605	1559	1600	1533	1605	1527	1426	1528	1429	1528	1410
LO TEMP.	1555	1599	1536	1588	1505	1600	1425	1333	1426	1335	1427	1314
40 HOUR												
AVG. TEMP.	1572	1598	1565	1591	1534	1603	1503	1418	1513	1426	1504	1405
STD. DEV.	18	3	15	4	37	2	41	13	20	5	31	5
HI TEMP.	1593	1603	1564	1597	1598	1606	1525	1427	1527	1431	1527	1410
LO TEMP.	1555	1595	1542	1587	1510	1600	1430	1395	1478	1420	1450	1398
45 HOUR												
AVG. TEMP.	1573	1597	1555	1588	1540	1606	1525	1426	1526	1429	1522	1408
STD. DEV.	18	4	7	2	20	1	5	4	3	3	2	3
HI TEMP.	1590	1602	1564	1591	1555	1607	1531	1431	1529	1432	1525	1412
LO TEMP.	1555	1594	1549	1586	1510	1604	1520	1423	1524	1427	1521	1405
50 HOUR												
AVG. TEMP.	1569	1592	1558	1587	1526	1606	1566	1467	1567	1470	1561	1450
STD. DEV.	14	6	9	4	20	1	29	29	29	29	26	29
HI TEMP.	1589	1598	1566	1592	1548	1608	1599	1501	1600	1502	1587	1484
LO TEMP.	1550	1584	1543	1583	1498	1604	1525	1427	1526	1429	1522	1410
55 HOUR												
AVG. TEMP.	1563	1591	1551	1587	1517	1606	1612	1515	1603	1519	1562	1502
STD. DEV.	11	2	17	3	22	1	6	6	7	7	14	6
HI TEMP.	1573	1594	1565	1590	1537	1607	1617	1521	1607	1526	1581	1508
LO TEMP.	1550	1589	1529	1584	1495	1606	1604	1507	1593	1509	1548	1494
60 HOUR												
AVG. TEMP.	1566	1590	1553	1585	1519	1605	1617	1522	1601	1527	1564	1509
STD. DEV.	14	2	13	2	15	1	3	3	6	2	11	1
HI TEMP.	1587	1593	1571	1589	1536	1606	1621	1525	1606	1530	1578	1511
LO TEMP.	1551	1588	1539	1583	1499	1603	1613	1518	1593	1524	1552	1507
65 HOUR												
AVG. TEMP.	1568	1591	1565	1590	1515	1606	1616	1522	1602	1526	1568	1509
STD. DEV.	10	4	15	3	10	2	3	3	2	3	10	2
HI TEMP.	1583	1596	1576	1593	1528	1608	1620	1525	1605	1529	1578	1512
LO TEMP.	1556	1587	1539	1586	1500	1605	1612	1519	1600	1523	1555	1507
70 HOUR												
AVG. TEMP.	1576	1590	1551	1589	1532	1606	1616	1525	1598	1529	1556	1511
STD. DEV.	4	2	21	4	7	1	3	6	8	7	18	5
HI TEMP.	1581	1592	1575	1593	1540	1606	1619	1532	1605	1536	1566	1516
LO TEMP.	1573	1589	1537	1586	1526	1605	1614	1520	1590	1523	1535	1507

LOCATION	IN BED						ABOVE BED					
PORT NO.	2	2	4	4	6	6	14	14	16	16	18	18
SPEC. MAT.	B	X	X	B	X	B	X	B	X	B	B	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	13	14	15	16	17	18	19	20	21	22	23	24
	DEGREES FAHRENHEIT											
5 HOUR												
AVG. TEMP.	1249	1419	1156	1472	1486	1409	1327	1320	1213	1389	1313	0
STD. DEV.	22	10	127	59	55	154	60	74	21	17	18	0
HI TEMP.	1287	1436	1348	1578	1525	1522	1359	1362	1238	1407	1339	0
LO TEMP.	1232	1411	1042	1436	1391	1166	1220	1188	1187	1366	1296	0
10 HOUR												
AVG. TEMP.	1235	1408	1024	1444	1462	1420	1380	1366	1228	1392	1343	1431
STD. DEV.	5	8	13	6	57	97	32	9	45	22	53	38
HI TEMP.	1242	1417	1041	1451	1526	1499	1427	1376	1284	1409	1404	1460
LO TEMP.	1228	1399	1010	1434	1374	1261	1350	1358	1195	1361	1291	1375
15 HOUR												
AVG. TEMP.	1243	1400	1012	1439	1390	1287	1436	1306	1308	1341	1409	1349
STD. DEV.	6	3	11	6	111	141	9	30	23	2	15	6
HI TEMP.	1250	1405	1025	1444	1497	1485	1444	1328	1332	1344	1426	1355
LO TEMP.	1239	1397	1001	1429	1227	1122	1421	1267	1281	1338	1389	1343
20 HOUR												
AVG. TEMP.	1248	1401	1002	1435	0	0	1460	1324	1302	1334	1415	1341
STD. DEV.	5	3	4	2	0	0	2	7	25	3	8	8
HI TEMP.	1254	1405	1008	1438	0	0	1462	1335	1327	1338	1424	1354
LO TEMP.	1243	1398	999	1432	0	0	1458	1319	1265	1331	1404	1333
25 HOUR												
AVG. TEMP.	785	873	627	893	0	0	1024	957	980	967	1016	969
STD. DEV.	435	493	358	513	0	0	401	346	335	353	377	351
HI TEMP.	1247	1402	1007	1441	0	0	1460	1328	1349	1345	1431	1347
LO TEMP.	290	346	221	341	0	0	589	580	599	580	606	587
30 HOUR												
AVG. TEMP.	1233	1409	1126	1438	0	0	1435	1278	1433	1318	1433	1300
STD. DEV.	19	11	66	18	0	0	64	65	61	65	62	67
HI TEMP.	1263	1421	1223	1453	0	0	1539	1366	1533	1413	1535	1397
LO TEMP.	1216	1392	1048	1407	0	0	1365	1182	1367	1229	1369	1208
35 HOUR												
AVG. TEMP.	1221	1404	1124	1437	0	0	1485	1326	1482	1363	1482	1344
STD. DEV.	7	4	33	5	0	0	46	39	45	40	46	41
HI TEMP.	1232	1410	1155	1442	0	0	1533	1371	1529	1407	1529	1389
LO TEMP.	1214	1399	1069	1432	0	0	1427	1279	1425	1315	1424	1294
40 HOUR												
AVG. TEMP.	1226	1395	1054	1440	1417	1395	1459	1327	1366	1333	1406	1370
STD. DEV.	14	8	27	8	225	249	42	25	94	45	74	11
HI TEMP.	1238	1400	1081	1445	1540	1545	1533	1372	1528	1408	1528	1390
LO TEMP.	1204	1382	1023	1425	1080	1023	1435	1314	1289	1304	1338	1362
45 HOUR												
AVG. TEMP.	1230	1398	1037	1438	1470	1476	1422	1300	1311	1320	1399	1367
STD. DEV.	4	2	15	3	44	93	28	26	40	30	6	3
HI TEMP.	1234	1400	1053	1441	1514	1539	1439	1314	1370	1364	1406	1371
LO TEMP.	1225	1395	1018	1434	1376	1339	1381	1261	1287	1304	1392	1364
50 HOUR												
AVG. TEMP.	1229	1398	1167	1438	1383	1372	1399	1263	1414	1383	1384	1398
STD. DEV.	5	4	63	3	41	69	12	16	19	4	22	18
HI TEMP.	1237	1405	1204	1441	1463	1466	1417	1288	1439	1387	1415	1418
LO TEMP.	1224	1395	1042	1432	1291	1301	1342	1249	1395	1378	1355	1373
55 HOUR												
AVG. TEMP.	1227	1400	1208	1447	1343	1403	1385	1241	1413	1390	1350	1427
STD. DEV.	7	3	25	3	38	52	8	4	13	1	22	3
HI TEMP.	1234	1403	1233	1451	1421	1447	1394	1246	1423	1391	1379	1431
LO TEMP.	1220	1397	1173	1444	1339	1343	1378	1237	1395	1388	1325	1423
60 HOUR												
AVG. TEMP.	1225	1398	1190	1444	1377	1394	1380	1234	1391	1390	1343	1430
STD. DEV.	5	5	34	4	74	57	3	2	15	1	8	2
HI TEMP.	1232	1404	1235	1448	1480	1448	1385	1237	1418	1391	1351	1432
LO TEMP.	1221	1393	1156	1438	1288	1309	1378	1231	1379	1389	1335	1428
65 HOUR												
AVG. TEMP.	1231	1401	1150	1419	1387	1398	1383	1237	1400	1394	1356	1436
STD. DEV.	1	3	6	6	11	65	7	4	16	4	14	6
HI TEMP.	1235	1406	1156	1447	1423	1451	1391	1241	1420	1399	1368	1444
LO TEMP.	1232	1398	1142	1432	1339	1286	1376	1232	1382	1390	1339	1430
70 HOUR												
AVG. TEMP.	1225	1396	1151	1436	1351	1309	1393	1244	1386	1399	1349	1448
STD. DEV.	5	3	2	2	24	93	2	7	17	3	15	4
HI TEMP.	1229	1398	1152	1438	1366	1391	1395	1251	1403	1401	1359	1452
LO TEMP.	1220	1394	1149	1435	1323	1225	1392	1238	1370	1397	1338	1444

LOCATION	IN BED						ABOVE BED					
PORT NO.	7	7	9	9	11	11	19	19	20	20	22	22
SPEC. MAT.	3	8	8	3	8	3	8	3	3	8	8	3
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	25	26	27	28	29	30	31	32	33	34	35	36
	DEGREES FAHRENHEIT											
5 HOUR												
AVG. TEMP.	1140	1174	1129	1251	1080	1230	1006	1170	917	1150	974	1135
STD. DEV.	9	18	32	22	13	13	17	18	23	26	15	23
HI TEMP.	1155	1262	1168	1270	1094	1242	1033	1199	944	1182	988	1175
LO TEMP.	1133	1154	1093	1226	1064	1206	999	1152	895	1122	954	1117
10 HOUR												
AVG. TEMP.	1135	1164	1131	1255	1089	1221	1028	1168	897	1119	960	1088
STD. DEV.	16	9	10	5	20	11	30	13	71	79	22	39
HI TEMP.	1163	1200	1146	1261	1119	1233	1074	1186	955	1196	978	1143
LO TEMP.	1124	1176	1122	1250	1054	1207	1001	1155	799	1016	926	1051
15 HOUR												
AVG. TEMP.	1148	1185	1148	1259	1119	1221	1034	1110	798	979	934	1056
STD. DEV.	10	8	4	4	27	4	8	15	12	6	22	16
HI TEMP.	1157	1198	1152	1262	1145	1233	1048	1127	812	983	954	1076
LO TEMP.	1134	1178	1144	1252	1076	1211	1030	1090	786	968	897	1034
20 HOUR												
AVG. TEMP.	1140	1187	1154	1263	1091	1224	1139	1135	1079	1109	959	1023
STD. DEV.	19	9	8	2	25	5	6	11	11	8	17	7
HI TEMP.	1163	1202	1165	1266	1130	1229	1146	1152	1094	1121	975	1035
LO TEMP.	1120	1178	1147	1261	1067	1217	1134	1127	1069	1101	935	1018
25 HOUR												
AVG. TEMP.	758	796	768	832	748	818	914	892	896	878	870	855
STD. DEV.	375	375	373	411	340	394	246	255	221	242	196	211
HI TEMP.	1149	1193	1156	1268	1119	1228	1201	1163	1142	1153	1127	1106
LO TEMP.	283	342	312	358	333	377	609	584	604	585	604	590
30 HOUR												
AVG. TEMP.	1136	1234	1121	1275	1091	1259	1430	1277	1428	1302	1419	1302
STD. DEV.	27	21	12	7	26	11	60	61	62	59	63	61
HI TEMP.	1182	1257	1133	1285	1121	1270	1530	1365	1528	1388	1521	1395
LO TEMP.	1113	1209	1107	1268	1055	1241	1364	1194	1359	1226	1348	1224
35 HOUR												
AVG. TEMP.	1129	1183	1132	1261	1076	1244	1477	1319	1477	1345	1470	1333
STD. DEV.	7	37	5	15	14	13	44	39	45	40	45	36
HI TEMP.	1138	1238	1137	1283	1098	1259	1523	1363	1523	1388	1517	1373
LO TEMP.	1122	1143	1125	1246	1059	1231	1421	1272	1421	1295	1413	1289
40 HOUR												
AVG. TEMP.	1141	1127	1136	1251	1085	1232	1272	1180	1204	1140	1139	1079
STD. DEV.	13	14	14	7	19	7	142	105	181	141	213	186
HI TEMP.	1162	1146	1151	1261	1114	1242	1523	1364	1524	1388	1517	1372
LO TEMP.	1130	1114	1119	1244	1044	1226	1193	1120	1107	1062	1025	952
45 HOUR												
AVG. TEMP.	1164	1132	1131	1253	1084	1232	1193	1117	1091	1075	1069	973
STD. DEV.	36	29	8	5	18	8	5	2	10	46	68	48
HI TEMP.	1204	1169	1137	1257	1099	1241	1198	1118	1100	1144	1163	1045
LO TEMP.	1129	1100	1119	1248	1064	1227	1189	1114	1081	1051	1012	944
50 HOUR												
AVG. TEMP.	1210	1158	1116	1248	1083	1227	1192	1111	1190	1152	1244	1092
STD. DEV.	12	10	9	6	17	8	4	3	12	4	8	3
HI TEMP.	1227	1165	1127	1255	1102	1239	1195	1114	1202	1159	1251	1096
LO TEMP.	1195	1140	1106	1238	1061	1220	1186	1108	1177	1149	1230	1090
55 HOUR												
AVG. TEMP.	1196	1156	1116	1247	1091	1235	1192	1112	1183	1170	1205	1092
STD. DEV.	19	10	5	6	11	4	6	1	8	7	19	4
HI TEMP.	1217	1163	1123	1252	1104	1240	1200	1113	1193	1179	1229	1096
LO TEMP.	1174	1142	1112	1238	1076	1230	1187	1111	1173	1165	1185	1088
60 HOUR												
AVG. TEMP.	1203	1155	1108	1248	1071	1223	1193	1112	1185	1192	1201	1120
STD. DEV.	15	8	6	6	10	10	7	2	3	7	21	23
HI TEMP.	1218	1167	1114	1257	1088	1231	1201	1114	1189	1201	1221	1143
LO TEMP.	1181	1147	1100	1240	1062	1206	1185	1110	1181	1183	1176	1094
65 HOUR												
AVG. TEMP.	1188	1150	1105	1245	1087	1228	1197	1116	1193	1222	1187	1174
STD. DEV.	8	10	4	5	19	4	4	3	6	14	22	14
HI TEMP.	1199	1164	1110	1251	1110	1235	1202	1119	1199	1238	1224	1186
LO TEMP.	1179	1140	1102	1239	1065	1225	1192	1112	1185	1207	1168	1152
70 HOUR												
AVG. TEMP.	1195	1157	1116	1254	1102	1232	1204	1121	1190	1246	1102	1167
STD. DEV.	3	15	2	3	27	7	9	4	2	0	21	4
HI TEMP.	1198	1174	1118	1257	1133	1240	1210	1125	1192	1246	1123	1170
LO TEMP.	1192	1148	1115	1252	1081	1226	1194	1117	1188	1246	1092	1163

LOCATION	IN BED					
PORT NO.	9	8	12	12	10	10
SPEC. MAT.	2	9			9	2
SPEC. LOC.	I	O	I	O	I	O
DATA LOG NO.	37	38	39	40	41	42
	DEGREES FAHR					
5 HOUR						
AVG. TEMP.	0	800	0	815	1001	1008
STD. DEV.	0	7	0	317	6	3
HI TEMP.	0	808	0	1070	1008	1010
LO TEMP.	0	791	0	467	994	1004
10 HOUR						
AVG. TEMP.	0	806	0	1076	1000	1009
STD. DEV.	0	6	0	15	12	4
HI TEMP.	0	816	0	1088	1016	1014
LO TEMP.	0	802	0	1054	985	1005
15 HOUR						
AVG. TEMP.	0	826	0	1025	995	1017
STD. DEV.	0	13	0	10	5	8
HI TEMP.	0	836	0	1034	999	1030
LO TEMP.	0	803	0	1013	986	1012
20 HOUR						
AVG. TEMP.	0	821	0	999	997	1014
STD. DEV.	0	7	0	13	7	6
HI TEMP.	0	830	0	1013	1002	1020
LO TEMP.	0	811	0	979	987	1006
25 HOUR						
AVG. TEMP.	0	698	0	717	724	721
STD. DEV.	0	243	0	307	286	315
HI TEMP.	0	1043	0	1064	1045	1073
LO TEMP.	0	396	0	334	373	324
30 HOUR						
AVG. TEMP.	0	1057	0	974	1085	1060
STD. DEV.	0	38	0	33	11	10
HI TEMP.	0	1113	0	1012	1100	1069
LO TEMP.	0	1016	0	939	1074	1046
35 HOUR						
AVG. TEMP.	0	1021	0	987	1064	1070
STD. DEV.	0	20	0	35	16	5
HI TEMP.	0	1055	0	1037	1090	1077
LO TEMP.	0	1005	0	955	1051	1064
40 HOUR						
AVG. TEMP.	0	1130	0	1073	1103	1040
STD. DEV.	0	67	0	39	43	24
HI TEMP.	0	1165	0	1104	1155	1065
LO TEMP.	0	1011	0	1006	1036	1007
45 HOUR						
AVG. TEMP.	0	1118	0	1086	1077	1059
STD. DEV.	0	55	0	13	30	9
HI TEMP.	0	1152	0	1105	1122	1069
LO TEMP.	0	1036	0	1076	1057	1047
50 HOUR						
AVG. TEMP.	0	1033	0	1026	1088	1081
STD. DEV.	0	8	0	12	13	14
HI TEMP.	0	1042	0	1034	1107	1098
LO TEMP.	0	1021	0	1004	1075	1064
55 HOUR						
AVG. TEMP.	0	1033	0	1030	1069	1053
STD. DEV.	0	12	0	7	35	39
HI TEMP.	0	1050	0	1040	1099	1088
LO TEMP.	0	1022	0	1025	1033	1016
60 HOUR						
AVG. TEMP.	0	1050	0	1038	1038	1024
STD. DEV.	0	3	0	12	9	9
HI TEMP.	0	1053	0	1056	1053	1038
LO TEMP.	0	1046	0	1023	1030	1013
65 HOUR						
AVG. TEMP.	0	1049	0	1037	1036	1021
STD. DEV.	0	3	0	5	2	5
HI TEMP.	0	1053	0	1044	1039	1027
LO TEMP.	0	1045	0	1029	1034	1013
70 HOUR						
AVG. TEMP.	0	1047	0	1041	1043	1026
STD. DEV.	0	1	0	6	11	6
HI TEMP.	0	1047	0	1046	1053	1030
LO TEMP.	0	1046	0	1035	1031	1019

Table C-4 (Cont'd)

Heat Exchanger Probes Temperature History (Run 81)

DEGREES FAHRENHEIT

LOCATION	IN BED						ABOVE BED					
PORT NO.	1	1	3	3	5	5	13	13	15	15	17	17
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	1	2	3	4	5	6	7	8	9	10	11	12
75 HOUR												
AVG. TEMP.	1573	1534	1552	1584	1528	1604	1619	1530	1596	1530	1525	1516
STD. DEV.	12	112	15	5	23	3	0	2	4	5	61	1
HI TEMP.	1588	1590	1566	1589	1547	1606	1619	1531	1600	1534	1558	1517
LO TEMP.	1558	1366	1536	1580	1500	1601	1619	1528	1592	1522	1417	1515
80 HOUR												
AVG. TEMP.	1550	1586	1548	1567	1496	1596	1608	1512	1563	1506	1530	1515
STD. DEV.	56	5	26	29	32	16	24	26	43	30	43	1
HI TEMP.	1590	1589	1578	1590	1523	1606	1621	1528	1593	1527	1556	1516
LO TEMP.	1451	1578	1532	1525	1461	1577	1572	1482	1532	1484	1453	1514
85 HOUR												
AVG. TEMP.	1577	1592	1551	1581	1523	1606	1613	1535	1590	1537	1552	1521
STD. DEV.	3	2	19	5	4	0	0	0	0	1	5	1
HI TEMP.	1580	1593	1564	1584	1526	1606	1613	1535	1590	1538	1556	1521
LO TEMP.	1575	1590	1537	1577	1520	1606	1613	1535	1590	1536	1547	1520
90 HOUR												
AVG. TEMP.	1554	1548	1538	1577	1504	1607	1620	1533	1589	1536	1556	1519
STD. DEV.	21	66	0	0	0	0	0	4	0	0	3	4
HI TEMP.	1582	1588	1538	1577	1504	1607	1620	1536	1589	1536	1560	1521
LO TEMP.	1531	1472	1538	1577	1504	1607	1620	1530	1589	1536	1552	1516
95 HOUR												
AVG. TEMP.	1578	1586	1548	1578	1524	1604	1616	1533	1598	1526	1550	1471
STD. DEV.	15	2	7	5	16	2	3	0	4	10	20	65
HI TEMP.	1592	1589	1555	1582	1541	1606	1619	1533	1601	1532	1568	1517
LO TEMP.	1555	1583	1539	1572	1510	1601	1614	1533	1592	1515	1516	1425
100 HOUR												
AVG. TEMP.	1561	1439	1521	1548	1507	1604	1597	1536	1591	1560	1555	1457
STD. DEV.	9	202	47	47	0	0	0	0	0	39	4	71
HI TEMP.	1574	1584	1550	1581	1507	1604	1597	1536	1591	1587	1559	1507
LO TEMP.	1552	1155	1467	1515	1507	1604	1597	1536	1591	1532	1549	1406
105 HOUR												
AVG. TEMP.	1567	1555	1546	1576	1524	1602	1579	1506	1577	1497	1553	1514
STD. DEV.	12	62	18	11	14	6	55	50	43	55	4	11
HI TEMP.	1582	1589	1566	1584	1538	1606	1618	1537	1613	1531	1559	1522
LO TEMP.	1552	1445	1523	1563	1511	1595	1498	1433	1502	1415	1547	1494
110 HOUR												
AVG. TEMP.	1566	1587	1544	1579	1525	1596	1604	1536	1592	1524	1553	1521
STD. DEV.	3	3	11	5	18	23	18	3	7	7	4	3
HI TEMP.	1569	1589	1563	1588	1541	1607	1618	1540	1600	1530	1559	1523
LO TEMP.	1563	1583	1538	1574	1501	1554	1579	1533	1540	1512	1548	1517
115 HOUR												
AVG. TEMP.	1563	1585	1564	1583	1521	1604	1616	1537	1593	1529	1555	1521
STD. DEV.	4	3	15	1	16	2	3	2	4	2	7	3
HI TEMP.	1566	1589	1581	1585	1531	1606	1619	1541	1598	1533	1560	1525
LO TEMP.	1557	1582	1548	1582	1494	1601	1612	1535	1589	1527	1544	1519
120 HOUR												
AVG. TEMP.	1569	1587	1541	1581	1515	1605	1602	1504	1585	1534	1545	1526
STD. DEV.	5	4	9	3	14	1	21	84	7	1	7	2
HI TEMP.	1577	1590	1551	1587	1529	1606	1613	1543	1592	1536	1553	1528
LO TEMP.	1564	1583	1533	1579	1498	1603	1565	1354	1574	1532	1536	1523
125 HOUR												
AVG. TEMP.	1565	1575	1545	1568	1510	1590	1598	1538	1592	1528	1557	1519
STD. DEV.	14	21	12	27	20	29	19	7	6	7	7	11
HI TEMP.	1584	1586	1561	1587	1541	1604	1618	1544	1598	1534	1566	1527
LO TEMP.	1549	1537	1530	1521	1489	1538	1576	1526	1585	1517	1550	1500
130 HOUR												
AVG. TEMP.	1568	1584	1537	1583	1498	1594	1606	1536	1584	1525	1555	1505
STD. DEV.	15	2	24	4	47	26	16	3	16	4	9	35
HI TEMP.	1588	1587	1575	1588	1534	1607	1619	1539	1596	1529	1569	1523
LO TEMP.	1551	1582	1510	1579	1417	1547	1579	1532	1555	1519	1544	1443
135 HOUR												
AVG. TEMP.	1573	1582	1547	1584	1511	1603	1617	1535	1595	1524	1562	1519
STD. DEV.	12	3	18	3	4	2	2	3	6	4	9	3
HI TEMP.	1590	1587	1572	1588	1515	1606	1620	1539	1601	1530	1574	1523
LO TEMP.	1556	1579	1532	1582	1505	1601	1616	1531	1589	1519	1555	1515
140 HOUR												
AVG. TEMP.	1570	1586	1558	1587	1519	1604	1619	1533	1597	1521	1568	1516
STD. DEV.	11	1	15	2	14	2	4	3	5	3	8	3
HI TEMP.	1587	1588	1573	1590	1538	1606	1622	1536	1603	1524	1579	1518
LO TEMP.	1559	1584	1535	1585	1504	1601	1614	1529	1549	1517	1559	1513

DEGREES FAHRENHEIT

LOCATION	IN BED						ABOVE BED					
PORT NO.	7	7	9	9	11	11	19	19	20	20	22	22
SPEC. MAT.	3	8	8	3	8	3	8	3	3	8	8	3
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	25	26	27	28	29	30	31	32	33	34	35	36
75 HOUR												
AVG. TEMP.	1180	1150	1103	1256	1069	1222	1166	1080	1181	1243	1072	1163
STD. DEV.	5	12	23	1	0	0	57	59	0	1	13	1
HI TEMP.	1184	1162	1129	1257	1069	1222	1201	1121	1181	1243	1081	1163
LO TEMP.	1175	1138	1086	1255	1069	1222	1100	1038	1181	1242	1063	1162
80 HOUR												
AVG. TEMP.	1159	1157	1113	1256	1117	1235	1198	1121	1178	1231	1102	1124
STD. DEV.	0	0	1	0	19	7	4	2	5	0	0	80
HI TEMP.	1159	1157	1114	1256	1139	1240	1202	1123	1183	1231	1102	1176
LO TEMP.	1159	1157	1112	1256	1105	1230	1193	1119	1174	1231	1102	1032
85 HOUR												
AVG. TEMP.	1192	1162	1107	1257	1081	1227	1194	1124	1151	1233	1087	1167
STD. DEV.	4	16	10	4	14	13	7	1	16	3	40	9
HI TEMP.	1194	1173	1115	1259	1099	1236	1204	1125	1168	1235	1115	1173
LO TEMP.	1149	1150	1096	1254	1068	1218	1190	1123	1136	1231	1059	1157
90 HOUR												
AVG. TEMP.	1177	1147	1133	1255	1095	1226	1184	1125	1098	1228	1093	1183
STD. DEV.	16	15	0	15	16	2	21	0	82	1	17	1
HI TEMP.	1195	1157	1133	1265	1106	1227	1200	1125	1151	1229	1105	1183
LO TEMP.	1157	1136	1133	1244	1083	1224	1147	1125	1004	1227	1081	1182
95 HOUR												
AVG. TEMP.	1211	1147	1136	1233	1079	1228	1195	1126	1139	1221	1085	1181
STD. DEV.	14	36	37	36	15	14	7	1	6	9	55	8
HI TEMP.	1226	1170	1162	1255	1097	1241	1204	1127	1145	1227	1150	1187
LO TEMP.	1198	1106	1110	1179	1065	1213	1148	1125	1132	1214	1017	1167
100 HOUR												
AVG. TEMP.	1166	1150	1105	1252	1078	1223	1190	0	1131	1221	1084	1187
STD. DEV.	30	28	11	16	44	14	2	0	0	0	41	6
HI TEMP.	1187	1169	1112	1263	1109	1233	1192	0	1131	1221	1113	1191
LO TEMP.	1144	1130	1097	1241	1047	1213	1188	0	1131	1221	1055	1183
105 HOUR												
AVG. TEMP.	1182	1150	1118	1246	1071	1219	1201	1137	1116	1207	1076	1172
STD. DEV.	47	23	39	40	25	27	5	16	17	19	36	24
HI TEMP.	1224	1173	1147	1275	1097	1249	1206	1157	1130	1222	1107	1195
LO TEMP.	1115	1119	1060	1187	1036	1190	1196	1107	1087	1180	1025	1140
110 HOUR												
AVG. TEMP.	1226	1383	1085	1411	1327	1306	1337	1243	1366	1360	1335	1438
STD. DEV.	36	30	62	48	50	105	94	71	51	58	19	24
HI TEMP.	1247	1400	1150	1436	1401	1377	1398	1303	1413	1408	1355	1460
LO TEMP.	1162	1329	985	1325	1268	1126	1177	1119	1305	1293	1310	1410
115 HOUR												
AVG. TEMP.	1236	1394	1179	1433	1351	1334	1402	1304	1288	1331	1319	1448
STD. DEV.	3	5	18	7	65	70	4	1	15	1	5	1
HI TEMP.	1239	1401	1209	1442	1461	1476	1407	1306	1307	1332	1324	1449
LO TEMP.	1232	1390	1166	1424	1302	1280	1396	1303	1268	1330	1311	1447
120 HOUR												
AVG. TEMP.	1236	1393	1225	1433	1349	1328	1360	1261	1280	1262	1236	1381
STD. DEV.	6	5	71	5	50	47	42	90	16	98	114	99
HI TEMP.	1245	1400	1292	1438	1435	1396	1405	1304	1297	1334	1321	1452
LO TEMP.	1230	1388	1110	1428	1313	1282	1306	1100	1264	1145	1082	1234
125 HOUR												
AVG. TEMP.	1251	1387	1228	1424	1384	1378	1402	1300	1279	1328	1317	1444
STD. DEV.	23	18	83	29	77	67	14	1	12	7	10	10
HI TEMP.	1292	1397	1297	1438	1461	1462	1425	1302	1293	1333	1332	1451
LO TEMP.	1239	1354	1137	1371	1291	1288	1391	1296	1265	1316	1306	1426
130 HOUR												
AVG. TEMP.	1241	1395	1089	1440	1359	1389	1391	1296	1283	1328	1317	1442
STD. DEV.	6	3	57	7	59	61	20	2	15	2	8	15
HI TEMP.	1247	1398	1162	1447	1405	1436	1410	1301	1304	1330	1325	1450
LO TEMP.	1233	1392	1040	1428	1256	1284	1357	1296	1263	1325	1304	1415
135 HOUR												
AVG. TEMP.	1240	1395	1020	1438	1413	1416	1401	1294	1293	1326	1317	1446
STD. DEV.	8	4	13	8	66	35	9	1	15	1	3	1
HI TEMP.	1250	1400	1035	1445	1470	1453	1411	1295	1305	1326	1320	1447
LO TEMP.	1230	1391	1005	1425	1327	1369	1393	1293	1268	1325	1312	1444
140 HOUR												
AVG. TEMP.	1243	1390	1018	1439	1349	1342	1401	1294	1296	1325	1319	1442
STD. DEV.	3	2	6	3	62	72	8	3	11	1	11	2
HI TEMP.	1247	1392	1029	1444	1459	1456	1412	1297	1304	1327	1331	1446
LO TEMP.	1240	1388	1013	1436	1310	1286	1395	1290	1275	1324	1306	1440

DEGREES FAHRENHEIT

LOCATION	IN BED						ABOVE BED					
PORT NO.	2	2	4	4	6	6	14	14	16	16	18	18
SPEC. MAT.	8	X	X	8	X	8	X	8	X	8	8	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	13	14	15	16	17	18	19	20	21	22	23	24
75 HOUR												
AVG. TEMP.	1227	1395	1188	1435	1343	1420	1333	1238	1408	1400	1336	1451
STD. DEV.	9	2	39	3	149	40	85	20	5	5	18	2
HI TEMP.	1236	1397	1232	1438	1452	1464	1382	1248	1416	1404	1355	1452
LO TEMP.	1216	1393	1157	1432	1131	1385	1285	1208	1405	1393	1313	1449
80 HOUR												
AVG. TEMP.	1152	1308	0	1431	1343	1295	1392	1280	1392	1381	1340	1455
STD. DEV.	96	0	0	0	0	0	1	36	9	31	0	0
HI TEMP.	1246	1308	0	1431	1343	1295	1392	1307	1401	1403	1340	1455
LO TEMP.	1055	1308	0	1431	1343	1295	1391	1253	1381	1338	1340	1455
85 HOUR												
AVG. TEMP.	1238	1400	1141	1438	1449	1447	1339	1276	1389	1403	1319	1457
STD. DEV.	6	5	6	11	31	7	50	46	16	5	32	1
HI TEMP.	1242	1403	1145	1446	1471	1452	1374	1332	1411	1406	1341	1458
LO TEMP.	1233	1396	1136	1430	1427	1442	1303	1251	1372	1397	1271	1456
90 HOUR												
AVG. TEMP.	1225	1344	1029	1436	1455	1445	1323	1261	1393	1406	1344	1416
STD. DEV.	14	15	0	0	0	0	99	0	20	1	0	59
HI TEMP.	1237	1394	1029	1436	1455	1445	1386	1261	1415	1406	1344	1457
LO TEMP.	1212	1373	1029	1436	1455	1445	1209	1261	1370	1405	1344	1374
95 HOUR												
AVG. TEMP.	1235	1404	1028	1432	1395	1377	1376	1262	1402	1400	1345	1447
STD. DEV.	3	17	10	2	81	68	16	4	16	9	4	20
HI TEMP.	1237	1428	1035	1433	1453	1455	1387	1264	1421	1406	1349	1459
LO TEMP.	1233	1393	1021	1430	1302	1333	1353	1259	1386	1387	1341	1424
100 HOUR												
AVG. TEMP.	1163	1288	1020	1325	1279	1294	1334	1166	1387	1397	1317	1439
STD. DEV.	60	0	39	0	104	121	57	6	10	15	29	23
HI TEMP.	1205	1288	1047	1325	1352	1379	1374	1170	1399	1406	1337	1455
LO TEMP.	1120	1288	992	1325	1205	1208	1293	1161	1378	1380	1296	1423
105 HOUR												
AVG. TEMP.	1237	1394	1136	1436	1370	1388	1340	1261	1389	1407	1331	1450
STD. DEV.	6	9	44	6	39	36	88	3	16	3	21	16
HI TEMP.	1242	1404	1188	1443	1421	1445	1391	1265	1406	1408	1345	1461
LO TEMP.	1230	1389	1085	1430	1322	1352	1182	1258	1376	1403	1300	1427
110 HOUR												
AVG. TEMP.	1173	1137	1126	1263	1073	1228	1210	1161	1064	1145	1023	1124
STD. DEV.	19	15	7	6	12	9	4	2	83	90	85	76
HI TEMP.	1192	1152	1138	1270	1084	1239	1216	1164	1136	1220	1092	1188
LO TEMP.	1142	1114	1121	1256	1057	1217	1206	1159	932	1001	909	1003
115 HOUR												
AVG. TEMP.	1137	1113	1120	1261	1091	1227	1210	1164	1028	1156	920	1093
STD. DEV.	16	10	17	8	20	9	5	2	11	2	20	17
HI TEMP.	1159	1123	1136	1272	1111	1237	1213	1167	1040	1158	941	1107
LO TEMP.	1122	1098	1099	1250	1069	1214	1202	1163	1018	1154	884	1063
120 HOUR												
AVG. TEMP.	1104	1083	1070	1224	1016	1202	1208	1168	1016	1155	910	1085
STD. DEV.	47	51	71	58	107	54	8	6	19	2	24	21
HI TEMP.	1149	1123	1127	1270	1103	1236	1216	1173	1036	1159	934	1104
LO TEMP.	1046	998	985	1139	866	1107	1200	1159	985	1154	889	1049
125 HOUR												
AVG. TEMP.	1159	1125	1120	1253	1095	1224	1205	1141	1005	1117	884	1051
STD. DEV.	32	22	8	13	15	14	6	35	35	52	8	60
HI TEMP.	1209	1161	1131	1266	1111	1236	1215	1167	1025	1155	890	1097
LO TEMP.	1129	1103	1113	1232	1076	1200	1201	1086	944	1049	878	979
130 HOUR												
AVG. TEMP.	1148	1104	1108	1248	1081	1212	1197	1152	1015	1154	948	1109
STD. DEV.	23	17	21	13	24	28	17	16	35	3	44	25
HI TEMP.	1173	1121	1131	1259	1111	1230	1223	1181	1042	1157	1019	1151
LO TEMP.	1114	1077	1081	1227	1048	1163	1178	1140	954	1151	898	1083
135 HOUR												
AVG. TEMP.	1147	1108	1114	1250	1076	1217	1204	1157	1032	1157	907	1094
STD. DEV.	17	4	12	6	20	5	22	19	6	2	16	4
HI TEMP.	1165	1112	1127	1260	1097	1221	1242	1191	1041	1159	929	1100
LO TEMP.	1132	1101	1100	1247	1055	1210	1187	1145	1022	1154	887	1091
140 HOUR												
AVG. TEMP.	1142	1099	1116	1248	1078	1219	1178	1138	1050	1151	917	1096
STD. DEV.	13	8	9	6	9	6	5	2	16	6	21	3
HI TEMP.	1154	1107	1128	1252	1092	1224	1183	1140	1064	1161	948	1099
LO TEMP.	1121	1090	1104	1237	1069	1210	1171	1135	1025	1147	891	1091

DEGREES FAHR

LOCATION	IN BED					
PORT NO.	8	8	12	12	10	10
SPEC. MAT.	2	9			9	2
SPEC. LOC.	I	O	I	O	I	O
DATA LOG NO.	37	38	39	40	41	42
75 HOUR						
AVG. TEMP.	0	1006	0	1038	1028	999
STD. DEV.	0	60	0	19	12	29
HI TEMP.	0	1048	0	1051	1038	1021
LO TEMP.	0	963	0	1024	1010	966
80 HOUR						
AVG. TEMP.	0	1026	0	1022	1039	1013
STD. DEV.	0	0	0	0	11	9
HI TEMP.	0	1026	0	1022	1054	1019
LO TEMP.	0	1026	0	1022	1029	1006
85 HOUR						
AVG. TEMP.	0	1053	0	1046	1047	1025
STD. DEV.	0	7	0	6	11	3
HI TEMP.	0	1058	0	1050	1058	1027
LO TEMP.	0	1048	0	1041	1033	1023
90 HOUR						
AVG. TEMP.	0	1049	0	1048	1028	1022
STD. DEV.	0	3	0	8	15	5
HI TEMP.	0	1051	0	1053	1040	1025
LO TEMP.	0	1047	0	1042	1006	1018
95 HOUR						
AVG. TEMP.	0	1046	0	1029	1039	1004
STD. DEV.	0	35	0	43	5	23
HI TEMP.	0	1070	0	1059	1046	1020
LO TEMP.	0	1021	0	998	1034	987
100 HOUR						
AVG. TEMP.	0	1053	0	1012	1032	997
STD. DEV.	0	0	0	64	10	13
HI TEMP.	0	1053	0	1057	1049	1006
LO TEMP.	0	1053	0	966	1025	987
105 HOUR						
AVG. TEMP.	0	1038	0	1033	1043	1008
STD. DEV.	0	21	0	32	6	34
HI TEMP.	0	1050	0	1054	1051	1029
LO TEMP.	0	1006	0	977	1037	949
110 HOUR						
AVG. TEMP.	0	997	0	1045	1027	1009
STD. DEV.	0	69	0	19	11	25
HI TEMP.	0	1059	0	1064	1041	1032
LO TEMP.	0	920	0	1015	1013	969
115 HOUR						
AVG. TEMP.	0	920	0	1059	1034	1016
STD. DEV.	0	4	0	13	11	11
HI TEMP.	0	925	0	1079	1047	1030
LO TEMP.	0	913	0	1044	1022	1002
120 HOUR						
AVG. TEMP.	0	922	0	1060	1038	1017
STD. DEV.	0	3	0	14	5	13
HI TEMP.	0	925	0	1083	1046	1031
LO TEMP.	0	918	0	1048	1033	997
125 HOUR						
AVG. TEMP.	0	896	0	1016	1025	968
STD. DEV.	0	48	0	54	30	69
HI TEMP.	0	931	0	1060	1045	1025
LO TEMP.	0	814	0	940	973	874
130 HOUR						
AVG. TEMP.	0	926	0	1070	1045	1029
STD. DEV.	0	5	0	7	26	39
HI TEMP.	0	932	0	1077	1068	1066
LO TEMP.	0	920	0	1063	1002	963
135 HOUR						
AVG. TEMP.	0	927	0	1067	1002	977
STD. DEV.	0	3	0	9	6	10
HI TEMP.	0	929	0	1080	1011	992
LO TEMP.	0	923	0	1056	994	966
140 HOUR						
AVG. TEMP.	0	924	0	1075	1004	977
STD. DEV.	0	6	0	4	3	10
HI TEMP.	0	929	0	1078	1008	988
LO TEMP.	0	916	0	1068	1000	966

Table C-4 (Cont'd)

Heat Exchanger Probes Temperature History (Run 81)

LOCATION	IN BED						ABOVE BED					
PORT NO.	1	1	3	3	5	5	13	13	15	15	17	17
SPEC. MAT.	X	M	M	X	M	X	X	M	M	X	M	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	1	2	3	4	5	6	7	8	9	10	11	12
	DEGREES FAHRENHEIT											
145 HOUR												
AVG. TEMP.	1569	1582	1553	1585	1516	1604	1620	1536	1597	1523	1565	1518
STD. DEV.	12	4	18	6	14	2	3	3	3	4	5	3
HI TEMP.	1588	1587	1578	1592	1535	1607	1623	1538	1600	1526	1572	1520
LO TEMP.	1555	1578	1536	1578	1497	1603	1416	1531	1592	1517	1560	1514
150 HOUR												
AVG. TEMP.	1576	1584	1551	1586	1509	1604	1614	1525	1604	1509	1571	1508
STD. DEV.	14	3	20	6	9	2	5	6	4	7	8	5
HI TEMP.	1590	1587	1568	1595	1516	1606	1619	1532	1608	1518	1583	1515
LO TEMP.	1553	1580	1518	1578	1496	1602	1608	1516	1598	1502	1562	1502
155 HOUR												
AVG. TEMP.	1571	1582	1565	1594	1518	1602	1613	1524	1606	1507	1572	1505
STD. DEV.	10	3	14	6	25	1	4	4	5	5	11	3
HI TEMP.	1582	1584	1579	1590	1551	1604	1616	1527	1611	1513	1585	1509
LO TEMP.	1559	1579	1543	1575	1494	1600	1607	1516	1598	1500	1555	1500
160 HOUR												
AVG. TEMP.	1580	1584	1554	1585	1521	1604	1616	1527	1602	1515	1566	1511
STD. DEV.	7	3	11	4	13	2	3	2	6	2	4	1
HI TEMP.	1589	1587	1566	1588	1533	1606	1619	1529	1611	1517	1572	1512
LO TEMP.	1570	1580	1542	1580	1498	1601	1613	1524	1596	1513	1560	1509
165 HOUR												
AVG. TEMP.	1565	1581	1555	1581	1525	1601	1616	1526	1604	1512	1576	1508
STD. DEV.	15	3	17	4	17	2	4	3	4	4	9	4
HI TEMP.	1583	1584	1576	1586	1551	1603	1619	1528	1609	1516	1588	1512
LO TEMP.	1553	1577	1538	1576	1510	1598	1609	1520	1599	1505	1565	1503
170 HOUR												
AVG. TEMP.	1564	1581	1550	1582	1519	1601	1616	1526	1603	1513	1571	1509
STD. DEV.	9	3	20	4	25	1	4	5	4	5	8	3
HI TEMP.	1577	1585	1560	1589	1561	1602	1621	1534	1607	1519	1583	1512
LO TEMP.	1556	1578	1534	1579	1496	1600	1609	1519	1598	1505	1561	1505
175 HOUR												
AVG. TEMP.	1572	1583	1570	1587	1516	1604	1615	1524	1605	1512	1564	1509
STD. DEV.	14	3	7	1	15	3	4	4	4	4	3	2
HI TEMP.	1590	1585	1579	1588	1534	1607	1618	1527	1610	1515	1567	1511
LO TEMP.	1558	1578	1561	1587	1501	1601	1610	1519	1600	1506	1559	1506

LOCATION	IN BED						ABOVE BED					
PORT NO.	2	2	4	4	6	6	14	14	16	16	18	18
SPEC. MAT.	8	X	X	8	X	8	X	8	X	8	8	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	13	14	15	16	17	18	19	20	21	22	23	24
	DEGREES FAHRENHEIT											
145 HOUR												
AVG. TEMP.	1243	1396	1023	1438	1407	1393	1404	1295	1294	1330	1322	1446
STD. DEV.	2	3	4	5	62	56	10	2	15	5	11	2
HI TEMP.	1245	1400	1026	1447	1461	1467	1416	1296	1306	1337	1342	1448
LO TEMP.	1239	1393	1016	1436	1321	1323	1395	1291	1268	1325	1314	1443
150 HOUR												
AVG. TEMP.	1237	1390	1021	1439	1380	1382	1403	1293	1281	1329	1322	1444
STD. DEV.	3	2	6	5	52	64	8	2	16	3	2	3
HI TEMP.	1241	1393	1029	1447	1438	1459	1413	1294	1297	1334	1326	1448
LO TEMP.	1234	1387	1014	1433	1325	1289	1393	1290	1262	1325	1321	1439
155 HOUR												
AVG. TEMP.	1241	1394	1021	1439	1325	1360	1401	1291	1288	1327	1321	1442
STD. DEV.	4	4	4	2	39	40	9	2	18	2	8	3
HI TEMP.	1247	1397	1026	1441	1385	1418	1413	1295	1306	1330	1331	1444
LO TEMP.	1238	1389	1017	1437	1287	1312	1392	1289	1265	1326	1312	1437
160 HOUR												
AVG. TEMP.	1244	1393	1021	1441	1369	1379	1400	1291	1278	1328	1319	1445
STD. DEV.	4	3	8	7	49	59	10	1	11	2	2	1
HI TEMP.	1248	1397	1035	1450	1413	1440	1412	1292	1293	1329	1322	1446
LO TEMP.	1240	1388	1013	1431	1300	1310	1391	1289	1267	1325	1316	1443
165 HOUR												
AVG. TEMP.	1244	1391	1021	1437	1379	1382	1409	1288	1320	1358	1320	1448
STD. DEV.	3	3	9	6	66	52	2	1	12	3	8	3
HI TEMP.	1247	1393	1032	1446	1460	1440	1410	1289	1338	1362	1327	1449
LO TEMP.	1240	1387	1006	1429	1285	1320	1406	1287	1306	1355	1308	1443
170 HOUR												
AVG. TEMP.	1247	1393	1026	1436	1361	1366	1397	1286	1321	1359	1321	1448
STD. DEV.	3	4	7	7	69	65	10	3	19	2	12	3
HI TEMP.	1251	1399	1032	1445	1448	1460	1413	1290	1343	1362	1330	1452
LO TEMP.	1242	1390	1015	1427	1293	1299	1388	1283	1303	1356	1302	1445
175 HOUR												
AVG. TEMP.	1244	1393	1053	1442	1414	1383	1398	1283	1327	1360	1336	1454
STD. DEV.	5	2	13	9	44	69	8	2	14	1	9	2
HI TEMP.	1248	1395	1068	1450	1454	1471	1409	1285	1345	1360	1344	1456
LO TEMP.	1237	1390	1041	1430	1373	1324	1390	1281	1312	1359	1325	1452

LOCATION	IN BED						ABOVE BED					
PORT NO.	7	7	9	9	11	11	19	19	20	20	22	22
SPEC. MAT.	3	8	8	3	8	3	8	3	3	8	8	3
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
DATA LOG NO.	25	26	27	28	29	30	31	32	33	34	35	36
	DEGREES FAHRENHEIT											
145 HOUR												
AVG. TEMP.	1148	1112	1100	1237	1070	1213	1168	1138	1054	1151	931	1103
STD. DEV.	13	6	7	5	18	20	6	2	7	3	19	4
HI TEMP.	1164	1121	1106	1240	1095	1226	1178	1141	1065	1153	949	1107
LO TEMP.	1131	1105	1089	1227	1051	1178	1162	1135	1046	1146	903	1096
150 HOUR												
AVG. TEMP.	1131	1107	1129	1257	1043	1218	1183	1142	1053	1153	912	1093
STD. DEV.	11	16	22	16	84	7	23	7	27	7	39	7
HI TEMP.	1143	1125	1159	1267	1089	1230	1206	1149	1073	1159	948	1099
LO TEMP.	1121	1096	1099	1229	893	1211	1144	1130	1006	1141	853	1081
155 HOUR												
AVG. TEMP.	1127	1119	1103	1242	1081	1223	1200	1149	1070	1166	925	1101
STD. DEV.	9	6	23	17	14	10	5	2	7	6	20	1
HI TEMP.	1135	1129	1140	1272	1102	1233	1205	1151	1078	1174	942	1102
LO TEMP.	1114	1112	1063	1228	1064	1207	1191	1146	1063	1160	895	1100
160 HOUR												
AVG. TEMP.	1126	1117	1102	1236	1082	1220	1198	1149	1071	1177	887	1098
STD. DEV.	5	8	8	5	26	10	8	3	5	3	19	4
HI TEMP.	1132	1129	1113	1242	1120	1229	1206	1152	1080	1181	920	1101
LO TEMP.	1118	1110	1090	1229	1058	1204	1189	1146	1066	1173	873	1092
165 HOUR												
AVG. TEMP.	1201	1174	1078	1214	1063	1216	1198	1149	1102	1208	977	1148
STD. DEV.	12	6	8	3	6	6	9	2	9	7	25	5
HI TEMP.	1220	1182	1086	1218	1067	1225	1208	1152	1113	1220	1021	1155
LO TEMP.	1188	1167	1066	1209	1052	1208	1189	1146	1092	1201	960	1144
170 HOUR												
AVG. TEMP.	1201	1175	1077	1216	1080	1225	1199	1147	1097	1215	979	1153
STD. DEV.	8	6	12	6	22	10	5	2	6	4	28	7
HI TEMP.	1210	1182	1086	1222	1116	1238	1203	1150	1105	1218	1016	1161
LO TEMP.	1189	1166	1056	1207	1062	1212	1191	1146	1092	1210	957	1147
175 HOUR												
AVG. TEMP.	1204	1177	1068	1212	1072	1228	1202	1149	1095	1223	955	1153
STD. DEV.	8	4	9	5	10	9	8	2	6	1	16	4
HI TEMP.	1211	1182	1079	1218	1079	1241	1210	1151	1102	1224	973	1157
LO TEMP.	1192	1174	1058	1206	1057	1221	1193	1147	1089	1222	939	1150

LOCATION	IN BED					
PORT NO.	8	8	12	12	10	10
SPEC. MAT.	2	9			9	2
SPEC. LOC.	I	O	I	O	I	O
DATA LOG NO.	37	38	39	40	41	42
	DEGREES FAHRE					
145 HOUR						
AVG. TEMP.	0	903	0	1068	1012	975
STD. DEV.	0	11	0	3	7	10
HI TEMP.	0	914	0	1071	1021	992
LO TEMP.	0	890	0	1064	1005	967
150 HOUR						
AVG. TEMP.	0	906	0	1076	995	977
STD. DEV.	0	9	0	14	23	11
HI TEMP.	0	920	0	1095	1014	988
LO TEMP.	0	895	0	1056	956	960
155 HOUR						
AVG. TEMP.	0	907	0	1084	1002	978
STD. DEV.	0	12	0	14	1	15
HI TEMP.	0	919	0	1104	1004	998
LO TEMP.	0	894	0	1070	1001	966
160 HOUR						
AVG. TEMP.	0	915	0	1079	1002	985
STD. DEV.	0	5	0	27	4	8
HI TEMP.	0	920	0	1114	1006	995
LO TEMP.	0	908	0	1058	996	976
165 HOUR						
AVG. TEMP.	0	997	0	1050	1040	1022
STD. DEV.	0	6	0	5	8	12
HI TEMP.	0	1005	0	1059	1048	1031
LO TEMP.	0	988	0	1046	1026	1001
170 HOUR						
AVG. TEMP.	0	985	0	1054	1039	1022
STD. DEV.	0	10	0	9	4	11
HI TEMP.	0	997	0	1068	1046	1037
LO TEMP.	0	972	0	1044	1034	1005

Table C-5

Heat Exchanger Probes Temperature History (Run 106)

DEGREES FAHRENHEIT

LOCATION	----IN BED----				-----ABOVE BED-----				----IN BED----				-----ABOVE BED-----
PORT NO.	1	1	3	3	13	13	15	15	2	2	6	14
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
5 HOUR	5/29/79											
AVG. TEMP.	1577	1605	1548	1568	1540	1580	1562	1591	1241	1402	1461	1430
STD. DEV.	13	4	20	8	23	3	6	6	6	4	39	12
HI TEMP.	1598	1611	1574	1582	1573	1583	1571	1598	1253	1410	1573	1454
LO TEMP.	1560	1597	1518	1553	1502	1572	1553	1579	1234	1397	1425	1412
10 HOUR	5/30/79											
AVG. TEMP.	1578	1589	1560	1575	1512	1588	1565	1593	1237	1395	1468	1395
STD. DEV.	15	11	11	10	30	6	10	6	6	9	22	21
HI TEMP.	1603	1611	1575	1595	1577	1594	1592	1603	1246	1410	1497	1439
LO TEMP.	1556	1577	1539	1566	1473	1576	1555	1581	1225	1382	1430	1366
15 HOUR	5/30/79											
AVG. TEMP.	1569	1585	1548	1567	1488	1585	1561	1588	1239	1393	1467	1388
STD. DEV.	12	9	23	5	34	2	4	3	10	7	21	20
HI TEMP.	1587	1603	1581	1576	1543	1588	1566	1593	1259	1406	1501	1430
LO TEMP.	1547	1572	1513	1553	1426	1582	1553	1583	1219	1384	1428	1352
20 HOUR	5/30/79											
AVG. TEMP.	1573	1580	1551	1566	1501	1585	1563	1569	1243	1393	1429	1380
STD. DEV.	15	11	23	5	35	2	7	3	9	8	47	15
HI TEMP.	1616	1605	1590	1574	1547	1589	1572	1593	1256	1406	1496	1407
LO TEMP.	1556	1566	1516	1558	1450	1582	1555	1584	1228	1379	1355	1350
25 HOUR	5/30/79											
AVG. TEMP.	1574	1581	1550	1562	1494	1586	1562	1586	1238	1393	1381	1379
STD. DEV.	13	9	22	5	26	2	11	3	9	8	21	18
HI TEMP.	1594	1598	1584	1571	1545	1588	1594	1592	1253	1406	1415	1399
LO TEMP.	1558	1567	1519	1556	1457	1582	1550	1582	1223	1384	1354	1341
30 HOUR	5/30/79											
AVG. TEMP.	1579	1582	1568	1567	1505	1589	1559	1567	1234	1394	1397	1381
STD. DEV.	12	6	16	5	32	2	5	2	8	5	25	16
HI TEMP.	1595	1595	1587	1576	1566	1593	1566	1590	1242	1402	1429	1418
LO TEMP.	1561	1572	1527	1559	1463	1586	1549	1584	1218	1384	1340	1346
35 HOUR	5/31/79											
AVG. TEMP.	1573	1577	1554	1570	1493	1589	1570	1595	1233	1388	1389	1367
STD. DEV.	11	7	19	6	26	1	10	8	9	6	23	16
HI TEMP.	1595	1588	1582	1579	1542	1591	1591	1614	1247	1398	1421	1386
LO TEMP.	1563	1568	1524	1559	1458	1587	1561	1586	1219	1376	1357	1334
40 HOUR	5/31/79											
AVG. TEMP.	1579	1581	1548	1569	1496	1589	1589	1615	1231	1389	1380	1373
STD. DEV.	14	6	19	5	23	3	6	3	10	5	22	21
HI TEMP.	1612	1590	1582	1579	1524	1592	1602	1620	1250	1396	1428	1395
LO TEMP.	1560	1568	1525	1560	1447	1585	1580	1608	1217	1377	1344	1324
45 HOUR	5/31/79											
AVG. TEMP.	1586	1585	1540	1571	1514	1592	1589	1617	1234	1390	1366	1366
STD. DEV.	7	8	19	5	10	1	6	2	7	4	28	22
HI TEMP.	1593	1595	1573	1580	1526	1593	1601	1621	1243	1394	1409	1390
LO TEMP.	1572	1570	1519	1566	1495	1591	1582	1614	1226	1383	1338	1328
50 HOUR	6/ 1/79											
AVG. TEMP.	1572	1584	1557	1579	1511	1571	1585	1587	1241	1405	1387	1341
STD. DEV.	15	19	24	18	30	43	30	51	21	6	23	37
HI TEMP.	1595	1597	1591	1588	1554	1591	1616	1610	1291	1413	1419	1422
LO TEMP.	1558	1537	1527	1533	1462	1464	1515	1461	1224	1394	1353	1314
55 HOUR	6/ 2/79											
AVG. TEMP.	1574	1590	1549	1583	1507	1588	1589	1611	1232	1405	1360	1346
STD. DEV.	14	6	21	4	21	2	5	2	6	7	17	24
HI TEMP.	1591	1599	1580	1587	1534	1590	1596	1615	1245	1415	1393	1395
LO TEMP.	1555	1575	1513	1573	1453	1585	1580	1608	1225	1393	1341	1319
60 HOUR	6/ 2/79											
AVG. TEMP.	1579	1582	1538	1576	1496	1588	1592	1615	1229	1404	1381	1348
STD. DEV.	14	22	20	11	23	4	9	5	8	6	23	25
HI TEMP.	1598	1595	1576	1590	1523	1591	1609	1625	1241	1413	1406	1373
LO TEMP.	1555	1534	1516	1553	1460	1580	1583	1611	1218	1398	1346	1312
65 HOUR	6/ 3/79											
AVG. TEMP.	1578	1593	1538	1583	1501	1590	1586	0	1224	1411	1367	1348
STD. DEV.	13	8	20	7	29	0	5	0	7	7	10	19
HI TEMP.	1590	1600	1570	1590	1530	1590	1590	0	1235	1420	1380	1370
LO TEMP.	1560	1580	1520	1575	1465	1590	1580	0	1220	1400	1355	1320
70 HOUR	6/ 3/79											
AVG. TEMP.	1578	1596	1548	1559	1516	1591	1595	0	1227	1409	1369	1343
STD. DEV.	23	4	22	53	20	2	4	0	12	5	7	17
HI TEMP.	1600	1600	1570	1590	1535	1595	1600	0	1240	1415	1375	1360
LO TEMP.	1550	1590	1520	1465	1490	1590	1590	0	1215	1400	1360	1320

DEGREES FAHRENHEIT

LOCATION	-----ABOVE BED-----		-----IN BED-----				---ABOVE BED---			--IN BED-	
PORT NO.	18	18	7	7	11	11	19	20	20	8	12
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I
5 HOUR	5/29/79										
AVG. TEMP.	1270	1458	1163	1278	1065	1250	1189	1038	1147	994	0
STD. DEV.	8	4	29	14	8	9	24	11	8	12	0
HI TEMP.	1288	1464	1194	1295	1079	1262	1222	1058	1160	1013	0
LO TEMP.	1261	1451	1076	1242	1054	1236	1158	1022	1135	976	0
10 HOUR	5/30/79										
AVG. TEMP.	1252	1434	1148	1259	1057	1250	1179	1001	1142	953	0
STD. DEV.	19	8	14	21	13	12	20	26	9	36	0
HI TEMP.	1288	1451	1169	1297	1074	1270	1215	1059	1155	1028	0
LO TEMP.	1202	1425	1117	1229	1038	1223	1144	966	1126	907	0
15 HOUR	5/30/79										
AVG. TEMP.	1263	1432	1145	1239	1062	1242	1180	993	1159	948	0
STD. DEV.	26	5	15	17	7	17	19	23	11	26	0
HI TEMP.	1286	1439	1166	1268	1073	1271	1217	1036	1179	1002	0
LO TEMP.	1189	1423	1117	1213	1049	1222	1140	957	1137	908	0
20 HOUR	5/30/79										
AVG. TEMP.	1273	1435	1142	1237	1063	1239	1172	997	1159	949	0
STD. DEV.	9	5	15	21	11	12	19	28	9	36	0
HI TEMP.	1283	1446	1161	1283	1078	1257	1214	1053	1173	1037	0
LO TEMP.	1254	1429	1111	1203	1046	1221	1142	961	1140	904	0
25 HOUR	5/30/79										
AVG. TEMP.	1265	1431	1142	1241	1060	1238	1161	995	1157	943	0
STD. DEV.	9	4	24	20	10	9	21	27	8	32	0
HI TEMP.	1278	1439	1183	1286	1072	1257	1184	1066	1170	1026	0
LO TEMP.	1246	1423	1096	1199	1038	1225	1102	949	1145	888	0
30 HOUR	5/30/79										
AVG. TEMP.	1277	1434	1141	1236	1059	1237	1175	1009	1165	942	0
STD. DEV.	7	4	22	14	10	10	13	21	10	25	0
HI TEMP.	1292	1443	1180	1262	1074	1250	1196	1043	1181	985	0
LO TEMP.	1264	1427	1118	1218	1042	1222	1158	975	1149	905	0
35 HOUR	5/31/79										
AVG. TEMP.	1265	1429	1130	1222	1067	1232	1163	985	1159	941	0
STD. DEV.	13	3	18	15	9	9	19	17	5	15	0
HI TEMP.	1281	1434	1156	1248	1081	1247	1199	1023	1170	962	0
LO TEMP.	1239	1425	1105	1193	1050	1210	1139	964	1151	915	0
40 HOUR	5/31/79										
AVG. TEMP.	1268	1432	1140	1240	1065	1233	1161	978	1161	942	0
STD. DEV.	10	3	20	18	7	9	19	15	8	20	0
HI TEMP.	1285	1437	1167	1265	1076	1252	1198	1007	1176	987	0
LO TEMP.	1247	1427	1100	1200	1051	1215	1123	955	1150	910	0
45 HOUR	5/31/79										
AVG. TEMP.	1280	1432	1132	1240	1071	1227	1153	987	1161	950	0
STD. DEV.	8	3	18	17	11	8	22	16	7	13	0
HI TEMP.	1296	1437	1167	1265	1087	1241	1177	1019	1174	970	0
LO TEMP.	1272	1428	1112	1217	1055	1215	1119	974	1151	934	0
50 HOUR	6/ 1/79										
AVG. TEMP.	1294	1411	1143	1240	1050	1218	1145	992	1144	934	0
STD. DEV.	57	26	24	19	17	12	22	16	17	17	0
HI TEMP.	1429	1429	1194	1271	1073	1236	1168	1005	1165	957	0
LO TEMP.	1255	1348	1111	1214	1026	1202	1098	966	1113	909	0
55 HOUR	6/ 2/79										
AVG. TEMP.	1271	1426	1129	1241	1037	1210	1131	980	1152	925	0
STD. DEV.	11	3	8	12	12	9	17	19	11	18	0
HI TEMP.	1287	1430	1140	1261	1055	1225	1151	1017	1173	955	0
LO TEMP.	1251	1420	1113	1222	1015	1196	1105	956	1138	900	0
60 HOUR	6/ 2/79										
AVG. TEMP.	1268	1419	1126	1246	1044	1211	1127	834	982	948	895
STD. DEV.	12	12	11	11	19	11	35	365	433	91	0
HI TEMP.	1290	1428	1148	1263	1070	1232	1172	1000	1165	1152	895
LO TEMP.	1250	1393	1112	1233	1020	1201	1067	9	0	895	895
65 HOUR	6/ 3/79										
AVG. TEMP.	1284	0	1134	1265	1064	1214	0	993	0	0	0
STD. DEV.	8	0	4	17	15	4	0	27	0	0	0
HI TEMP.	1290	0	1140	1290	1090	1220	0	1020	0	0	0
LO TEMP.	1270	0	1130	1250	1055	1210	0	950	0	0	0
70 HOUR	6/ 3/79										
AVG. TEMP.	1287	0	1138	1270	1053	1216	0	992	0	0	0
STD. DEV.	8	0	8	12	4	5	0	14	0	0	0
HI TEMP.	1295	0	1150	1290	1060	1220	0	1010	0	0	0
LO TEMP.	1275	0	1130	1260	1050	1210	0	975	0	0	0

Table C-5 (Cont'd)

Heat Exchanger Probes
Temperature History (Run 106)

LOCATION	----IN BED----				----ABOVE BED----				---IN BED---			---ABOVE BED---
PORT NO.	1	1	3	3	13	13	15	15	2	2	6	14
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
	DEGREES FAHRENHEIT											
75 HOUR	6/ 3/79											
AVG. TEMP.	1594	1597	1567	1587	1531	1591	1597	0	1227	1411	1378	1351
STD. DEV.	5	7	16	7	19	2	3	0	4	3	5	23
HI TEMP.	1600	1605	1580	1595	1555	1595	1600	0	1230	1415	1380	1380
LO TEMP.	1590	1590	1550	1580	1510	1590	1595	0	1220	1410	1370	1330
80 HOUR	6/ 3/79											
AVG. TEMP.	1597	1600	1571	1582	1499	1590	1597	0	1232	1409	1374	1339
STD. DEV.	4	4	12	4	27	0	4	0	8	4	4	22
HI TEMP.	1600	1605	1580	1590	1530	1590	1600	0	1240	1415	1380	1370
LO TEMP.	1590	1595	1555	1580	1470	1590	1590	0	1220	1405	1370	1310
85 HOUR	6/ 4/79											
AVG. TEMP.	1593	1597	1551	1588	1488	1593	1594	0	1234	1408	1380	1335
STD. DEV.	4	4	16	8	19	4	2	0	9	4	0	22
HI TEMP.	1600	1600	1575	1600	1510	1600	1595	0	1240	1415	1380	1360
LO TEMP.	1590	1590	1535	1580	1460	1590	1590	0	1220	1405	1380	1305
90 HOUR	6/ 4/79											
AVG. TEMP.	1587	1593	1554	1590	1500	1590	1596	0	1232	1410	1379	1348
STD. DEV.	16	7	11	4	24	0	2	0	4	4	2	26
HI TEMP.	1600	1600	1570	1595	1540	1590	1600	0	1240	1415	1380	1390
LO TEMP.	1560	1585	1540	1585	1480	1590	1595	0	1230	1405	1375	1325
95 HOUR	6/ 4/79											
AVG. TEMP.	1576	1594	1549	1583	1497	1590	1589	0	1216	1403	1373	1349
STD. DEV.	13	6	19	6	31	1	2	0	8	4	3	26
HI TEMP.	1590	1598	1571	1590	1532	1590	1590	0	1224	1407	1376	1371
LO TEMP.	1564	1587	1537	1579	1475	1589	1587	0	1209	1399	1371	1320
100 HOUR	6/ 4/79											
AVG. TEMP.	1573	1595	1546	1585	1492	1590	1587	1611	1223	1405	1373	1327
STD. DEV.	11	3	21	6	28	2	6	1	5	3	3	15
HI TEMP.	1588	1598	1574	1591	1528	1593	1594	1611	1229	1409	1378	1343
LO TEMP.	1559	1592	1523	1577	1466	1588	1582	1609	1216	1401	1370	1305
105 HOUR	6/ 4/79											
AVG. TEMP.	1577	1595	1555	1589	1482	1588	1586	1606	1223	1407	1373	1354
STD. DEV.	15	5	16	5	13	2	6	2	4	2	2	27
HI TEMP.	1590	1600	1573	1594	1499	1590	1592	1610	1228	1409	1375	1372
LO TEMP.	1556	1589	1542	1583	1469	1586	1580	1605	1218	1404	1371	1314
110 HOUR	6/ 5/79											
AVG. TEMP.	1580	1596	1540	1584	1487	1588	1578	1604	1225	1407	1373	1342
STD. DEV.	12	5	20	4	21	2	5	2	10	5	3	21
HI TEMP.	1594	1601	1575	1590	1527	1592	1587	1607	1241	1416	1378	1366
LO TEMP.	1562	1585	1520	1578	1466	1584	1572	1600	1213	1398	1368	1304
115 HOUR	6/ 5/79											
AVG. TEMP.	1576	1594	1551	1590	1494	1590	1575	1603	1226	1406	1372	1356
STD. DEV.	13	4	17	11	30	2	4	2	7	10	5	17
HI TEMP.	1589	1600	1574	1627	1542	1593	1581	1606	1244	1435	1381	1378
LO TEMP.	1549	1589	1525	1579	1446	1586	1570	1600	1218	1395	1364	1323
120 HOUR	6/ 5/79											
AVG. TEMP.	1575	1588	1535	1570	1495	1586	1573	1601	1218	1399	1374	1344
STD. DEV.	12	28	57	65	37	20	11	12	11	19	4	28
HI TEMP.	1593	1603	1579	1594	1541	1595	1583	1606	1237	1413	1382	1381
LO TEMP.	1557	1489	1338	1335	1377	1515	1536	1558	1189	1336	1368	1308
125 HOUR	6/ 5/79											
AVG. TEMP.	1576	1596	1551	1589	1493	1590	1579	1606	1219	1400	1373	1336
STD. DEV.	9	6	18	5	26	2	4	1	7	5	3	22
HI TEMP.	1587	1604	1577	1598	1531	1594	1584	1609	1230	1406	1378	1371
LO TEMP.	1559	1589	1524	1579	1454	1584	1572	1604	1207	1390	1365	1297
130 HOUR	6/ 6/79											
AVG. TEMP.	1573	1595	1549	1585	1494	1592	1579	1607	1222	1403	1374	1347
STD. DEV.	12	6	19	5	26	2	3	1	16	5	3	16
HI TEMP.	1593	1604	1577	1592	1540	1594	1584	1608	1266	1415	1382	1373
LO TEMP.	1557	1584	1521	1577	1455	1589	1574	1605	1205	1396	1370	1315
135 HOUR	6/ 6/79											
AVG. TEMP.	1576	1597	1548	1587	1498	1591	1579	1608	1225	1403	1372	1334
STD. DEV.	12	4	23	7	27	2	3	2	8	6	3	17
HI TEMP.	1595	1602	1598	1609	1537	1595	1585	1613	1247	1413	1377	1369
LO TEMP.	1556	1588	1519	1580	1455	1586	1574	1604	1214	1393	1368	1309
140 HOUR	6/ 6/79											
AVG. TEMP.	1576	1594	1547	1586	1495	1590	1580	1610	1221	1401	1373	1338
STD. DEV.	17	5	16	4	24	3	4	2	7	6	4	21
HI TEMP.	1611	1602	1578	1593	1535	1596	1589	1613	1236	1412	1380	1379
LO TEMP.	1555	1587	1522	1576	1458	1587	1575	1606	1208	1393	1365	1307

LOCATION	---ABOVE BED---		-----IN BED-----				--ABOVE BED--			--IN BED--	
PORT NO.	18	18	7	7	11	11	19	20	20	8	12
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I
	DEGREES FAHRENHEIT										
75 HOUR	6/ 3/79										
AVG. TEMP.	1271	0	1135	1254	1060	1218	0	981	0	0	0
STD. DEV.	10	0	7	22	6	4	0	5	0	0	0
HI TEMP.	1280	0	1140	1280	1070	1225	0	990	0	0	0
LO TEMP.	1255	0	1125	1220	1055	1215	0	975	0	0	0
80 HOUR	6/ 3/79										
AVG. TEMP.	1286	0	1145	1267	1056	1218	0	994	0	0	0
STD. DEV.	4	0	17	7	11	9	0	18	0	0	0
HI TEMP.	1290	0	1165	1275	1070	1230	0	1010	0	0	0
LO TEMP.	1280	0	1130	1260	1040	1210	0	970	0	0	0
85 HOUR	6/ 4/79										
AVG. TEMP.	1279	0	1141	1261	1060	1215	0	1001	0	0	0
STD. DEV.	7	0	8	11	0	13	0	19	0	0	0
HI TEMP.	1290	0	1155	1280	1060	1235	0	1025	0	0	0
LO TEMP.	1270	0	1135	1250	1060	1200	0	980	0	0	0
90 HOUR	6/ 4/79										
AVG. TEMP.	1275	0	1139	1267	1057	1214	0	993	0	0	0
STD. DEV.	4	0	11	10	8	11	0	16	0	0	0
HI TEMP.	1280	0	1150	1275	1065	1230	0	1020	0	0	0
LO TEMP.	1270	0	1125	1250	1045	1200	0	980	0	0	0
95 HOUR	6/ 4/79										
AVG. TEMP.	1274	0	1120	1262	1049	1213	0	986	0	866	961
STD. DEV.	4	0	9	12	8	9	0	16	0	0	0
HI TEMP.	1277	0	1130	1273	1056	1221	0	1004	0	866	961
LO TEMP.	1270	0	1113	1249	1041	1204	0	975	0	866	961
100 HOUR	6/ 4/79										
AVG. TEMP.	1272	1423	1120	1249	1060	1212	1124	989	1165	896	973
STD. DEV.	10	1	7	12	11	7	20	10	8	11	4
HI TEMP.	1279	1424	1127	1270	1075	1221	1153	999	1173	905	980
LO TEMP.	1254	1422	1108	1239	1049	1203	1103	975	1156	881	969
105 HOUR	6/ 4/79										
AVG. TEMP.	1269	1426	1122	1259	1047	1207	1121	986	1162	884	978
STD. DEV.	5	4	7	8	6	9	32	16	7	11	11
HI TEMP.	1275	1431	1132	1270	1054	1219	1163	1004	1170	900	988
LO TEMP.	1262	1423	1115	1250	1040	1198	1090	968	1153	876	967
110 HOUR	6/ 5/79										
AVG. TEMP.	1263	1424	1119	1261	1050	1203	1114	978	1161	894	974
STD. DEV.	14	3	8	16	12	9	18	16	6	16	6
HI TEMP.	1282	1430	1135	1295	1075	1220	1147	1007	1173	918	985
LO TEMP.	1225	1418	1107	1233	1033	1185	1089	952	1151	866	963
115 HOUR	6/ 5/79										
AVG. TEMP.	1272	1424	1124	1264	1044	1198	1126	987	1165	882	978
STD. DEV.	7	3	13	17	15	14	18	14	7	18	8
HI TEMP.	1281	1428	1147	1289	1072	1216	1153	1009	1173	911	990
LO TEMP.	1259	1415	1102	1226	1024	1161	1098	962	1150	854	962
120 HOUR	6/ 5/79										
AVG. TEMP.	1268	1425	1096	1236	1037	1195	1114	989	1170	891	974
STD. DEV.	13	3	56	36	24	18	25	35	15	13	11
HI TEMP.	1287	1431	1134	1283	1067	1214	1164	1035	1197	922	998
LO TEMP.	1236	1420	898	1123	960	1140	1065	890	1154	872	961
125 HOUR	6/ 5/79										
AVG. TEMP.	1266	1423	1103	1245	1051	1204	1142	1028	1197	890	980
STD. DEV.	11	4	9	8	10	9	17	19	8	14	8
HI TEMP.	1285	1433	1122	1258	1065	1216	1169	1061	1211	914	992
LO TEMP.	1245	1418	1089	1228	1038	1185	1112	999	1185	867	967
130 HOUR	6/ 6/79										
AVG. TEMP.	1267	1422	1118	1250	1048	1206	1138	1034	1197	893	977
STD. DEV.	6	4	11	13	11	8	14	19	7	14	11
HI TEMP.	1278	1429	1140	1270	1063	1219	1161	1059	1214	922	994
LO TEMP.	1254	1416	1100	1221	1029	1192	1119	1006	1187	874	958
135 HOUR	6/ 6/79										
AVG. TEMP.	1268	1424	1107	1248	1051	1205	1135	1027	1198	887	975
STD. DEV.	6	3	10	12	9	7	21	16	6	14	12
HI TEMP.	1275	1428	1126	1267	1070	1221	1172	1063	1215	907	1013
LO TEMP.	1258	1420	1088	1226	1039	1196	1106	1010	1189	868	961
140 HOUR	6/ 6/79										
AVG. TEMP.	1266	1423	1118	1252	1048	1201	1152	1020	1195	892	973
STD. DEV.	11	3	13	8	13	7	18	17	9	19	8
HI TEMP.	1286	1427	1139	1269	1071	1211	1180	1046	1210	914	993
LO TEMP.	1252	1419	1098	1237	1032	1190	1117	996	1180	851	962

Table C-5 (Cont'd)

Heat Exchanger Rrobes
Temperature History (Run 106)

LOCATION	IN BED				ABOVE BED				IN BED			ABOVE BED
PORT NO.	1	1	3	3	13	13	15	15	2	2	6	14
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
	DEGREES FAHRENHEIT											
145 HOUR	6/ 6/79											
AVG. TEMP.	1573	1595	1547	1588	1501	1592	1585	1613	1223	1401	1373	1330
STD. DEV.	10	5	20	7	22	5	4	2	11	5	4	25
HI TEMP.	1594	1603	1577	1598	1530	1609	1591	1617	1242	1413	1380	1368
LO TEMP.	1561	1585	1521	1577	1456	1588	1579	1609	1208	1395	1364	1289
150 HOUR	6/ 6/79											
AVG. TEMP.	1578	1594	1545	1593	1495	1590	1589	1614	1227	1403	1373	1335
STD. DEV.	12	4	24	8	23	1	5	2	7	5	5	20
HI TEMP.	1593	1602	1581	1607	1542	1592	1598	1618	1240	1415	1387	1367
LO TEMP.	1555	1583	1515	1579	1460	1588	1582	1612	1214	1395	1363	1307
155 HOUR	6/ 7/79											
AVG. TEMP.	1579	1595	1534	1588	1500	1591	1594	1619	1222	1401	1373	1335
STD. DEV.	9	4	18	5	22	2	6	4	9	6	2	19
HI TEMP.	1591	1601	1571	1596	1525	1595	1602	1630	1243	1410	1377	1366
LO TEMP.	1561	1588	1510	1582	1447	1589	1582	1616	1208	1391	1370	1295
160 HOUR	6/ 7/79											
AVG. TEMP.	1575	1593	1551	1588	1484	1589	1597	1621	1220	1399	1373	1344
STD. DEV.	12	6	24	5	30	3	5	3	10	6	2	20
HI TEMP.	1591	1602	1585	1597	1538	1594	1603	1625	1236	1410	1376	1379
LO TEMP.	1558	1579	1509	1577	1443	1585	1590	1615	1197	1391	1369	1306
165 HOUR	6/ 7/79											
AVG. TEMP.	1571	1593	1537	1587	1493	1591	1598	1621	1221	1393	1374	1324
STD. DEV.	12	5	21	5	19	2	27	21	7	21	4	25
HI TEMP.	1587	1605	1567	1597	1517	1594	1654	1654	1235	1409	1378	1372
LO TEMP.	1547	1584	1506	1582	1456	1587	1547	1584	1211	1323	1366	1285
170 HOUR	6/ 7/79											
AVG. TEMP.	1576	1596	1555	1588	1493	1590	1552	1585	1223	1400	1372	1334
STD. DEV.	10	4	15	5	27	2	4	2	9	5	3	18
HI TEMP.	1592	1603	1574	1594	1533	1594	1559	1588	1243	1409	1379	1369
LO TEMP.	1556	1591	1518	1578	1454	1587	1546	1581	1209	1389	1368	1295
175 HOUR	6/ 7/79											
AVG. TEMP.	1568	1590	1548	1590	1507	1584	1559	1583	1230	1401	1373	1341
STD. DEV.	14	10	24	10	36	16	8	18	15	6	5	26
HI TEMP.	1596	1600	1594	1599	1598	1592	1584	1594	1265	1410	1387	1400
LO TEMP.	1554	1559	1512	1557	1448	1530	1550	1524	1209	1390	1366	1309
180 HOUR	6/ 8/79											
AVG. TEMP.	1572	1592	1534	1592	1496	1592	1561	1592	1221	1404	1374	1334
STD. DEV.	15	6	15	4	22	2	4	2	7	6	4	25
HI TEMP.	1587	1603	1556	1599	1541	1597	1568	1597	1235	1414	1381	1371
LO TEMP.	1541	1581	1512	1585	1461	1588	1555	1588	1212	1394	1369	1295
185 HOUR	6/ 8/79											
AVG. TEMP.	1567	1595	1535	1591	1481	1590	1561	1593	1226	1402	1374	1338
STD. DEV.	11	4	14	6	26	2	4	3	11	6	3	21
HI TEMP.	1584	1600	1564	1601	1521	1596	1571	1599	1239	1413	1378	1370
LO TEMP.	1553	1588	1518	1583	1437	1586	1555	1588	1200	1391	1367	1300
190 HOUR	6/ 8/79											
AVG. TEMP.	1567	1592	1541	1591	1488	1592	1562	1594	1223	1402	1374	1344
STD. DEV.	10	5	17	3	28	2	5	2	9	6	3	25
HI TEMP.	1584	1604	1564	1595	1541	1595	1568	1598	1238	1410	1379	1380
LO TEMP.	1555	1583	1510	1587	1443	1588	1556	1590	1204	1387	1370	1301
195 HOUR	6/ 8/79											
AVG. TEMP.	1569	1592	1542	1590	1480	1591	1561	1594	1224	1404	1375	1344
STD. DEV.	10	7	17	3	31	2	4	3	10	5	5	25
HI TEMP.	1583	1602	1569	1597	1530	1595	1569	1598	1245	1414	1382	1377
LO TEMP.	1555	1579	1523	1585	1435	1587	1554	1591	1206	1392	1368	1304
200 HOUR	6/ 8/79											
AVG. TEMP.	1575	1594	1539	1590	1481	1591	1562	1594	1222	1405	1375	1352
STD. DEV.	12	7	15	5	26	3	5	2	5	6	3	23
HI TEMP.	1592	1603	1568	1600	1520	1599	1568	1598	1231	1418	1381	1393
LO TEMP.	1548	1579	1521	1584	1444	1587	1553	1591	1213	1397	1370	1326
205 HOUR	6/ 9/79											
AVG. TEMP.	1570	1592	1547	1590	1482	1591	1559	1594	1224	1405	1373	1348
STD. DEV.	12	6	21	8	21	2	5	2	7	4	2	18
HI TEMP.	1586	1601	1573	1617	1521	1595	1568	1598	1235	1410	1378	1382
LO TEMP.	1550	1582	1516	1583	1451	1589	1553	1592	1215	1400	1371	1311
210 HOUR	6/ 9/79											
AVG. TEMP.	1570	1596	1537	1586	1494	1592	1560	1593	1221	1403	1373	1346
STD. DEV.	12	4	17	3	31	2	4	2	8	5	3	23
HI TEMP.	1588	1601	1566	1592	1545	1596	1566	1597	1233	1410	1378	1380
LO TEMP.	1551	1588	1512	1582	1454	1587	1553	1589	1201	1391	1367	1311

LOCATION	ABOVE BED		IN BED				ABOVE BED			IN BED	
PORT NO.	18	18	7	7	11	11	19	20	20	8	12
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I
	DEGREES FAHRENHEIT										
145 HOUR	6/ 6/79										
AVG. TEMP.	1264	1421	1098	1240	1057	1210	1144	1025	1197	893	981
STD. DEV.	7	4	11	21	10	8	19	19	7	11	9
HI TEMP.	1272	1429	1119	1266	1072	1226	1182	1056	1207	908	997
LO TEMP.	1250	1417	1084	1208	1035	1197	1117	998	1181	873	965
150 HOUR	6/ 6/79										
AVG. TEMP.	1272	1424	1100	1238	1047	1202	1147	1040	1196	888	982
STD. DEV.	9	3	10	11	11	8	17	14	6	18	7
HI TEMP.	1293	1428	1114	1255	1067	1215	1173	1064	1209	920	993
LO TEMP.	1257	1417	1084	1213	1032	1184	1115	1018	1187	851	969
155 HOUR	6/ 7/79										
AVG. TEMP.	1249	1422	1103	1240	1048	1204	1136	1028	1194	886	982
STD. DEV.	28	4	10	15	10	12	17	19	8	12	8
HI TEMP.	1276	1427	1118	1268	1066	1229	1164	1059	1208	903	1001
LO TEMP.	1196	1414	1083	1216	1025	1176	1111	1001	1180	863	969
160 HOUR	6/ 7/79										
AVG. TEMP.	1238	1422	1099	1225	1047	1205	1129	1029	1196	897	980
STD. DEV.	43	3	10	19	12	8	17	16	7	15	7
HI TEMP.	1282	1428	1115	1261	1075	1220	1156	1054	1210	923	992
LO TEMP.	1116	1417	1077	1183	1024	1195	1102	1005	1186	868	969
165 HOUR	6/ 7/79										
AVG. TEMP.	1252	1422	1104	1233	1048	1207	1140	1025	1190	894	981
STD. DEV.	30	3	9	16	14	7	14	21	7	18	10
HI TEMP.	1281	1427	1121	1266	1069	1216	1166	1064	1202	916	997
LO TEMP.	1174	1415	1093	1204	1024	1195	1113	990	1180	857	964
170 HOUR	6/ 7/79										
AVG. TEMP.	1243	1423	1102	1238	1046	1205	1132	1033	1194	902	979
STD. DEV.	56	4	14	16	9	8	17	20	7	16	9
HI TEMP.	1279	1428	1140	1267	1067	1219	1164	1059	1206	925	992
LO TEMP.	1051	1411	1086	1212	1035	1188	1106	1006	1181	873	956
175 HOUR	6/ 7/79										
AVG. TEMP.	1261	1424	1117	1240	1046	1199	1144	1041	1194	898	984
STD. DEV.	41	5	13	10	9	24	20	20	8	14	11
HI TEMP.	1311	1434	1148	1258	1063	1219	1173	1083	1206	920	1005
LO TEMP.	1136	1415	1094	1221	1035	1117	1106	1015	1179	875	968
180 HOUR	6/ 8/79										
AVG. TEMP.	1260	1425	1117	1233	1057	1207	1150	1034	1196	898	980
STD. DEV.	27	3	12	21	11	8	20	16	8	18	5
HI TEMP.	1289	1429	1142	1279	1075	1215	1179	1063	1210	923	989
LO TEMP.	1185	1420	1095	1198	1039	1181	1118	1011	1183	870	971
185 HOUR	6/ 8/79										
AVG. TEMP.	1256	1423	1116	1235	1049	1208	1143	1031	1192	889	1577
STD. DEV.	31	3	13	16	14	11	19	18	9	15	2296
HI TEMP.	1298	1429	1135	1256	1083	1234	1178	1060	1210	916	9877
LO TEMP.	1192	1419	1098	1199	1025	1188	1114	1006	1179	866	964
190 HOUR	6/ 8/79										
AVG. TEMP.	1289	1435	1118	1241	1056	1206	1155	1031	1195	890	985
STD. DEV.	19	6	11	17	10	10	19	14	8	12	11
HI TEMP.	1307	1443	1145	1277	1069	1225	1189	1053	1212	909	1005
LO TEMP.	1247	1427	1098	1210	1033	1186	1128	1014	1182	864	968
195 HOUR	6/ 8/79										
AVG. TEMP.	1283	1438	1119	1242	1054	1206	1208	1038	1199	892	988
STD. DEV.	36	5	9	12	11	5	23	19	8	12	8
HI TEMP.	1311	1445	1136	1259	1071	1214	1239	1069	1211	910	1006
LO TEMP.	1173	1429	1105	1221	1036	1198	1160	1006	1185	872	977
200 HOUR	6/ 8/79										
AVG. TEMP.	1291	1432	1118	1242	1053	1206	1192	1043	1198	890	986
STD. DEV.	16	13	10	12	12	9	21	14	12	17	8
HI TEMP.	1306	1453	1144	1262	1072	1219	1224	1063	1221	924	998
LO TEMP.	1239	1407	1104	1223	1022	1191	1145	1017	1180	862	966
205 HOUR	6/ 9/79										
AVG. TEMP.	1301	1409	1111	1248	1056	1211	1196	1037	1196	896	989
STD. DEV.	22	4	9	17	16	9	19	16	9	11	11
HI TEMP.	1327	1416	1125	1286	1072	1232	1225	1062	1213	915	1013
LO TEMP.	1262	1402	1097	1222	1021	1197	1164	1011	1181	874	970
210 HOUR	6/ 9/79										
AVG. TEMP.	1288	1426	1109	1239	1050	1202	1197	1040	1197	842	989
STD. DEV.	47	7	12	16	14	12	15	17	10	16	7
HI TEMP.	1363	1438	1128	1266	1072	1219	1218	1069	1215	869	1002
LO TEMP.	1185	1413	1089	1211	1034	1172	1175	1015	1183	815	977

Table C-5 (Cont'd)

Heat Exchanger Probes
Temperature History (Run 106)

DEGREES FAHRENHEIT

LOCATION	IN BED				ABOVE BED				IN BED			ABOVE BED
PORT NO.	1	1	3	3	13	13	15	15	2	2	6	14
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H	X
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I	O
215 HOUR	6/ 9/79											
AVG. TEMP.	1575	1595	1542	1592	1491	1592	1559	1595	1221	1407	1375	1353
STD. DEV.	10	8	17	7	23	2	2	2	9	5	3	15
HI TEMP.	1594	1609	1570	1614	1529	1595	1563	1598	1235	1414	1380	1380
LO TEMP.	1560	1579	1518	1584	1450	1588	1555	1592	1206	1399	1369	1320
220 HOUR	6/ 9/79											
AVG. TEMP.	1569	1592	1539	1589	1486	1591	1562	1595	1222	1404	1375	1345
STD. DEV.	13	7	22	3	18	3	5	1	7	6	3	19
HI TEMP.	1587	1606	1594	1596	1530	1595	1568	1597	1232	1413	1382	1373
LO TEMP.	1544	1580	1510	1583	1462	1587	1554	1593	1206	1395	1370	1304
225 HOUR	6/ 9/79											
AVG. TEMP.	1569	1595	1544	1587	1482	1592	1558	1594	1224	1407	1374	1357
STD. DEV.	14	6	18	4	24	4	4	2	9	5	3	17
HI TEMP.	1595	1602	1567	1594	1514	1602	1566	1598	1236	1417	1382	1378
LO TEMP.	1546	1580	1515	1580	1455	1587	1553	1591	1210	1400	1370	1318
230 HOUR	6/10/79											
AVG. TEMP.	1568	1595	1548	1589	1475	1591	1560	1594	1224	1405	1374	1354
STD. DEV.	12	4	17	3	24	2	5	2	8	6	3	24
HI TEMP.	1587	1601	1569	1595	1516	1593	1568	1598	1235	1415	1380	1388
LO TEMP.	1547	1589	1511	1583	1445	1586	1552	1591	1212	1395	1369	1313
235 HOUR	6/10/79											
AVG. TEMP.	1571	1595	1537	1593	1486	1591	1559	1595	1225	1406	1374	1360
STD. DEV.	11	7	16	9	25	2	7	3	7	6	3	18
HI TEMP.	1588	1605	1561	1613	1520	1596	1576	1599	1240	1416	1382	1386
LO TEMP.	1553	1583	1509	1583	1452	1588	1552	1590	1216	1394	1371	1330
240 HOUR	6/10/79											
AVG. TEMP.	1564	1593	1515	1614	1480	1591	1559	1594	1224	1406	1374	1339
STD. DEV.	11	4	9	4	19	2	4	2	10	5	3	18
HI TEMP.	1583	1601	1530	1619	1524	1594	1567	1598	1250	1418	1379	1384
LO TEMP.	1551	1588	1499	1606	1452	1588	1551	1591	1209	1396	1368	1316
245 HOUR	6/10/79											
AVG. TEMP.	1570	1597	1513	1613	1485	1591	1557	1592	1221	1407	1375	1345
STD. DEV.	12	3	8	3	24	2	4	2	6	9	3	25
HI TEMP.	1590	1602	1528	1617	1528	1596	1563	1596	1231	1431	1382	1378
LO TEMP.	1555	1593	1499	1604	1457	1588	1550	1590	1209	1394	1369	1308
250 HOUR	6/10/79											
AVG. TEMP.	1572	1597	1512	1613	1481	1590	1560	1593	1220	1405	1374	1339
STD. DEV.	9	4	8	4	17	1	3	2	6	5	3	21
HI TEMP.	1579	1601	1521	1617	1497	1590	1563	1595	1229	1410	1379	1353
LO TEMP.	1559	1594	1502	1609	1458	1589	1556	1591	1211	1399	1371	1308

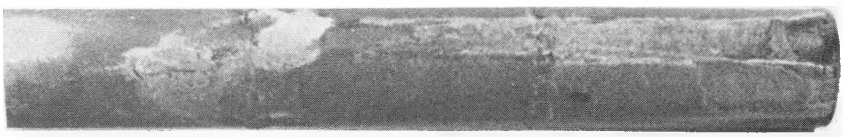
DEGREES FAHRENHEIT

LOCATION	ABOVE BED		IN BED				ABOVE BED			IN BED	
PORT NO.	18	18	7	7	11	11	19	20	20	8	12
SPEC. MAT.	X	H	H	X	H	X	X	H	H	X	H
SPEC. LOC.	I	O	I	O	I	O	I	O	I	O	I
215 HOUR	6/ 9/79										
AVG. TEMP.	1312	1441	1112	1250	1048	1204	1201	1039	1198	837	986
STD. DEV.	69	19	14	15	13	7	18	11	5	15	6
HI TEMP.	1441	1500	1129	1286	1067	1215	1231	1058	1205	859	1000
LO TEMP.	1169	1418	1081	1231	1025	1189	1177	1020	1187	808	978
220 HOUR	6/ 9/79										
AVG. TEMP.	1343	1430	1116	1247	1052	1211	1212	1042	1201	840	986
STD. DEV.	41	27	13	17	11	5	17	13	10	16	8
HI TEMP.	1464	1507	1137	1272	1069	1218	1232	1063	1216	863	999
LO TEMP.	1292	1401	1092	1216	1033	1203	1180	1024	1183	802	969
225 HOUR	6/ 9/79										
AVG. TEMP.	1316	1407	1124	1247	1048	1210	1199	1046	1201	837	995
STD. DEV.	45	32	9	11	11	10	19	18	7	16	7
HI TEMP.	1438	1488	1145	1267	1065	1227	1232	1074	1213	869	1007
LO TEMP.	1259	1359	1111	1232	1030	1188	1173	1020	1190	803	983
230 HOUR	6/10/79										
AVG. TEMP.	1214	860	1126	1245	1055	1209	1197	1041	1196	837	987
STD. DEV.	146	211	14	12	12	9	19	16	7	18	6
HI TEMP.	1312	1426	1161	1258	1069	1226	1230	1063	1210	874	1002
LO TEMP.	705	383	1105	1223	1035	1196	1178	1019	1187	812	976
235 HOUR	6/10/79										
AVG. TEMP.	1249	966	1120	1247	1047	1205	1202	1039	1194	834	988
STD. DEV.	17	120	12	18	10	5	16	18	7	22	8
HI TEMP.	1264	1150	1146	1276	1066	1212	1239	1066	1208	877	1002
LO TEMP.	1210	776	1100	1208	1030	1195	1181	1014	1147	797	976
240 HOUR	6/10/79										
AVG. TEMP.	1211	1066	1117	1246	1049	1204	1207	1041	1192	822	988
STD. DEV.	56	44	9	14	12	10	13	17	9	18	10
HI TEMP.	1257	1165	1135	1270	1067	1218	1228	1064	1216	853	1003
LO TEMP.	1024	986	1105	1216	1029	1185	1187	1017	1178	796	971
245 HOUR	6/10/79										
AVG. TEMP.	1209	865	1120	1245	1045	1204	1204	1042	1196	822	987
STD. DEV.	100	93	16	11	10	7	17	17	11	16	5
HI TEMP.	1267	1056	1163	1266	1062	1213	1236	1070	1220	845	997
LO TEMP.	870	765	1100	1226	1029	1191	1178	1022	1183	782	976
250 HOUR	6/10/79										
AVG. TEMP.	1225	805	1119	1247	1049	1206	1218	1038	1192	824	990
STD. DEV.	21	86	15	13	19	21	4	11	5	11	11
HI TEMP.	1256	901	1134	1259	1071	1228	1222	1046	1199	838	998
LO TEMP.	1211	728	1099	1230	1026	1179	1213	1024	1187	913	974

Figure C-1

Hot Corrosion Heat Exchanger Probes After 1117 Hours

1600°F Above Bed



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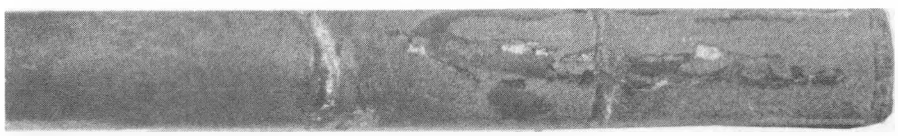
Port No. 15



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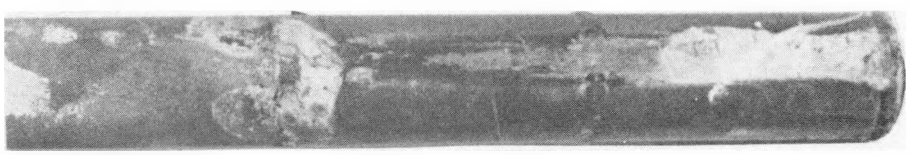

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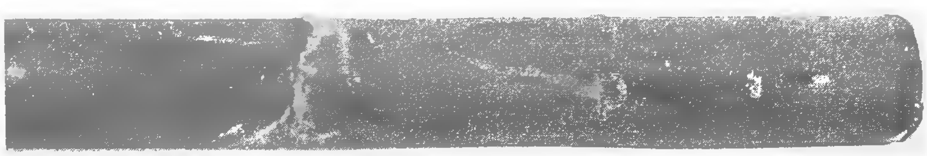
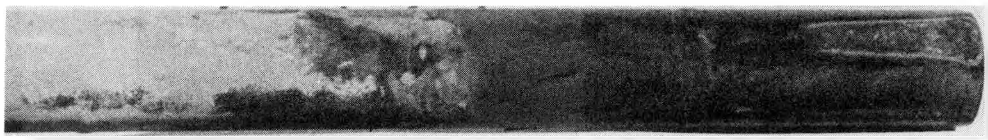


Bottom

Figure C-2

Hot Corrosion Heat Exchanger Probes After 1117 Hours

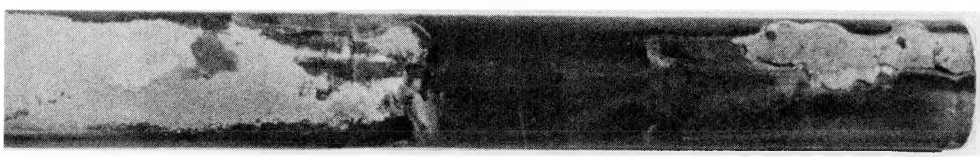
1400°F Above Bed



Top

Port No. 18

Bottom



Top

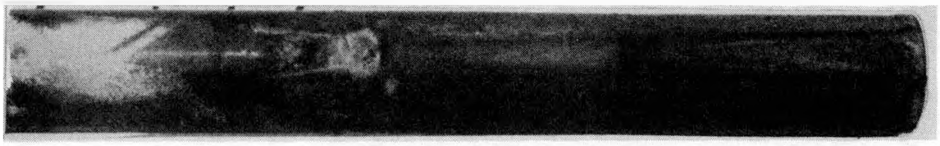
Port No. 14

Bottom

Figure C-3

Hot Corrosion Heat Exchanger Probes After 1117 Hours

1200°F Above Bed



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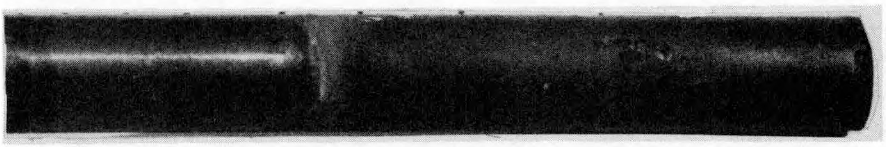
Port No. 20



Bottom

Top

Port No. 19

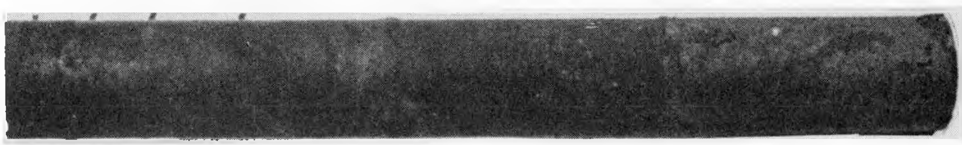
Bottom

Figure C-4

Hot Corrosion Heat Exchanger Probes After 1117 Hours
1600°F In Bed

Top

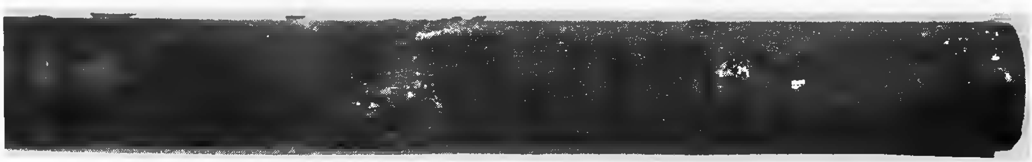
Port No. 3



Bottom

Top

Port No. 1

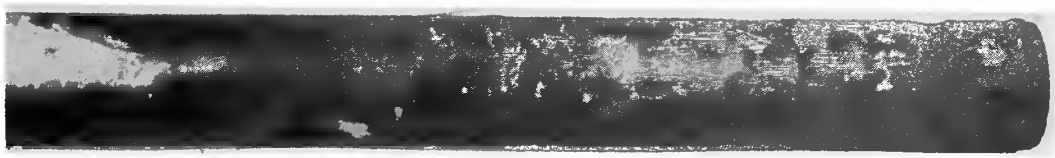


Bottom

Figure C-5

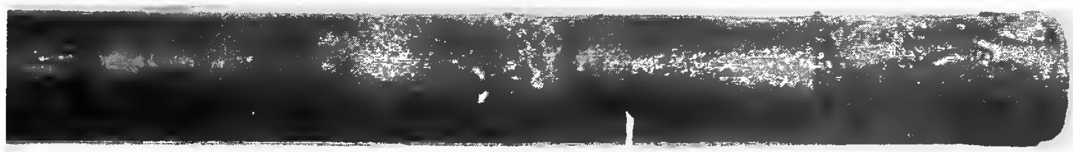
Hot Corrosion Heat Exchanger Probes After 1117 Hours

1400°F In Bed



Top

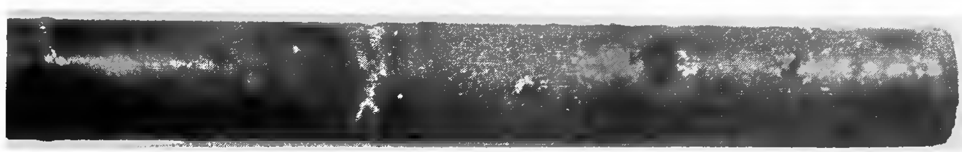
Port No. 6



Bottom

Top

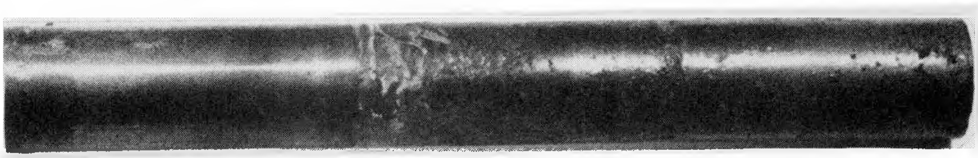
Port No. 2



Bottom

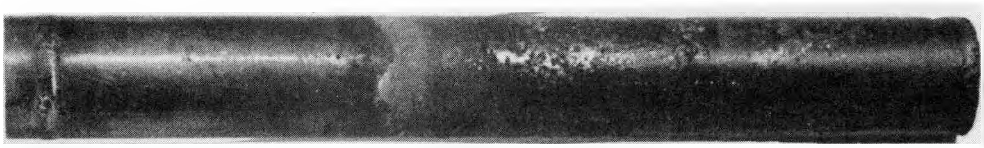
Figure C-6

Hot Corrosion Heat Exchanger Probes After 1117 Hours
1200°F In Bed



Top

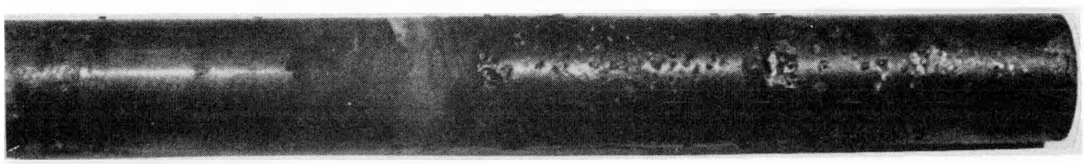
Probe No. 11



Bottom

Top

Probe No. 7

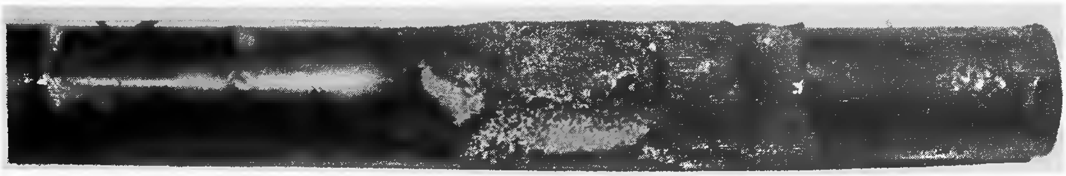


Bottom

Figure C-7

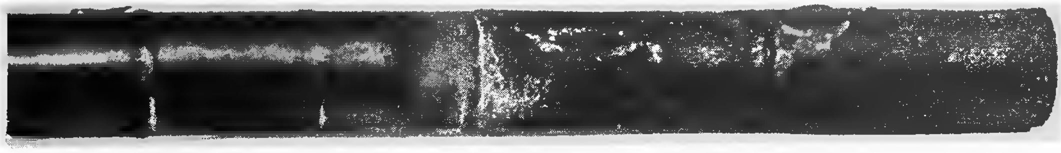
Hot Corrosion Heat Exchanger Probes After 1117 Hours

1050°F In Bed



Top

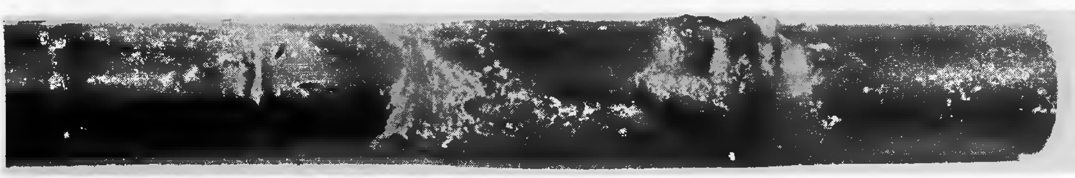
Probe No. 12



Bottom

Top

Probe No. 8

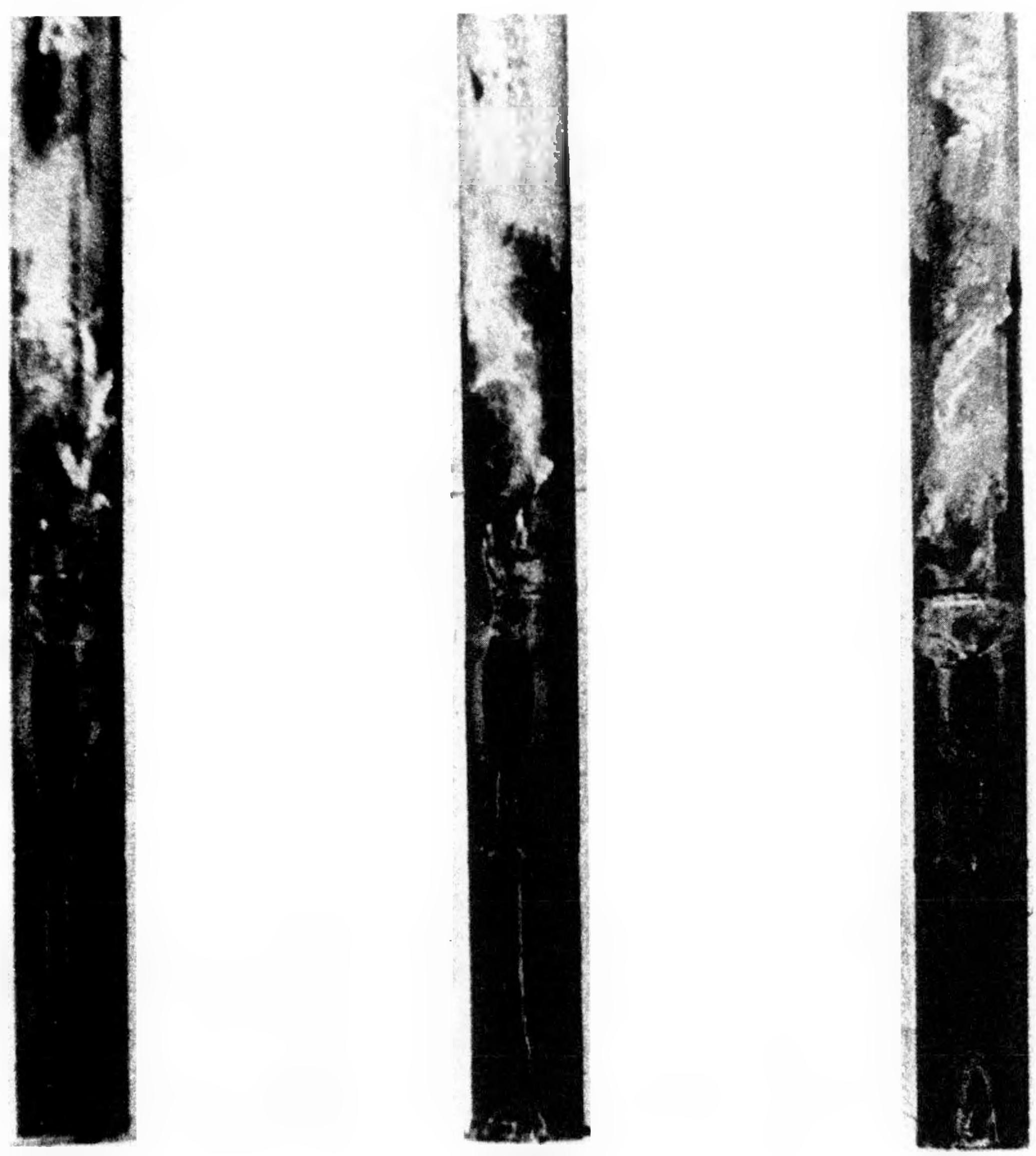


Bottom

Figure C-8

Hot Corrosion Heat Exchanger Probes After 682 Hours

1200°F Above Bed (Bottom Side View)



Probe No. 19 Probe No. 20 Probe No. 22

Figure C-9

Hot Corrosion Heat Exchanger Probes After 682 Hours

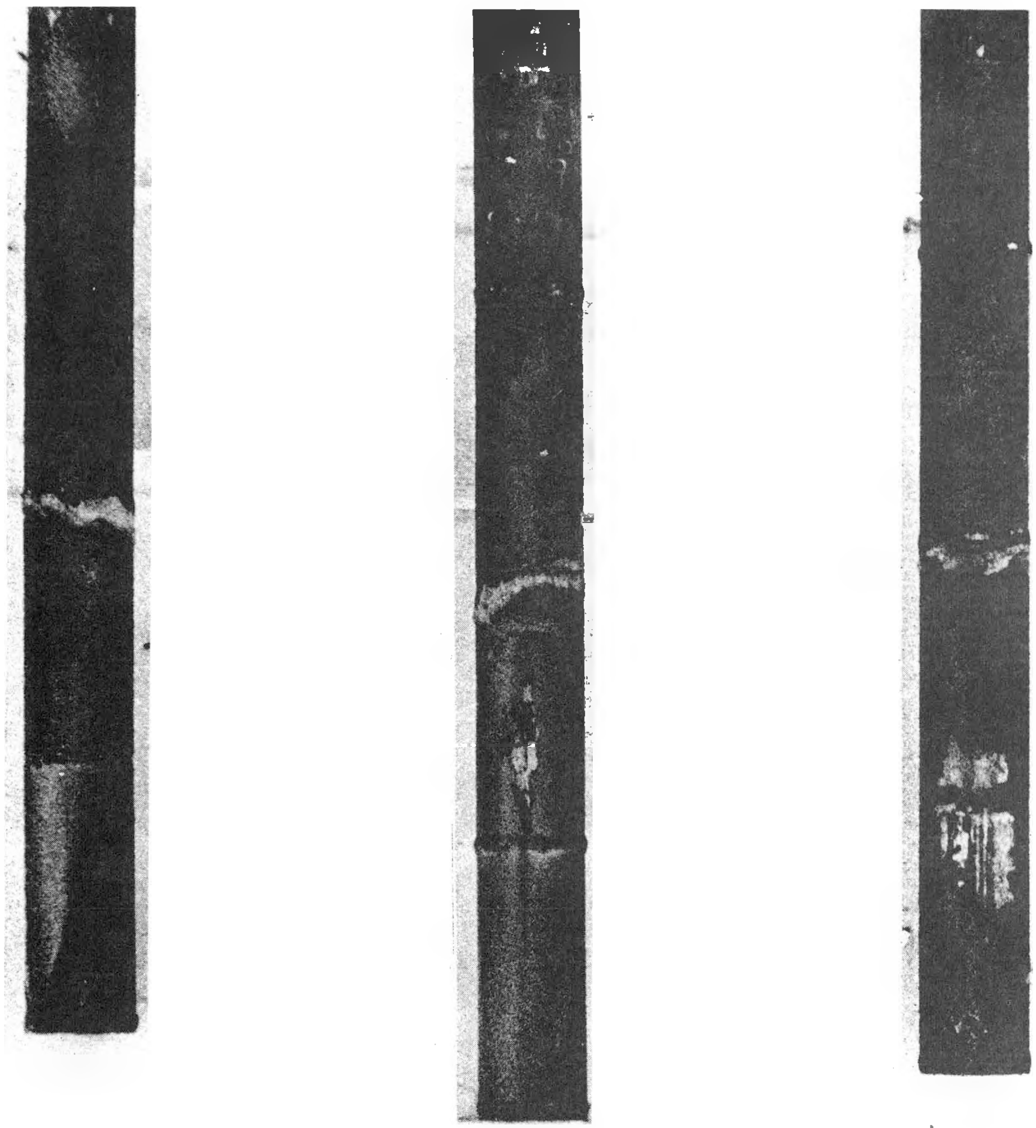
1400°F Above Bed (Top Side View)

Probe No. 14 Probe No. 16 Probe No. 18

Figure C-10

Hot Corrosion Heat Exchanger Probes After 682 Hours

1600°F Above Bed (Top Side View)

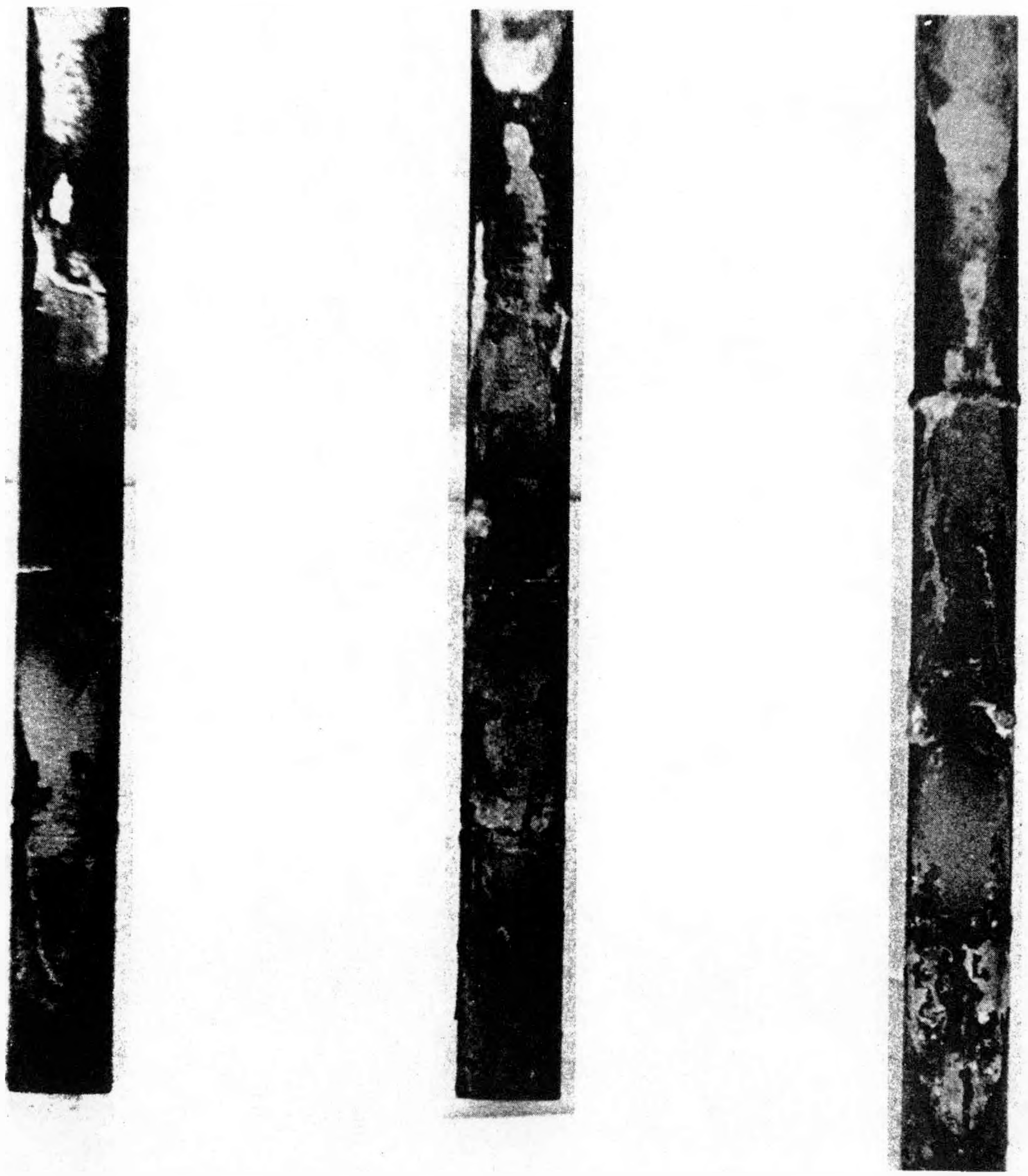


Probe No. 13 | Probe No. 15 | Probe No. 17

Figure C-11

Hot Corrosion Heat Exchanger Probes After 682 Hours

1600°F in Bed (Bottom Side View)

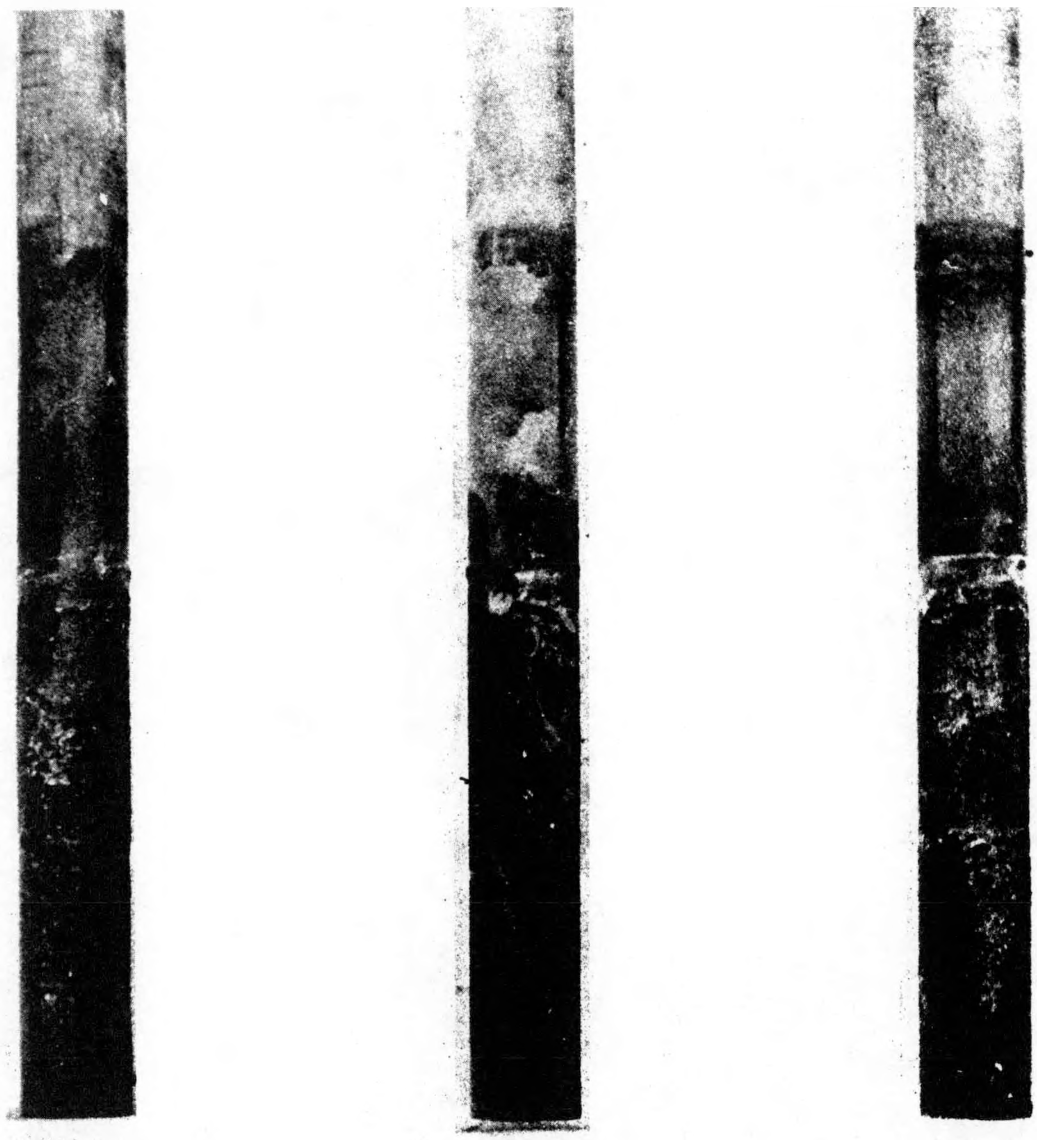


Probe No. 1 Probe No. 3 Probe No. 5

Figure C-12

Hot Corrosion Heat Exchanger Probes After 682 Hours

1200°F In Bed (Top Side View)

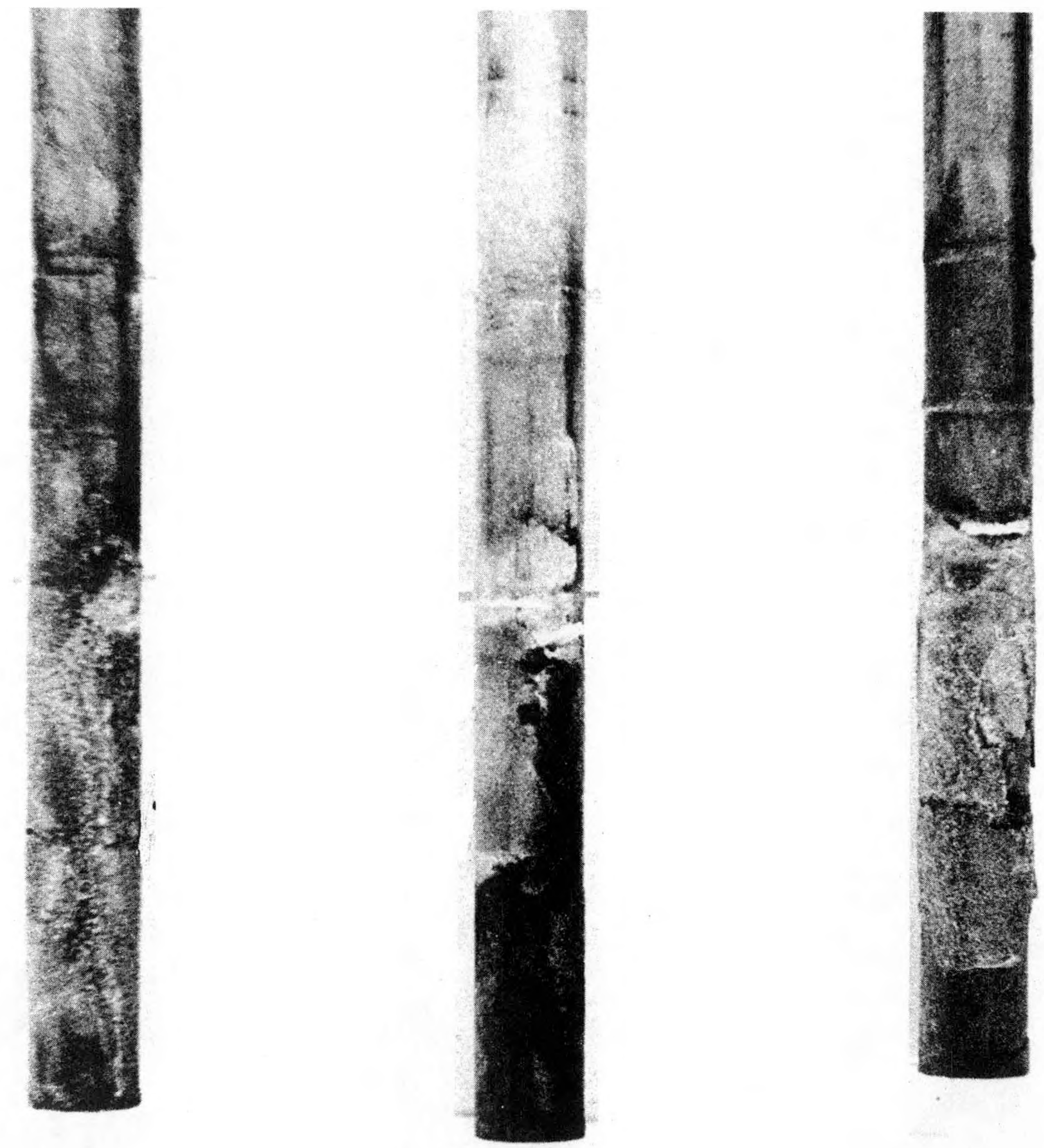


Probe No. 7 Probe No. 9 Probe No. 11

Figure C-13

Hot Corrosion Heat Exchanger Probes After 682 Hours

1050°F In Bed (Top Side View)



Probe No. 8 Probe No. 12 Probe No. 10

Figure C-14

Hot Corrosion Heat Exchanger Probes After 682 Hours

1400°F In Bed (Top Side View)

Probe No. 2 Probe No. 4 Probe No. 6

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