JAERI-M

8968

EXPERIMENT DATA OF ROSA-Ⅲ TEST RUN 704

(STANDARD TEST WITH ECCS ACTUATION)

July 1980

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(Received June 27, 1980)

Run 704 in the ROSA-III program is the forth test of standard BWR LOCA test series, simulating a double-ended break in the recirculation pump inlet side with the whole emergency core cooling system (ECCS) activation. The test conditions were the same as those specified except a 2 sec delay in the two breaks. The purpose of Run 704 were to provide data to evaluate ECCS behavior during LOCE operation to assess the system computer code. Therefore, the ROSA-III facility was configured to simulate a large (~1000 MWe) BWR LOCA resulting from a 200 % double-ended ofset shear break on the inlet side of the pump in a recirculation loop. The primary initial conditions are stam dome pressure 7.04 MPa, steam dome temperature 560 K, lower plenum subcooling 14 K, and core inlet flow 35.7 kg/s. The data from Run 704 are presented; the experiment achieved the above purposes successfully.

keywords: BWR, LOCA, ROSA-III Facility, Data Report, Double-Ended Break, Recirculation Loop, Reactor Safety, ECCS

ROSA-Ⅲ実験データレポート：RUN 704
（ECCS作動の標準実験）

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（1980年6月27日受理）

ROSA-Ⅲ実験RUN704は，標準BWR LOCA実験シリーズの4回目の実験であり，再循環ポンプ吸込側配管の両端破断を模擬し，緊急炉心冷却系をすべて作動させた標準ケースである。ポンプ側と圧力容器側の破断時期に2秒のずれがあったものの，他の実験条件は予定通りであった。RUN704の目的は，LOCA時のECCS作動特性及び冷却材挙動を評価することと，解析コード評価のための総合実験データを提供することにある。そのため，ROSA-Ⅲ装置は，1000MWe規模の大型BWRの再循環ポンプ入口配管の200%両端破断にともなうLOCAを模擬する構成となっている。主要な初期条件は，蒸気ドーム圧力7.04 MPa，同温度560K，下部プレナム未飽和度14K，炉心入口流量35.7 kg/s 等である。実験目的はすべて達成され実験は成功であった。本稿にはその実験データが示されている。

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ABBREVIATIONS

Systemes

ROSA	Rig of Safety Assessment
BWR	Boiling Water Reactor
LBWR	Large Boiling Water Reactor
ECCS	Emergency Core Cooling System
HPCS	High Pressure Core Spray
LPCS	Low Pressure Core Spray
LPCI	Low Pressure Coolant Injection
ADS	Automatic Depressurization System

Vessels

PV	Pressure Vessel
PWT	Pure Water Tank
FWT	Feed Water Tank
AT	Air Tank
CWT	Cooling Water Tank
HPCST	High Pressure Core Spray Tank
LPCST	Low Pressure Core Spray Tank
LPCIT	Low Pressure Core Injection Tank
POOL	Pool

Pumps

JP	Jet Pump
MRP	Main Recirculation Pump
HPWP	High Pressure Water Pump
WSP	Water Supply Pump
FWP	Feed Water Pump
HPCSP	High Pressure Core Spray Pump
LPCSP	Low Pressure Core Spray Pump
LPCIP	Low Pressure Core Injection Pump

Piping

V	Valve
AV	Air actuation Valve
CV	Control Valve
CHV	Check Valve
QSV	Quick Shut-off Valve
OR	Orifice
RD	Rupture Disk
RCN	Rapid Condencer
(2)B	(2) inchs pipe of Schedule 80
DL(+100)	Elevation (+100 mm) from the bottom of PV

Measurements

P	Pressure
D	Differential Pressure
F	Flow Rate
T	Temperature
TS	Temperature of Solid
TF	Temperature of Fuel
L	Liquid Level
LB	Liquid Level in Channel Box
LL	Liquid Level in the Lower Plenum
S	Signal
W	Power
N	Rotation Speed
DF	Density of Fluid
M	Momentum Flux

Units

K	Kelvin
kg	Kilogram
ℓ	Liter
m	Meter
mm	Milimeter
MPa	Megapascal
rpm	Revolution per Minute
s	Second
W	Watt

Miscellaneous

ESF	Engineered Safety Features
LOCA	Loss-of-Coolant Accident
LOCE	Loss-of-Coolant Experiment
MLHR	Maximum Linear Heat Rate

1. INTRODUCTION

The ROSA (Rig of Safety Assessment)-III Program is one of several water reactor research test programs conducted by JAERI (Japan Atomic Energy Research Institute).

The ROSA-III facility is a volumetrically scaled (1/424) boiling water reactor (BWR) system with electrically heated core designed to study the response of the engineered safety features (ESF) in commercial BWR systems during the postulated loss-of-coolant accident (LOCA). With recognition of the differences in commercial BWR designs and inherent distortions in reduced scale systems, the design objective for the ROSA-III facility was to produce the significant thermal-hydraulic phenomena that would occur in commercial BWR systems in the same sequence and with approximately the same time frames and magnitudes. The objectives of the ROSA-III experimental program are:

(1) To provide data required to evaluate the adequacy and improve the analytical methods currently used to predict the LOCA response of large BWRs. The performance of the ESFs, with particular emphasis on emergency core cooling systems (ECCS), and the quantitative magins of safety inherent in performance of the ESF are of primary interest.

(2) To identify and investigate any unexpected event(s) or threshold(s) in the response of either the plant or the ESF and develop analytical techniques that adequately describe and account for such unexpected behavior.

The information acquired from loss-of-coolant experiments (LOCE) is thus used for evaluation and development of LOCA analytical methods and assessment for the quantitative margins of safety of ESFs in response to a LOCA.

RUN 704 conducted on February 27, 1979 was the fourth test at ROSA-III facility. The test was specified to simulate a 200 % double-ended shear break at the recirculation pump inlet side. The primary objectives of the test were to:

(1) Provide data to evaluate ROSA-III emergency core cooling system (ECCS) behavior during LOCE operation.

(2) Provide data to assess the system computer code.

RUN 704 was conducted from initial conditions of 560 K and 7.04 MPa in the steam dome of the vessel. The subcooling in the lower plenum was 14 K. The core inlet flow rate was 35.7 kg/s and the core outlet quality was 3.4%. The steady state power for the core was 3.27 MW corresponding to 40% of a BWR steady state power, and the trasient power simulated the delayed neutron fission power, the decay power of fission products and actinides and the stored heat in the fuel pin.

The purpose of this report is to present the data from RUN 704 in an uniterpreted but readily usable form for use by the nuclear community in advance of detailed analysis and interpretation. Section 2 briefly describes the ROSA-III configuration. Section 3 discusses the ROSA-III instrumentation system and methods of obtaining certain measurements, and Section 4 summarizes RUN 704 initial conditions and test procedures. Section 5 presents the data with supporting information for data interpretation. Section 6 describes concluding remarks.

2. ROSA-III TEST FACILITY

The ROSA-III facility is a volumetrically scaled (1/424) boiling water reactor (BWR) system with electrically heated core designed to study the response of the engineered safety features (ESF) in commercial BWR systems during the postulated loss-of-coolant accident (LOCA).

The test assembly consists of four major subsystems which have been instrumented such that desirable system parameters can be measured and recorded during a LOCE. The subsystems include: (a) the pressure vessel, (b) the steam line and the feedwater line, (c) the coolant recirculation system, and (d) the ECCS. System instrumentation is discussed in Section III. The ROSA-III major components and the pressure vessel internal structure are shown schematically in Figure 2.1 and 2.2, respectively. The ROSA-III piping system is shown in Figure 2.3, and the major characteristics of the ROSA-III facility are compared with those of a LBWR in Table 2.1.

The pressure vessel simulates the pressure vessel of a BWR. It has a simulated core, a lower plenum, an upper plenum, an annular downcomer, a steam separator, a simulated steam dryer plate, and a steam dome. The core is composed of four half-length simulated fuel assemblies and a control rod simulator. Each fuel assembly contains 62 fuel rods which are spaced and supported in a square (8 × 8) array by lower and upper tie plates. The simulated fuel rod is heated electrically with chopped-cosine axial power distribution. The effective heated length is 1880 mm, one half of the active length of a BWR fuel rod. The orifice plate assembly at core inlet simulates the flow resistance of the nuclear core.

The steam line and the feedwater line simulate those of a BWR. Steam is discharged into the atmosphere through the steam line connected to the steam dome. The steam line has three branches. The first branch has a control valve to control the steady-state steam dome pressure before blowdown. The second branch simulates the automatic depressurization system (ADS). The third branch has an orifice to simulate the flow resistance of a steam turbine-generator. Immediately after the blowdown initiation, the steam line is changed from the first branch to the third one. The feedwater line is connected to the feedwater sparger located above the downcomer region. The ambient-temperature feedwater is supplied from the pure water tank (PWT) at steady state, and the feedwater tank (FWT) supplies preheated feedwater during the first two seconds in the blowdown.

The coolant recirculation system simulates the BWR recirculation loop. The system consists of two loops provided with a recirculation pump and two jet pumps in each loop. One is the intact loop which simulates the unbroken loop of a BWR and the other is the broken loop which simulates the broken loop of a BWR. The broken loop has two break simulators and a quick shutoff valve to simulate a double-ended shear break or a split break. Each break simulator is composed of an orifice which determines the break area, a rupture disk, and a spear to break the rupture disk. The break type, position, and area are experimental variables. The standard break condition is a 200 % double-ended shear break at the recirculation pump inlet side with the orifice diameter of 26.2 mm.

The ECCS of ROSA-III simulate those of a BWR. The ECC systems include HPCS, LPCS, LPCI and ADS. The spray systems, the HPCS and the LPCS, spray the emergency cooling water on the top surface of the core. The LPCI system supplies the emergency cooling water into the core-shroud directly. Each ECCS is provided with a tank, a pump, a valve, and a control system to control the valve trip delay, valve opening speed, and the pump flow rate.

3. INSTRUMENTATION

The instrumentation system of the ROSA-III was designed to obtain thermo-hydraulic data in a BWR LOCA to contribute to assess the analytical code. The channel configuration of the instrumentation differs following the renewal of the simulated fuel assembly or remodeling of the loop system. The measurement list for the present run is shown in Table 3.1. Most of the measurements are recorded on the main data acquisition system (DATAC-2000B) with a half-inch width magnetic tape and the rest are recorded on the supplemental recording system with a casset tape of 100 channel capacity (cf. Table 3.2). The list number corresponds to the fuel assembly number. In the case of list with two figures the first digit indicates the fuel assembly number and the second digit indicates the revised version number of the instrumentation system for the same assembly.

Pressure measurements are done with semi-conductor transducers measuring the piezoelectric resistance. The detector is cooled by water for the protection from high temperature environment.

Differential pressure transducers with two direct current cables convert displacement of a diaphragm to electric charge and then to proportional voltage. The pressure lead pipes are dual circular pipes for circulating cooling water to eliminate flashing of the fluid.

Flow rate is measured by orifice, venturi, turbine or electro-magnetic flow meters depending on the fluid condition and the measurement location.

Electric power for simulated fuel rods is controlled by the predetermined function of time for the after power simulation and it is measured by fast response electric power meter.

Pump revolution speed is measured by counting the number of gear blades on the axis of a pump.

On-off signals such as valve position, pump revolution direction, rupture disk break and pump power supply are converted to voltage or current and recorded in respective channels in order to specify the exact time of the signal.

Temperatures of fluid, structure materials and fuel rods are measured with thermocouples of 1.6 mmϕ or 1.0 mmϕ.

Liquid levels are measured by means of needle type electrical conductivity probes developed in the ROSA-III program. The probes are attached on the walls of core barrel and channel boxes at several elevations and detect the existence of liquid water or steam at each level.

The void fraction of fluid is measured by a needle type electrical resistance probe or a correlation type electrical capacitance probe. The former detects passing bubble and the void fraction is obtained by integrating the void signal. The latter detects the average void distribution around the probe with the capacitance. The correlation between two sensors gives the velocity of the bubble.

Fluid density in the pipe is measured by means of a gamma ray densitometer. Each gamma ray densitometer has two or three beams to estimate the flow regime. The gamma source is Cs-137 and the detector is NaI scintillator which is cooled by water.

Flow direction in the core is measured from the canti-lever contact signal. The canti-lever is moved to the direction of the fluid flow and generates a contact signal.

Two-phase flow rate measurement is done by means of the combination of two signals from drag disk, turbine and gamma ray densitometer in a pipe.

Some of measurement methods described above are still under development and further improvements are expected in accuracy and reliability.

The measurement location of each instrumentation in the measurement list are shown in the figures of flow diagram, loop instrumentation, in-vessel instrumentation, or in-core instrumentation (Figs. 3.1 - 3.14).

The data acquisition system utilizes two recording systems of major and minor importance. The data recorded on the magnetic tape of the main acquisition system are processed by the FACOM 230-75 computer at JAERI by off-line. After the evaluation of each data by comparing the initial and the final values with the standard values of the pressure for example, the data tape is re-processed using the correct conversion factors determined from consistency examination. Data processing program developed for the ROSA-III test can compare the measured data in a figure not only with other channels of the same test but also with the data of other runs or with calculated results by LOCA anslysis code such as RELAP or ALARM.

4. TEST CONDITIONS

The test conditions of RUN 704 are summarized in Table 4.1. RUN 704 simulates a 200% double-ended shear break at the recirculation pump inlet. The steam dome of the pressure was saturated at pressure of 7.04 MPa and the corresponding fluid temperature of 560 K. The core inlet flow rate was 35.7 kg/s and the core outlet quality was estimated as 3.4 %. The initial flow rate in the steam line at steady state was not measured because of unsuitable measurement range of the flow meter. The feed water flow rate at steady state was 1.15×10^{-3} m^3/s.

The steady state power supply to the simulated fuel rods was 3.27 MW which corresponds to 40 % of the BWR steady state power, and the maximum linear heat rate (MLHR) was 9.96 kw/m. The power supply to the core was switched to the transient power specified as shown in Fig. 2.5 at the break initiation to simulate the shutdown power. The transient power simulated the delayed neutron fission power, the decay power of fission products and actinides and the stored heat release from the fuel pin.

The steam line and feed water line are independent open loops for the present test. The steam line has steady and transient lines as shown in the flow diagram in Fig.3.1 and the steady line was switched to the transient line at the time of break. The closure of the valves in the steam line and feed water line takes a few seconds as shown in Table 4.2. Closure of the feed water line valve was initiated at 2.5 s and the line was closed completely at 4.0 s. Closure of the steam line valve was initiated at 4.5 s and the line was closed completely at 7.0 s.

Emergency core coolant injection was directed to the upper plenum during blowdown. Injection rates from high pressure core spray (HPCS), low pressure core spray (LPCS) and low pressure coolant injection (LPCI) are shown in Fig. 5.14. Injection from HPCS began at 27.0 s after break with the injection rate of 0.0011 m^3/s. LPCS was initiated by LOCE control 66.0 s after break when the system pressure reached 2.17 MPa. LPCI was initiated 13 s after LPCS activation, that is for LPCS and LPCI 80.0 s after the break. Injection flow rates were 0.0010 m^3/s and 0.0038 m^3/s, respectively.

Automatic depressurization system (ADS) valve was opened at 132.0 s after the break and closed at 480 s after the actuation. The orifice with diamater of 6.0 mm was inserted in ADS line to simulate a typical ADS line flow of a BWR.

5. DATA PRESENTATION

The experiment RUN 704 proceeded as planned, starting with a 200% double-ended break simulated by breaking two rupture disks and closing the quick shut-off valve between the two break units. The sequence of major events is shown in Table 5.1. The feed water line valve and the steam line valve were closed completly at 4 s and 7 s, after break respectively. Jet pump suction nozzle was uncoverd at 10.0s and recirculation pump suction nozzle was uncovered at 12s. Core power was reduced as specified after 12.7s to simulate decay heat and stored heat of a nuclear fuel rod. The lower plenum saturated and initiated flashing at 17s. HPCS, LPCS and LPCI systems inititiated injection at 27.0s, 66.0s and 80.0s, respectively. ADS valve was opened at 132.0s and closed approximately at 480s after break. The surface temperature of fuel rods began to rise at 13s following the decrease in mixture level in the core. The fuel rods quenched from bottom to top following the recovery of the liquid level in the core by ECCS. The latest quench occured at 120s after break.

The test data are presented in Fig. 5.1 through 5.74. They are devided into four groupes, system data, flow data, temperature data and mixture level data.

Fig. 5.1 throught 5.12 show system data, of which Fig. 5.1 gives power transients of three power suppliers for simulated fuel rods with the maximum capacities of 550, 1800 and 2100 kw. Fig. 5.2 through 5.5 show pressure transients in the vessel and loops, and Fig. 5.6 through 5.12 display differential pressures in the vessel and loops.

Fig. 5.13 through 5.18 give flow data, of which Fig. 5.13 through 5.17 show flow rates of main steam line, ECCS flows, feed water line and jet pump discharges. Fig. 5.18 shows the revolution rates of two main recirculation pumps.

Fig. 5.19 through 5.47 exhibit temperature data, of which Fig. 5.19 through 5.23 show fluid temperature in the system. Fig. 5.24 through 5.27 show surface temperatures of structure materiales. Fig. 5.28 through 5.69 give temperature data showing thermal-hydraulic responses in the core. Fig. 5.28 through 5.55 show fuel surface temperatures, Fig. 5.56 through 5.59 show fluid temperature around the tie rod, Fig. 5.60 and 5.61 show channel box outlet and inlet fluid temperatures, Fig. 5.62 and 5.63 show channel box surface temperatures, Fig. 5.64 and 5.65 show lower plenum surface temperatures and fluid temperatures, and Fig. 5.66 through 5.69 show fluid temperature near the upper tieplate.

Fig 5.70 through 5.73 show liquid level signals. The mixture level transient in shroud estimated from liquid level signals of the conductance probes is shown in Fig. 5.48.

6. CONCLUDING REMARKS

The conduct of ROSA-III RUN 704 and the experimental data acquired concerning integral system phsnomena associated with a loss of coolant accident are considered to have met the objectives as described in Section 1.

The ROSA-III facility and its instrumentation worked well, and the obtained experimental data are useful for assessing computer codes for BWR LOCA/ECCS analysis in a rather extreme transient with a 200% double-ended break at recirculation pump suction, ECCS actuation, 40% steady state power, and a transient power simulating the decay power of fission products and actinides, the delayed neutron fission power and the stored heat in the fuel pin.

ACKNOWLEDGMENTS

The authors are grateful to H. Itoh, H. Osaki, T. Chiba of Safety Facility Engineering Services Section, and to H. Asahi, T. Odaira, S. Sekiguchi, M. Tokoi, H. Yamada, and J. Tamura of Nuclear Engineering Corporation who conducted the experiment.

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ACKNOWLEDGMENTS

The authors are grateful to H. Itoh, H. Osaki, T. Chiba of Safety Facility Engineering Services Section, and to H. Asahi, T. Odaira, S. Sekiguchi, M. Tokoi, H. Yamada, and J. Tamura of Nuclear Engineering Corporation who conducted the experiment.

REFERENCES

1. Tasaka, K. et al. 1976. Study on the similarity between ROSA-III experiment and BWR LOCA (preanalysis of ROSA-III). JAERI-M 6703.

2. Kitaguchi, H. et al. 1978. Preliminary analysis of ROSA-III experiment (II). JAERI-M 7488.

3. Kitaguchi, H. et al. 1978, Preliminary analysis of ROSA-III experiment (III). JAERI-M 7791.

4. Kitaguchi, H. et al. 1979. LOCA analysis of BWR/6 for the ROSA-III test. JAERI-M 8185.

5. Soda, K. 1978. Prediction of ROSA-III experiment Run 701. JAERI-M 7712.

6. Koizumi, Y. et al. 1978. Prediction of ROSA-III experiment Run 702. JAERI-M 7970.

7. Koizumi, Y. et al. 1979. Prediction of ROSA-III experiment Run 703. JAERI-M 8300.

8. Soda, K. et al. 1979. Post test analysis of ROSA-III test Run 701. JAERI-M 8473.

9. Koizumi, Y. et al. 1980. Post test analysis of ROSA-III test Run 702. JAREI-M 8627.

10. Kikuchi, O. et al. 1979. Test results and post test analysis of ROSA-III Run 703. JAERI-M 8588.

11. Kikuchi, O. et al. 1980. Post test analysis of ROSA-III test Run 704. JAERI-M 8729.

12. Sobajima, M. et al. 1979. Instrumentation and data processing method of the ROSA-III test. JAERI-M 8499.

13. Suzuki, M. and Tasaka, K. 1980. Characteristic of the ROSA-III test facility (Characteristics test of the jet pumps in normal and reverse flow). JAERI-M 8670.

14. Sobajima, M. et al. 1979. Experiment data of ROSA-III test Run 701 (decay heat simulation test with ECCS activation). JAERI-M 8604.

15. Okazaki, M. et al. 1980. Experiment data of ROSA-III integral test Run 705 (isothermal blowdown test without ECCS actuation). JAERI-M 8723.

16. Suzuki, M. et al. 1980 Experiment data of ROSA-III integral test Run 706 (standard test without ECCS actuation). JAERI-M 8737.

17. Abe, N. and Tasaka, K. 1980 Electric power transient curve for ROSA-III tests. JAERI-M 8728.

Table 2.1 Primary characteristics of BWR-6 and ROSA-III.

	BWR-6	ROSA-III	BWR/ROSA
No. of Recirc. Loops	2	2	1
No. of Jet Pumps	24	4	6
No. of Separators	251	1	251
No. of Fuel Assemblies	848	4	212
Active Fuel Length (m)	3.76	1.88	2
Total Coolant Volume (m^3)	623	1.37	455
Power (MW)	3800	4.24	896
Pressure (MPa)	7.23	7.23	1
Core Flow (kg/sec)	1.39×10^4	36.4	382
Recirculation Flow (l/sec)	2970	7.01	424
Feedwater Flow (kg/sec)	2060	4.86	424
Feedwater Temp (°K)	489	489	1

Table 3.1 POSA-III measurement List 2

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Ronge & Output	Accuracy	Data Fig. No.	Measurement comments
1	Press.	P - 1	Lower Plenum		3.2	0∿100kg/cm^2 0∿10 V	±1.08 % F.S.	5.2	
2	"	P - 2	Upper Plenum		"	"	"	"	
3	"	P - 3	Steam Dome		"	"	"	"	
4	"	P - 4	Downcomer Bottom		"	"	"	"	
5	"	P - 5	JP - 3 Drive	broken loop	3.3	"	"	5.3	
6	"	P - 6	JP - 4 Drive	"	"	"	"	"	
7	"	P - 7	JP - 3 Suction	"	"	"	"	"	
8	"	P - 8	JP - 4 Suction	"	"	"	"	"	
9	"	P - 9	MRP - 1 Suction	intact loop	3.4	"	"	5.4	
10	"	P -10	MRP - 2 Suction	broken loop	3.3	"	"	"	
11	"	P -11	MRP - 2 Discharge	"	"	"	"	"	
12	"	P -12	Above Break A	pump side	"	"	"	5.5	
13	"	P -13	Below Break A	"	"	"	"	"	
14	"	P -14	Above Break B	vessel side	"	"	"	"	
15	"	P -15	Below Break B	"	"	"	"	"	
16	"	P -16	Steam Line	"	"	"	"	5.2	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
17	Diff. P	D - 1	Lower PL.- Upper PL.		3.2	$-0.5\sim3.5$kg/cm^2 $2\sim10$ V	±0.63 % F.S.	5.6	
18	"	D - 2	Upper PL.-Steam Dome		"	$-0.1\sim0.9$kg/cm^2 $2\sim10$ V	"	5.7	
19	"	D - 3	Lower Plenum Head		"	$0\sim1.5$kg/cm^2 $2\sim10$ V	"		not measured
20	"	D - 4	Downcomer Head		"	$0\sim1.0$kg/cm^2 $2\sim10$ V	"	5.8	
21	"	D - 5	PV. Bottom-Top		"	$-1.0\sim9.0$kg/cm^2 $2\sim10$ V	"	5.9	
22	"	D - 6	JP - 1 Discharge-Suction	intact loop	3.4	$-1.0\sim3.0$kg/cm^2 $2\sim10$ V	"	5.10	
23	"	D - 7	JP - 1 Drive-Suction	"	"	$0\sim25$ kg/cm^2 $2\sim10$ V	"	5.11	
24	"	D - 8	JP - 2 Discharge-Suction	"	"	$-1.0\sim3.0$kg/cm^2 $2\sim10$ V	"	5.10	
25	"	D - 9	JP - 2 Drive-Suction	"	"	$0\sim25$ kg/cm^2 $2\sim10$ V	"	5.11	
26	"	D -10	JP - 3 Discharge-Suction	broken loop	3.3	$-1.0\sim3.0$kg/cm^2 $2\sim10$ V	"	5.10	
27	"	D -11	JP - 3 Drive-Suction	"	"	$-5.0\sim25$ kg/cm^2 $2\sim10$ V	"	5.11	
28	"	D -12	JP - 4 Discharge-Suction	"	"	$-1.0\sim3.0$kg/cm^2 $2\sim10$ V	"	5.10	
29	"	D -13	JP - 4 Drive-Suction	"	"	$-5.0\sim25$ kg/cm^2 $2\sim10$ V	"	5.11	
30	"	D -14	MRP - 1 Discharge-Suction	intact loop	3.4	$-1.0\sim25$ kg/cm^2 $2\sim10$ V	"	5.12	
31	"	D -15	MRP - 2 Discharge-Suction	broken loop	3.3	$-1.0\sim25$ kg/cm^2 $2\sim10$ V	"	"	
32	Flow	F - 1	Main Steam Line		3.6	$0\sim15$ kg/sec $2\sim10$ V	±0.92 % F.S.		not measured
33	"	F - 2	ADS. Steam Line		"	$0\sim3.0$kg/sec $2\sim10$ V	"	5.13	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Renge & Output	Accu racy	Data Fig. No.	Measurement comments
34	Flow	F - 3	Condensed Water A		3.5	0∿250kg/sec 2∿10 V	±1.4% F.S.		not presented
35	"	F - 4	Cooling Water A		"	"	"		"
36	"	F - 5	Condensed Water B		"	"	"		"
37	"	F - 6	Cooling Water B		"	"	"		"
38	"	F - 7	HPCS (Upper Plenum)		3.1	0∿150 ℓ/min 2∿10 V	±0.79 % F.S.	5.14	
39	"	F - 8	HPCS (Lower Plenum)	not used	"	"	"		
40	"	F - 9	LPCS (Upper Plenum)		"	"	"	5.14	
41	"	F -10	LPCS (Lower Plenum)	not used	"	"	"		
42	"	F -11	LPCI (In-Shroud)		"	0∿500 ℓ/min 2∿10 V	"	5.14	
43	"	F -12	LPCI (Lower Plenum)	not used	"	"	"		
44	"	F -13	LPCI MRP - 2 Suction	"	"	0∿250 ℓ/min 2∿10 V	"		
45	"	F -14	LPCI MRP - 1 Suction	"	"	"	"		
46	"	F -15	Transient Feed Water		3.7	0∿600 ℓ/min 2∿10 V	"	5.15	
47	"	F -16	Steady Feed Water		"	0∿250 ℓ/min 2∿10 V	"	"	
48	"	F -17	JP - 1 Discharge	intact loop	3.4	0∿1000ℓ/min 2∿10 V	±0.88 % F.S.	5.16	
49	"	F -18	JP - 2 Discharge	"		"	"	"	
50	"	F -19	JP - 3 Discharge +	broken loop	3.3	"	±0.92 % F.S.	5.17	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	Loc. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
51	Flow	F -20	JP - 3 Discharge -	reverse flow	3.3	0∿300 ℓ/min 2∿10 V	±0.92 % F.S.	5.17	
52	"	F -21	JP - 4 Discharge +		"	0∿1000ℓ/min 2∿10 V	"	"	
53	"	F -22	JP - 4 Discharge -	reverse flow	"	0∿300 ℓ/min 2∿10 V	"	"	
54	Power	W - 1	550 KVA Power			0∿550 KVA 0∿10 V	±1.0% F.S.	5.1	
55	"	W - 2	1800 KVA Power			0∿1700 KVA 0∿10 V	"	"	
56	"	W - 3	2100 KVA Power			0∿2100 KVA 0∿10 V	"	"	
57	Rev. No	N - 1	MRP - 1	intact loop	3.4	0∿5000 rpm 0∿10 V	±1.08 % F.S.	5.18	
58	"	N - 2	MRP - 2	broken loop	3.3	"	"	"	
59	Signal	S - 1	Break Signal A		3.5	0 ∿ 5 V	-		cf. sequence of events
60	"	S - 2	Break Signal B		"	"	-		(Table 5.1)
61	"	S - 3	QSV Signal		"	close open 0 ∿ 5 V	-		
62	"	S - 9	Transient Feed Water Line		3.7	"	-		
63	"	S -10	Main Steam Isolation Valve		3.6	"	-		
64	"	S -11	Steam Line Valve		"	"	-		
65	Temp.	T - 1	Lower Plenum	recirculation inlet fluid temp.	3.8	0 ∿ 400 °C 0 ∿ 10 V	±0.64 % F.S.	5.19	
66	"	T - 2	Mixing Plenum	fluid temp.	3.2	"	"	"	
67	"	T - 3	Steam Dome	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	Loc. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
68	Temp.	T - 4	Upper Downcomer	fluid temp.	3.2	0 ∿ 400 °C 0 ∿ 10 V	±0.64 % F.S.	5.19	
69	"	T - 5	Lower Downcomer	"	3.8	"	"	"	
70	"	T - 6	JP - 1 Driving Water	"	3.4	"	"	5.20	
71	"	T - 7	JP - 2 Driving Water	"	"	"	"	"	
72	"	T - 8	JP - 3 Driving Water	"	3.3	"	"	5.21	
73	"	T - 9	JP - 4 Driving Water	"	"	"	"	"	
74	"	T -10	JP - 1 Discharge	"	3.4	"	"	5.20	
75	"	T -11	JP - 2 Discharge	"	"	"	"	"	
76	"	T -12	JP - 3 Discharge	"	3.3	"	"	5.21	
77	"	T -13	JP - 4 Discharge	"	"	"	"	"	
78	"	T -14	MRP - 1 Suction	"	3.4	"	"	5.22	
79	"	T -15	MRP - 1 Discharge	"	"	"	"	"	
80	"	T -16	MRP - 2 Suction	"	3.3	"	"	"	
81	"	T -17	MRP - 2 Discharge	"	"	"	"	"	
82	"	T -18	Above Break A	"	3.5	"	"	5.23	
83	"	T -19	Above Break B	"	"	"	"	"	
84	"	T -20	Condensed Water A	"	"	"	"		not presented

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	Loc. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
85	Temp.	T -21	Condensed Water B	fluid temp.	3.5	0 ∿ 400 °C 0 ∿ 10 V	±0.64 % F.S.		not presented
86	"	T -22	Discharged Steam Above V.	"	3.6	"	"	5.19	
87	"	T -23	Discharged Steam Below V.	"	"	"	"		not measured
88	"	TS-15	Dummy Block B Side 3	slab surface temp.	3.11	"	"	5.24	
89	"	TS-18	Dummy Block B Side 6	"	"	"	"	"	
90	"	TS-21	Dummy Block O Side 9	"	"	"	"	"	
91	"	TS-24	Dummy Block O Side 12	"	"	"	"	"	
92	"	TS-25	JP - 1 Diffuser Wall	slab temp.	3.4	"	"	5.25	
93	"	TS-26	JP - 2 Diffuser Wall	"	"	"	"	"	
94	"	TS-27	JP - 3 Diffuser Wall	"	3.3	"	"	"	
95	"	TS-28	JP - 4 Diffuser Wall	"	"	"	"	"	
96	"	TS-29	PV. Wall Inside 1 - 1	"	3.8	"	"	5.27	
97	"	TS-30	PV. Inner Surface 1 - 2	"	"	"	"	5.26	
98	"	TS-31	PV. Inner Surface 1 - 3	slab surface temp.	"	"	"	"	
99	"	TS-32	PV. Wall Inside 2	"	"	"	"	5.27	
100	"	TS-33	PV. Wall Inside 3	slab temp.	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
101	Temp.	TS-34	PV. Wall Inside 4	slab temp.	3.8	0 ∿ 400 °C 0 ∿ 10 V	±0.64 % F.S.	5.27	
102	"	TS-35	Lower Plenum Inner Surface	surface temp.	"	"	"	5.26	
103	"	TS-36	Lower Plenum Wall Inside	slab temp.	"	"	"	5.27	
104	"	TF2- 1	A - 11 Fuel Rod Pos. 3	surface temp.	3.12	0 ∿ 1200 °C 0 ∿ 10 V	"	5.28	
105	"	- 2	" 4	"	"	"	"	"	
106	"	- 3	" 5	"	"	"	"	"	
107	"	- 4	A - 13 Fuel Rod Pos. 3	"	"	"	"	5.29	
108	"	- 5	" 4	"	"	"	"	"	
109	"	- 6	" 5	"	"	"	"	"	
110	"	- 7	A - 15 Fuel Rod Pos. 3	"	"	"	"	5.30	
111	"	- 8	" 4	"	"	"	"	"	
112	"	- 9	" 5	"	"	"	"	"	
113	"	-10	A - 17 Fuel Rod Pos. 3	"	"	"	"	5.31	
114	"	-11	" 4	"	"	"	"	"	
115	"	-12	" 5	"	"	"	"	"	
116	"	-13	A - 31 Fuel Rod Pos. 3	"	"	"	"	5.32	
117	"	-14	" 4	"	"	"	"	"	

Table 3.1 (continued)

OH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
118	Temp.	TF2-15	A - 31 Fuel Rod Pos. 5	surface temp.	3.12	0 ∿ 1200 °C 0 ∿ 10 V	±0.64 % F.S.	5.32	
119	"	-16	A - 33 Fuel Rod Pos. 1	"	"	"	"	5.33	
120	"	-17	" 2	"	"	"	"	"	
121	"	-18	" 3	"	"	"	"	"	
122	"	-19	" 4	"	"	"	"	"	
123	"	-20	" 5	"	"	"	"	"	
124	"	-21	" 6	"	"	"	"	"	
125	"	-22	" 7	"	"	"	"	"	
126	"	-23	A - 35 Fuel Rod Pos. 3	"	"	"	"	5.34	
127	"	-24	" 4	"	"	"	"	"	
128	"	-25	" 5	"	"	"	"	"	
129	"	-26	A - 37 Fuel Rod Pos. 3	"	"	"	"	5.35	
130	"	-27	" 4	"	"	"	"	"	
131	"	-28	" 5	"	"	"	"	"	
132	"	-29	A - 51 Fuel Rod Pos. 3	"	"	"	"	5.36	
133	"	-30	" 4	"	"	"	"	"	
134	"	-31	" 5	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
135	Temp.	TF2-32	A - 53 Fuel Rod Pos. 3	surface temp.	3.12	0 ∿ 1200 °C 0 ∿ 10 V	±0.64 % F.S.	5.37	
136	"	-33	" 4	"	"	"	"	"	
137	"	-34	" 5	"	"	"	"	"	
138	"	-35	A - 57 Fuel Rod Pos. 3	"	"	"	"	5.38	
139	"	-36	" 4	"	"	0 ∿ 1220 °C 0 ∿ 10 V	"	"	
140	"	-37	" 5	"	"	"	"	"	
141	"	-38	A - 71 Fuel Rod Pos. 3	"	"	"	"	5.39	
142	"	-39	" 4	"	"	"	"	"	
143	"	-40	" 5	"	"	"	"	"	
144	"	-41	A - 73 Fuel Rod Pos. 3	"	"	"	"	5.40	
145	"	-42	" 4	"	"	"	"	"	
146	"	-43	" 5	"	"	"	"	"	
147	"	-44	A - 75 Fuel Rod Pos. 3	"	"	"	"	5.41	
148	"	-45	" 4	"	"	"	"	"	
149	"	-46	" 5	"	"	"	"	"	
150	"	TF2-47	A - 77 Fuel Rod Pos. 1	"	"	"	"	5.42	

Table 3.1 (continued)

CH. No.	Item	Symb	Locations	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
151	Temp.	TF2-48	A - 77 Fuel Rod Pos. 2	surface temp.	3.12	0 ∿ 1220 °C 0 ∿ 10 V	±0.64 % F.S.	5.42	
152	"	-49	" 3	"	"	"	"	"	
153	"	-50	" 4	"	"	"	"	"	
154	"	-51	" 5	"	"	"	"	"	
155	"	-52	" 6	"	"	"	"	"	
156	"	-53	" 7	"	"	"	"	"	
157	"	-54	B - 15 Fuel Rod Pos. 1	"	"	"	"	5.43	
158	"	-55	" 2	"	"	"	"	"	
159	"	-56	" 3	"	"	"	"	"	
160	"	-57	" 4	"	"	"	"	"	
161	"	-58	" 5	"	"	"	"	"	
162	"	-59	" 6	"	"	"	"	"	
163	"	-60	" 7	"	"	"	"	"	
164	"	-61	B - 85 Fuel Rod Pos. 1	"	"	"	"	5.44	
165	"	-62	" 2	"	"	"	"	"	
166	"	-63	" 3	"	"	"	"	"	
167	"	-64	" 4	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
168	Temp.	TF2-65	B - 85 Fuel Rod Pos. 5	surface temp.	3.12	0 ∿ 1220 °C 0 ∿ 10 V	±0.64 % F.S.	5.44	
169	"	-66	" 6	"	"	"	"	"	
170	"	-67	" 7	"	"	0 ∿ 976 °C 0 ∿ 10 V	"	"	
171	"	-68	C - 11 Fuel Rod Pos. 3	"	"	"	"	5.45	
172	"	-69	" 4	"	"	"	"	"	
173	"	-70	" 5	"	"	"	"	"	
174	"	-71	C - 13 Fuel Rod Pos. 3	"	"	"	"	5.46	
175	"	-72	" 4	"	"	"	"	"	
176	"	-73	" 5	"	"	"	"	"	
177	"	-74	C - 15 Fuel Rod Pos. 3	"	"	"	"	5.47	
178	"	-75	" 4	"	"	"	"	"	
179	"	-76	" 5	"	"	"	"	"	
180	"	-77	C - 31 Fuel Rod Pos. 3	"	"	"	"	5.48	
181	"	-78	" 4	"	"	"	"	"	
182	"	-79	" 5	"	"	"	"	"	
183	"	-80	C - 33 Fuel Rod Pos. 1	"	"	"	"	5.49	
184	"	-81	" 2	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
185	Temp.	TF2-82	C - 33 Fuel Rod Pos. 3	surface temp.	3.12	0 ~ 976 °C 0 ~ 10 V	±0.64 % F.S.	5.49	
186	"	-83	" 4	"	"	"	"	"	
187	"	-84	" 5	"	"	"	"	"	
188	"	-85	" 6	"	"	"	"	"	
189	"	-86	" 7	"	"	"	"	"	
190	"	-87	C - 35 Fuel Rod Pos. 3	"	"	"	"	5.50	
191	"	-88	" 4	"	"	"	"	"	
192	"	-89	" 5	"	"	"	"	"	
193	"	-90	C - 51 Fuel Rod Pos. 3	"	"	"	"	5.51	
194	"	-91	" 4	"	"	"	"	"	
195	"	-92	" 5	"	"	"	"	"	
196	"	-93	C - 53 Fuel Rod Pos. 3	"	"	"	"	5.52	
197	"	-94	" 4	"	"	"	"	"	
198	"	-95	" 5	"	"	"	"	"	
199	"	-96	C - 77 Fuel Rod Pos. 1	"	"	"	"	5.53	
200	"	-97	" 2	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
201	Temp.	TF2-98	C - 77 Fuel Rod Pos. 3	surface temp.	3.12	0 ∿ 976 °C 0 ∿ 10 V	±0.64 % F.S.	5.53	
202	"	- 99	" 4	"	"	"	"	"	
203	"	-100	" 5	"	"	"	"	"	
204	"	-101	" 6	"	"	"	"	"	
205	"	-102	" 7	"	"	"	"	"	
206	"	-103	D - 27 Fuel Rod Pos. 1	"	"	"	"	5.54	
207	"	-104	" 2	"	"	"	"	"	
208	"	-105	" 3	"	"	"	"	"	
209	"	-106	" 4	"	"	"	"	"	
210	"	-107	" 5	"	"	"	"	"	
211	"	-108	" 6	"	"	"	"	"	
212	"	-109	" 7	"	"	"	"	"	
213	"	-110	D - 88 Fuel Rod Pos. 1	"	"	"	"	5.55	
214	"	-111	" 2	"	"	"	"	"	
215	"	-112	" 3	"	"	"	"	"	
216	"	-113	" 4	"	"	"	"	"	
217	"	-114	" 5	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
218	Temp.	TF2-115	D - 88 Fuel Rod Pos. 6	surface temp.	3.12	0 ∿ 976 °C 0 ∿ 10 V	±0.64 % F.S.	5.55	
219	"	-116	" 7	"	"	"	"	"	
220	"	-117	A - 55 Tie Rod Pos. 1	fluid temp.	"	"	"	5.56	
221	"	-118	" 2	"	"	"	"	"	
222	"	-119	" 3	"	"	"	"	"	
223	"	-120	" 4	"	"	"	"	"	
224	"	-121	" 5	"	"	"	"	"	
225	"	-122	" 6	"	"	"	"	"	
226	"	-123	" 7	"	"	"	"	"	
227	"	-124	B - 55 Tie Rod Pos. 1	"	"	"	"	5.57	
228	"	-125	" 2	"	"	"	"	"	
229	"	-126	" 3	"	"	"	"	"	
230	"	-127	" 4	"	"	"	"	"	
231	"	-128	" 5	"	"	"	"	"	
232	"	-129	" 6	"	"	"	"	"	
233	"	-130	" 7	"	"	"	"	"	
234	"	-131	C - 55 Tie Rod Pos. 1	"	"	"	"	5.58	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
235	Temp.	TF2-132	C - 55 Tie Rod Pos. 2	fluid temp.	3.12	0 ∿ 976 °C 0 ∿ 10 V	±0.64 % F.S.	5.58	
236	"	-133	" 3	"	"	"	"	"	
237	"	-134	" 4	"	"	"	"	"	
238	"	-135	" 5	"	"	"	"	"	
239	"	-136	" 6	"	"	"	"	"	
240	"	-137	" 7	"	"	"	"	"	
241	"	-138	D - 55 Tie Rod Pos. 1	"	"	"	"	5.59	
242	"	-139	" 2	"	"	"	"	"	
243	"	-140	" 3	"	"	"	"	"	
244	"	-144	" 4	"	"	"	"	"	
245	"	-141	" 5	"	"	"	"	"	
246	"	-143	" 6	"	"	"	"	"	
247	"	-144	" 7	"	"	"	"	"	
248	"	TC- 1	Channel Box A Outlet	"	"	"	"	5.60	
249	"	- 2	" A Inlet	"	"	"	"	5.61	
250	"	- 3	" B Outlet	"	"	"	"	5.60	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
251	Temp.	TC- 4	Channel Box B Inlet	fluid temp.	3.12	0 ∿ 976 °C 0 ∿ 10 V	±0.64 % F.S.	5.61	
252	"	- 5	" C Outlet	"	"	"	"	5.60	
253	"	- 6	" C Inlet	"	"	"	"	5.61	
254	"	- 7	" D Outlet	"	"	"	"	5.60	
255	"	- 8	" D Inlet	"	"	"	"	5.61	
256	"	TB- 1	C.B. Inner Surface Pos. A-1	surface temp.	3.12 3.13	"	"	5.62	
257	"	- 2	" A-2	"	"	"	"	"	
258	"	- 3	" A-3	"	"	"	"	"	
259	"	- 4	" A-4	"	"	"	"	"	
260	"	- 5	" A-5	"	"	"	"	"	
261	"	- 6	" A-6	"	"	"	"	"	
262	"	- 7	" A-7	"	"	"	"	"	
263	"	- 8	C.B. Inner Surface Pos. A-8	"	"	"	"	5.63	
264	"	- 9	" A-9	"	"	"	"	"	
265	"	-10	" A-10	"	"	"	"	"	
266	"	-11	" A-11	"	"	"	"	"	
267	"	-12	" A-12	"	"	"	"	"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
268	Temp.	TB-13	C.B. Inner Surface pos.A-13	surface temp.	3.12 3.13	0 ∿ 976 °C 0 ∿ 10 V	±0.64 % F.S.	5.63	
269	"	-14	" A-14	"	"	"	"	"	
270	"	TP- 1	Lower PL. 0° High	"	3.10	"	"	5.64	
271	"	- 2	" Middle	"	"	"	"	"	
272	"	- 3	" Low	"	"	"	"	"	
273	"	- 4	Lower PL. 180° High	"	"	"	"	"	
274	"	- 5	" Middle	"	"	"	"	"	
275	"	- 6	" Low	"	"	"	"	"	
276	"	- 7	Low PL. Center Low	fluid temp.	"	"	"	5.65	
277	"	- 8	" Bottom	"	"	"	"	"	
278	"	- 9	Lower PL. Guide Tube	"	"	"	"	"	
279	"	-10	Lower PL. Outer Bottom	"	"	"	"	"	
280	"	TG2- 1	Upper Tieplate A Up. 1	"	3.12	"	"	5.66	
281	"	- 2	" 2	"	"	"	"	"	
282	"	- 3	" 3	"	"	"	"	"	
283	"	- 4	" 4	"	"	"	"	"	
284	"	- 5	" 5	"	"	"		"	

Table 3,1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
285	Temp.	TG2- 6	Upper Tieplate A Up. 6	fluid temp.	3.12	0 ∿ 976 °C 0 ∿ 10 V	±0.64 % F.S.	5.67	
286	"	- 7	" 7	"	"	"	"	"	
287	"	- 8	" 8	"	"	"	"	"	
288	"	- 9	" 9	"	"	"	"	"	
289	"	-10	" 10	"	"	"	"	"	
290	"	-11	Upper Tieplate A low 11	"	"	"	"	5.68	
291	"	-12	" 12	"	"	"	"	"	
292	"	-13	" 13	"	"	"	"	"	
293	"	-14	" 14	"	"	"	"	"	
294	"	-15	" 15	"	"	"	"	"	
295	"	-16	" 16	"	"	"	"	5.69	
296	"	-17	" 17	"	"	"	"	"	
297	"	-18	" 18	"	"	"	"	"	
298	"	-19	" 19	"	"	"	"	"	
299	"	-20	" 20	"	"	"	"	"	
300	Water Level	LB- 1	C.B. Water Level Pos. 1-1		"	ON ∿ OFF 0 ∿ 10 V		5.70	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
301	Water Level	LB- 2	C.B. Water Level Pos. 1-2		3.12 3.13	ON - OFF		5.70	
302	"	- 3	" 1-3		"	"		"	
303	"	- 4	" 1-4		"	"		"	
304	"	- 5	" 1-5		"	"		"	
305	"	- 6	" 1-6		"	"		"	
306	"	- 7	" 1-7		"	"		"	
307	"	- 8	C.B. Water Level Pos. 2-1		"	"		5.71	
308	"	- 9	" 2-2		"	"		"	
309	"	-10	" 2-3		"	"		"	
310	"	-11	" 2-4		"	"		"	
311	"	-12	" 2-5		"	"		"	
312	"	-13	" 2-6		"	"		"	
313	"	-14	" 2-7		"	"		"	
314	"	-15	C.B. Water Level Pos. 3-1		"	"		5.72	
315	"	-16	" 3-2		"	"		"	
316	"	-17	" 3-3		"	"		"	
317	"	-18	" 3-4		"	"		"	

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
318	Water Level	LB-19	C.B. Water Level Pos. 3-5		3.12 3.13	On - OFF		5.72	
319	"	-20	" 3-6		"	"		"	
320	"	-21	" 3-7		"	"		"	
321	"	LL- 1	Lower PL. Center High		3.10	"		5.73	
322	"	- 2	" Middle 1		"	"		"	
323	"	- 3	" Middle 2		"	"		"	
324	"	- 4	" Low		"	"		"	
325	"	- 5	Lower PL. 0° Low		"	"		"	
326	"	- 6	" Bottom		"	"		"	
327	"	- 7	Lower PL. 180° Low		"	"		"	
328	"	- 8	" Bottom		"	"		"	
329	Void	VE- 1	Lower PL. Void 0°		3.12	0 ∿ 1.0 0 ∿ 10 V			not measured
330	"	- 2	" Center		"	"			"
331	"	- 3	" 180°		"	"			"
332	"	- 4	Outlet of Channel A		"	"			"
333	"	- 5	"		"	"			"
334	"	- 6	"		"	"			"

Table 3.1 (continued)

CH. No.	Item	Symb	Location	Descriptions	LOC. Fig. No.	Range & Output	Accuracy	Data Fig. No.	Measurement comments
335	Void	VE- 7	Outlet of Channel B		3.12	0 ∿ 1.0 0 ∿ 10 V			not measured
336	"	- 8	"		"	"			"
337	"	- 9	"		"	"			"
338	"	-10	Outlet of Channel C		"	"			"
339	"	-11	"		"	"			"
340	"	-12	"		"	"			"
341	"	-13	Outlet of Channel D		"	"			"
342	"	-14	"		"	"			"
343	"	-15	"		"	"			"
344	"	VP- 1	Lower PL. Void 1-1		"	"			"
345	"	- 2	" 1-2		"	"			"
346	"	- 3	" 2-1		"	"			"
347	"	- 4	" 2-2		"	"			"
348	Flow	FE- 1	Channel A Outlet			0∿3.0m/sec 0∿10 V			"
349	"	- 2	" B "			"			"
350	"	- 3	" C "			"			"

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
351	Direc.	FE- 4	Channel D Outlet			0∿3.0m/sec 0∿10 V			not measured
352	"	FD- 1	Channel A Outlet			Pos.-Neg. +10∿-10 V			undefined data
353	"	- 2	" B "			"			"
354	"	- 3	" C "			"			"
355	"	- 4	" D "			"			"
356	Dens.	DF- 1	J.P. - 1.2 Outlet Beam 1			0∿1000kg/m^3 0∿10 V			not measured
357	"	- 2	" 2			"			"
358	"	- 3	" 3			"			"
359	"	- 4	JP - 3.4 Outlet Beam 1			"			"
360	"	- 5	" 2			"			"
361	"	- 6	" 3			"			"
362	"	- 7	Break A Beam 1			"			"
363	"	- 8	Break A Beam 2			"			"
364	Mome. F	M - 1	JP - 1.2 Outlet			0∿1.5×10^{5}kg/m.s^2 0∿10 V			"
365	"	- 2	JP - 3.4 Outlet			"			"
366	"	- 3	Break A			"			"
367	Flow	F -23	JP - 1.2 Outlet			0∿30 ℓ/sec 0∿10 V			"

Table 3.1 (continued)

CH. No.	Item	Symb.	Location	Descriptions	LOC. Fig. No.	Range & Output	Accu racy	Data Fig. No.	Measurement comments
368	Flow	F -24	JP - 3.4 Outlet			0∿30 ℓ/sec 0∿10 V			not measured
369	"	-25	Break A			0∿30kg/sec 0∿10 V			"
370	Press.	P -17	JP - 1.2 Outlet			0∿100kg/cm^2 0∿10 V			"
371	"	-18	JP - 3.4 "			"			"
372	"	-19	Break A			"			"
373	Temp	T -24	JP - 1.2 Outlet			0 ∿ 400 °C 0 ∿ 10 V			"
374	"	-25	JP - 3.4 "			"			"
375	"	-26	Break A			"			"

Table 4.1 Test Conditions of the ROSA-III RUN 704

Parameter		Specified Value	Measured Value
Break Conditions			
Location		Recirculation pump suction line	Recirculation pump suction line
Type		Double-ended	Double-ended
Break Orifice Diameter	(mm)	26.2	26.2
Initial System Conditions			
Steam Dome Pressure	(MPa)	7.16	7.04
Lower Plenum Temperature	(K)	----	560
Lower Plenum Subcooling	(K)	----	14.0
Core Inlet Flow Rate	(kg/s)	36.4	35.7
Broken Loop Flow Rate	(m^3/s)	----	2.34×10^{-3}
Intact Loop Flow Rate	(m^3/s)	----	2.42×10^{-3}
Core Outlet Quality	(-)	----	0.034 (Estimated)
Power Level	(kW)	3384 (524+846+2014)	3268 (418+843+2007)
Maximum Linear Heat Rate			
of Region 1 [39 rods]	(kW/m)	10.0	7.98
Region 2 [63 rods]	(kW/m)	10.0	9.96
Region 3 [150 rods]	(kW/m)	10.0	9.96
Power Curve		Fig 2.5	Fig 5.1
Water Level in PV	(m)	4.62	4.62
Feedwater Conditions			
Steady State Line			
Temperature	(K)	----	294
Flow Rate	(m^3/s)	----	1.15×10^{-3} (Fig 5.15)

Table 4.1 (Continued)

Parameter		Spesified Value	Measured Value
Feedwater Conditions (Continued)			
Transient Line			
Temperature	(K)	478	478
Flow Rate	(m^3/s)	$2.41x10^{-3}$	(Fig 5.15)
Termination Time	(s)	2.0	2.5 − 5.0
Steam Discharge Conditions			
Steady State Line			
Flow Rate	(kg / s)	----	Not Measured
Transient Line			
Flow Rate	(kg / s)	----	Not Measured
Orifice Diameter	(mm)	20.0	20.0
Termination Time	(s)	3.0	4.5 − 7.0
ECCS Conditions			
HPCS			
Injection Location		Upper plerum	Upper plenum
Initiation Time	(s)	27.0	27.0
at Pressure in PV	(MPa)	----	----
Water Level in PV	(m)	----	----
Coolant Temperature	(K)	----	297
Injection Flow Rate	(m^3/s)	$2.28x10^{-4}$ at 8.0 MPa $9.67x10^{-4}$ at0.95 MPa	Fig 5.14

Table 4.1 (Continued)

Parameter		Specified Value	Measured Value
ECCS Conditions (Continued)			
LPCS			
Injection Location		Upper plenum	Upper plenum
Initiation Time	(s)	----	66.0
at Pressure in PV	(MPa)	2.16	2.00
Water Level in PV	(m)	----	----
Coolant Temperature	(K)	----	297
Injection Flow Rate	(m^3/s)	$9.67x10^{-4}$	Fig 5.14
LPCI			
Injection Location		in-shroud	in-shroud
Initiation Time	(s)	13 s after LPCS activation	80.0
at Pressure in PV	(MPa)	----	1.59
Coolant Temperature	(K)	----	297
Injection Flow Rate	(m^3/s)	$3.83x^{-3}$	Fig 5.14
ADS Conditions			
Valve Opening Time	(s)	120	87.8 (completely opened at 132.0 s)
Valve Closed Time	(s)	480	480 (Approx.)
Flow Rate	(m^3/s)	----	Not Measured
Orifice Diameter	(mm)	6.0	6.0

Table 4.2 Valve Caracteristics of Steam Discharge Line

Valve	Close to Open (sec)	Open to Close (sec)
AV165 (MSIV Valve)	0.1	1.5
AV168 (Steady State Line)	-	0.1
AV169 (ADS Valve)	0.3	2.0

Orifice	Diamater (mm)	Area (mm^2)
OR3	Not Used	-
OR4	6.0	28.27
OR5	20.0	314.16

Table 5.1 Sequence of Events in RUN 704

Time After Break (s)	Events
0.0	Break (as 100% split) Initiation of core power control (1) Terminate intact loop recirculation pump power Terminate broken loop recirculation pump power
1.7	Break (as 200% double-ended) QSV closure
2.5	Initiation of feed water valve closure
4.0	Closure of feed water line
4.5	Initiation of steam discharge line valve closure
7.0	Closure of steam discharge line
10	Jet pump suction nozzle uncovery
12	Recirculation pump suction nozzle uncovery
12.7	Initiation of core power reduction
13	Exposure of rod above core mid plane (pos. 4)
17	Lower plenum flashing initiation
19	Rewetting at pos.4
27.0	HPCS injection initiation
40	Reexposure at pos.4
66.0	LPCS injection initiation
72	Increase in core mixture level
80.0	LPCI injection initiation
84	Quench at pos.4
97	Quench at pos.3
110	Quench at pos.2
116	Quench at pos.1
132.0	ADS valve opening
(480)*	ADS valve closure End of data acquisition

Notes: (1) See Fig. 5.1

* Approximate value

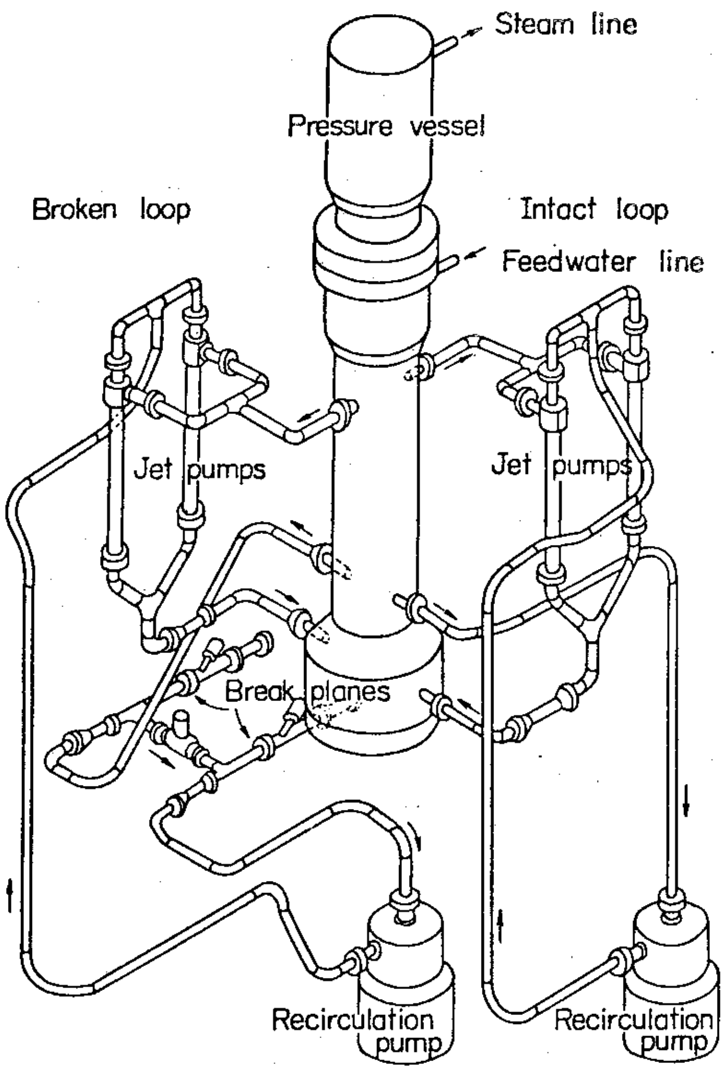


Fig. 2.1 Schmatic Diagram of ROSA-III Test Facility

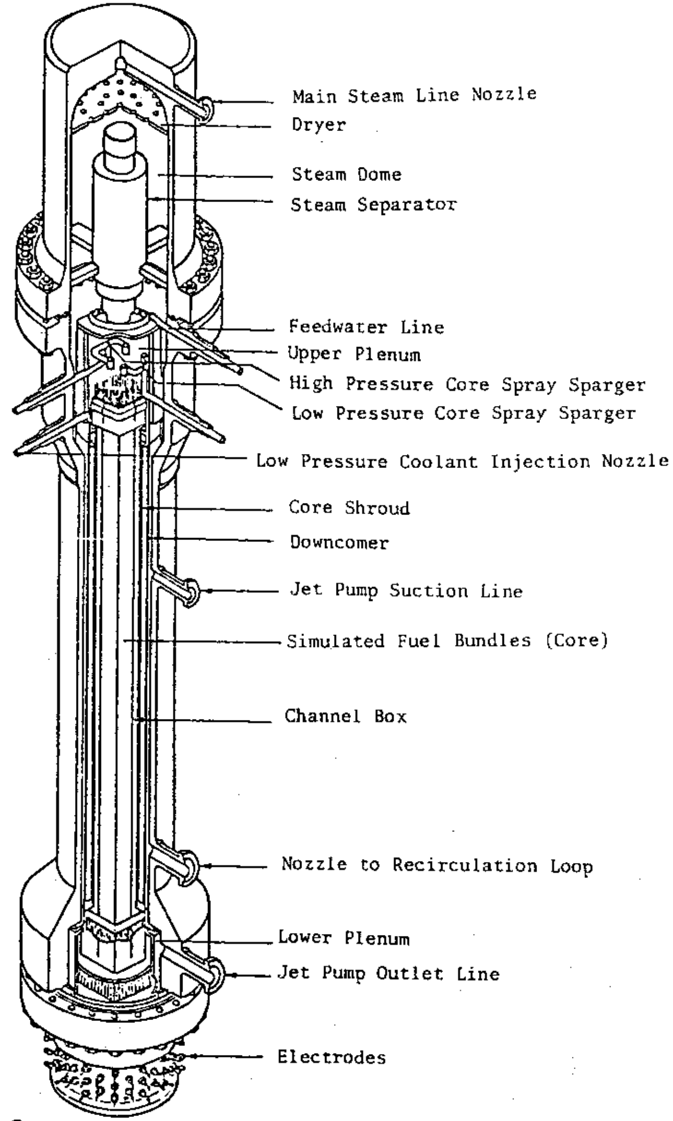


Fig. 2.2
Internal Structure of Pressure Vessel of ROSA-III

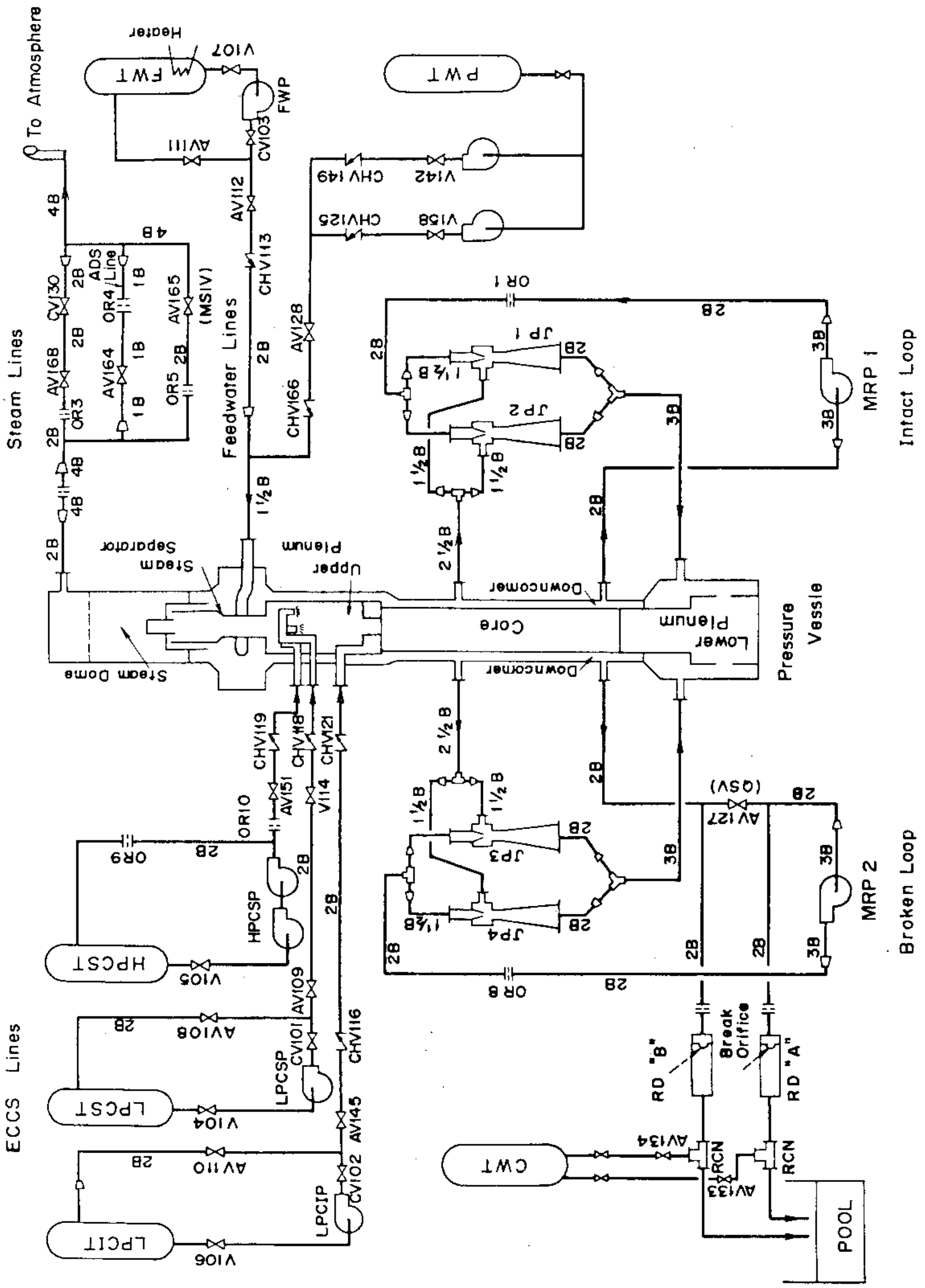
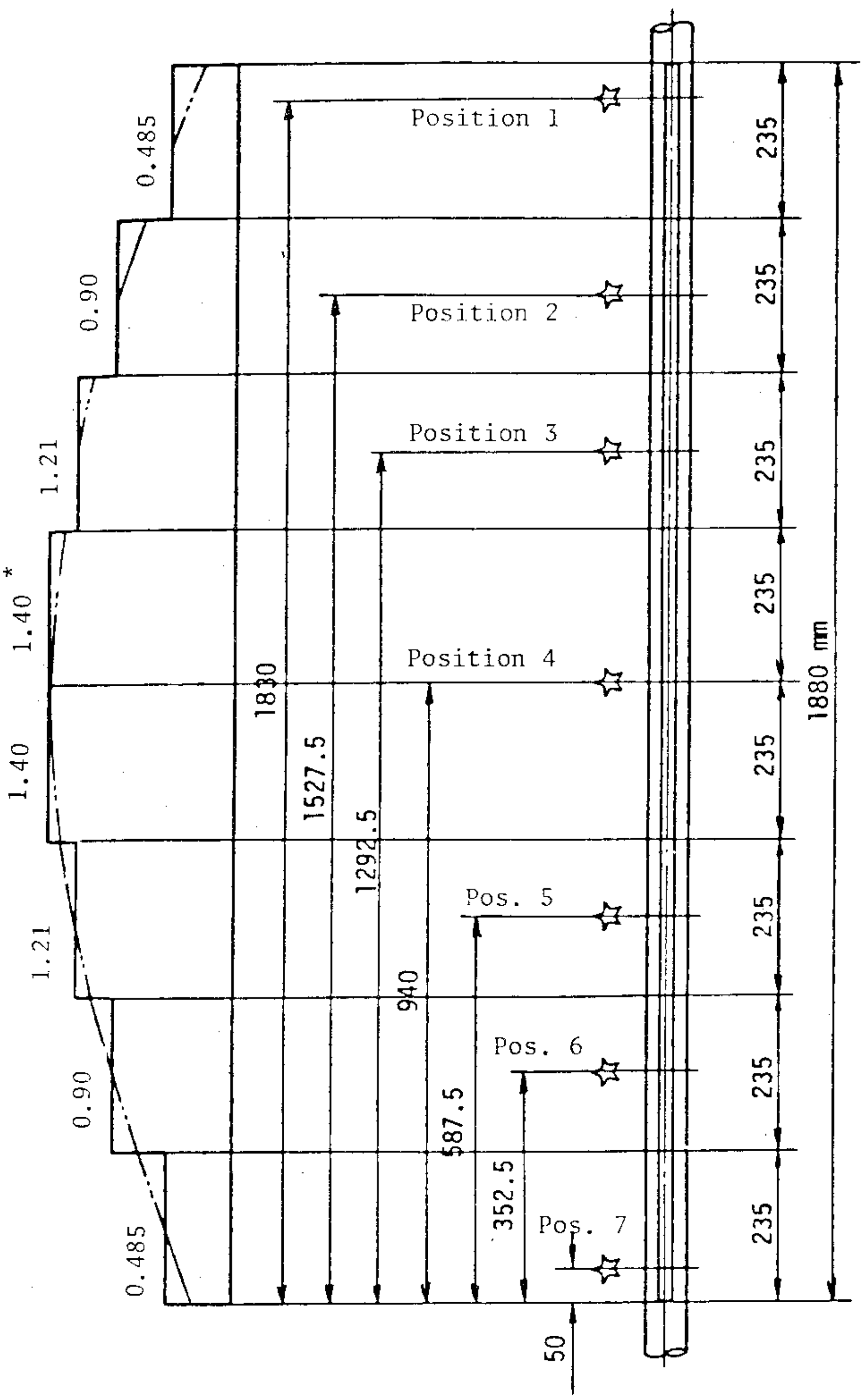


Fig. 2.3 ROSA-III piping schematic.



☆ indicates position of thermocouple. * Axial Peaking Factor

Fig. 2.4 Axial power distribution of heater rod.

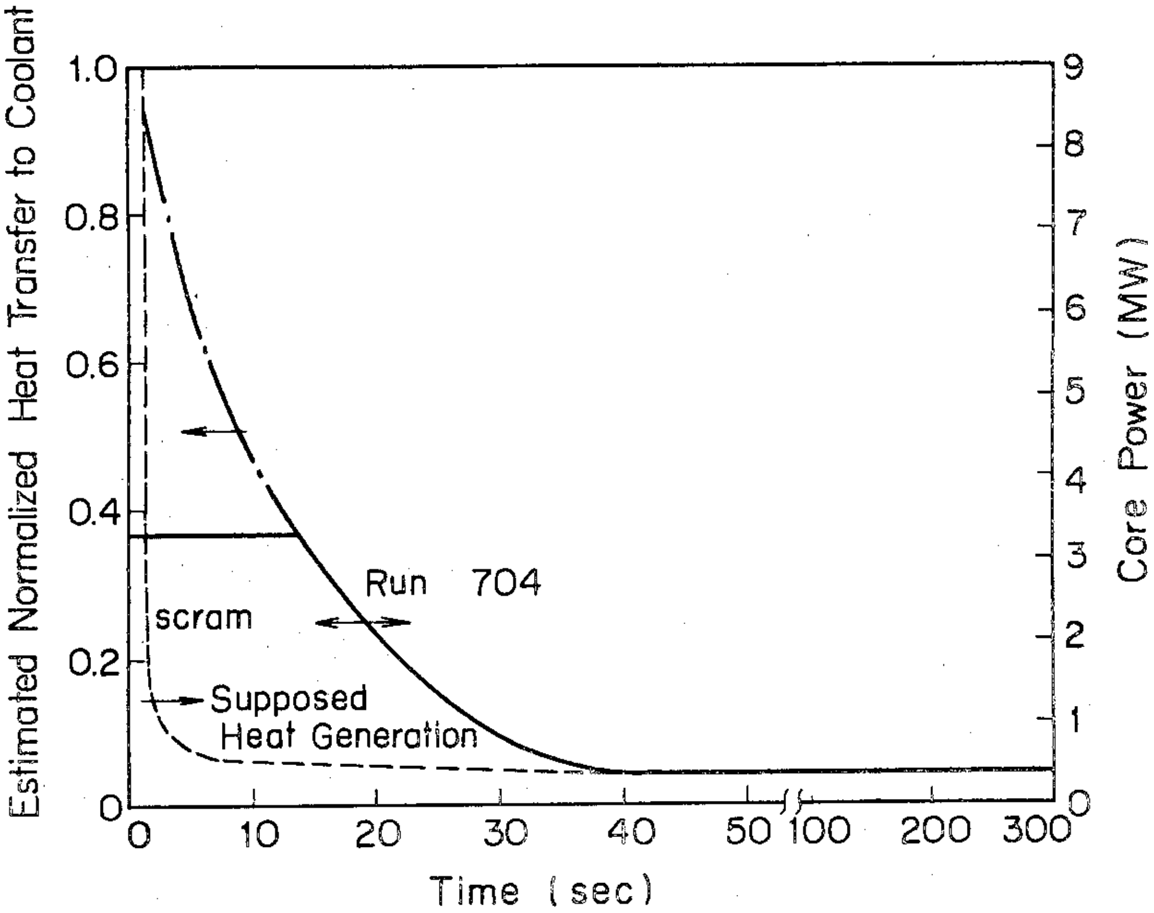


Fig. 2.5 Specified Transient Power Curve

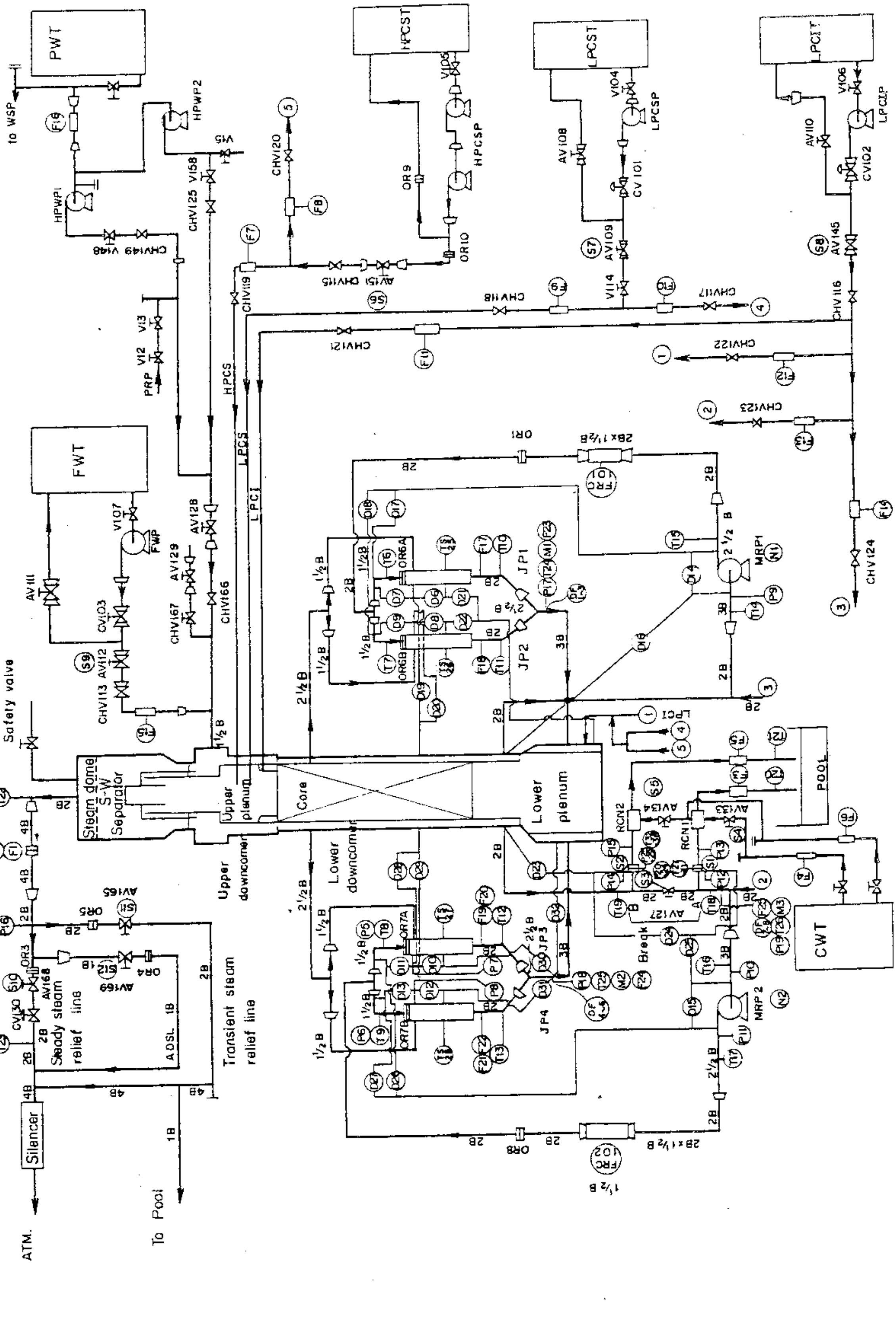


Fig. 3.1 Flow Diagram and Instrumentation Location of ROSA-III Facility

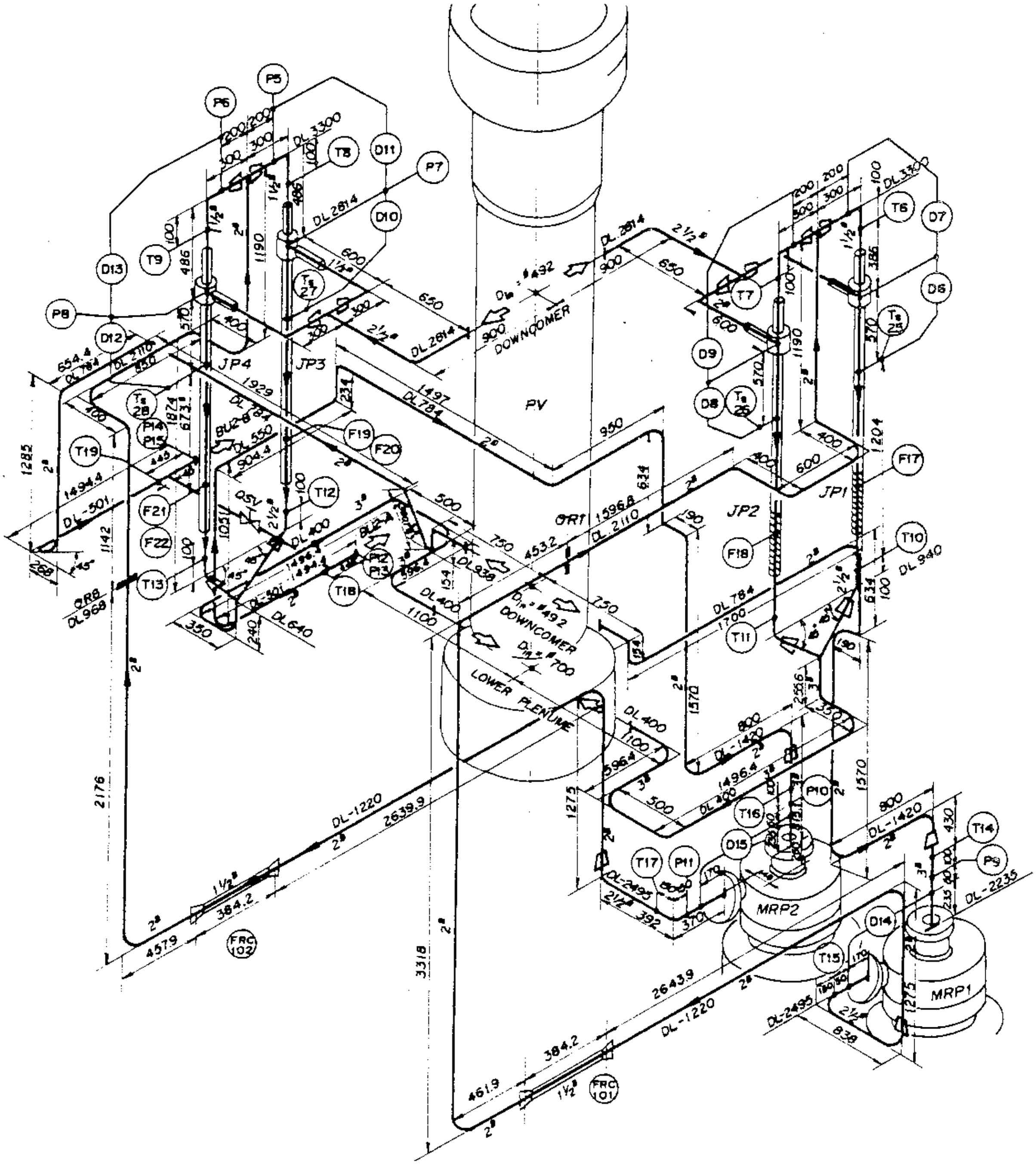


Fig. 3.2 ROSA-III Recirculation Loops with Instrumentation

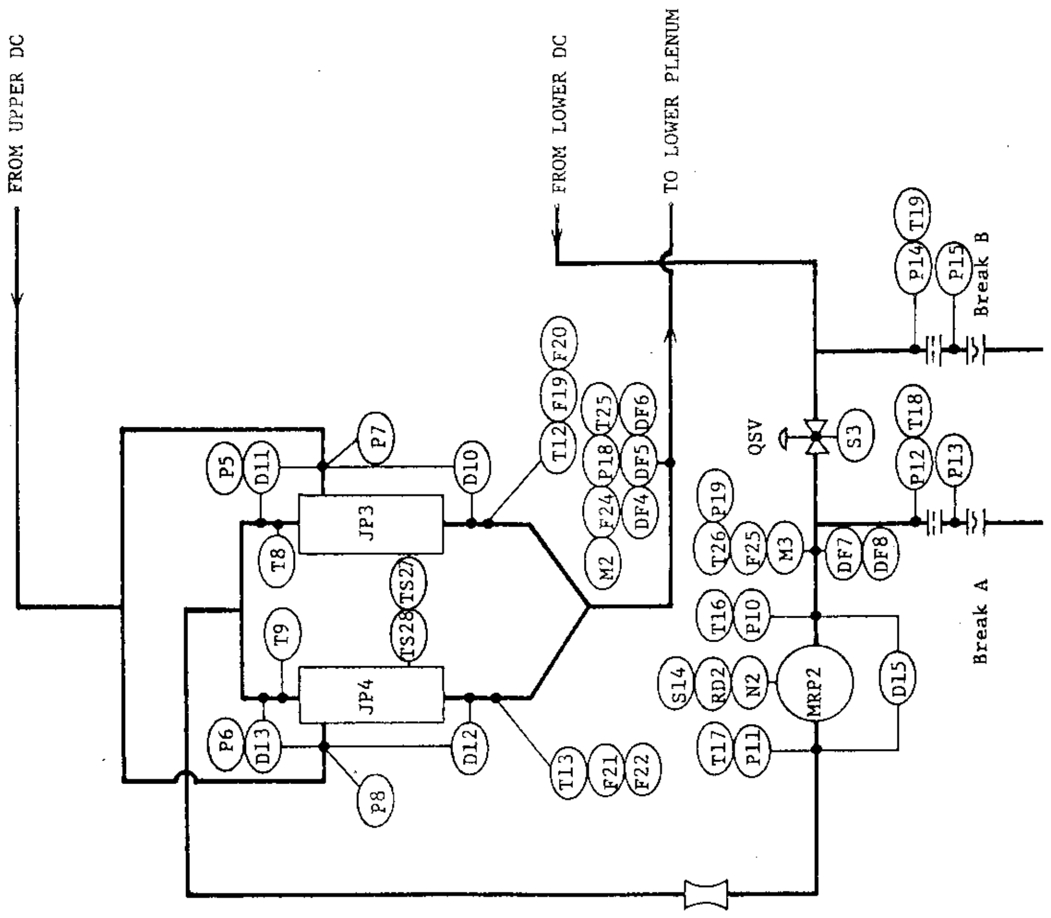


Fig. 3.3　Instrumentation in the Broken Loop

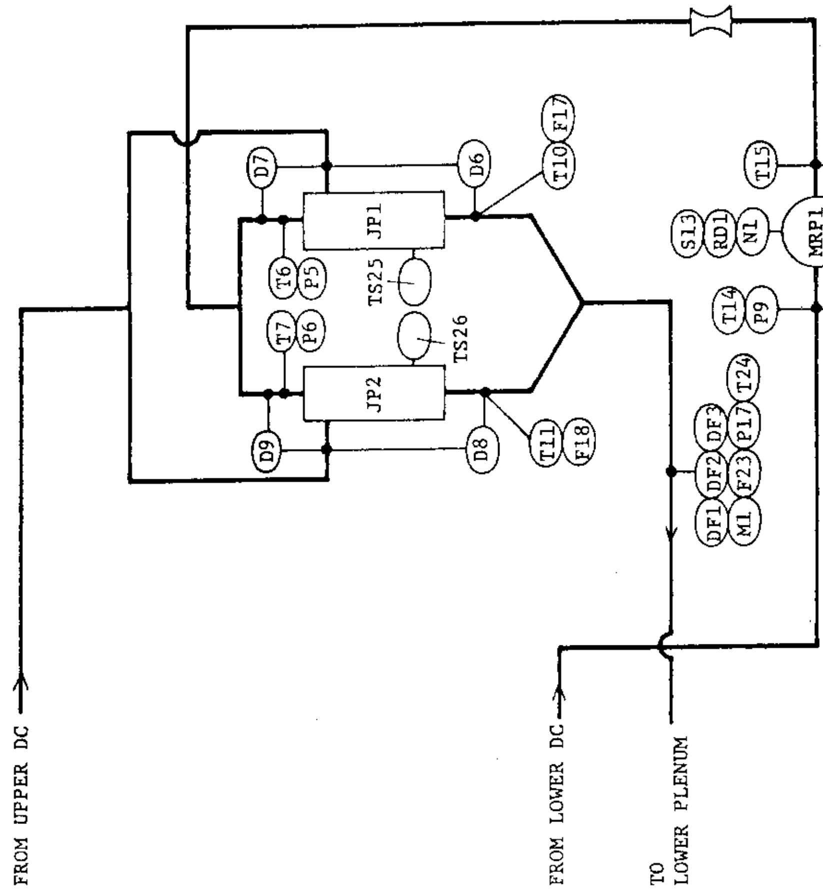


Fig. 3.4　Instrumentation in the Intact Loop

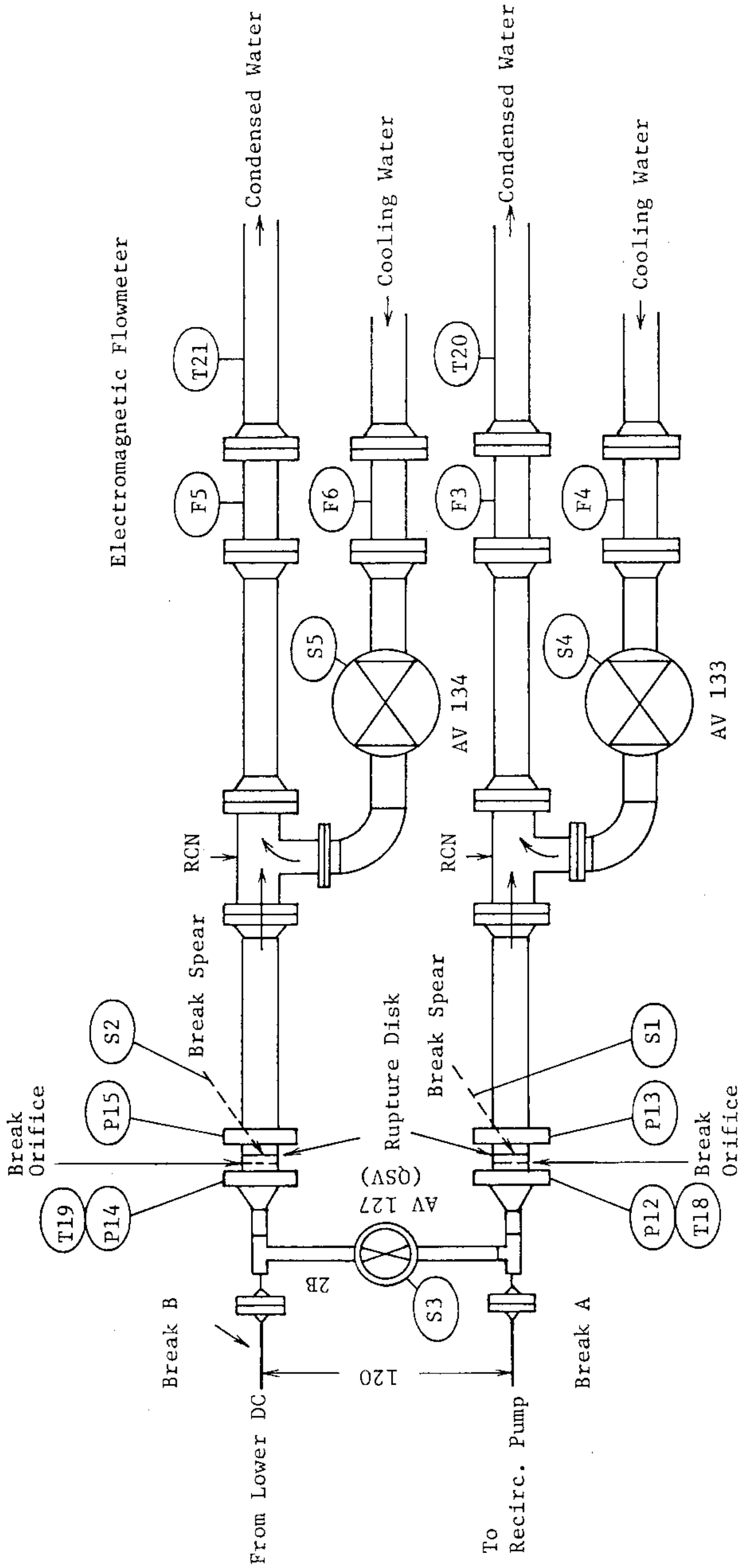


Fig. 3.5 Instrumentation in the break unit.

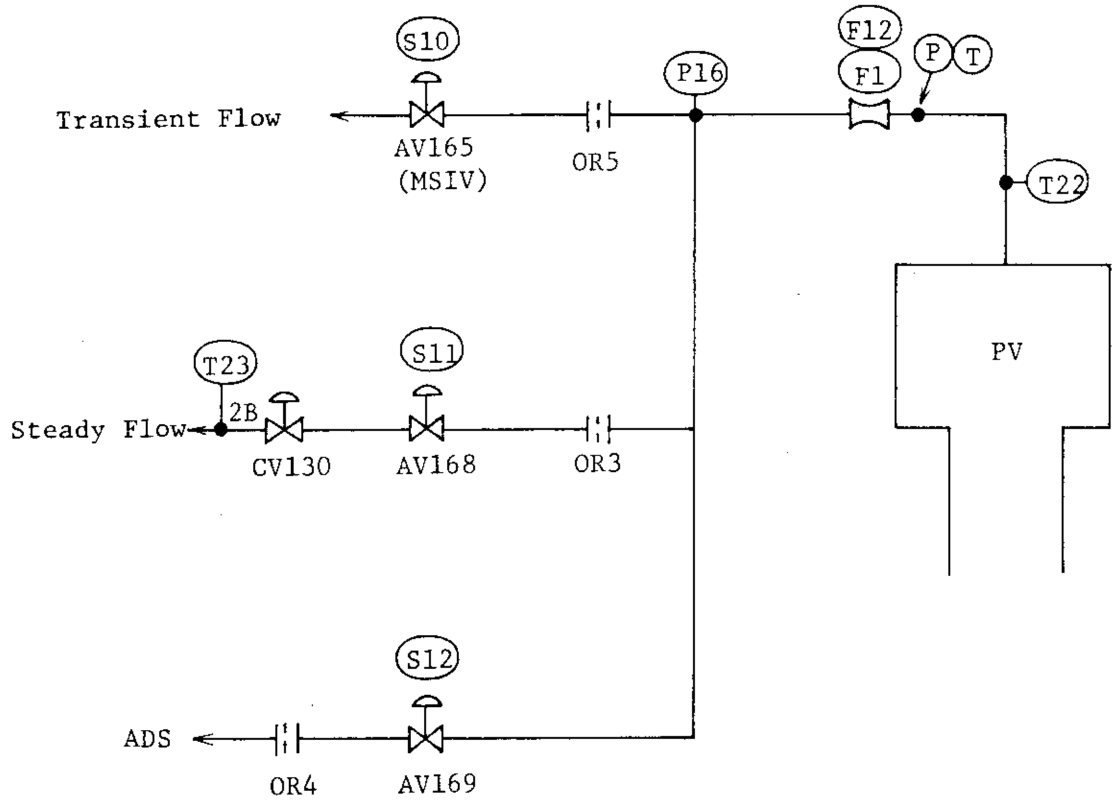


Fig. 3.6 Instrumentation in the Steam Line

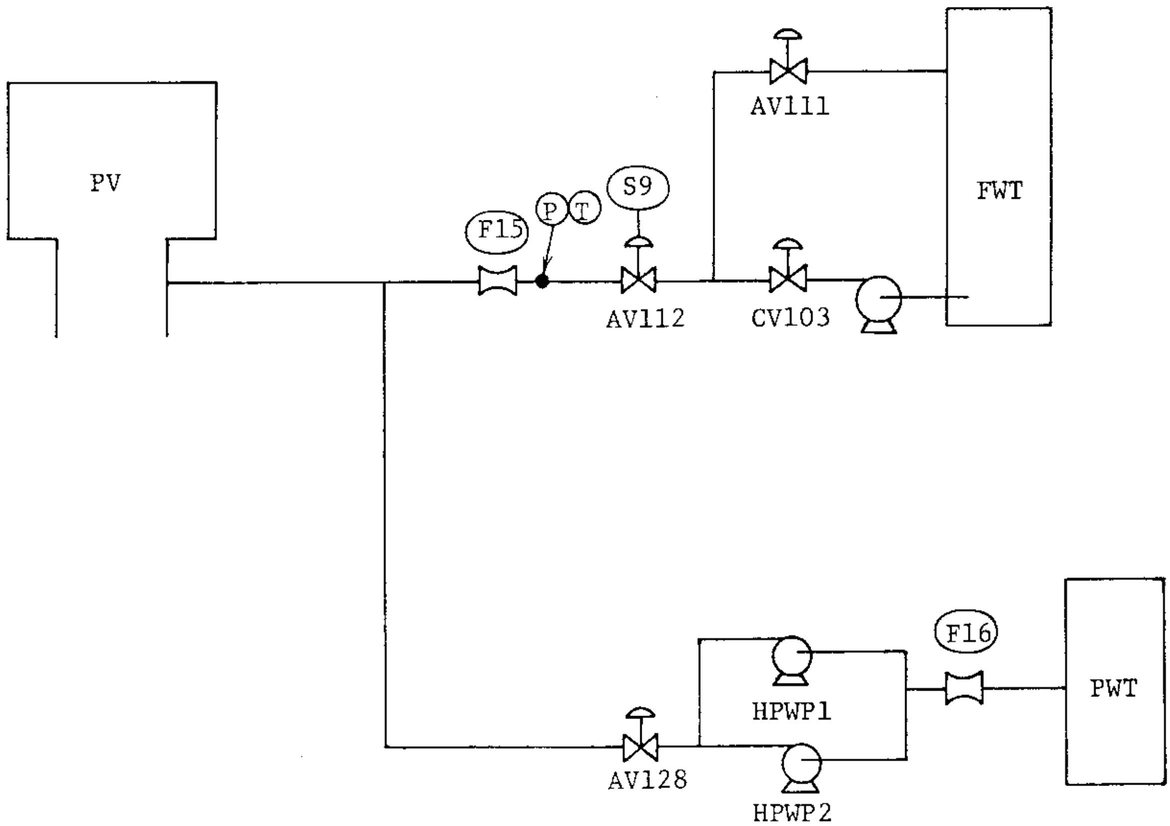


Fig. 3.7 Instrumentation in the feedwater line.

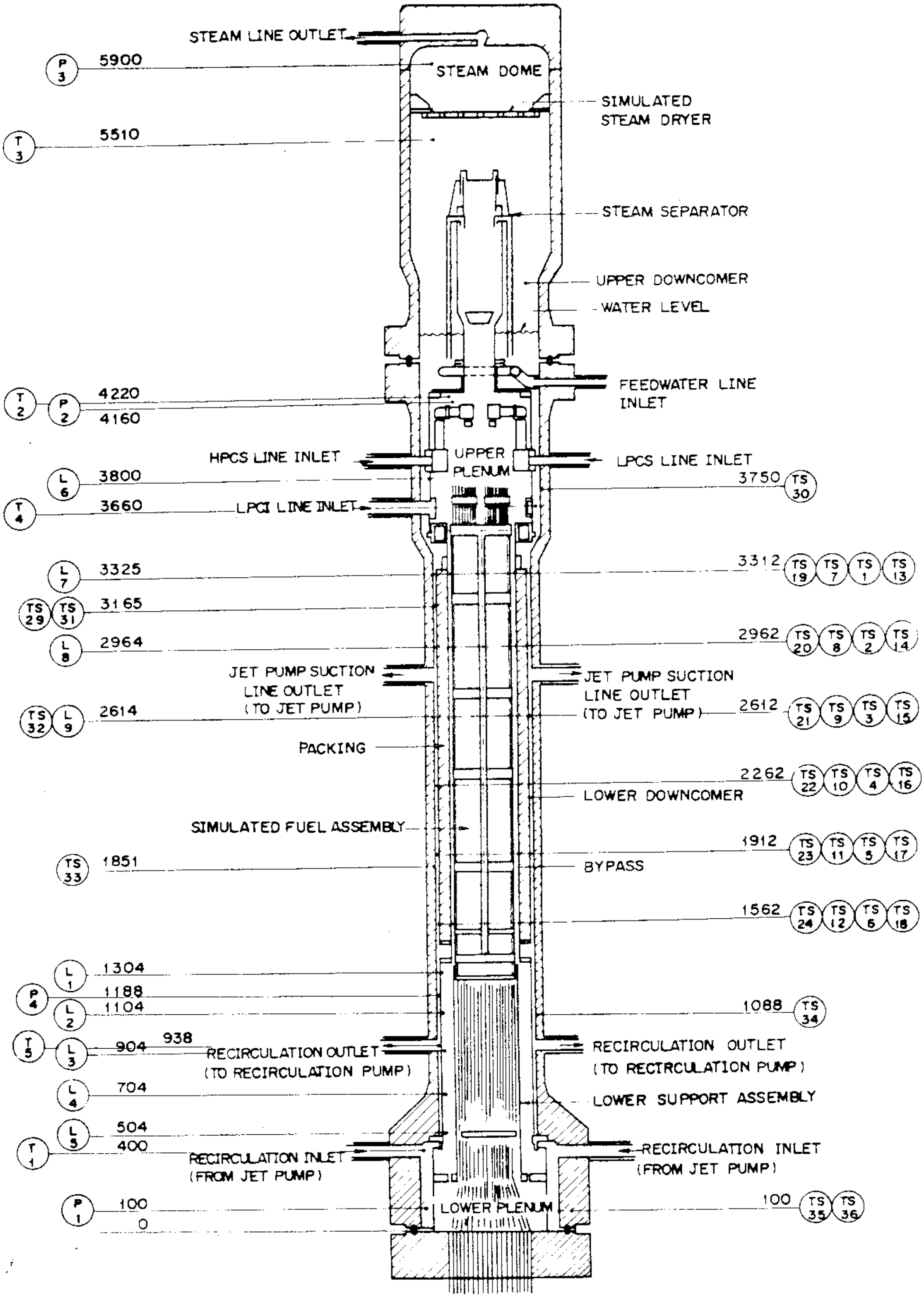


Fig. 3.8 INSTRUMENTATION IN THE ROSA III PRESSURE VESSEL

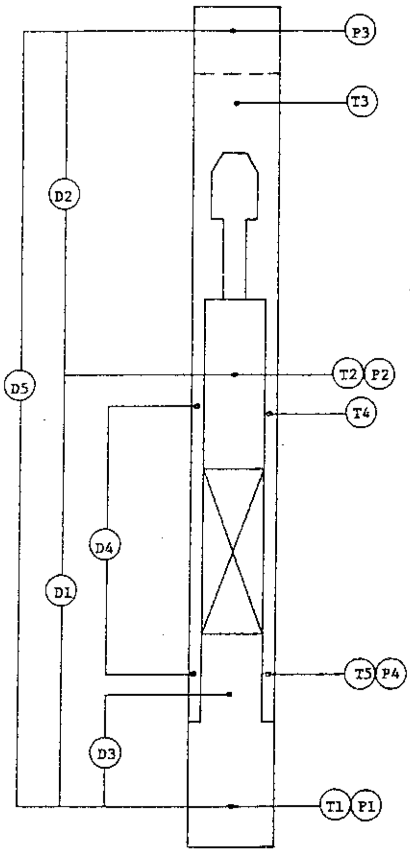


Fig. 3.9 Instrumentation in the Pressure Vessel

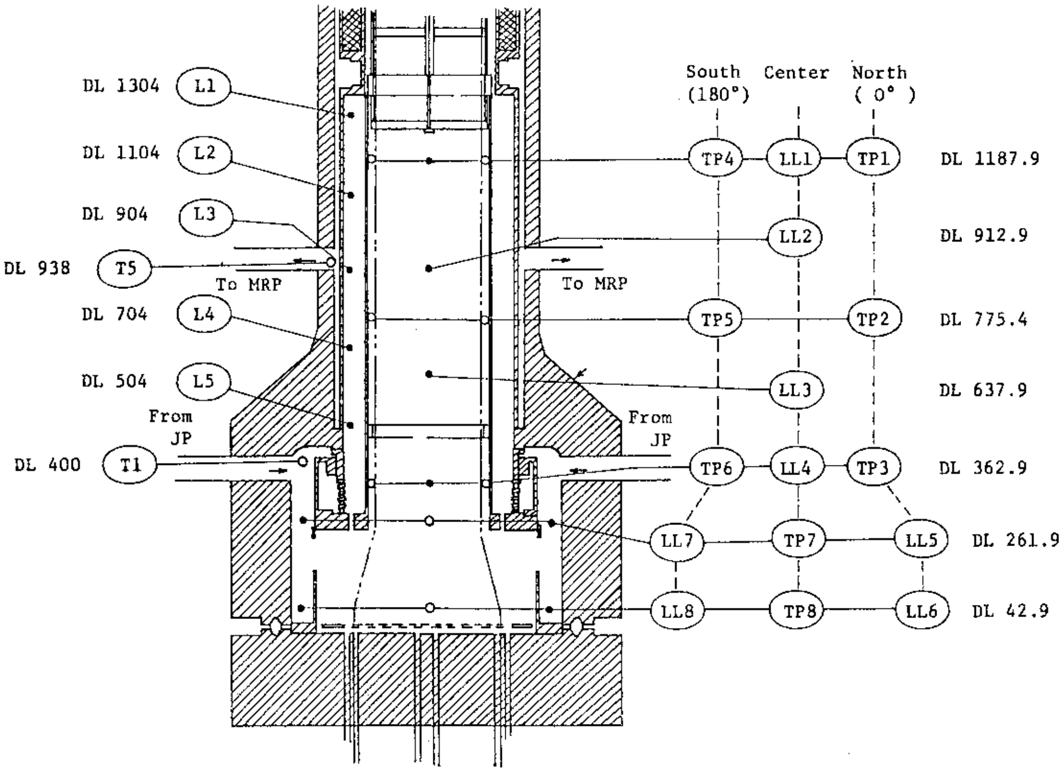


Fig. 3.10 Instrumentation in the Lower Plenum

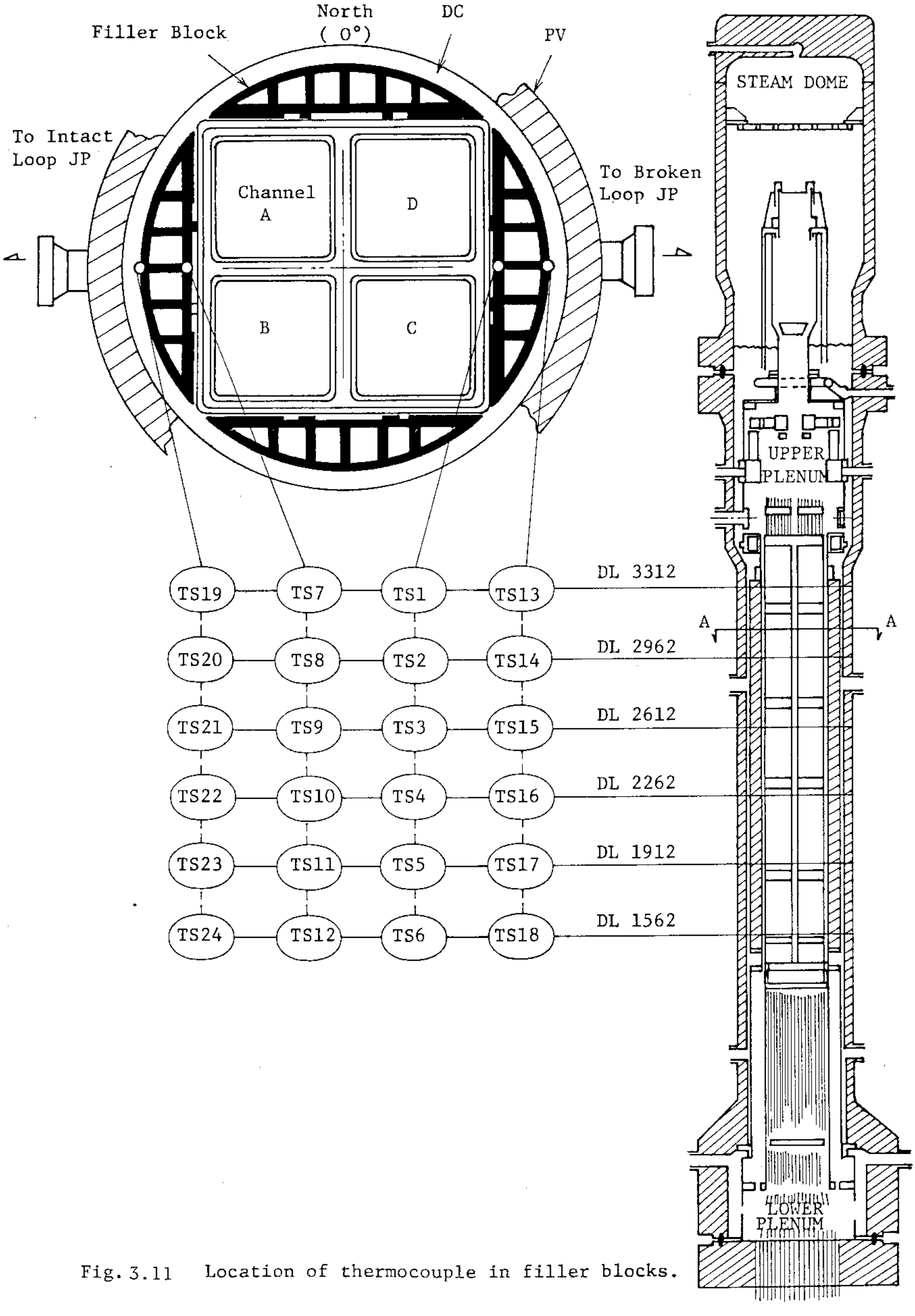


Fig. 3.11 Location of thermocouple in filler blocks.

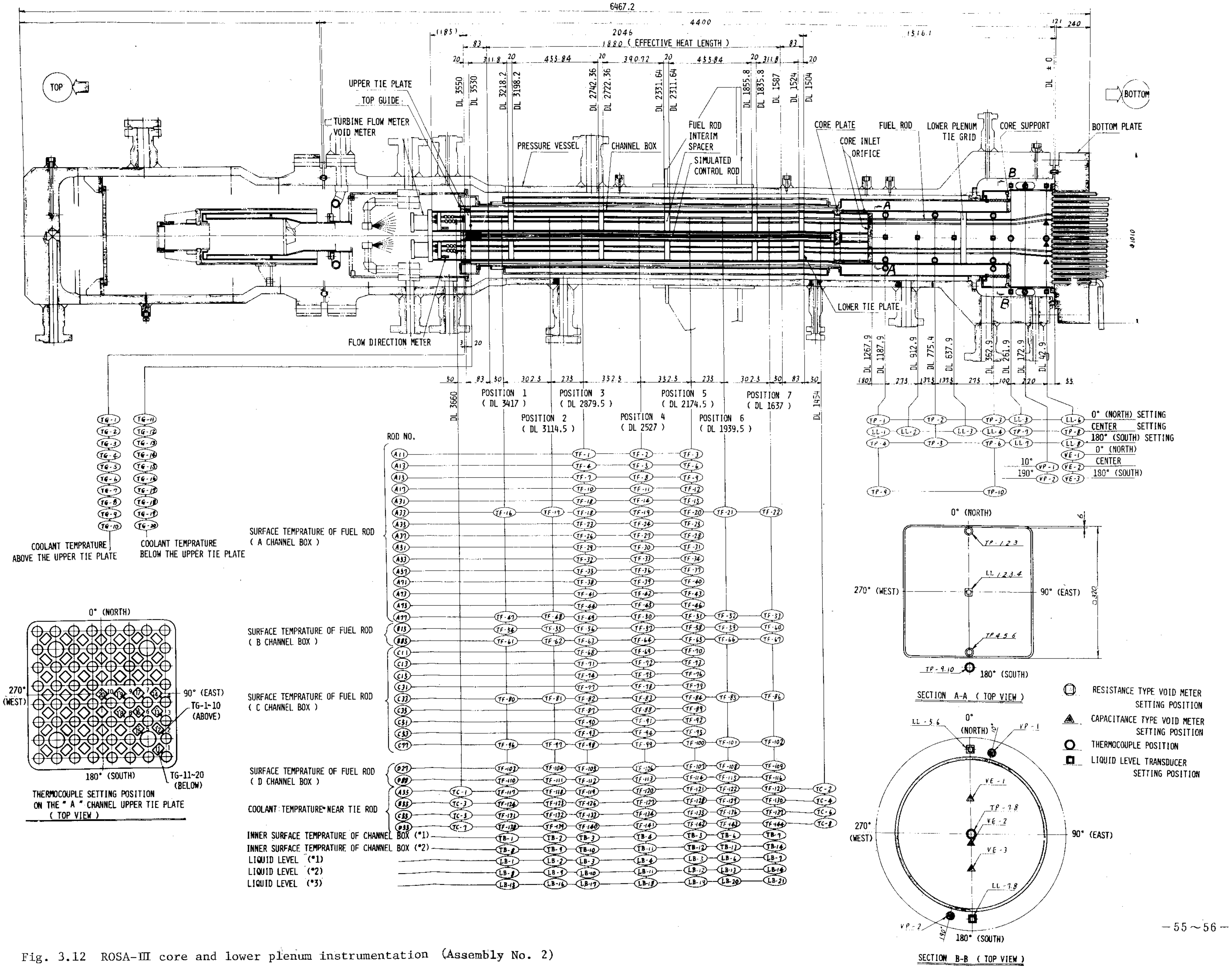


Fig. 3.12 ROSA-III core and lower plenum instrumentation (Assembly No. 2)

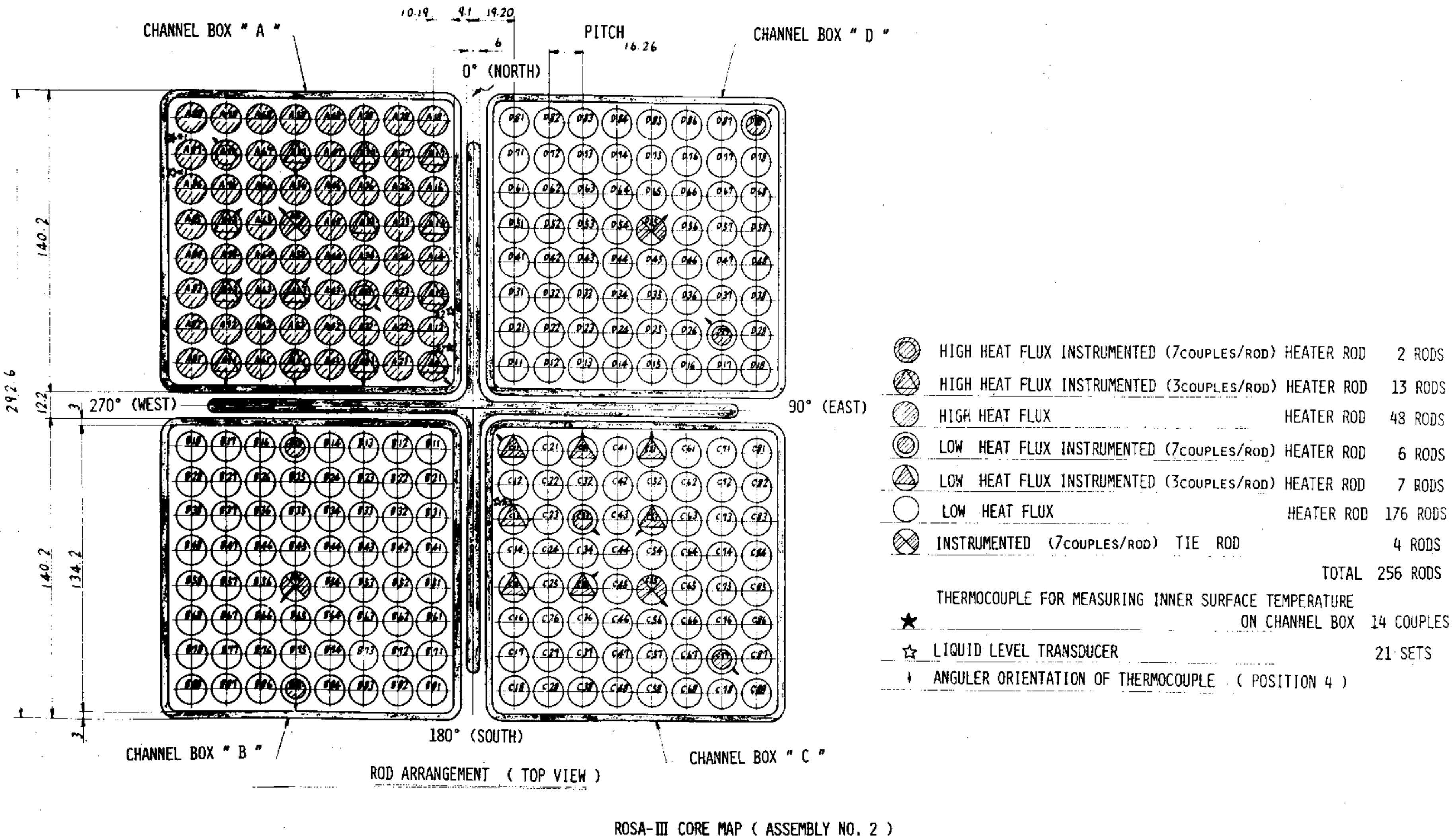


Fig. 3.13 ROSA-III core map

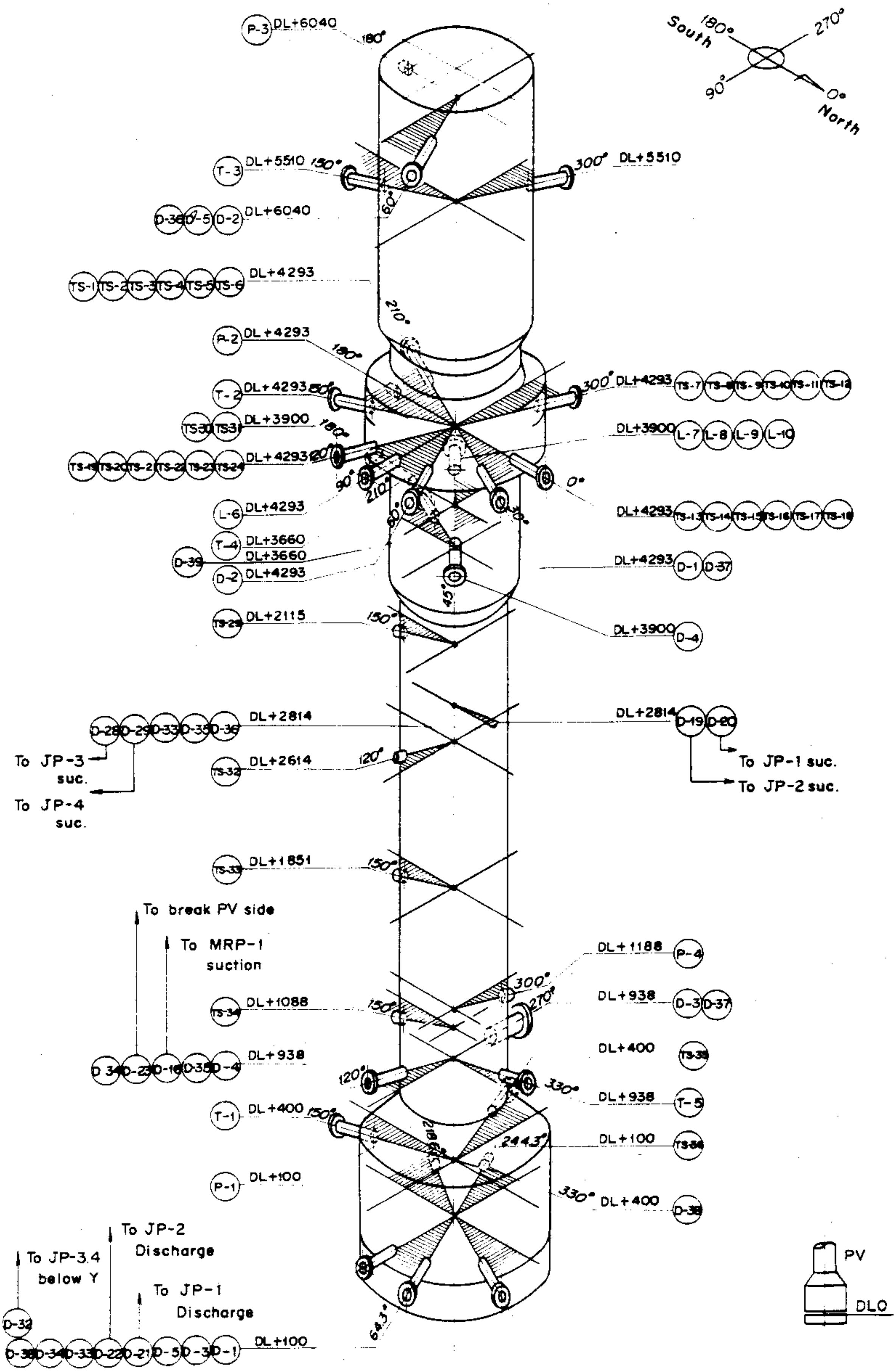


Fig. 3.14 Lead Out Nozzles of Measurement in the Pressure Vessel

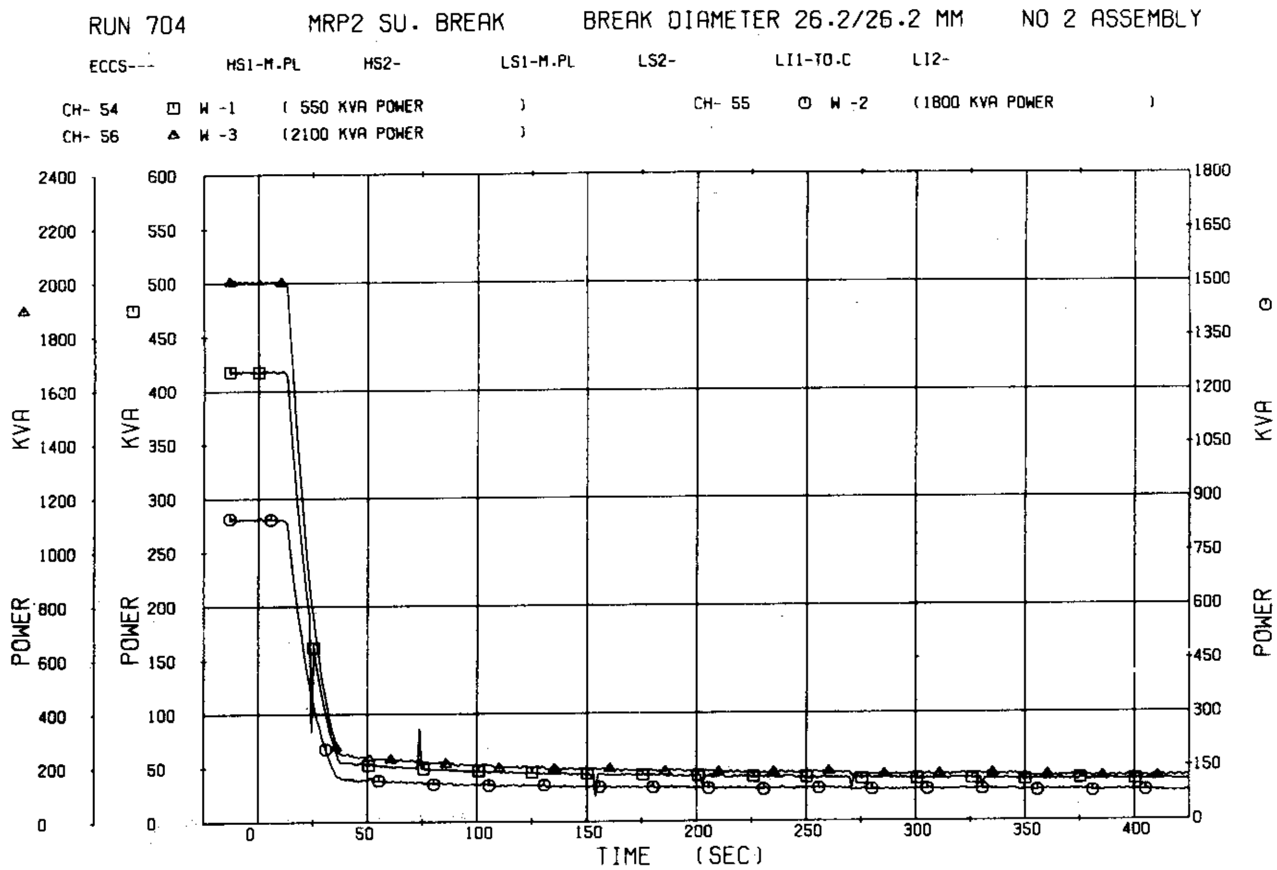


Fig. 5.1 Core Power

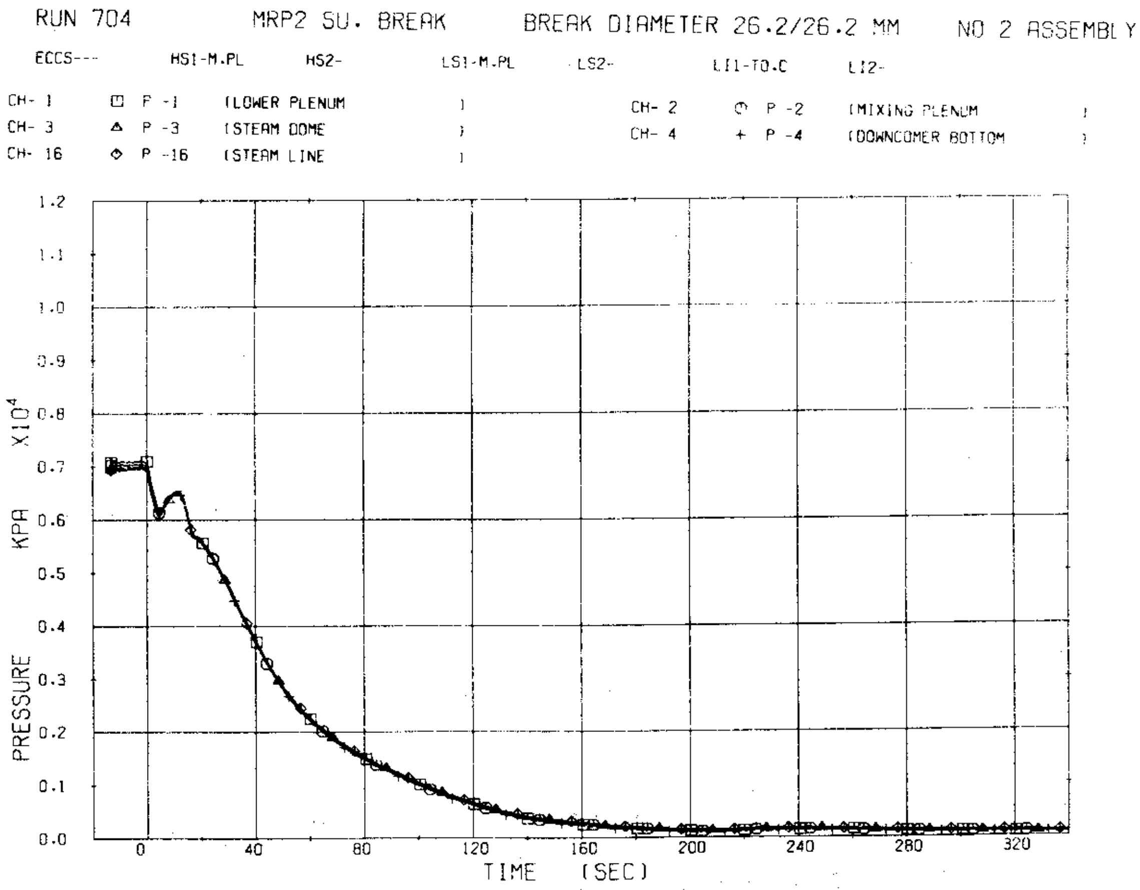


Fig. 5.2 Pressure in the Vessel

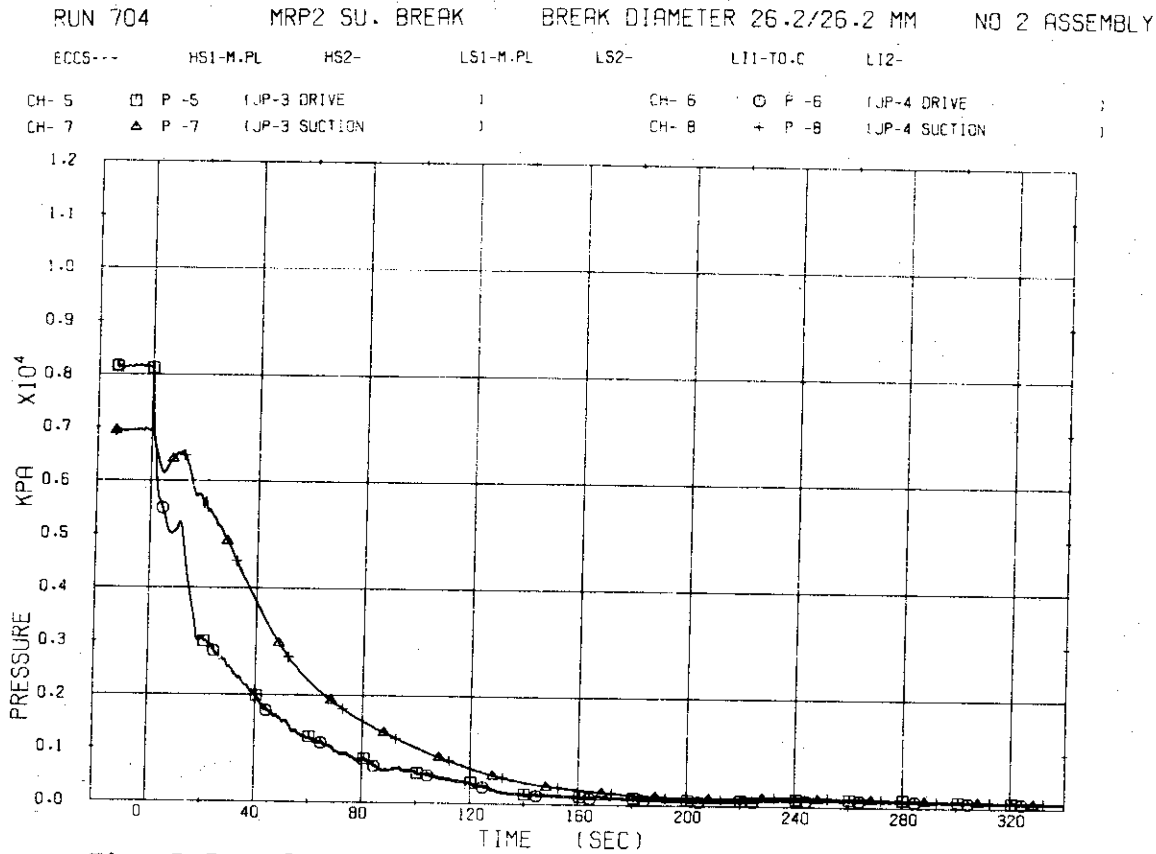


Fig. 5.3 Pressure in Broken Loop Jet Pump

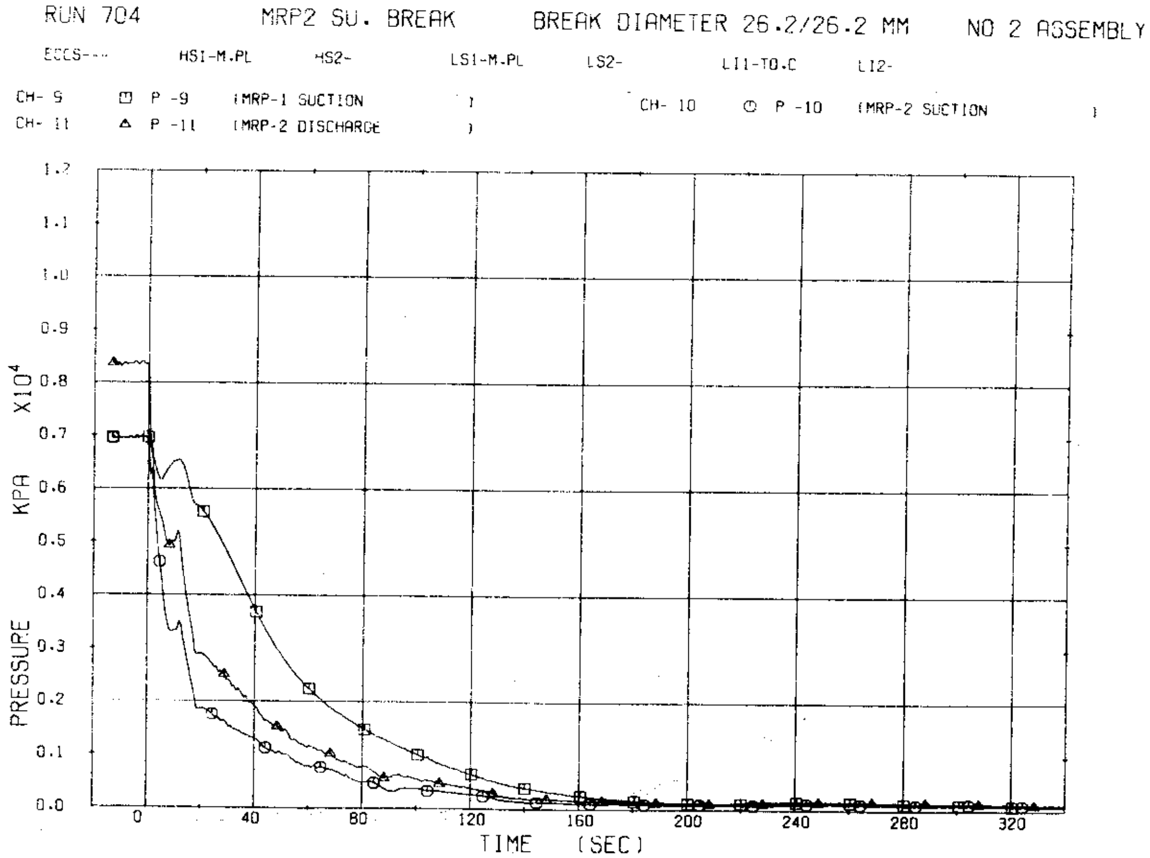


Fig. 5.4 Pressure near the Recirculation Pump

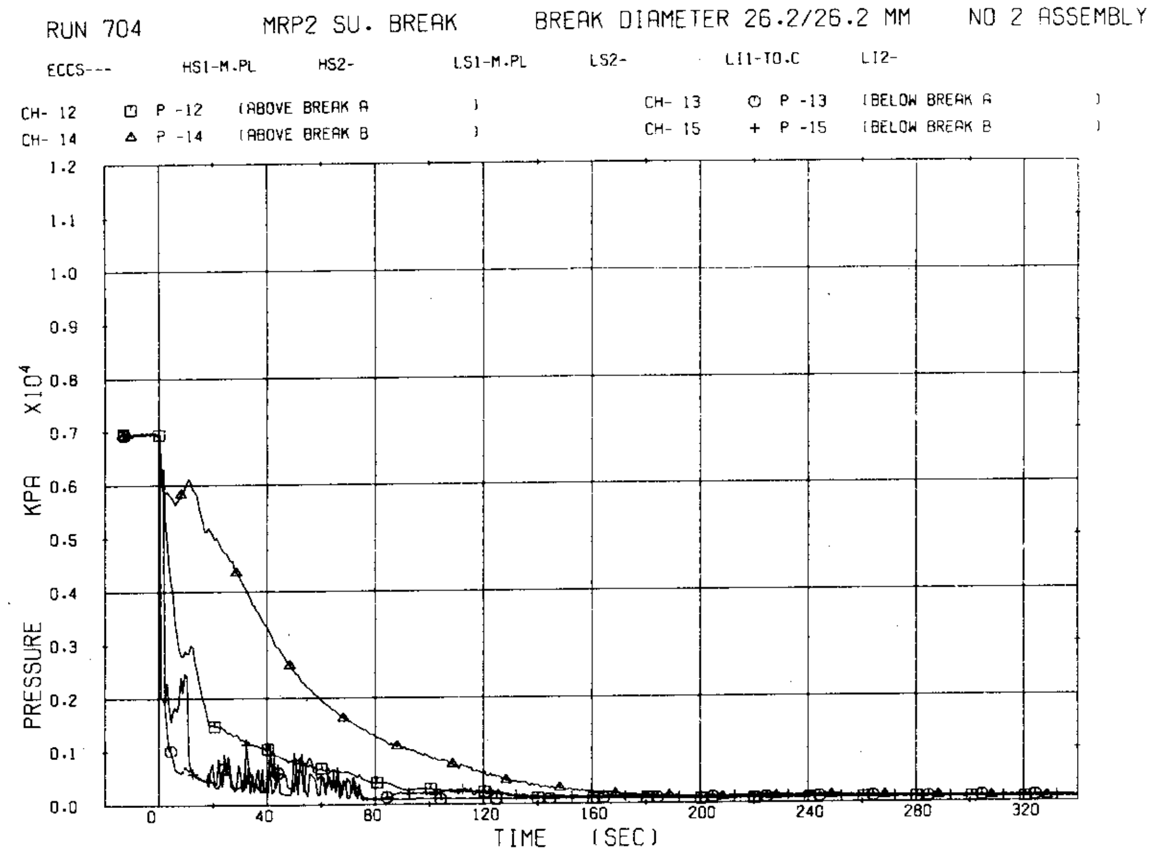


Fig. 5.5 Pressure near the Break A (Pump side) and the Break B (Vessel side)

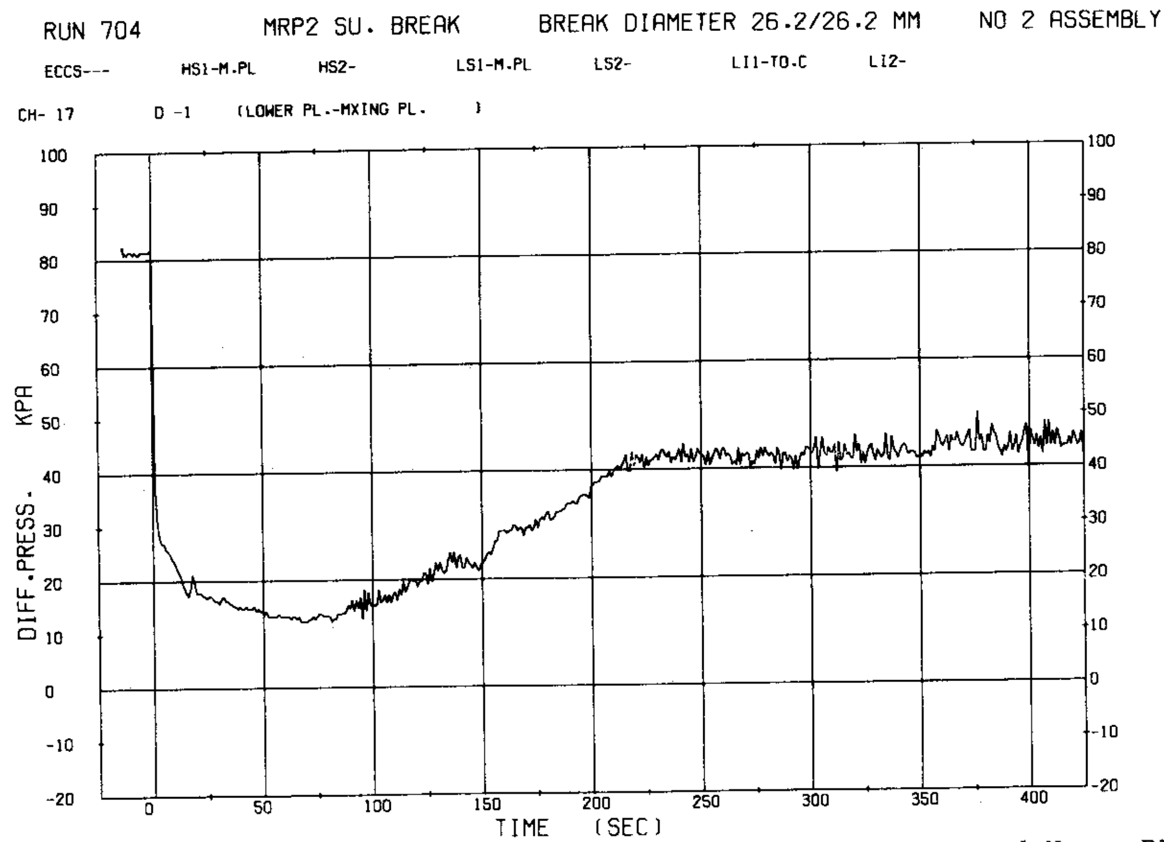


Fig. 5.6 Differential Pressure between Lower Plenum and Upper Plenum

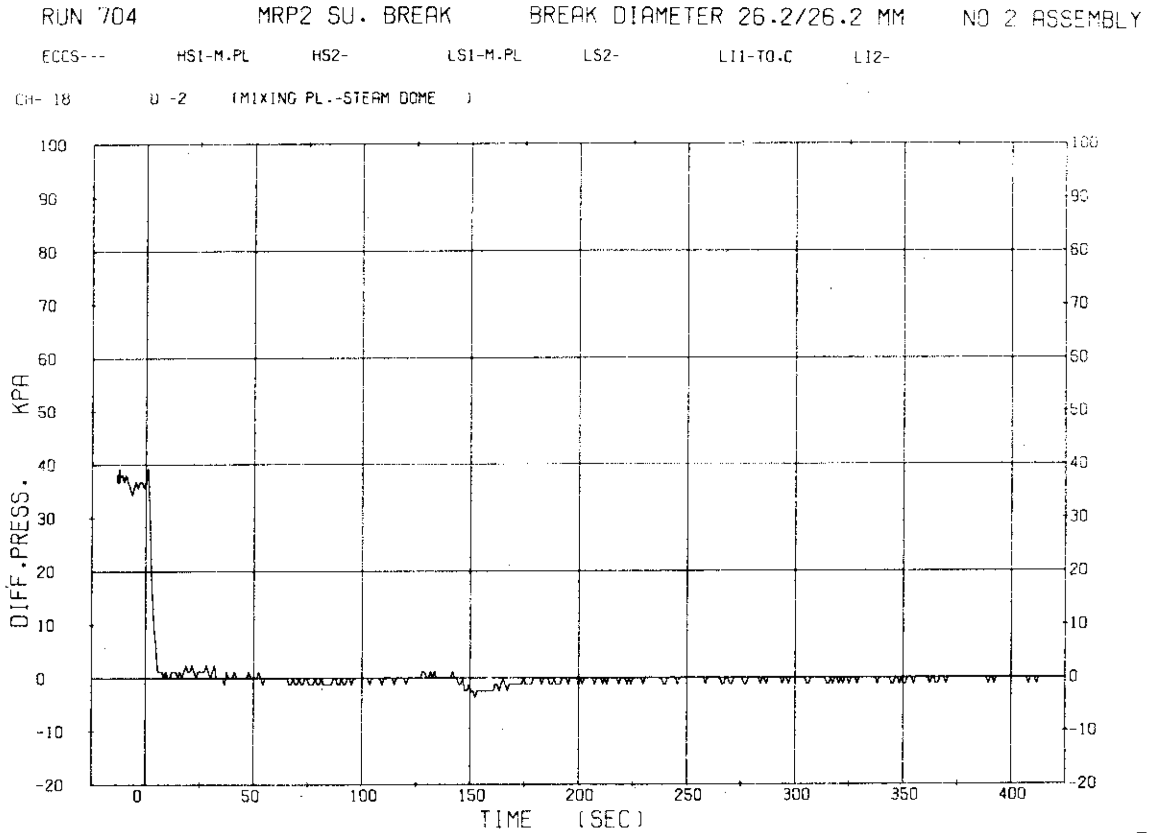


Fig. 5.7 Differential Pressure between Upper Plenum and Steam Dome

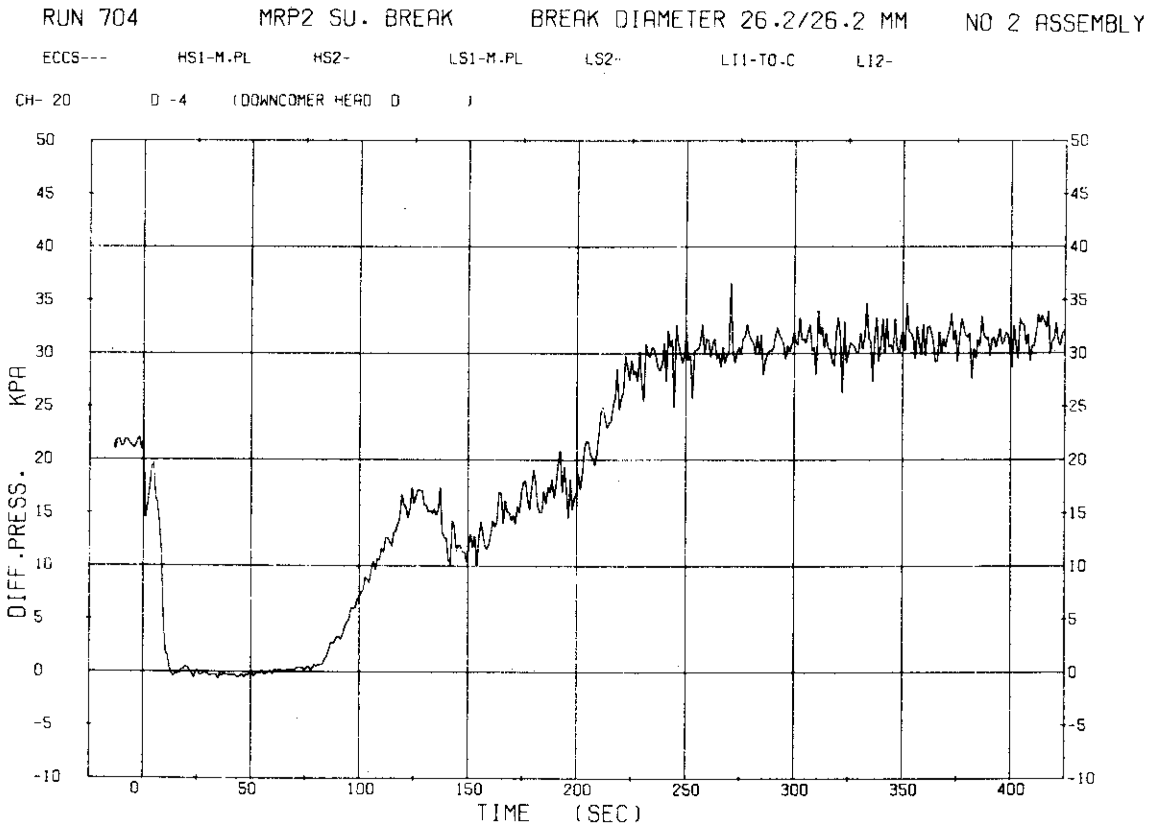


Fig. 5.8 Differential Pressure in the Downcomer

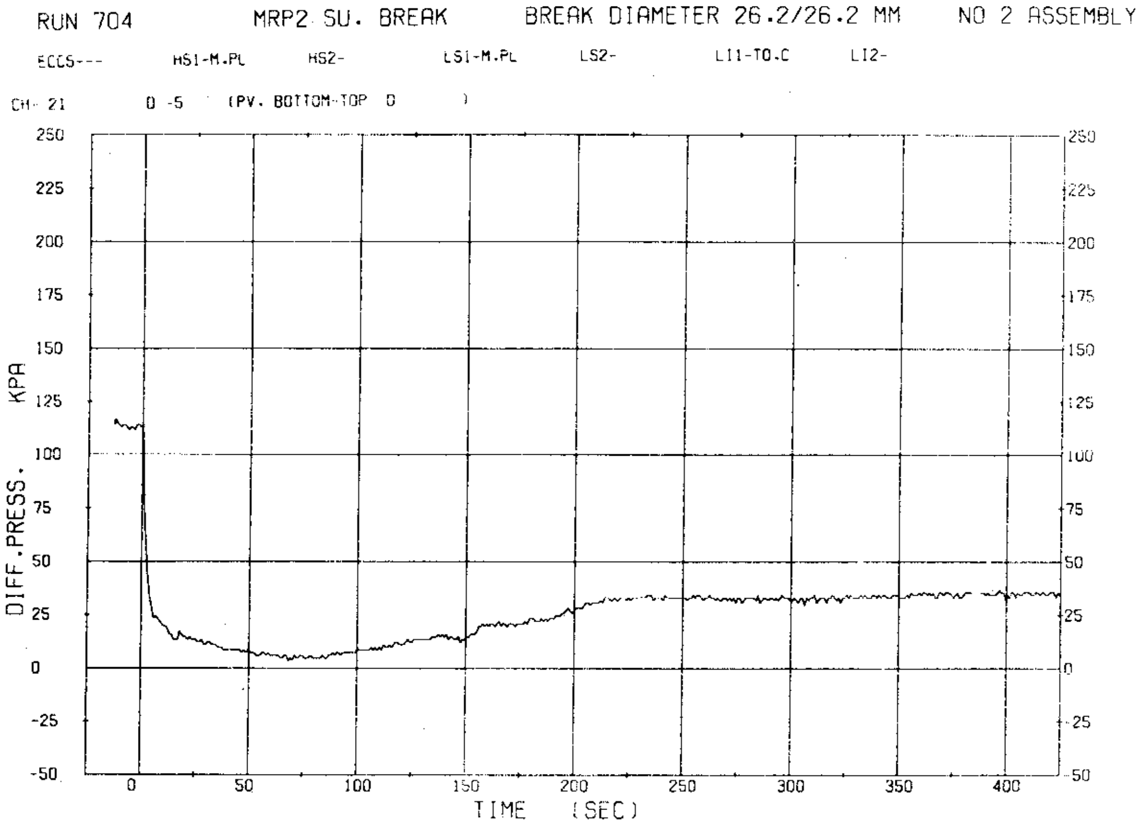


Fig. 5.9 Differential Pressure between Vessel Bottom and Top

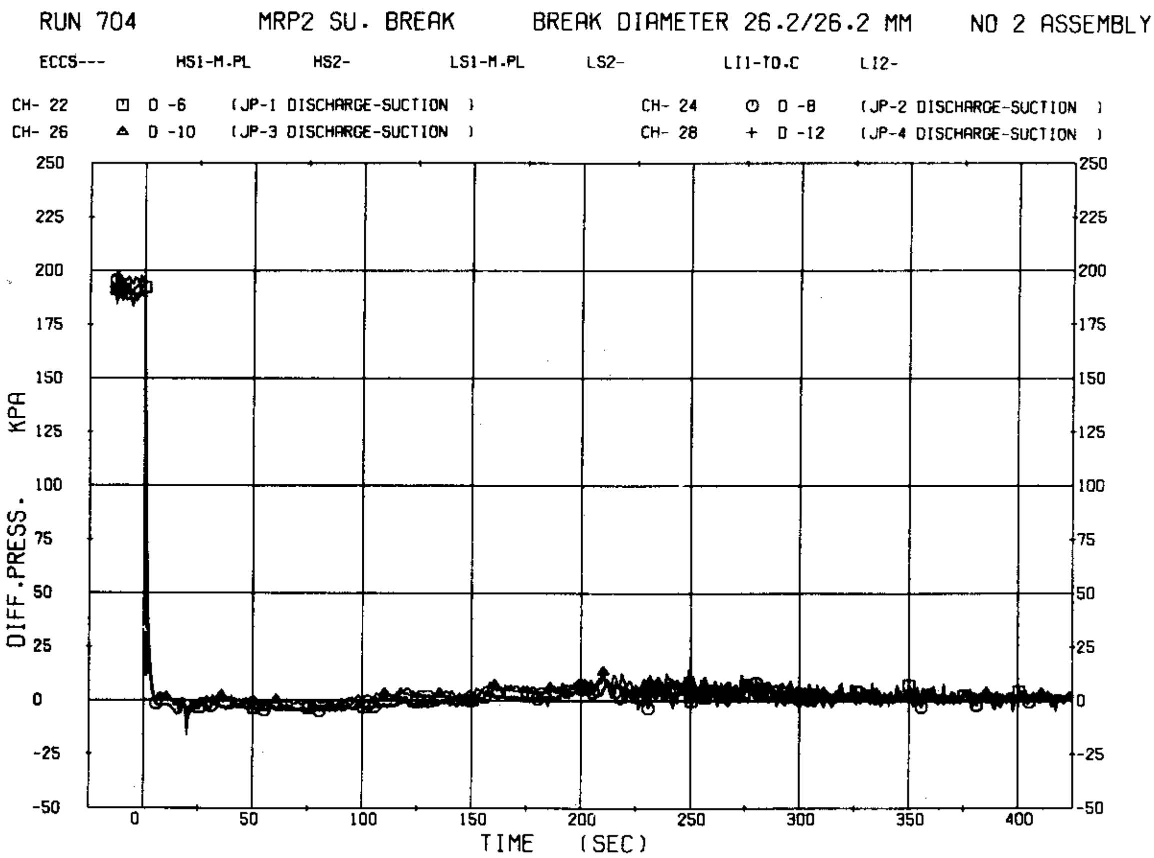


Fig. 5.10 Differential Pressure between Jet Pump Discharge and Suction

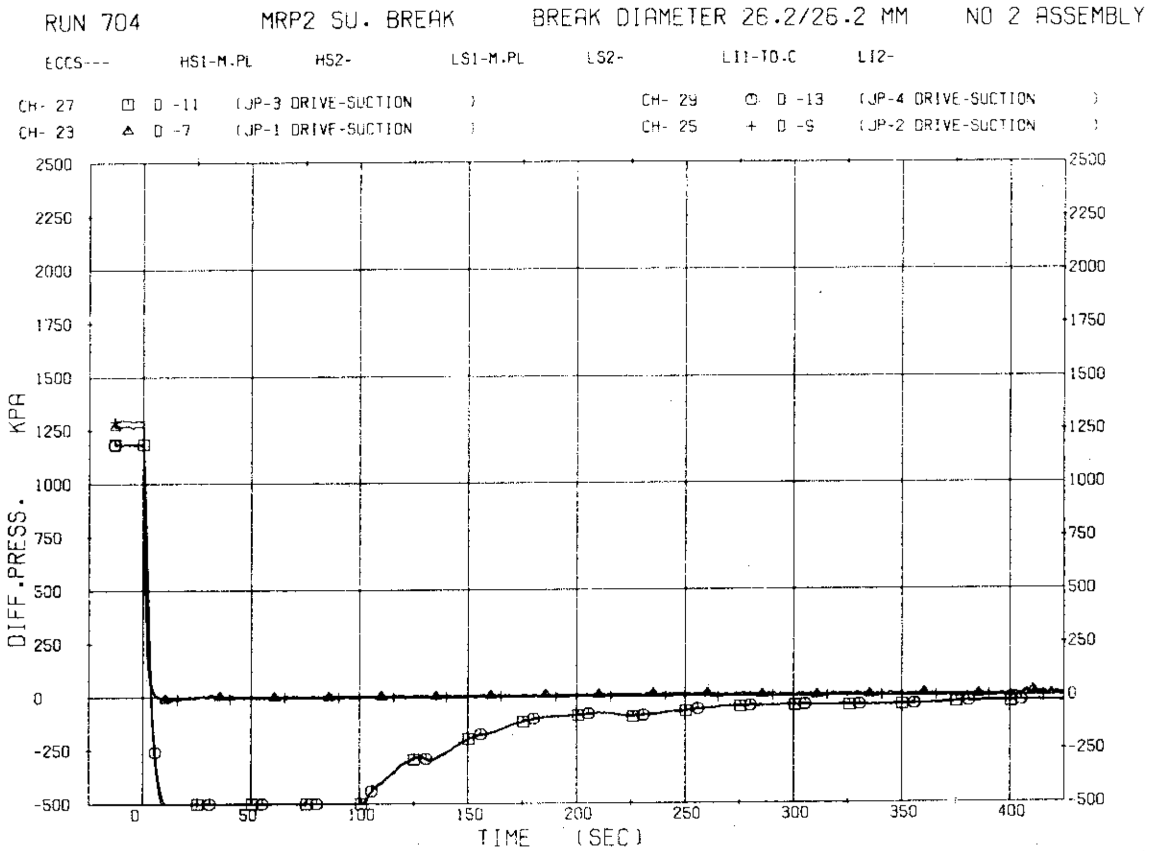


Fig. 5.11 Differential Pressure between Jet Pump Drive and Suction

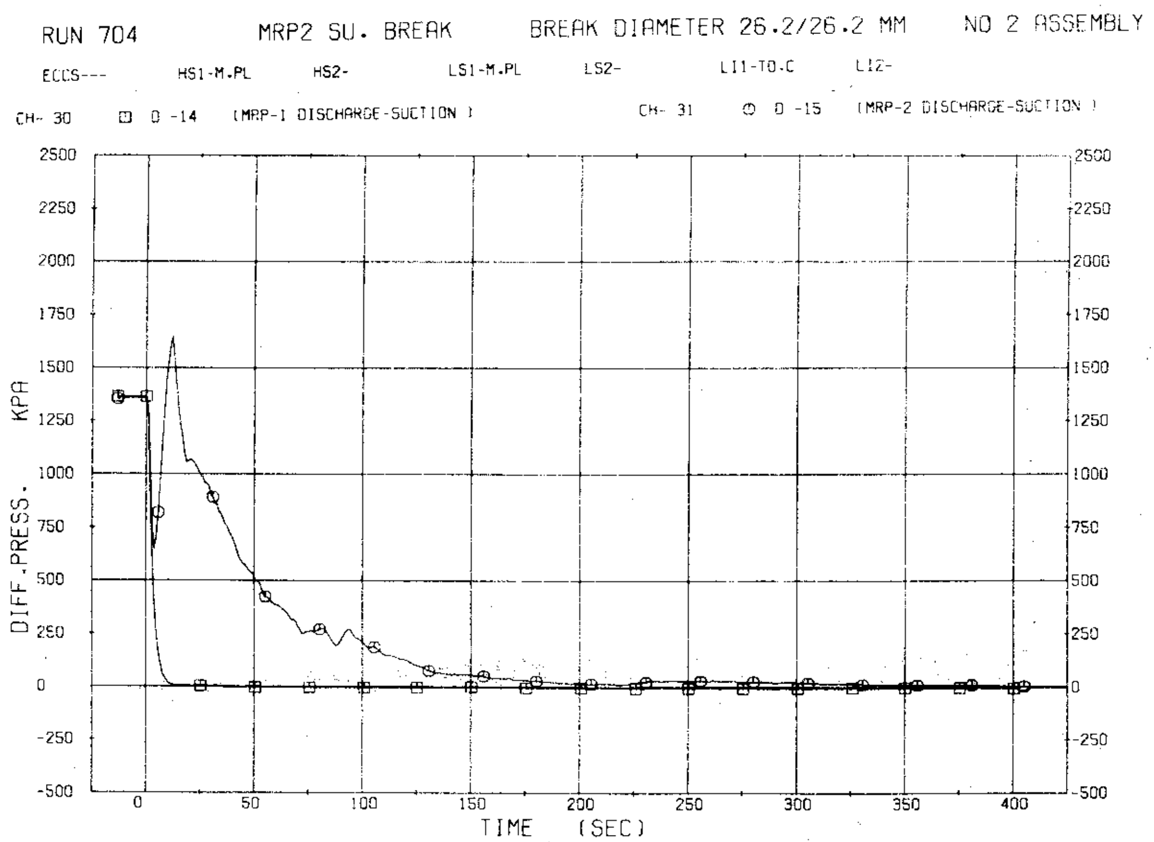


Fig. 5.12 Differential Pressure between MRP-1,2 Delivery and Suction

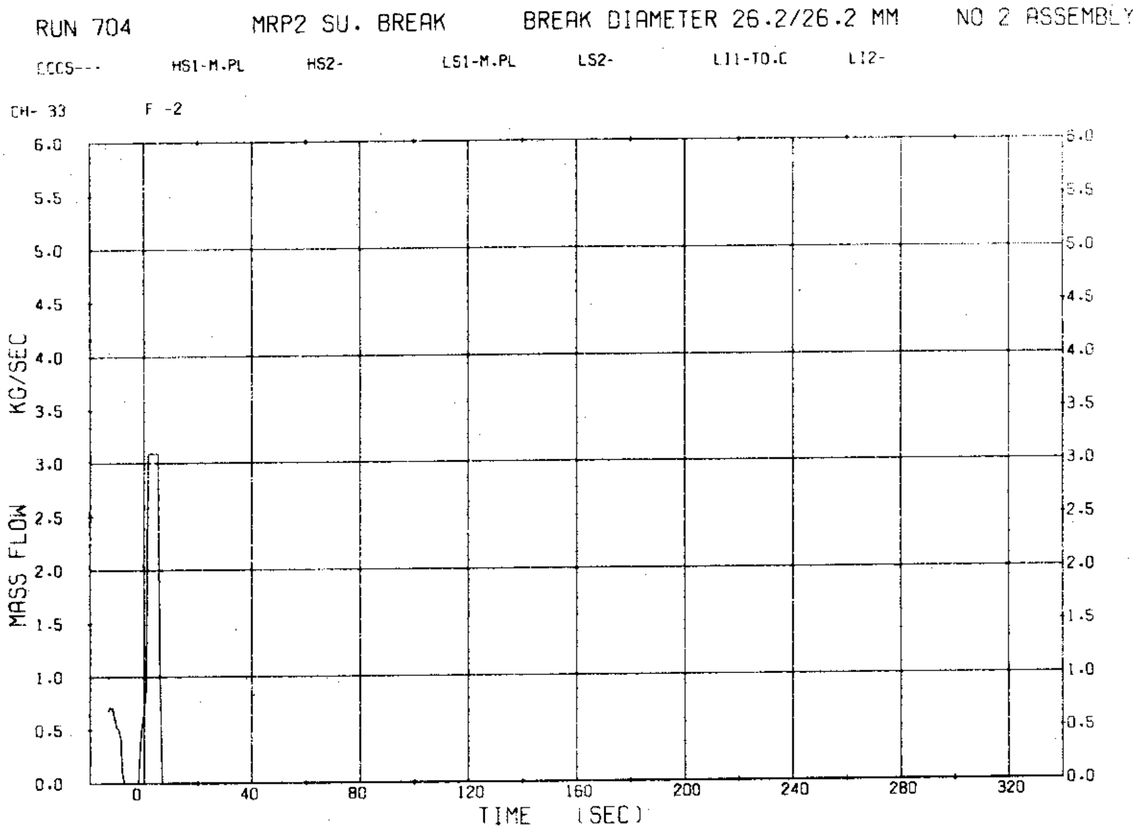


Fig. 5.13 Mass Flow Rate in the Steam Discharge Line

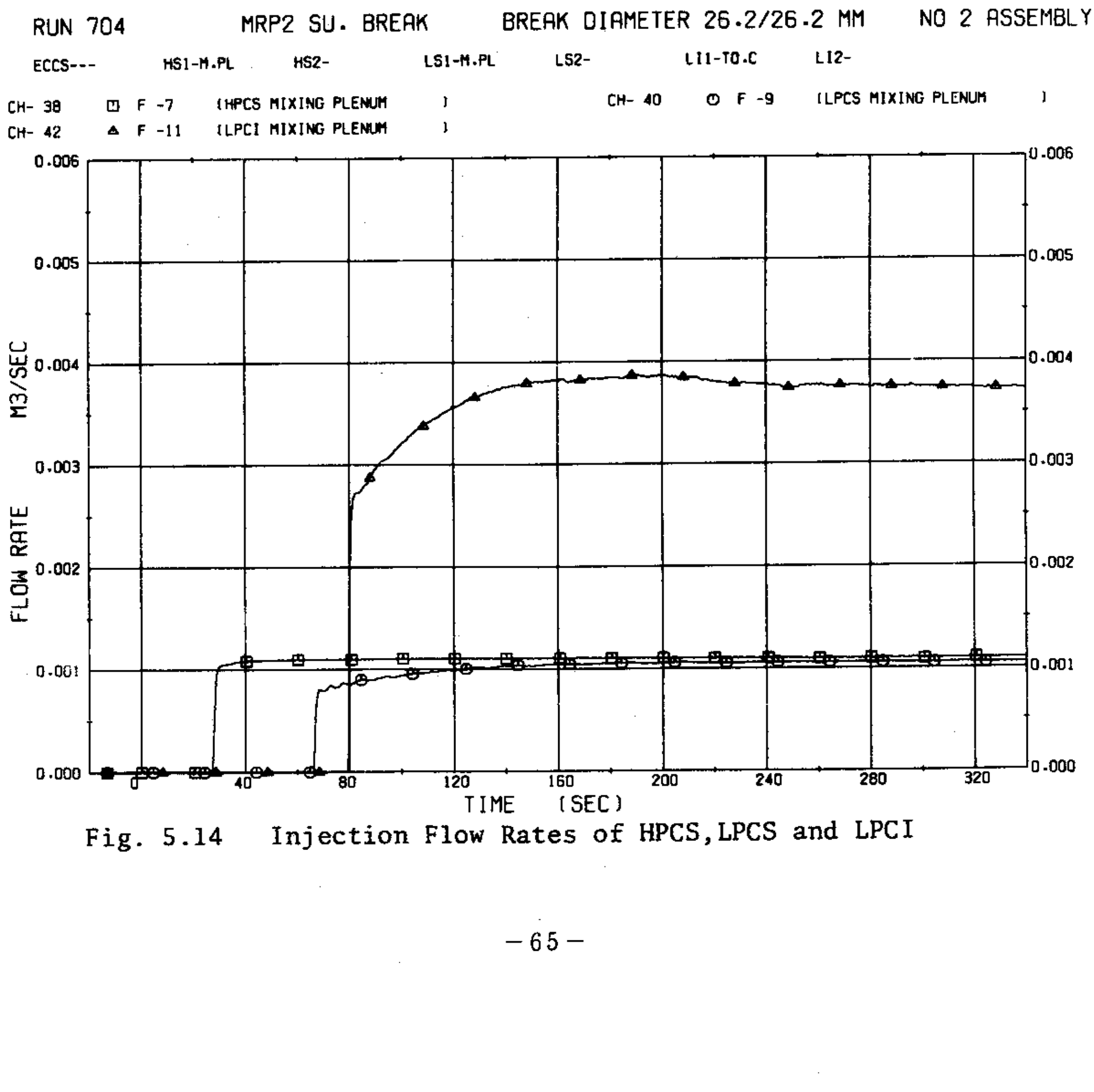


Fig. 5.14 Injection Flow Rates of HPCS,LPCS and LPCI

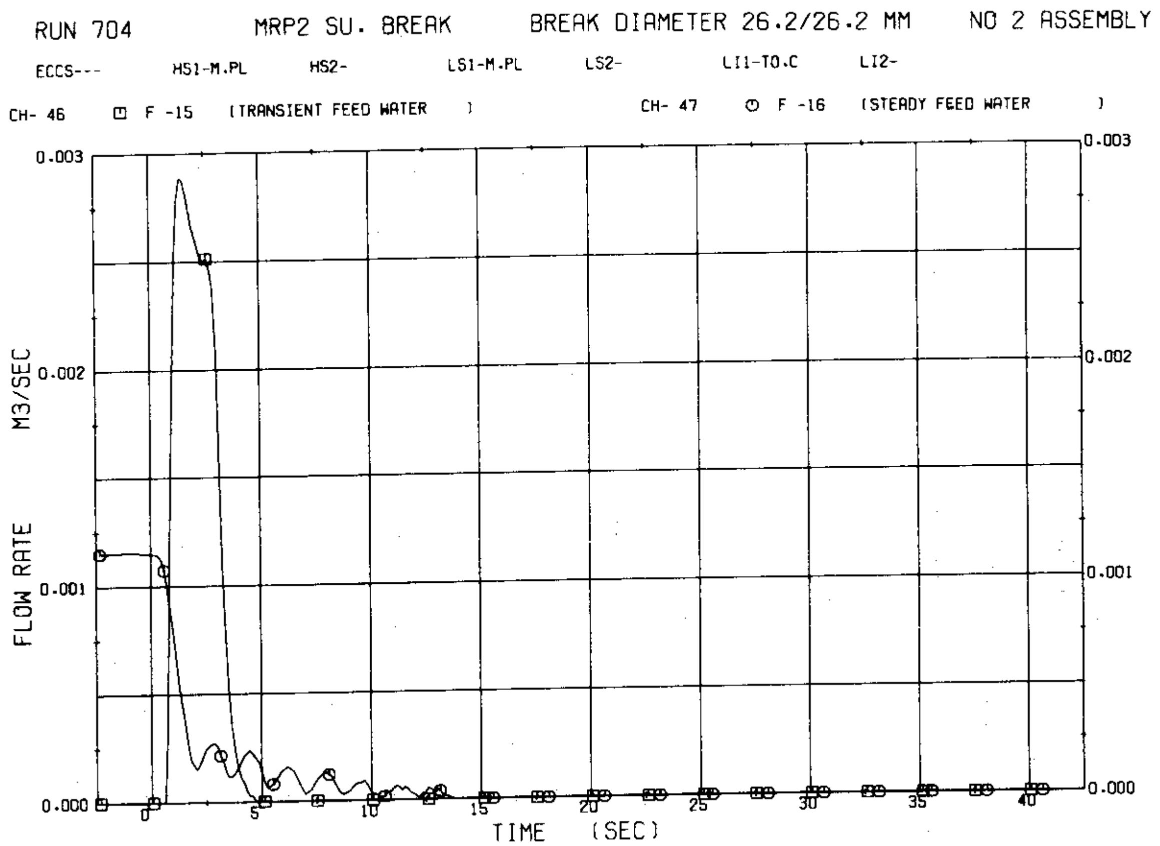


Fig. 5.15 Feed Water Flow Rate

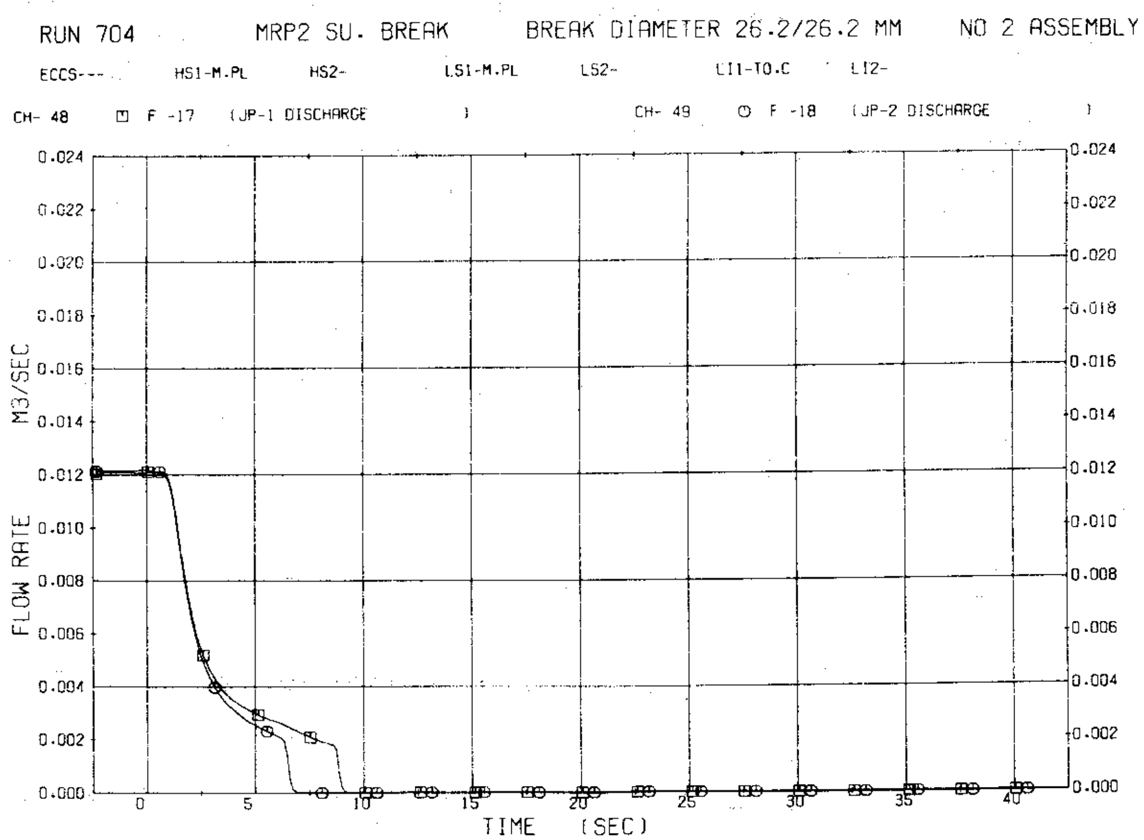


Fig. 5.16 Intact Loop Jet Pump Discharge Flow Rate

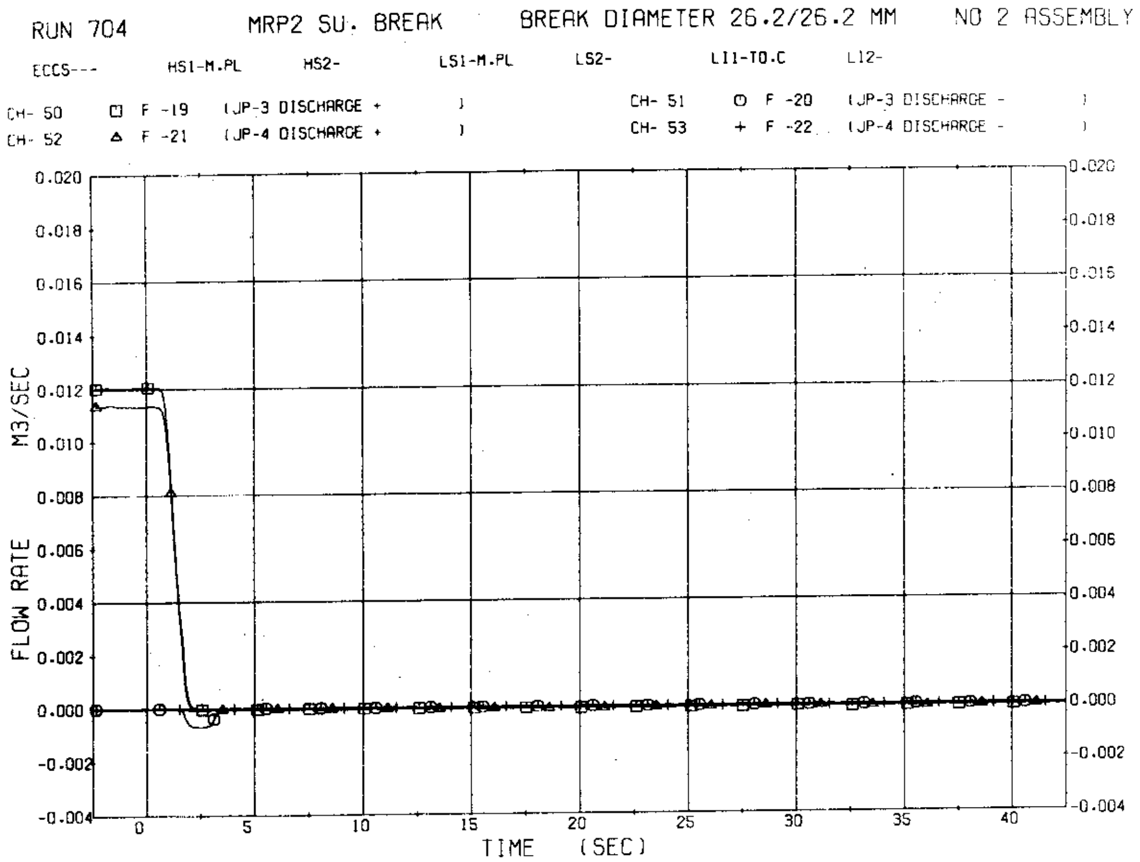


Fig. 5.17 Broken Loop Jet Pump Discharge Flow Rate

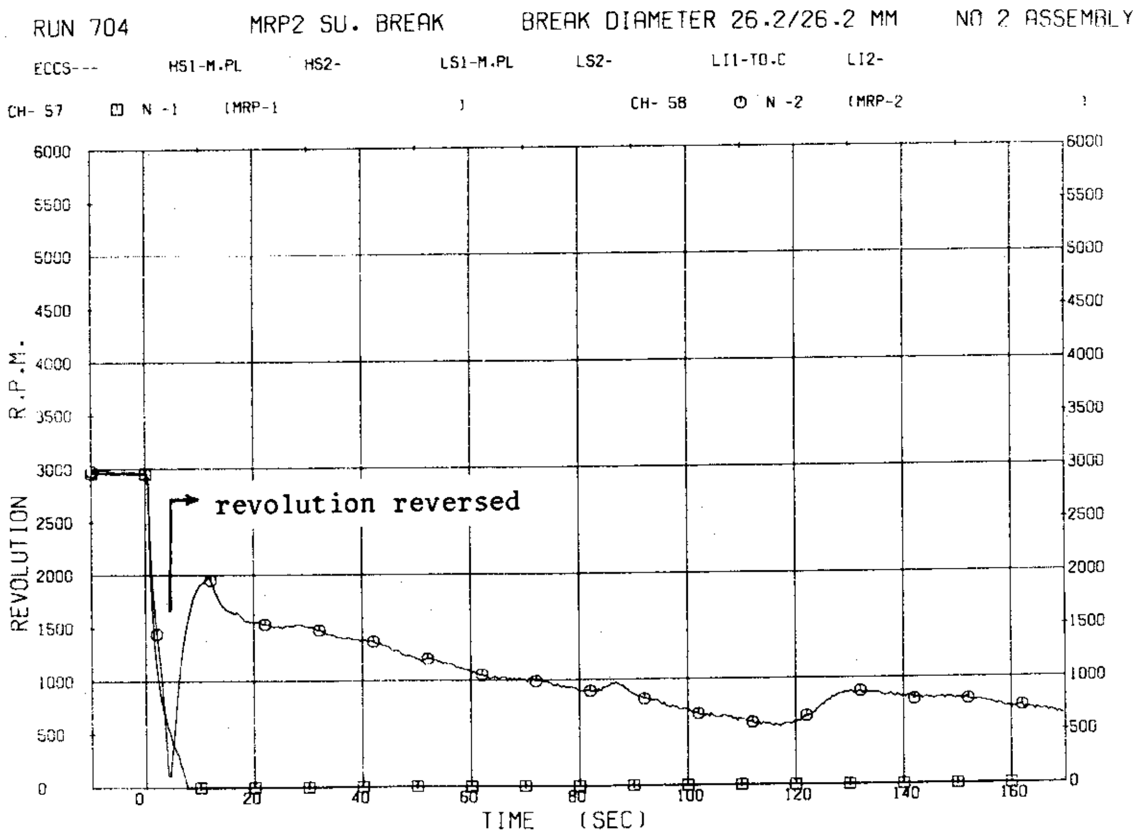


Fig. 5.18 Pump Speed

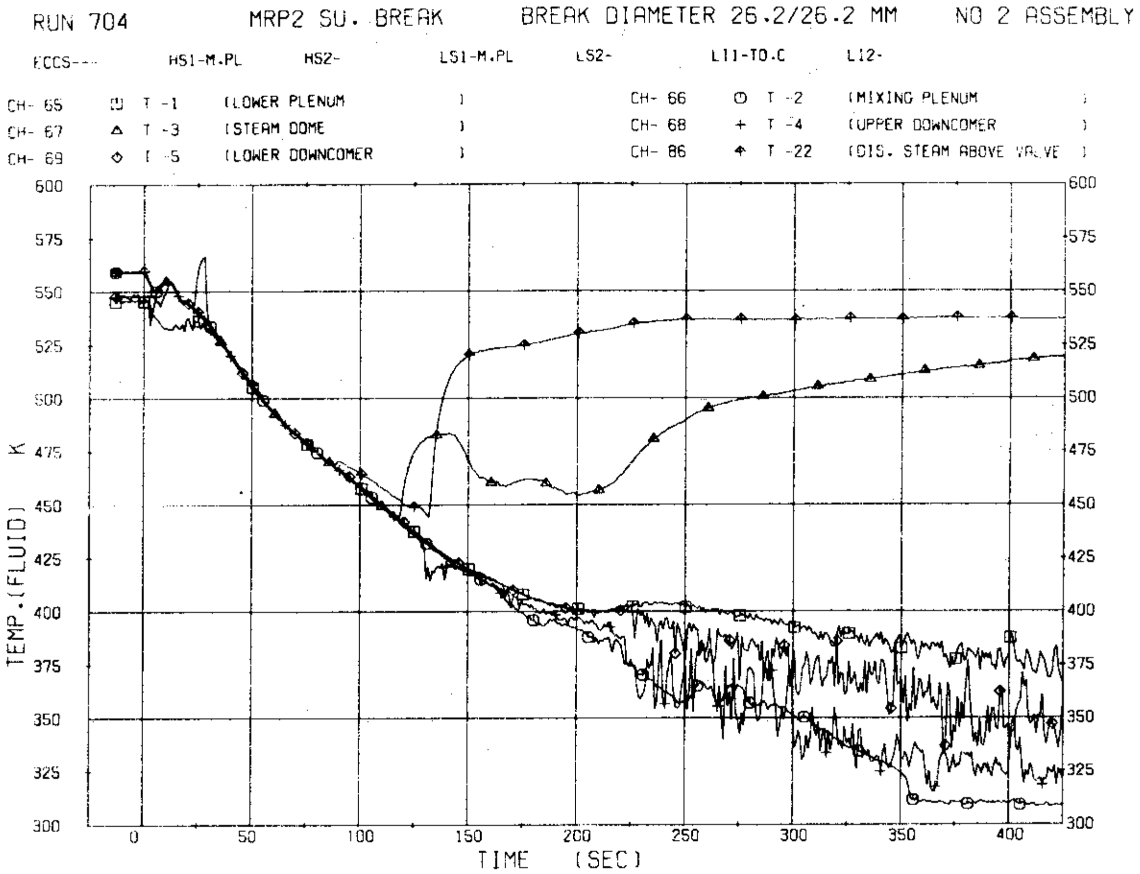


Fig. 5.19 Fluid Temperature in the Vessel

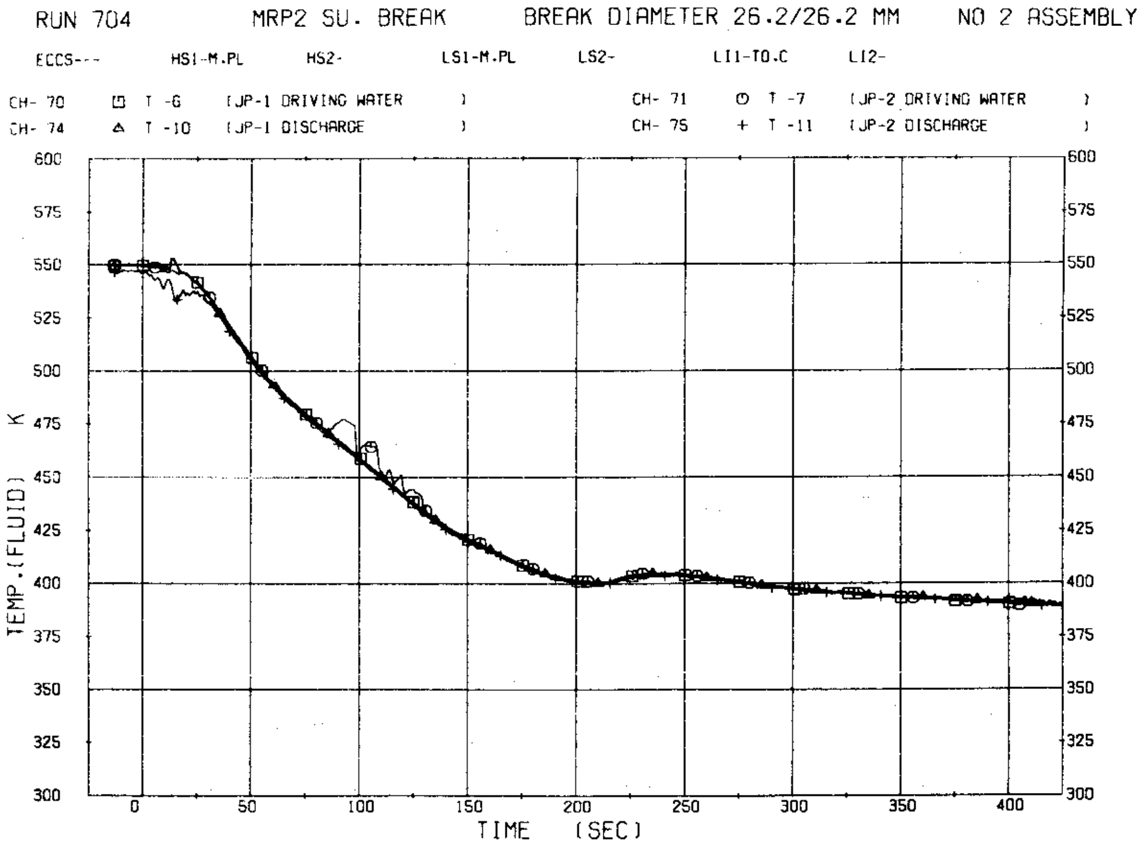


Fig. 5.20 Fluid Temperature in Intact Loop Jet Pumps

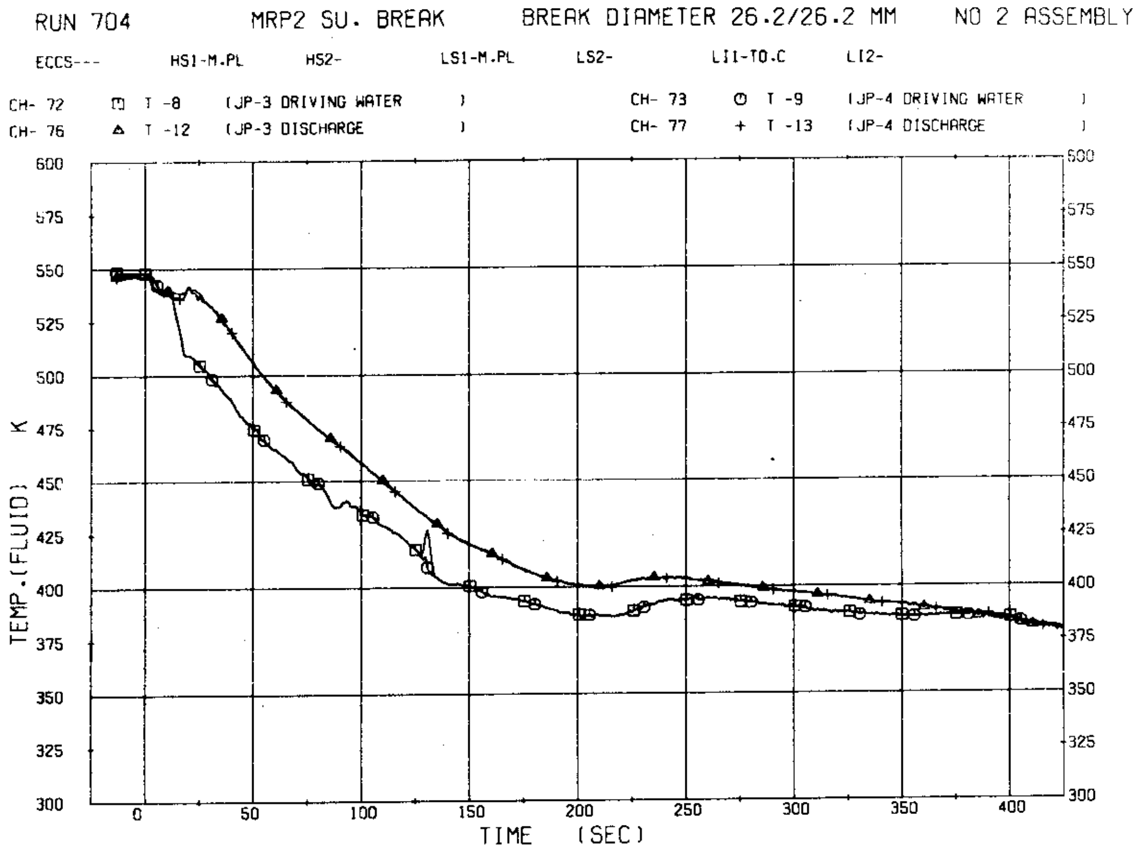


Fig. 5.21 Fluid Temperature in Broken Loop Jet Pumps

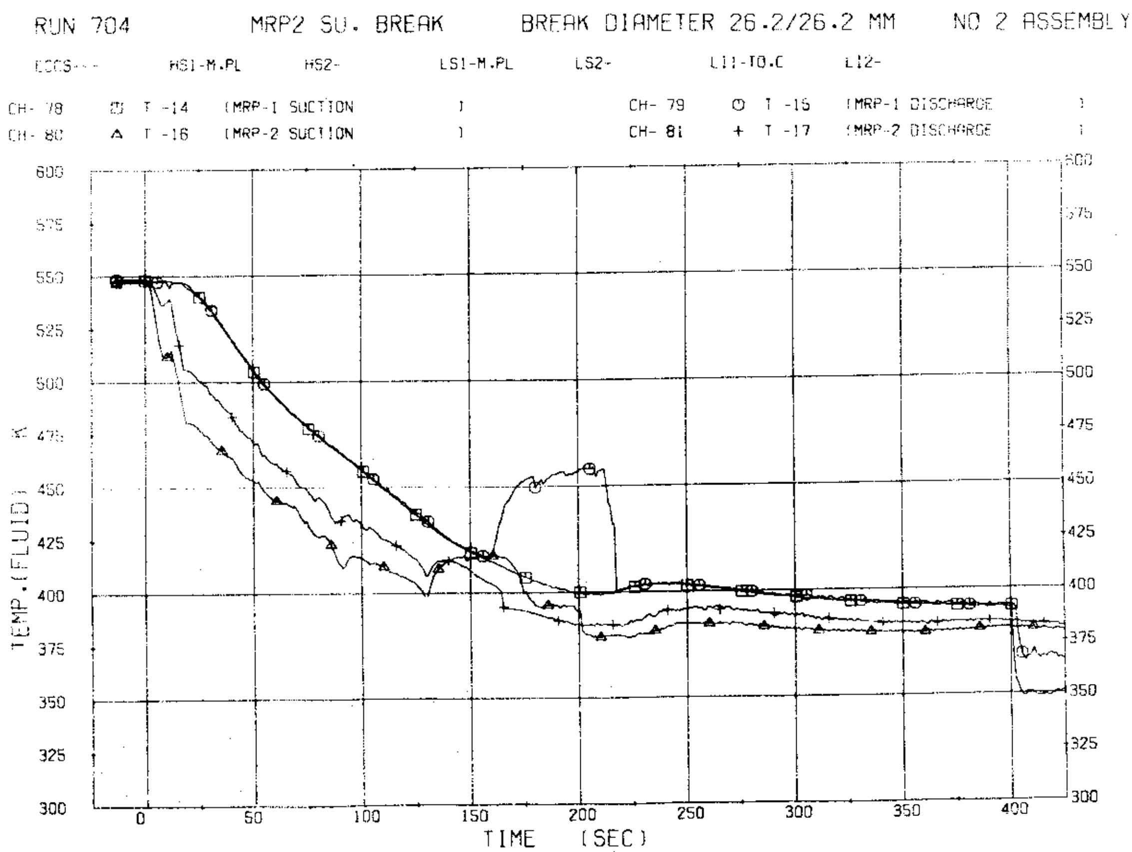


Fig. 5.22 Fluid Temperature in Recirculation Pump

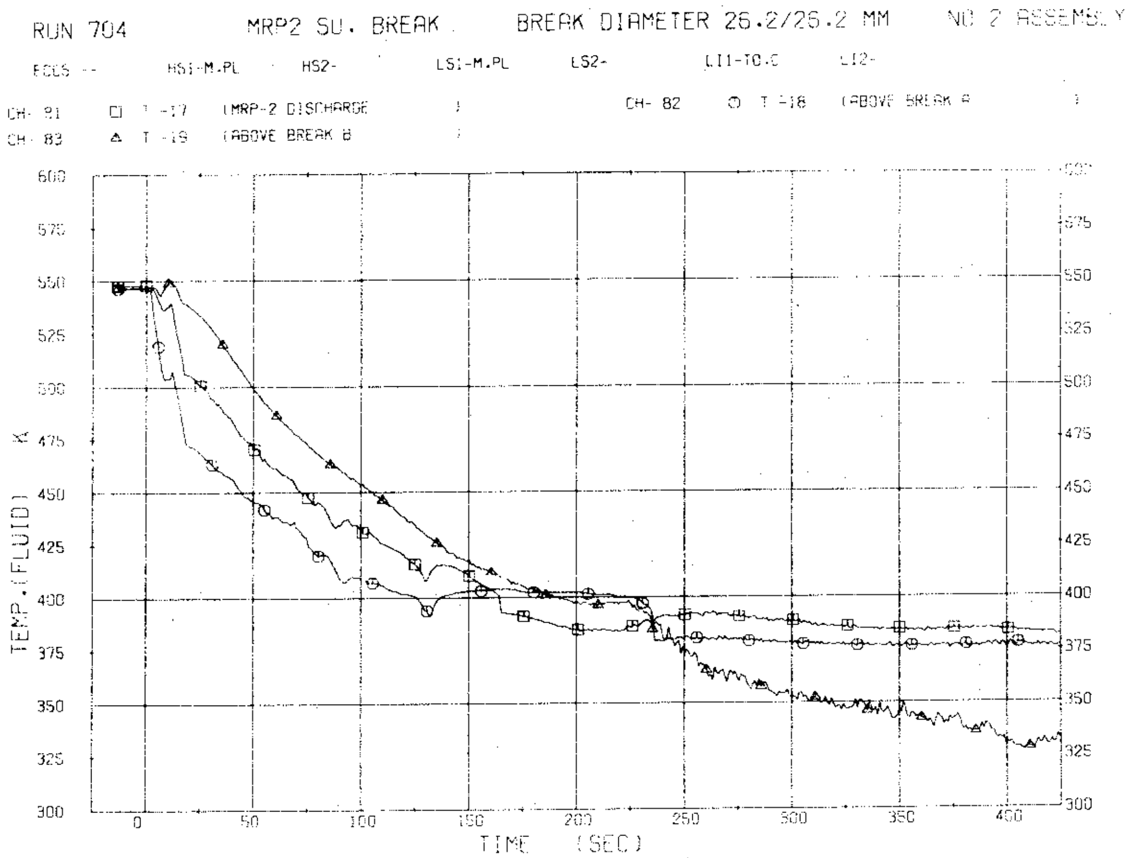


Fig. 5.23 Fluid Temperature in Break A and B

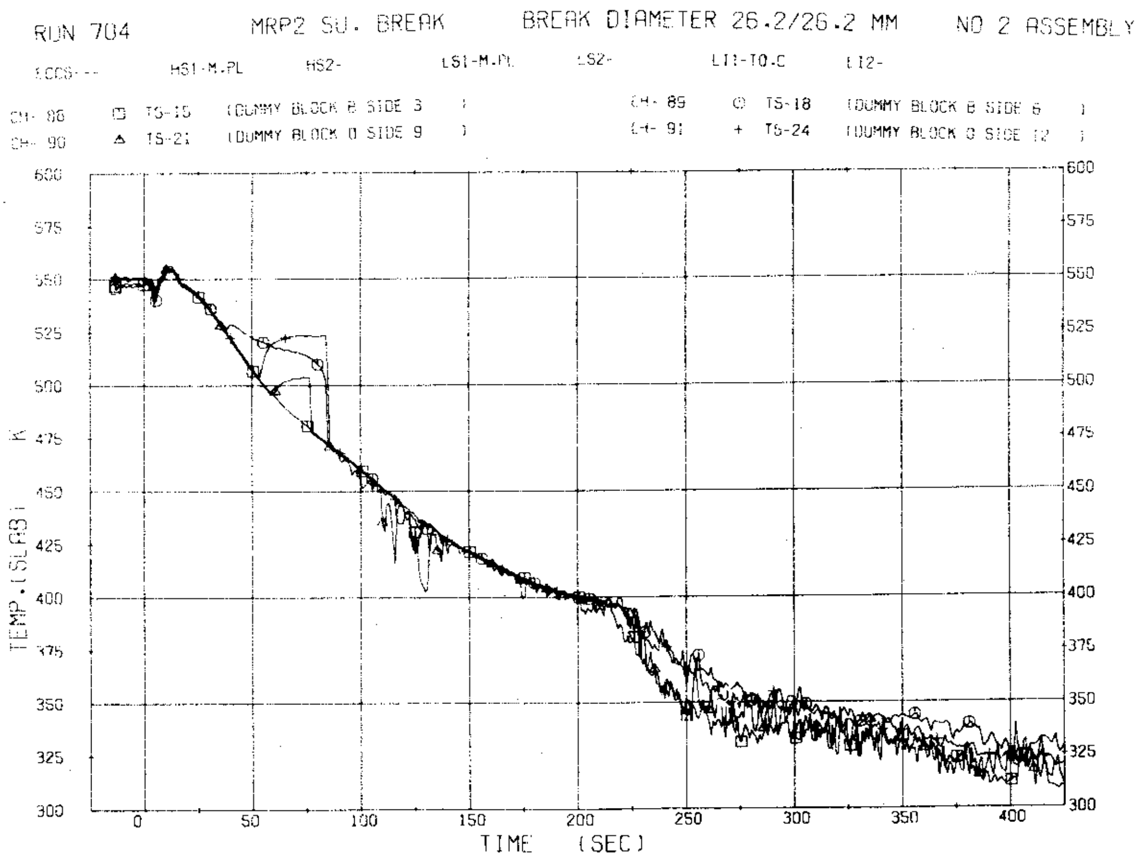


Fig. 5.24 Surface Temperature of Filler Block

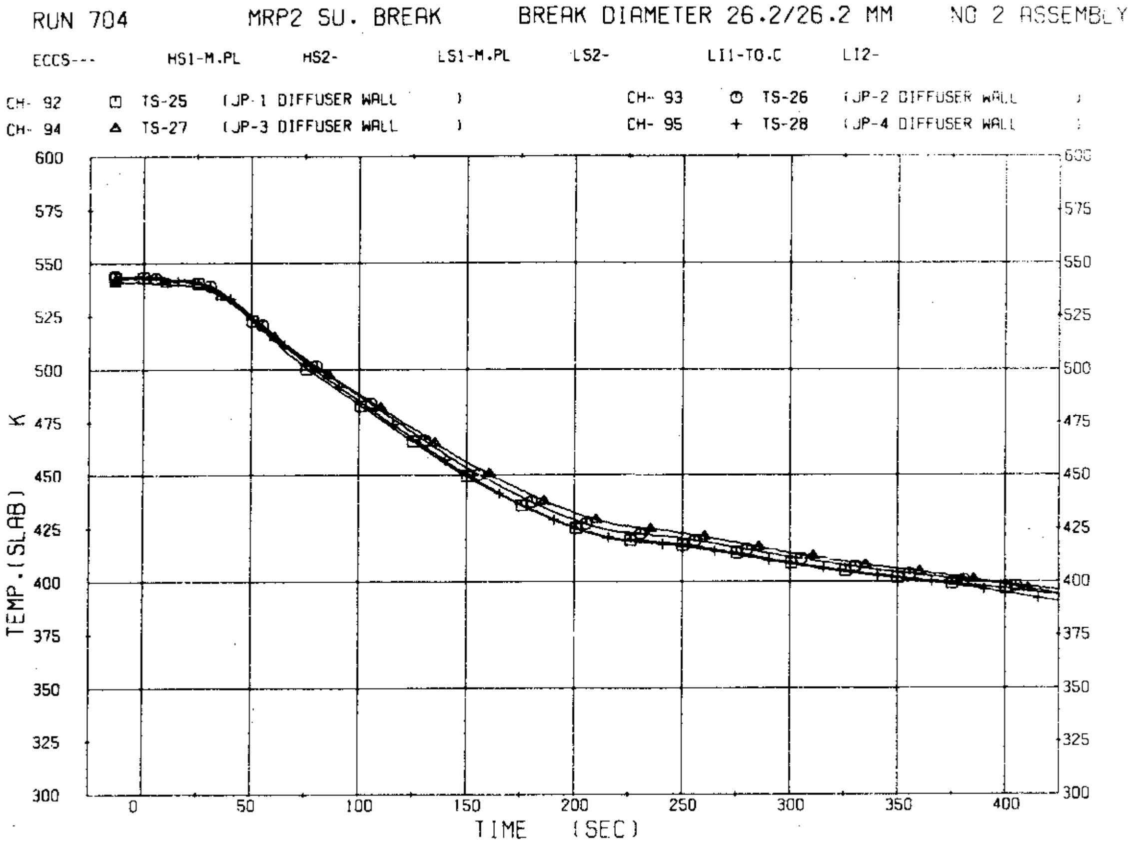


Fig. 5.25 Slab Temperature of Jet Pump Diffuser

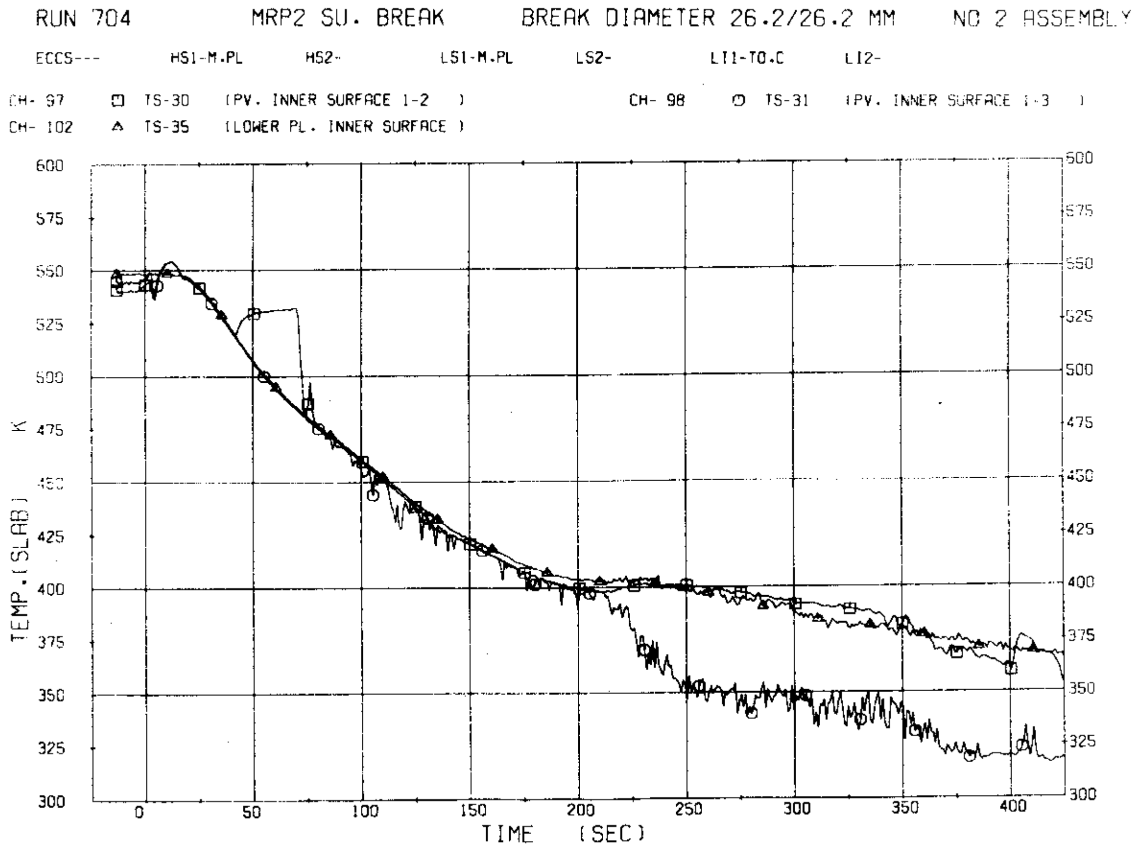


Fig. 5.26 Inner Surface Temperature of Pressure Vessel

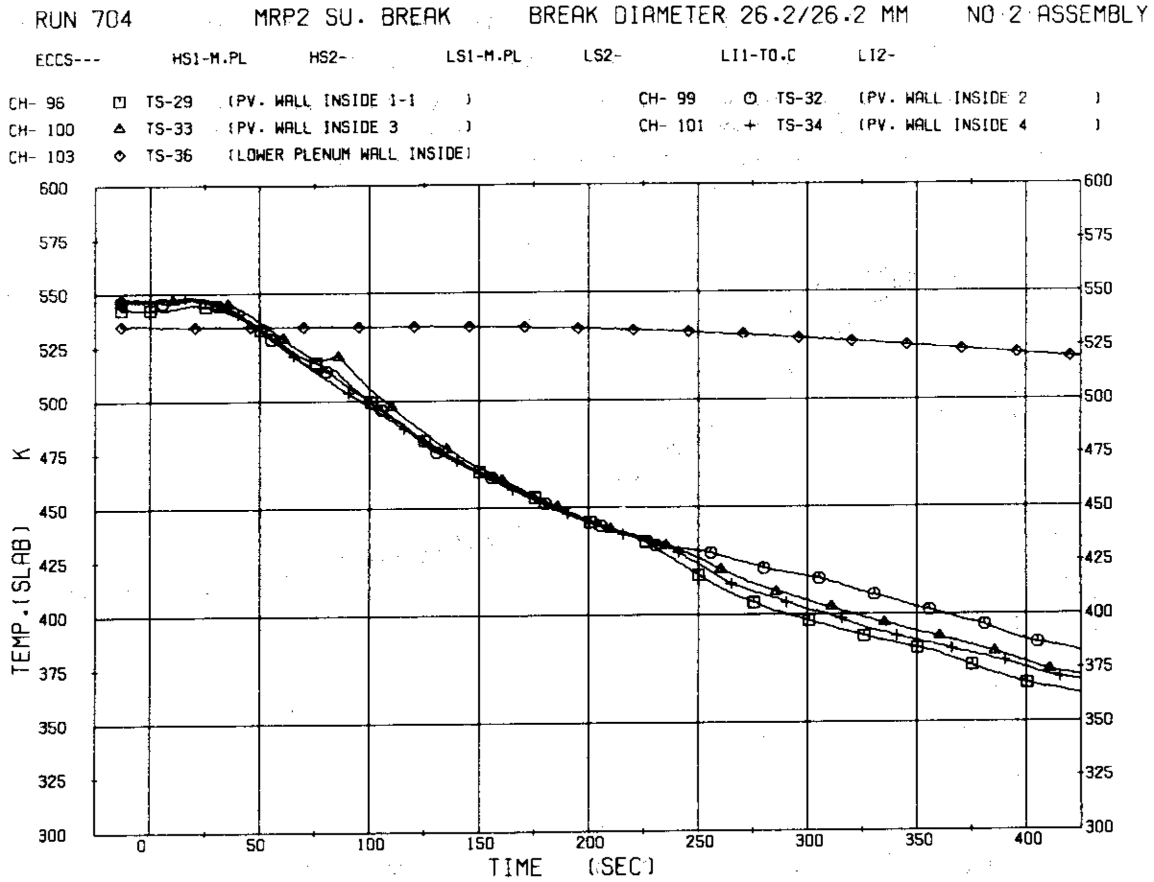


Fig. 5.27 Slab Temperature of Pressure Vessel

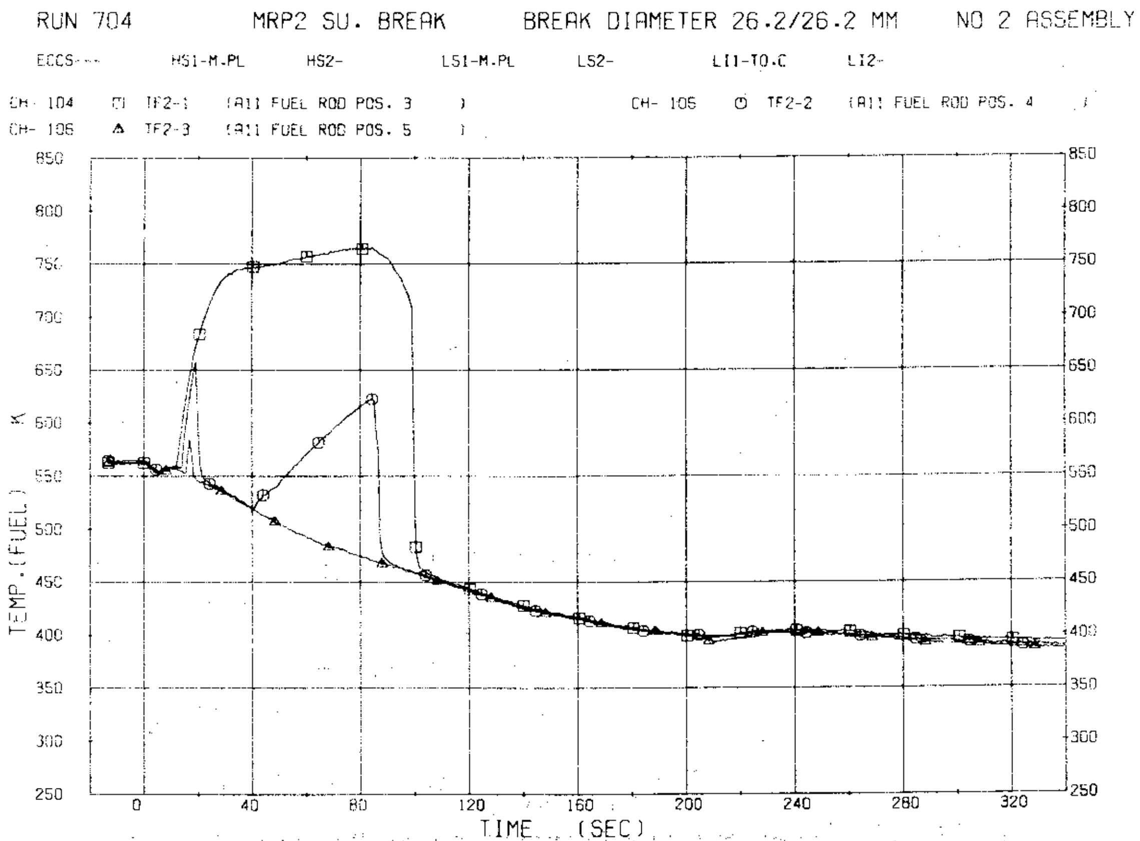


Fig. 5.28 Heater Rod Surface Temperature of All Rod

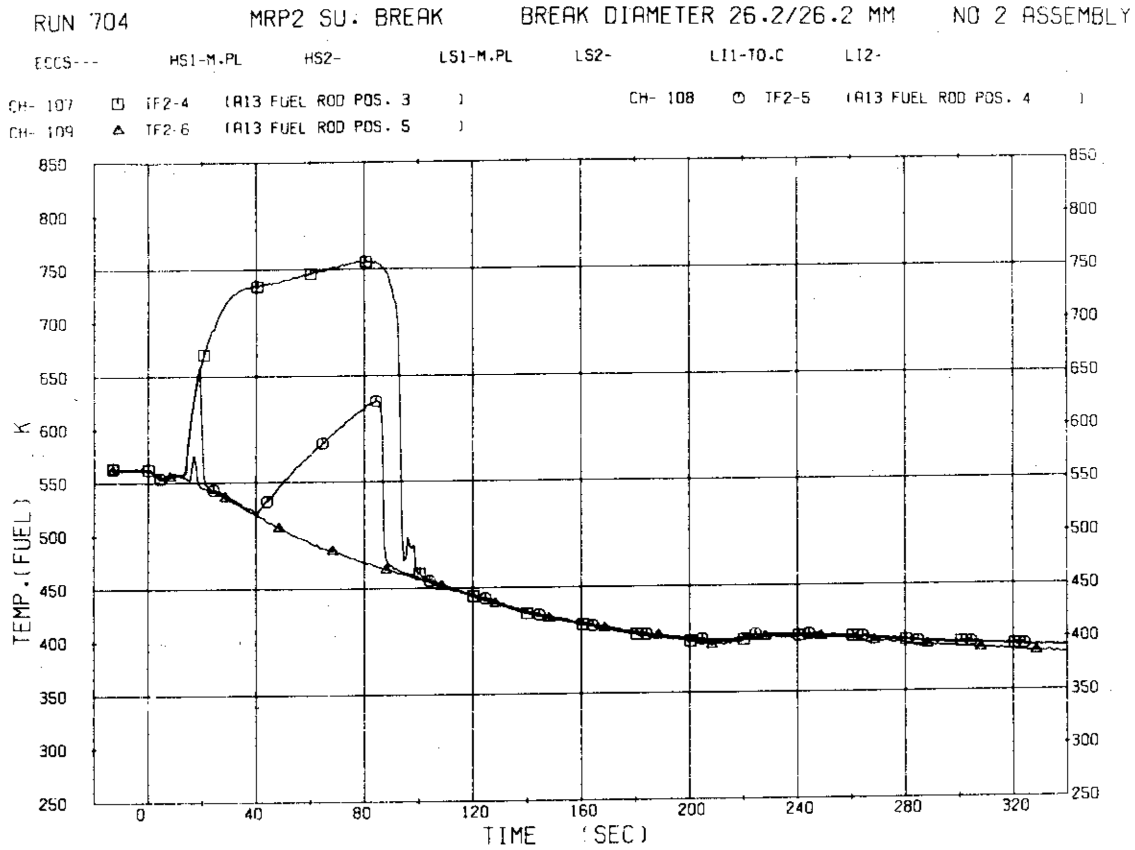


Fig. 5.29 Heater Rod Surface Temperature of A13 Rod

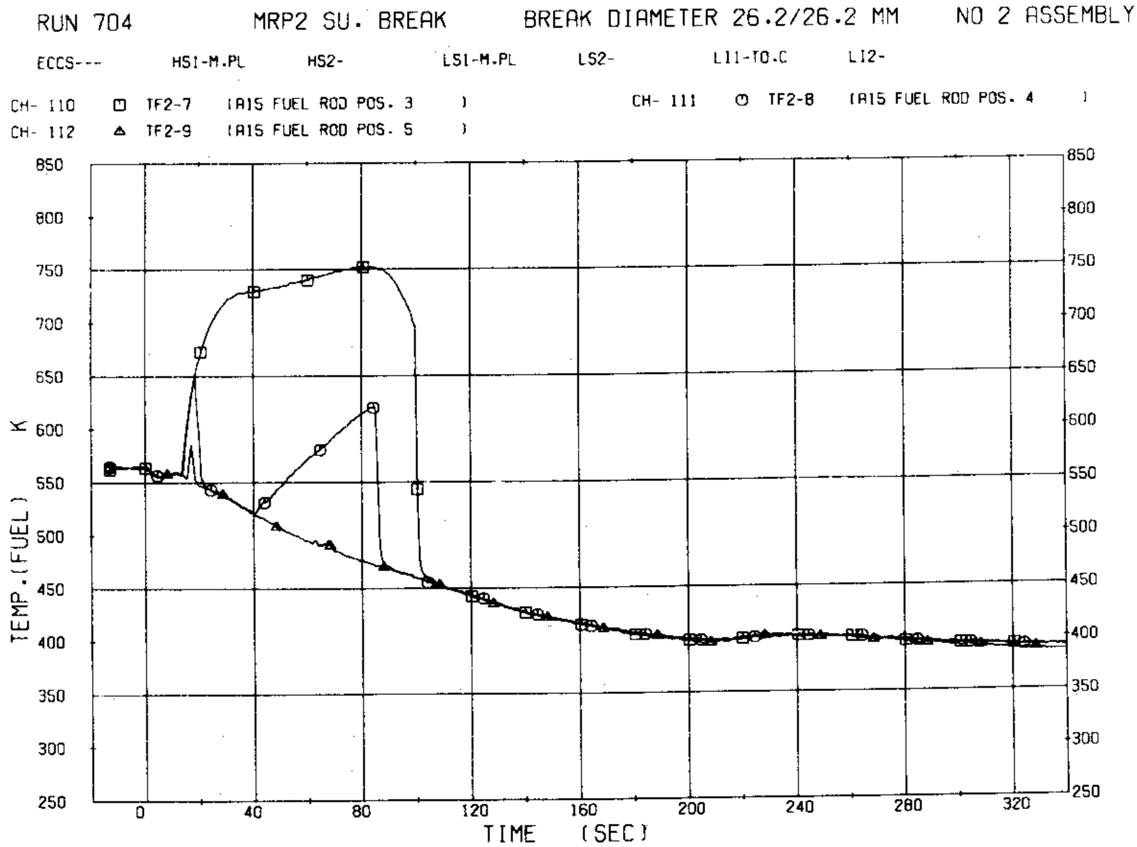


Fig. 5.30 Heater Rod Surface Temperature of A15 Rod

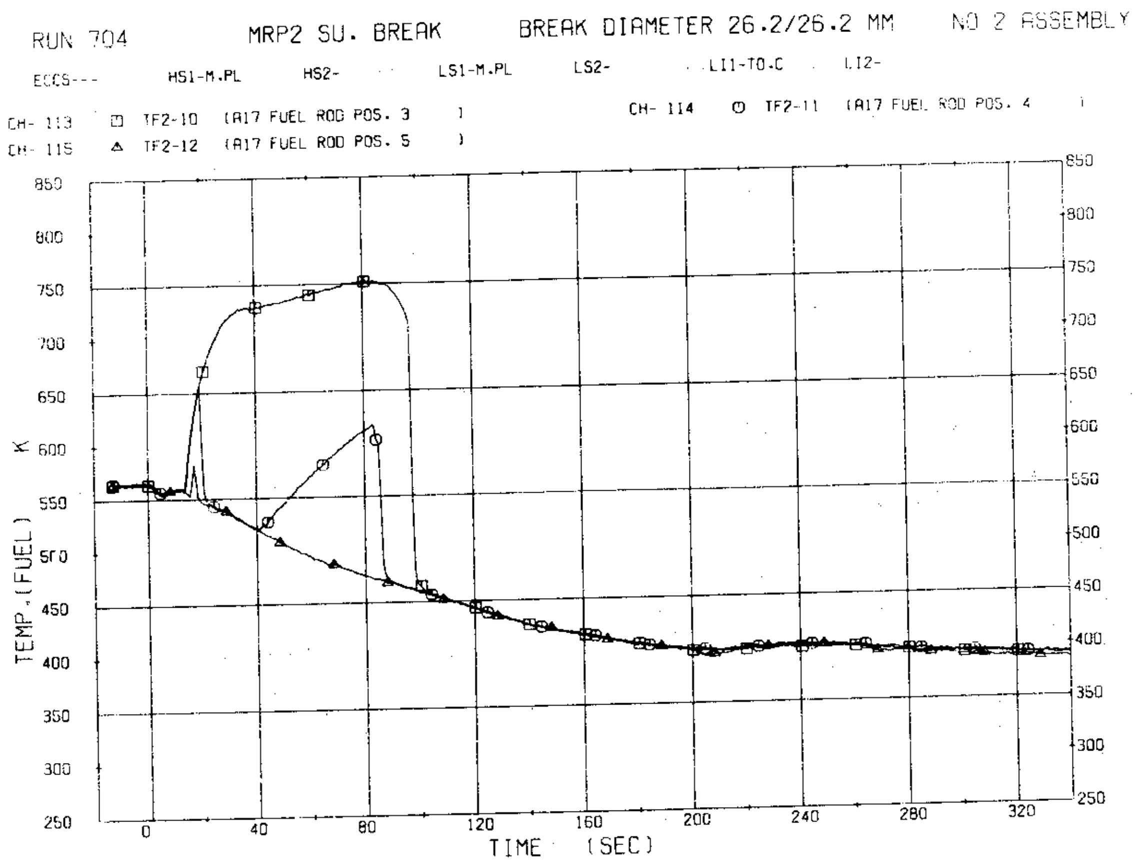


Fig. 5.31 Heater Rod Surface Temperature of A17 Rod

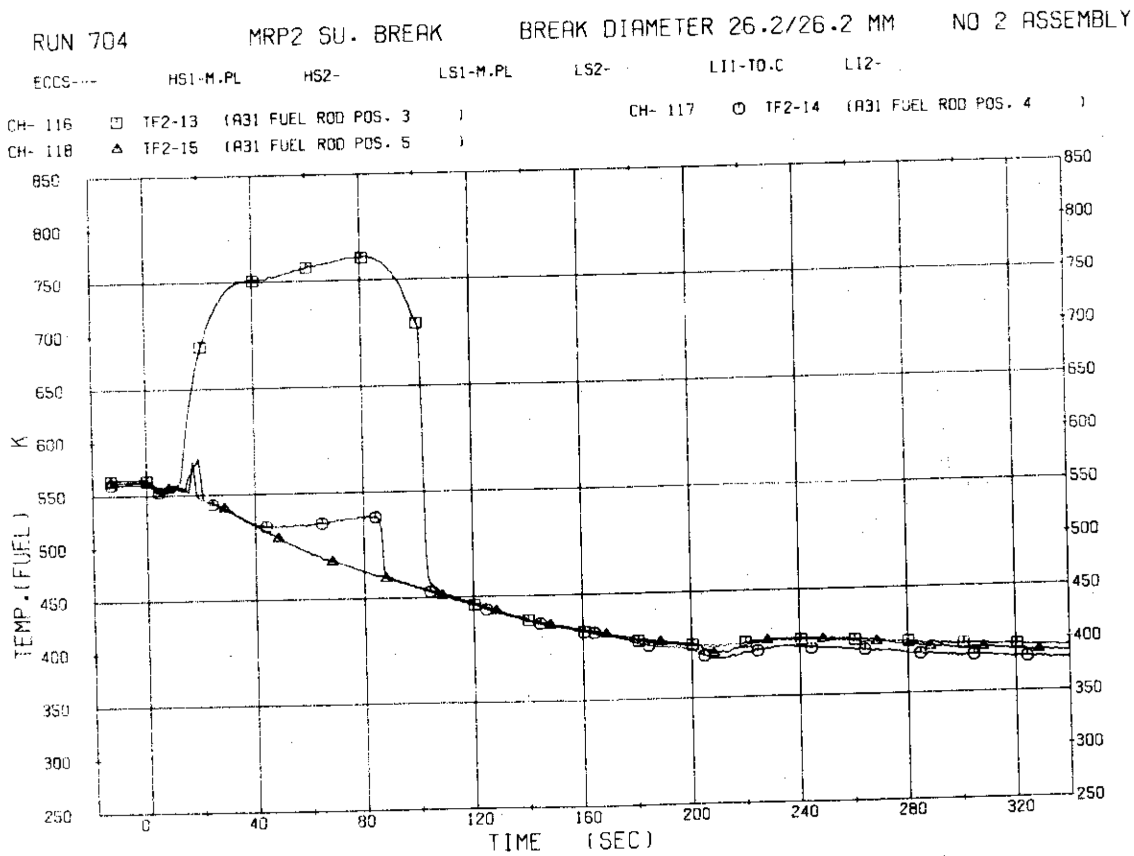


Fig. 5.32 Heater Rod Surface Temperature of A31 Rod

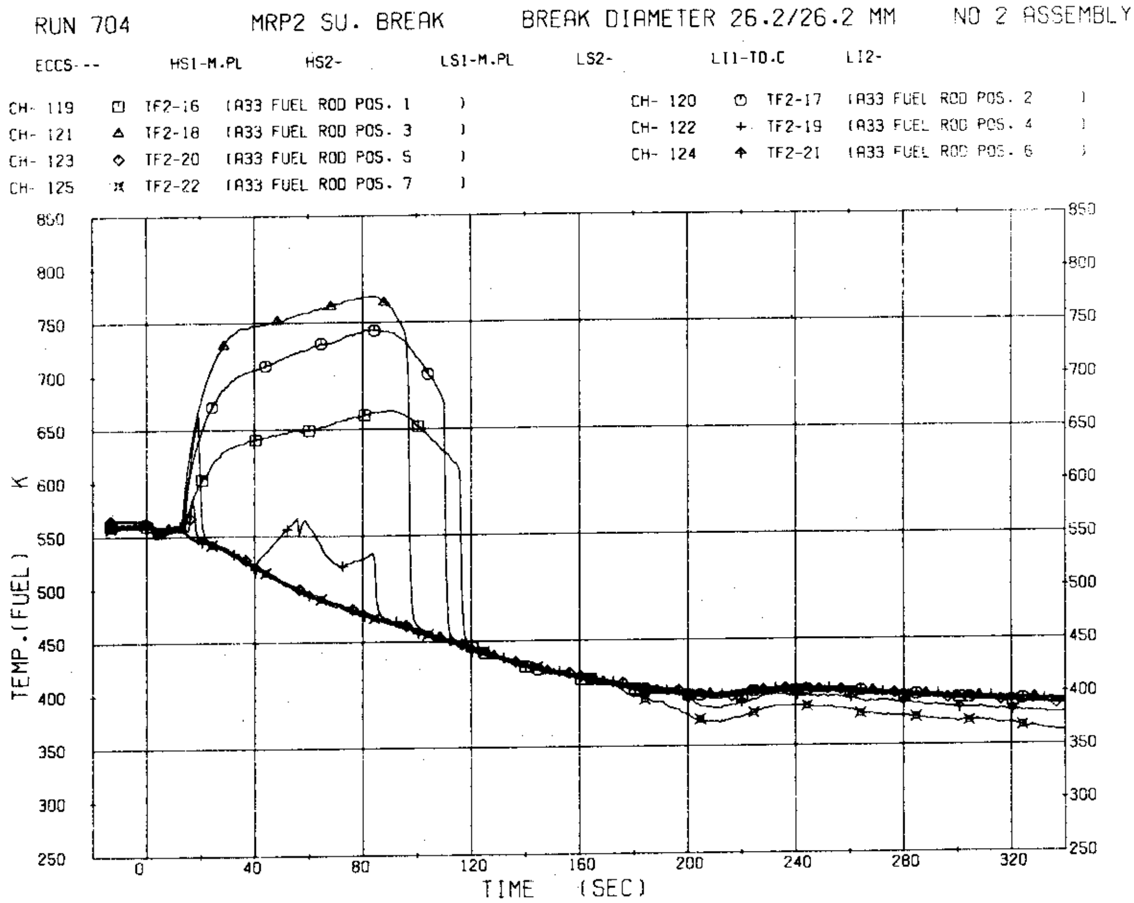


Fig. 5.33 Heater Rod Surface Temperature of A33 Rod

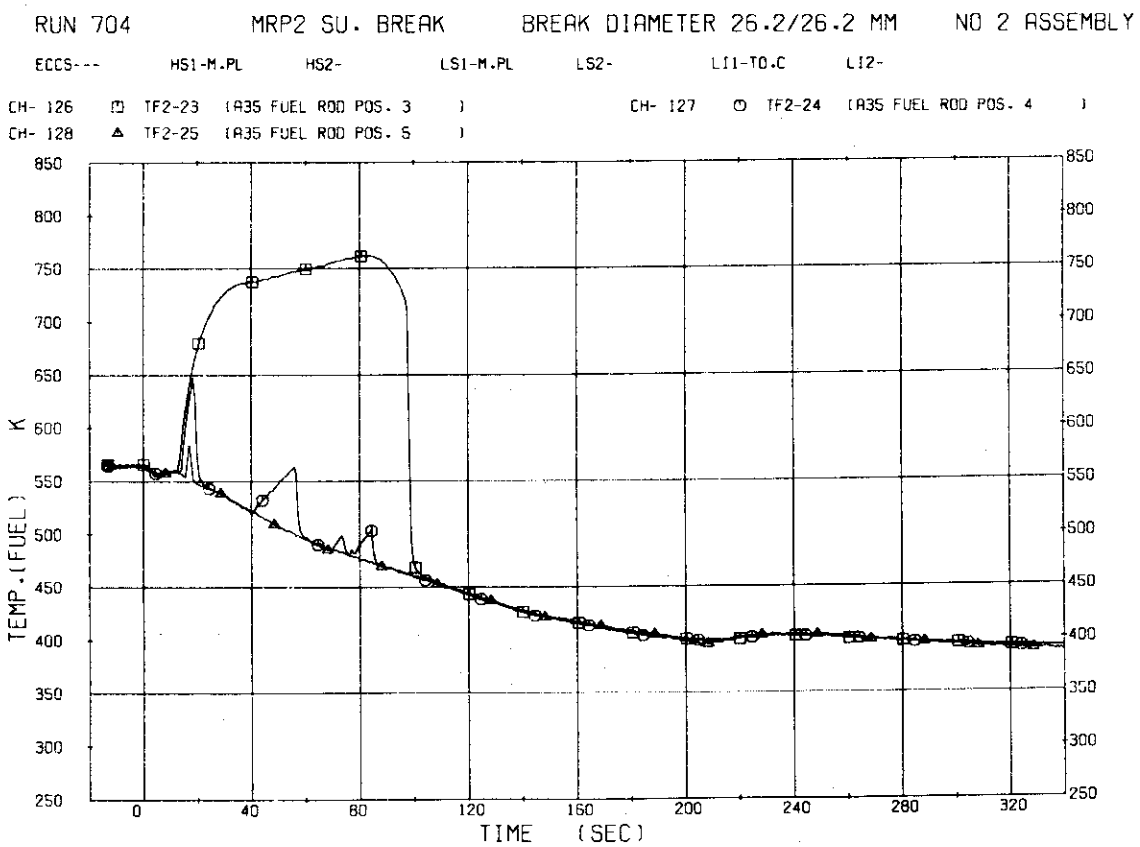


Fig. 5.34 Heater Rod Surface Temperature of A35 Rod

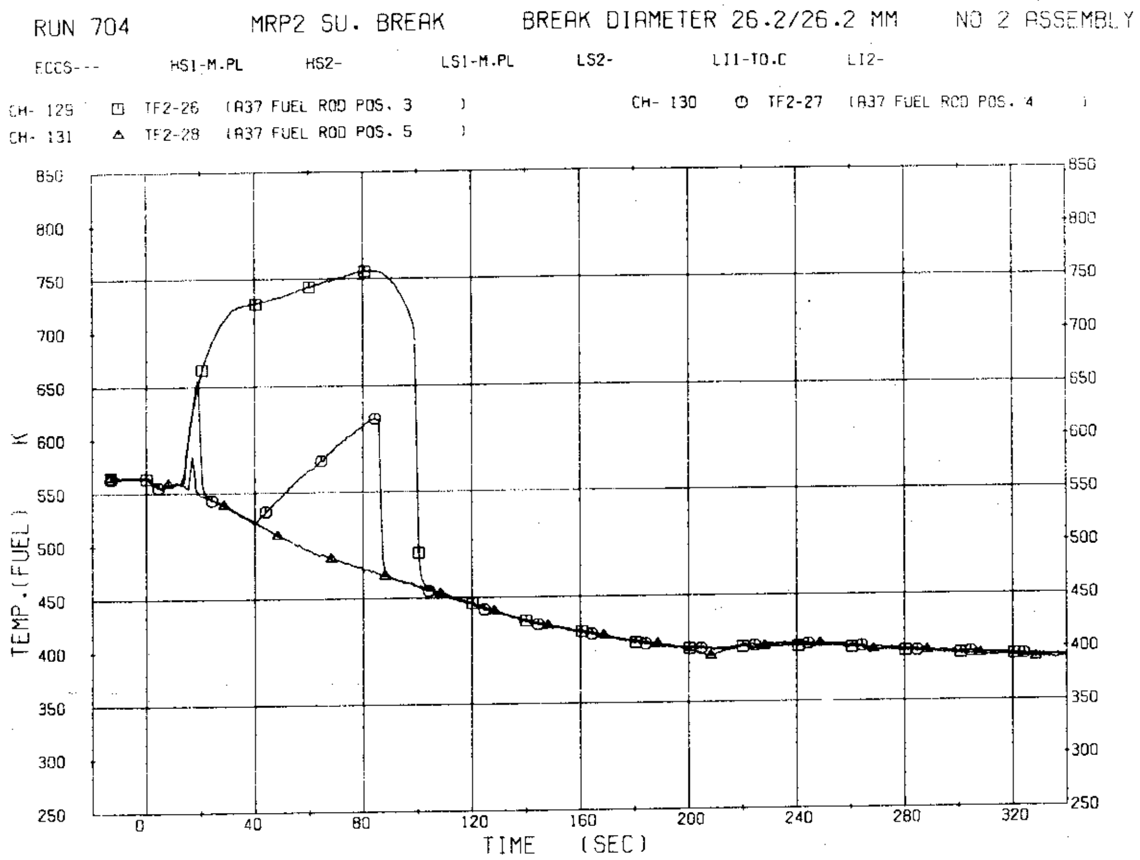


Fig. 5.35 Heater Rod Surface Temperature of A37 Rod

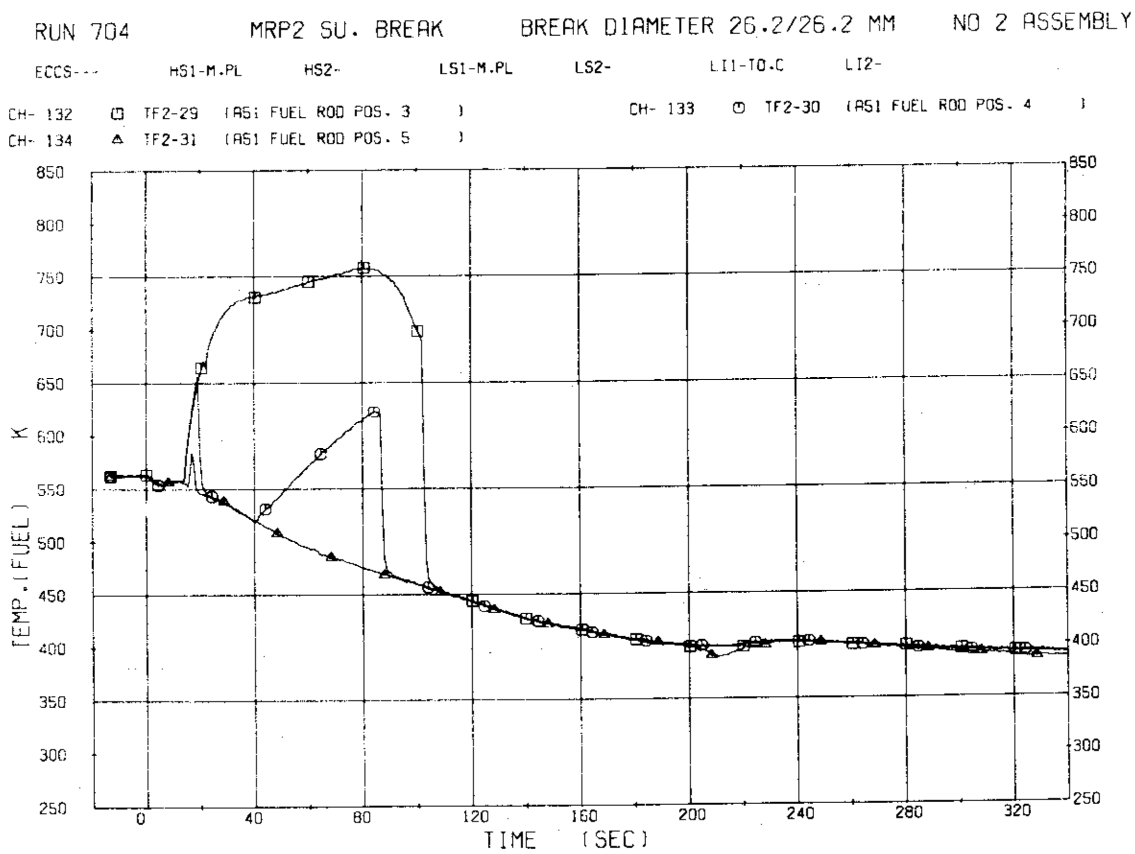


Fig. 5.36 Heater Rod Surface Temperature of A51 Rod

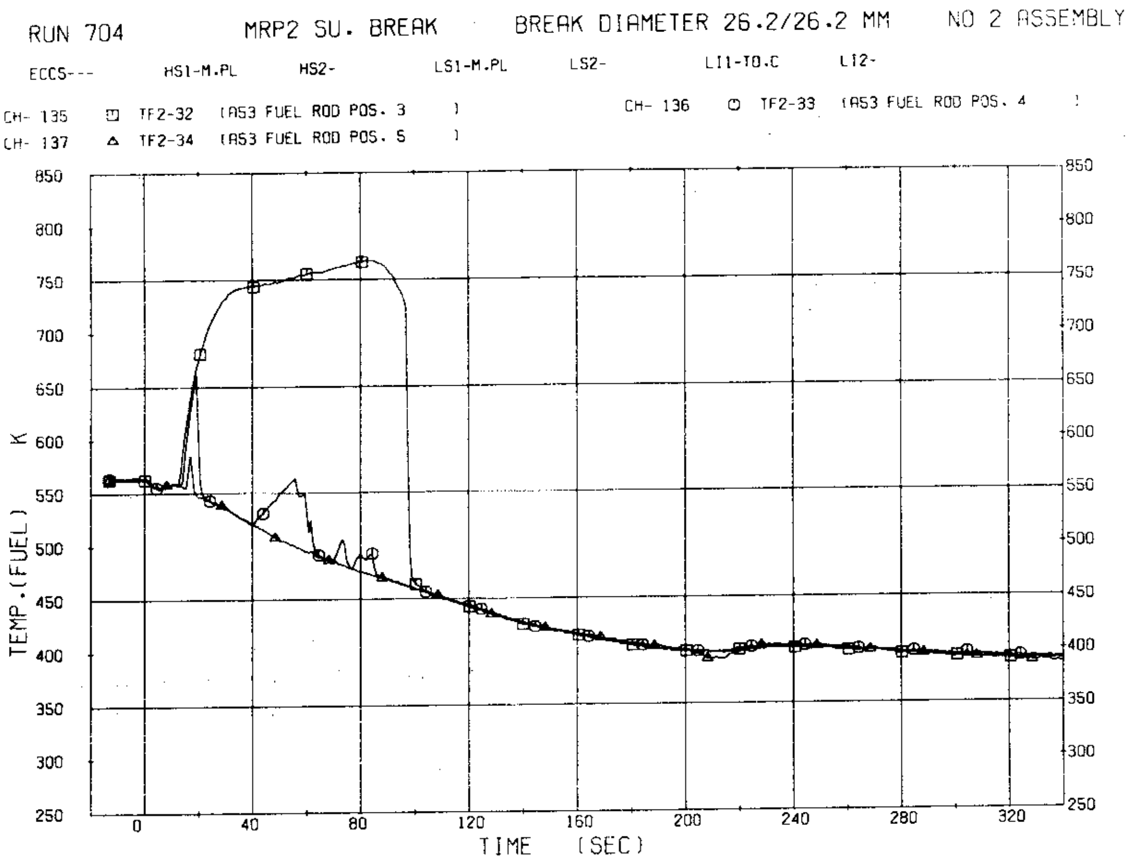


Fig. 5.37 Heater Rod Surface Temperature of A53 Rod

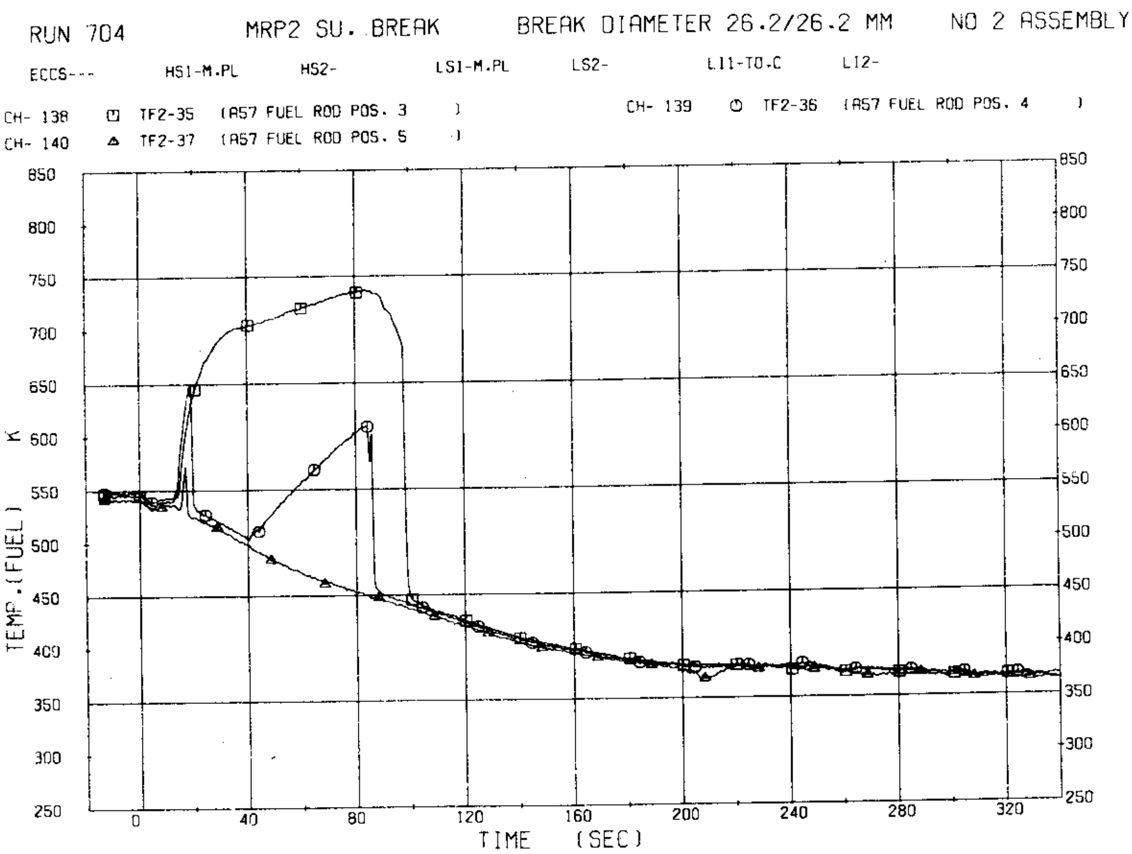


Fig. 5.38 Heater Rod Surface Temperature of A57 Rod

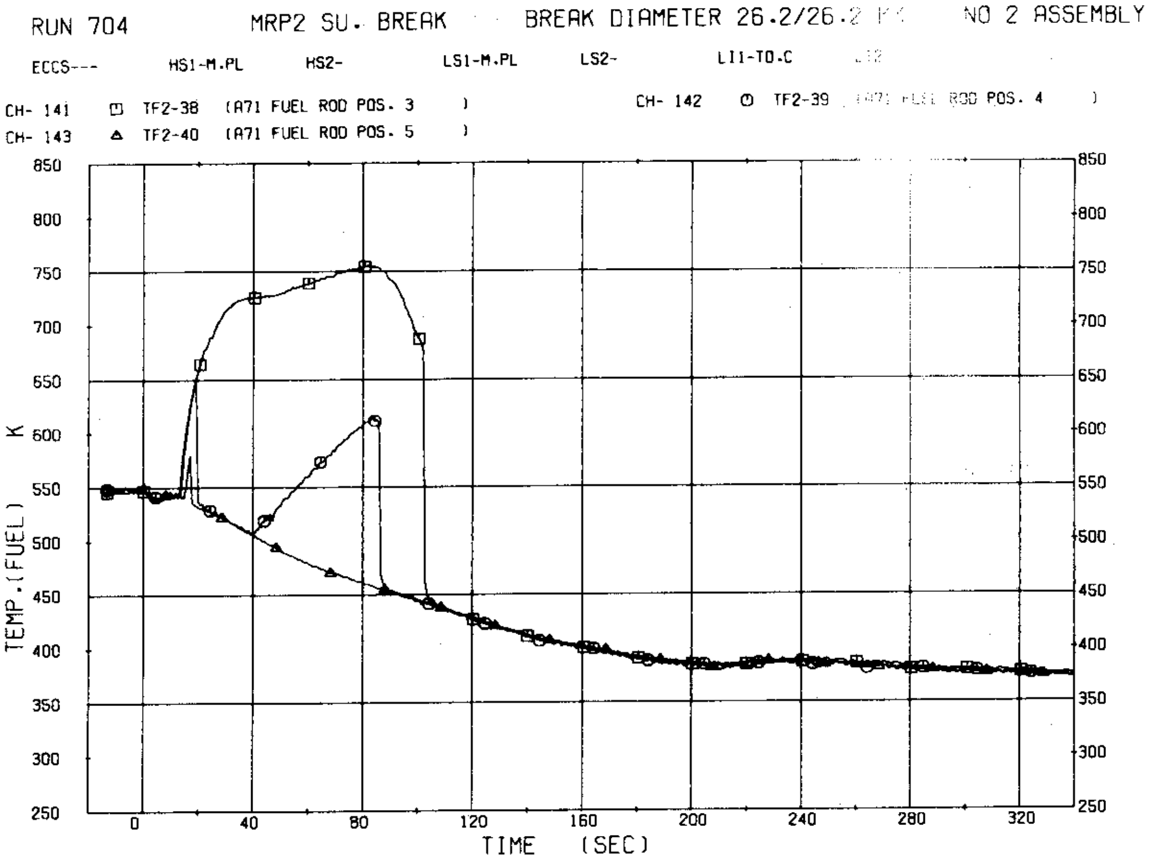


Fig. 5.39 Heater Rod Surface Temperature of A71 Rod

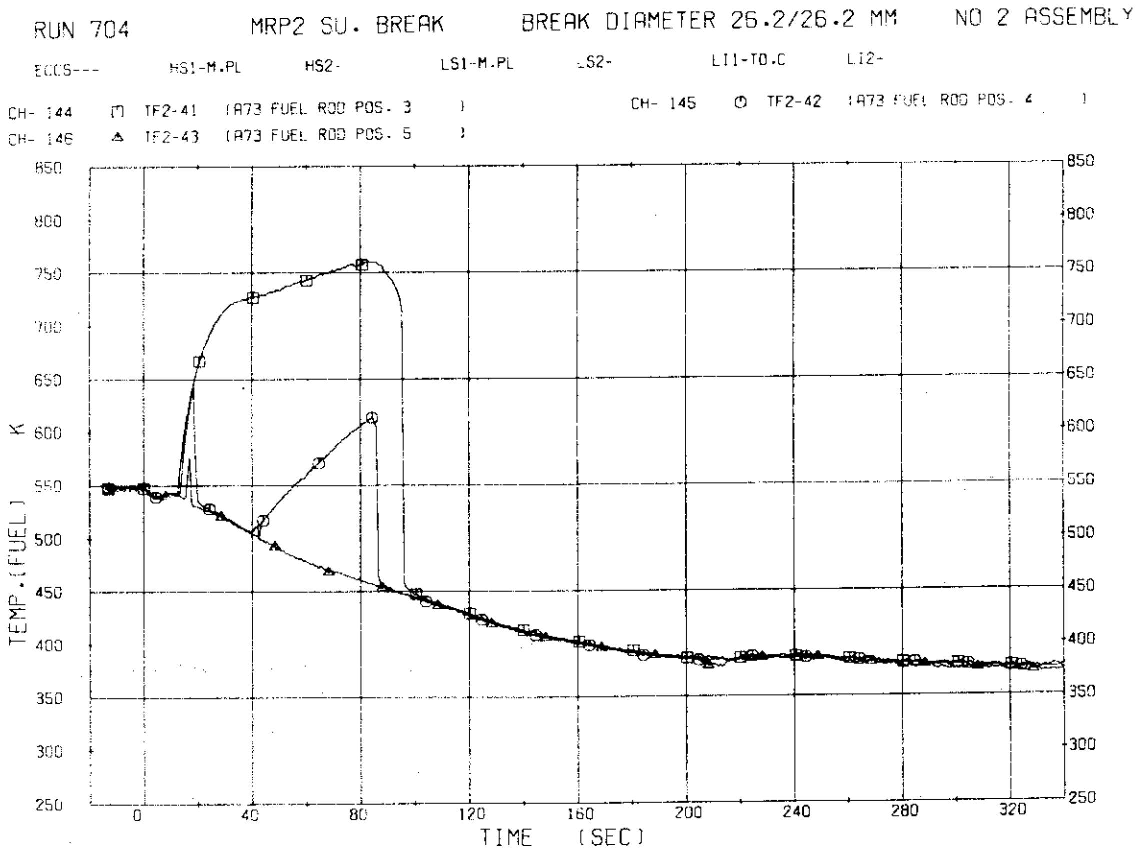


Fig. 5.40 Heater Rod Surface Temperature of A73 Rod

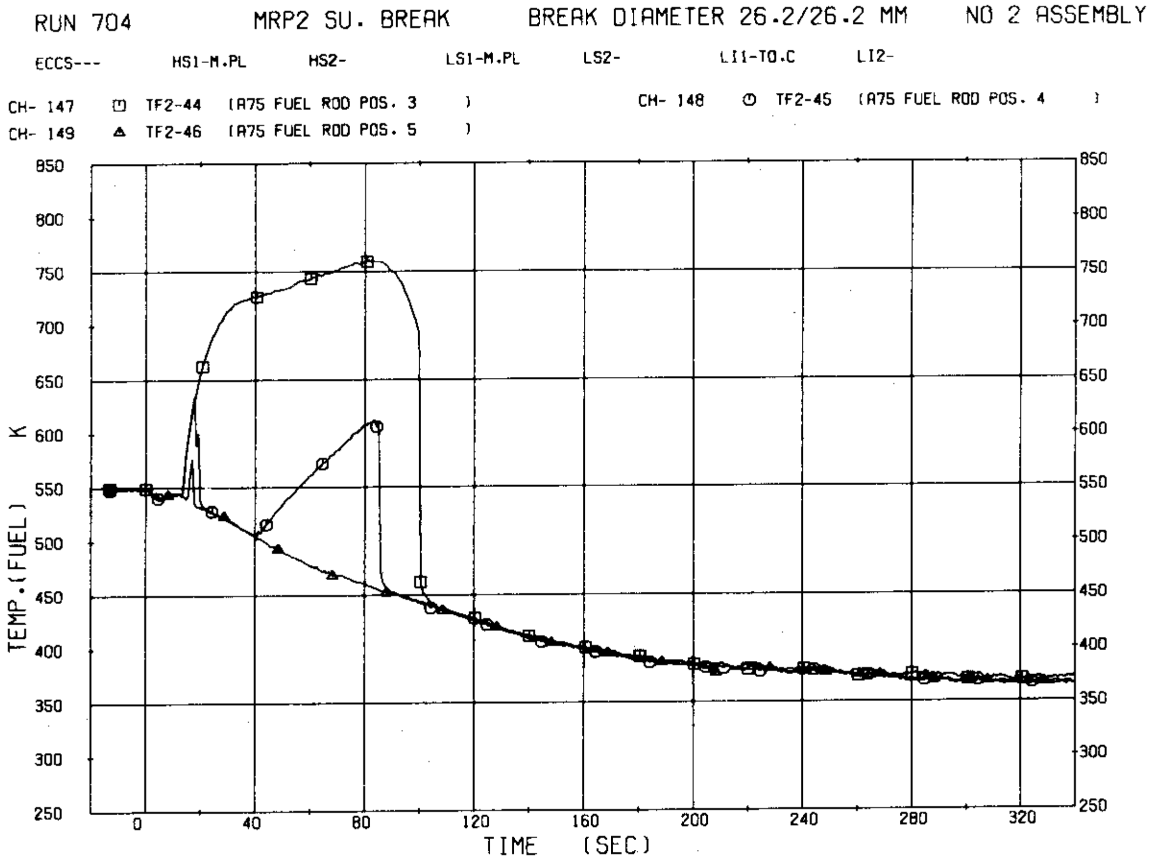


Fig. 5.41 Heater Rod Surface Temperature of A75 Rod

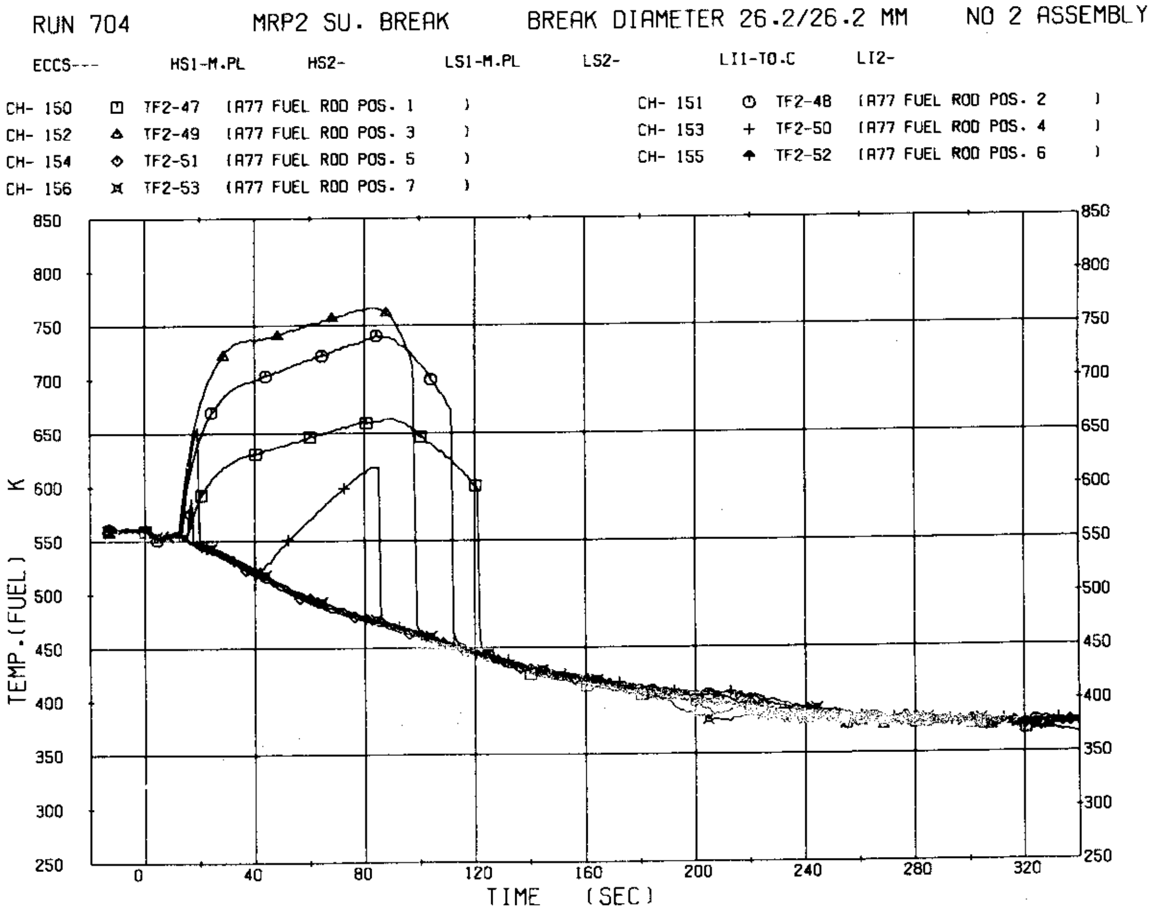


Fig. 5.42 Heater Rod Surface Temperature of A77 Rod

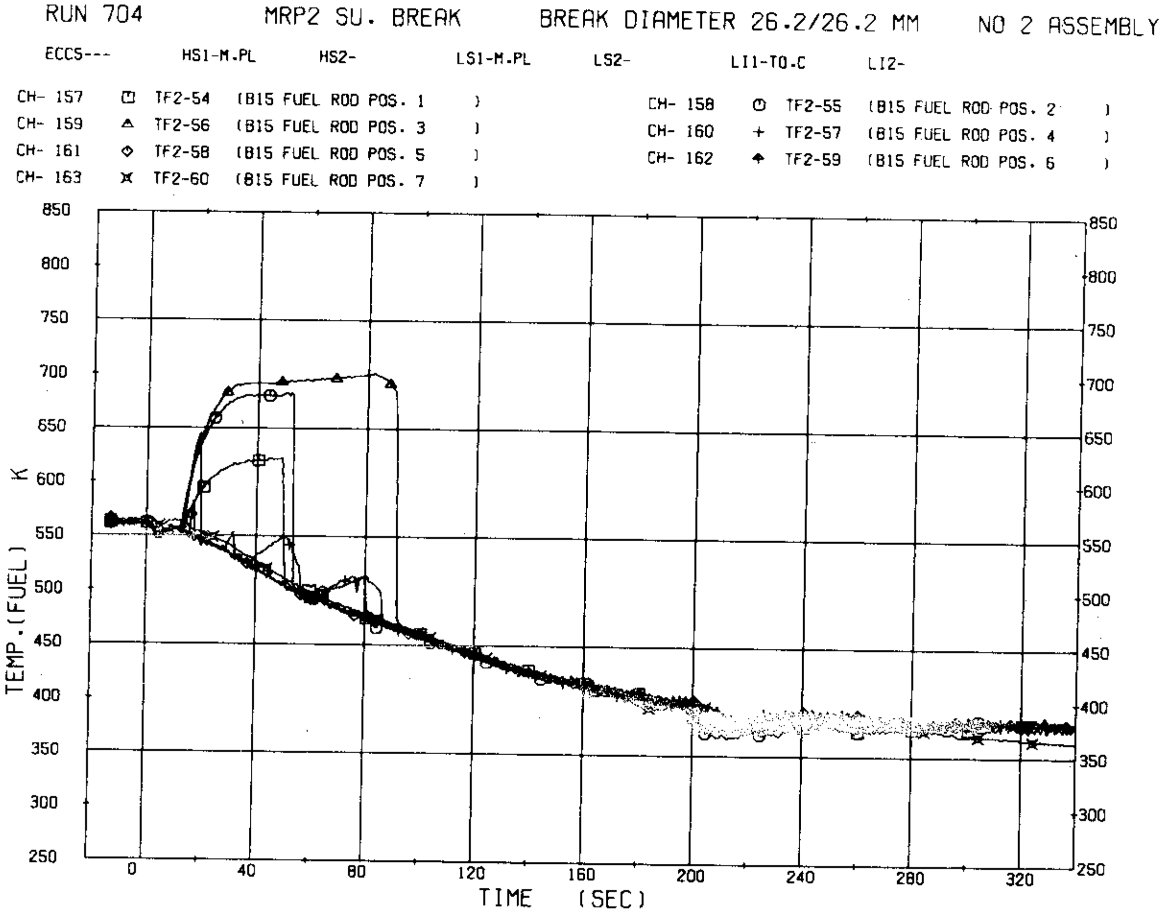


Fig. 5.43 Heater Rod Surface Temperature of B15 Rod

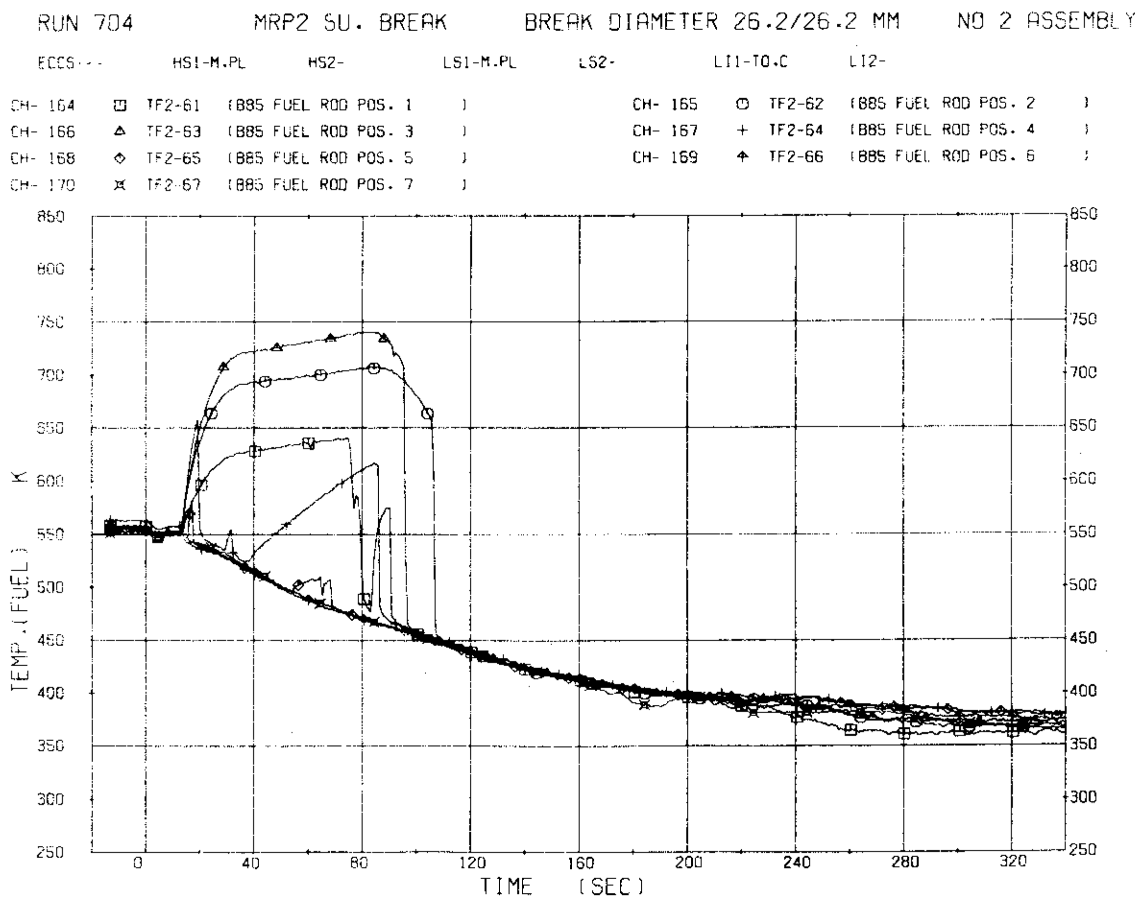


Fig. 5.44 Heater Rod Surface Temperature of B85 Rod

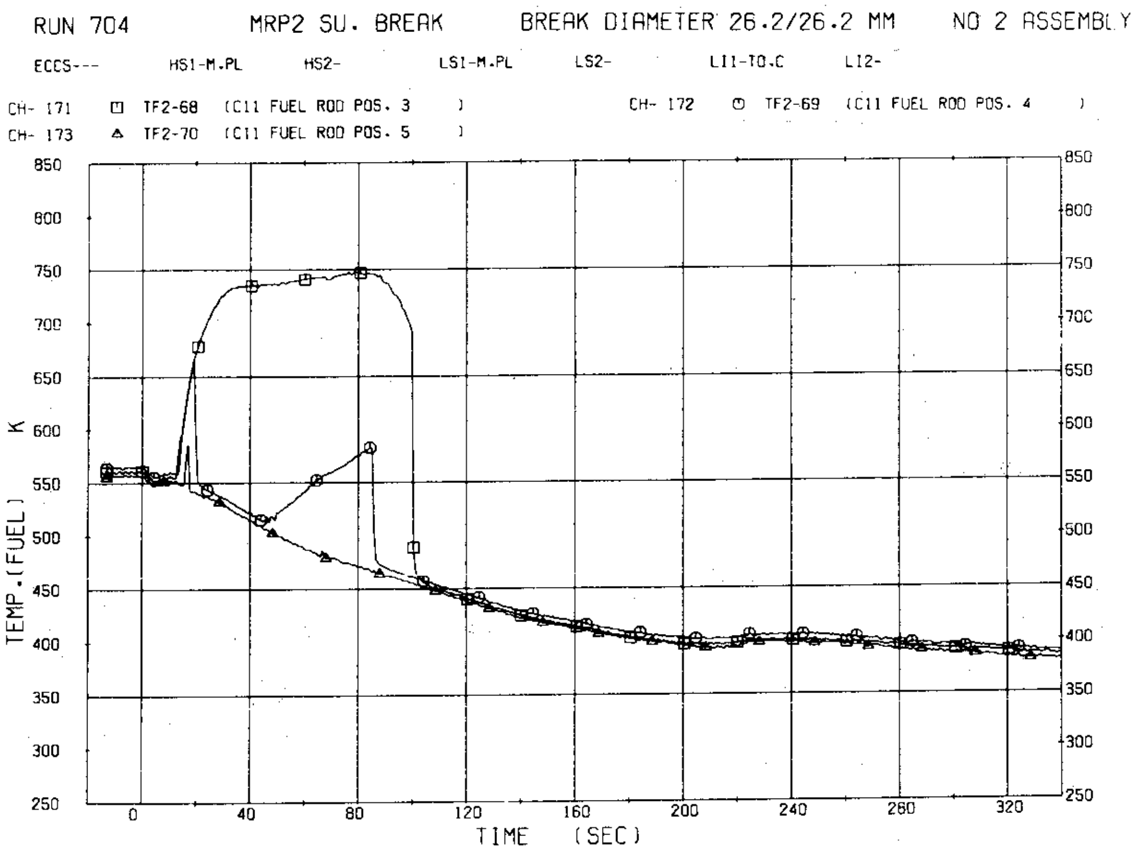


Fig. 5.45 Heater Rod Surface Temperature of C11 Rod

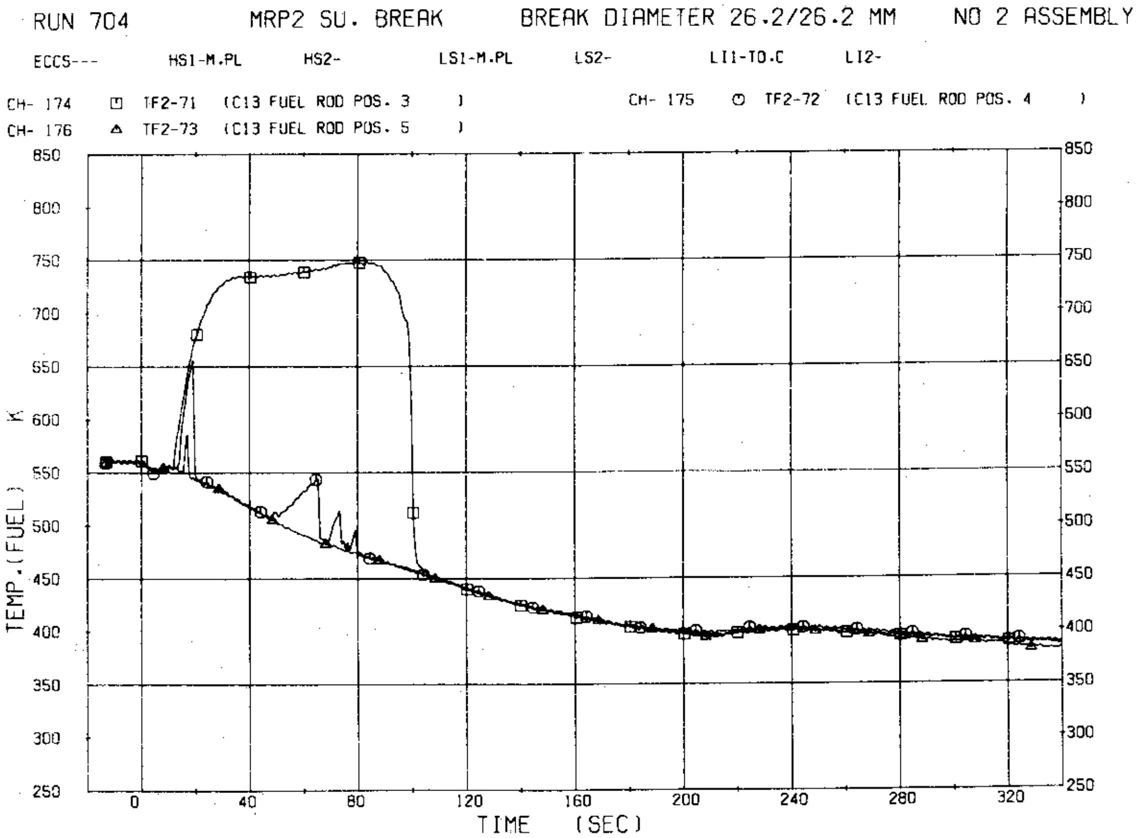


Fig. 5.46 Heater Rod Surface Temperature of C13 Rod

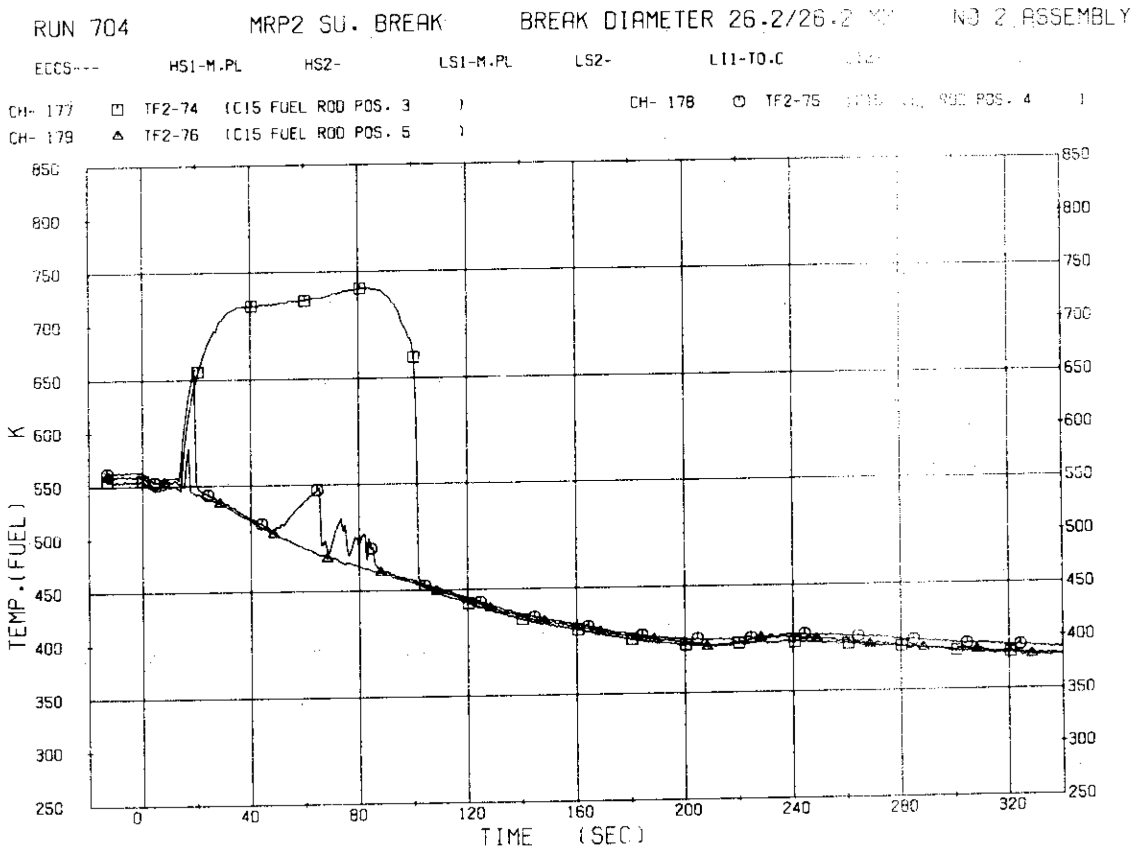


Fig. 5.47 Heater Rod Surface Temperature of C15 Rod

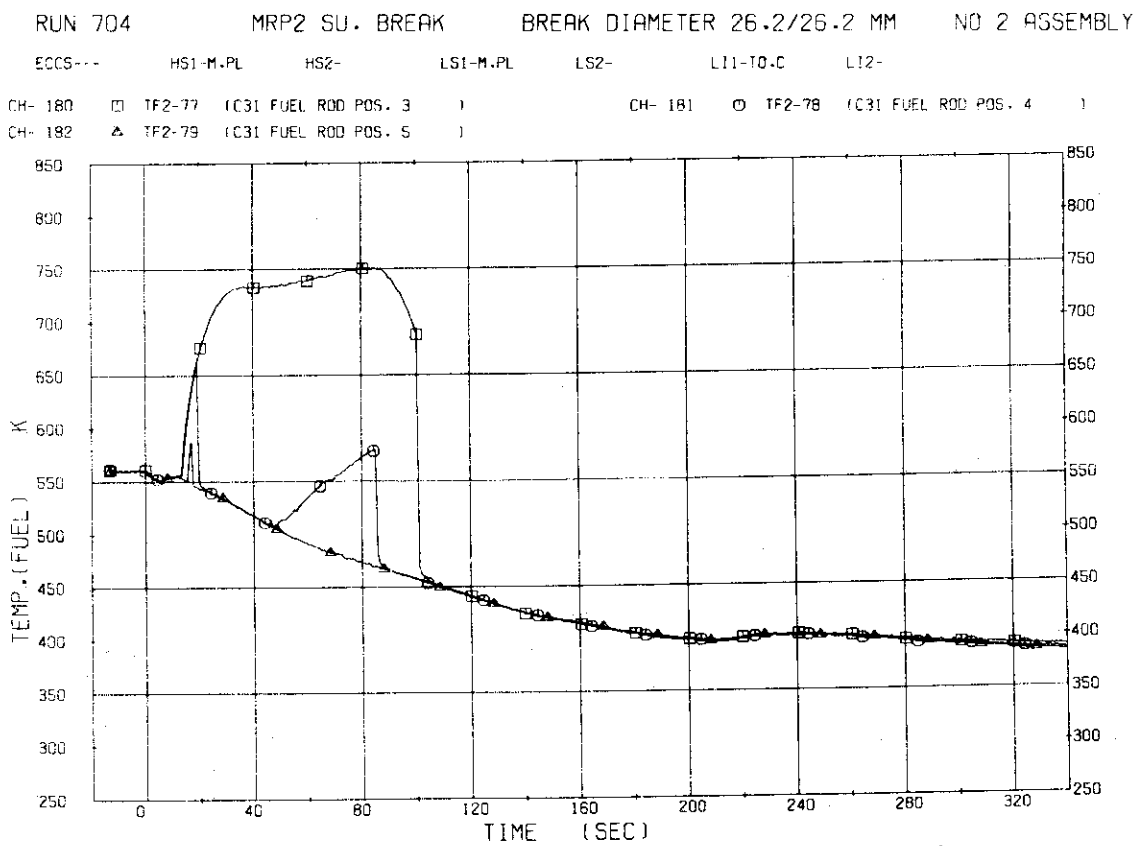


Fig. 5.48 Heater Rod Surface Temperature of C31 Rod

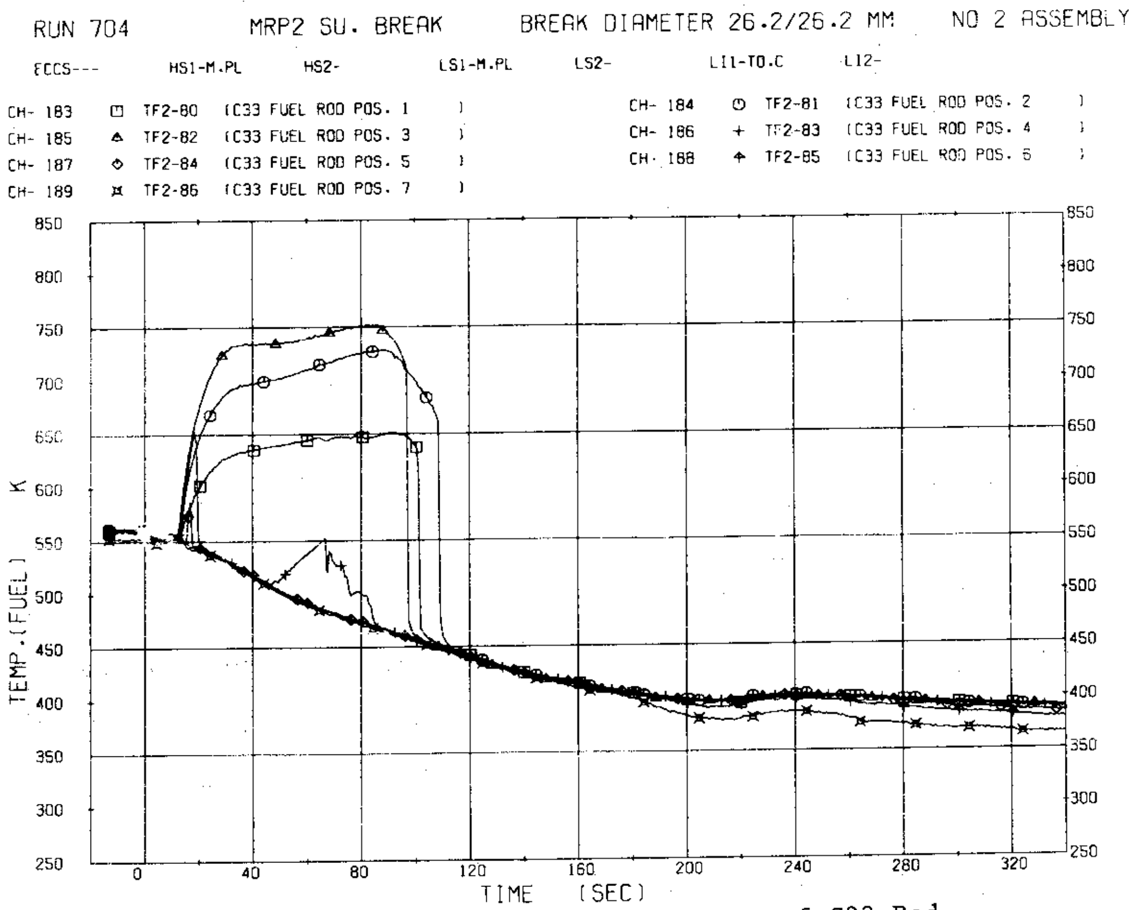


Fig. 5.49 Heater Rod Surface Temperature of C33 Rod

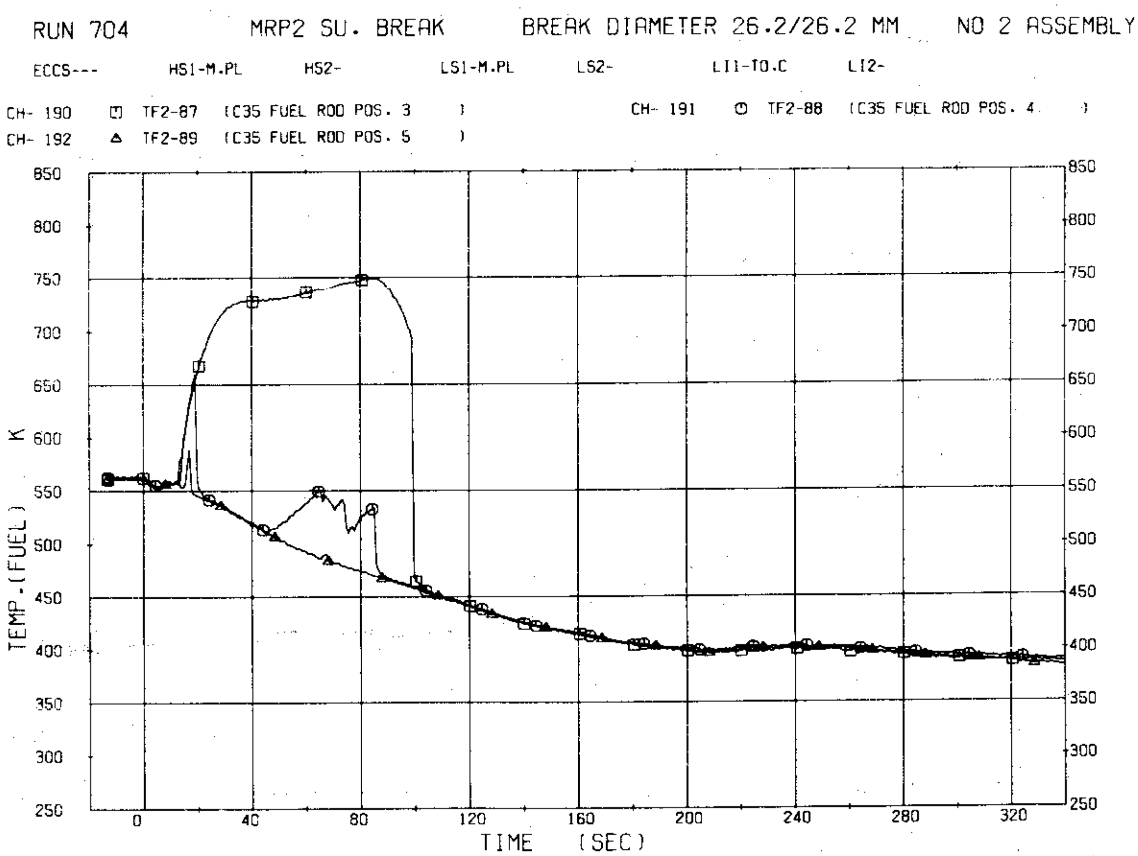


Fig. 5.50 Heater Rod Surface Temperature of C35 Rod

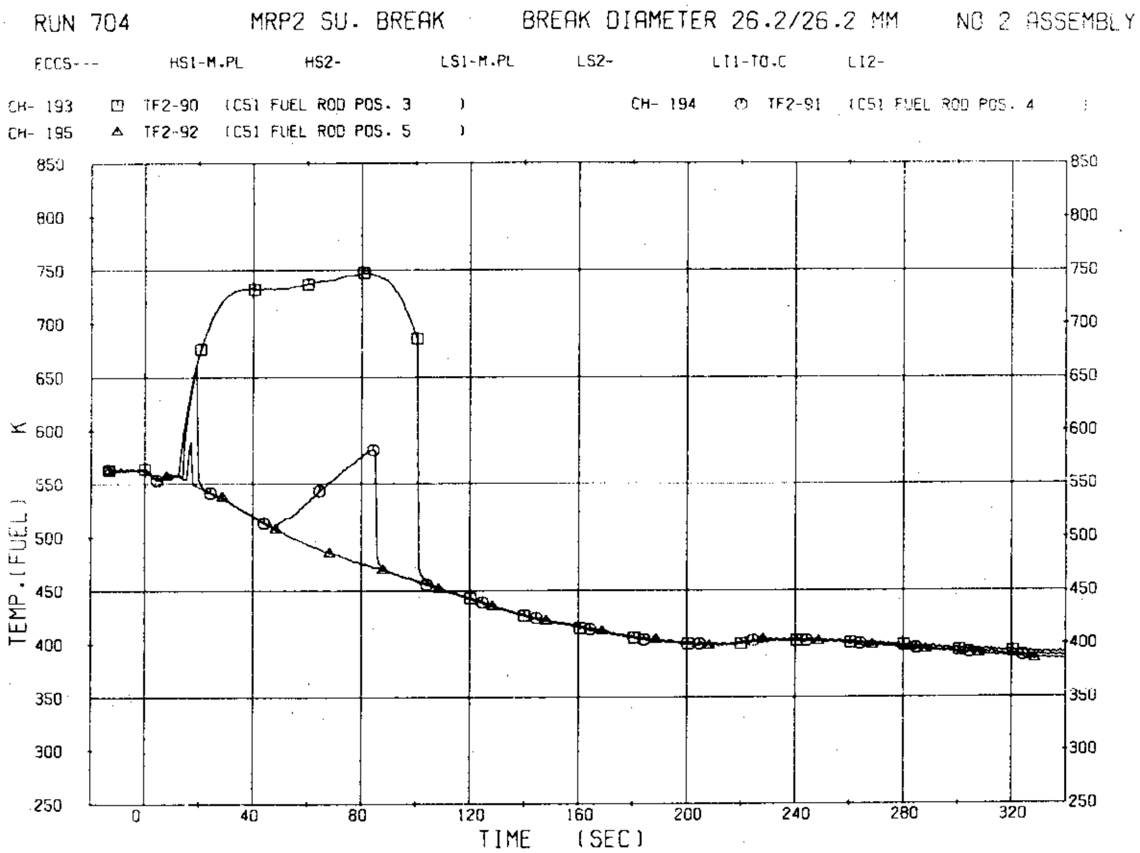


Fig. 5.51 Heater Rod Surface Temperature of C51 Rod

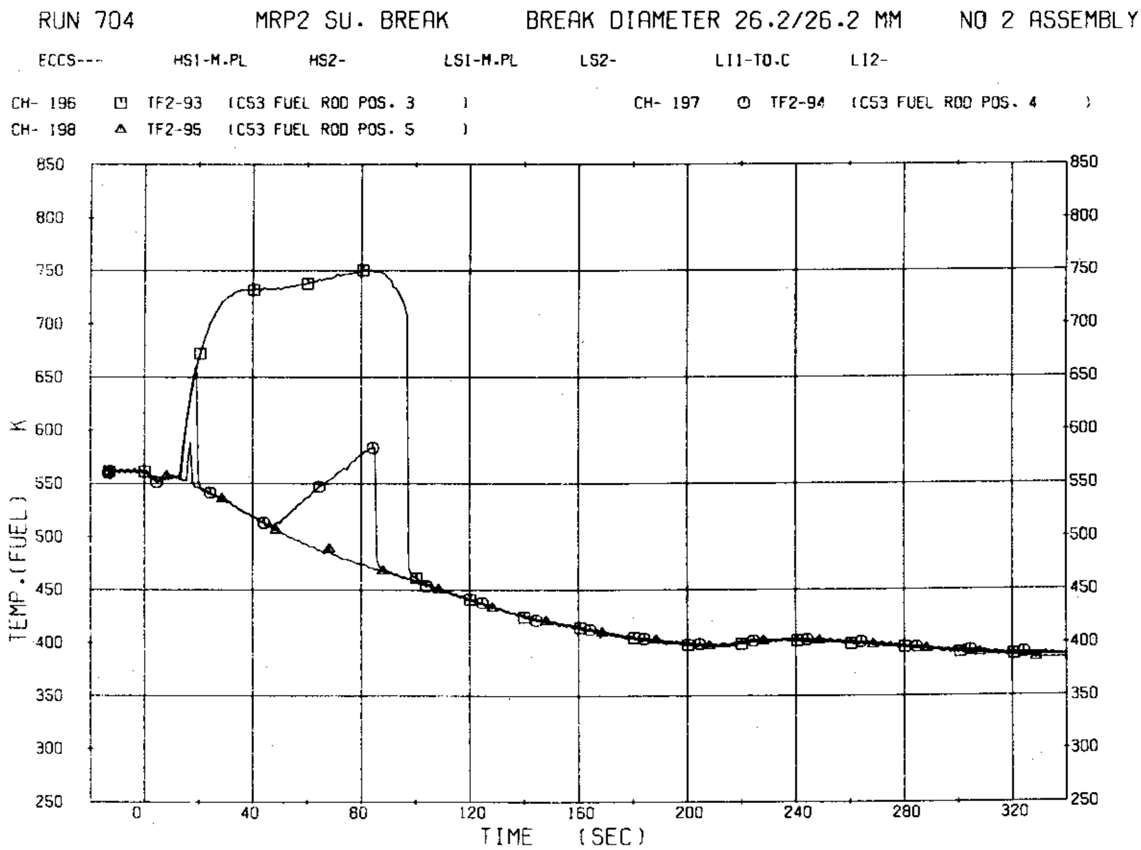


Fig. 5.52 Heater Rod Surface Temperature of C53 Rod

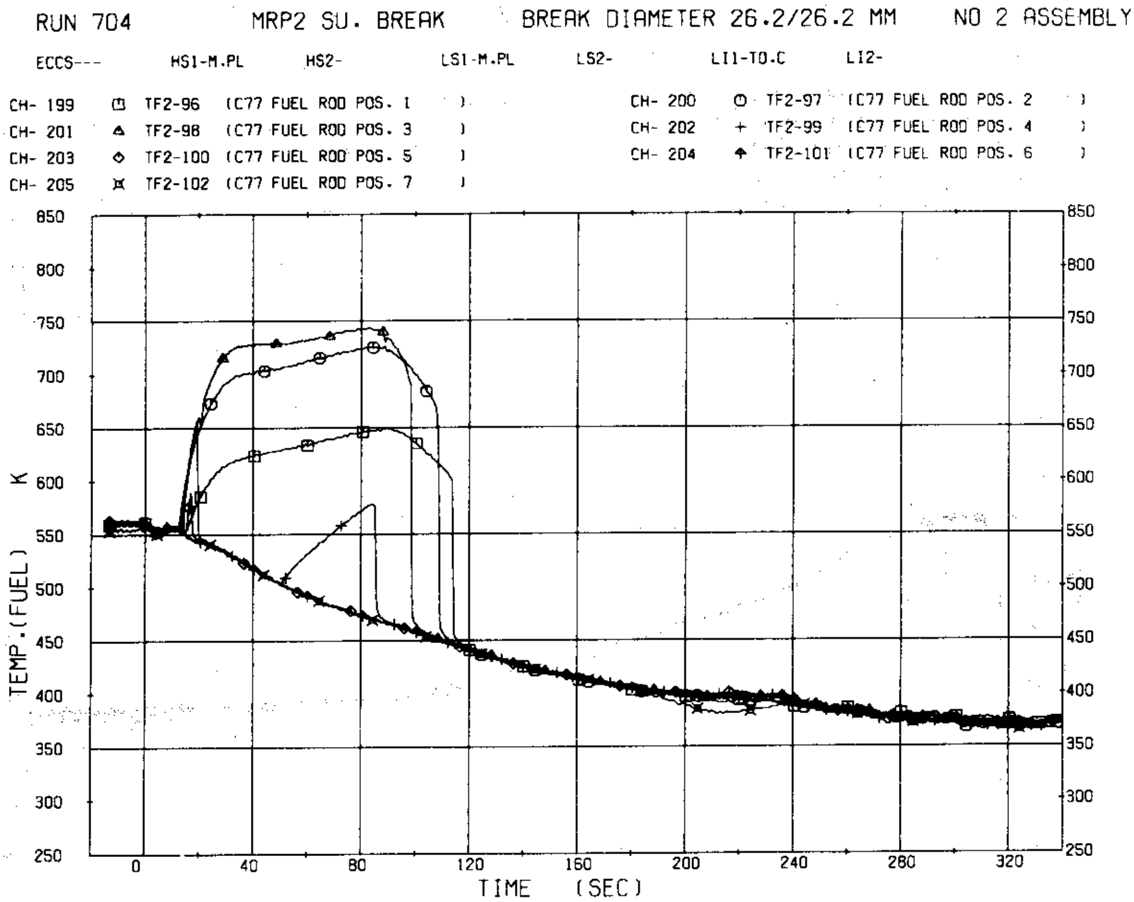


Fig. 5.53 Heater Rod Surface Temperature of C77 Rod

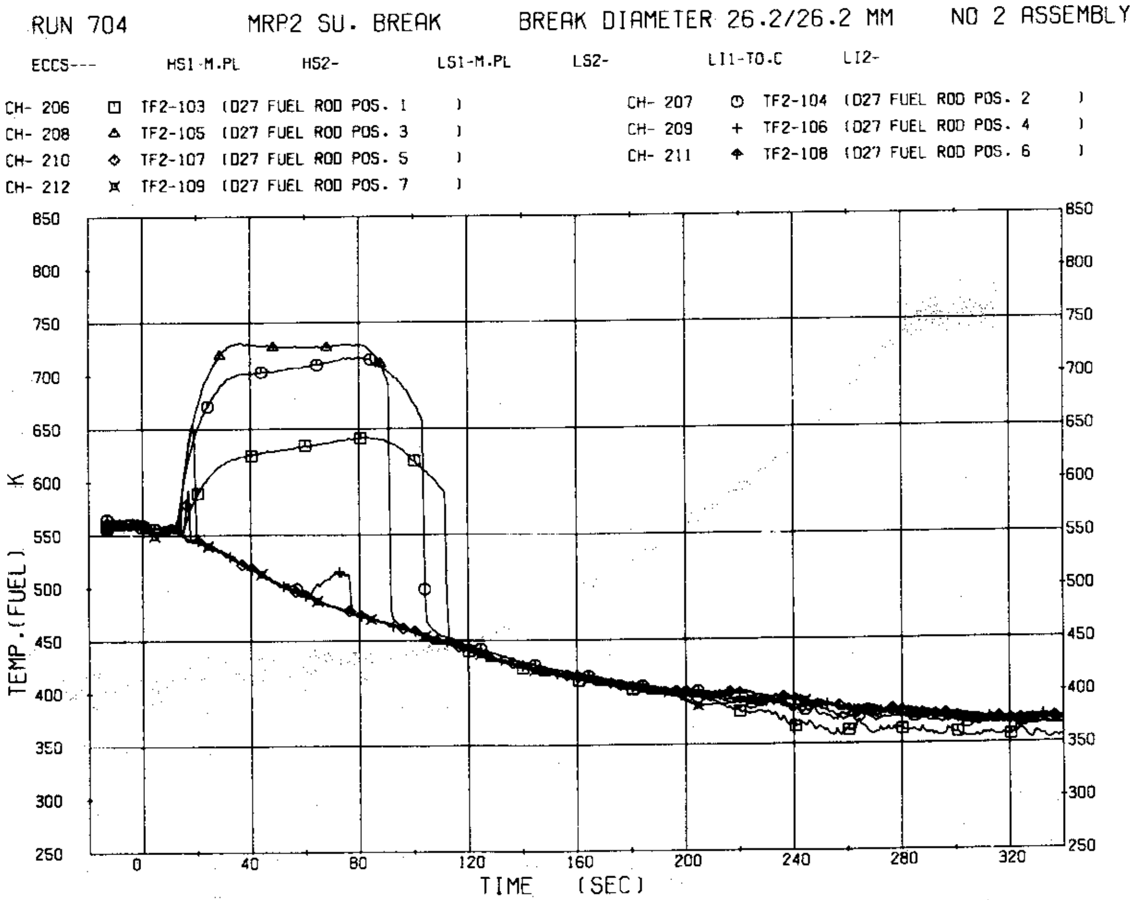


Fig. 5.54 Heater Rod Surface Temperature of D27 Rod

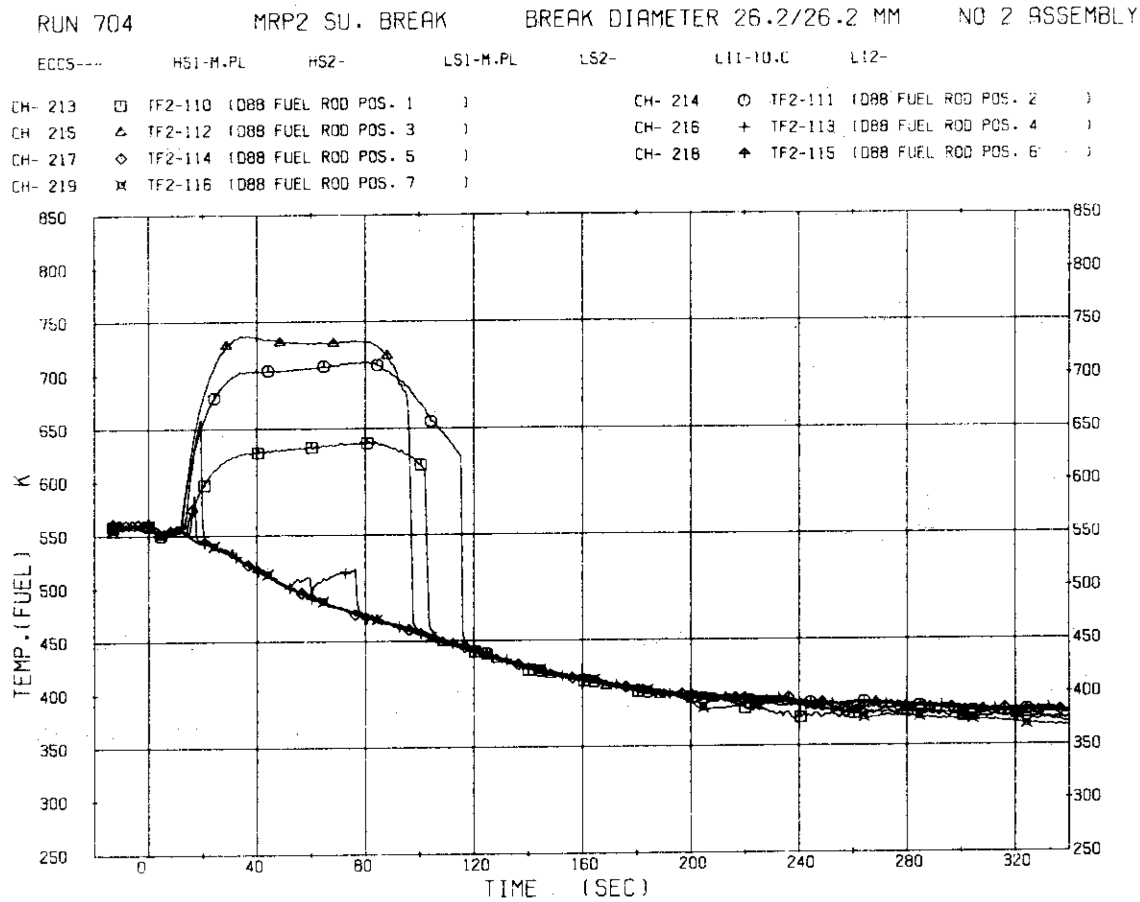


Fig. 5.55 Heater Rod Surface Temperature of D88 Rod

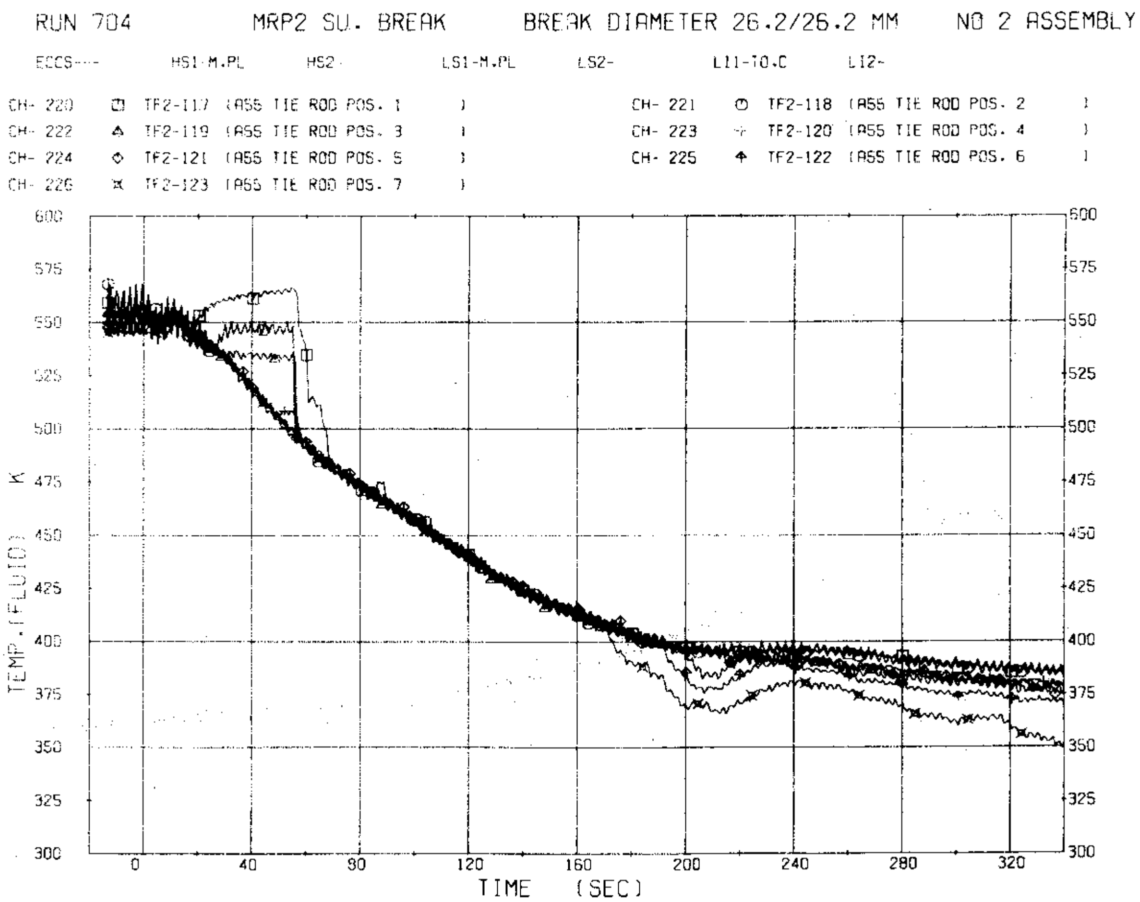


Fig. 5.56 Surface Temperature of Water Rod Simurator, A55

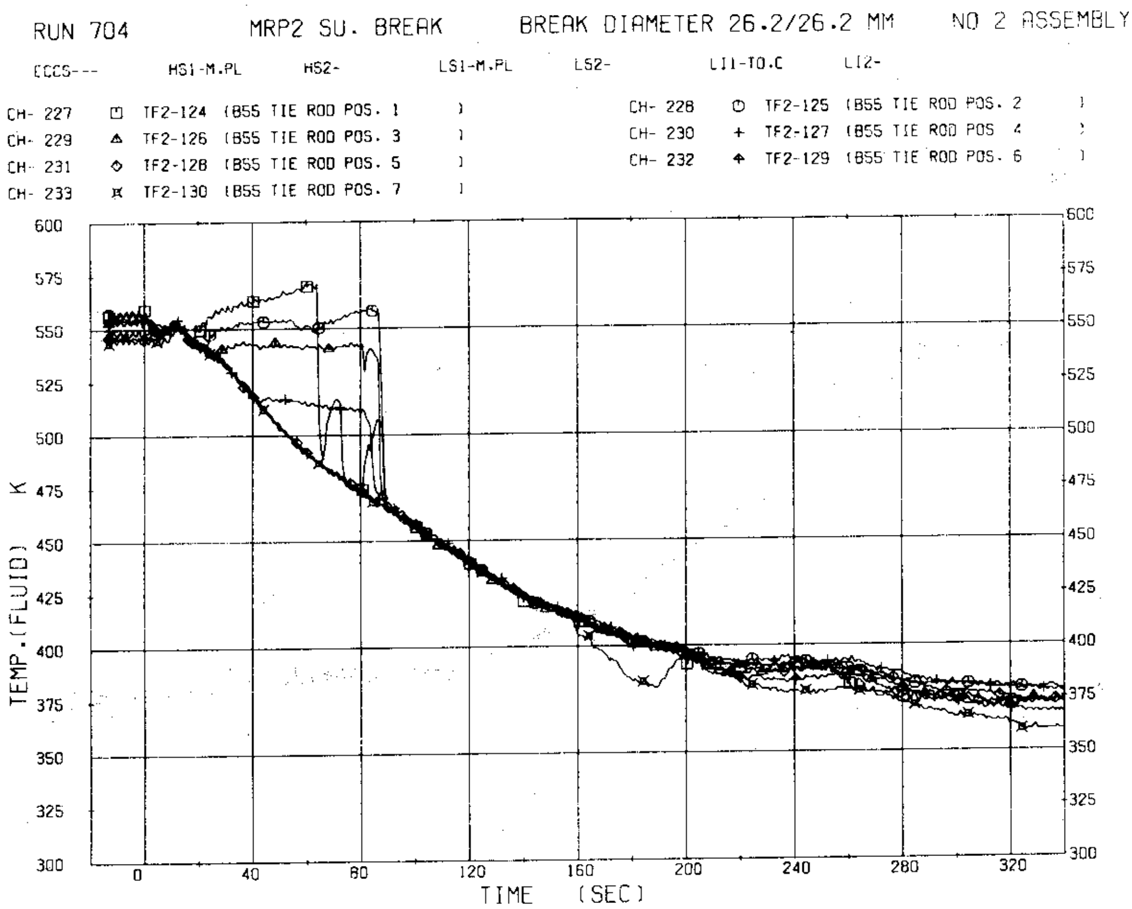


Fig. 5.57 Surface Temperature of Water Rod Simurator, B55

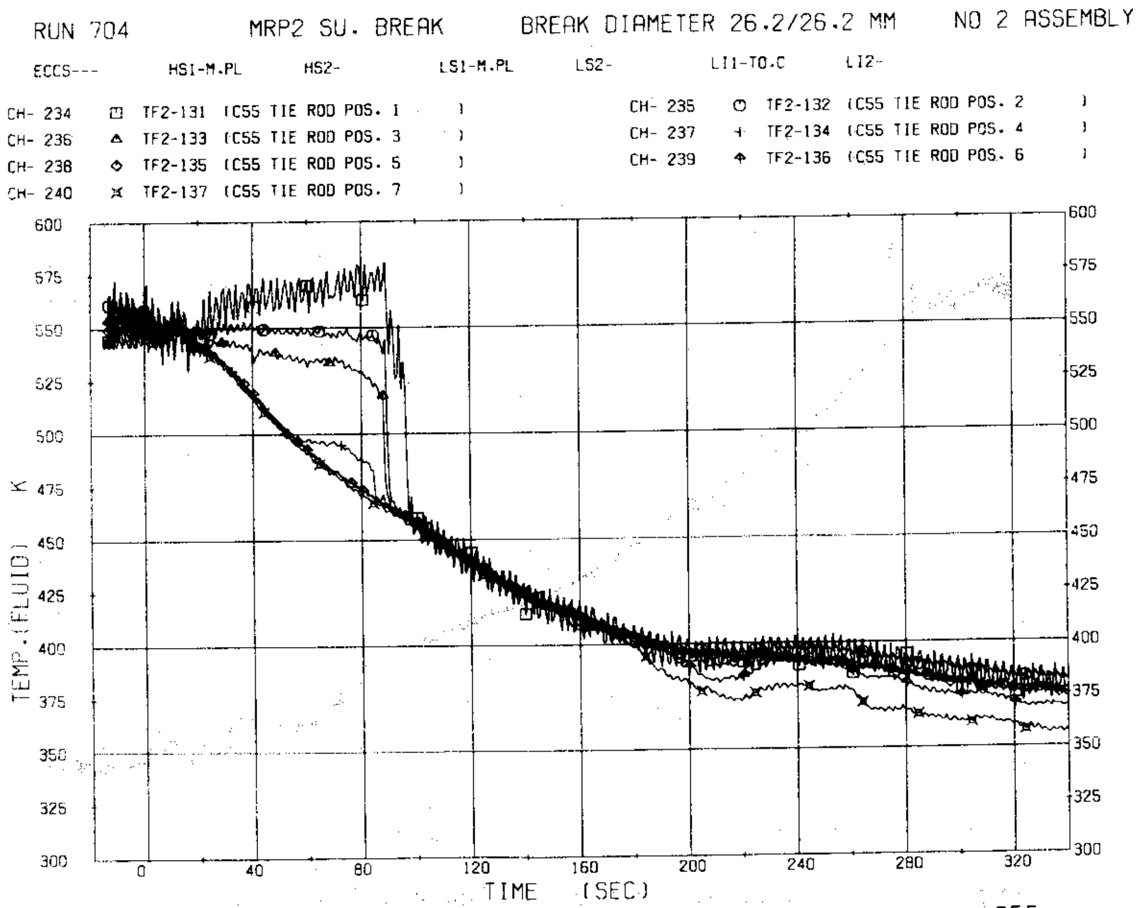


Fig. 5.58 Surface Temperature of Water Rod Simurator, C55

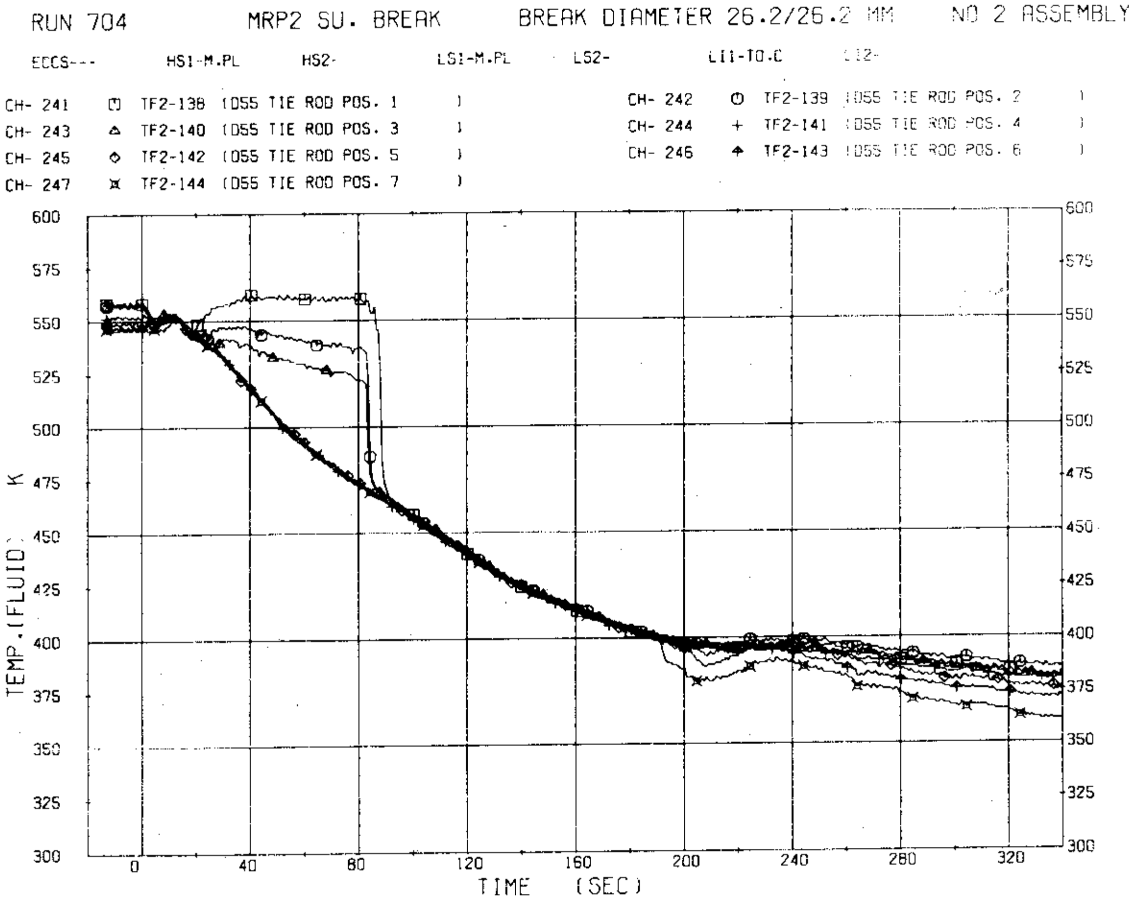


Fig. 5.59 Surface Temperature of Water Rod Simurator, D55

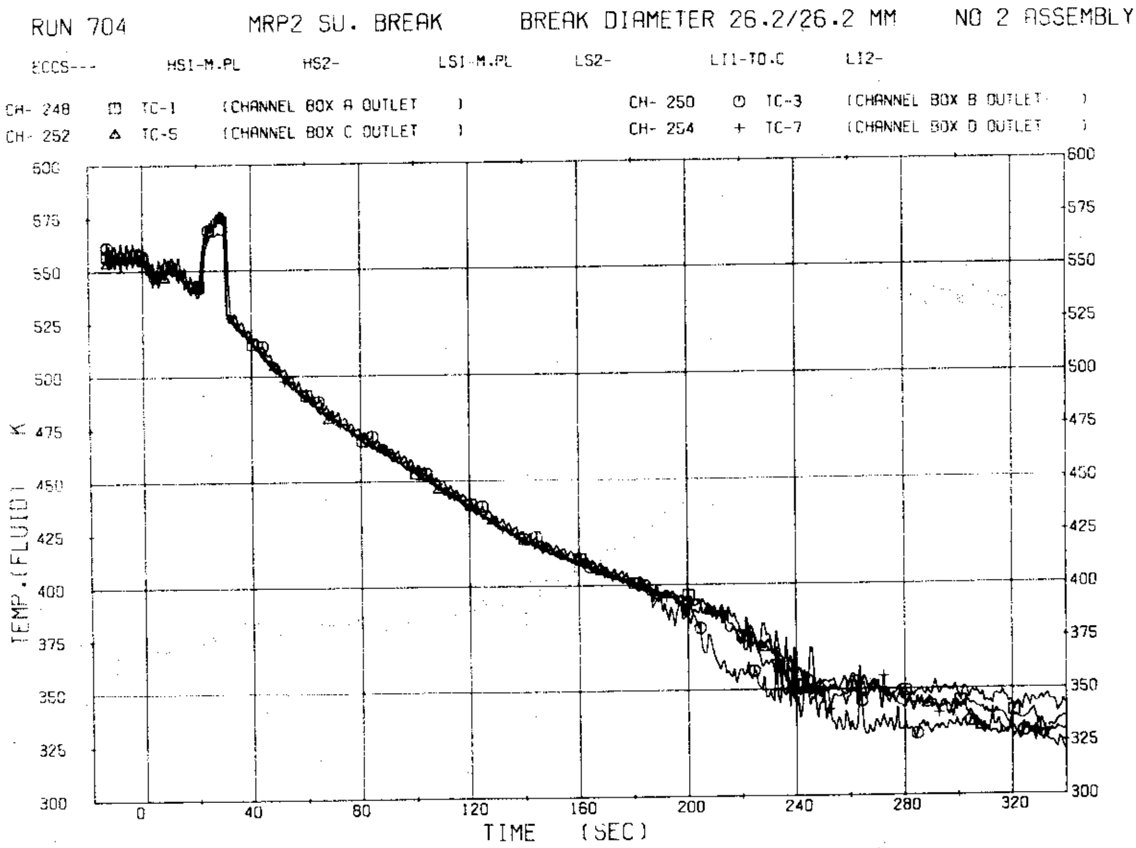


Fig. 5.60 Fluid Temperature at Channel Box Outlet

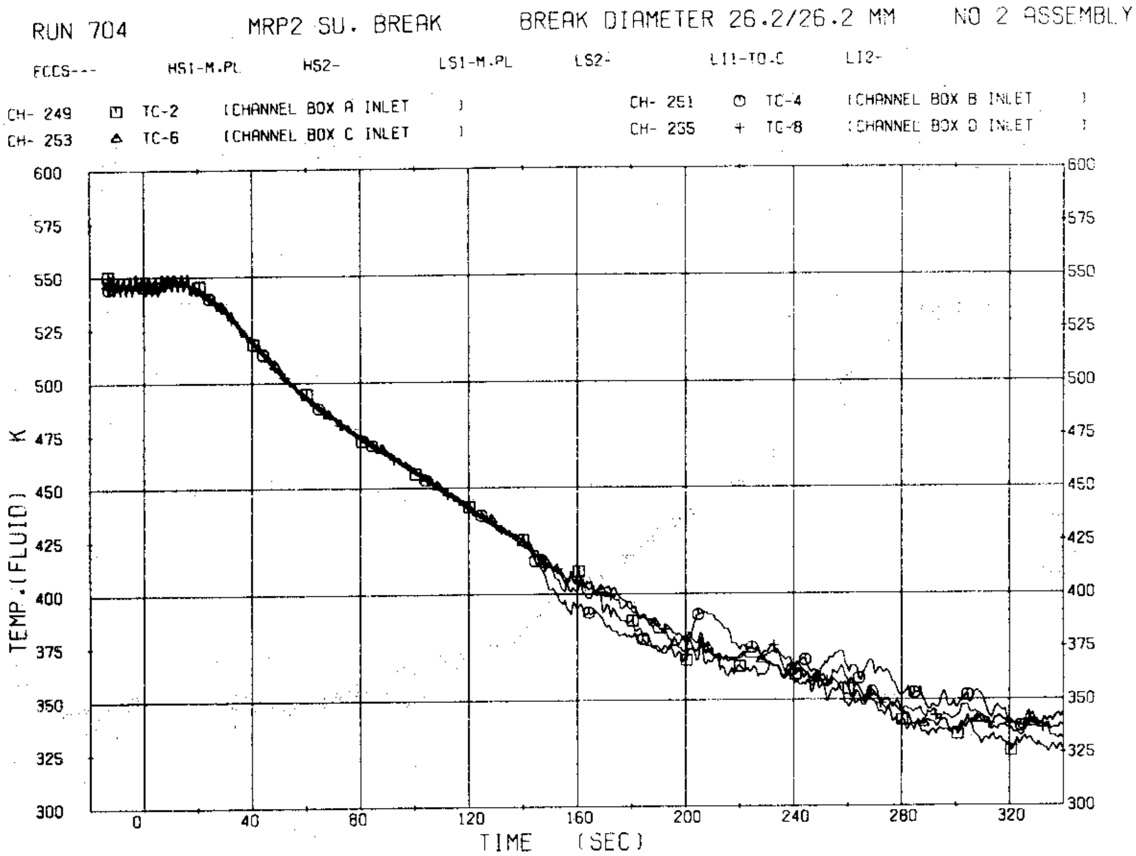


Fig. 5.61 Fluid Temperature at Channel Box Inlet

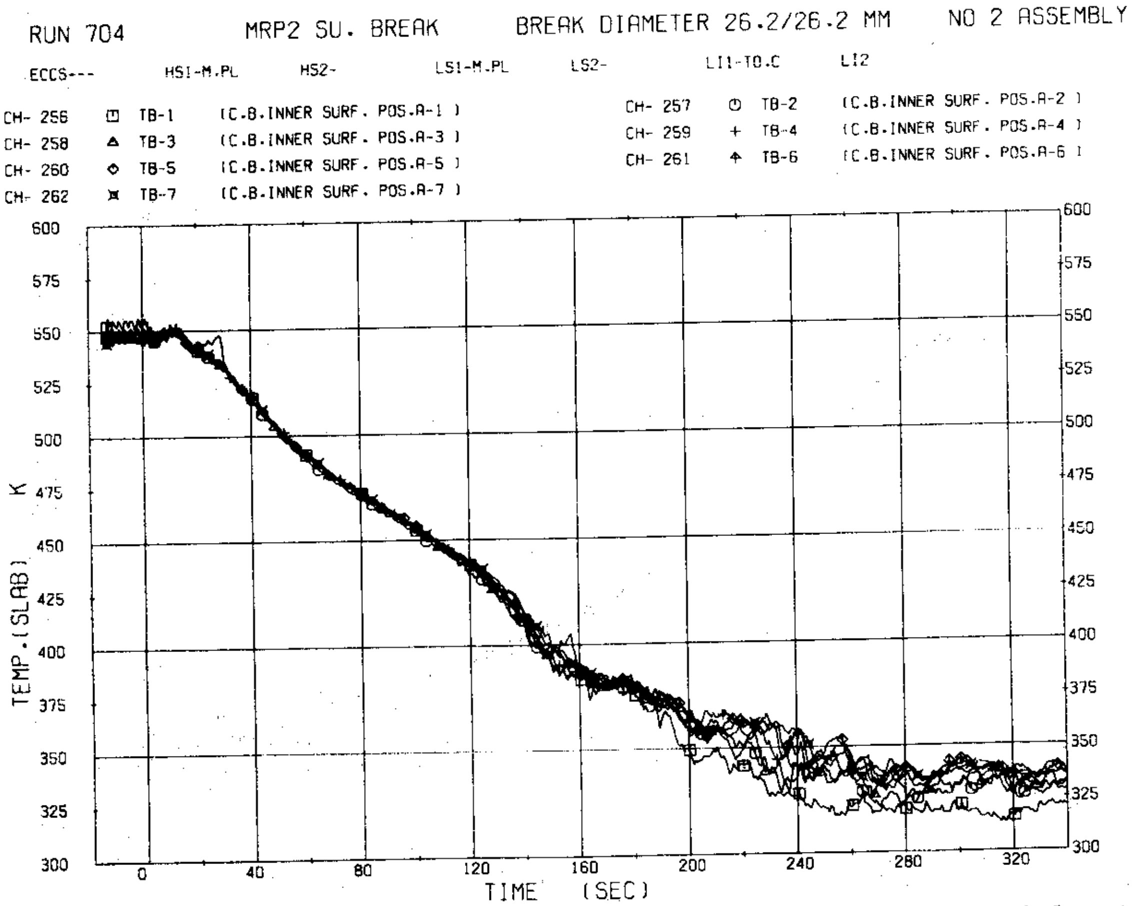


Fig. 5.62 Inner Surface Temperature of Channel Box A, A1 Location

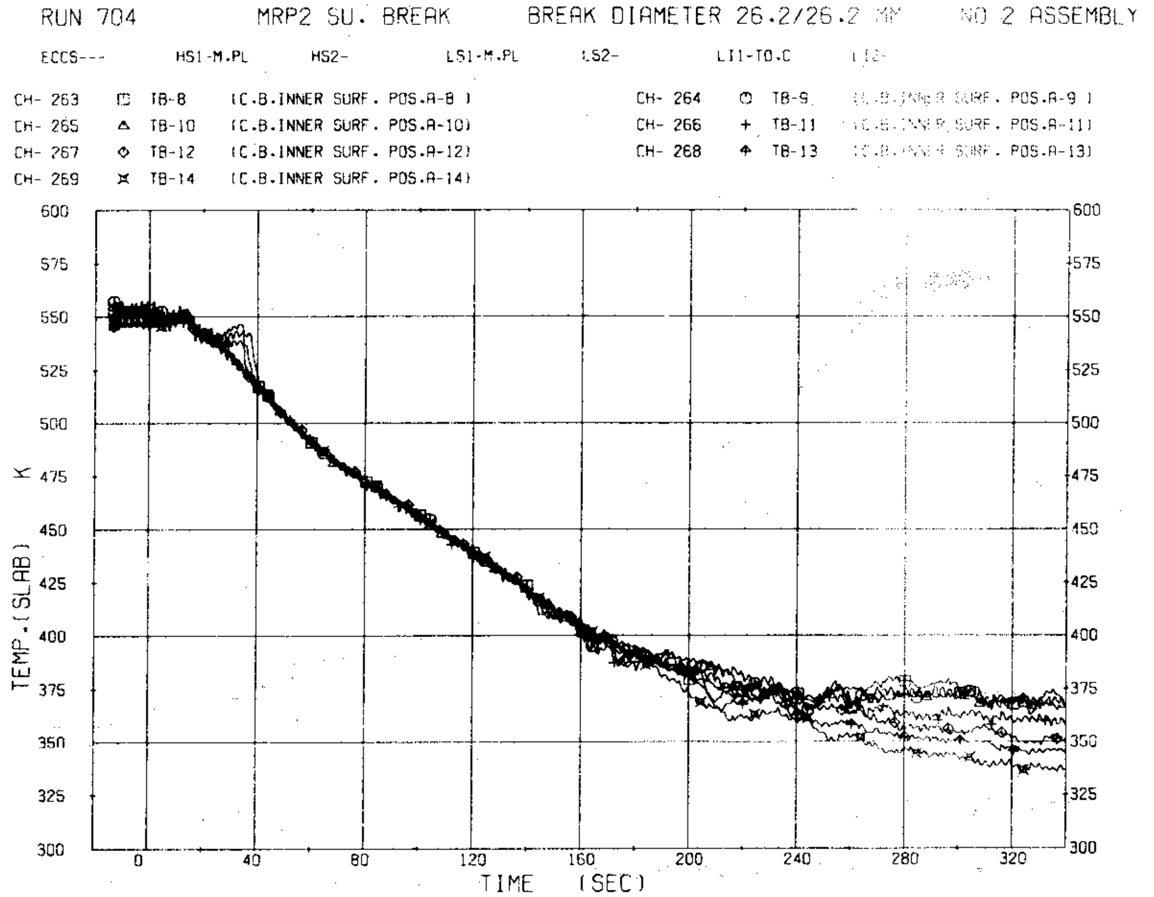


Fig. 5.63 Inner Surface Temperature of Channel Box A, A2 Location

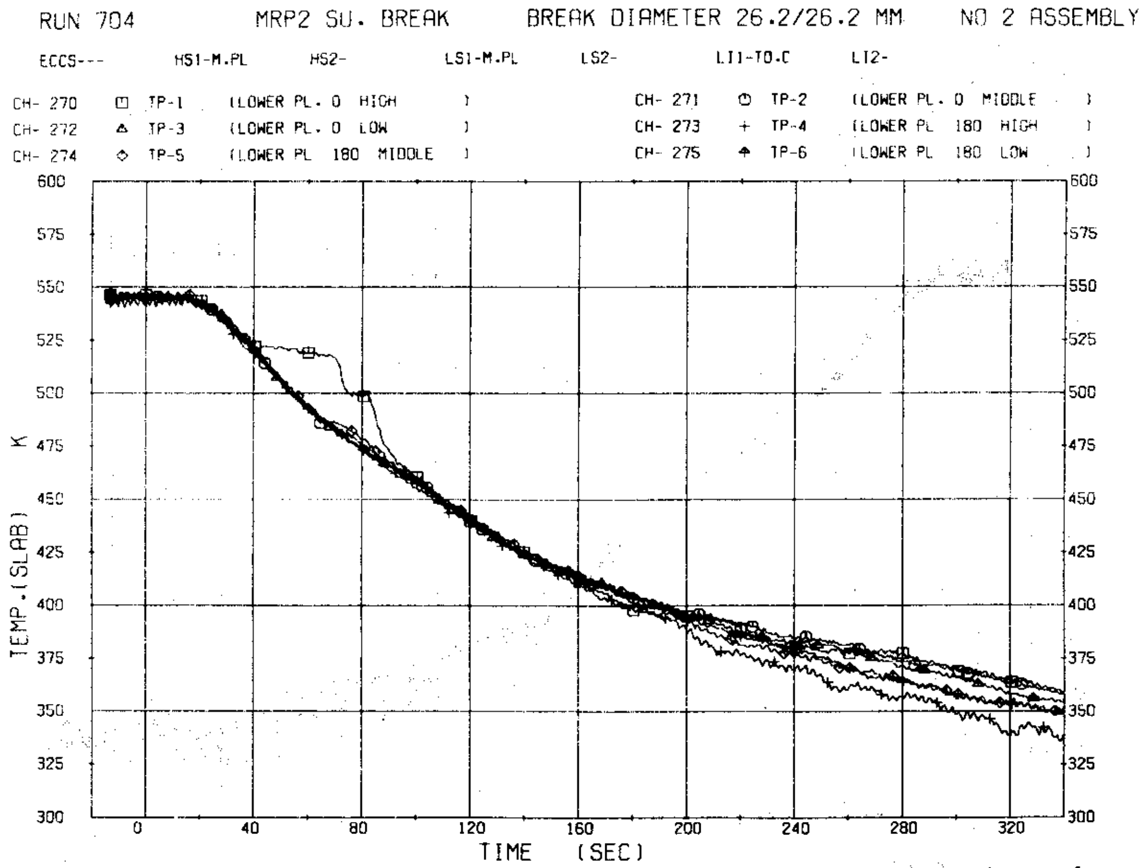


Fig. 5.64 Fluid Temperature in Lower Plenum, North and South

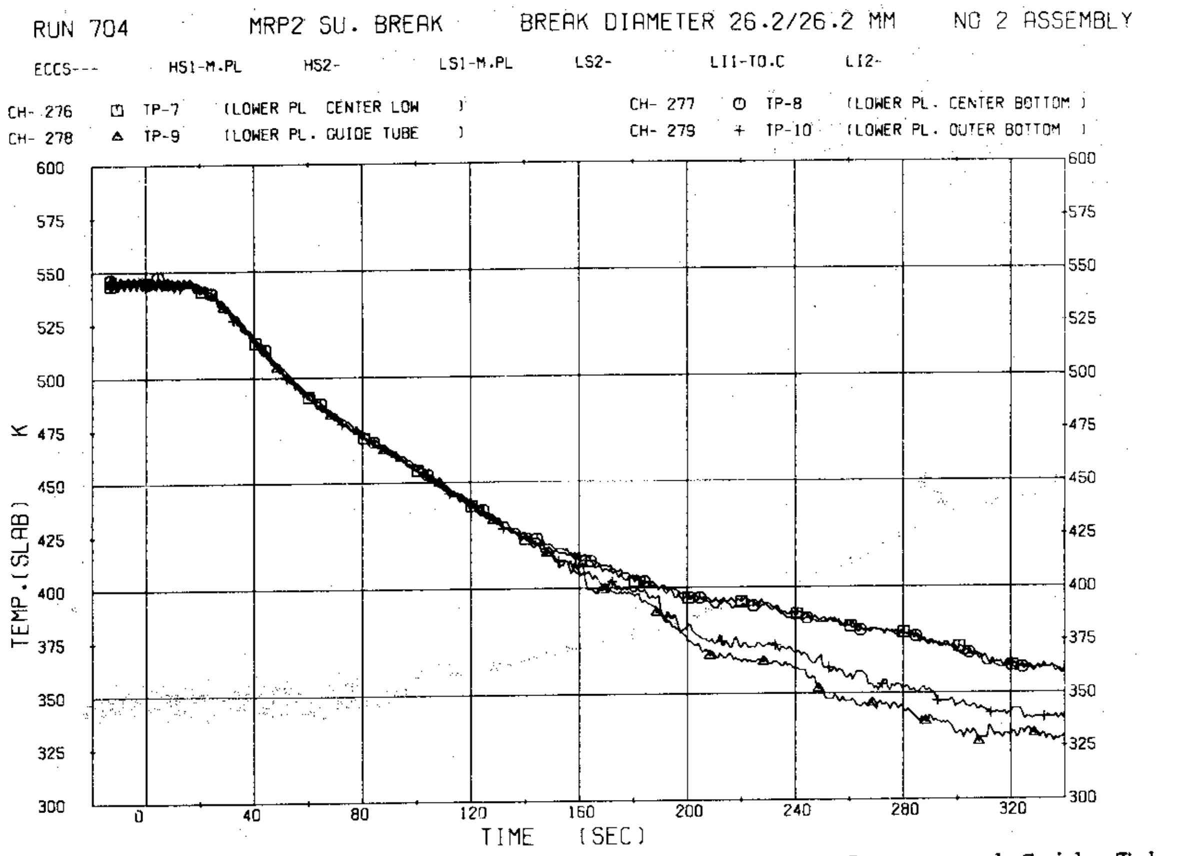


Fig. 5.65 Fluid Temperature in Lower Plenum Center and Guide Tube

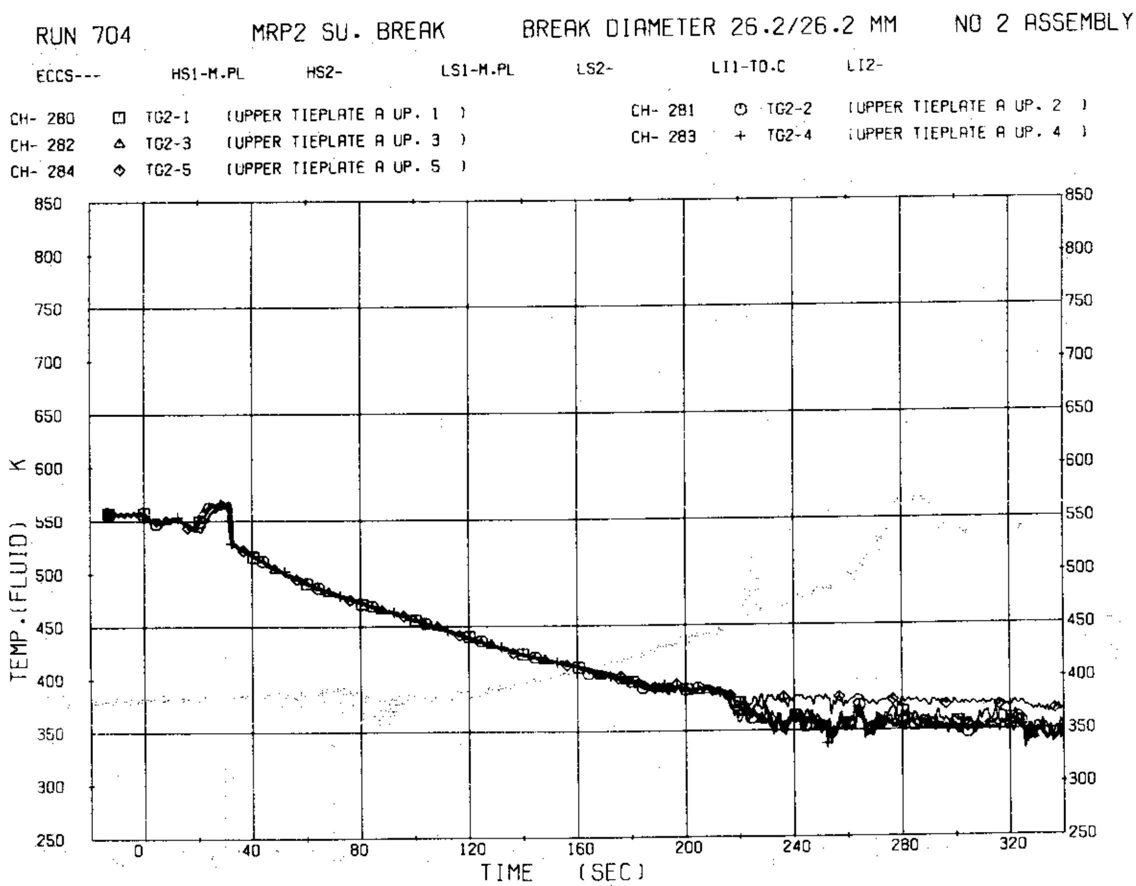


Fig. 5.66 Fluid Temperature in Upper Region of Upper Tie Plate

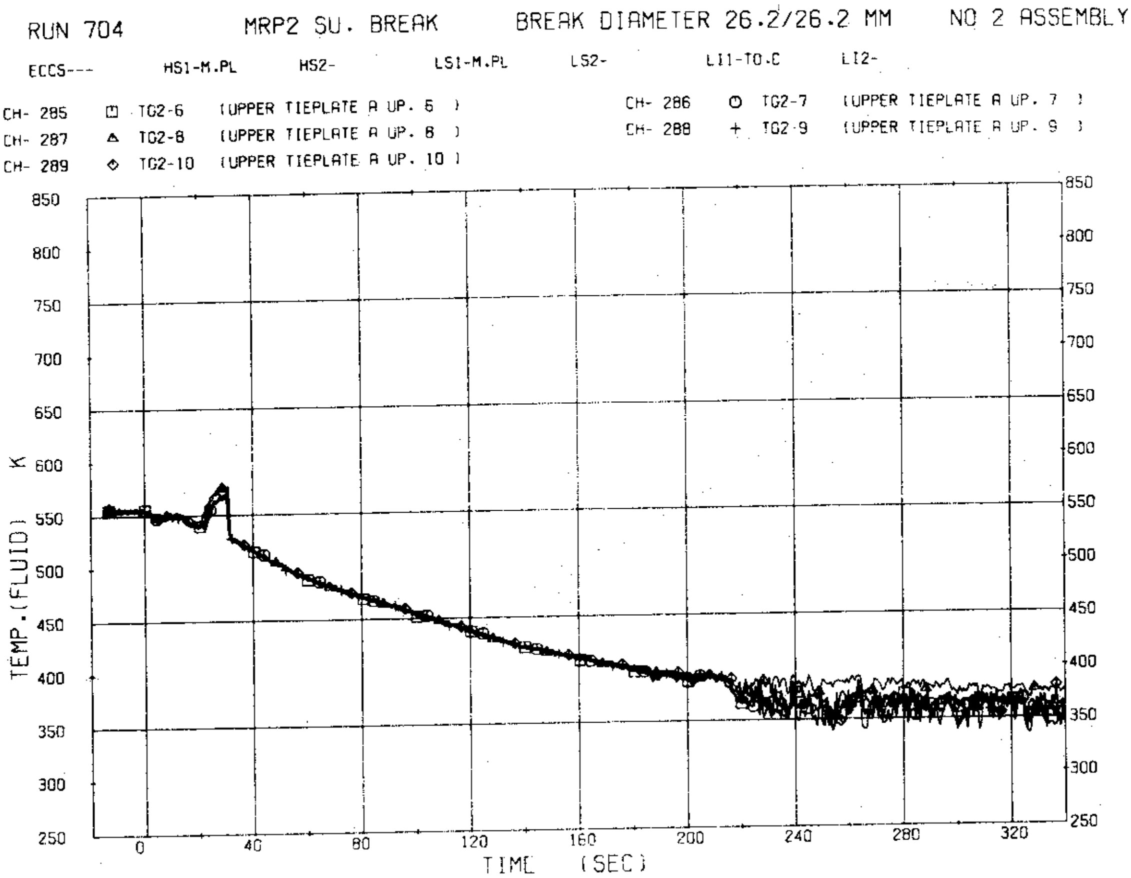


Fig. 5.67 Fluid Temperature in Upper Region of Upper Tie Plate

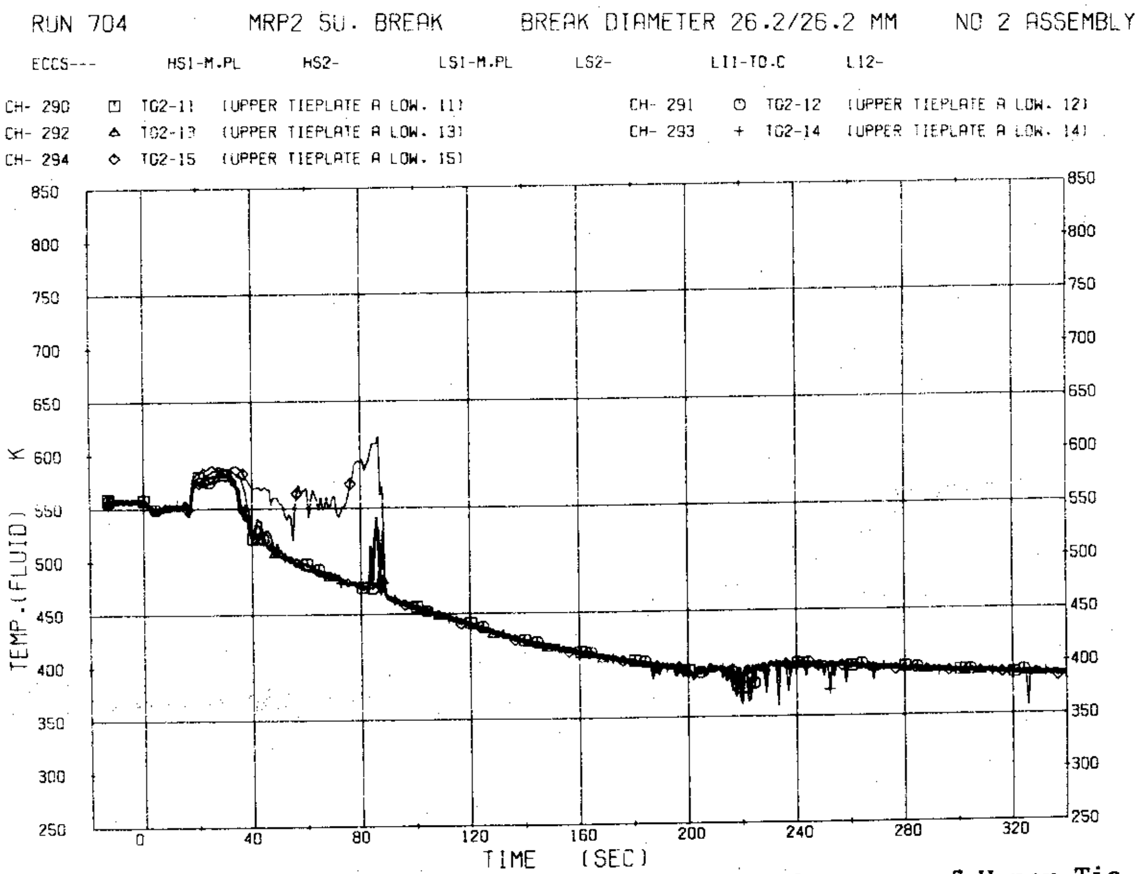


Fig. 5.68 Fluid Temperature in Immediate Upstream of Upper Tie Plate

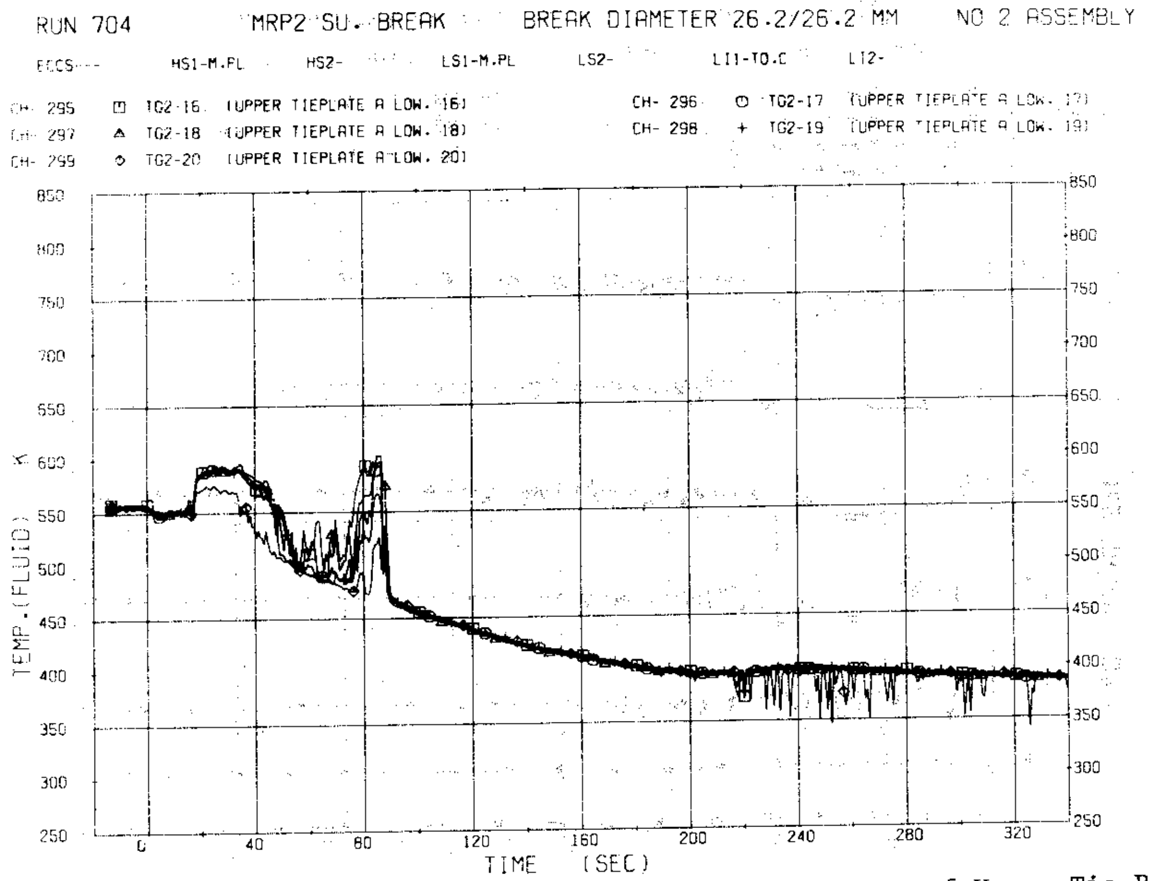


Fig. 5.69 Fluid Temperature in Immediate Upstream of Upper Tie Plate

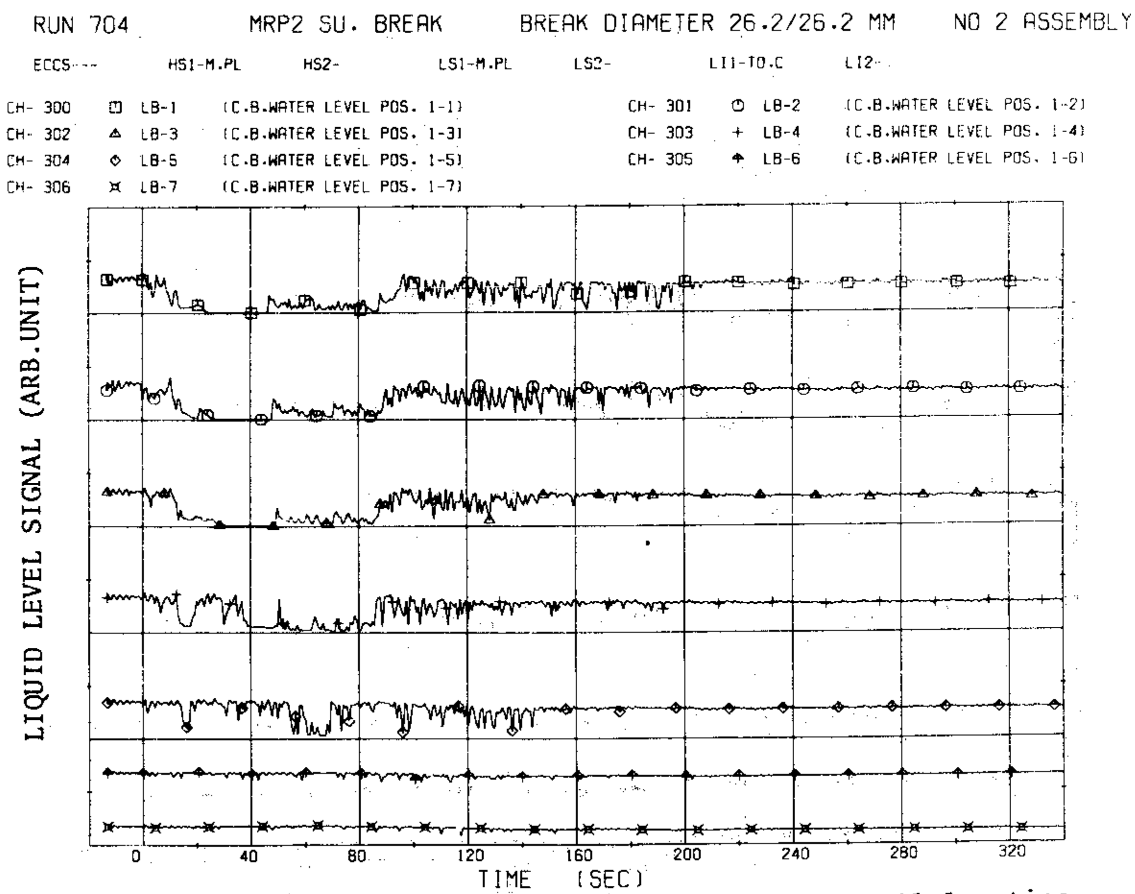


Fig. 5.70 Liquid Level Signal in Channel Box A, A1 Location

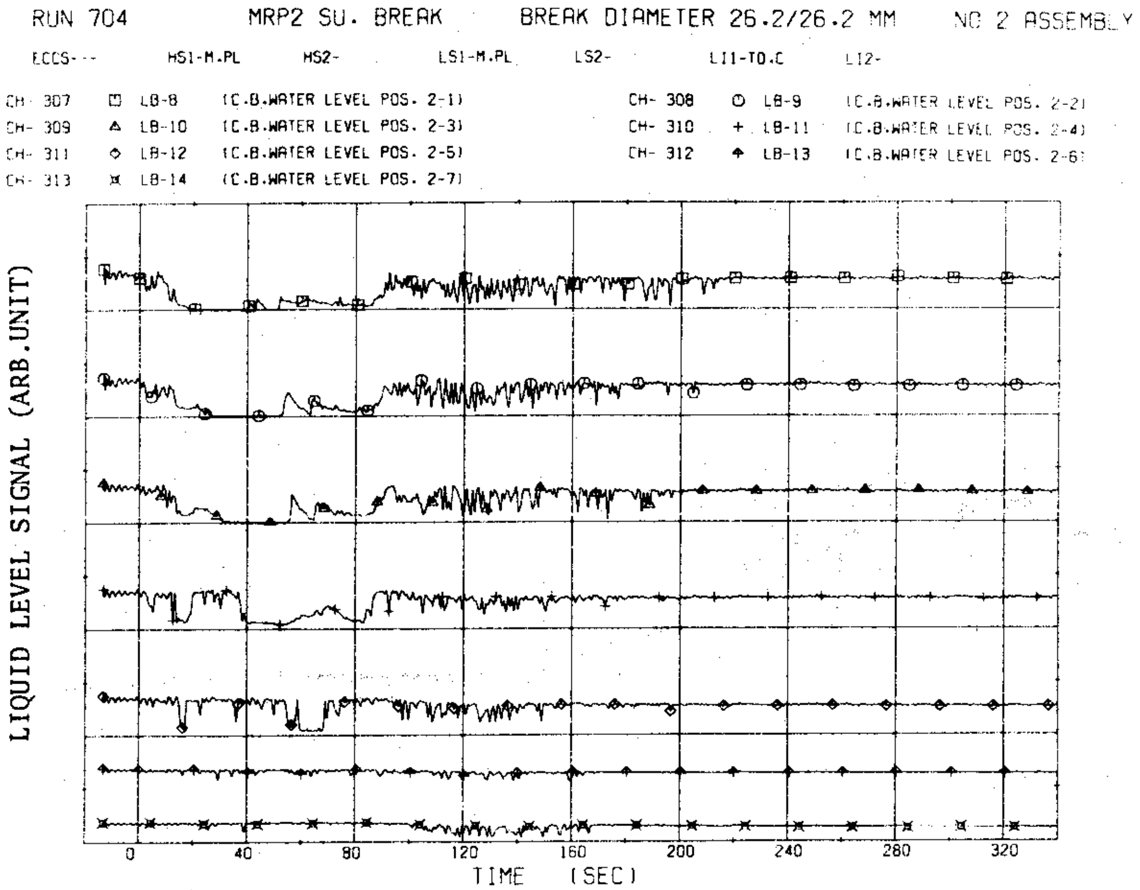


Fig. 5.71 Liquid Level Signal in Channel Box A, A2 Location

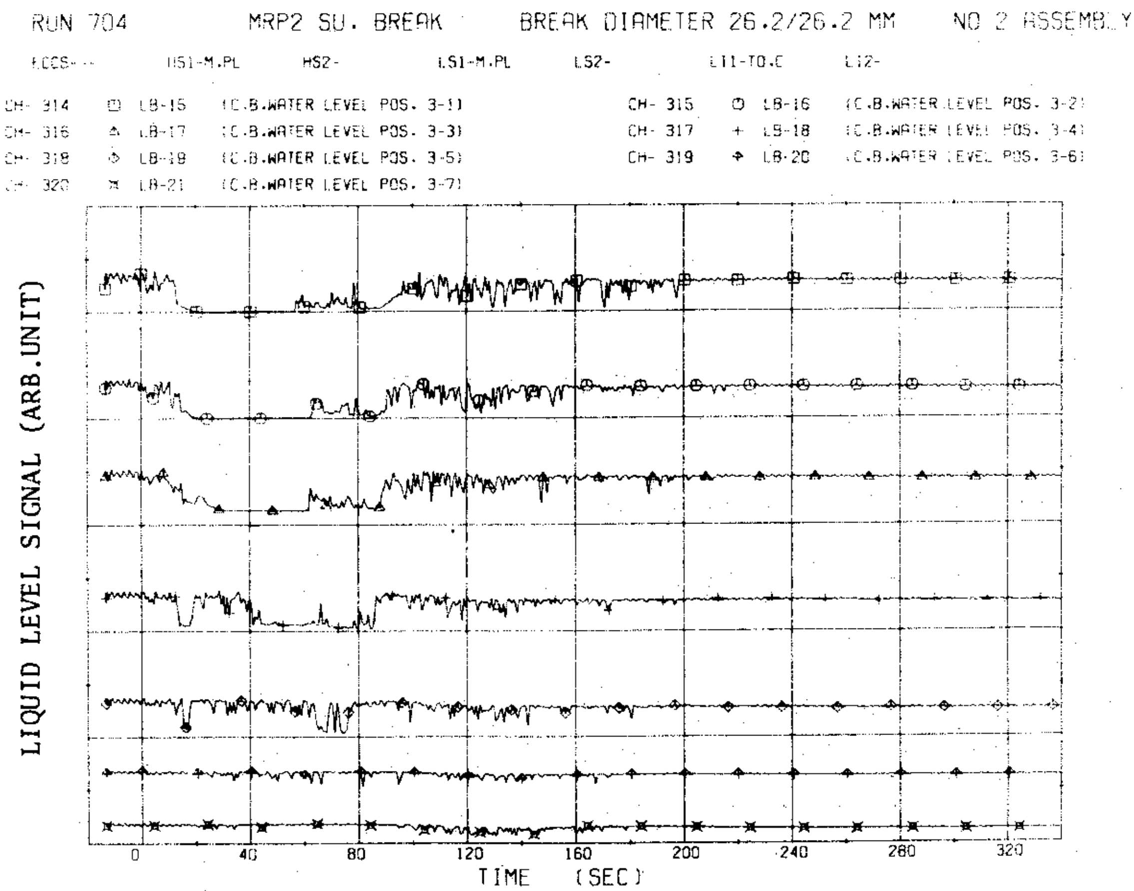


Fig. 5.72 Liquid Level Signal in Channel Box C

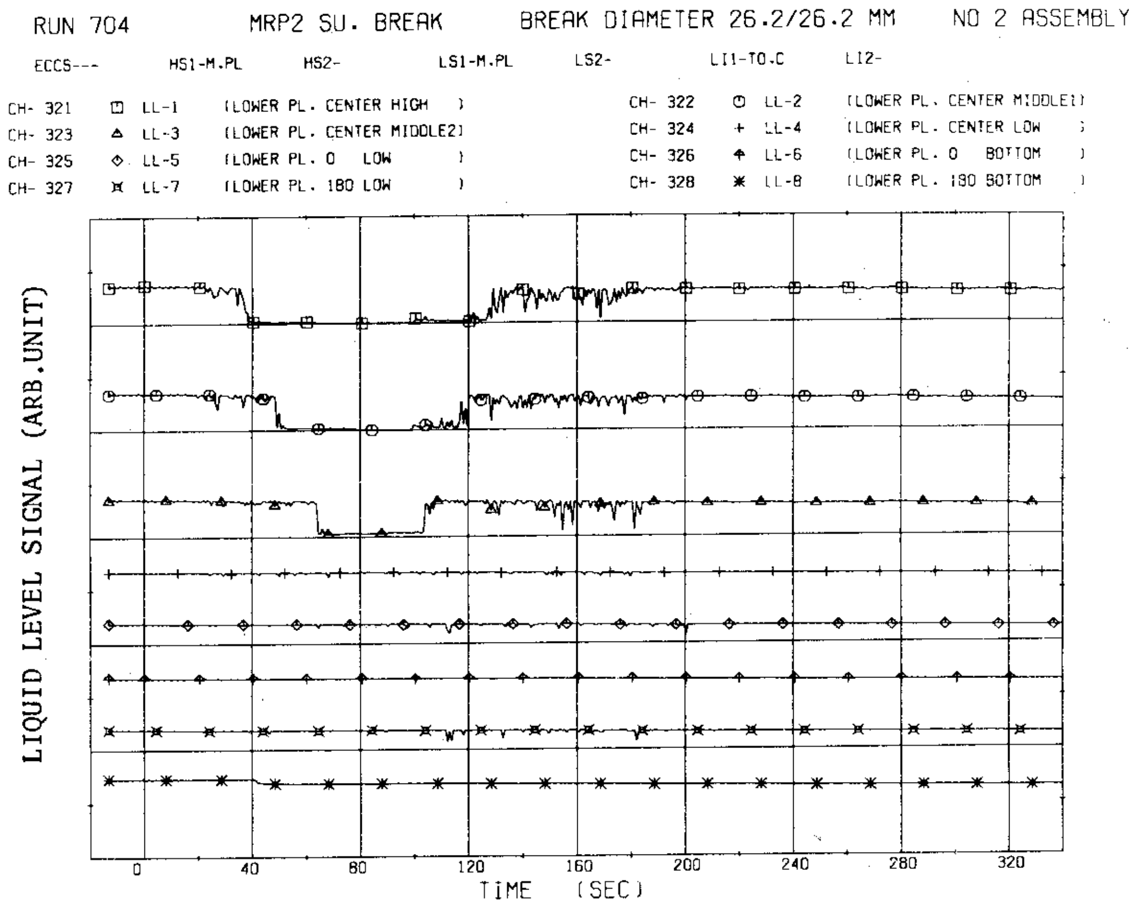


Fig. 5.73 Liquid Level Signal in Lower Plenum

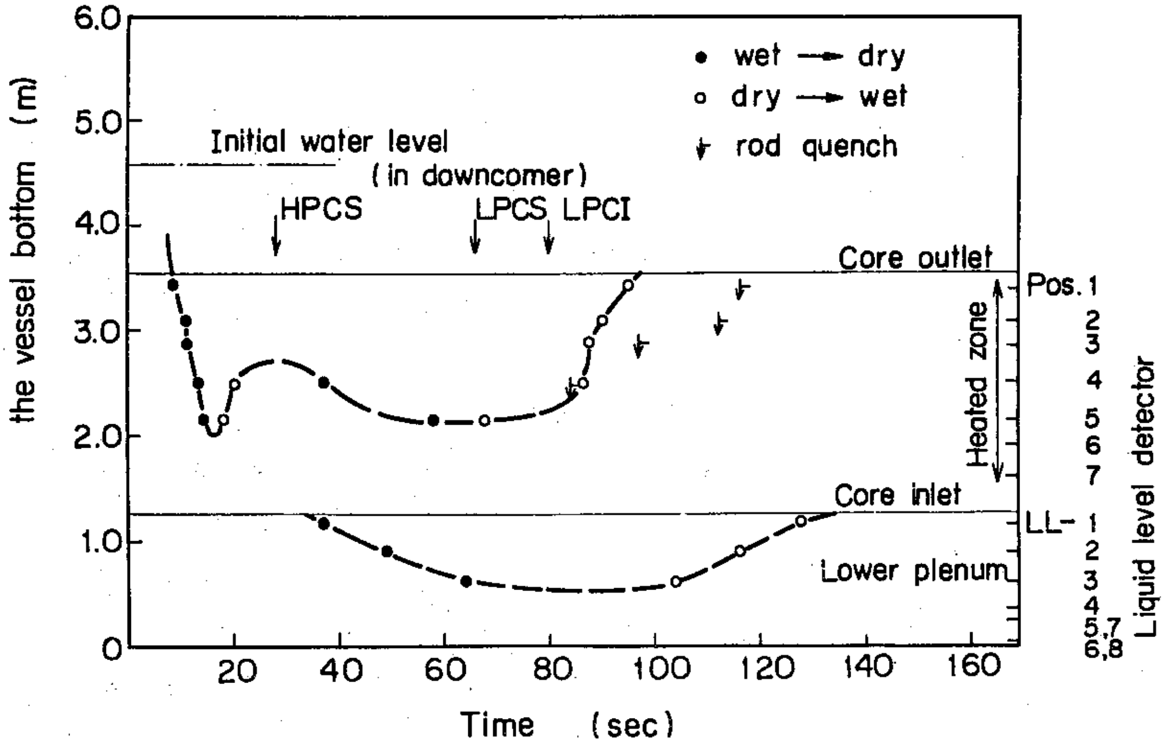


Fig. 5.74 Mixture Level Transients in Core and Lower Plenum