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EXPERIMENTAL INVESTIGATION OF SNAP-8 SHUTDOWN CHARACTERISTICS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ABSTRACT

An experimental study of the shutdown of a SNAP-8 power conversion system was conducted to determine the transient response of the system to two shutdown modes, viz., a normal shutdown and an emergency shutdown. For the emergency shutdown, a failure of the condenser-coolant pump was simulated. Neither mode of shutdown resulted in parametric excursions beyond the limit considered safe for the components. Transient data for three normal shutdown tests and three emergency shutdown tests are presented.

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E-5448

SUMMARY

An experimental study of the shutdown of a SNAP-8 power conversion system was conducted to determine the transient response of the system to normal and emergency shutdown modes. The normal shutdown was conducted from the system's self-sustaining mercury flow rate of 6600 lbs/hr. Results of the normal shutdown indicate that the system can be repeatably shut down in such a way as to insure restart capability even in zero gravity. For the emergency shutdown, a failure of the condenser coolant pump was simulated. This resulted in a rapid increase of pressure in the mercury condenser. The emergency shutdown procedure employed, however, limited this pressure to values considered safe for the condenser.

INTRODUCTION

SNAP-8 is a nuclear auxiliary power system, capable of producing more than 35 kilowatts of usable electric power. It is a four-loop system utilizing three working fluids. A nuclear reactor in the primary loop supplies thermal energy to NaK (the eutectic mixture of sodium and potassium). The thermal energy is transferred to a mercury loop by means of a NaK-to-mercury heat exchanger (or boiler). The mercury vaporized in the boiler drives the turbine-alternator; it is then liquefied in the condenser and pumped back to the boiler. The condenser's waste heat is removed by the NaK of the heat-rejection loop and is rejected to space by a radiator. The fourth loop contains a polyphenyl-ether oil mixture (4P3E) that lubricates and cools the turbine-alternator, the mercury-pump-motor assembly bearings, and cools the NaK pumps and electrical equipment. All four loops use centifugal pumps driven by electric motors, the power for which is generated by the turbine-alternator.

It is intended that the SNAP-8 system have shutdown and restart capability for long-term use in space. Shutdowns must not impair the operability of the components for further long-term service. Also, shutdowns must be accomplished in a way that puts the system in the proper condition for subsequent startup. One important implication of this is that mercury inventory must be withdrawn from the power loop during shutdown in order to ensure successful injection-starting of the turbine-alternator. The detailed procedures used in SNAP-8 startup are discussed in references 1, 2, and 3. In order to evaluate the proposed shutdown procedures, shutdown tests were included during extensive startup testing of SNAP-8 at Lewis Research Center. The tests were conducted with a full-scale SNAP-8 power conversion system using an electric heater and a computer to simulate the reactor. This report presents the preliminary results of the shutdown tests. The transient data obtained from three normal system shutdowns and three emergency shutdowns are presented and discussed herein.

DESCRIPTION OF SNAP-8 TEST SYSTEM AND INSTRUMENTATION

Test System

The SNAP-8 test system included all of the major SNAP-8 components except the reactor and radiator. The test system was assembled in a way that permits easy access to the components and allows for system instrumentation. Two computer-controlled, air-cooled heat exchangers, were used to simulate the radiator. A computer-controlled electric heater in the primary loop simulated the reactor (ref. 4). The SNAP-8 test system is described in reference 5. A schematic diagram of the test system, showing the four loops, is shown in figure 1.

Several controls pertinent to shutdown are indicated in figure 1. The mercury-loop flow-control valve is a computer-controlled electro-hydraulic valve (V-230) on the discharge of the mercury pump. A flow feedback signal was used to control positioning of the valve. The control circuit utilized a combination of open loop, integral, and proportional controls. The condensing pressure in the mercury condenser was controlled by varying the flow rate of the heat-rejection-loop NaK in a dead-band mode. The dead-band control sensed the condensing pressure and converted it into a command signal to activate the heat-rejection-loop flow-control valve (V-314) shown in figure 1. The standpipe was used as the mercury injection reservoir during startup and also was used to withdraw inventory in the shutdown tests. The standpipe gas pressure was set by a hand-adjusted regulator and could be varied from 0 to 50 psia. The NaK-to-NaK heat exchanger in the primary loop transferred heat from the primary loop to the heat-rejection loop by means of an auxiliary loop, before the startup and after the shutdown of the mercury loop. Flow in the auxiliary loop was controlled by valve V-117 (fig. 1). A variable-frequency motor-generator set was used as an auxiliary power supply for the pumps.

Instrumentation

Instrumentation used for the shutdown investigations consisted of: thermocouples, electro-magnetic flowmeters, pressure transducers, voltage, current, and power transducers, flow venturis, and magnetic speed pickups. A complete description of the instrumentation is given in reference 6.

The data presented were partially acquired from control-room strip-chart recorders, and supplemented by data from a computerized digital data system. The digital data system scanned and recorded 400 channels of data every 11.43 seconds, when in operation.

PROCEDURE

Normal Shutdown

In the normal shutdown, the mercury flow rate was first ramped from the rated level of 12,300 lb/hr to the self-sustaining level of 6,600 lbs/hr in a period of 900 seconds. Since this throttling of the system was in a low quasi-steady manner, it is not considered a pertinent part of the shutdown procedures. At this self-sustaining flow level of 6,600 lbs/hr, all four pumps were receiving their power from the alternator, and condensing pressure was being maintained by the dead-band control of the heat-rejection loop. When the system had settled out at the 6,600 lb/hr flow, the mercury flow rate was then ramped down to a value of 400 lbs/hr in a period of 150 seconds. Condenser coolant NaK flow rate was controlled by the dead-band control throughout the shutdown to maintain condensing pressure in the range of 11 to 14 psia. As the turbine-alternator frequency fell to 300 hertz, the lift-off seals were lowered into contact (seated) and the lubricant-coolant flow to the bearings was stopped. When the turbine-alternator frequency decreased to 220 hertz, the pumps were transferred to the auxiliary power supply. At a mercury flow rate of 400 lbs/hr, valve V-217 (fig. 1) was opened so that the mercury inventory could be transferred from the condenser to the standpipe. To accomplish this transfer, the mercury flow rate was held at 400 lbs/hr for 160 seconds with the mercury pump running on 220-hertz auxiliary power. During this transfer period, the standpipe gas pressure was regulated in an attempt to simulate a zero-gravity condition; argon gas pressure above the liquid mercury level in the standpipe was maintained equal to the hydrostatic head of liquid mercury between the liquid heads in the condenser and in the standpipe. After the inventory transfer was completed, the mercury-flow-control valve was shut, flow was established in the auxiliary loop, and the condenser outlet valve (V-210) closed. The heat-rejection-loop flow control valve was then opened to the initial position for the next startup. The reactor simulator control was in the normal dead-band mode throughout the shutdown.

Emergency Shutdown

For the emergency shutdowns, a failure of the heat-rejection-loop pump was simulated. The pumps were receiving their power from the auxiliary power supply during both emergency shutdowns presented in this report. The first emergency shutdown presented was executed from a mercury flow rate of 6,600 lbs/hr, with all of the alternator power going to the parasitic load of the speed control. The second emergency shutdown presented was conducted from a mercury flow rate of 12,300 lbs/hr with 15 kilowatts of external load on the alternator to simulate the power requirement of the four pumps. The shutdown was initiated by shutting off heat-rejection-loop NaK flow to the condenser by means of valve V-314 (fig. 1), which took about one second to completely close. When the condenser coolant flow had stopped, the mercury flow control valve (V-230) was ramped by the computer, in about one second, to a small opening and then closed manually. Inventory withdrawal was also initiated when the condenser-coolant flow stopped, and the standpipe gas pressure was regulated as in the normal shutdown to simulate a zero-gravity condition.

In the shutdown from the rated condition of 12,300 lbs/hr mercury flow, the primary loop flow was decreased to 23,000 lbs/hr, after the mercury flow was stopped, by throttling valve V-115 (primary loop flow control valve). This was done in order to simulate the primary pump's being switched to the auxiliary power supply during shutdown. For each emergency shutdown test, the reactor-simulator control was in the normal dead-band mode. The auxiliary-loop flow was started about 4½ minutes after the mercury flow was stopped.

RESULTS AND DISCUSSION

Normal Shutdown

Time-history recordings of the pertinent variables for a normal shutdown are shown in figure 2. All four pumps were receiving power from the turbine-alternator and decelerated with it until the frequency reached 220 hertz, at which frequency all four pumps were switched simultaneously to the auxiliary power supply operating at 220 hertz. This transfer of the pumps was smooth and produced no significant disturbances of pump speeds or flows. This is illustrated by the recordings of the primary, mercury, and heat-rejection loop flows. Alternator frequency increased from 220 hertz to 300 hertz after the electrical load of the pumps was removed. As shown in figure 2(a), the mercury liquid flow ramp was smooth, even though the mercury pump speed was decreasing during the ramp.

The turbine began to decelerate (fig. 2(b)) as the boiler inlet pressure reached 300 psia and the boiler outlet pressure was 130 psia (figs. 2(c) and 2(d)). Alternator power output and parasitic load of the speed control during turbine deceleration are shown in figures 2(g) and 2(h). The turbine ceased to rotate about 340 seconds after initiation of the shutdown process. The bearing lubricant flow was stopped and the lift-off seals applied at 300 hertz, so the total time of lift-off seal contact was 260 seconds for this shutdown.

Throughout the shutdown transient, condensing pressure was regulated by the dead-band control of the heat-rejection-loop NaK flow (fig. 2(j)). The 400 lb/hr mercury flow rate, combined with a near-zero heat-rejection-loop NaK flow rate, maintained the condensing pressure between 5 and 14 psia during the condenser inventory withdrawal period. The standpipe gas pressure was manually regulated during the shutdown in an attempt to simulate a zero-gravity condition for the withdrawal process. The success of this simulation can be ascertained from figure 2(m), showing the difference between standpipe pressure and the condenser liquid head. The maximum variation between the standpipe pressure and the condenser liquid head was 3.5 psi, with the greater pressure in the standpipe. Throughout the shutdown, the liquid head in the condenser never exceeded the standpipe pressure. This shows that the zero-gravity simulation during the shutdown was very close to the desired conditions and the condenser pressure had to work against the standpipe pressure in order to move the mercury into the standpipe. During this period, 54 pounds of mercury were transferred to the standpipe, representing 100 percent of the inventory in the boiler and condenser before the shutdown.

The primary-loop transients during the normal shutdown were minimal. As shown in figure 2(o), the primary loop flow rate reached 26,000 lbs/hr as the pump was transferred to the 220-hertz auxiliary power unit. The reactor simulator inlet temperature increased from 1180° F to 1290° F, with a maximum rate of change of 40° F/minute, which lasted for 80 seconds (fig. 2(p)). This was well within the reactor's envelope for acceptable rate of temperature change, as shown in figure 3. The reactor-simulator outlet temperature (fig. 2(q)) increased from 1280° F to only 1307° F during the shutdown, showing that the reactor-simulator power reduction was sufficiently fast. The power reduction was due to the inherent temperature-feedback of the reactor-simulator. No action of the control was involved, since the outlet temperature remained within the control deadband of 1280° F to 1320° F.

Emergency Shutdowns

Shutdown from 6600 lbs/hr mercury flow. - During the emergency shutdown test from a mercury flow rate of 6,600 lbs/hr, the excursions of all the variables were within the limit considered safe for the system and components. The variables are shown in figure 4 for this shutdown. All four pumps were operating on a 400-hertz auxiliary power supply and were running at rated speed throughout the shutdown. The fast deceleration of the turbine (fig. 4(b)) was due to the quick stoppage of mercury flow (fig. 4(a)) and also the high back pressure on the turbine caused by the high condensing pressure. The turbine rotated for 60 seconds after the mercury flow was stopped, and 50 seconds of that time was with the lift-off seals seated and the bearing-lubricant flow stopped. The decay rates of the boiler pressures and alternator power output are shown in figures 4(c) through 4(f).

Condensing pressure increased from 15 psia to a maximum of 24 psia during the shutdown because of the stoppage of the condenser coolant flow (figs. 4(i) and 4(k)). Figure 4(m) shows the zero-gravity simulation during this shutdown. Due to the rapid shutdown, the zero-gravity simulation was very difficult to achieve. The maximum difference between the standpipe pressure and the condenser liquid head was 3 psi with the greater pressure being the condenser liquid head. This assisted the condensing pressure in moving the mercury into the standpipe during this period, which does not accurately simulate zero-gravity. Of the mercury inventory in the condenser and boiler, only 66 percent was transferred to the standpipe because, through human intervention, the condenser mercury outlet valve (V-210) was closed early; this early valve closure makes irrelevant the 66-percent mercury withdrawal during this shutdown. In another test from 6,600 lb/hr mercury flow, 97 percent of the boiler and condenser inventories was withdrawn. In this shutdown the condenser coolant/flow was ramped to 0 in 10 seconds rather than being abruptly stopped in one second; however, it is believed that the inventory withdrawal portion was representative of the emergency shutdown test. This shows that most of the boiler and condenser inventories can be withdrawn even in an emergency shutdown test from the self-sustaining mercury flow of 6,600 lbs/hr.

The primary-loop transients during this emergency shutdown were significant, but still within the operating envelope of the reactor (fig. 3). Reactor-simulator inlet temperature increased from 1178° F to 1287° F (fig. 4(r)), and the maximum rate of change was 400° F per minute, which lasted for 10 seconds. These values are below the reactor operating constraints shown in figure 3. Reactor-simulator outlet temperature increased from 1275° F to 1298° F during the shutdown (fig. 4(s)). The auxiliary loop NaK flow was not established until well after the shutdown test and thus no heat was dissipated from the primary loop to the heat-rejection loop during the portion of the transient shown. The reactor simulator control was in the dead-band mode during the shutdown; however, no control action was required.

Shutdown from rated mercury flow. - The simulated failure of the heat-rejection pump with the mercury flow at the rated value of 12,300 lbs/hr was a more severe test of the emergency shutdown procedure. This shutdown is shown in figure 5. All four pumps were running on the auxiliary power supply at 400 hertz throughout the shutdown. 15 kW of external load were applied to the alternator in order to simulate the power requirement of the pumps. The fast deceleration of the turbine (fig. 5(b)) was due to this external load, the sudden stoppage of mercury flow, and the high turbine back pressure. The turbine rotated for 50 seconds after the condenser coolant flow was stopped, and 42 seconds of that time were with the lift-off seals seated and with no bearing lubricant flow. The decay rates of the boiler pressures and the alternator power output are shown in figures 5(c) through 5(f).

Condensing pressure increased rapidly from 15 to 41 psia (fig. 5(i)) during the shutdown, because of the stoppage of the condenser coolant flow. However, a margin of 32 percent below the operational-limit pressure of 60 psia still remained. Condensing pressure then decayed rapidly to about 15 psia from the combined effects of mercury flow stoppage and inventory withdrawal to the standpipe. The zero-gravity simulation for this shutdown was very good even though it was a very rapid shutdown. Figure 5(m) shows the unbalanced pressure during the zero-gravity simulation. The maximum pressure difference was 3.5 psi with the greater pressure in the standpipe. For only a very short time was the condenser liquid head greater than the standpipe pressure. Approximately 73 pounds of mercury were withdrawn to the standpipe, representing 95 percent of the initial boiler and condenser inventories. Condensing pressure remained at 6 psia for some time due to the boil-off of the liquid mercury remaining in the boiler.

The primary-loop transients during the rated-power emergency shutdown were significant, but still within the operating envelope for the reactor (fig. 3). The reactor-simulator inlet temperature increased from 1110° F to 1300° F (fig. 5(r)), and the maximum rate of change was 220° F per minute, for about 10 seconds, values within the range tolerated by the reactor. This maximum rate of change of inlet temperature was less than for the 6,600 lbs/hr emergency shutdown because the primary flow was reduced to 23,000 lbs/hr in order to simulate the pump's being switched over to a 220-hertz auxiliary power supply. Reactor-simulator outlet temperature rose from 1285° F to 1317° F (fig. 5(s)) during the shutdown. Once again the dead-band control was not required to take corrective action. The auxiliary loop flow was not established until well after the shutdown, and hence did not affect the primary-loop transients shown.

Plots from the digital computer for five of the shutdowns of the SNAP-8 test system are presented in the Appendix. They contain a more complete set of parameters than the chart-recorder plots. Because the equations for determining the mercury vapor quality and efficiencies are based on steady-state conditions, they are to be disregarded in the data plots for the shutdowns.

SUMMARY OF RESULTS

Both normal and emergency shutdowns of a SNAP-8 system were investigated. The results of a normal shutdown are as follows:

(1) The pumps were switched from the decelerating turbine-alternator to the auxiliary power supply with no significant disturbances in pump speeds or flows, and there was no overspeed of the turbine after the pump load was removed.

(2) Condensing pressure was within acceptable limits during the shutdown with a 400 lb/hr mercury flow rate, utilizing the dead-band control of the heat-rejection-loop flow.

(3) Of the boiler and condenser inventories, 100 percent was removed to an injection reservoir, even under simulated zero-gravity condition.

(4) Reactor simulator temperature transients were minimal with the reactor simulator control in the normal dead-band mode.

The results of the emergency shutdown are as follows:

(1) Up to 97 percent of the boiler and condenser inventories was withdrawn from the system to an injection reservoir under simulated zero-gravity conditions.

(2) Following a simulated failure of the condenser-coolant pump, the maximum pressure in the condenser rose to only 64 percent of the operational limit on the condenser. This was accomplished by stopping the flow of liquid mercury to the boiler and withdrawing inventory through the condenser.

(3) Reactor simulator temperature transients were well within the estimated operating limits for the reactor. Fast setback of the reactor control was not necessary in order to maintain these acceptable transients.

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APPENDIX - DIGITAL DATA PLOTS

In these computer-plotted figures, using the data from the digital-data system, the following symbols and abbreviations are used:

PRI	Primary loop
IGNITRON	Reactor simulator
PWR	Power
REACT	Reactivity of reactor simulator control
PN PMA	Primary NaK pump motor assembly
HTR	Heater
HRL	Heat rejection loop
HRL PMA	Heat rejection loop pump motor assembly
BV10	Valve for controlling air to radiator 1
BV12	Valve for controlling air to radiator 2
RAD1	NaK to air heat exchanger in third loop
RAD2	NaK to air heat exchanger in third loop
COND	Condenser
L/C	Lubricant coolant
T.SSHE-A.HE	Turbine spare seal heat exchanger - alternator heat exchanger
TURB	Turbine
ALT	Alternator
H.E.	Heat Exchanger
HG	Mercury
MHE	Motor heat exchanger
PMA	Pump motor assembly
NPSH	Net positive suction head
FCU	Flow control valve
IMM	Immersion
HT. BAL	Heat balance
TERM	Terminal
BOGUE/MG	Motor generator power supply
VENT	Venturi
TAA	Turbine alternator assembly
PLR	Parasitic load resistor (for speed control)
VLB	Vehicle load bank (external load)
POS	Position
ASHE	Auxiliary start heat exchanger

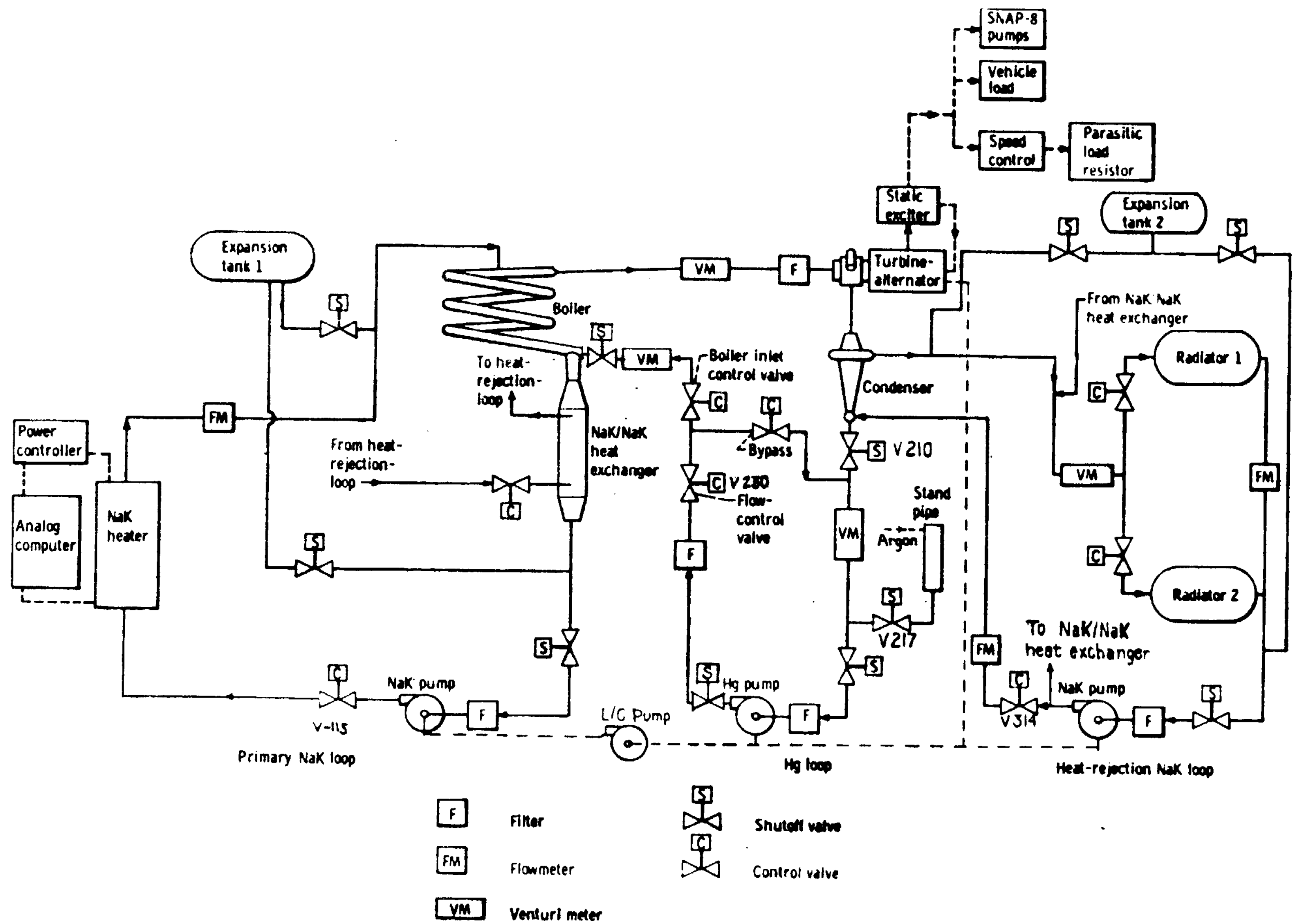
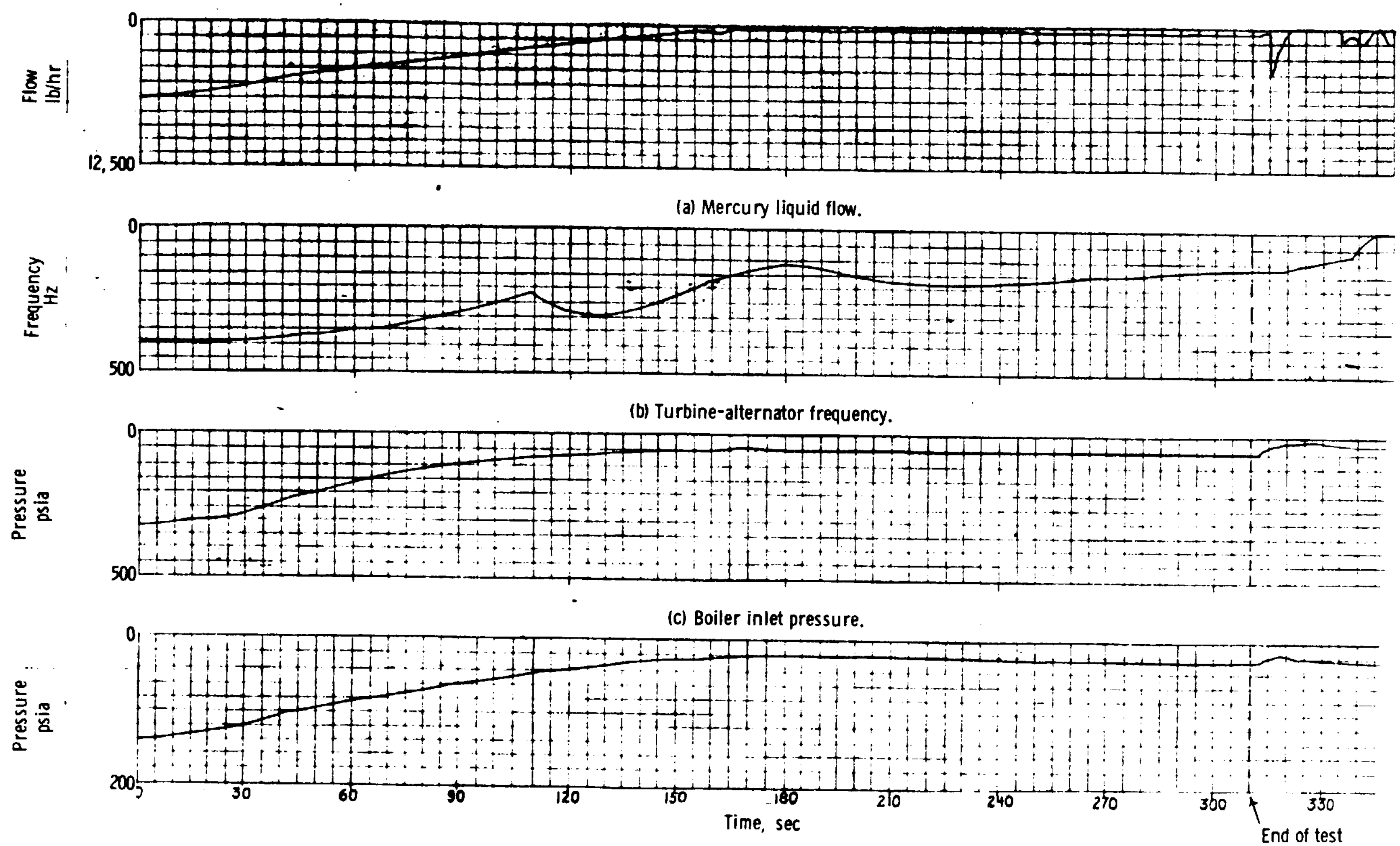


Figure 1. - SNAP-8 Test System Schematic



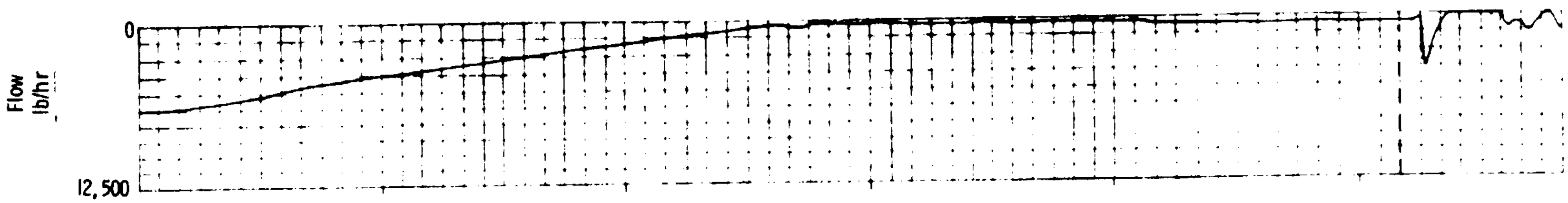
(a) Mercury liquid flow.

(b) Turbine-alternator frequency.

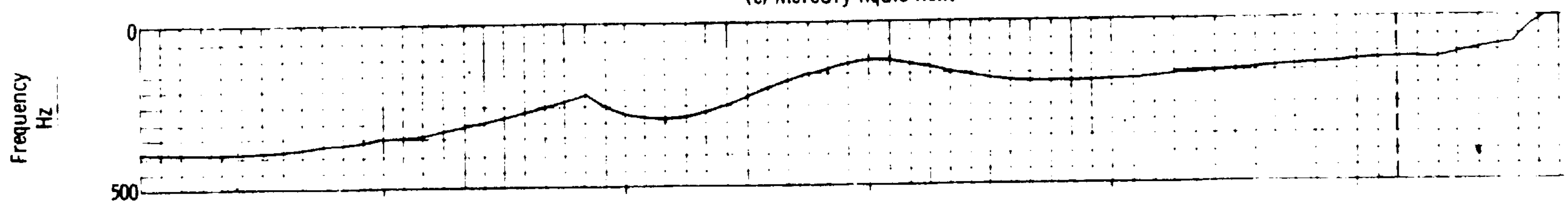
(c) Boiler inlet pressure.

(d) Boiler outlet pressure.

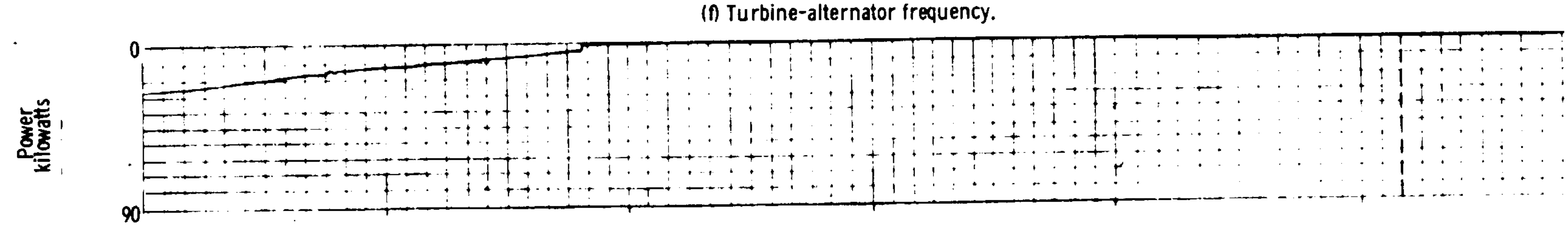
Figure 2. - Normal shutdown test-



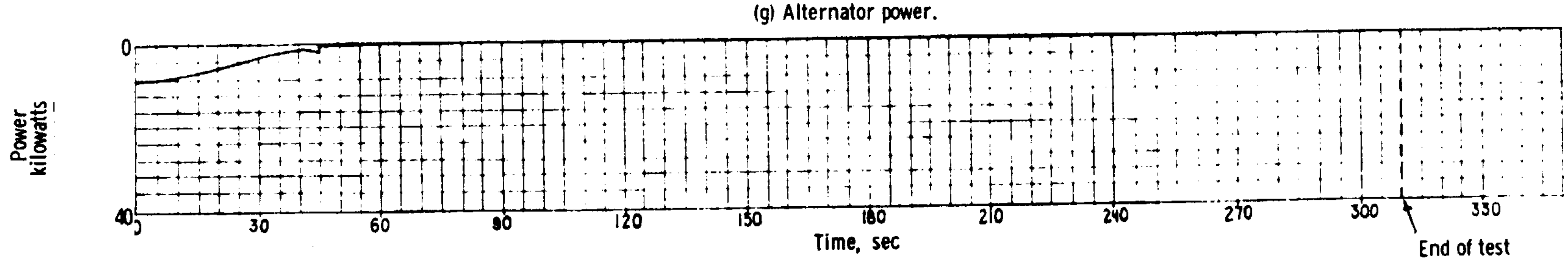
(e) Mercury liquid flow.



(f) Turbine-alternator frequency.

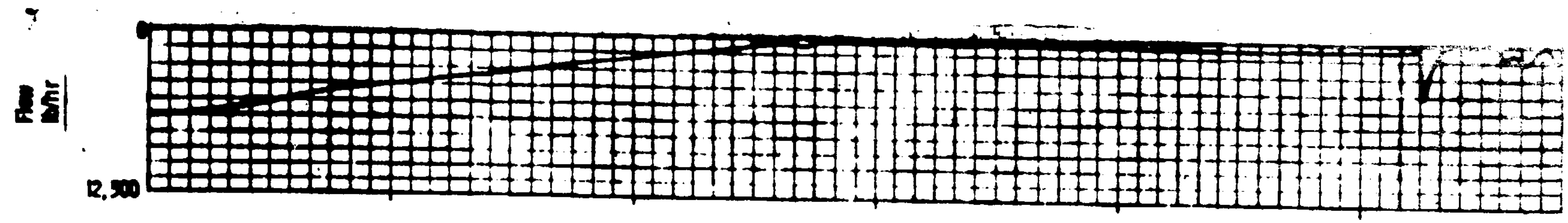


(g) Alternator power.

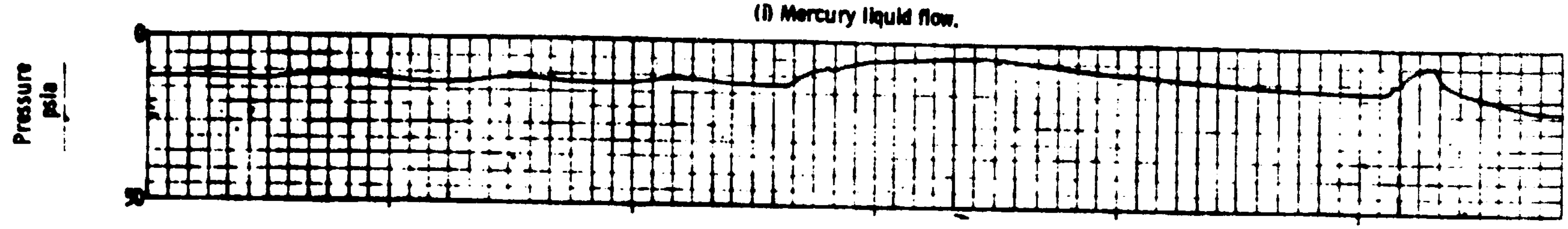


(h) Parasitic load power.

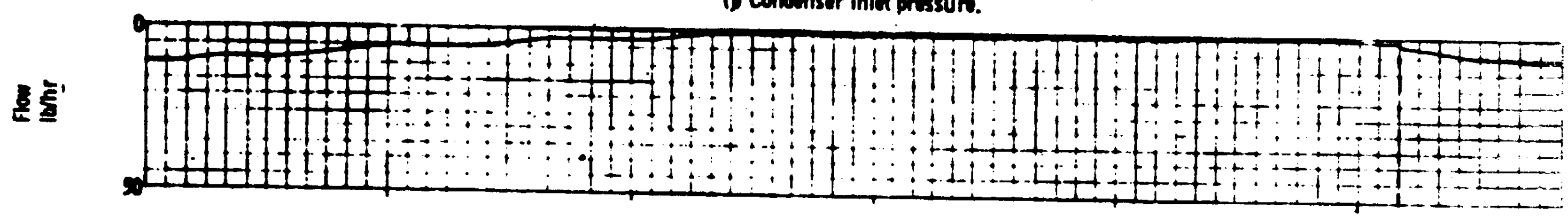
Figure 2. - Continued.



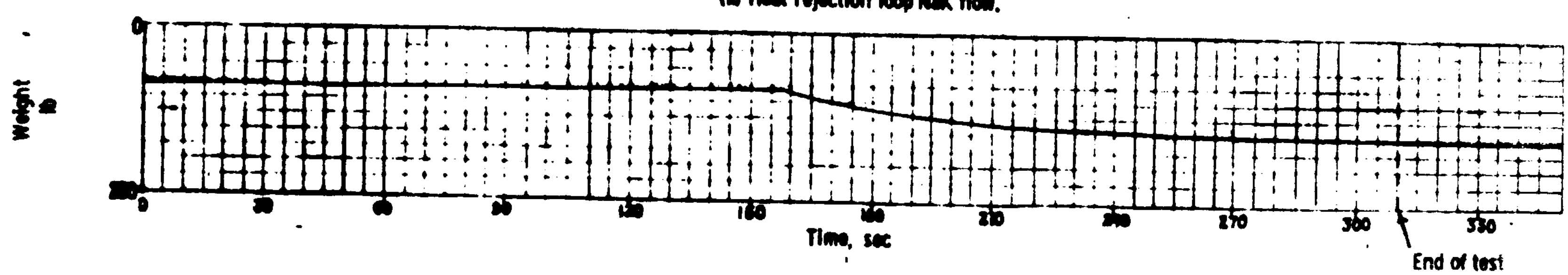
(i) Mercury liquid flow.



(j) Condenser inlet pressure.

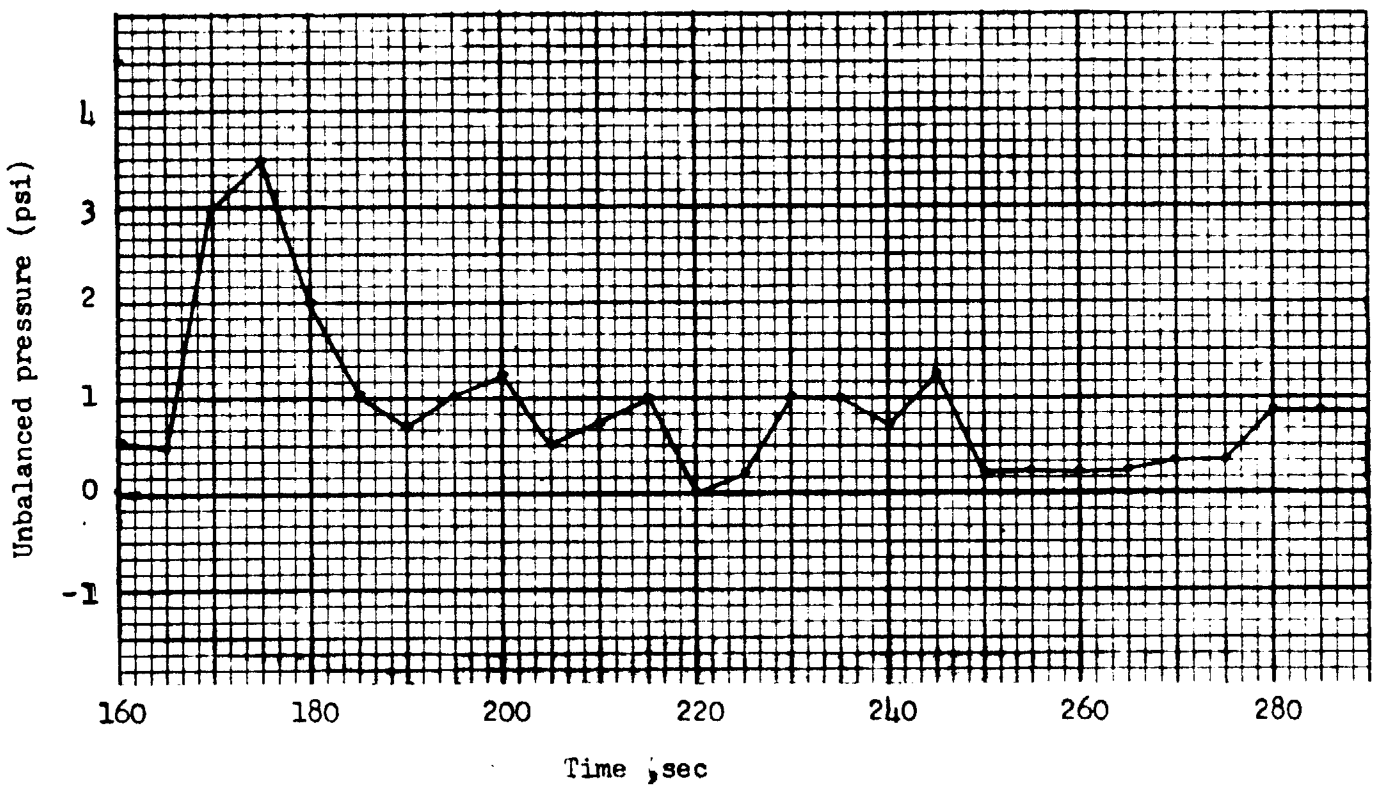


(k) Heat rejection loop NaK flow.



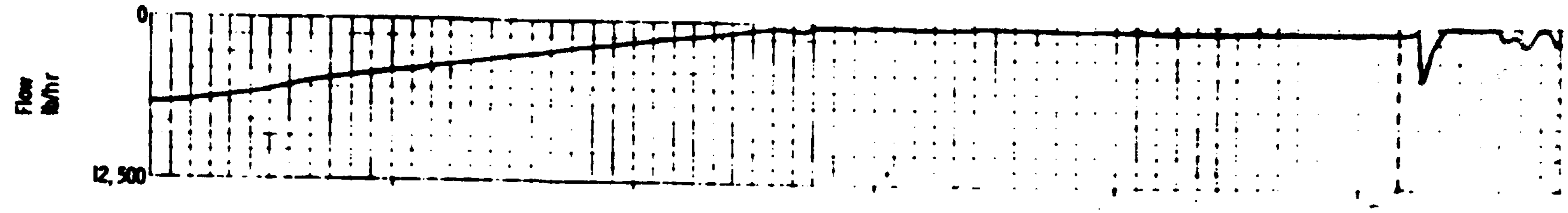
(l) Standpipe inventory.

Figure 2. - Continued.

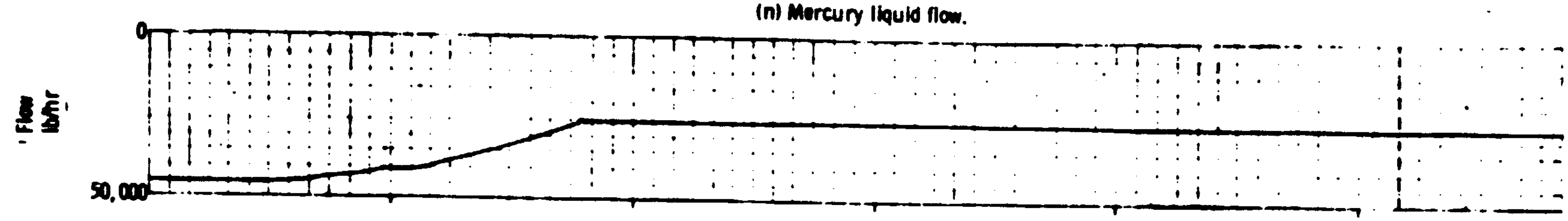


(m) Zero gravity simulation for inventory withdrawal. Unbalanced pressure equals standpipe-pressure minus condenser liquid head.

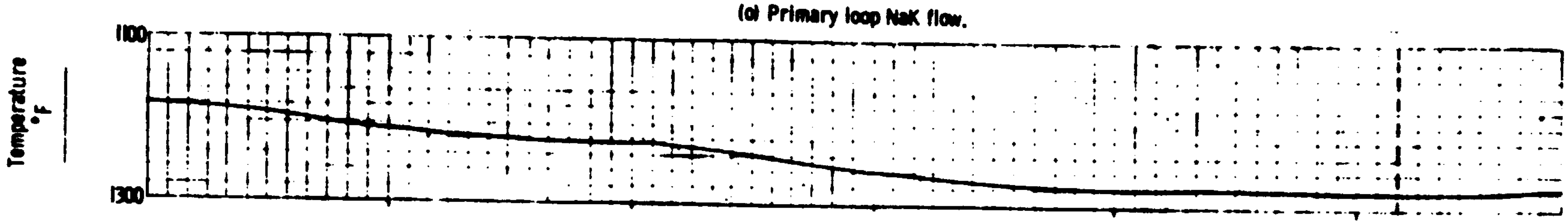
Figure 2.- Continued.



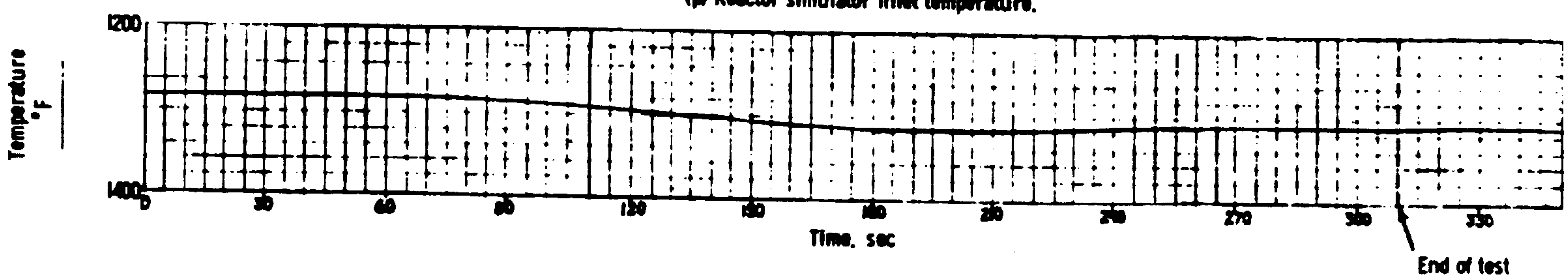
(n) Mercury liquid flow.



(o) Primary loop NaK flow.



(p) Reactor simulator inlet temperature.



(q) Reactor simulator outlet temperature.

Figure 2. - Concluded

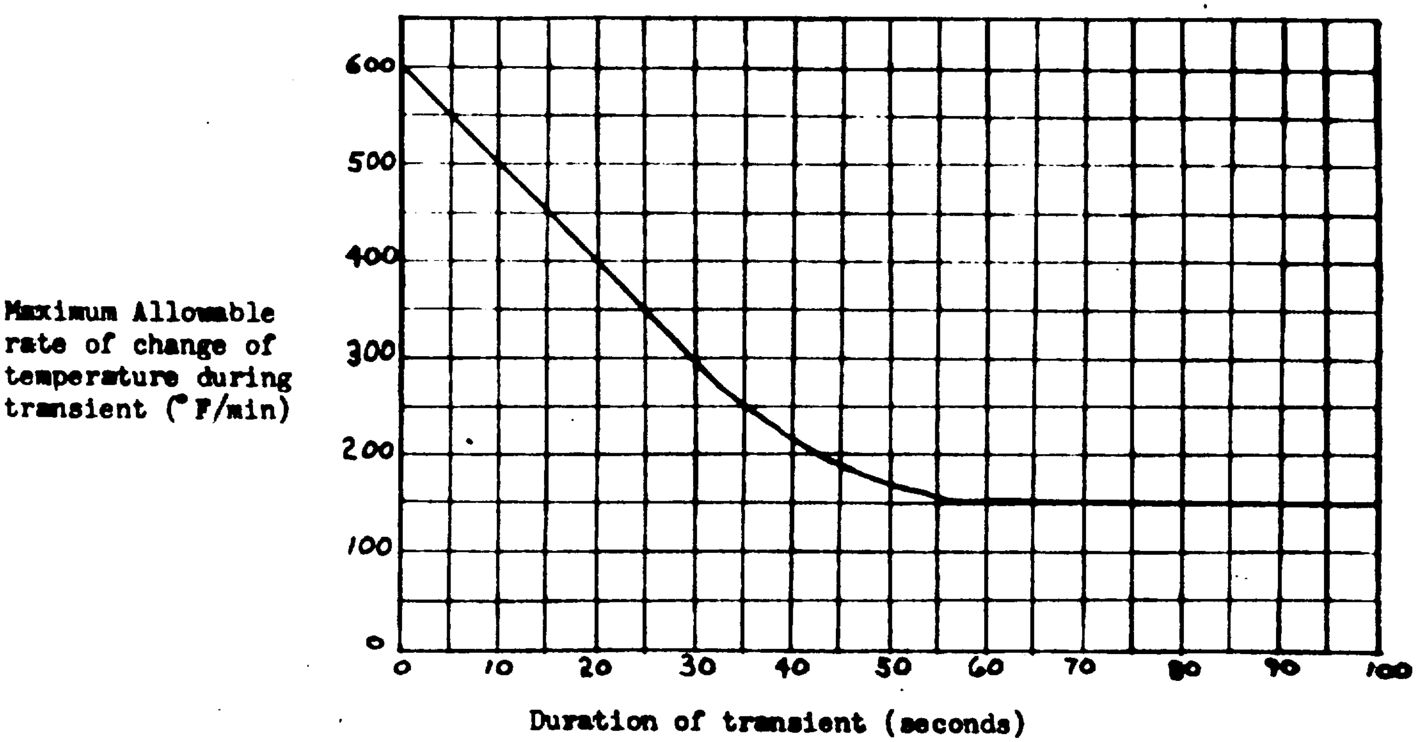
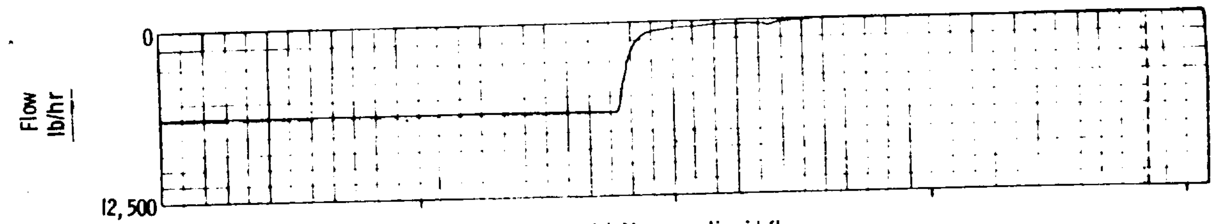
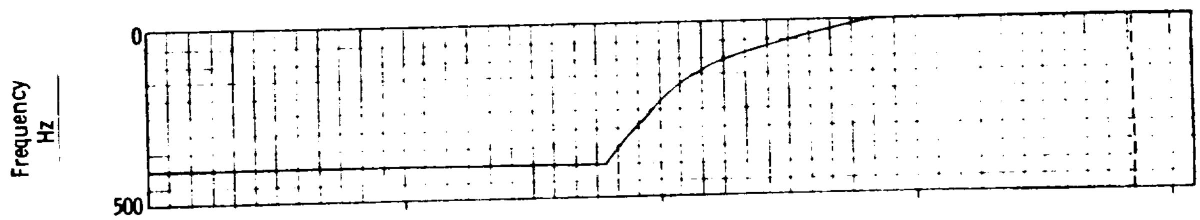


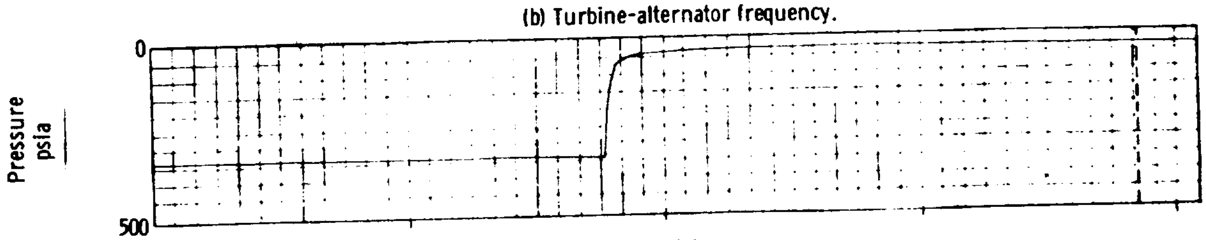
Figure 3. - Allowable transient characteristics vs. transient duration for the SNAP-8 reactor.



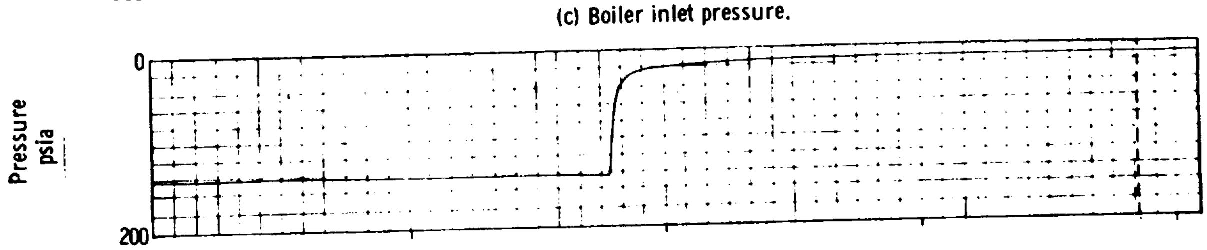
(a) Mercury liquid flow.



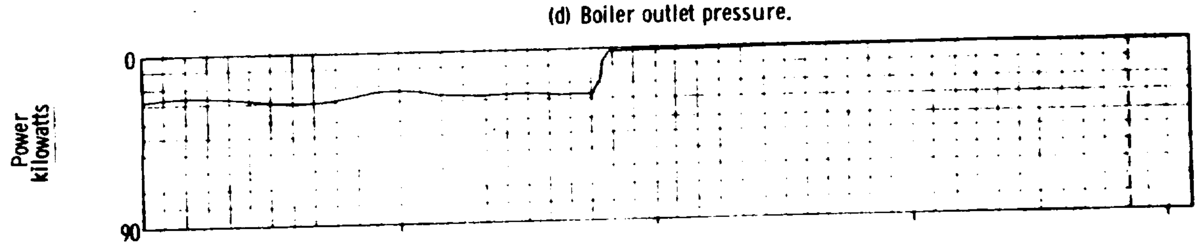
(b) Turbine-alternator frequency.



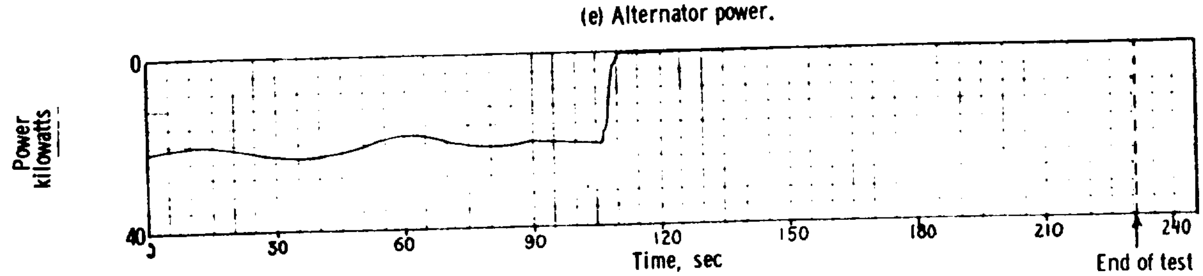
(c) Boiler inlet pressure.



(d) Boiler outlet pressure.

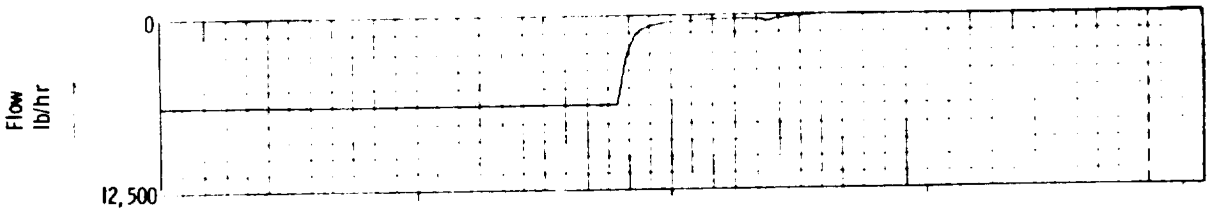


(e) Alternator power.

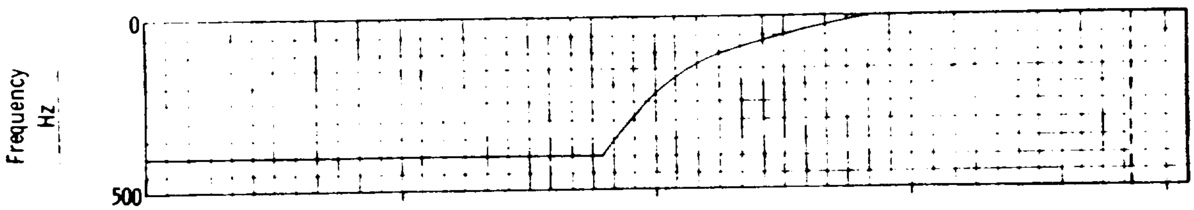


(f) Parasitic load power.

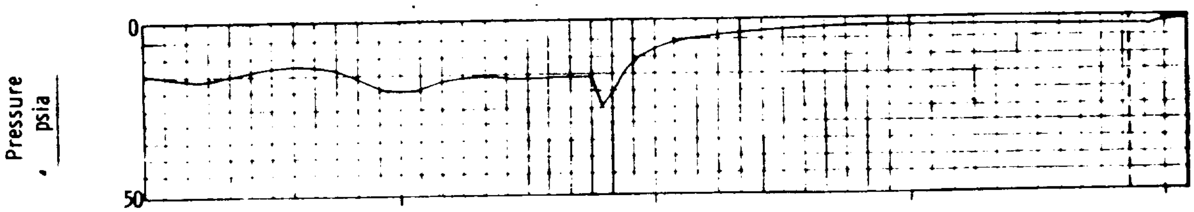
Figure 4. - Emergency shutdown test-



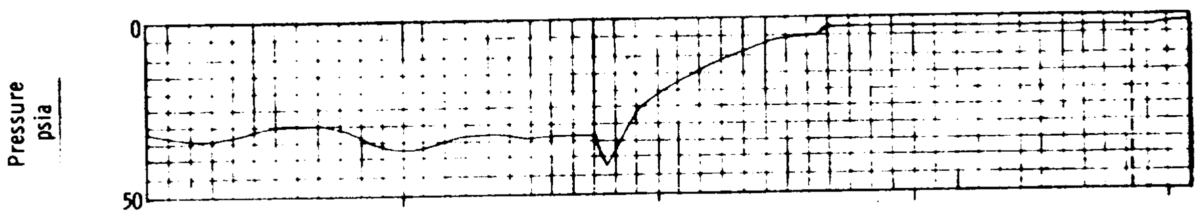
(g) Mercury liquid flow.



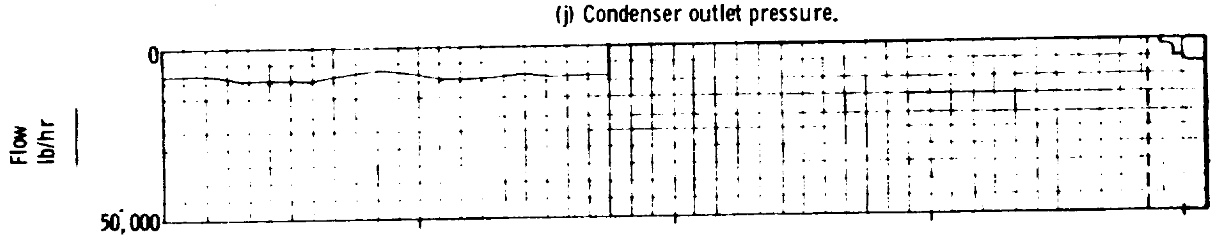
(h) Turbine-alternator frequency.



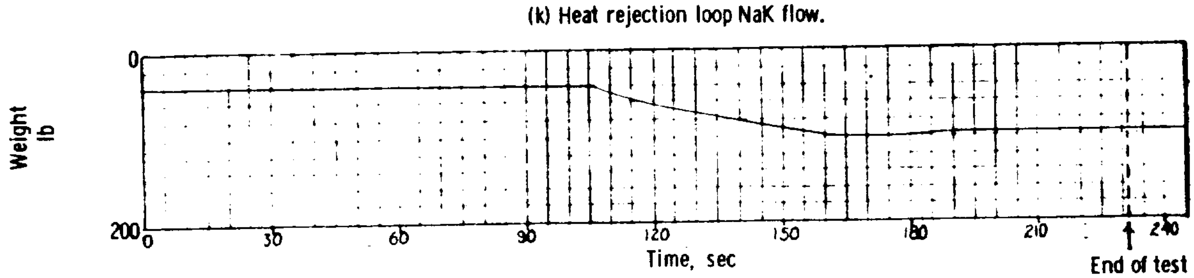
(i) Condenser inlet pressure.



(j) Condenser outlet pressure.

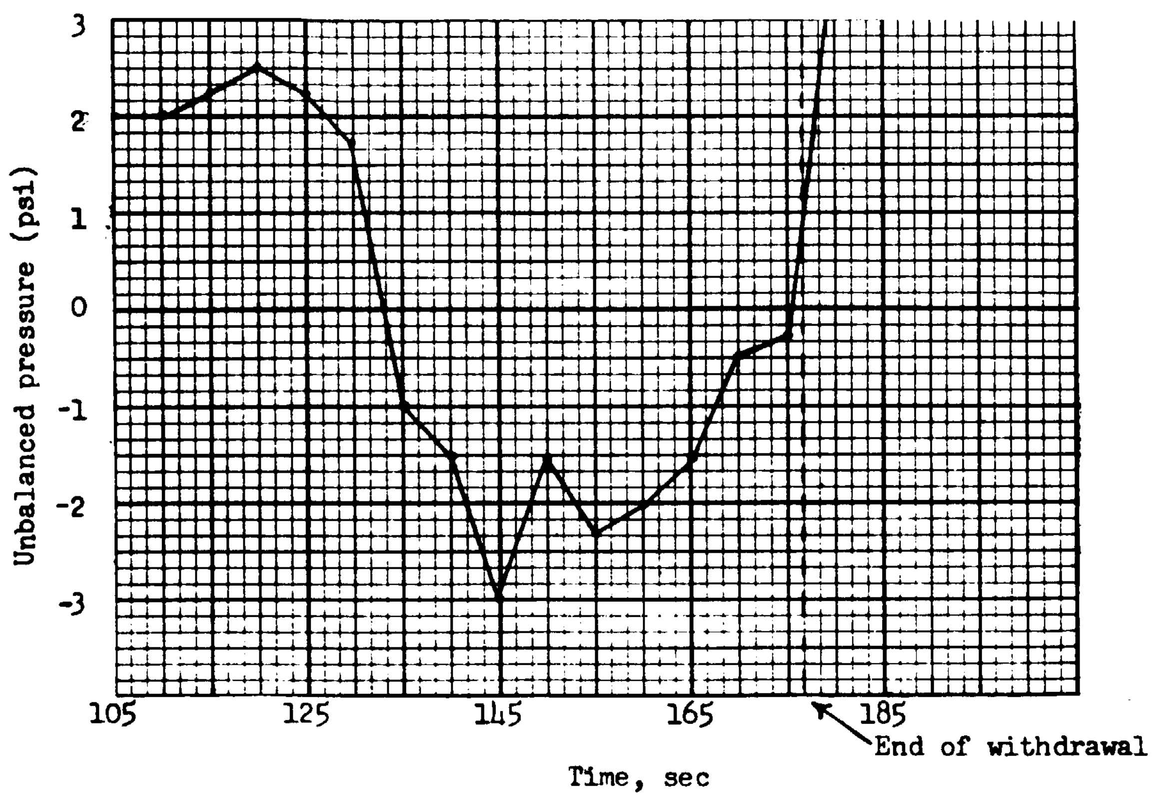


(k) Heat rejection loop NaK flow.



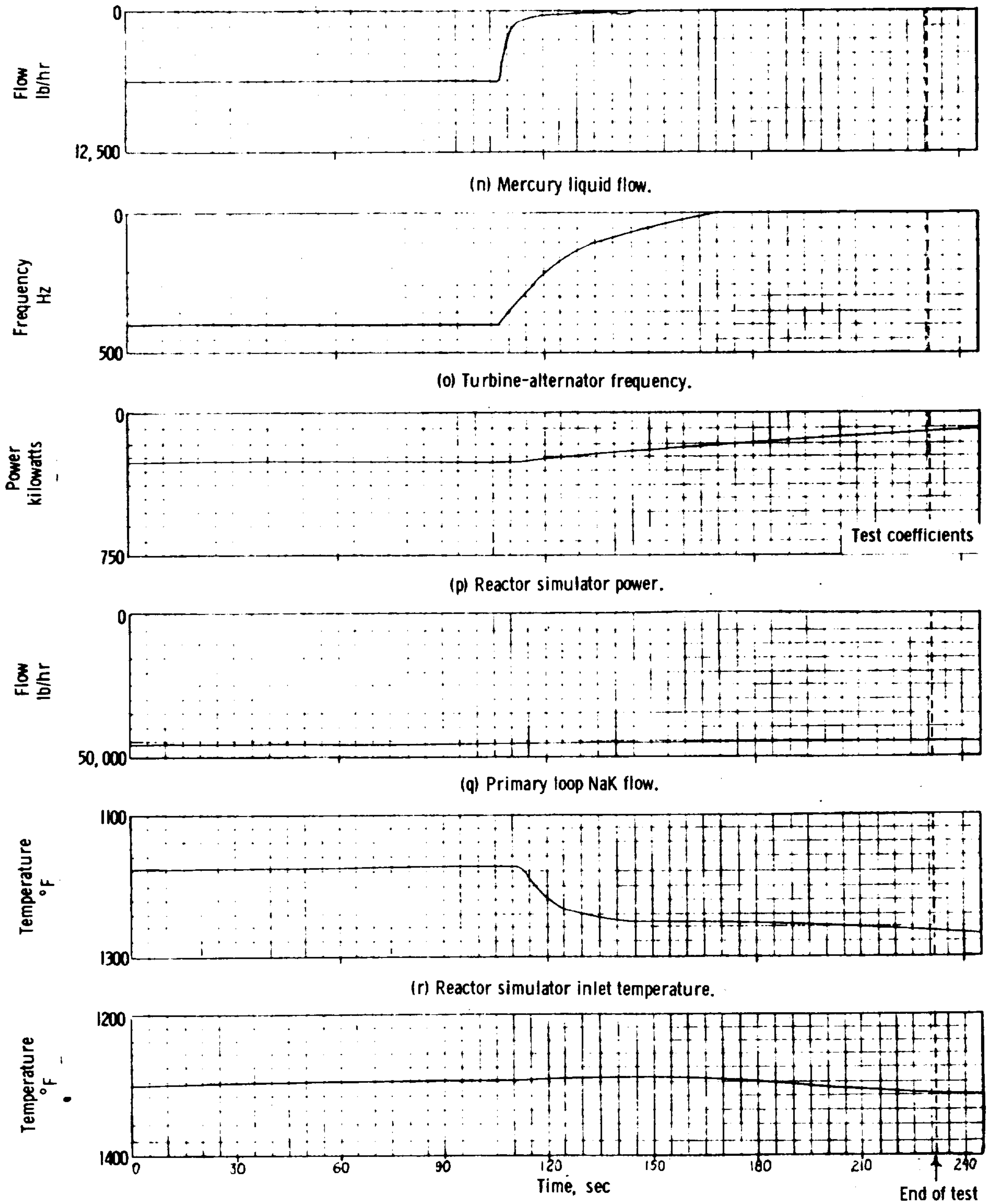
(l) Standpipe inventory.

Figure 4. - Continued.



(m) Zero gravity simulation for inventory withdrawal. Unbalanced pressure equals standpipe-pressure minus condenser liquid head.

Figure 4.- Continued



(n) Mercury liquid flow.

(o) Turbine-alternator frequency.

(p) Reactor simulator power.

(q) Primary loop NaK flow.

(r) Reactor simulator inlet temperature.

(s) Reactor simulator outlet temperature.

Figure 4. - Concluded.

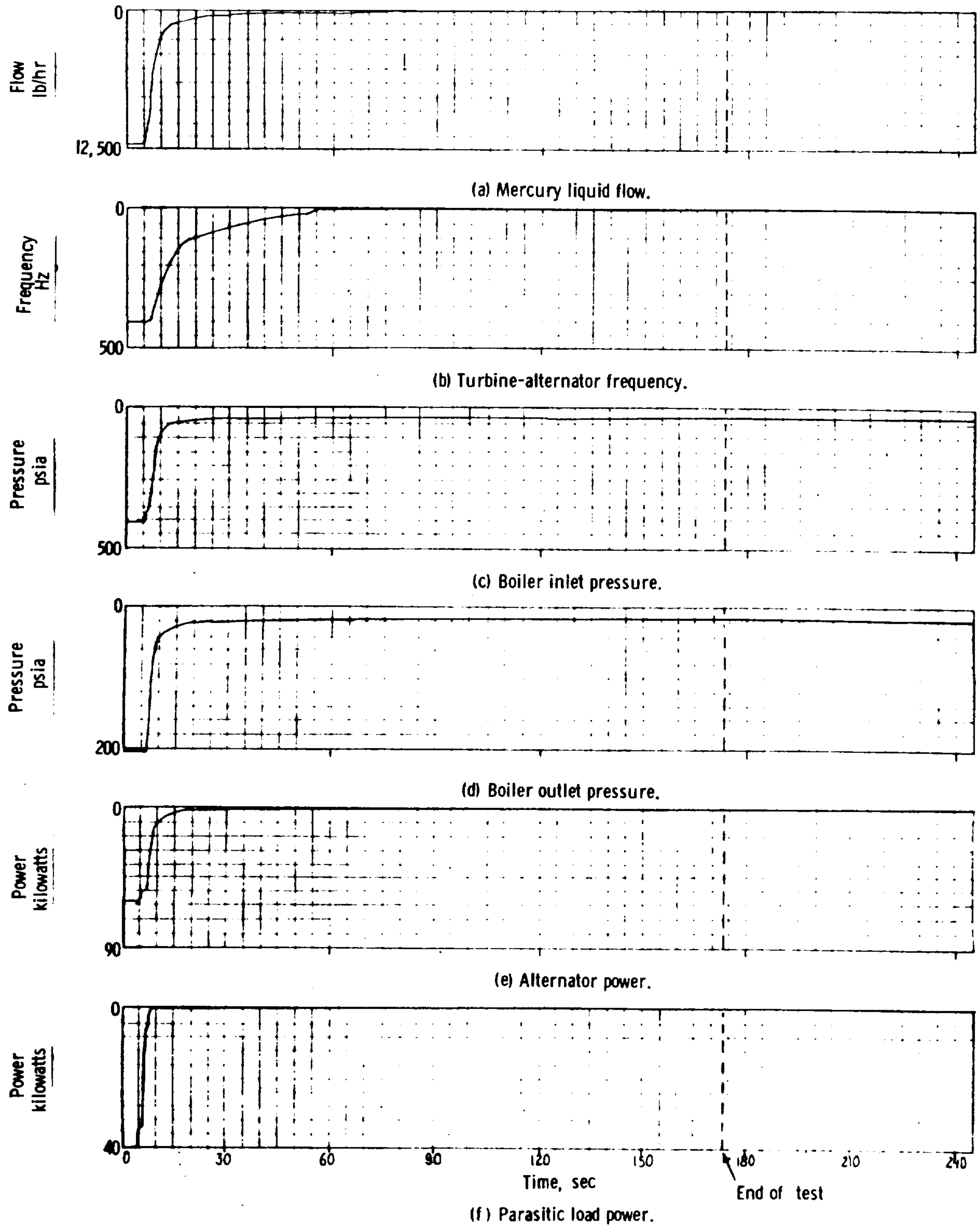
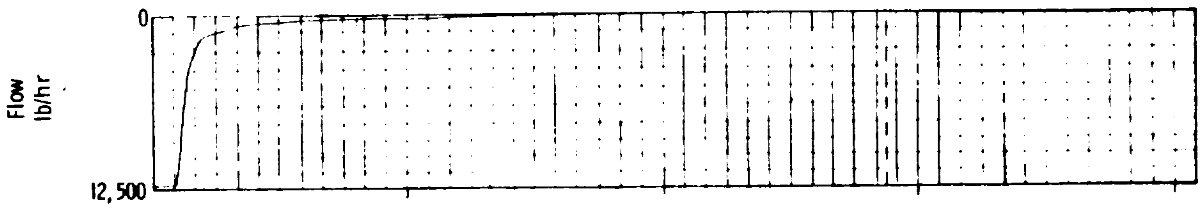
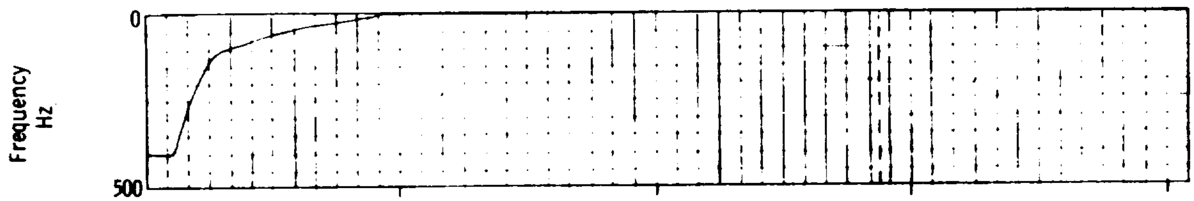


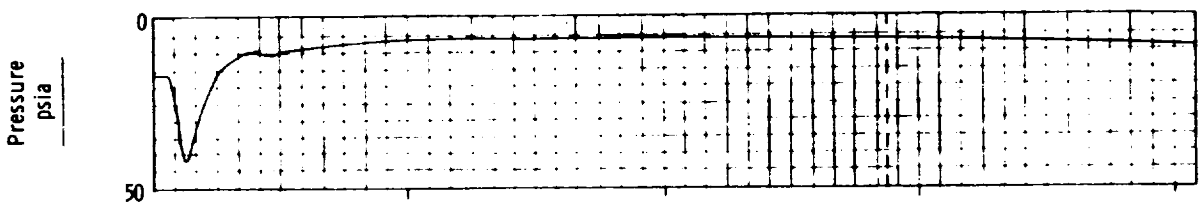
Figure 5. - Emergency shutdown test-



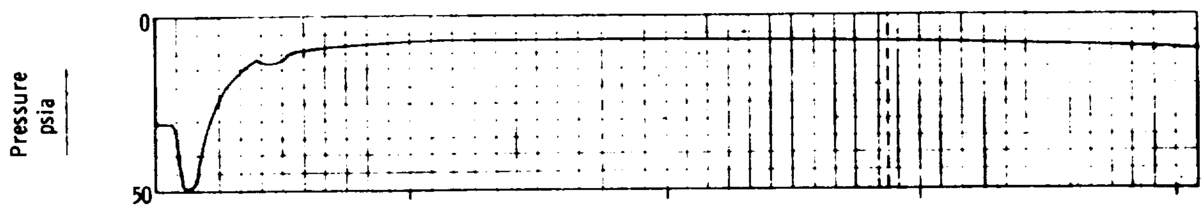
(g) Mercury liquid flow.



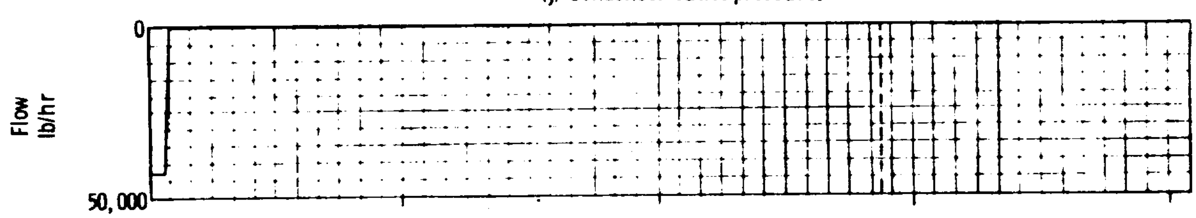
(h) Turbine-alternator frequency.



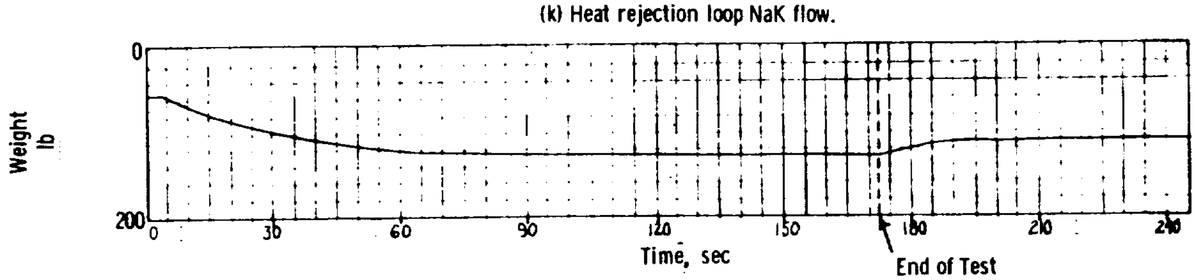
(i) Condenser inlet pressure.



(j) Condenser outlet pressure.

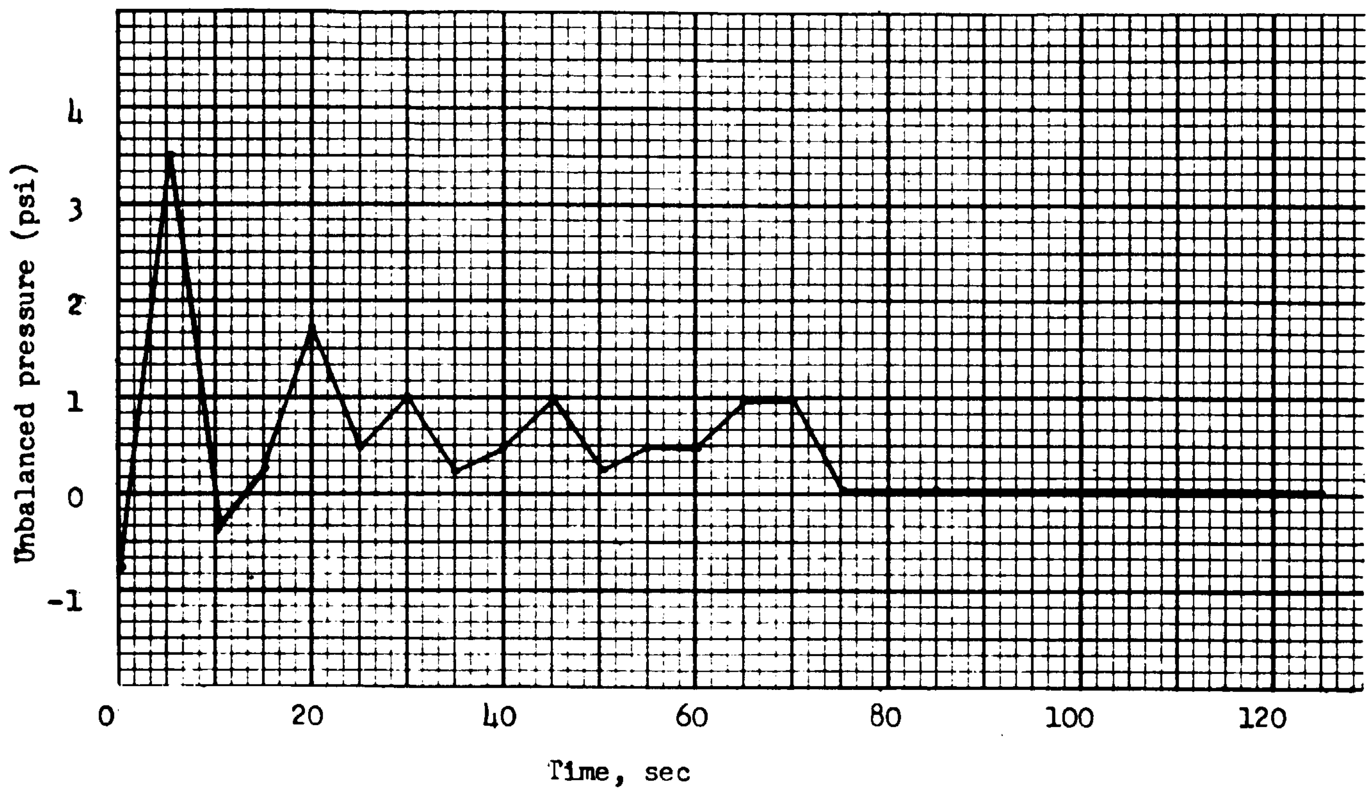


(k) Heat rejection loop NaK flow.



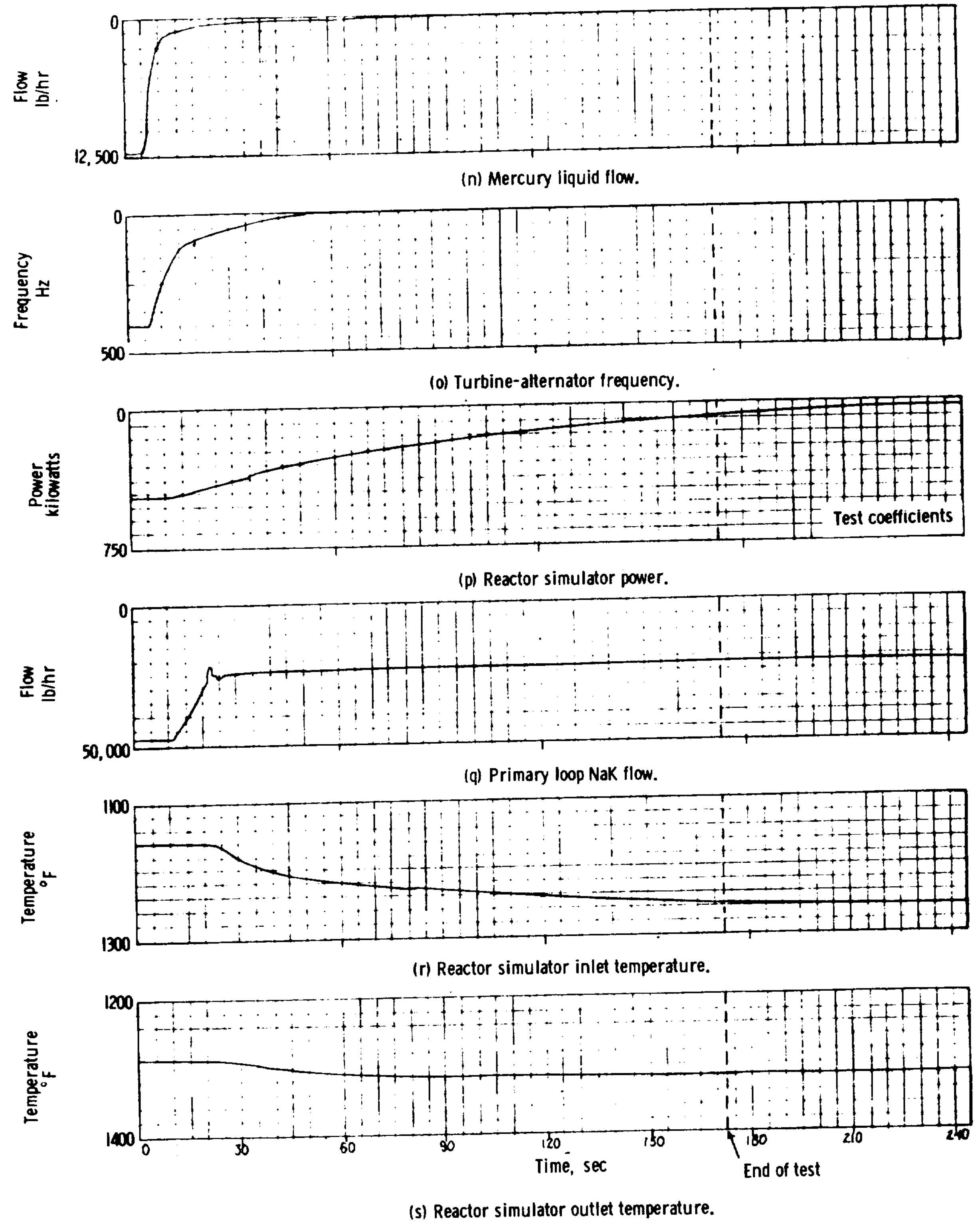
(l) Standpipe inventory.

Figure 5. - Continued.



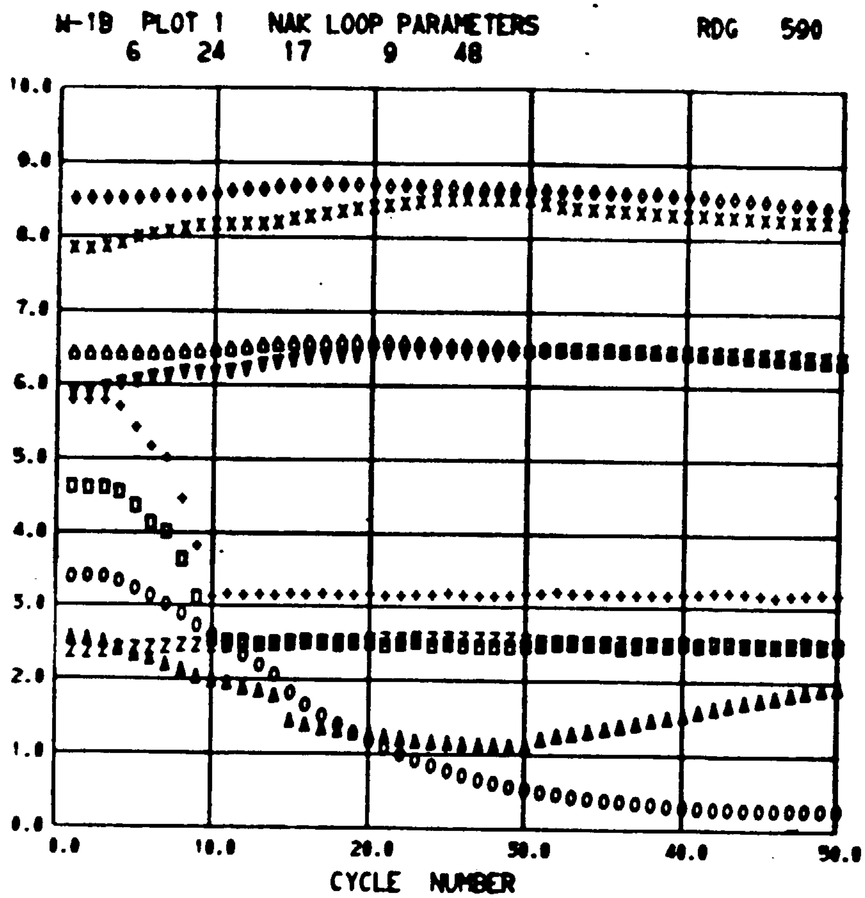
(m) Zero gravity simulation for inventory withdrawal. Unbalanced pressure equals standpipe-pressure minus condenser liquid head.

Figure 5.- Continued.



(s) Reactor simulator outlet temperature.

Figure 5. - Concluded.



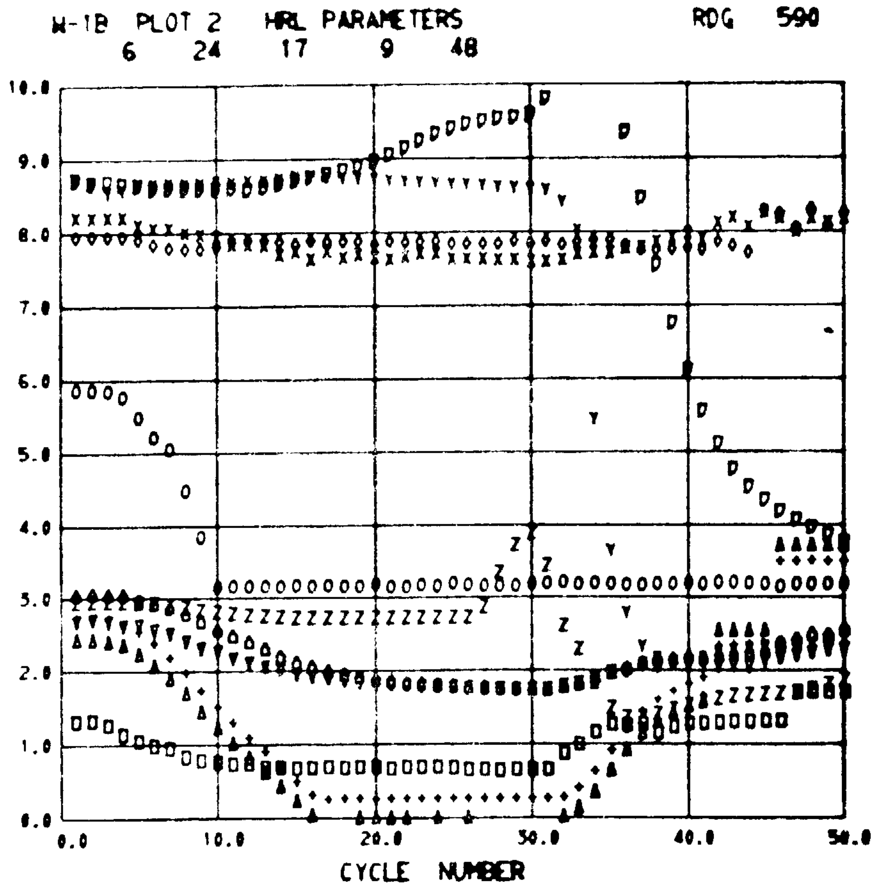
11.43 seconds between cycles

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 590
6 24 17 9 48

□	PRI NAK FLOW	X	10000 LB/HR
O	IGNITRON PWR	X	100 KW
Δ	EXCESS REACT	X	10 -25 CENT
+	PNPMA SPEED	X	1000 RPM
X	HEATER INLET TEMP	X	150 F
◊	HTR OUTLET TEMP	X	150 F
◁	BOILER INLET TEMP	X	200 F
▽	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

(a) Primary NaK loop parameters.

Figure 6. Normal shutdown



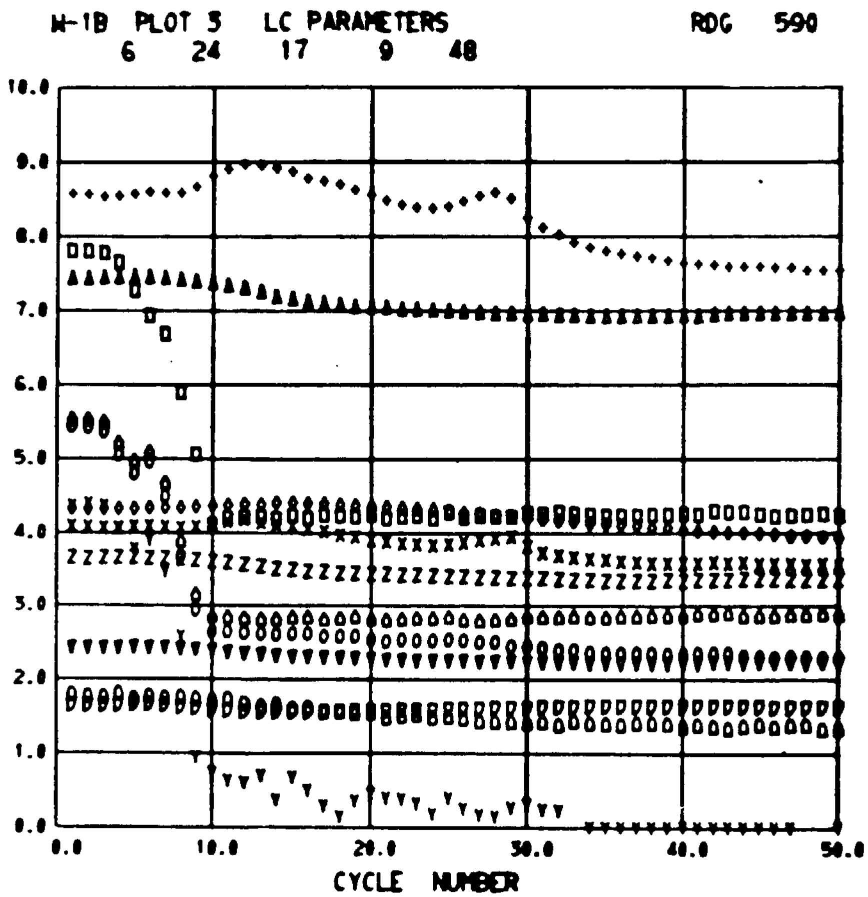
11.43 seconds between cycles

W-1B PLOT 2 HRL PARAMETERS RDG 590
6 24 17 9 48

D	HRL NAK FLOW	X	10000 LB/HR
O	HRLPMA SPEED	X	1000 RPM
Δ	BV-10 POSITION	X	20 0/0
+	BV-12 POSITION	X	20 0/0
X	RAD-1 AIR INLET	X	10 F
◊	RAD-2 AIR INLET	X	10 F
ô	RAD-1 AIR OUTLET	X	50 F
∇	RAD-2 AIR OUTLET	X	50 F
Z	COND. INLET TEMP	X	100 F
Y	COND. OUTLET TEMP	X	75 F
Ɒ	RAD. INLET TEMP	X	75 F

(b) Heat rejection loop parameters

Figure 6. Continued



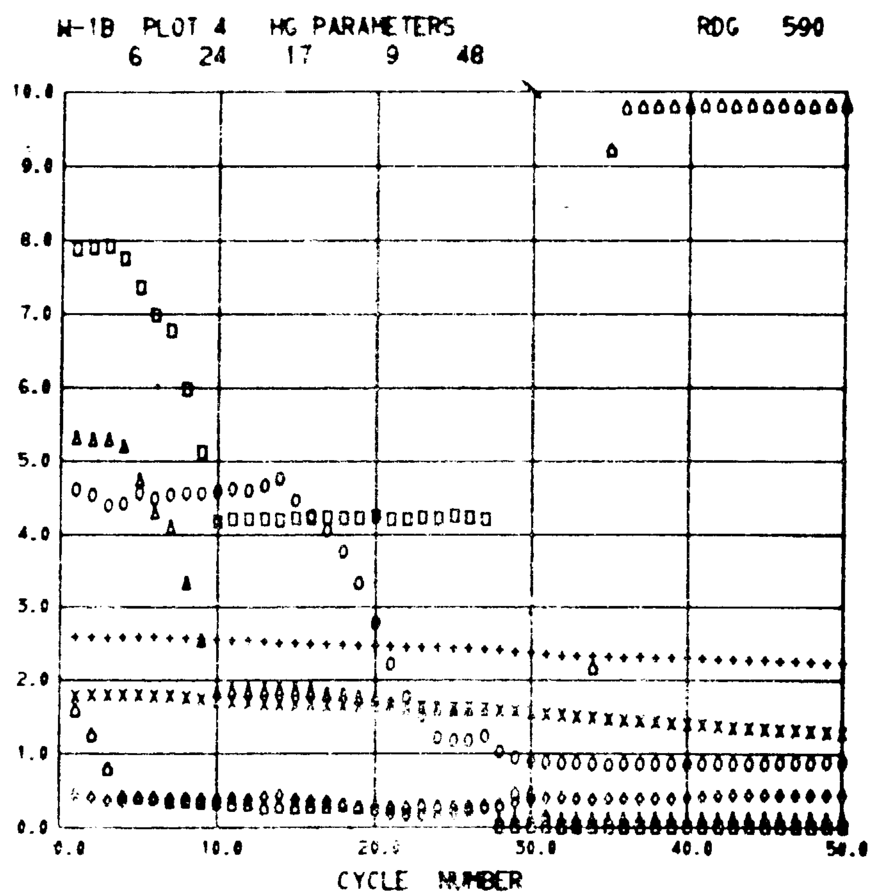
11.43 seconds between cycles

W-1B PLOT 3 LC PARAMETERS RDG 591
6 24 17 9 48

□	L/C PMA SPEED	X	1000	RPM
O	T.SSHE-A.HE FLOW	X	300	LB/HR
Δ	TURB. SSHE INLET TEMP	X	25	F
+	TURB. SSHE OUTLET TEMP	X	25	F
X	ALT. H.E. INLET TEMP	X	50	F
◊	ALT. H.E. OUTLET TEMP	X	50	F
◬	HG PMA SSHE FLOW	X	350	LB/HR
∇	HG PMA SSHE INLET TEMP	X	75	F
Z	HG PMA SSHE OUTLET TEMP	X	50	F
Y	HG PMA MOTOR HE FLOW	X	30	LB/HR
D	HG PMA MHE INLET TEMP	X	100	F
Ω	HG PMA MHE OUTLET TEMP	X	100	F

(c) Lubricant coolant loop parameters

Figure 6. Continued



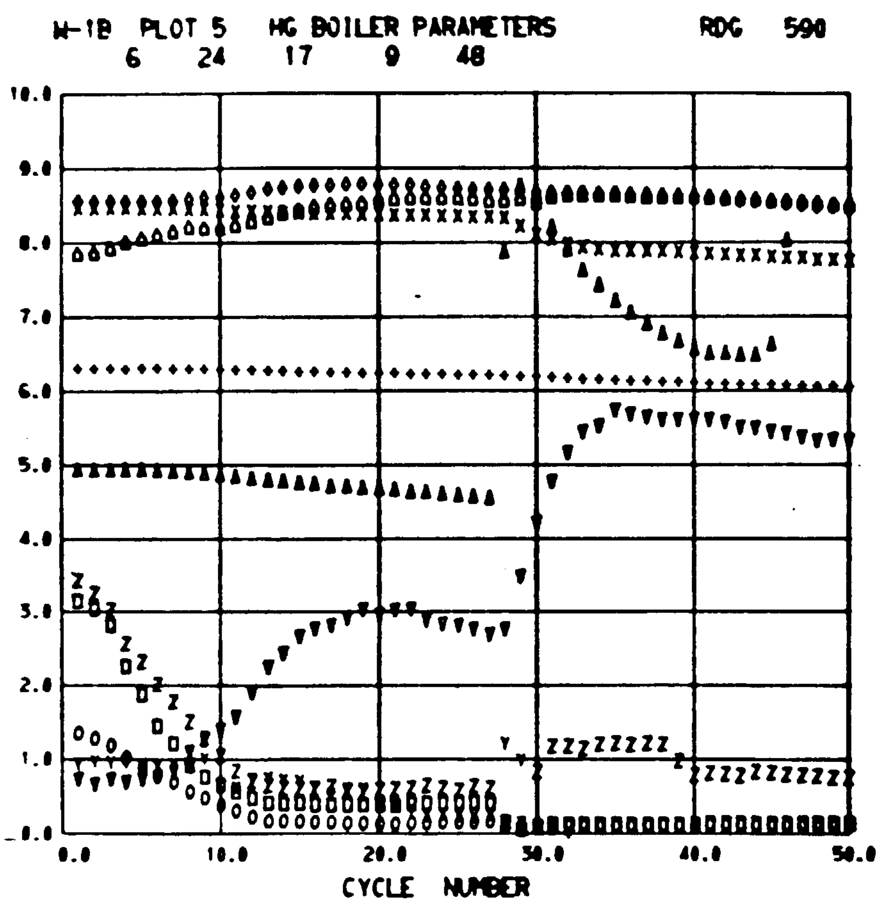
11.43 seconds between cycles

W-1B PLOT 4 HG PARAMETERS RDG 59
6 24 17 9 48

□	HG PMA SPEED	X	1000 RPM
O	HG PMA INLET PRESS	X	10 PSIA
Δ	HG PMA OUTLET PRESS	X	100 PSIA
+	HG PMA INLET TEMP	X	100 F
X	HG PMA OUTLET TEMP	X	150 F
◇	HG PMA ZERO G NPSH	X	5 FT
▽	HG FCV POSITION	X	10 0/0

(d) Mercury loop parameters

Figure [illegible]. Continued



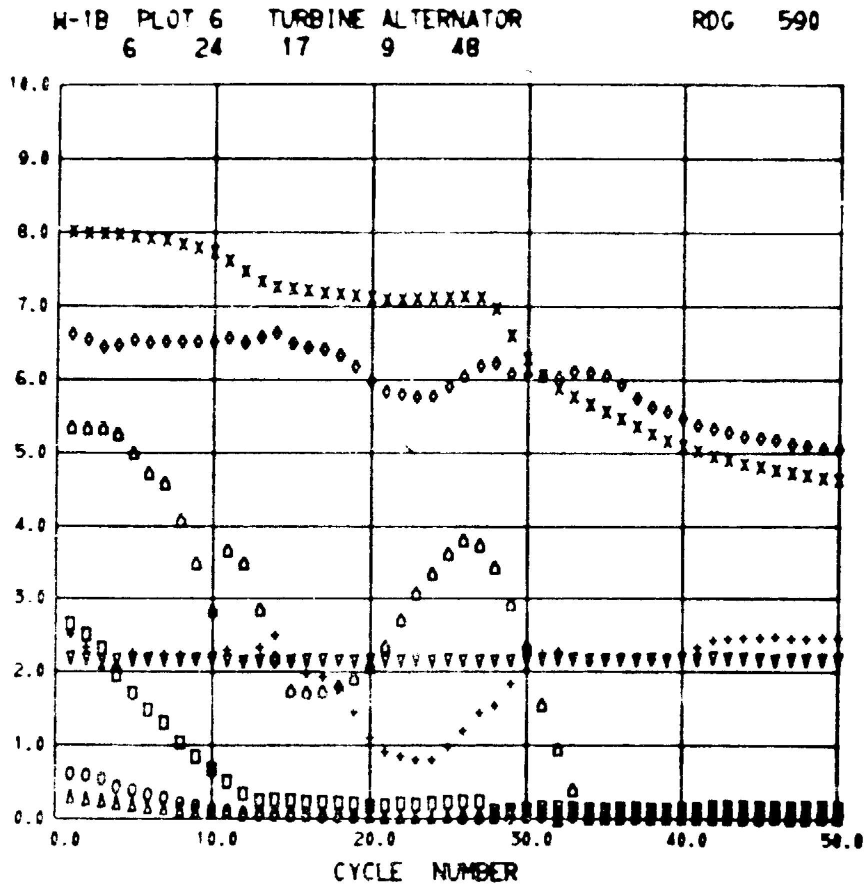
11.43 seconds between cycles

W-1B PLOT 5 HG BOILER PARAMETERS RDG 590
6 24 17 9 48

□	BOILER HG INLET PRESS	X	100 PSIA
O	BOILER HG OUTLET PRESS	X	100 PSIA
Δ	BOILER HG INLET TEMP	X	50 F
+	BOILER HG OUT SKIN TEMP	X	200 F
X	BOILER HG OUT IMM TEMP	X	150 F
◊	BOILER NAK INLET TEMP	X	150 F
Δ	BOILER NAK OUTLET TEMP	X	150 F
∇	BOILER TERM. TEMP DIFF.	X	20 F
Z	BOILER HG LIQUID FLOW	X	2000 LB/HR
Y	BOILER HT. BAL. QUALITY		

(e) Mercury boiler parameters

Figure 6. Continued



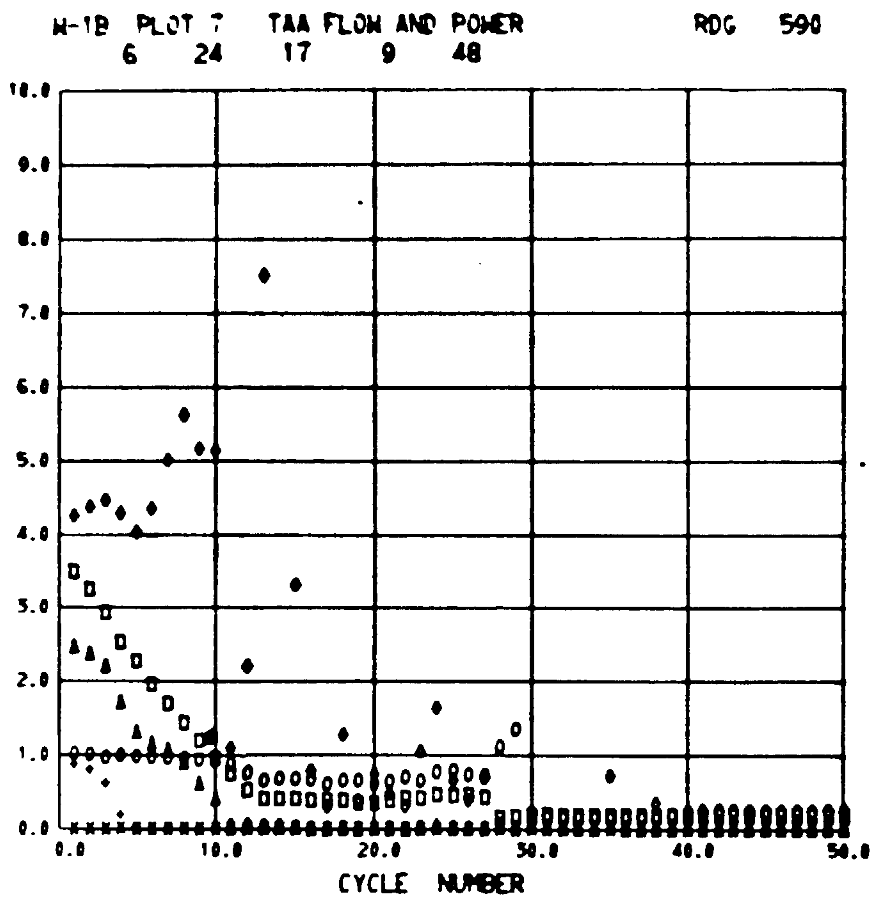
11.43 seconds between cycles

W-1B PLOT 6 TURBINE ALTERNATOR
6 24 17 9 48

□	TURB. NOZZLE BOWL PRESS	X	50 PSIA
○	TURB. 1ST STAGE DISC. PRESS	X	100 PSIA
Δ	TURB. 3RD STAGE IN PRESS	X	100 PSIA
+	COND. HG INLET PRESS	X	5 PSIA
X	TURB. NOZZLE BOWL TEMP	X	150 F
◇	TURB. EXHAUST TEMP	X	100 F
◊	TAA FREQUENCY	X	75 HZ
▽	BOGUE/MG SET FREQUENCY	X	100 HZ

(f) Turbine alternator parameters

Figure 6. Continued



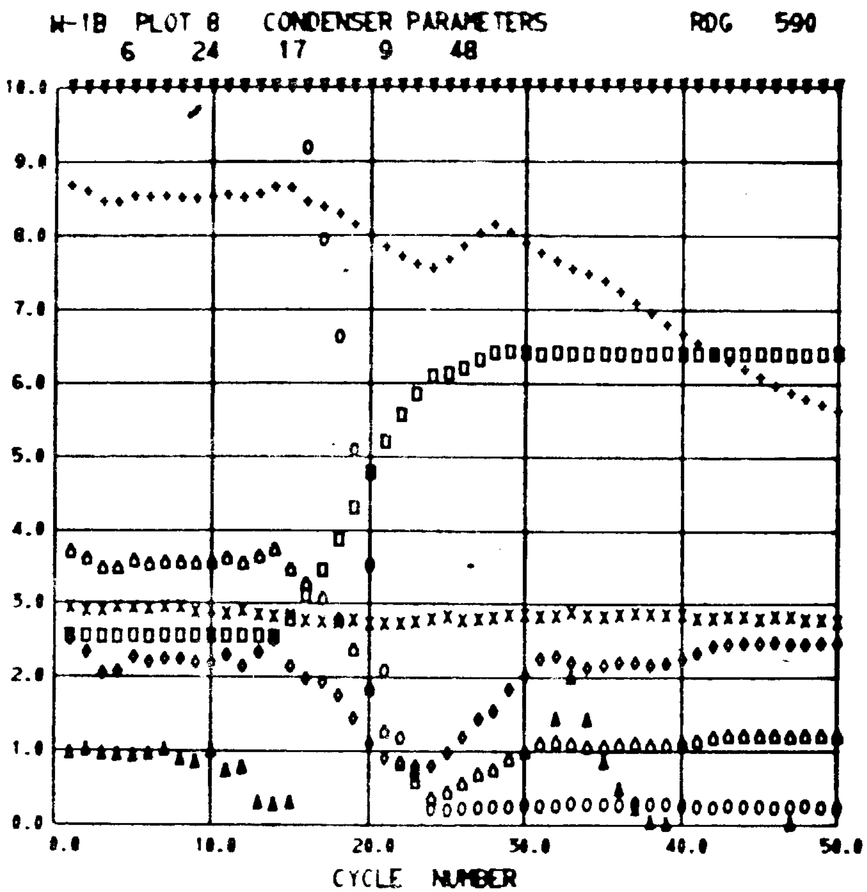
11.43 seconds between cycles

W-1B PLOT 7 TAA FLOW AND POWER RDG 59_
6 24 17 9 48

□	HG VAPOR VENT. FLOW	X 2000 LB/HR
O	HG FLOW RATIO QUALITY	
Δ	TAA POWER	X 10 KW
+	PLR POWER	X 10 KW
X	VLB POWER	X 10 KW
◊	TAA OVERALL EFFICIENCY	X 10 0/0

(g) Turbine flow and power parameters

Figure 6. Continued



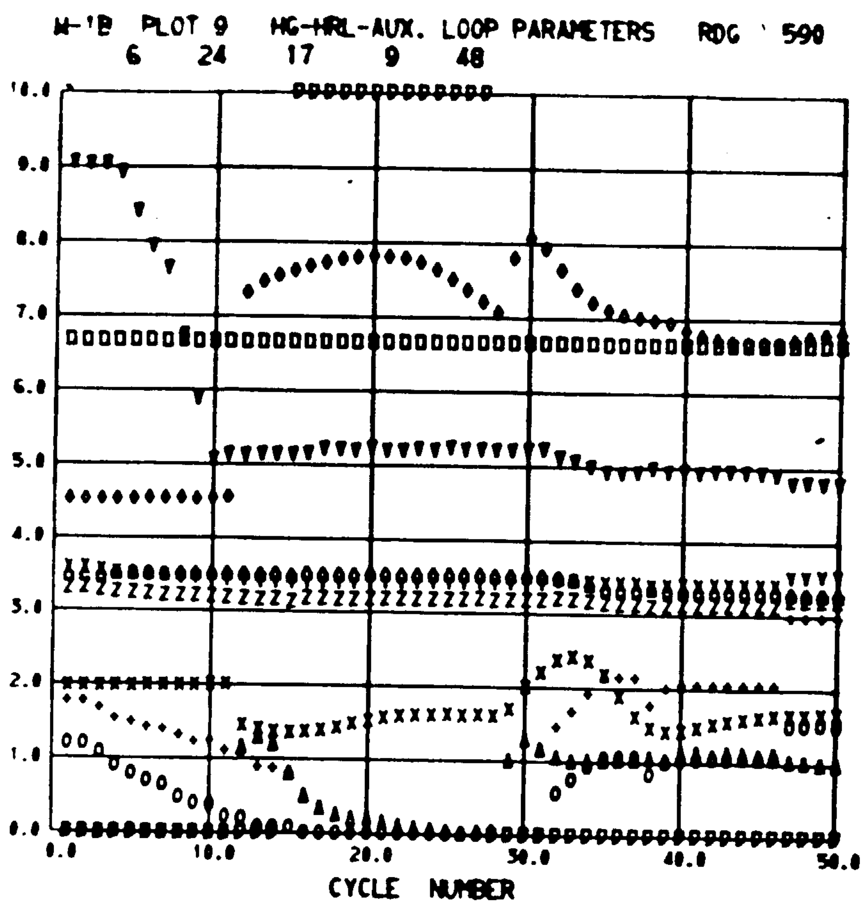
11.43 seconds between cycles

(h) Condenser parameters

Figure 6. Continued

W-1B PLOT 8 CONDENSER PARAMETERS RDG 5[illegible]
6 24 17 9 48

□	HG STANDPIPE WEIGHT	X	25 LB
O	COND. HG INVENTORY	X	10 LB
Δ	COND. HG INLET QUALITY		
+	COND. HG INLET TEMP	X	75 F
X	COND. HG OUTLET TEMP	X	100 F
◊	COND. HG INLET PRESS	X	5 PSIA
Δ	COND. HG OUTLET PRESS	X	10 PSIA
∇	COND. OUTLET V-210 POS.	X	10 0/0



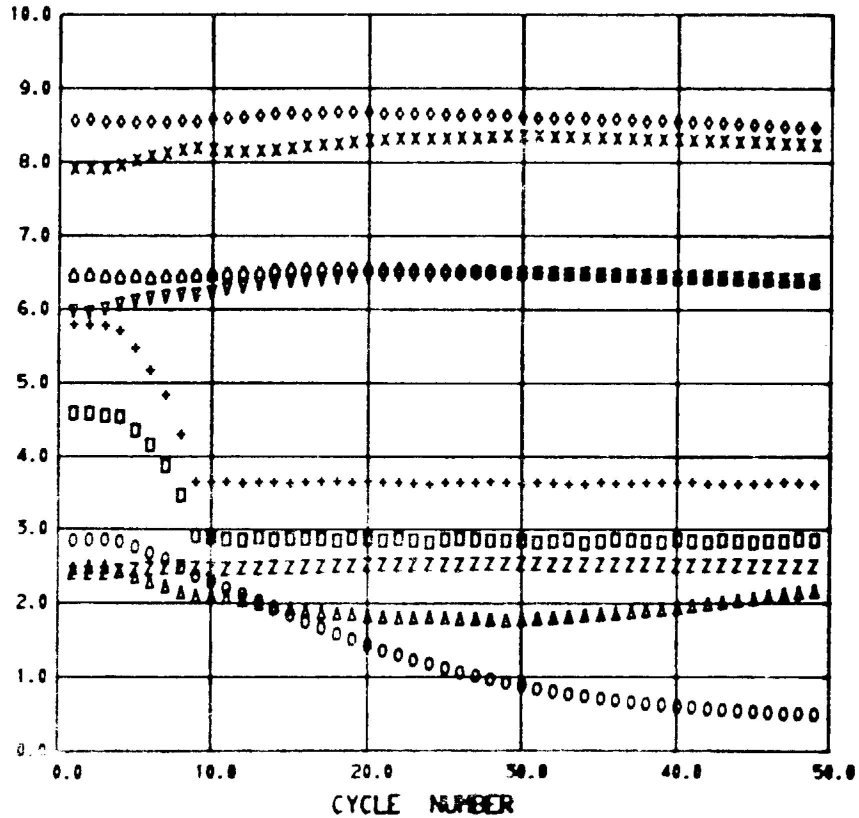
11.43 seconds between cycles

M-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 590
6 24 17 9 48

D	HG V-206 POSITION	X	15 0/0
O	COND. NAK FLOW RATE	X	10000 LB/HR
Δ	AUX. LOOP FLOW RATE	X	1000 LB/HR
+	HRL V-314 POSITION	X	10 0/0
X	ASHE AUX. SIDE INLET TEMP	X	100 F
◊	ASHE AUX. SIDE OUTLET TEMP	X	150 F
Δ	HRL PMA INLET PRESS	X	10 PSIA
∇	HRL PMA OUTLET PRESS	X	10 PSIA
Z	RAD. NAK INLET PRESS	X	10 PSIA
Y	COND. NAK INLET PRESS	X	10 PSIA
D	HG STAND PIPE V-217 POS	X	10 0/0

(i) Mercury, Heat Rejection, and Auxiliary loop parameters

Figure 6. Concluded



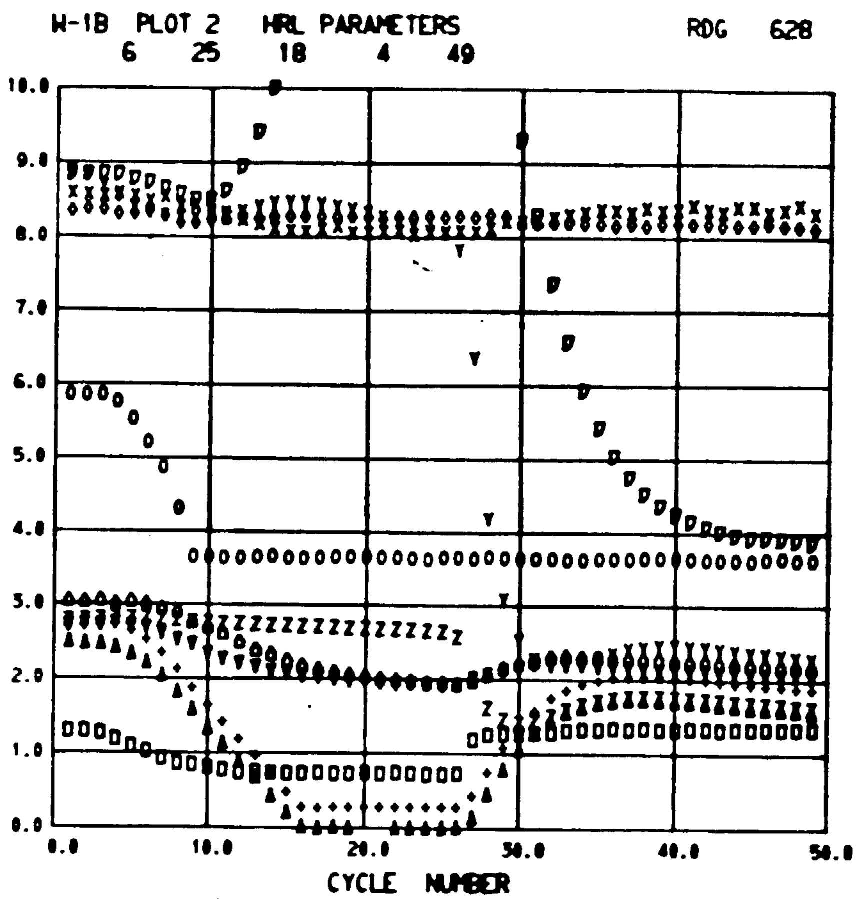
11.43 seconds between cycles

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 628
6 25 18 4 49

□	PRI NAK FLOW	X	10000 LB/HR
O	IGNITRON PWR	X	100 KW
▲	EXCESS REACT	X	10 -25 CENT
+	PNPMA SPEED	X	1000 RPM
X	HEATER INLET TEMP	X	150 F
◊	HTR OUTLET TEMP	X	150 F
Δ	BOILER INLET TEMP	X	200 F
∇	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

(a) Primary NaK loop parameters.

Figure 7. Normal shutdown



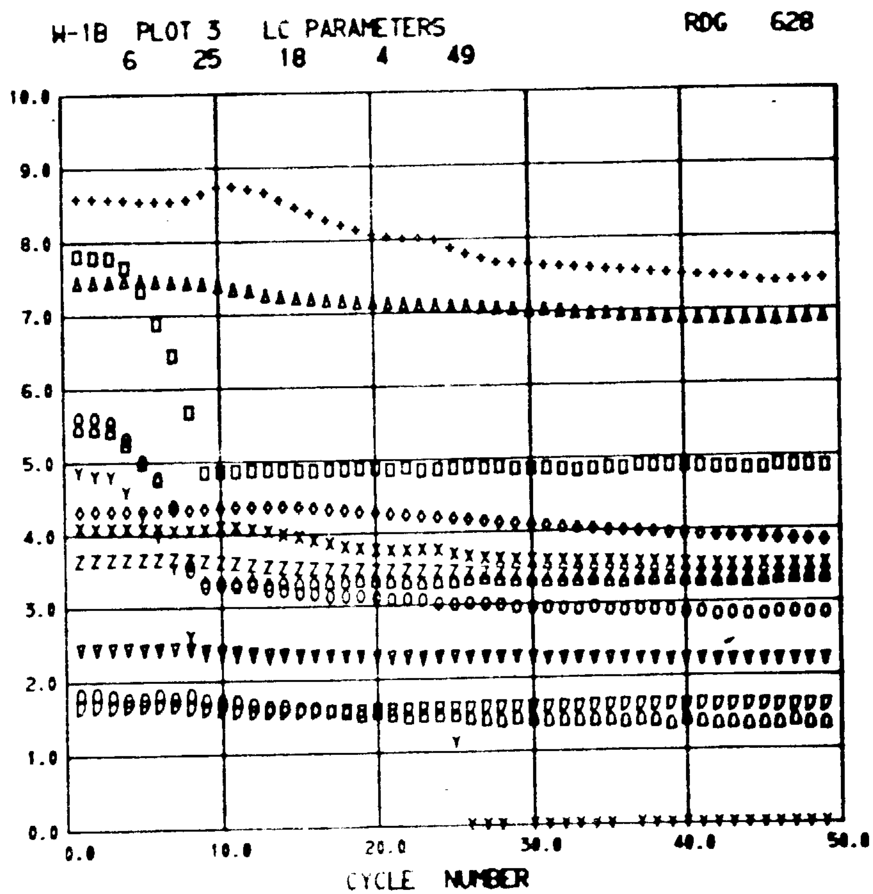
11.43 seconds between cycles

W-1B PLOT 2 HRL PARAMETERS RDG 628
6 25 18 4 49

◻	HRL NAK FLOW	X	10000 LB/HR
O	HRLPMA SPEED	X	1000 RPM
▲	BV-10 POSITION	X	20 0/0
+	BV-12 POSITION	X	20 0/0
X	RAD-1 AIR INLET	X	10 F
◆	RAD-2 AIR INLET	X	10 F
Δ	RAD-1 AIR OUTLET	X	50 F
▼	RAD-2 AIR OUTLET	X	50 F
Z	COND. INLET TEMP	X	100 F
Y	COND. OUTLET TEMP	X	75 F
D	RAD. INLET TEMP	X	75 F

(b) Heat rejection loop parameters

Figure 7. Continued



11.43 sec

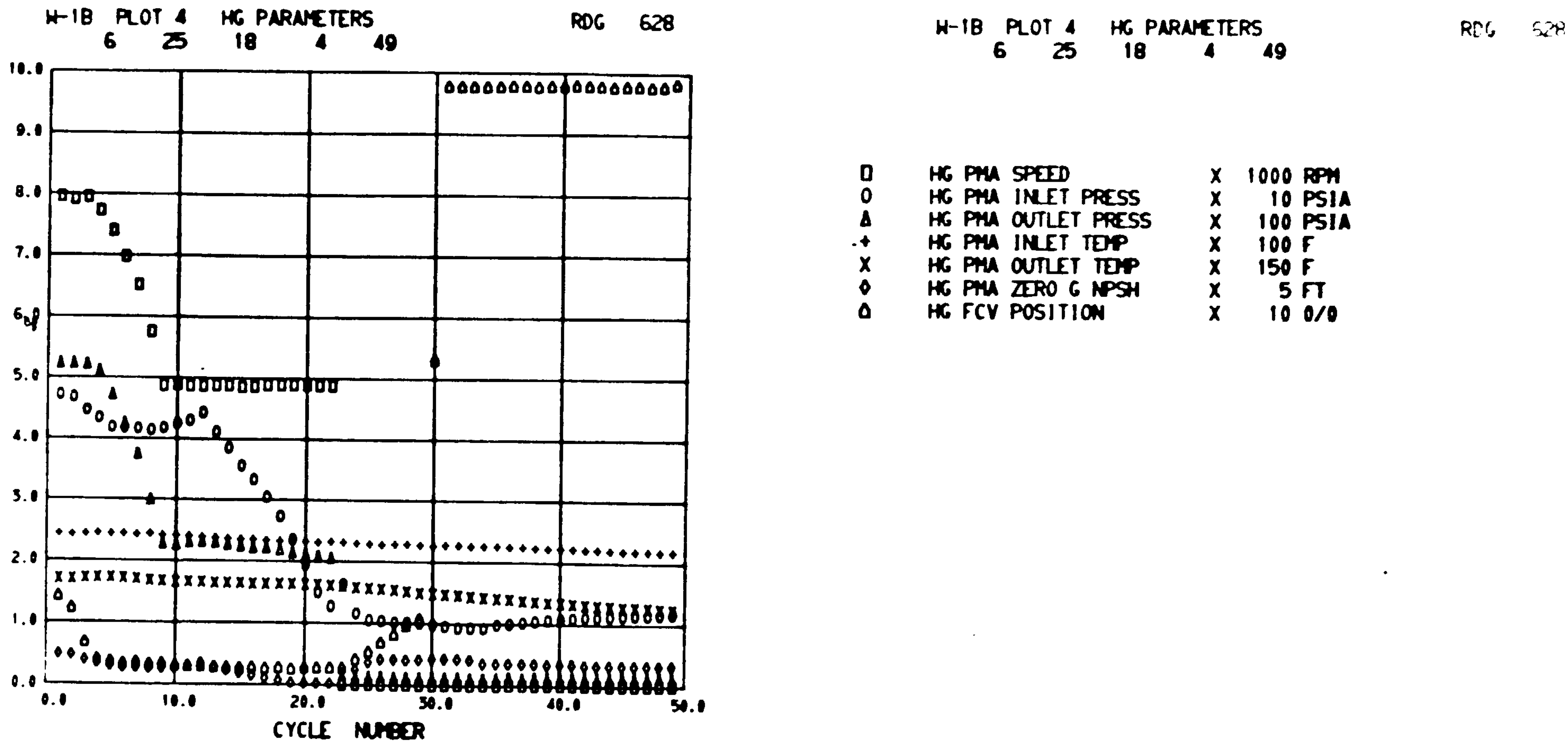
W-1B PLOT 3 LC PARAMETERS RDG 6

6 25 18 4 49

□	L/C PMA SPEED	X	1000 RPM
O	T.SSHE-A.HE FLOW	X	300 LB/HR
Δ	TURB. SSHE INLET TEMP	X	25 F
+	TURB. SSHE OUTLET TEMP	X	25 F
X	ALT. H.E. INLET TEMP	X	50 F
◊	ALT. H.E. OUTLET TEMP	X	50 F
Δ	HG PMA SSHE FLOW	X	350 LB/HR
∇	HG PMA SSHE INLET TEMP	X	75 F
Z	HG PMA SSHE OUTLET TEMP	X	50 F
Y	HG PMA MOTOR HE FLOW	X	30 LB/HR
D	HG PMA MHE INLET TEMP	X	100 F
O	HG PMA MHE OUTLET TEMP	X	100 F

(c) lubricant coolant loop parameters

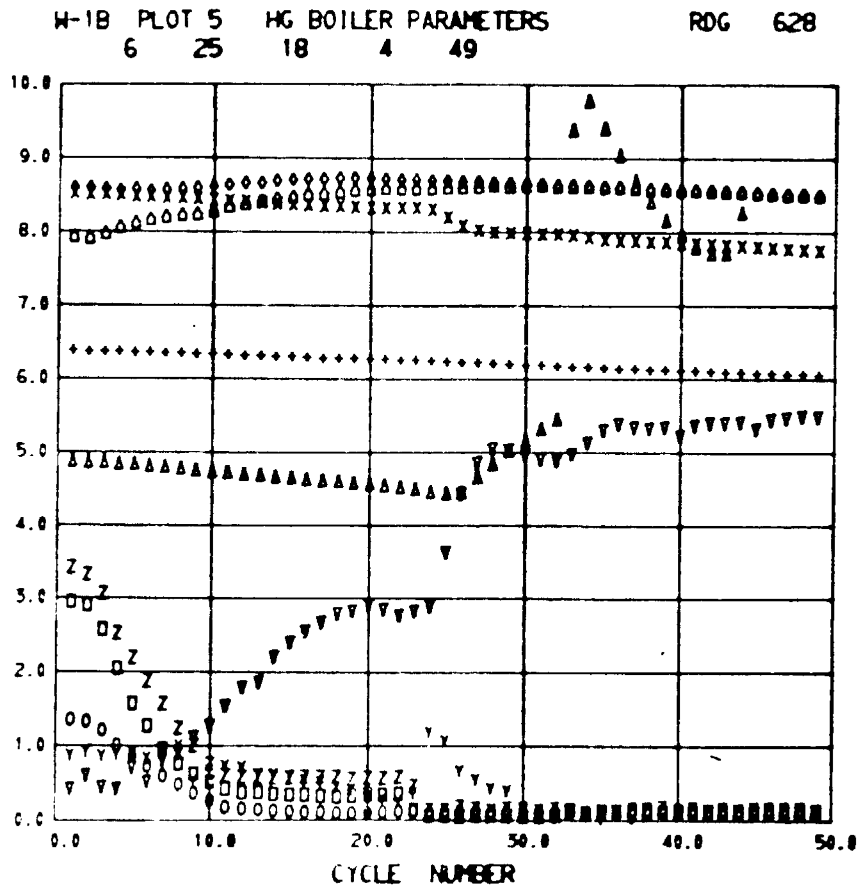
Figure 7. Continued



11.43 seconds between cycles

(d) Mercury loop parameters

Figure 7. Continued



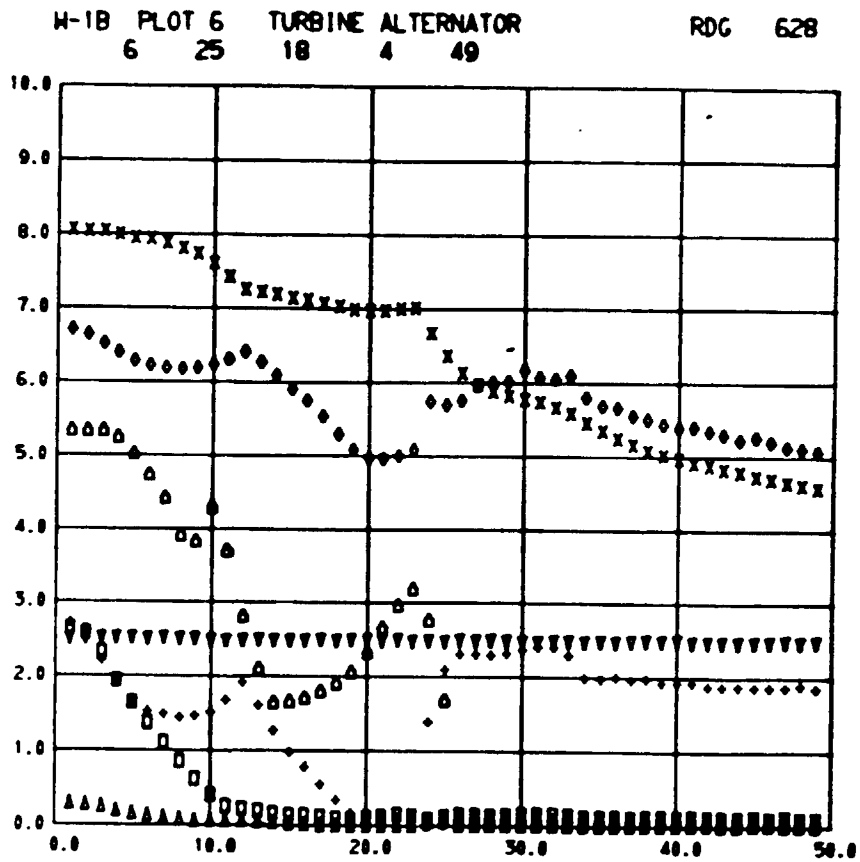
11.43 seconds between cycles

W-1B PLOT 5 HG BOILER PARAMETERS RDG 62
6 25 18 4 49

□	BOILER HG INLET PRESS	X	100 PSIA
O	BOILER HG OUTLET PRESS	X	100 PSIA
△	BOILER HG INLET TEMP	X	50 F
+	BOILER HG OUT SKIN TEMP	X	200 F
X	BOILER HG OUT IMM TEMP	X	150 F
◇	BOILER NAK INLET TEMP	X	150 F
△	BOILER NAK OUTLET TEMP	X	150 F
▽	BOILER TERM. TEMP DIFF.	X	20 F
Z	BOILER HG LIQUID FLOW	X	2000 LB/HR
Y	BOILER HT. BAL. QUALITY		

(e) Mercury boiler parameters

Figure 7. Continued



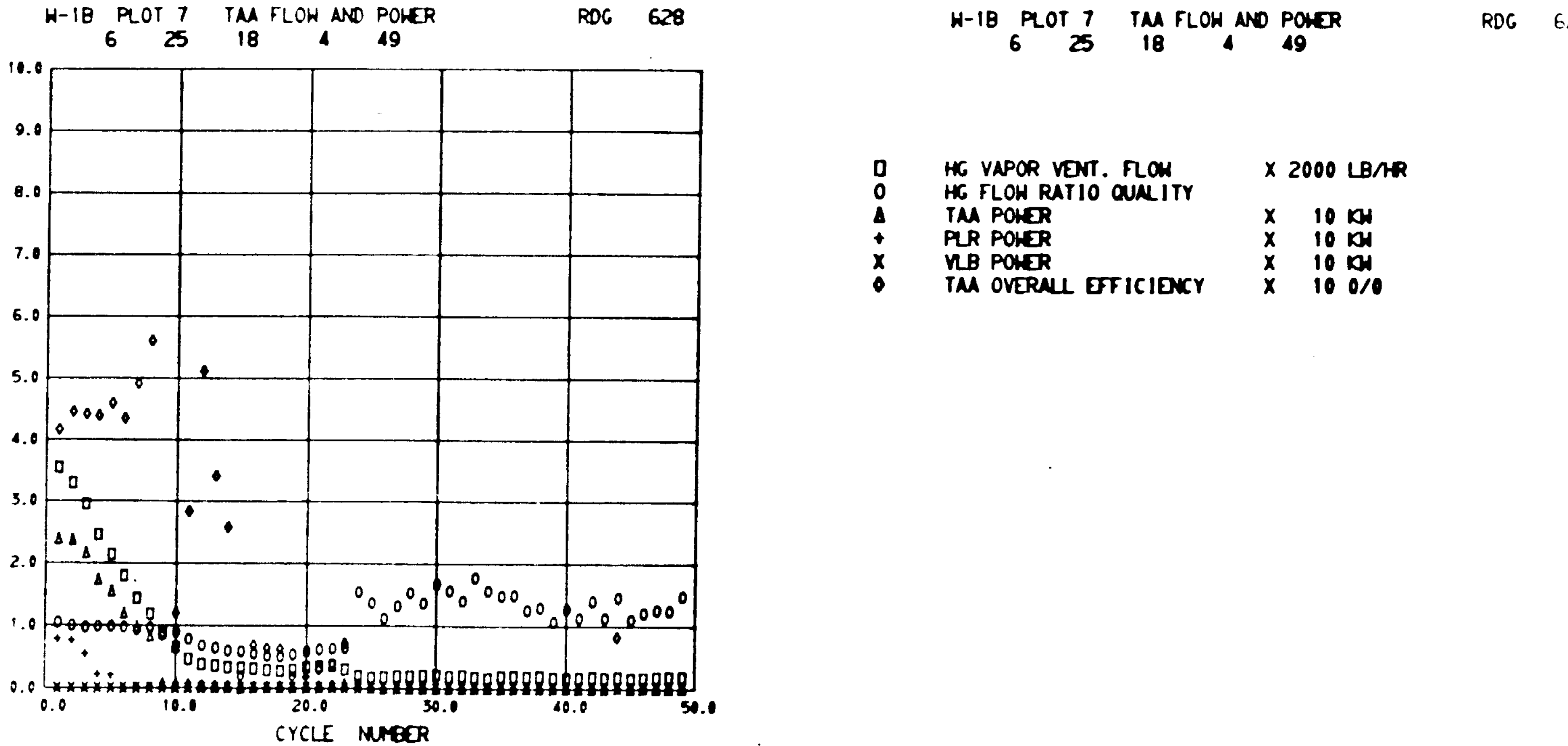
11.43 seconds between cycles

H-1B PLOT 6 TURBINE ALTERNATOR RDG 628
6 25 18 4 49

□	TURB. NOZZLE BOWL PRESS	X 50 PSIA
O	TURB. 1ST STAGE DISC. PRESS	X 100 PSIA
Δ	TURB. 3RD STAGE IN PRESS	X 100 PSIA
+	COND. HG INLET PRESS	X 5 PSIA
X	TURB. NOZZLE BOWL TEMP	X 150 F
◊	TURB. EXHAUST TEMP	X 100 F
⌂	TAA FREQUENCY	X 75 HZ
∇	BOGUE/MG SET FREQUENCY	X 100 HZ

(f) Turbine alternator parameters

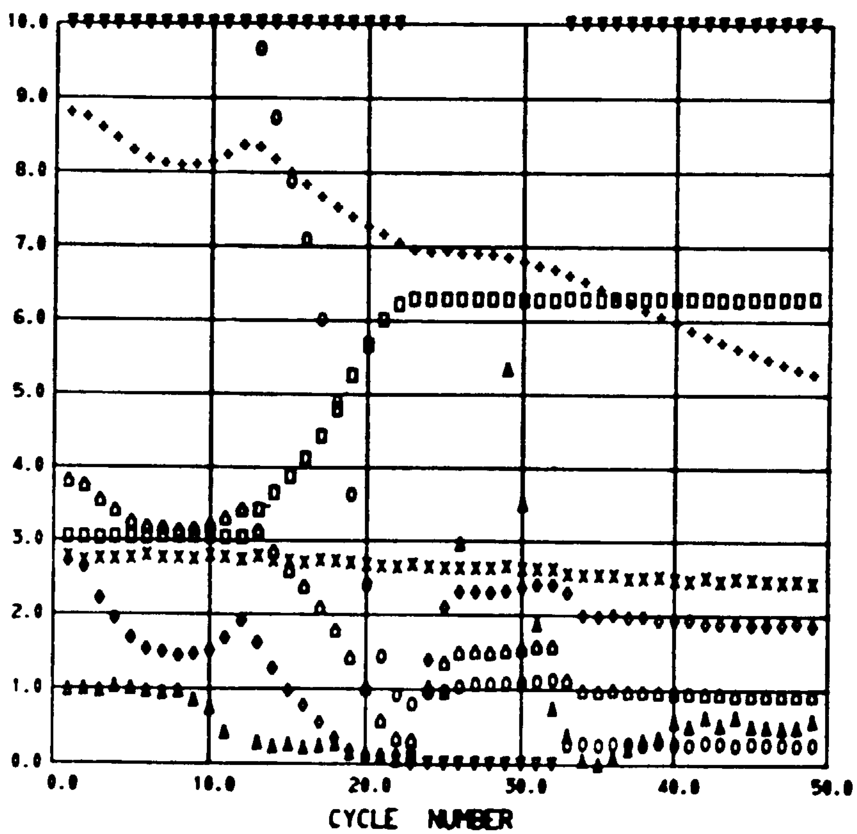
Figure 7. Continued



11.43 seconds between cycles

(g) Turbine flow and power parameters

Figure 7. Continued



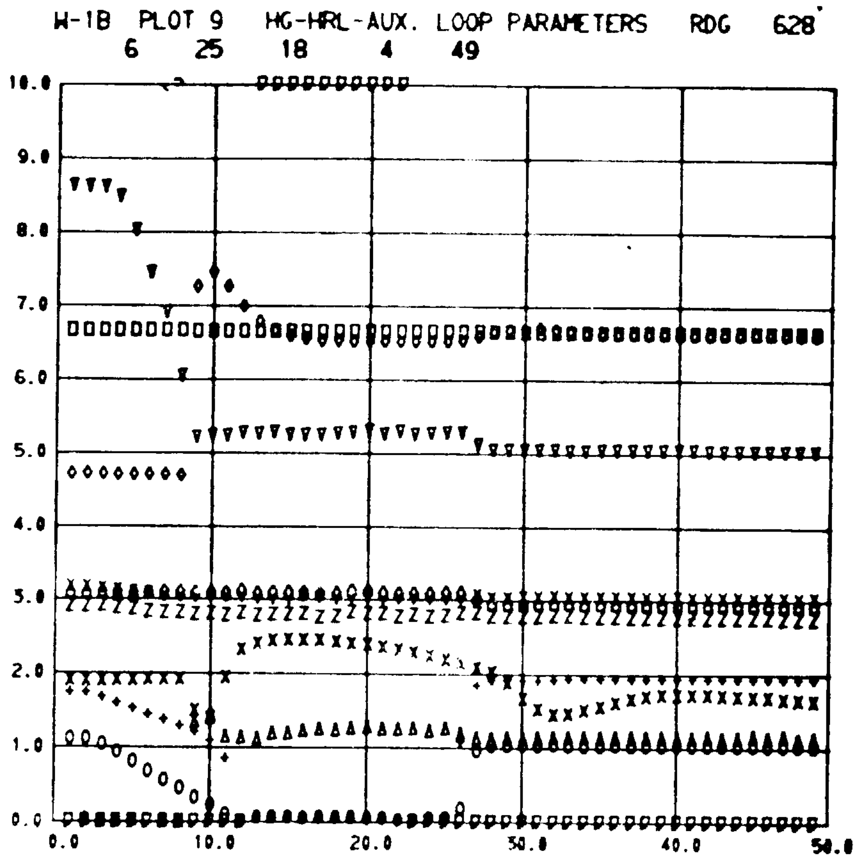
11.43 seconds between cycles

(h) Condenser parameters

W-1B PLOT 8 CONDENSER PARAMETERS RDG 628
6 25 18 4 49

□	HG STANDPIPE WEIGHT	X 25 LB
O	COND. HG INVENTORY	X 10 LB
Δ	COND. HG INLET QUALITY	
+	COND. HG INLET TEMP	X 75 F
X	COND. HG OUTLET TEMP	X 100 F
◇	COND. HG INLET PRESS	X 5 PSIA
⌂	COND. HG OUTLET PRESS	X 10 PSIA
∇	COND. OUTLET V-210 POS.	X 10 0/0

Figure 7. Continued



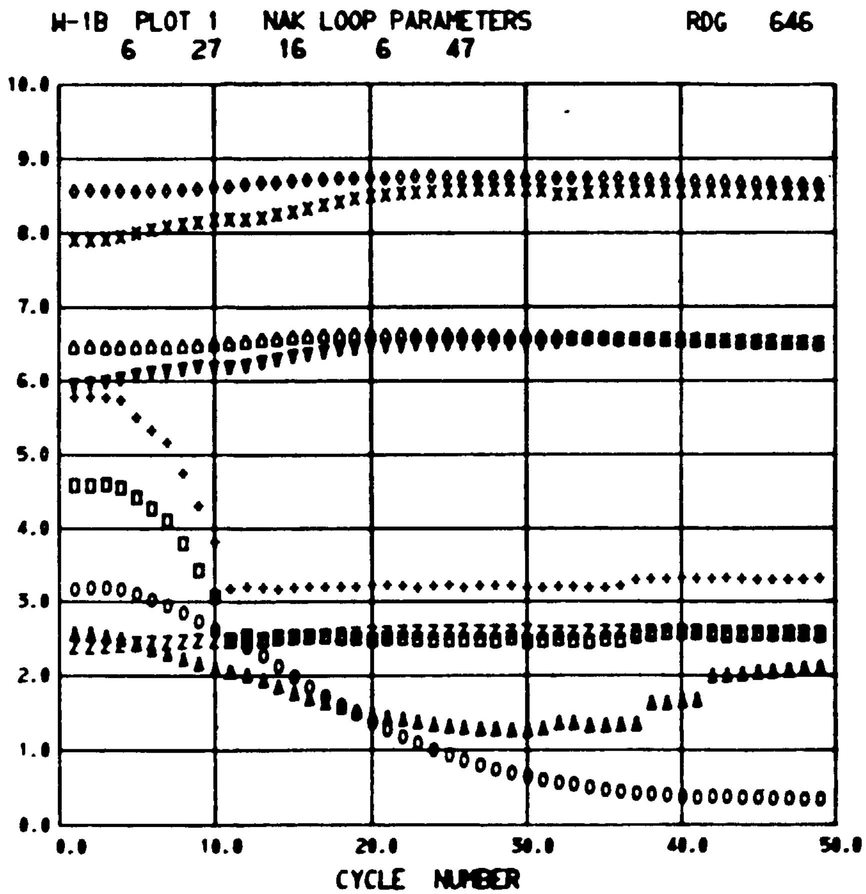
11.43 seconds between cycles

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 628
6 25 18 4 49

□	HG V-206 POSITION	X	15 0/0
O	COND. NAK FLOW RATE	X	10000 LB/HR
Δ	AUX. LOOP FLOW RATE	X	1000 LB/HR
+	HRL V-314 POSITION	X	10 0/0
X	ASHE AUX. SIDE INLET TEMP	X	100 F
◊	ASHE AUX. SIDE OUTLET TEMP	X	150 F
Δ	HRL PMA INLET PRESS	X	10 PSIA
∇	HRL PMA OUTLET PRESS	X	10 PSIA
Z	RAD. NAK INLET PRESS	X	10 PSIA
Y	COND. NAK INLET PRESS	X	10 PSIA
D	HG STAND PIPE V-217 POS	X	10 0/0

(i) Mercury, Heat Rejection, and Auxiliary loop parameters

Figure 7. Concluded



11.43 seconds between cycles

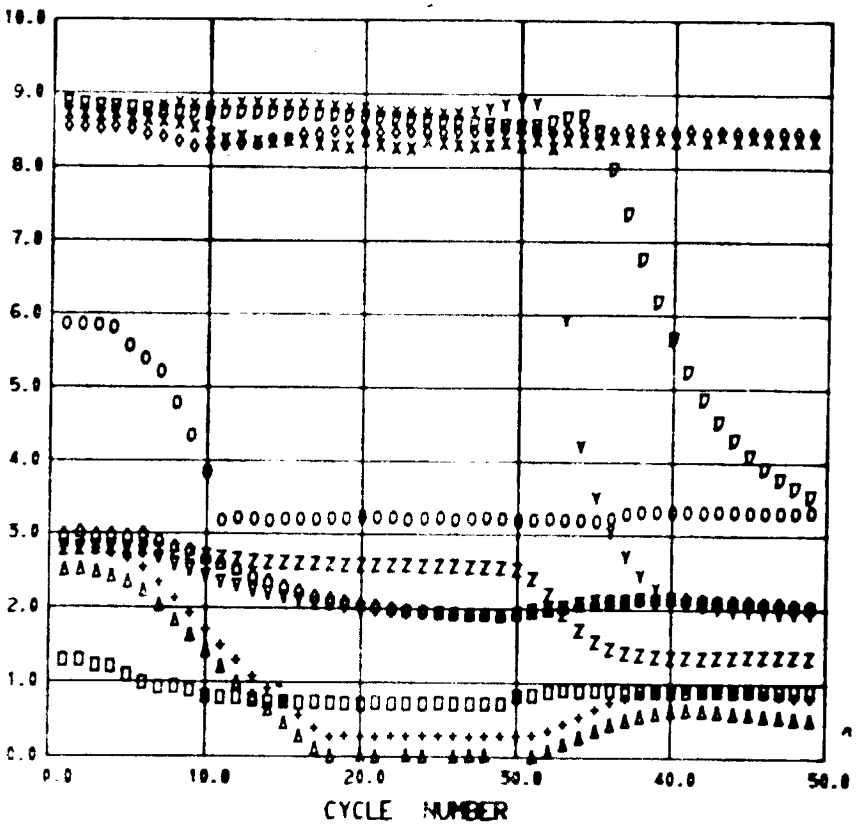
W-1B PLOT 1 NAK LOOP PARAMETERS RDG 646
6 27 16 6 47

□	PRI NAK FLOW	X	10000 LB/HR
O	IGNITRON PWR	X	100 KW
Δ	EXCESS REACT	X	10 -25 CENT
+	PNPMA SPEED	X	1000 RPM
X	HEATER INLET TEMP	X	150 F
◊	HTR OUTLET TEMP	X	150 F
Δ	BOILER INLET TEMP	X	200 F
∇	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

(a) Primary NaK loop parameters.

Figure 8. Normal shutdown (Same as figure 2)

H-1B PLOT 2 HRL PARAMETERS RDG 646
6 27 16 6 47



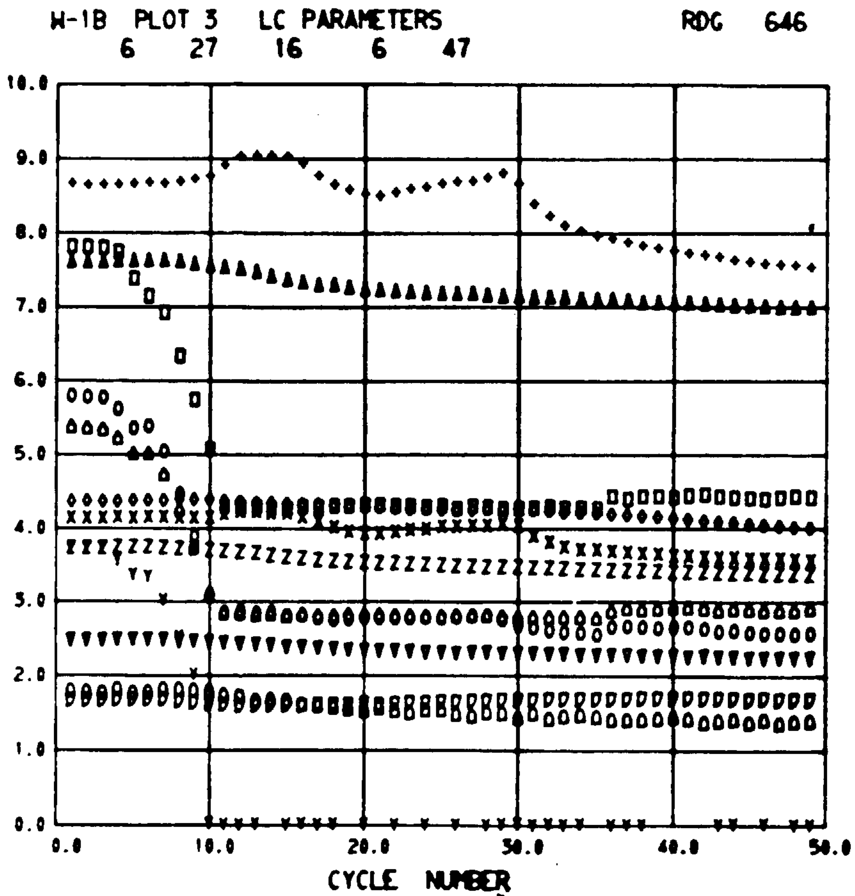
11.43 seconds between cycles

(b) Heat rejection loop parameters

Figure [illegible]. Continued

H-1B PLOT 2 HRL PARAMETERS RDG 646
6 27 16 6 47

□	HRL NAK FLOW	X	10000 LB/HR
O	HRLPMA SPEED	X	1000 RPM
Δ	BV-10 POSITION	X	20, 0/0
+	BV-12 POSITION	X	20 0/0
X	RAD-1 AIR INLET	X	10 F
◊	RAD-2 AIR INLET	X	10 F
Δ	RAD-1 AIR OUTLET	X	50 F
∇	RAD-2 AIR OUTLET	X	50 F
Z	COND. INLET TEMP	X	100 F
Y	COND. OUTLET TEMP	X	75 F
D	RAD. INLET TEMP	X	75 F



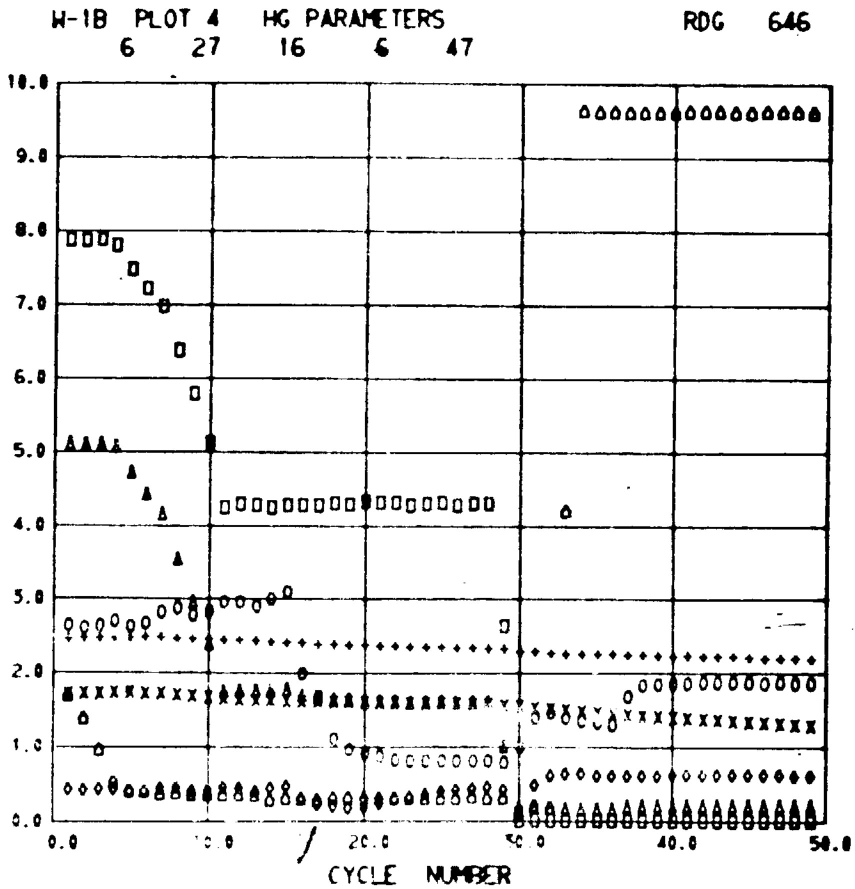
11.43 seconds between cycles

W-1B PLOT 3 LC PARAMETERS RDG 646
6 27 16 6 47

□	L/C PMA SPEED	X	1000 RPM
O	T.SSHE-A.HE FLOW	X	300 LB/HR
Δ	TURB. SSHE INLET TEMP	X	25 F
+	TURB. SSHE OUTLET TEMP	X	25 F
X	ALT. H.E. INLET TEMP	X	50 F
◊	ALT. H.E. OUTLET TEMP	X	50 F
Δ	HG PMA SSHE FLOW	X	350 LB/HR
∇	HG PMA SSHE INLET TEMP	X	75 F
Z	HG PMA SSHE OUTLET TEMP	X	50 F
Y	HG PMA MOTOR HE FLOW	X	30 LB/HR
D	HG PMA MHE INLET TEMP	X	100 F
O	HG PMA MHE OUTLET TEMP	X	100 F

(c) lubricant coolant loop parameters

Figure 8. Continued



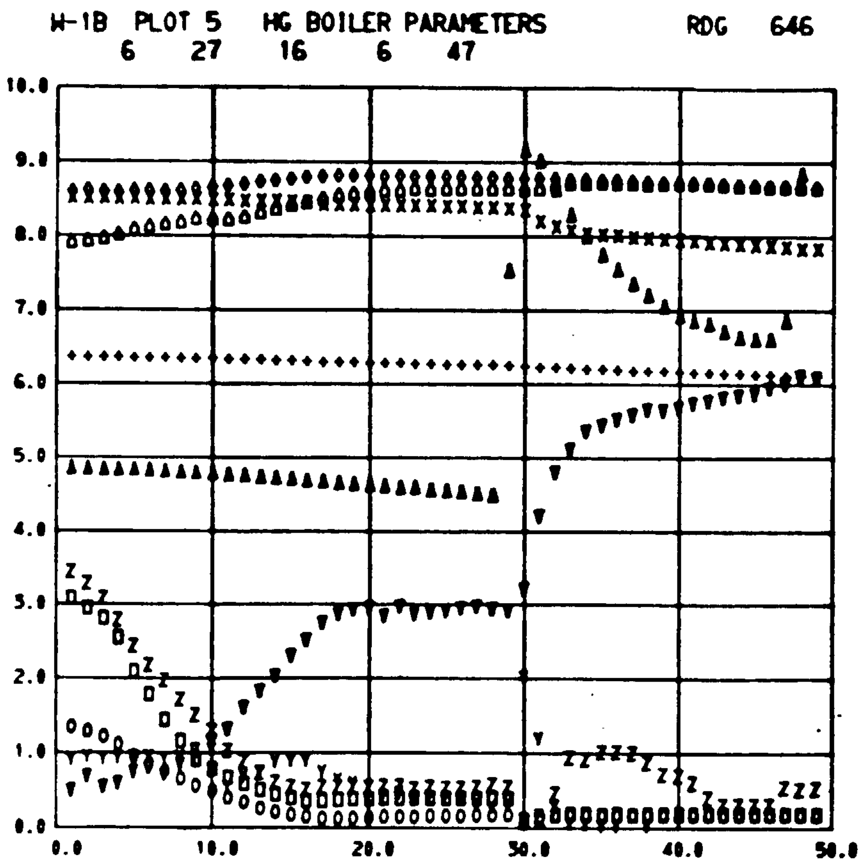
W-1B PLOT 4 HG PARAMETERS RDG 646
6 27 16 6 47

□	HG PMA SPEED	X	1000 RPM
O	HG PMA INLET PRESS	X	10 PSIA
Δ	HG PMA OUTLET PRESS	X	100 PSIA
+	HG PMA INLET TEMP	X	100 F
X	HG PMA OUTLET TEMP	X	150 F
◊	HG PMA ZERO G NPSH	X	5 FT
Δ	HG FCV POSITION	X	10 0/0

11.43 seconds between cycles

(d) Mercury loop parameters

Figure 8. Continued



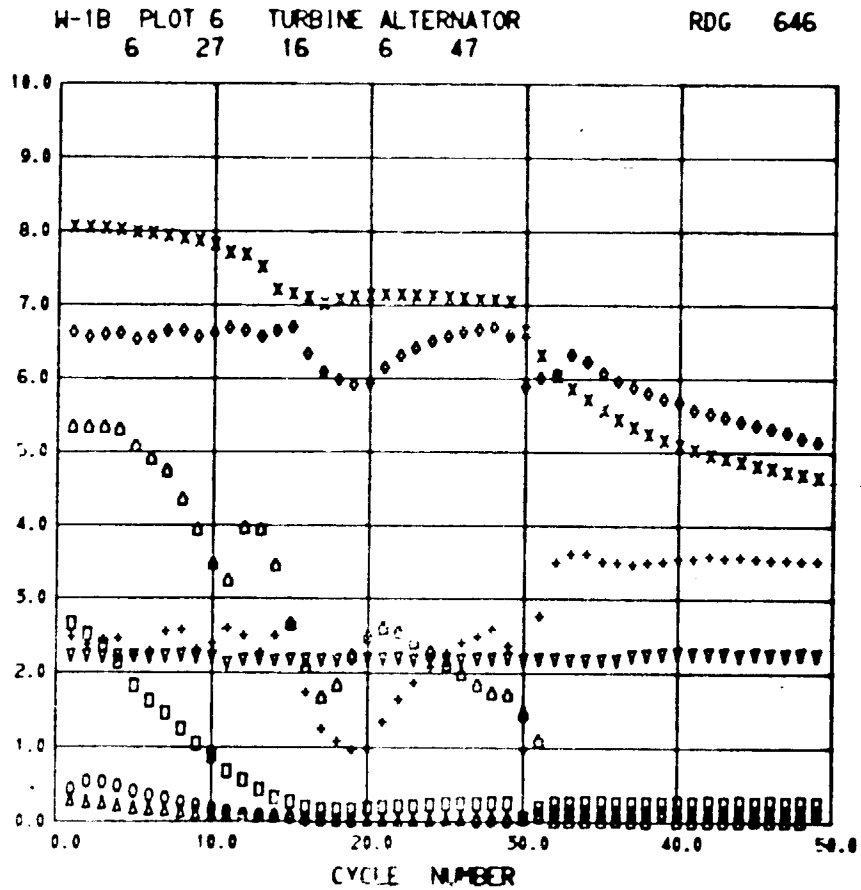
11.43 seconds between cycles

W-1B PLOT 5 HG BOILER PARAMETERS RDG 646
6 27 16 6 47

□	BOILER HG INLET PRESS	X	100 PSIA
O	BOILER HG OUTLET PRESS	X	100 PSIA
▲	BOILER HG INLET TEMP	X	50 F
+	BOILER HG OUT SKIN TEMP	X	200 F
X	BOILER HG OUT IMM TEMP	X	150 F
◆	BOILER NAK INLET TEMP	X	150 F
◊	BOILER NAK OUTLET TEMP	X	150 F
▼	BOILER TERM. TEMP DIFF.	X	20 F
Z	BOILER HG LIQUID FLOW	X	2000 LB/HR
Y	BOILER HT. BAL. QUALITY		

(e) Mercury boiler parameters

Figure 8. Continued



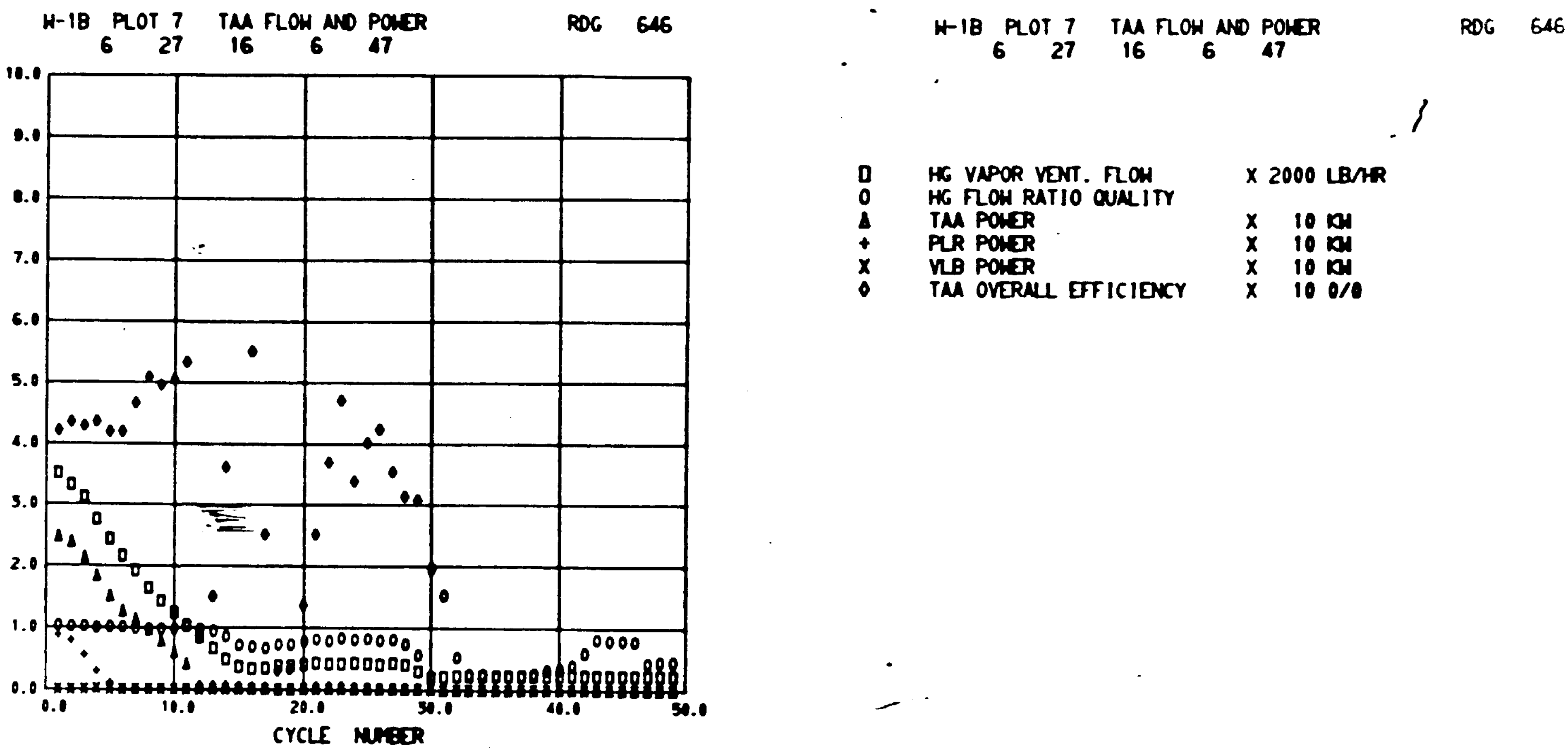
11.43 seconds between cycles

(f) Turbine alternator parameters

Figure 8. Continued

W-1B PLOT 6 TURBINE ALTERNATOR RDG 646
6 27 16 6 47

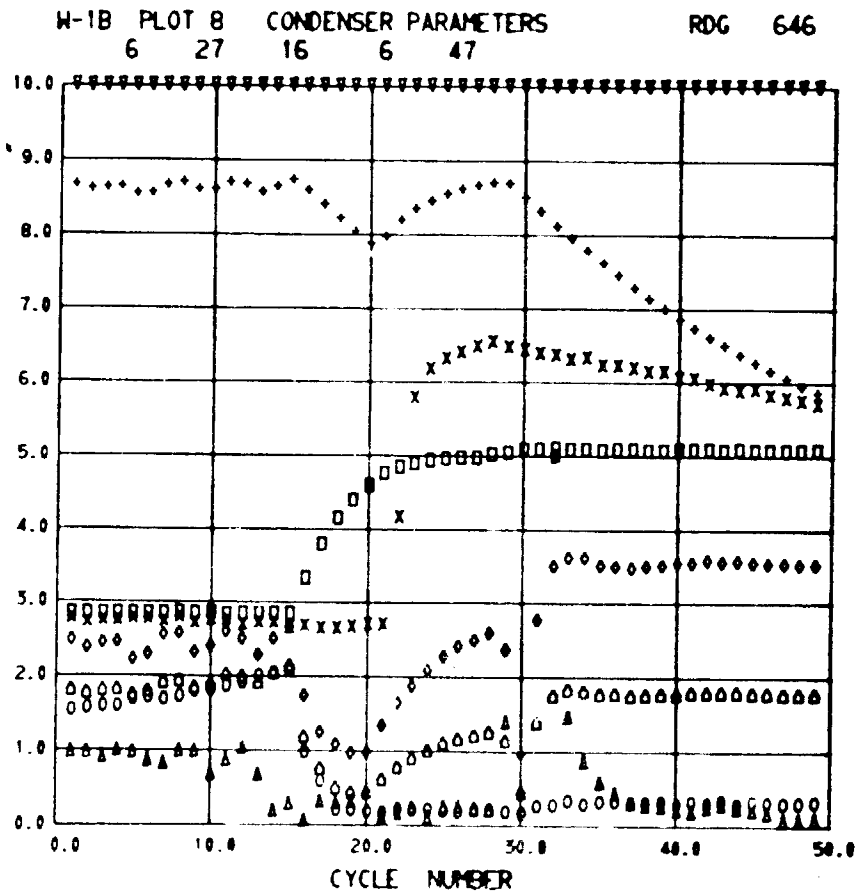
□	TURB. NOZZLE BOWL PRESS	X 50 PSIA
O	TURB. 1ST STAGE DISC. PRESS	X 100 PSIA
▲	TURB. 3RD STAGE IN PRESS	X 100 PSIA
+	COND. HG INLET PRESS	X 5 PSIA
X	TURB. NOZZLE BOWL TEMP	X 150 F
◆	TURB. EXHAUST TEMP	X 100 F
◇	TAA FREQUENCY	X 75 HZ
▼	BOGUE/MG SET FREQUENCY	X 100 HZ



11.43 seconds between cycles

(g) Turbine flow and power parameters

Figure 8. Continued



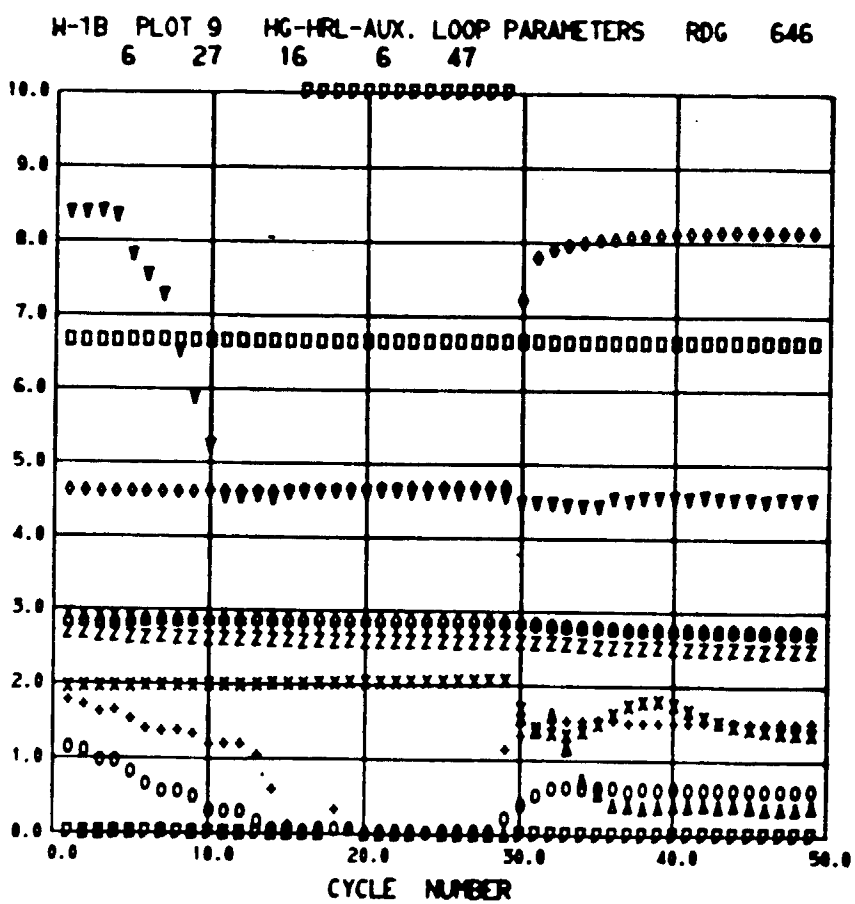
11.43 seconds between cycles

(h) Condenser parameters

Figure [illegible]. Continued

W-1B PLOT 8 CONDENSER PARAMETERS RDG 64ᶜ
6 27 16 6 47

□	HG STANDPIPE HEIGHT	X 25 LB
O	COND. HG INVENTORY	X 10 LB
Δ	COND. HG INLET QUALITY	
+	COND. HG INLET TEMP	X 75 F
X	COND. HG OUTLET TEMP	X 100 F
◊	COND. HG INLET PRESS	X 5 PSIA
◊	COND. HG OUTLET PRESS	X 10 PSIA
∇	COND. OUTLET V-210 POS.	X 10 0/0



11.43 secon[illegible] between cycles

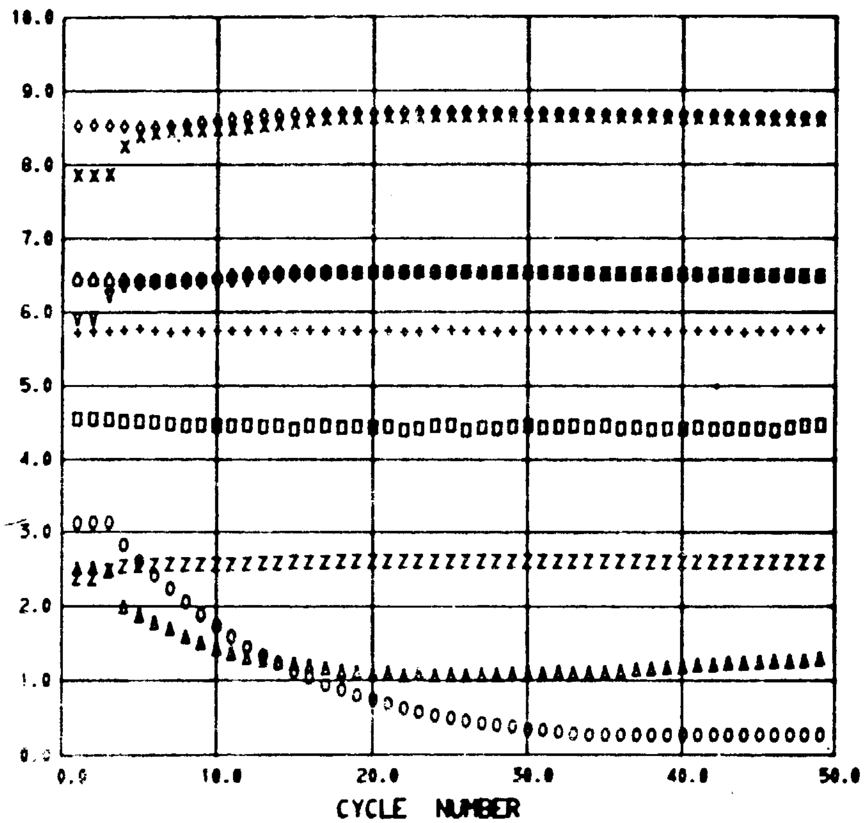
W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 646
6 27 16 6 47

D	HG V-206 POSITION	X	15 0/0
O	COND. NAK FLOW RATE	X	10000 LB/HR
Δ	AUX. LOOP FLOW RATE	X	1000 LB/HR
+	HRL V-314 POSITION	X	10 0/0
X	ASHE AUX. SIDE INLET TEMP	X	100 F
◊	ASHE AUX. SIDE OUTLET TEMP	X	150 F
Ô	HRL PMA INLET PRESS	X	10 PSIA
∇	HRL PMA OUTLET PRESS	X	10 PSIA
Z	RAD. NAK INLET PRESS	X	10 PSIA
Y	COND. NAK INLET PRESS	X	10 PSIA
D	HG STAND PIPE V-217 POS	X	10 0/0

(i) Mercury, Heat Rejection, and Auxiliary loop parameters

Figure 8. Concluded

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 640
6 27 13 21 47



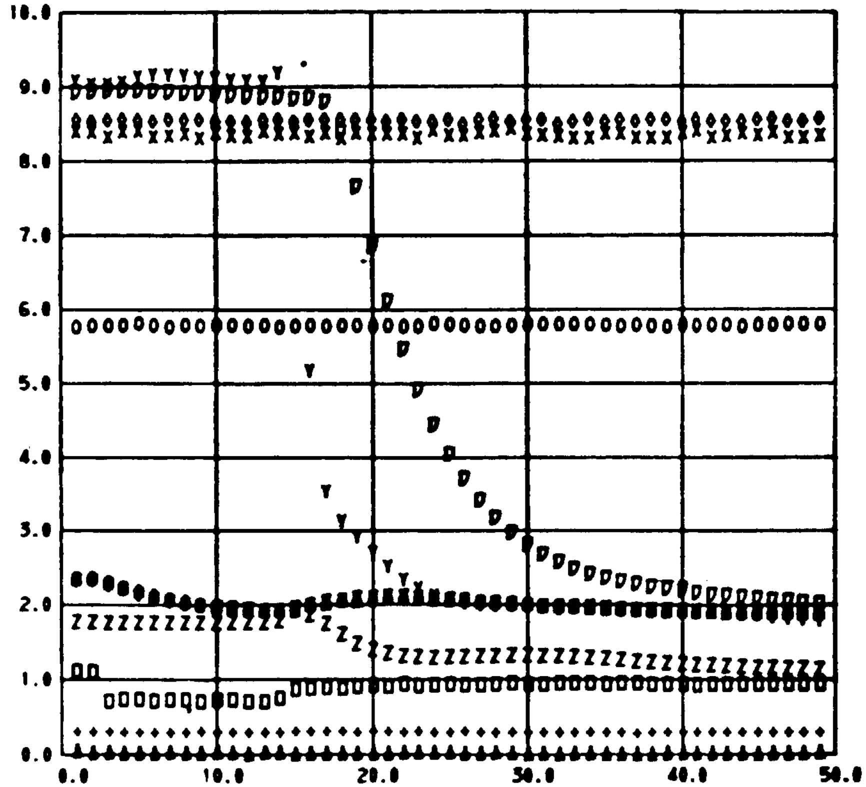
13.43 seconds between cycles

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 640
6 27 13 21 47

□	PRI NAK FLOW	X	10000 LB/HR
O	IGNITRON PWR	X	100 KW
▲	EXCESS REACT	X	10 -25 CENT
+	PNPMA SPEED	X	1000 RPM
X	HEATER INLET TEMP	X	150 F
◊	HTR OUTLET TEMP	X	150 F
Δ	BOILER INLET TEMP	X	200 F
▼	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

(a) Primary NaK loop parameters.

Figure 9. Emergency shutdown (Same as figure 4)



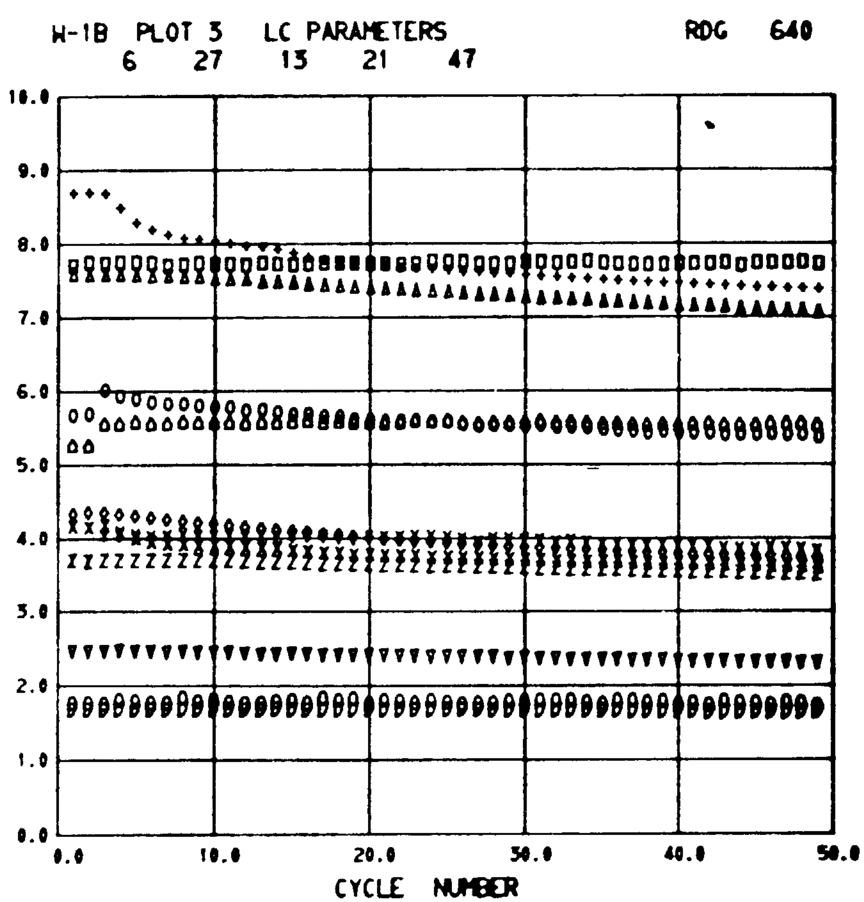
W-1B PLOT 2 HRL PARAMETERS RDG 640
6 27 13 21 47

□	HRL NAK FLOW	X	10000 LB/HR
O	HRLPMA SPEED	X	1000 RPM
▲	BV-10 POSITION	X	20 0/0
+	BV-12 POSITION	X	20 0/0
X	RAD-1 AIR INLET	X	10 F
◆	RAD-2 AIR INLET	X	10 F
Δ	RAD-1 AIR OUTLET	X	50 F
∇	RAD-2 AIR OUTLET	X	50 F
Z	COND. INLET TEMP	X	100 F
Y	COND. OUTLET TEMP	X	75 F
D	RAD. INLET TEMP	X	75 F

11.43 seconds between cycles

(b) Heat rejection loop parameters

Figure 9. Continued



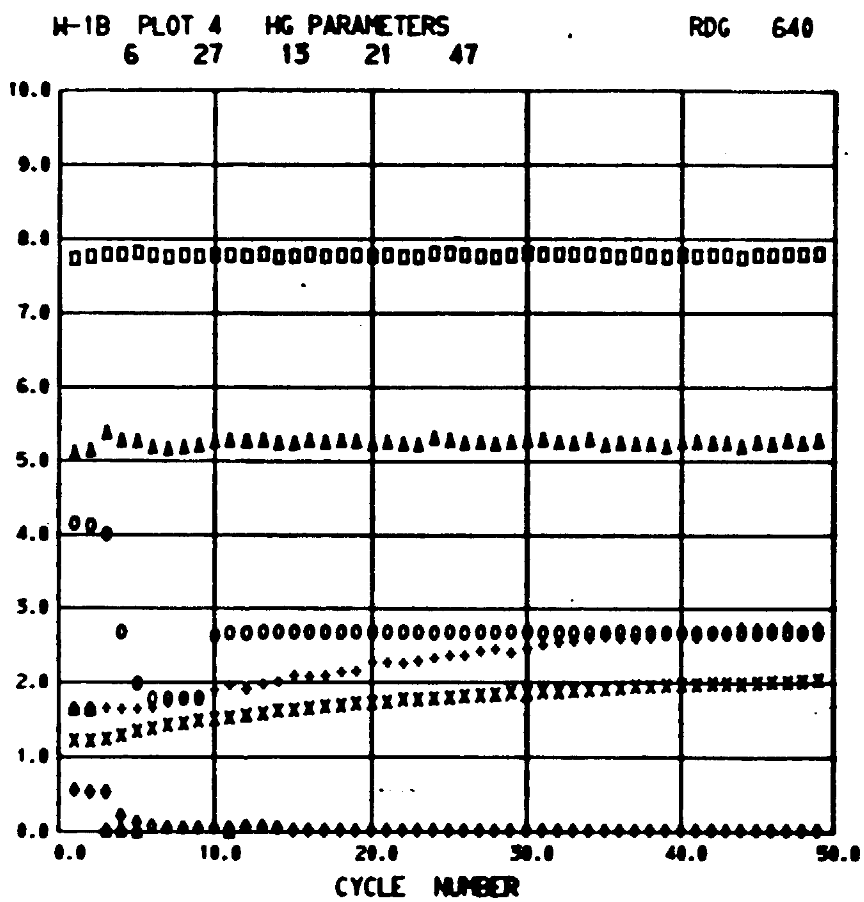
11.43 seconds between cycles

H-1B PLOT 3 LC PARAMETERS RDG 640
6 27 13 21 47

□	L/C PMA SPEED	X	1000 RPM
O	T.SSHE-A.HE FLOW	X	300 LB/HR
△	TURB. SSHE INLET TEMP	X	25 F
+	TURB. SSHE OUTLET TEMP	X	25 F
X	ALT. H.E. INLET TEMP	X	50 F
◇	ALT. H.E. OUTLET TEMP	X	50 F
△	HG PMA SSHE FLOW	X	350 LB/HR
▽	HG PMA SSHE INLET TEMP	X	75 F
Z	HG PMA SSHE OUTLET TEMP	X	50 F
Y	HG PMA MOTOR HE FLOW	X	30 LB/HR
D	HG PMA MHE INLET TEMP	X	100 F
Ω	HG PMA MHE OUTLET TEMP	X	100 F

(c) Lubricant coolant loop parameters

Figure 9. Continued



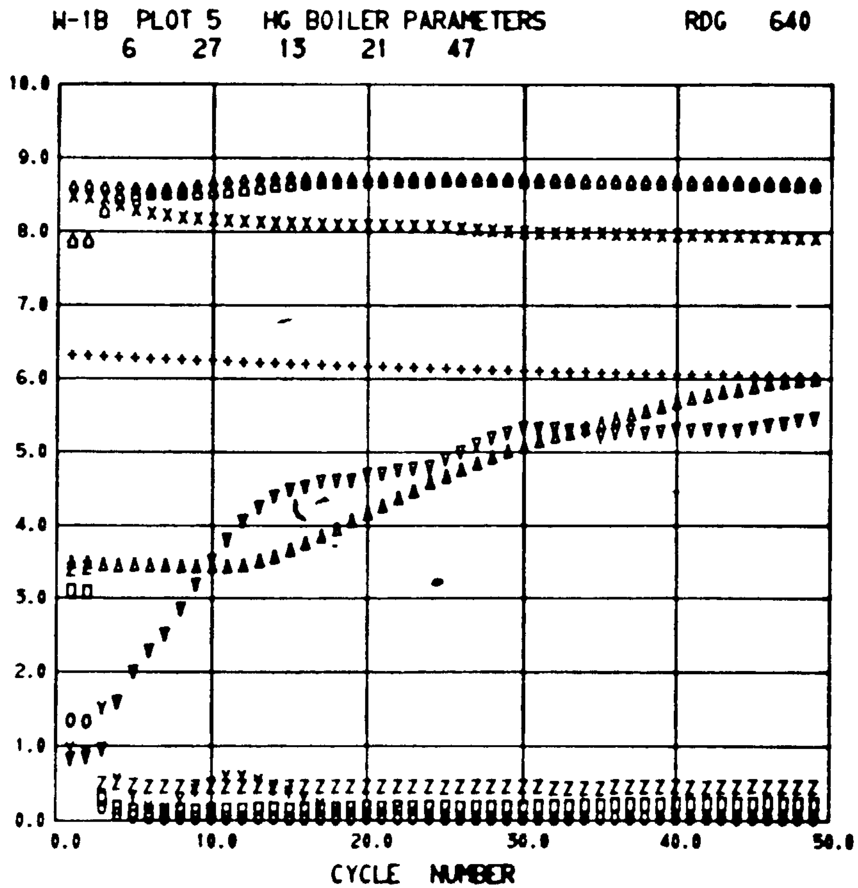
11.43 seconds between cycles

(d) Mercury loop parameters

Figure 9. Continued

W-1B PLOT 4 HG PARAMETERS RDG 640
6 27 13 21 47

□	HG PMA SPEED	X	1000 RPM
O	HG PMA INLET PRESS	X	10 PSIA
Δ	HG PMA OUTLET PRESS	X	100 PSIA
+	HG PMA INLET TEMP	X	100 F
X	HG PMA OUTLET TEMP	X	150 F
◊	HG PMA ZERO G NPSH	X	5 FT
Δ	HG FCV POSITION	X	10 0/0



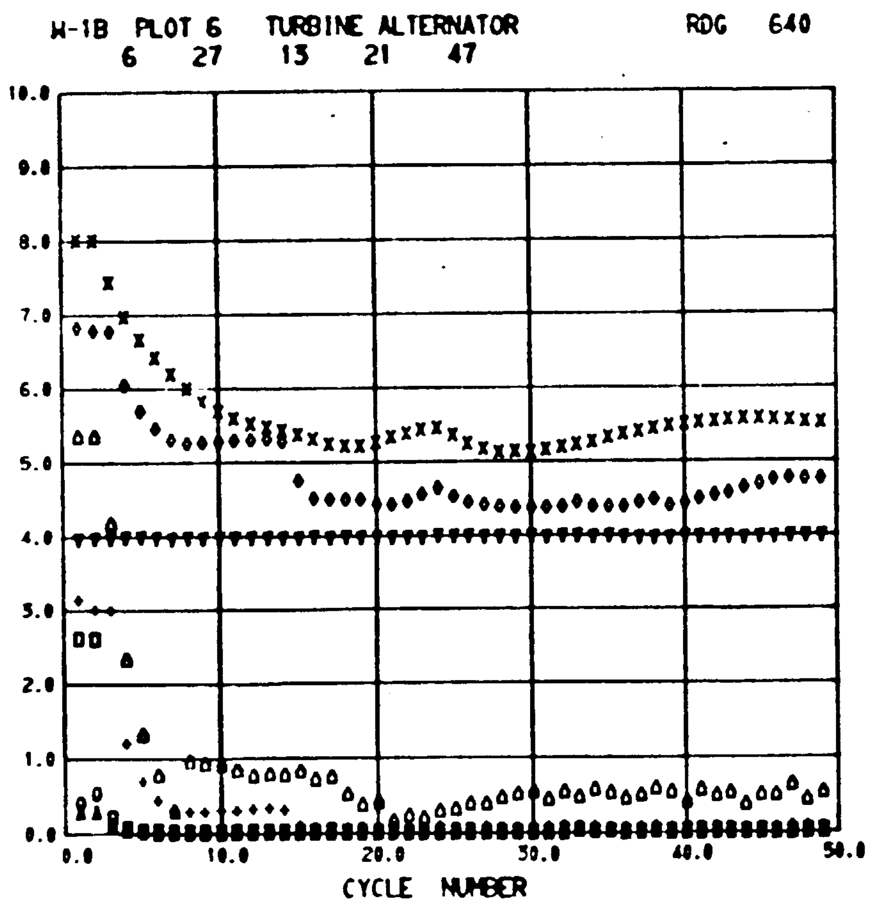
11.43 seconds between cycles

(e) Mercury boiler parameters

Figure 9. Continued

W-1B PLOT 5 HG BOILER PARAMETERS RDG 640
6 27 13 21 47

□	BOILER HG INLET PRESS	X	100 PSIA
O	BOILER HG OUTLET PRESS	X	100 PSIA
Δ	BOILER HG INLET TEMP	X	50 F
+	BOILER HG OUT SKIN TEMP	X	200 F
X	BOILER HG OUT IMM TEMP	X	150 F
◊	BOILER NAK INLET TEMP	X	150 F
Δ	BOILER NAK OUTLET TEMP	X	150 F
▽	BOILER TERM. TEMP DIFF.	X	20 F
Z	BOILER HG LIQUID FLOW	X	2000 LB/HR
Y	BOILER HT. BAL. QUALITY		



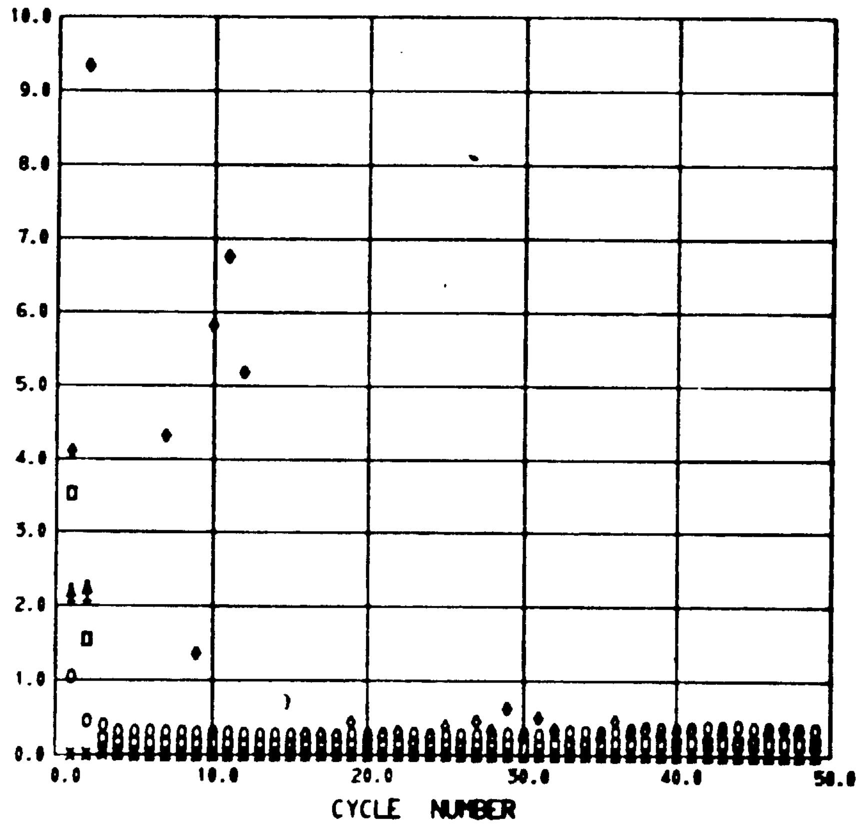
11.43 seconds between cycles

H-1B PLOT 6 TURBINE ALTERNATOR
6 27 13 21 47

□	TURB. NOZZLE BOWL PRESS	X 50 PSIA
O	TURB. 1ST STAGE DISC. PRESS	X 100 PSIA
Δ	TURB. 3RD STAGE IN PRESS	X 100 PSIA
+	COND. HG INLET PRESS	X 5 PSIA
X	TURB. NOZZLE BOWL TEMP	X 150 F
◊	TURB. EXHAUST TEMP	X 100 F
◊	TAA FREQUENCY	X 75 HZ
∇	DOGUE/MG SET FREQUENCY	X 100 HZ

(f) Turbine alternator parameters

Figure 9. Continued



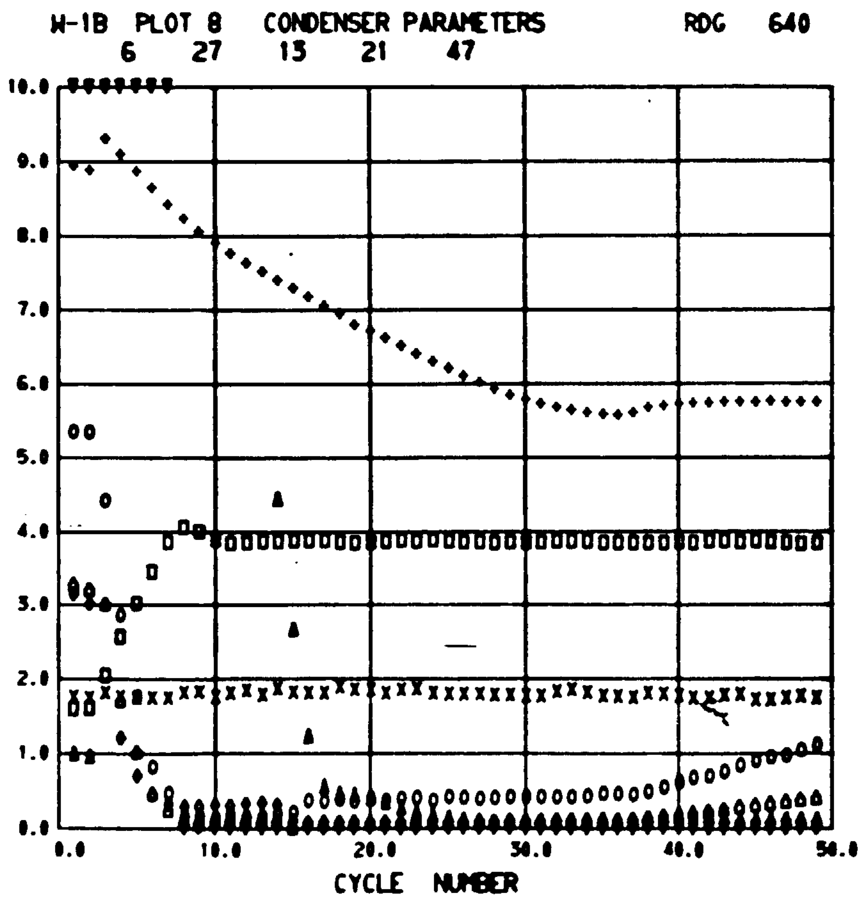
11.43 seconds between cycles

W-1B PLOT 7 TAA FLOW AND POWER RDG 640
6 27 13 21 47

□	HG VAPOR VENT. FLOW	X 2000 LB/HR
O	HG FLOW RATIO QUALITY	
▲	TAA POWER	X 10 KW
+	PLR POWER	X 10 KW
X	VLB POWER	X 10 KW
◆	TAA OVERALL EFFICIENCY	X 10 0/0

(g) Turbine flow and power parameters

Figure 9. Continued



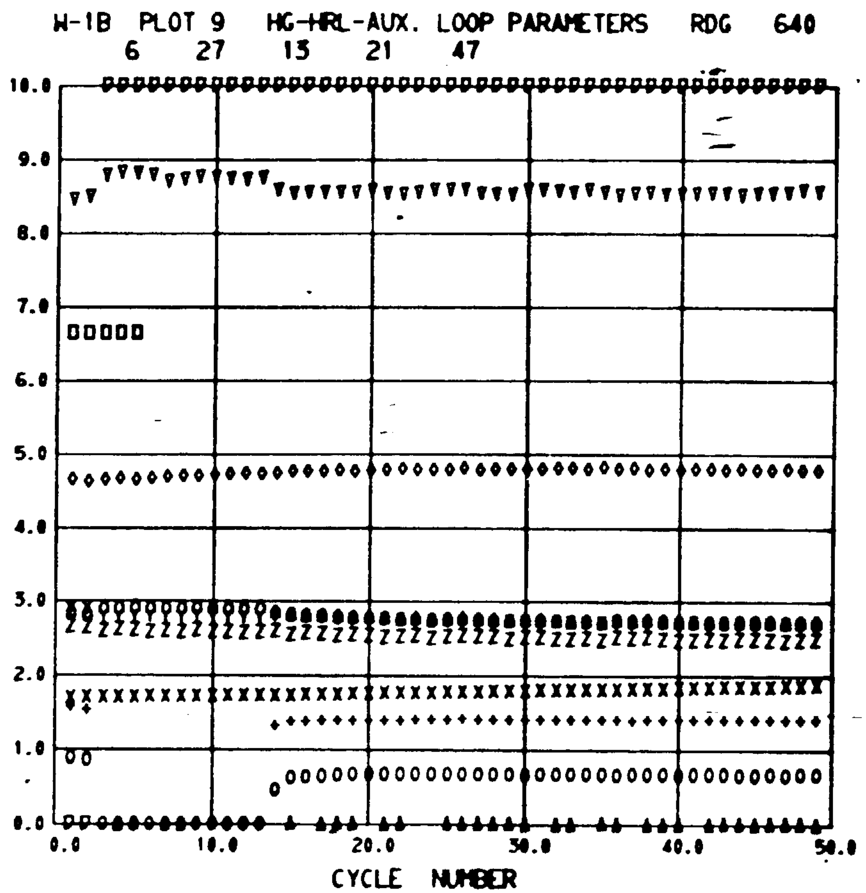
11.43 seconds between cycles

W-1B PLOT 8 CONDENSER PARAMETERS RDG 64?
6 27 13 21 47

□	HG STANDPIPE WEIGHT	X 25 LB
O	COND. HG INVENTORY	X 10 LB
▲	COND. HG INLET QUALITY	
+	COND. HG INLET TEMP	X 75 F
X	COND. HG OUTLET TEMP	X 100 F
◆	COND. HG INLET PRESS	X 5 PSIA
△	COND. HG OUTLET PRESS	X 10 PSIA
▼	COND. OUTLET V-210 POS.	X 10 0/0

(h) Condenser parameters

Figure 9. Continued



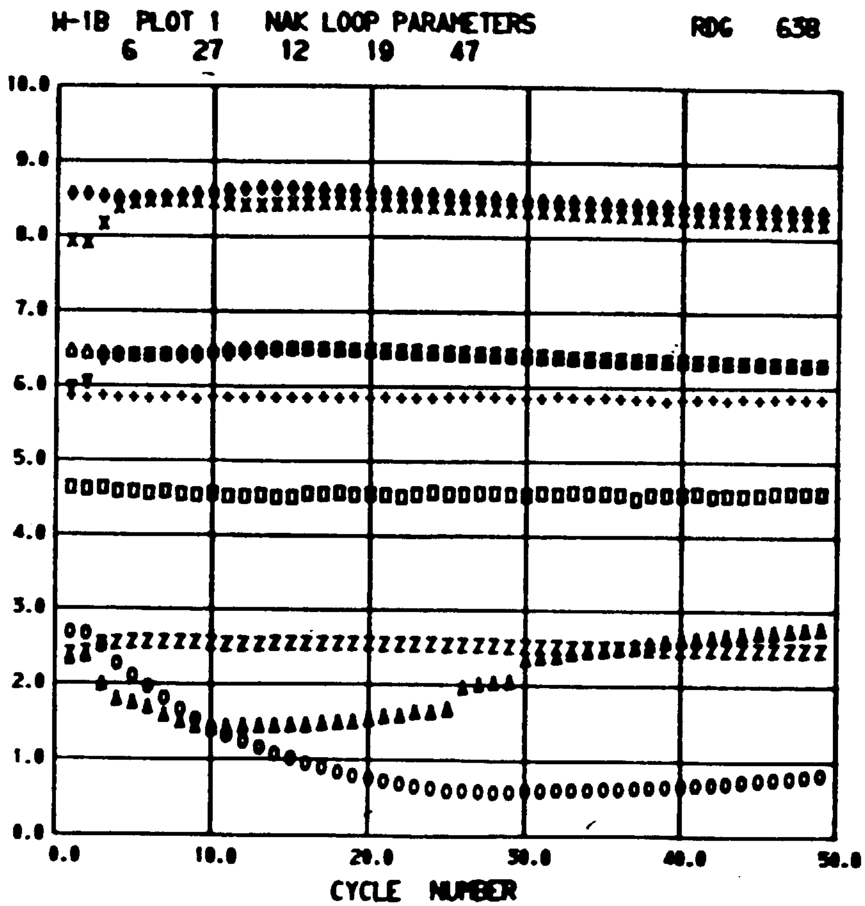
W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 640
6 27 13 21 47

Symbol	Parameter		Scale
□	HG V-206 POSITION	X	15 0/0
O	COND. NAK FLOW RATE	X	10000 LB/HR
Δ	AUX. LOOP FLOW RATE	X	1000 LB/HR
+	HRL V-314 POSITION	X	10 0/0
X	ASHE AUX. SIDE INLET TEMP	X	100 F
◊	ASHE AUX. SIDE OUTLET TEMP	X	150 F
Δ	HRL PMA INLET PRESS	X	10 PSIA
∇	HRL PMA OUTLET PRESS	X	10 PSIA
Z	RAD. NAK INLET PRESS	X	10 PSIA
Y	COND. NAK INLET PRESS	X	10 PSIA
D	HG STAND PIPE V-217 POS	X	10 0/0

11.43 seconds between cycles

(i) Mercury, Heat Rejection, and Auxiliary loop parameters

Figure 9. Concluded



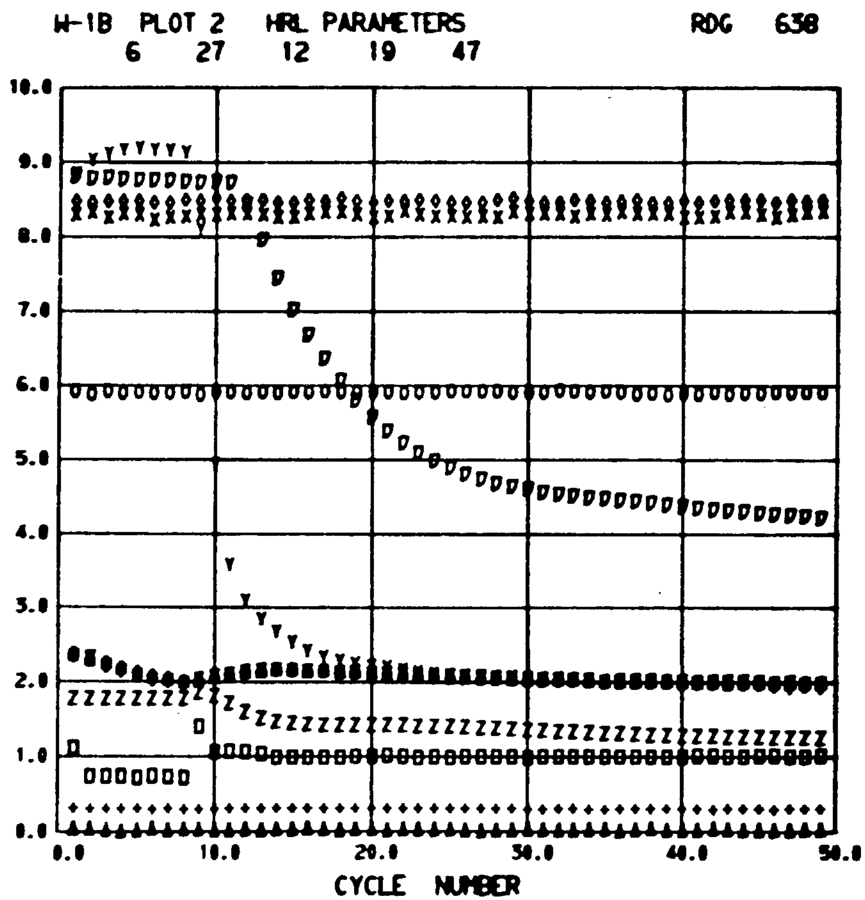
11.43 seconds between cycles

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 638
6 27 12 19 47

□	PRI NAK FLOW	X	10000 LB/HR
O	IGNITRON PWR	X	100 KW
▲	EXCESS REACT	X	10 -25 CENT
+	PNPMA SPEED	X	1000 RPM
X	HEATER INLET TEMP	X	150 F
◊	HTR OUTLET TEMP	X	150 F
Δ	BOILER INLET TEMP	X	200 F
∇	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

(a) Primary NaK loop parameters.

Figure 10. Emergency shutdown



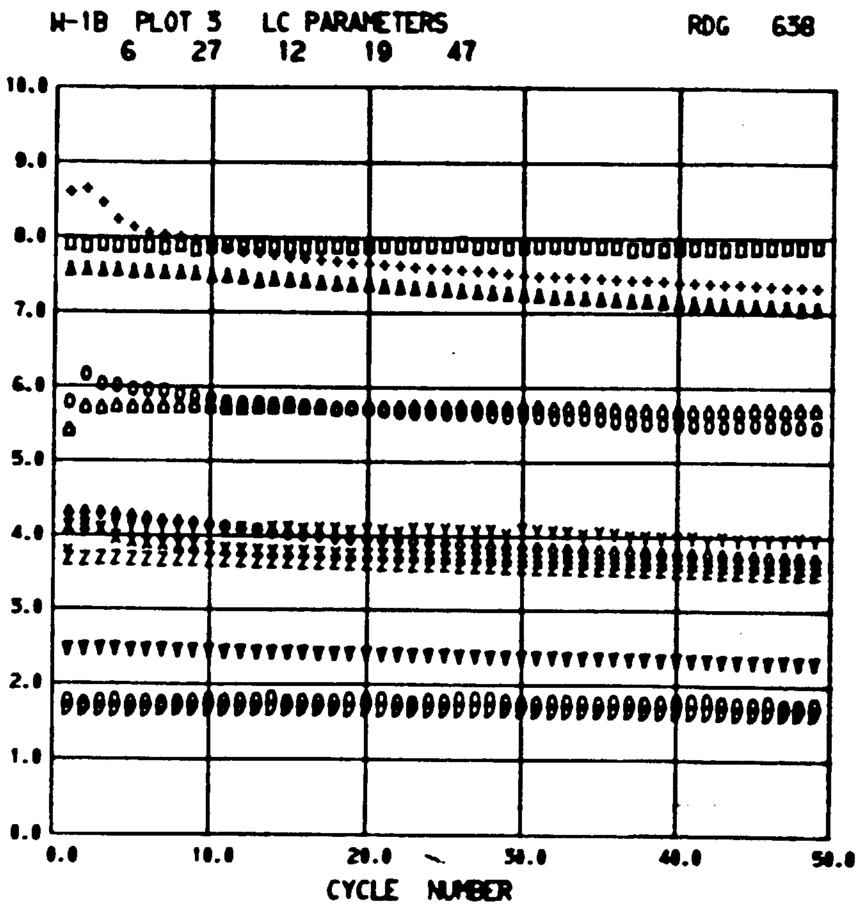
11.43 seconds between cycles

(b) Heat rejection loop parameters

W-1B PLOT 2 HRL PARAMETERS RDG 638
6 27 12 19 47

□	HRL NAK FLOW	X	10000 LB/HR
O	HRLPMA SPEED	X	1000 RPM
Δ	BV-10 POSITION	X	20 0/0
+	BV-12 POSITION	X	20 0/0
X	RAD-1 AIR INLET	X	10 F
◊	RAD-2 AIR INLET	X	10 F
Δ	RAD-1 AIR OUTLET	X	50 F
∇	RAD-2 AIR OUTLET	X	50 F
Z	COND. INLET TEMP	X	100 F
Y	COND. OUTLET TEMP	X	75 F
D	RAD. INLET TEMP	X	75 F

Figure 10. Continued



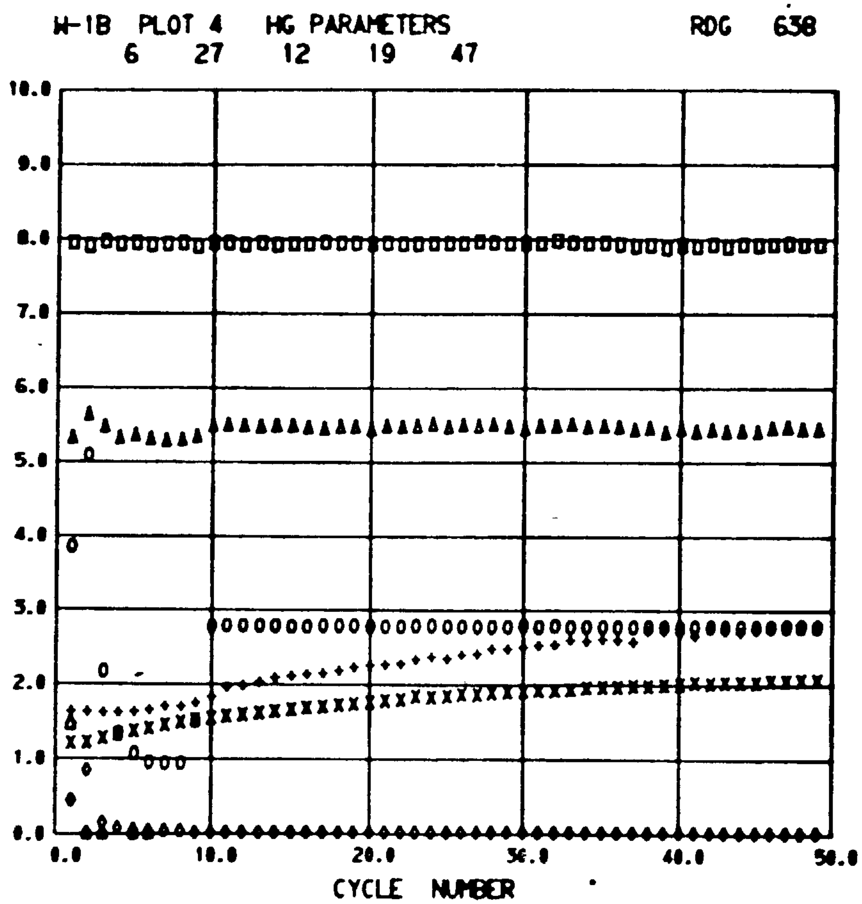
11.43 seconds between cycles

W-1B PLOT 3 LC PARAMETERS RDG 638
6 27 12 19 47

□	L/C PMA SPEED	X	1000 RPM
O	T.SSHE-A.HE FLOW	X	300 LB/HR
▲	TURB. SSHE INLET TEMP	X	25 F
+	TURB. SSHE OUTLET TEMP	X	25 F
X	ALT. H.E. INLET TEMP	X	50 F
◊	ALT. H.E. OUTLET TEMP	X	50 F
Δ	HG PMA SSHE FLOW	X	350 LB/HR
▼	HG PMA SSHE INLET TEMP	X	75 F
Z	HG PMA SSHE OUTLET TEMP	X	50 F
Y	HG PMA MOTOR HE FLOW	X	30 LB/HR
D	HG PMA MHE INLET TEMP	X	100 F
D	HG PMA MHE OUTLET TEMP	X	100 F

(c) Lubricant coolant loop parameters

Figure 10. Continued



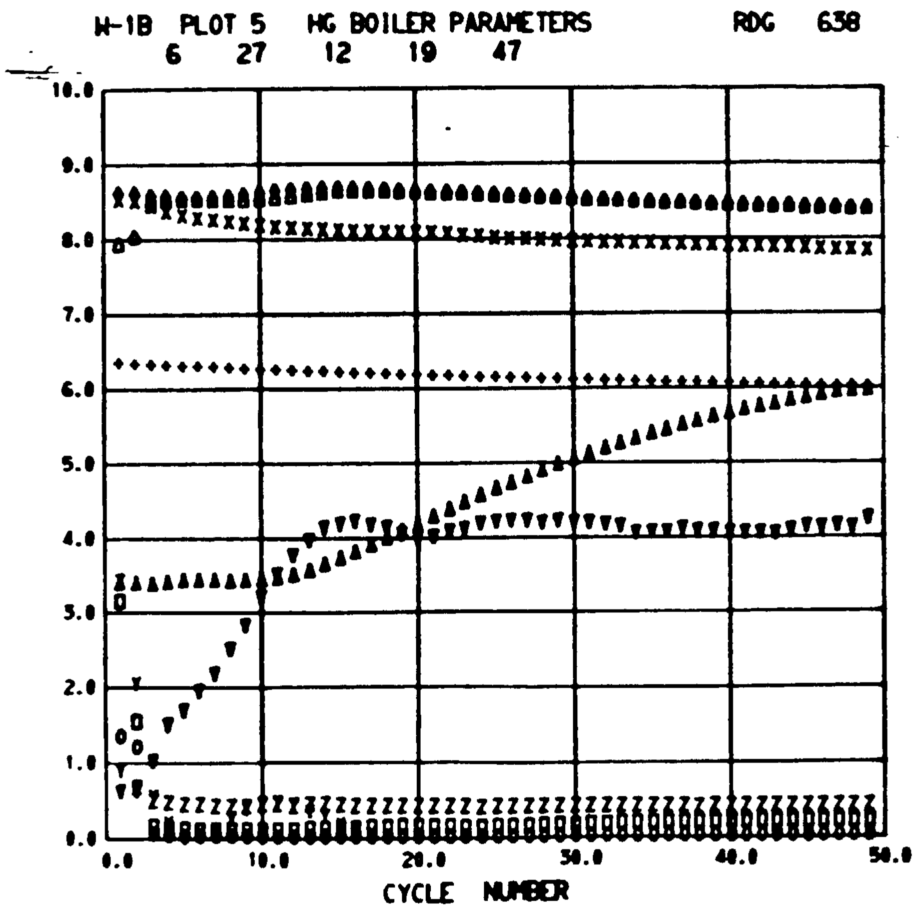
11.43 seconds between cycles

W-1B PLOT 4 HG PARAMETERS RDG 636
6 27 12 19 47

Symbol	Parameter		Scale
□	HG PMA SPEED	X	1000 RPM
O	HG PMA INLET PRESS	X	10 PSIA
▲	HG PMA OUTLET PRESS	X	100 PSIA
+	HG PMA INLET TEMP	X	100 F
X	HG PMA OUTLET TEMP	X	150 F
◊	HG PMA ZERO G NPSH	X	5 FT
Δ	HG FCV POSITION	X	10 O/O

(d) Mercury loop parameters

Figure 10. Continued



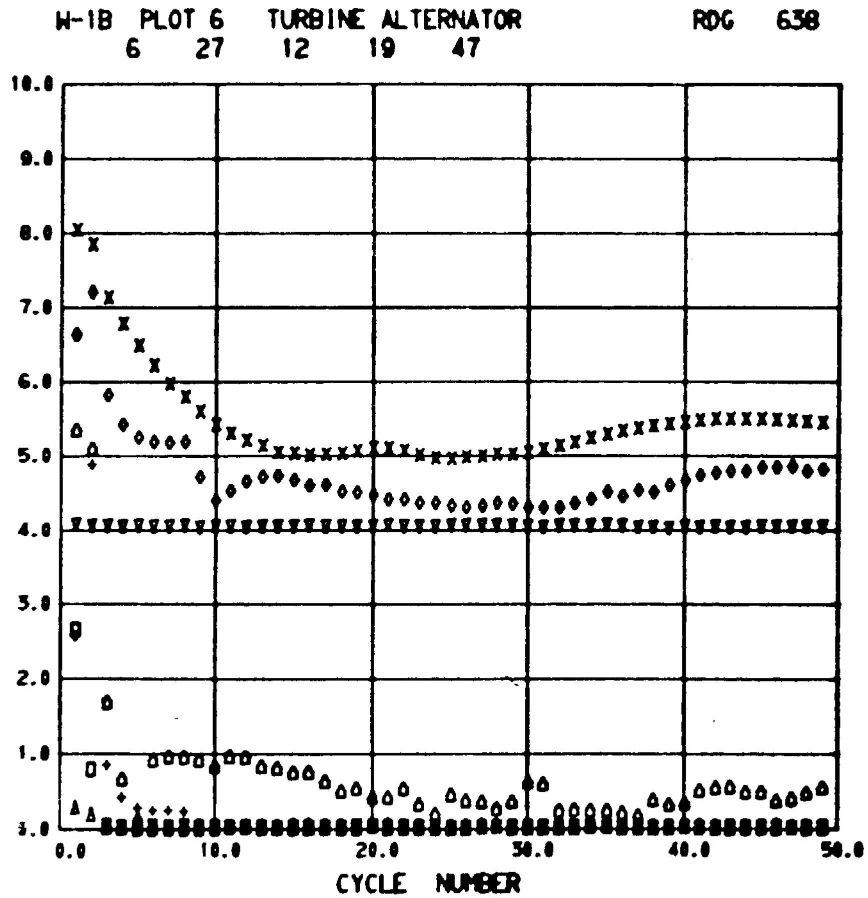
11.43 seconds between cycles

W-1B PLOT 5 HG BOILER PARAMETERS RDG 638
6 27 12 19 47

□	BOILER HG INLET PRESS	X	100	PSIA
O	BOILER HG OUTLET PRESS	X	100	PSIA
Δ	BOILER HG INLET TEMP	X	50	F
+	BOILER HG OUT SKIN TEMP	X	200	F
X	BOILER HG OUT IMM TEMP	X	150	F
◊	BOILER NAK INLET TEMP	X	150	F
Δ	BOILER NAK OUTLET TEMP	X	150	F
∇	BOILER TERM. TEMP DIFF.	X	20	F
Z	BOILER HG LIQUID FLOW	X	2000	LB/HR
Y	BOILER HT. BAL. QUALITY			

(e) Mercury boiler parameters

Figure 10. Continued



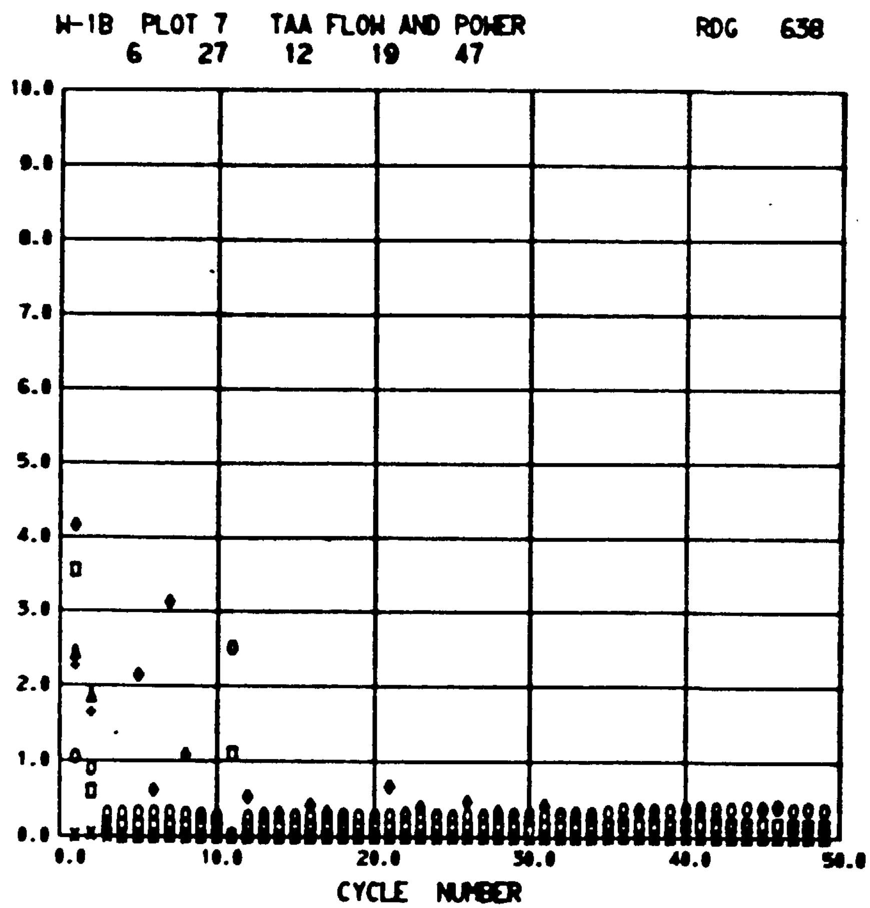
11.43 seconds between cycles

W-1B PLOT 6 TURBINE ALTERNATOR RDG 638
6 27 12 19 47

□	TURB. NOZZLE BOWL PRESS	X 50 PSIA
O	TURB. 1ST STAGE DISC. PRESS	X 100 PSIA
Δ	TURB. 3RD STAGE IN PRESS	X 100 PSIA
+	COND. HG INLET PRESS	X 5 PSIA
X	TURB. NOZZLE BOWL TEMP	X 150 F
◊	TURB. EXHAUST TEMP	X 100 F
Δ	TAA FREQUENCY	X 75 HZ
∇	BOGUE/MG SET FREQUENCY	X 100 HZ

(f) Turbine alternator parameters

Figure 10. Continued



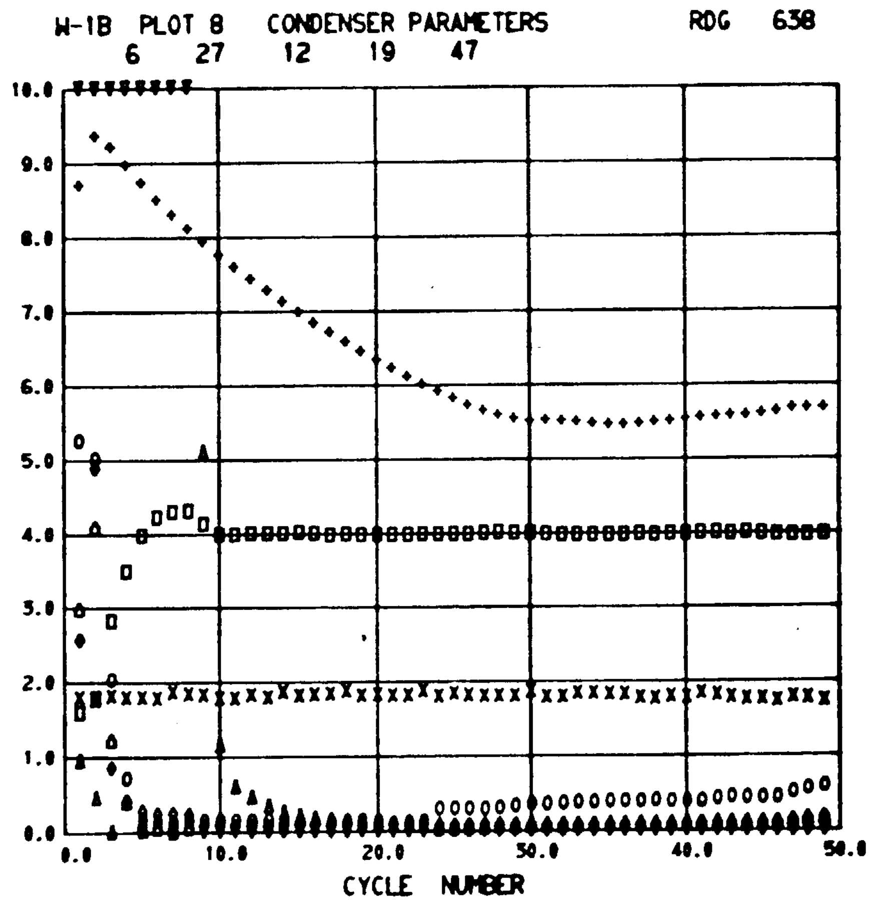
11.43 seconds between cycles

W-1B PLOT 7 TAA FLOW AND POWER RDG 638
6 27 12 19 47

□	HG VAPOR VENT. FLOW	X 2000 LB/HR
O	HG FLOW RATIO QUALITY	
Δ	TAA POWER	X 10 KW
+	PLR POWER	X 10 KW
X	VLB POWER	X 10 KW
◊	TAA OVERALL EFFICIENCY	X 10 0/0

(g) Turbine flow and power parameters

Figure 10. Continued



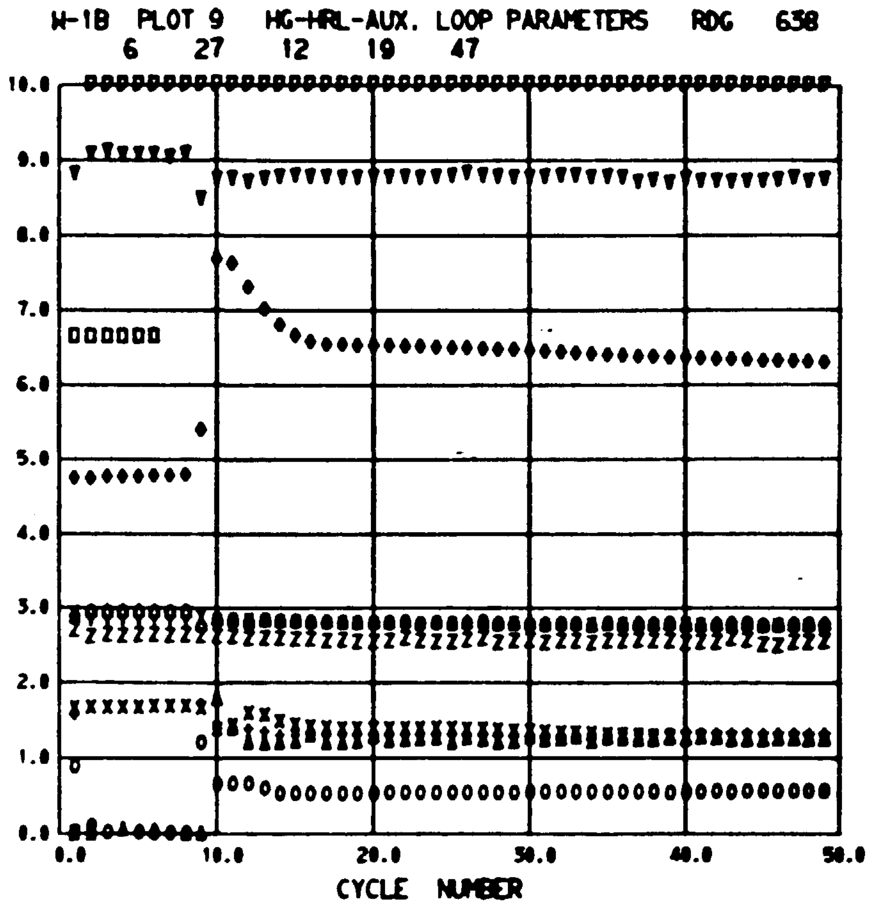
11.43 seconds between cycles

W-1B PLOT 8 CONDENSER PARAMETERS RDG 638
6 27 12 19 47

□	HG STANDPIPE WEIGHT	X 25 LB
O	COND. HG INVENTORY	X 10 LB
Δ	COND. HG INLET QUALITY	
+	COND. HG INLET TEMP	X 75 F
X	COND. HG OUTLET TEMP	X 100 F
◊	COND. HG INLET PRESS	X 5 PSIA
⌂	COND. HG OUTLET PRESS	X 10 PSIA
∇	COND. OUTLET V-210 POS.	X 10 0/0

(h) Condenser parameters

Figure 10. Continued



11.43 seconds between cycles

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 638
6 27 12 19 47

□	HG V-206 POSITION	X	15 0/0
O	COND. NAK FLOW RATE	X	10000 LB/HR
▲	AUX. LOOP FLOW RATE	X	1000 LB/HR
+	HRL V-314 POSITION	X	10 0/0
X	ASHE AUX. SIDE INLET TEMP	X	100 F
◆	ASHE AUX. SIDE OUTLET TEMP	X	150 F
Δ	HRL PMA INLET PRESS	X	10 PSIA
▼	HRL PMA OUTLET PRESS	X	10 PSIA
Z	RAD. NAK INLET PRESS	X	10 PSIA
Y	COND. NAK INLET PRESS	X	10 PSIA
D	HG STAND PIPE V-217 POS	X	10 0/0

(i) Mercury, Heat Rejection, and Auxiliary loop parameters

Figure 10. Concluded