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INVESTIGATION OF MERCURY-FLOW RAMP RATES FOR STARTUP OF THE SNAP-8 SYSTEM

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This information is being published in preliminary form in order to expedite its early release.

ABSTRACT

A critical parameter in the startup of the SNAP-8 system is the rate at which the mercury flow is brought up to the level required to make the system self-sustaining. Startup tests were conducted in which the duration of the flow ramp from 0 to 6600 pounds mass per hour (3000 kg/hr) was varied from 30 to 145 seconds. It was concluded that for the flight-type system a 100-second ramp was a good compromise between a ramp that was too short, precluding use of open-loop flow control, and a ramp that was too long, causing marginal acceleration of the turboalternator.

E-5324

INVESTIGATION OF MERCURY-FLOW RAMP

RATES FOR STARTUP OF THE SNAP-8 SYSTEM

by Roy A. Lottig and Ronald H. Soeder

Lewis Research Center

SUMMARY

The development of the SNAP-8 power system prompted an investigation to determine the best startup and shutdown modes for the system. The investigation included 135 startup transient tests conducted in the SNAP-8 test facility at the Lewis Research Center. One of the critical parameters for system startup is the rate of the initial mercury-flow ramp. The initial mercury-flow ramp is from 0 to 6600 pounds mass per hour (3000 kg/hr). At this flow level the system becomes self-sustaining. This means that the turbine-alternator assembly provides sufficient electrical power to drive the four system pumps plus enough excess power to insure proper turbine speed control. During the startup testing the time duration of this initial flow ramp was varied from 30 to 145 seconds.

It was concluded that a 100-second ramp resulted in a good compromise between a ramp that was too short, which would prohibit use of open-loop flow control, and a ramp that was too long, causing marginal acceleration of the turboalternator.

INTRODUCTION

SNAP-8 is a nuclear-Rankine-cycle power system presently under development to produce electrical power for space applications. The basic system will produce 35 kilowatts of usable electricity and utilize a nuclear reactor as the system energy source. Liquid metals are used in the heating loop, power loop, and heat rejection loop. The primary (heating) and heat rejection loop fluid is an eutectic mixture of sodium and potassium (NaK-78), whereas the power loop uses mercury as the working fluid. A loop to cool and lubricate rotating components in the three main loops uses polyphenol ether. Descriptions of SNAP-8 system and component performance are given in references 1 to 8.

In order to evaluate the startup mode for SNAP-8, a sequence of 135 tests was conducted in the SNAP-8 test facility at NASA's Lewis Research Center in Cleveland, Ohio. A breadboard SNAP-8 system using SNAP-8 flight-type components with the exception of a nuclear reactor, space radiator, mercury injection system and valves was tested in this facility.

One important startup parameter investigated during these transient tests was the initial mercury-flow ramp rate. The startup of the mercury loop requires an initial flow increase from 0 to 6600 pounds mass per hour (3000 kg/hr). At 6600 pounds mass per hour (3000 kg/hr) the turbine-alternator assembly reaches a power level sufficient to sustain the system. This means that the power is sufficient to operate all the pumps on alternator power and to provide for turbine speed control. After the principle transients resulting from this initial ramp have settled out, the system is brought to its rated power by slowly increasing the mercury flow to 12,300 pounds mass per hour (5500 kg/hr).

This report presents the results of the startup tests that were made to determine the most satisfactory rate for the initial mercury-flow ramp. The flow ramps investigated were from 30 to 145 seconds in duration. The startups included tests where the primary, heat-rejection, mercury and lubrication pumps were all simultaneously transferred from auxiliary power to alternator power as the alternator accelerated up to 400 cycles per second. Startups where only the mercury pump was transferred from auxiliary power to alternator power were also investigated. The frequency at which the pumps were transferred to alternator power was varied from 220 to 300 cycles per second. This pump transfer is known as "bootstrapping." A description of the effect of "bootstrap" frequency on mercury loop startup is discussed in reference 9.

A list of symbols used throughout the report and in the digital data plots is found in Appendix A.

SNAP-8 TEST SYSTEM

The three main loops of the SNAP-8 test system are shown in figure 1. The primary loop contained a pump-motor assembly, an electric heater, electromagnetic flow meter, a tube-in-tube boiler and an auxiliary start heat exchanger. The electric heater, ignitron power controller and analog computer simulated the operation of a nuclear reactor (ref. 8). The auxiliary start heat exchanger was used to transfer the simulated reactor heat to the heat rejection loop prior to startup of the mercury system. Primary loop flow rate variation was achieved by changing the position of valve (V-115) at the pump outlet.

The power loop (mercury loop) used AISI type 316 stainless steel for all piping from the boiler outlet to the condenser inlet and for all three venturi meters. AISI type 304 stainless steel was used for the remaining loop piping. Mercury flowed through the mercury pump-motor assembly, a gas operated valve (V-247), an electro-hydraulic flow-control valve (V-230) actuated by an analog computer signal and a hydraulic backup valve (V-206). It then flowed through a venturi meter, a gas operated valve (V-260) upstream of the boiler inlet and through the boiler. The vapor then flowed through the turbine into the condenser where it was condensed and subcooled. The mercury then passed through a gas operated valve (V-210), a venturi meter and V-207, a gas operated valve at the mercury pump inlet. Valve V-217 was a gas operated valve in a line connecting the mercury standpipe with the power loop. V-204 is a variable position gas controlled valve in the mercury bypass line. The following valves in the mercury loop were used in a fully open or closed position: V-207, V-247, V-260, V-210 and V-217.

The feedback control circuit, shown schematically in figure 2, was used for automatic control of the electro-hydraulic flow control valve (V-230). The control circuit utilized a combination of open loop and integral and proportional control. The electronic start programmer in figure 2 was used for the last 27 mercury loop startups. Its function in connection with the feedback circuit was to initiate both feedback control and mercury flow ramp. These programmer functions were performed manually during the first 108 startups.

The heat rejection loop consisted of a pump-motor assembly, a condenser, venturi meter, two finned NaK-to-air multi-tube heat exchangers and two electromagnetic flow meters. Butterfly valves controlled by an analog computer signal varied the air flow to the NaK-to-air heat exchangers, to simulate operation of a space radiator. The pressure at the mercury inlet side of the condenser was controlled by varying third loop flow. Condenser mercury inlet pressure was sensed and converted into a command signal to actuate valve V-314, at the pump outlet, and control heat rejection loop flow.

Both NaK loops contained an expansion tank to serve as a reservoir for a change in volume of the NaK fluid due to temperature variations and to maintain sufficient pressure at the inlet of the pumps. The mercury and NaK fill lines were valved off during system operation. An oxide control system, common to both NaK loops was used to precipitate out oxides from the NaK fluid since increased oxide concentration causes plugging of system valves and piping. A lubricant-coolant loop containing polyphenol ether (4P3E) was used to lubricate the turbine-alternator assembly and mercury pump-motor assembly bearings. It was also used to cool the remaining pumps and certain parts of the turbine-alternator assembly and mercury pump-motor assembly. Vacuum, argon, and nitrogen systems were also used for proper operation of the three main loops.

INSTRUMENTATION

A discussion of instrumentation used in the SNAP-8 test facility is found in references 1 and 10. A description of the instrumentation for the principle variables used in this report follows. Mercury liquid flow was obtained by measuring the pressure differential across a calibrated venturi meter upstream of the boiler inlet (fig. 1). The liquid mercury flow was determined from the differential pressure with the analog computer and recorded on a strip-chart recorder (fig. 2). The differential pressure transducer was of the slack diaphragm and capillary tube type. The pressure differential across two separate diaphragms was transmitted, by means of NaK filled capillary tubes, to a third diaphragm. The third diaphragm was part of an air-operated force-balance system. The resulting output of this system was a 3 to 15 pounds per square inch (21 to 104 kn/m^2) air output signal proportional to the pressure difference across the third diaphragm. The 3 to 15 pounds per square inch (21 to 104 kn/m^2) air output signal was fed to a remote unit to operate a servomotor. The servomotor in turn, positioned the shaft of a potentiometer having a known voltage across it. The electrical resistance of the potentiometer would change proportionately to the pneumatic input. Thus, the electrical output voltage was directly proportional to the pressure differential across the venturi meter. The differential pressure transducer was adjusted and calibrated over a 0 to 20 pounds per square inch (0 to 138 kn/m^2) range. The accuracy of the differential pressure reading was 1 percent of 20 pounds per square inch (138 kn/m^2).

The mercury flow control valve (V-230) position was acquired by using a linear potentiometer. The potentiometer was attached to the valve body and its stem in such a manner that valve movement was directly proportional to electrical resistance change of the potentiometer. A power supply and signal conditioner in the control room was connected to the potentiometer by shielded cables. The power supply was adjusted to give the desired output voltage for valve positions of 0 percent and 100 percent open. A calibration circuit also allowed a frequent check of the power supply. Thus, the valve position was directly proportional to the electrical output voltage.

The mercury boiler inlet and mercury pump outlet absolute pressures were measured with slack diaphragm and capillary tube pressure transducers. The pressure at the diaphragm was transmitted, by means of a NaK filled capillary tube, to a Bourdon tube located in a remote case. Movement of the Bourdon tube produced mechanical movement of a set of linkages. These linkage movements produced a mechanical readout and a constant current output by using a linear-variable-differential transformer and a solid state amplifier. The output of the amplifier was proportional to the pressure at the diaphragm. Each pressure transducer was calibrated over its full range. The boiler inlet pressure transducer was calibrated over a 0 to 500 pounds per square inch absolute (0 to 3450 kn/m^2) range. The pump outlet pressure transducer was calibrated over a 0 to 600 pounds per square inch absolute (0 to 4140 kn/m^2) range. The accuracy of each pressure transducer measurement was within 1 percent of its range.

The alternator frequency was obtained from the voltage line frequency. This voltage line frequency was conditioned by a step-down transformer and then a frequency-DC converter. The converter was calibrated over the expected operating range using a frequency generator as an input signal source.

The mercury pump-motor assembly speed was measured with an electromagnetic speed pickup. The output of the speed pickup was sent to a frequency-DC converter signal conditioner. The frequency generator mentioned earlier was used to calibrate the converter.

Properly conditioned voltage signals from the aforementioned instrumentation were sent to strip-chart recorders. Each channel on the strip-chart recorder was calibrated at zero, full span and mid span using a voltage source to create expected recorder input voltage values.

A computerized digital data recording system was also used to record transient test system conditions. The recording system scanned and recorded a cycle of data, containing 400 different instrument outputs, in approximately 11.43 seconds. During transient tests the recording system was run continuously. A computer program, used to calculate the test system parameters, processed each cycle of data individually. The results were saved on magnetic tape and used to produce the figures of transient data shown in Appendix A.

STARTUP PROCEDURE

During the test program, mercury loop startups were performed both manually and automatically. Manual startups required operator manipulation of valves and switches, while the automatic startups were accomplished with an electronic start programmer initiating and controlling the startup. Of the 135 mercury loop startups, the first 108 were manual and the last 27 were automatic. For both the manual and automatic startups, the mercury flow control valve (V-230) position was controlled by the analog computer (fig. 2). The sequence of events leading to the startup was the same for both the manual and automatic startups.

A typical mercury loop startup was accomplished as follows. Before each startup, all of the mercury lines were filled with liquid mercury up to the closed valves, V-210 and V-260 (fig. 1). The mercury standpipe line was also filled and more than the required amount of mercury to be injected was stored in the standpipe. Valves V-203, V-204, V-206, and V-230 were closed. Valves V-207, V-217, and V-247 were open. The pump or pumps to be bootstrapped were running on auxiliary power at the bootstrap frequency. At the desired time valves V-206 and V-260 were opened and valve V-230 was opened slightly to provide a flow feedback signal for the analog computer, see figures 1 and 2. After a 30 second delay, to allow any disturbances in the mercury loop to settle out, the mercury flow ramp started. The mercury was injected into the loop by manually pressurizing the standpipe. Valve V-230 position was automatically manipulated by the analog computer to provide the desired flow ramp.

As the mercury flow rate increased, the turbine began to accelerate. When the alternator accelerated through the bootstrap frequency, the pump or pumps to be bootstrapped were transferred to alternator electrical power. Shortly after the start of bootstrapping the lube-coolant valves were opened to the mercury pump-motor assembly and turbine-alternator assembly and the lift-off seals for both components were pressurized. Near the end of the mercury flow ramp, valve V-210 at the condenser outlet was opened. When the desired amount of mercury loop inventory was reached valve V-217 was closed.

At the termination of the startup ramp the turbine-alternator assembly was at rated speed (12,000 rpm) and the pump or pumps bootstrapped were running on alternator power.

DISCUSSION AND RESULTS

Recordings of pertinent parameters for a typical startup are shown in figure 3. The first parameter recorded is liquid mercury flow rate. The time duration of the flow ramp was determined by drawing a straight line through the liquid mercury flow trace using the initial, nearly-linear portion, as a guide. This line extended from the point of intersection with zero flow on the trace, to the intersection of a horizontal line representing a flow level of 6600 pounds mass per hour (3000 kg/hr). The projection of the straight line ramp on the time scale (abscissa) gave the duration of the ramp.

The value of the bootstrap frequency was determined by examination of the traces of alternator frequency and mercury pump speed (figs. 3(e) and 3 (f)). A vertical dashed line was projected from the point on the mercury pump speed trace, where the first indication of increased speed was noted, to the point of intersection on the alternator frequency trace.

As can be seen in figure 3(a), the mercury-liquid-flow ramp departed considerably from a straight line. From the 70 to the 75 second, on the time interval scale, the liquid flow trace drops off rapidly. The reason for this occurrence is that during this time interval, the boiler mercury inlet pressure rises to a level approaching the outlet pressure of the mercury pump (figs. 3(c) and 3(d)). The boiler inlet pressure rise causes immediate reduction in liquid mercury flow rate. The reduced liquid flow rate means a reduced venturi pressure drop. Since the flow control valve (V-230) feedback circuit compares the demand pressure drop with the venturi pressure drop (fig. 2) the analog computer integral and proportional control sends an increased command signal to the flow control valve. This causes it to open quickly, in an attempt to match demand and actual flow rate. At approximately 82 seconds the pumps are bootstrapped. The mercury pump-motor assembly pumping capability now increases and the mercury flow rate rises. As the mercury flow rate approaches the demand flow rate the flow control valve starts to close (figs. 3(a) and 3(b)). The flow control valve continues to close until the actual and demand flow rates coincide. It was observed that the 100-second flow ramp used for startup 126 did not cause any severe liquid mercury flow rate overshoot problems.

Startup 15 with a 60-second ramp and a bootstrap frequency of 220 cycles per second is shown in figure 4. All pumps were bootstrapped except the mercury pump which was operated on auxiliary power at 400 cycles per second. It was observed that for this startup the flow control valve trace (fig. 4(b)) was relatively smooth. There was no fall off in mercury flow because the mercury pump was already running at 400 cycles per second. At this frequency the pump produced enough pressure head to overcome the increase in boiler inlet pressure during the flow ramp. Thus, valve V-230 movement was minimized resulting in the actual mercury flow ramp closely following the demand flow ramp (fig. 4(a)). Operation of the mercury pump at 400 cycles per second on auxiliary power during the startup is impractical, however, when considering the weight and size of a battery-inverter package required for such operation.

A comparison of 30, 60, and 80 second mercury-flow ramps is shown in figure 5. Only the mercury pump-motor assembly was bootstrapped for these runs. The bootstrap frequency was 260 cycles per second. The two parameters selected for ramp comparison were liquid mercury flow and flow control valve (V-230) position. An examination of figure 5(a), startup 61, shows the result of the 30 second ramp. After approximately 20 seconds had elapsed during the startup ramp, the liquid mercury flow dropped off from a value of 5000 to 3750 pounds mass per hour (2300 to 1700 kg/hr). This reduction in flow was the result of a buildup of boiler mercury inlet pressure to a level nearly equivalent to mercury pump outlet pressure. This problem was previously discussed in conjunction with the 100-second flow ramp of startup 126 (fig. 3). For the 30-second ramp, however, the flow reduction results in a larger error from the demand flow than for the 100-second ramp. The result is that the feedback control of valve V-230 causes it to move rapidly to a more fully open position. This valve position is greater than required for the final flow of 6600 pounds mass per hour (3000 kg/hr). This results in a large overshoot in flow when the pump accelerates even though the valve then closes down rapidly. The same effects are also manifested in the 60- and 80-second ramp times but to a lesser degree as ramp time is increased.

The conclusion obtained from figure 5 is that flow ramps of 80 seconds or less are not desirable for startup of the SNAP-8 flight system. These short ramps would complicate use of open loop control of the flow control valve. For dependability open-loop flow control is preferred in the flight system instead of feedback control as used during system startup tests. This flight-type open-loop flow control valve will be driven by an electric motor. Upon command from the start programmer the valve will be driven open, over a specified period of time, to a plateau position that will result in a mercury liquid flow of 6600 pounds mass per hour (3000 kg/hr).

For the short ramps (80 seconds or less), valve V-230 with feedback control reached maximum openings of about 65, 40, and 20 percent of full open for the 30, 60, and 80 second flow ramps, respectively (fig. 5). These valve positions were considerably in excess of the final valve position required for the 6600 pounds mass per hour (3000 kg/hr) flow. If an open-loop flow control valve were opened to a position required for the final flow, then a very intricate variation of flow coefficient versus position would be required to provide the necessary maximum flow coefficient prior to pump bootstrap. The valve contour would require accurate knowledge of flight system pressure-drop variations with flow rate and would probably not be suitable for flow control during shutdown. Tests have shown that valve pressure drop variation is different in shutdown than in startup. If an open-loop valve with a monotonic variation of flow coefficient with position were used, it would have to be driven open to a position corresponding to the maximum openings of figure 5. This would result in mercury flow rates much larger than 6600 pounds mass per hour (3000 kg/hr) at the conclusion of the flow ramp. Excessively high mercury flows achieved over a relatively short time would impart severe temperature transients on the nuclear reactor.

When ramp times from 100 to 145 seconds were used, the flow control valve (V-230) was not required to overshoot its final position. This can be seen by observing the V-230 position traces associated with figures 6 and 7. Therefore, open-loop flow control can readily be accomplished for these longer ramp times.

In figures 6 and 7, the startups are compared on the basis of three parameters: mercury liquid flow, valve (V-230) position, and alternator frequency. All four pumps were transferred from auxiliary to alternator power. The bootstrap frequency in figures 6(a), 7(a), and 7(b) was 290 cycles per second and the bootstrap frequency in figure 6(b) was 220 cycles per second. The effect of bootstrap frequency on flow ramp is discussed in reference 9.

The long flow ramps displayed in figures 6(a) and 6(b) are ideal from the standpoint of minimizing liquid mercury flow excursions and the movement of valve (V-230) necessary to accomplish system startup. The major problem in using a long flow ramp for startup of the SNAP-8 system is insufficient turbine acceleration. The long ramp causes the turbine-alternator speed to increase slowly after bootstrapping begins and therefore the necessary alternator power to sustain four pumps results in a marginal startup region. A study of the alternator frequency traces between the interval of 120 to 135 seconds on both figures 6(a) and 6(b) indicates a reduction in frequency during bootstrapping before a level of 400 cycles per second is attained. This reduction occurs when power required for speed control is added to the alternator load. In particular, the frequency trace for the 145-second ramp (fig. 6(b)) shows severe turbine deceleration when speed control load is added to the alternator. In order to prevent an aborted startup all four pumps had to be removed from alternator to auxiliary power. The frequency trace for the 140-second ramp (fig. 6(a)), using a bootstrap frequency of 290 cycles per second, indicates a slight amount of deceleration before attaining a frequency of 400 cycles per second. Although the deceleration problem is not as serious as observed for the 145-second ramp, the startup sequence is still of a marginal nature. It was concluded that startup ramps of 140 to 145 seconds defined the upper limit of system ramp times.

The final flow-ramp rate comparisons are shown in figures 7(a) and 7(b), startups 119 and 116, respectively. The traces of liquid mercury flow and flow control valve position (V-230) for these 100- and 120-second ramps are quite smooth. The flow control valve did not overshoot its final position indicating that open-loop flow control could be accomplished readily for either ramp. The liquid mercury flow traces also show that minimal flow excursions from a straight line ramp occurred during these startups. The one factor which resulted in selecting the 100-second ramp over the 120-second ramp was the alternator frequency trace. The bootstrap frequency for all four pumps was 290 cycles per second for both startups. The 100-second ramp, startup 119, shows a smooth increase in alternator frequency from 290 to 400 cycles per second, whereas the 120-second ramp, startup 116, shows a slight turbine deceleration over the same frequency range. It was concluded that a 120-second ramp did not provide enough margin from the upper limit of acceptable ramp times (140 to 145 sec.). The 100-second ramp rate resulted in the most favorable startup mode of all the ramps investigated.

Appendix A contains additional plots of the 9 startups previously discussed in the report. The computer plots of digital data in figures 8 through 16 show the results of all pertinent parameters associated with the four main SNAP-8 loops. The time interval between cycles plotted along the abscissa is approximately 11.43 seconds. A list of symbols and abbreviations precedes the plots. The parameters of boiler heat balance quality, mercury flow ratio quality, turbine-alternator overall efficiency, and condenser mercury inlet quality should be ignored in the transient plots, since steady-state equations were used to calculate them.

SUMMARY OF RESULTS

1. Short mercury flow ramps, of 80 seconds or less, are not desirable for startup of the mercury loop. They prohibit use of open-loop flow control. A ramp rate of 80 seconds, therefore, defines the lower limit of startup ramp times.

2. Long ramps, of 140 seconds or more, are not acceptable due to marginal turbine acceleration. The turbine accelerated slowly during the bootstrapping of the pumps. When the speed control power was added to the alternator load near rated speed unacceptable turbine deceleration resulted. A ramp time of 140 seconds, therefore, defines the upper limit of startup ramp time.

3. A startup ramp of 120 seconds resulted in only small liquid-mercury flow excursions, and no overshoot of the flow control valve. However, there was a slight deceleration in the turbine after the bootstrapping of all four pumps was initiated. This result indicated that a ramp time with more margin form the upper limit would be preferrable.

4. A ramp time of 100 seconds resulted in the most favorable startup mode for the system. The liquid mercury flow rate nearly achieved a straight line ramp. The flow control valve (V-230) was required to make only slight adjustments in flow rate. Finally, the turbine acceleration was continuous and no difficulty was encountered in transferring from auxiliary power to alternator power during bootstrapping of all four pumps.

APPENDIX A

Digital Data Transient Plots and Legend Symbols

A or ALT	Alternator
ASHE	Auxiliary Start Heat Exchanger
AUX	Auxiliary
BAL	Balance
BV	Butterfly Valve
COND	Condenser
DIFF	Difference
DISC	Discharge
FCV	Flow Control Valve
G	Gravity
HE	Heat Exchanger
HG	Mercury
HRL	Heat Rejection Loop
HT	Heat
HTR	Heater
IMM	Immersion
IN	Inlet
L/C	Lube Coolant
MG	Motor Generator
MHE	Motor Heat Exchanger
NAK	Sodium Potassium
NPSH	Net Positive Suction Head
OUT	Outlet
REACT	Reactivity
PLR	Parasitic Load Resistor
PMA	Pump-Motor Assembly
PN	Primary NaK
POS	Position
PRESS	Pressure
PRI	Primary
PWR	Power
RAD	Radiator
SSHE	Space Seal Heat Exchanger
T or TURB	Turbine
TAA	Turbine-Alternator Assembly
TEMP	Temperature
TERM	Terminal
V	Valve
VENT	Venturi
VLB	Vehicle Load Bank

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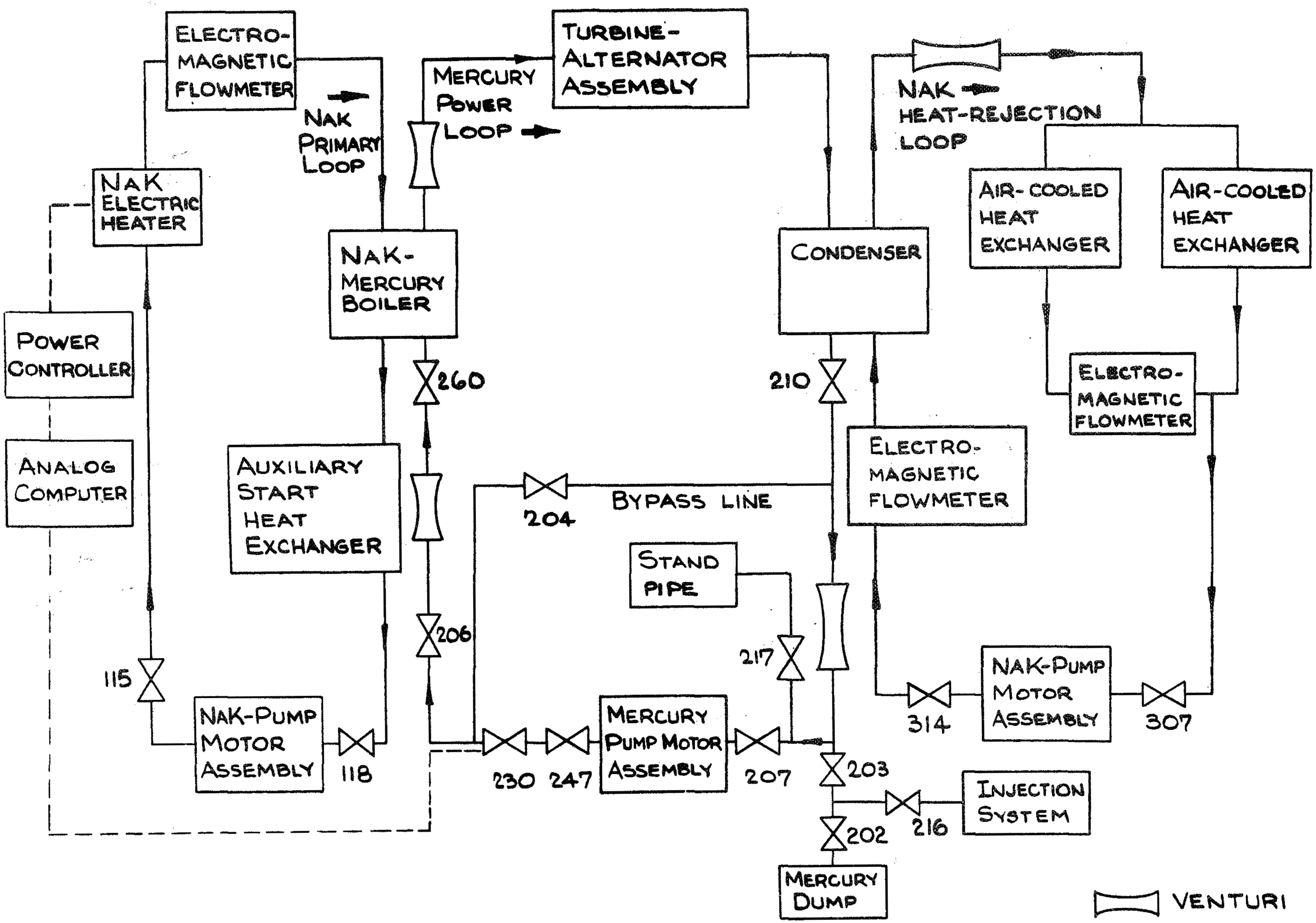


FIGURE 1.- SCHEMATIC OF SNAP-8 TEST SYSTEM

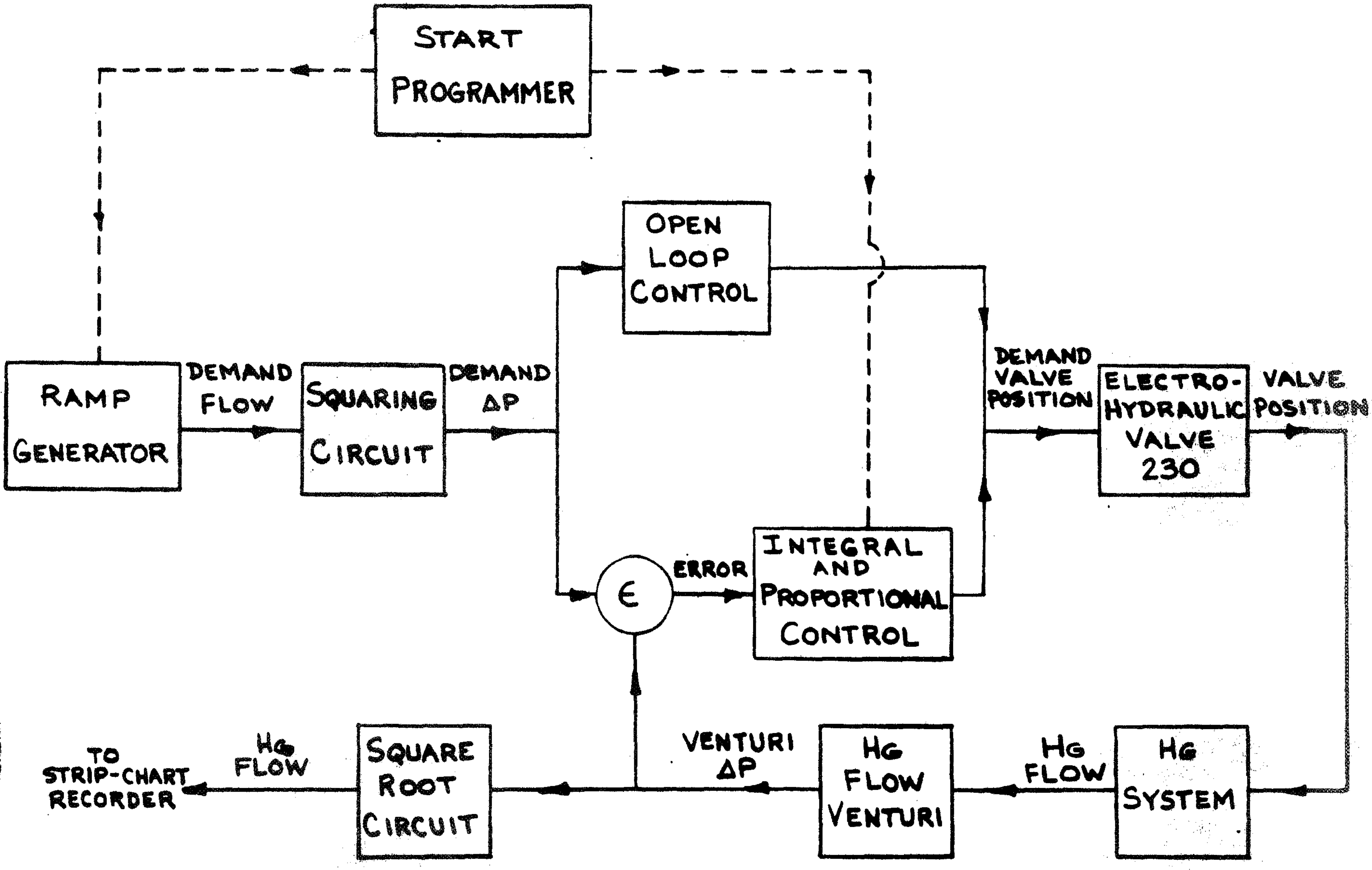


FIGURE 2. - ELECTRO-HYDRAULIC VALVE 230 FEEDBACK CONTROL CIRCUIT

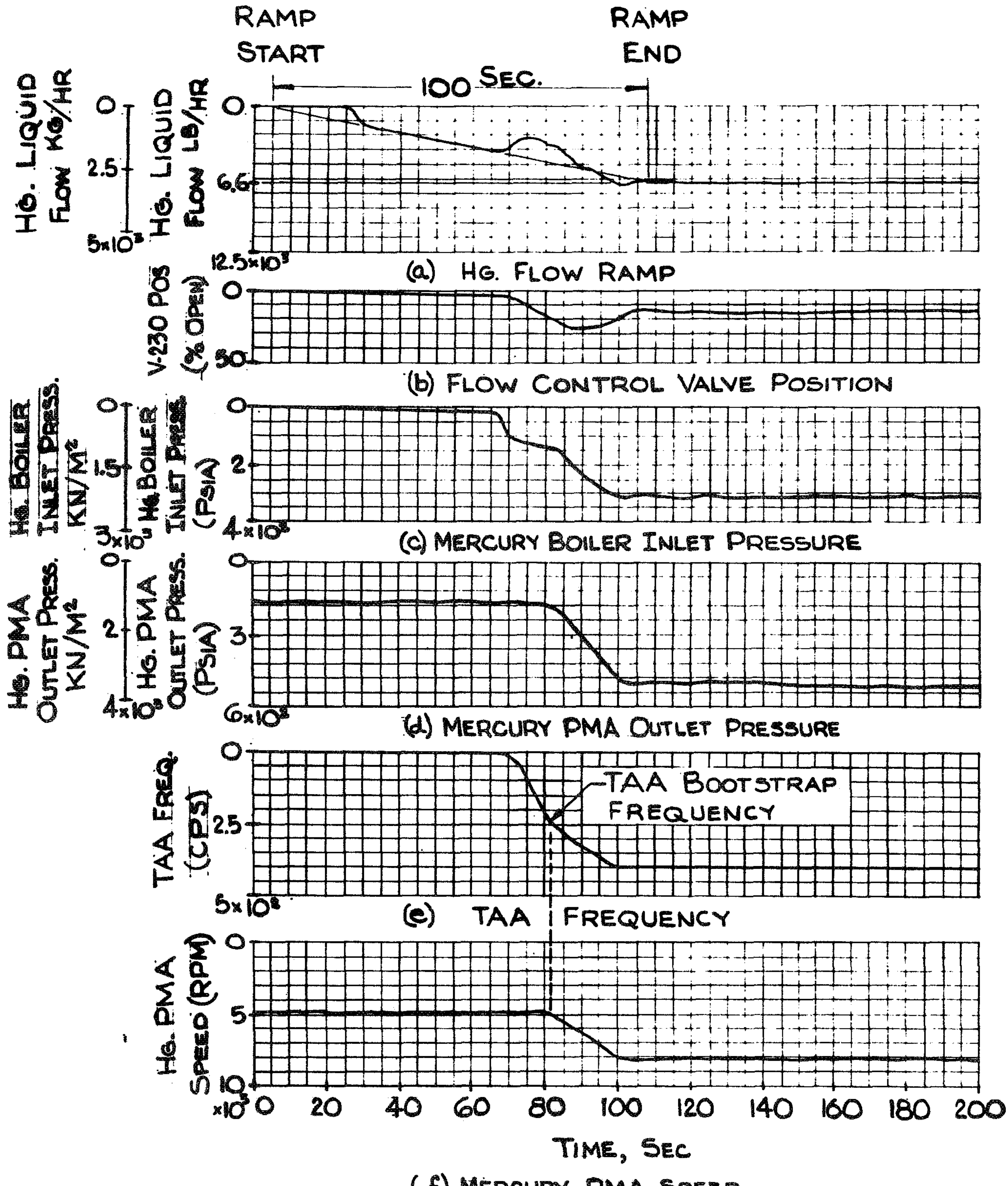


FIGURE 3 - TRANSIENT BEHAVIOR OF MERCURY LOOP PARAMETERS FOR STARTUP 126. MERCURY FLOW RAMP RATE IS 100 SECONDS WITH A BOOT-STRAP FREQUENCY OF 240 CPS FOR ALL 4 PUMPS.

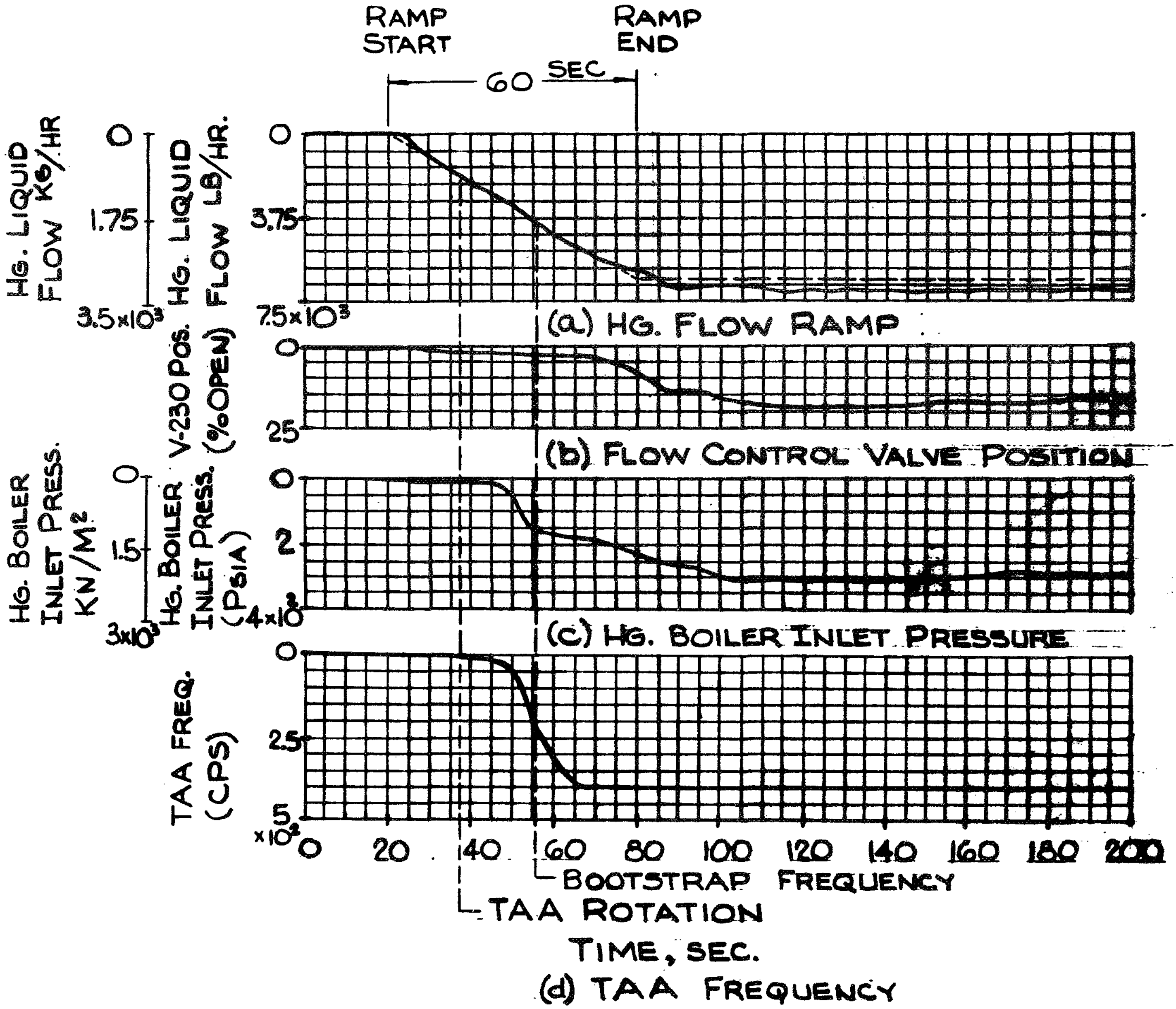
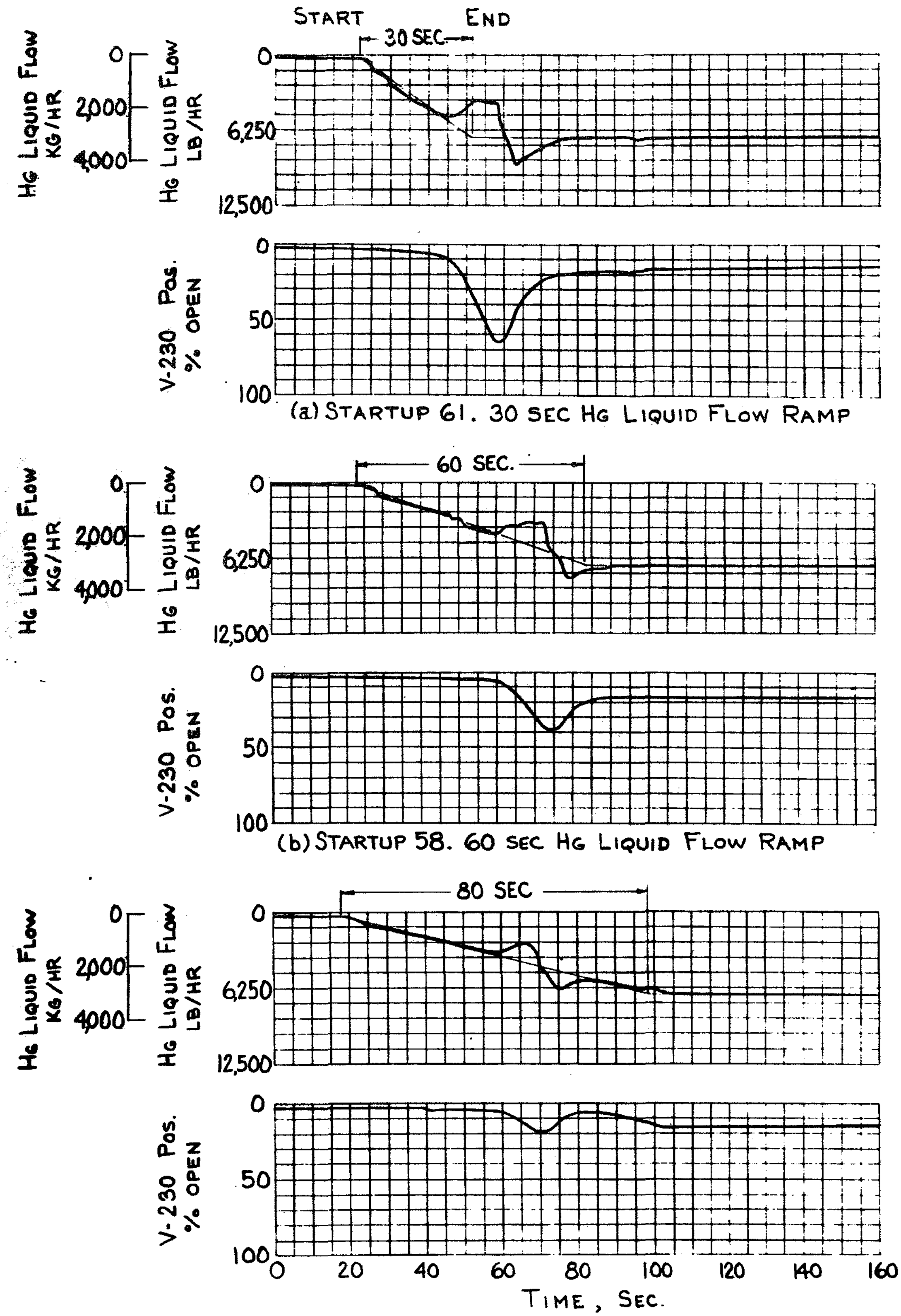


FIGURE 4 - TRANSIENT BEHAVIOR OF MERCURY LOOP PARAMETERS FOR STARTUP 15. MERCURY FLOW RAMP IS 60 SECONDS WITH A BOOTSTRAP FREQUENCY OF 220 CPS FOR THE PRIMARY, HRL AND L/C PMA'S.

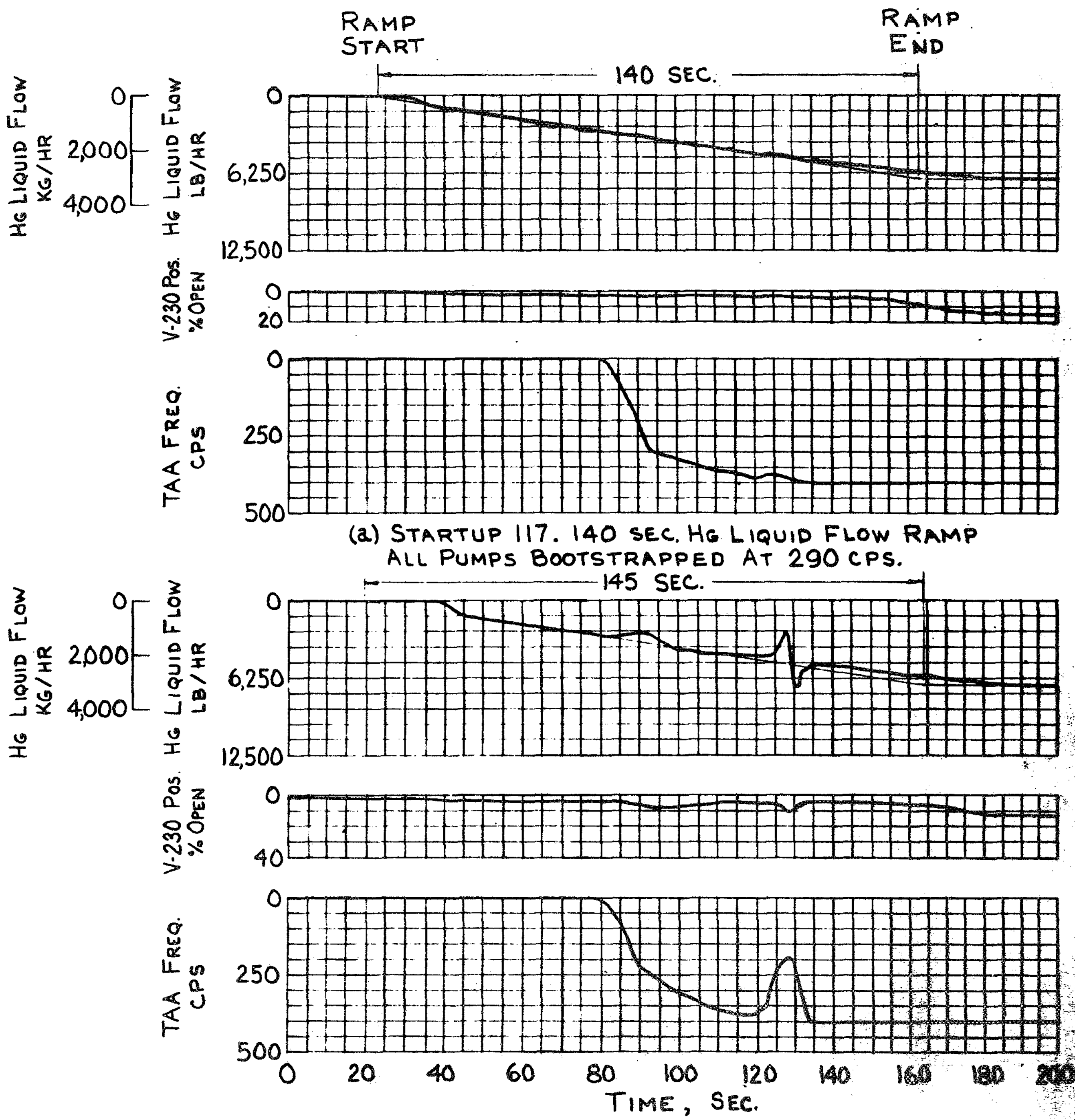


(a) STARTUP 61. 30 SEC Hg LIQUID FLOW RAMP

(b) STARTUP 58. 60 SEC Hg LIQUID FLOW RAMP

(c) STARTUP 60. 80 SEC Hg LIQUID FLOW RAMP

FIGURE 5. - COMPARISON OF 30, 60, AND 80 SEC Hg LIQUID FLOW RAMP STARTUPS. Hg PUMP-MOTOR ASSEMBLY BOOTSTRAPPED AT 260 CPS.



(b) STARTUP 115. 145 SEC. Hg LIQUID FLOW RAMP.
ALL PUMPS BOOTSTRAPPED AT 220 CPS.

FIGURE 6. - COMPARISON OF 140 AND 145 SEC. Hg LIQUID FLOW RAMP STARTUPS.

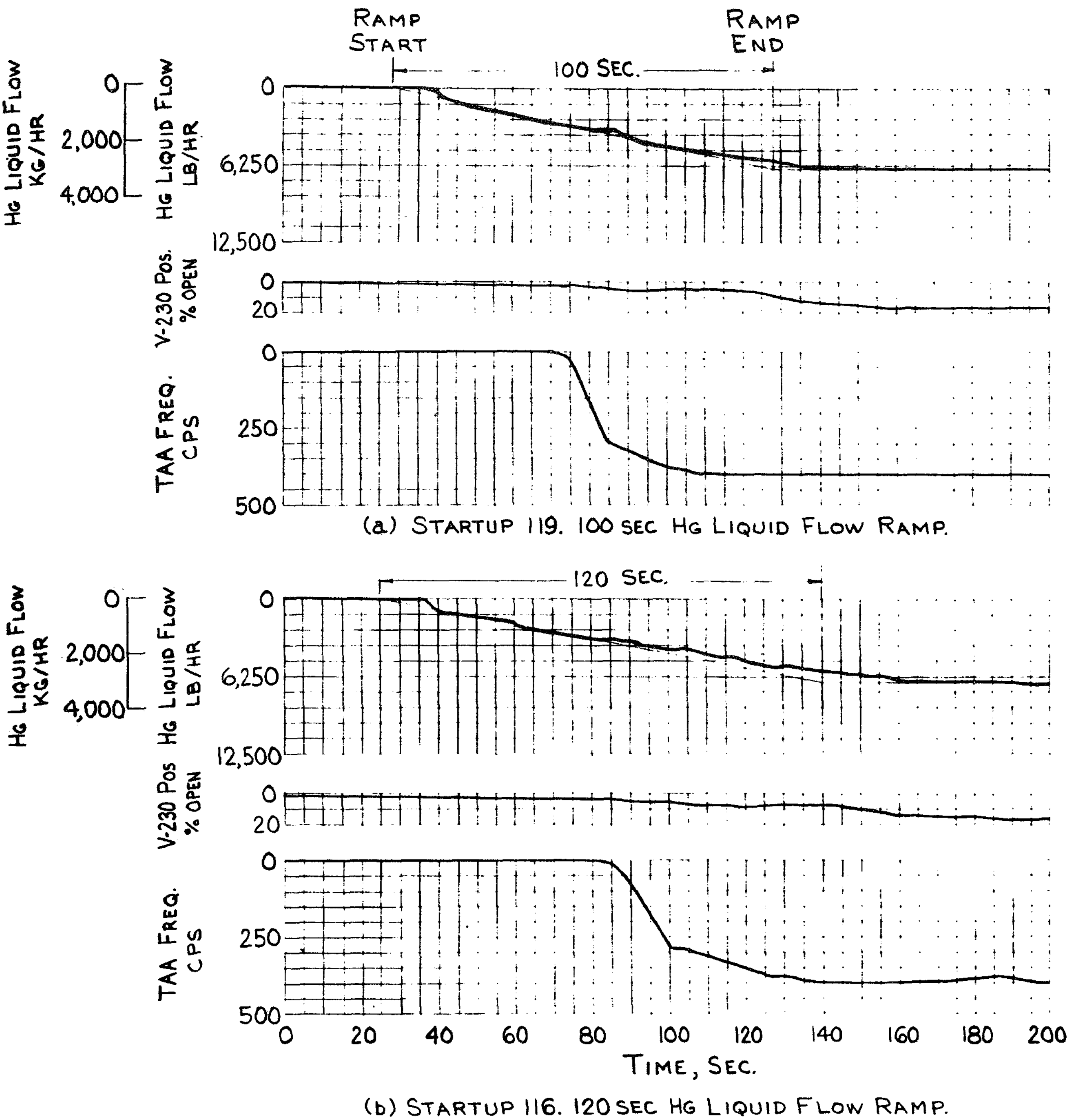
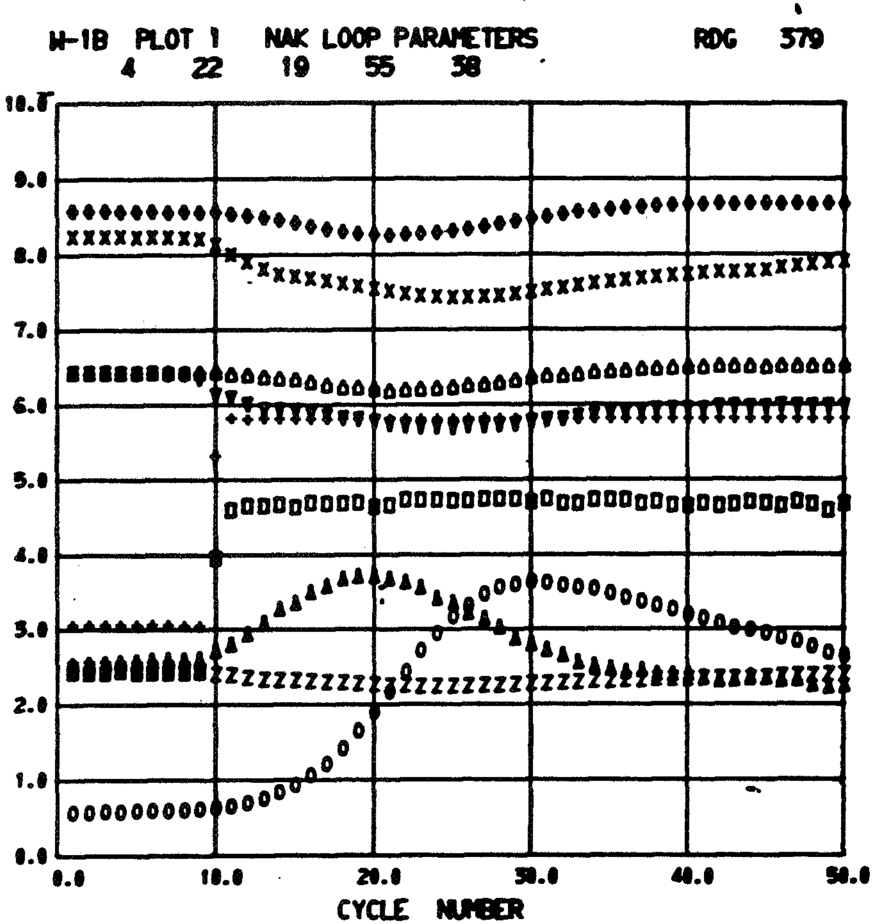


Figure 7. - Comparison of 100 and 120 sec. Hg Liquid Flow Ramp Startups. All Pumps Bootstrapped At 290 cps.



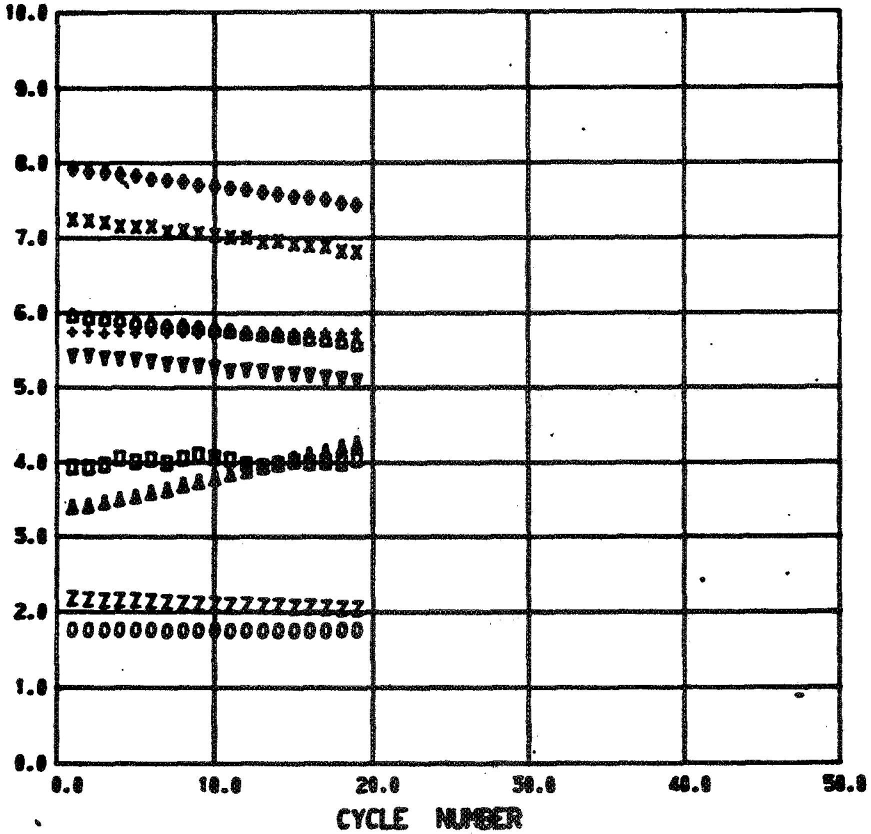
W-1B PLOT 1 NAK LOOP PARAMETERS RDG 379
4 22 19 55 38

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 8(a). - STARTUP 15. CYCLES 1 TO 50. NAK LOOP PARAMETERS.

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 379
4 22 19 55 38

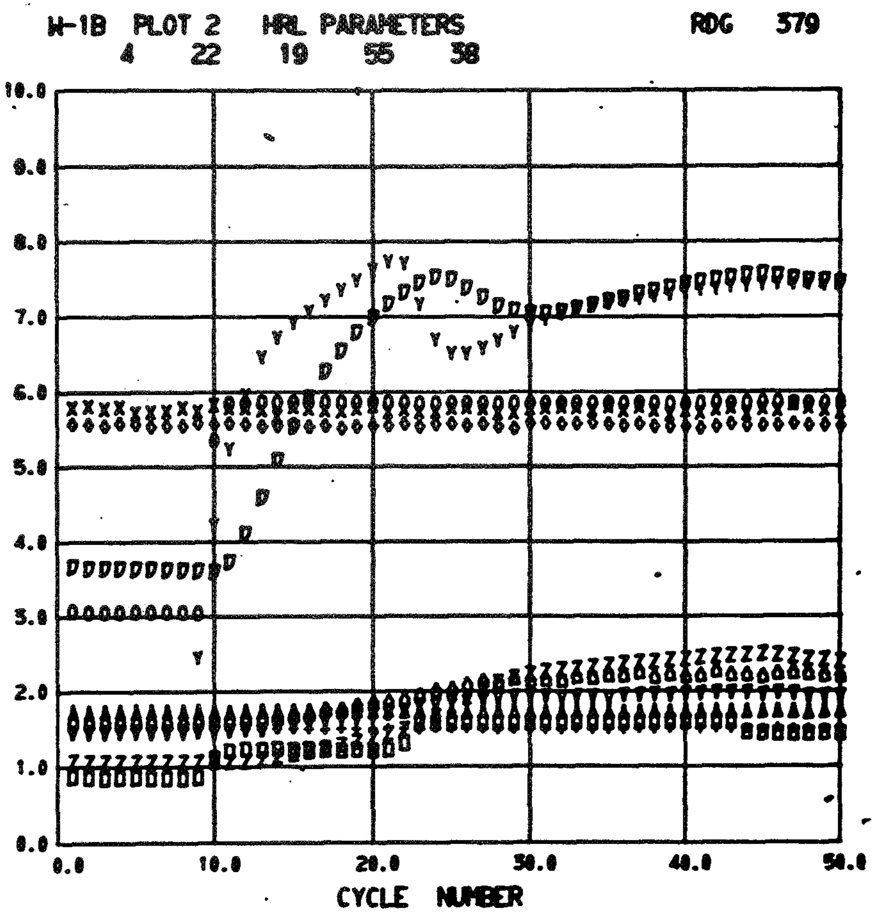


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 57
4 22 19 55 38

□	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

FIGURE 8(2) CONTINUED. - STARTUP 15. CYCLES 51 TO 69. NAK LOOP PARAMETERS.

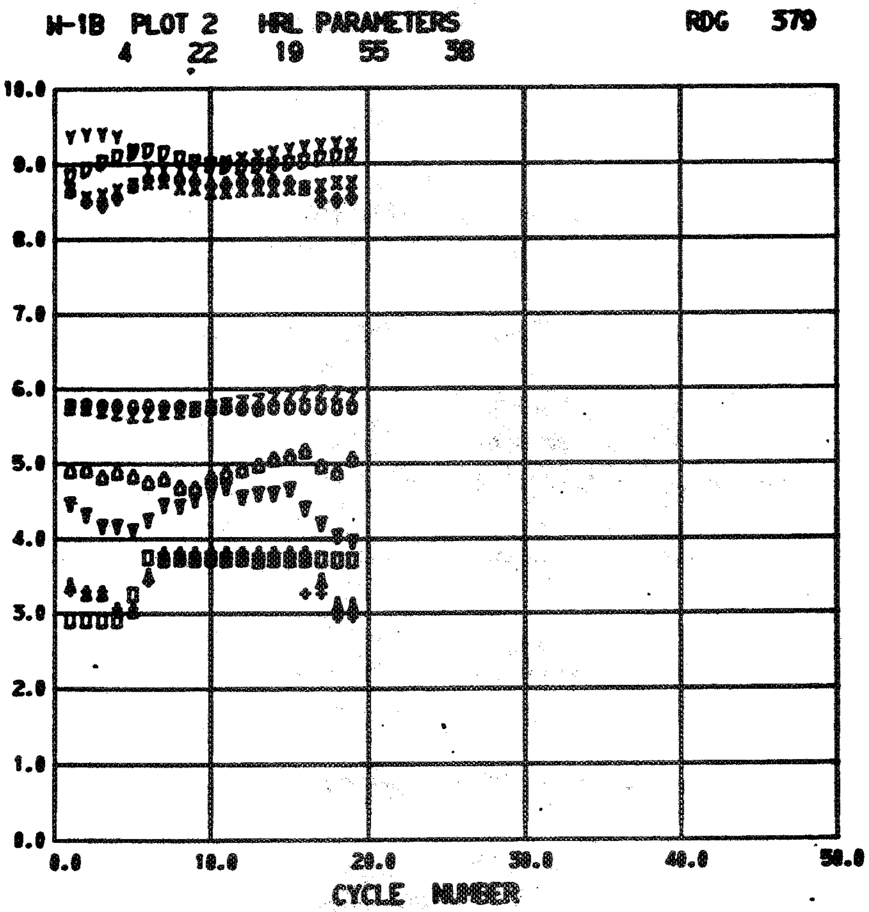


H-1B PLOT 2 HRL PARAMETERS RDG 379
4 22 19 55 38

□	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

FIGURE 8(b). – STARTUP 15. CYCLES 1 TO 50. HRL PARAMETERS.



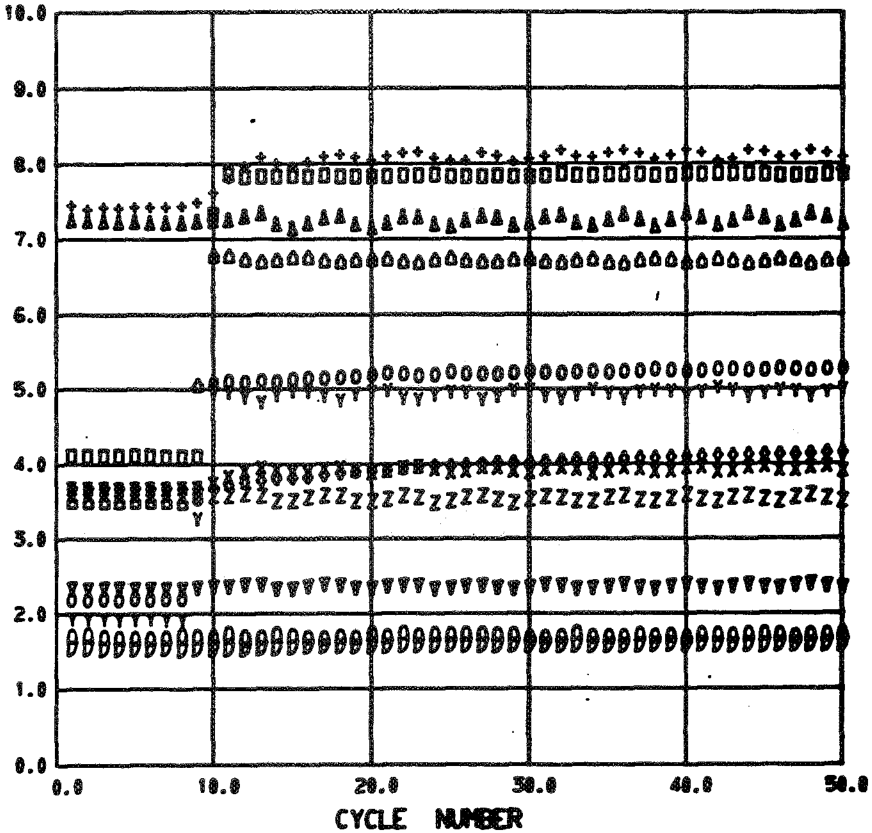
W-1B PLOT 2 HRL PARAMETERS RDG 37
4 22 19 55 38

□	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
Ɗ	RAD. INLET TEMP	X	75 F

11.43 SECONDS BETWEEN CYCLES

FIGURE 8 (b) CONTINUED. - STARTUP 15. CYCLES 51 TO 69. HRL PARAMETERS.

W-1B PLOT 3 LC PARAMETERS RDG 379
4 22 19 55 38

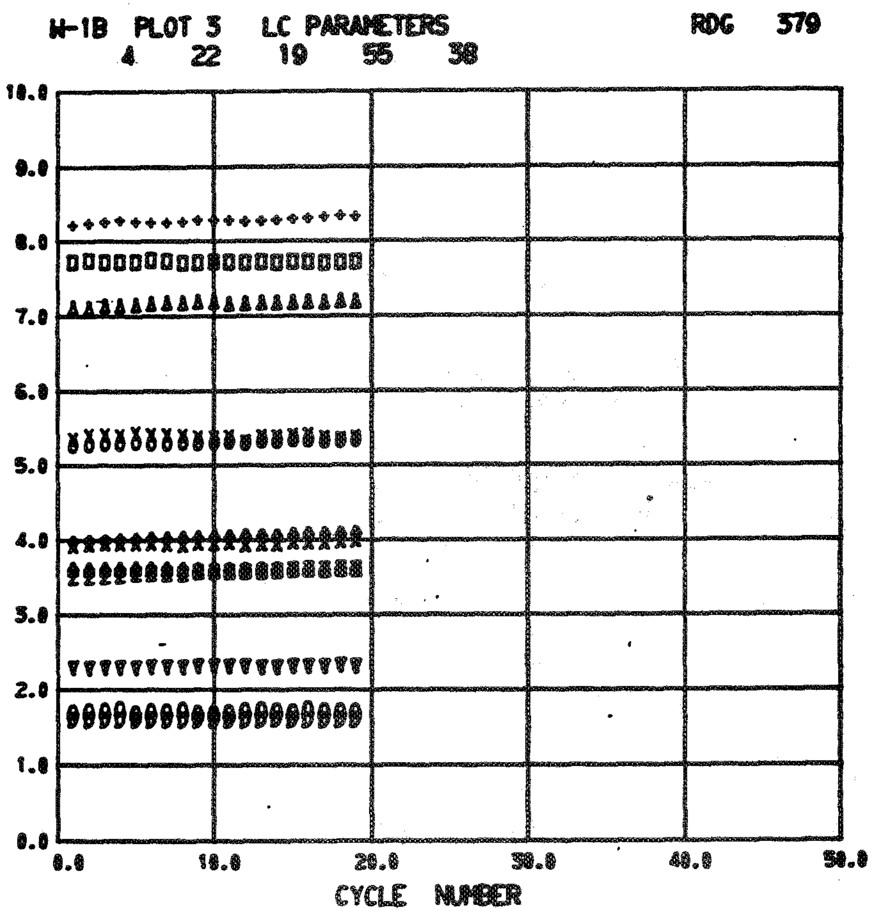


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 3 LC PARAMETERS RDG 379
4 22 19 55 38

□	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
Ω	HG PMA MHE OUTLET TEMP	X	100 F

FIGURE 8(c). - STARTUP 15. CYCLES 1 TO 50. L/C PARAMETERS.

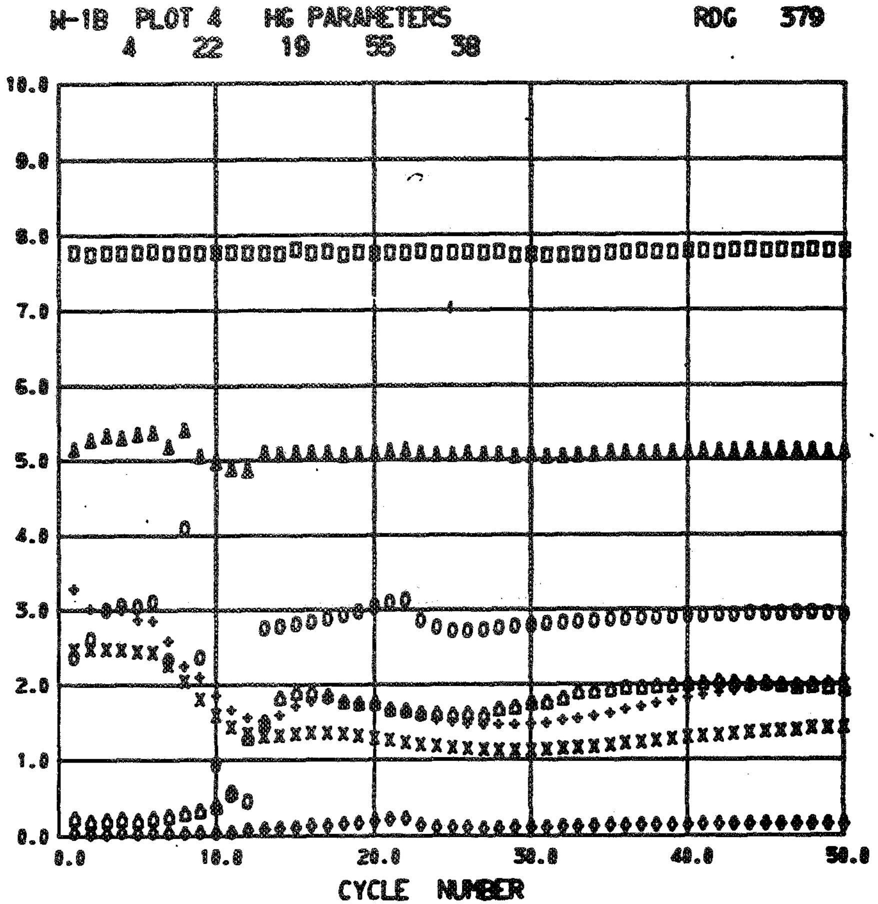


H-1B PLOT 3 LC PARAMETERS RDG 379
4 22 19 55 38

□	L/C PMA SPEED	X	1000 RPM
○	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 8(l) CONTINUED. – STARTUP 15, CYCLES 51 TO 69. L/C PARAMETERS.

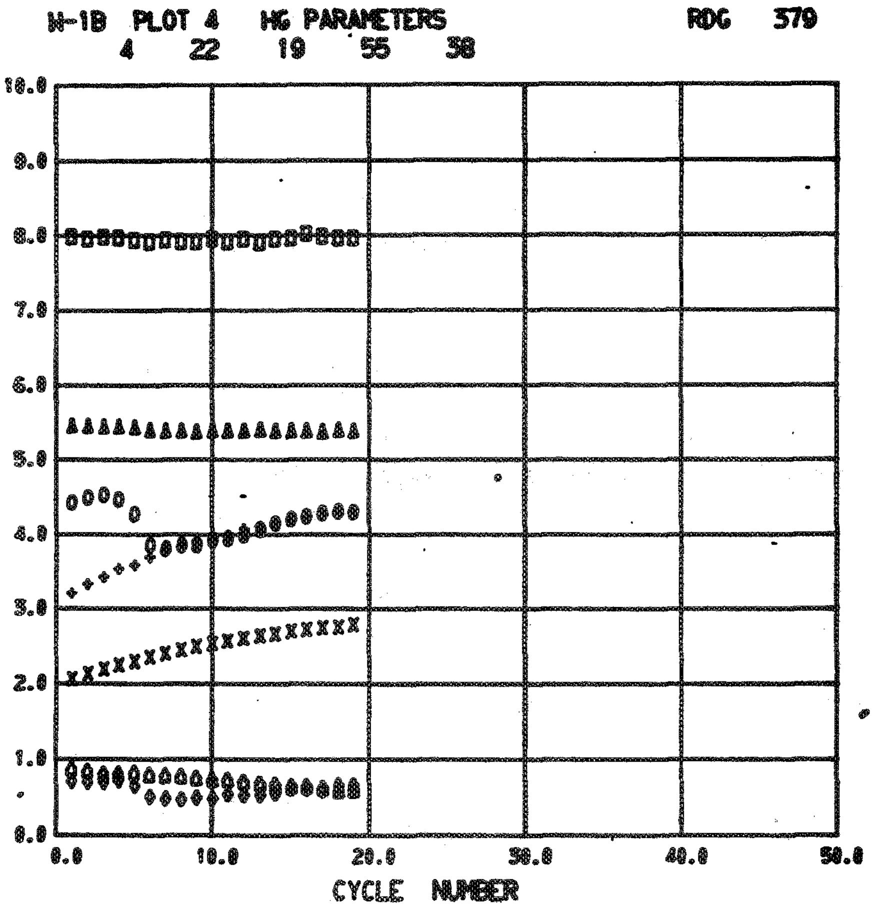


H-1B PLOT 4 HG PARAMETERS RDG 379
4 22 19 55 38

□	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

FIGURE 8(d). - STARTUP 15. CYCLES 1 TO 50. HG LOOP PARAMETERS.

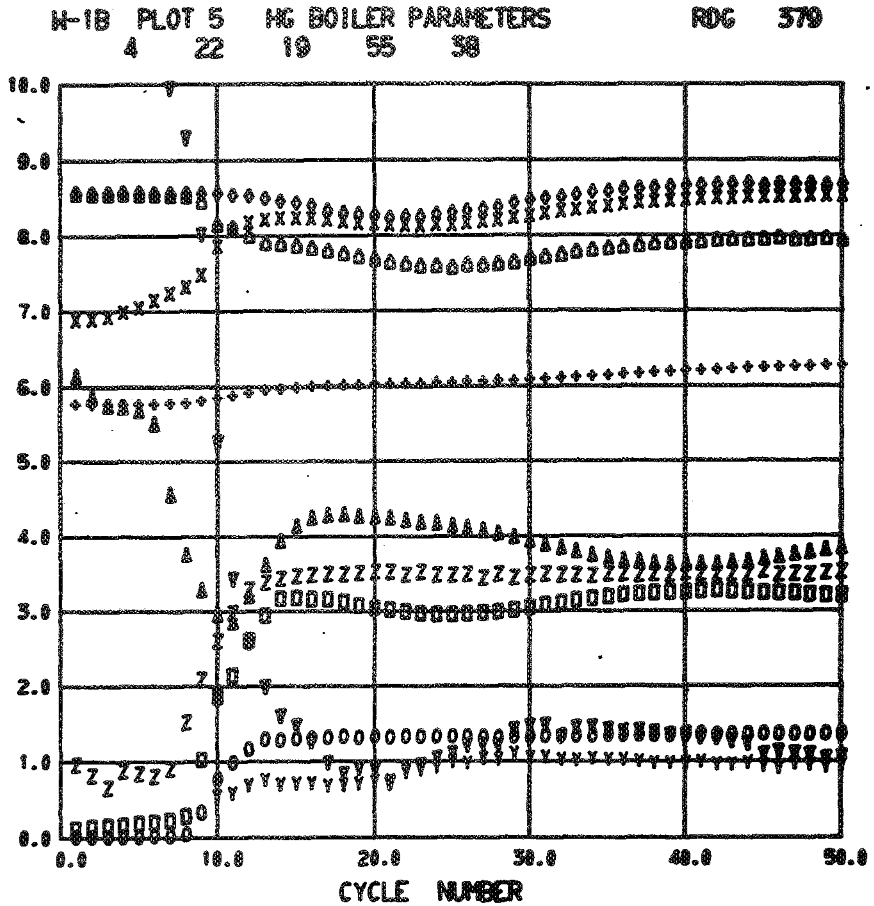


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 4 HG PARAMETERS RDG 379
4 22 19 55 38

□	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

FIGURE 8(d) CONTINUED. — STARTUP 15. CYCLES 51 TO 69. HG LOOP PARAMETERS.

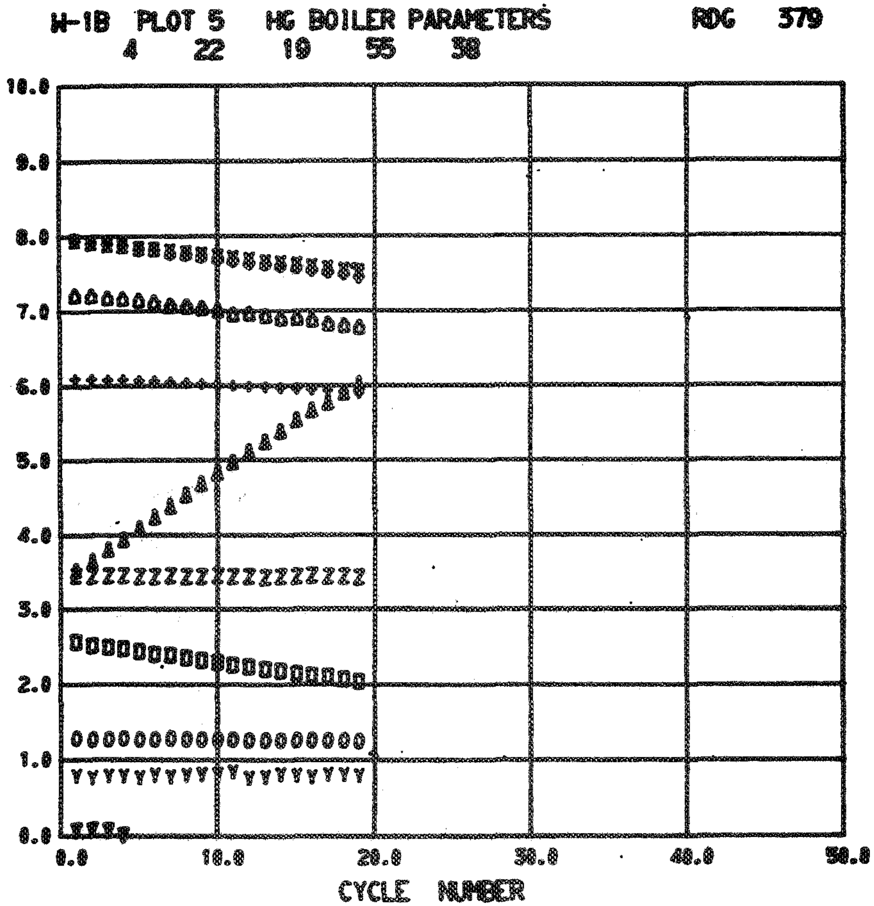


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 5 HG BOILER PARAMETERS RDG 379
4 22 19 55 38

□	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		

FIGURE 8(e). - STARTUP 15. CYCLES 1 TO 50. HG BOILER PARAMETERS.

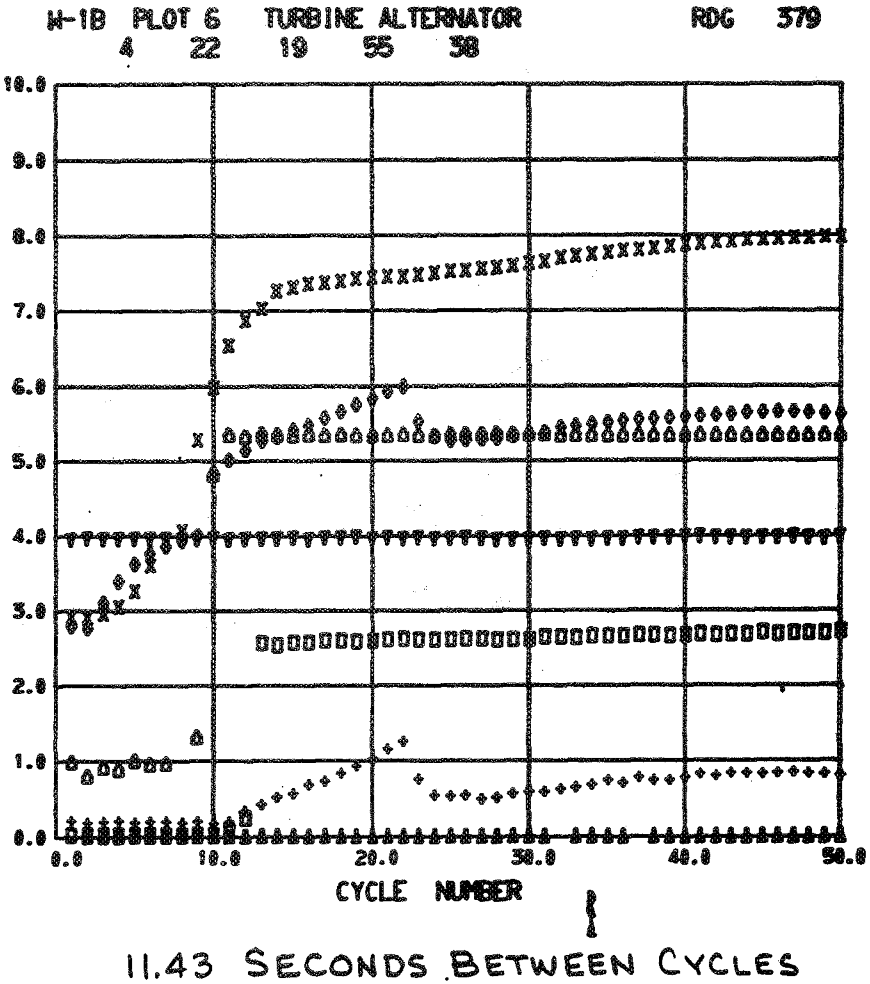


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 5 HG BOILER PARAMETERS RDG 379
4 22 19 55 38

□	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		

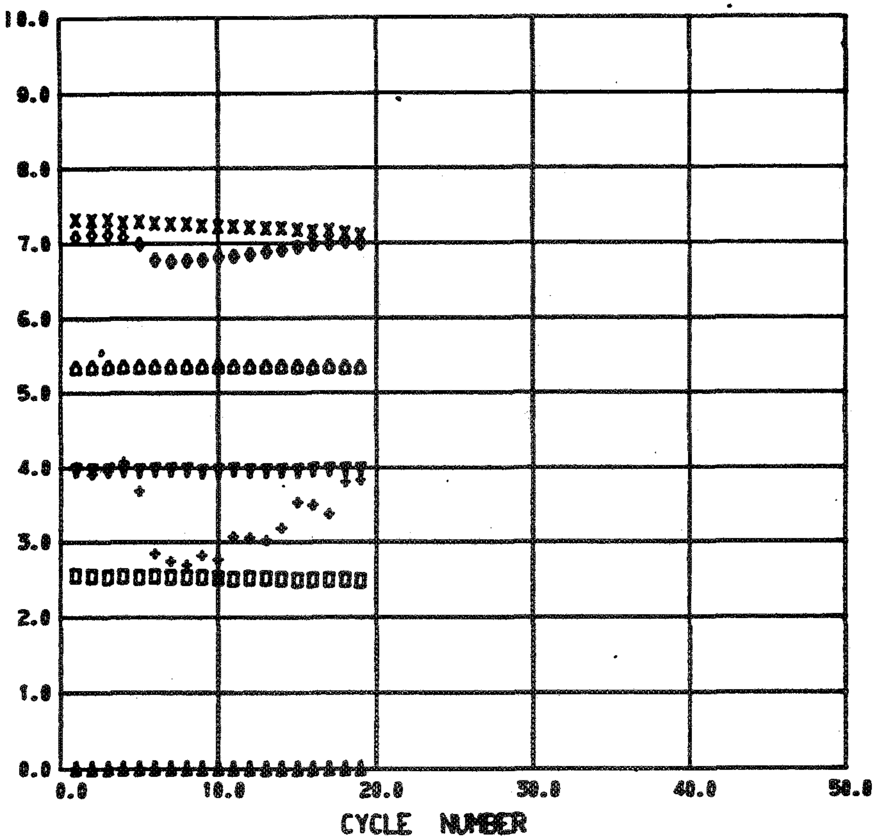
FIGURE 8(e) CONTINUED. - STARTUP 15. CYCLES 51 TO 69. HG BOILER PARAMETERS.



H-1B PLOT 6 TURBINE ALTERNATOR RDG 379
4 22 19 55 38

□	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
Δ	TAA FREQUENCY	X 75 HZ
∇	BOGUE/MG SET FREQUENCY	X 100 HZ

FIGURE 8(f). - STARTUP 15. CYCLES 1 TO 50. TURBINE - ALTERNATOR PARAMETERS.



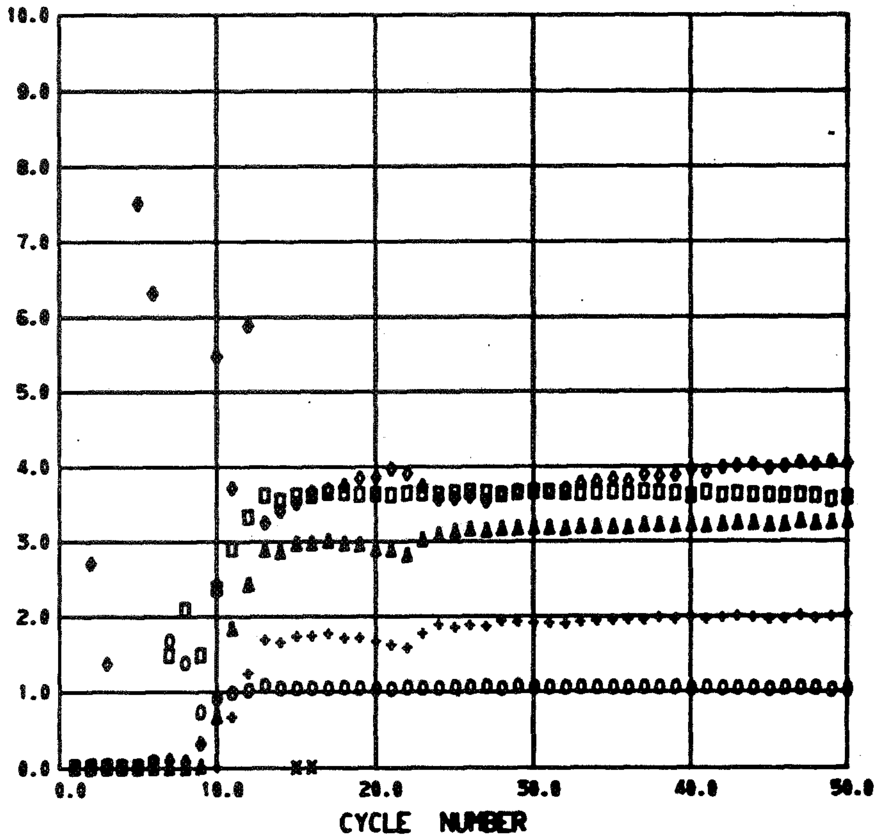
H-1B PLOT 6 TURBINE ALTERNATOR RDG 379

4 22 19 55 38

□	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

FIGURE 8(f) CONTINUED. – STARTUP 15. CYCLES 51 TO 69. TURBINE - ALTERNATOR PARAMETERS.



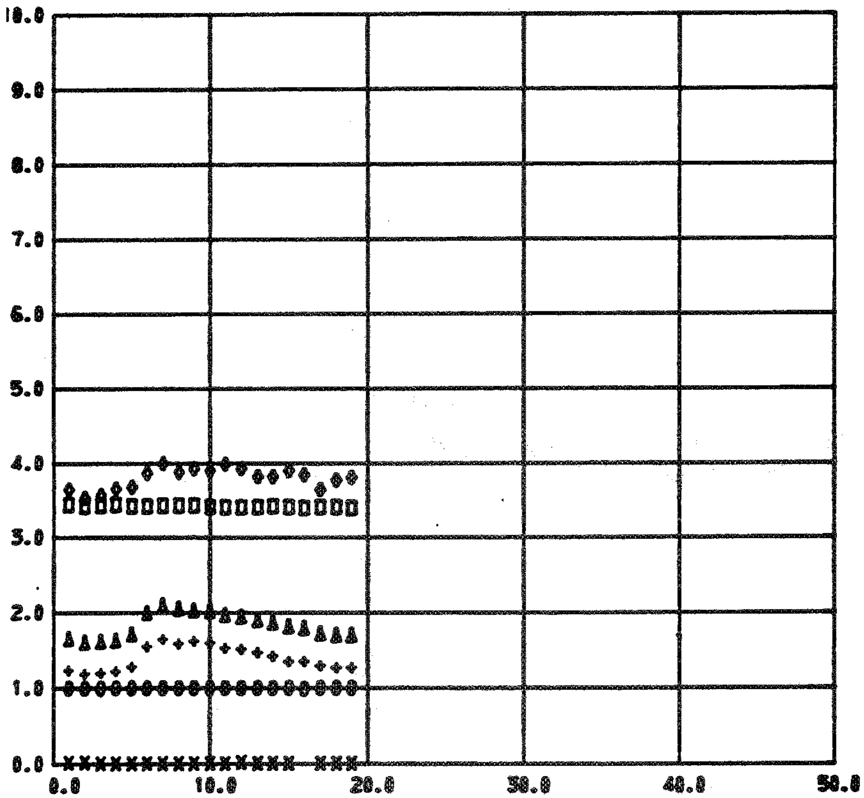
H-1B PLOT 7 TAA FLOW AND POWER RDG 379
4 22 19 55 38

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 8(g). - STARTUP 15. CYCLES 1 TO 50. TAA FLOW AND POWER PARAMETERS.

H-1B PLOT 7 TAA FLOW AND POWER RDG · 379
4 22 19 55 38

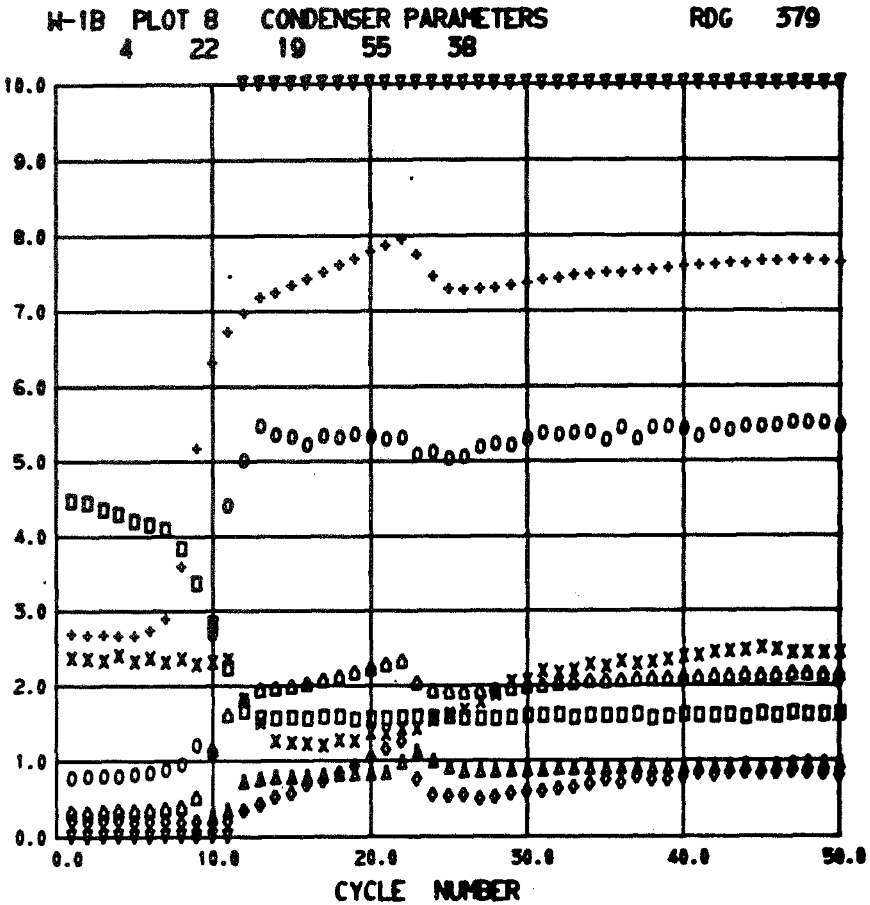


11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 7 TAA FLOW AND POWER RDG 379
4 22 19 55 38

□ 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

FIGURE 8(8) CONTINUED.- STARTUP 15. CYCLES 51 TO 69. TAA FLOW AND POWER PARAMETERS.

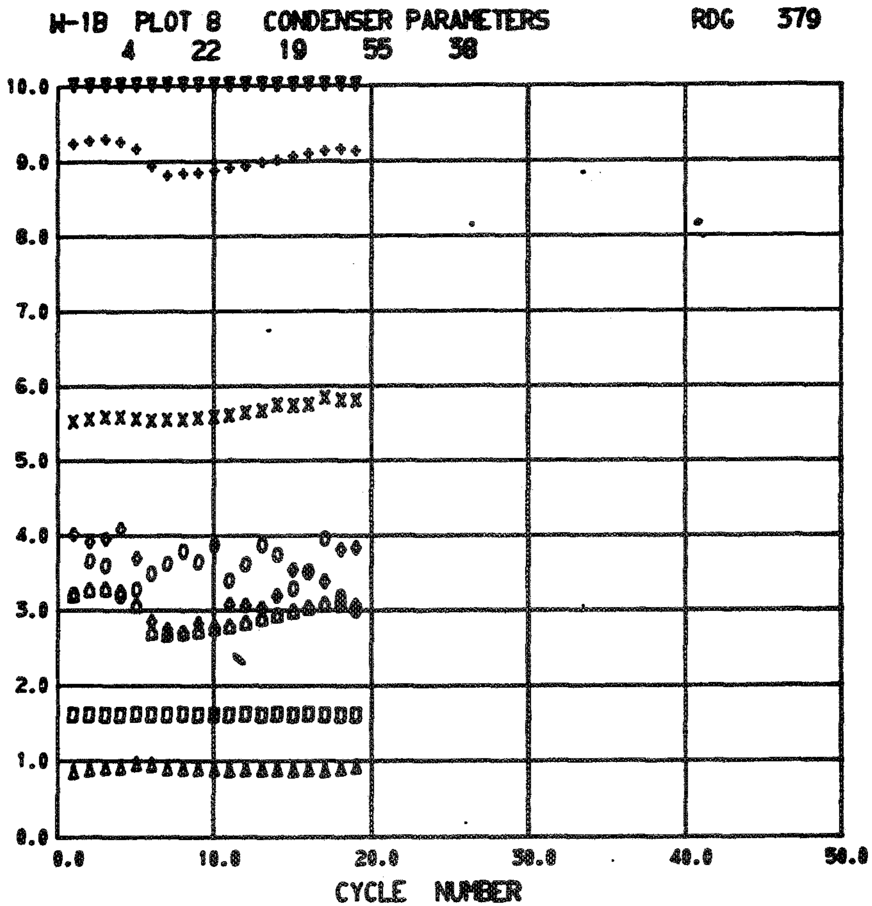


11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 8 CONDENSER PARAMETERS RDG 379
4 22 19 55 38

□	HG STANDPIPE HEIGHT	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
Δ	COND. HG OUTLET PRESS	X 10 PSIA
▽	COND. OUTLET V-210 POS.	X 10 0/0

FIGURE 8(h).- STARTUP 15. CYCLES 1 TO 50. CONDENSER PARAMETERS.



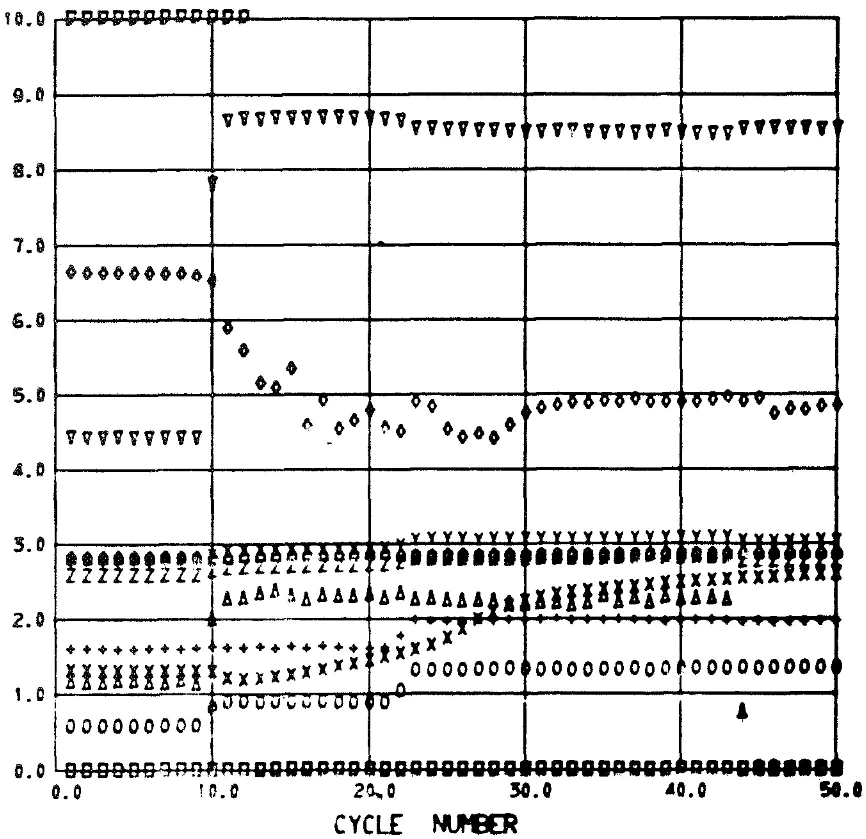
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 8 CONDENSER PARAMETERS RDG 379
4 22 19 55 38

□	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
Δ	COND. HG OUTLET PRESS	X	10 PSIA
∇	COND. OUTLET V-210 POS.	X	10 0/0

FIGURE 8(h) CONTINUED. - STARTUP 15. CYCLES 51 TO 69. CONDENSER PARAMETERS.

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 379
4 22 19 55 38



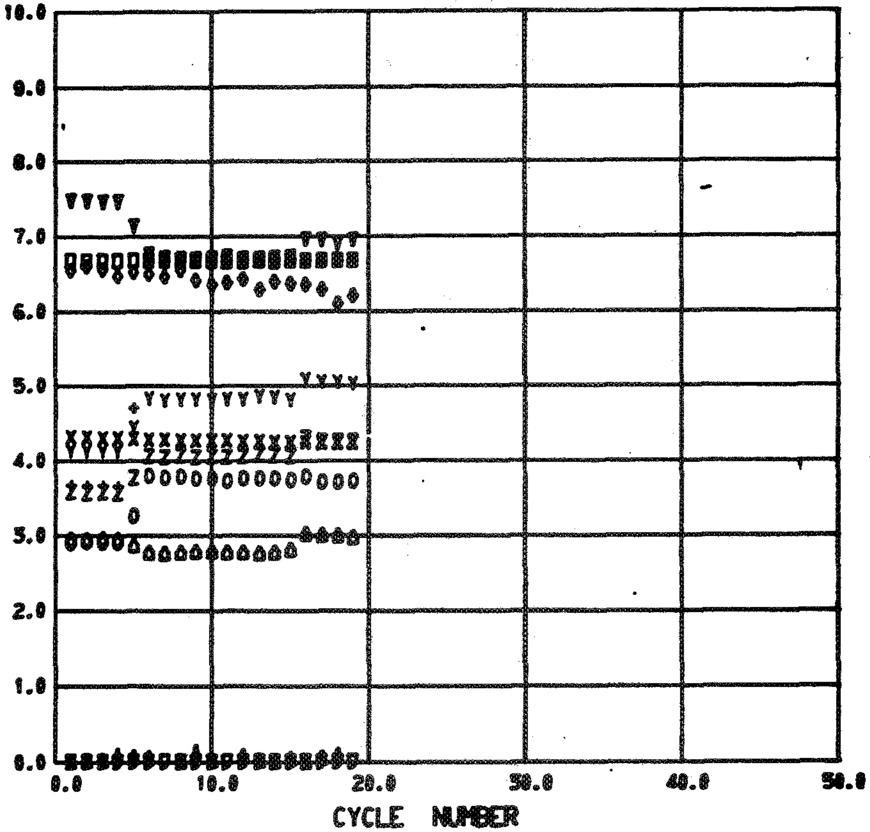
W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 379
4 22 19 55 38

□	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

11.42 SECONDS BETWEEN CYCLES

FIGURE B[illegible] - STARTUP 15. CYCLES 1 TO 50. HG-HRL-AUX. LOOP PARAMETERS

H-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 379
4 22 19 55 38

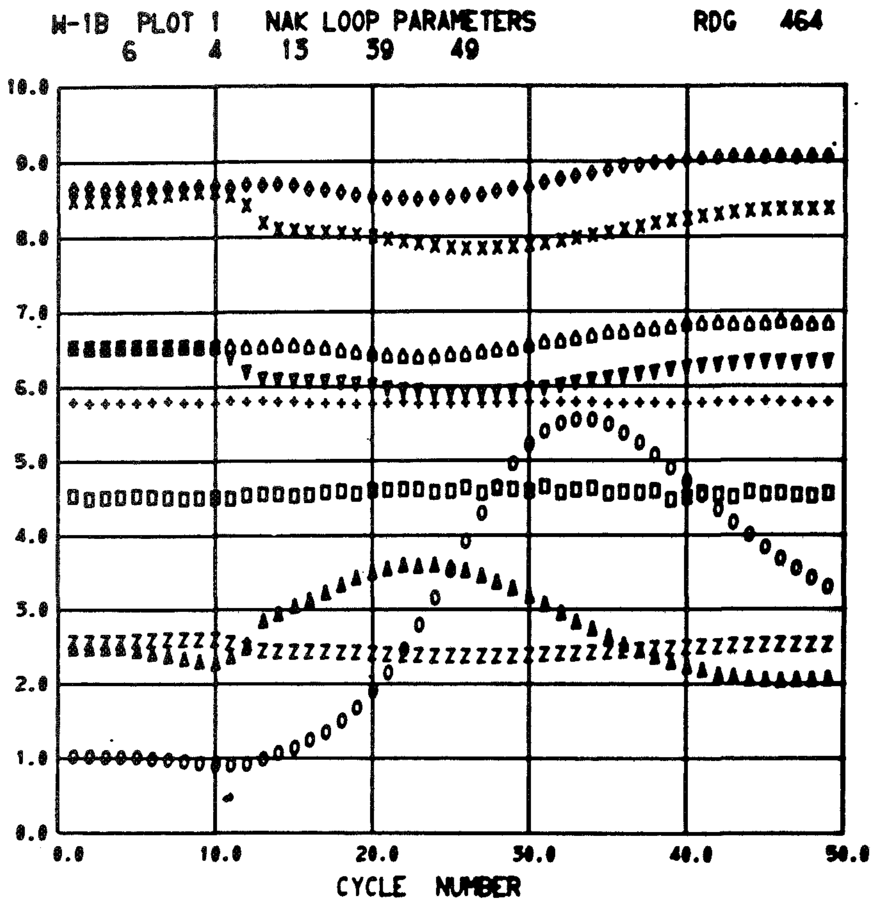


11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 379
4 22 19 55 38

□	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

FIGURE. 8(i) CONTINUED. - STARTUP 15. CYCLES 51 TO 69. HG-HRL-AUX. LOOP PARAMETERS.



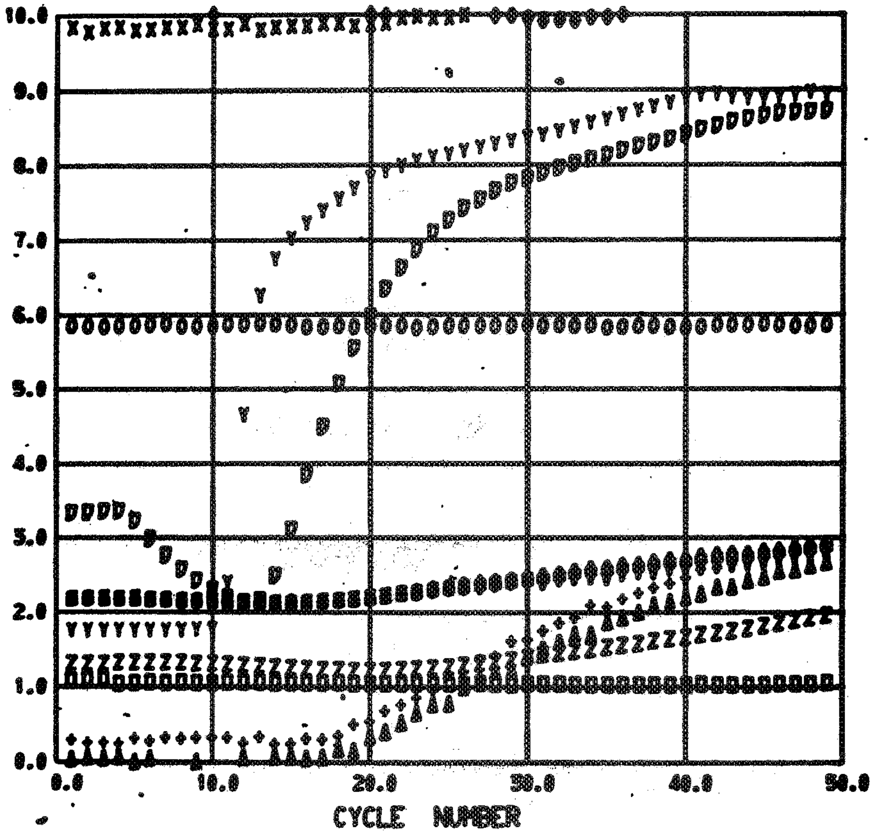
W-1B PLOT 1 NAK LOOP PARAMETERS RDG 464
6 4 13 39 49

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 9(a). - STARTUP 58. NAK LOOP PARAMETERS.

W-1B PLOT 2 HRL PARAMETERS RDG 464
6 4 13 39 49

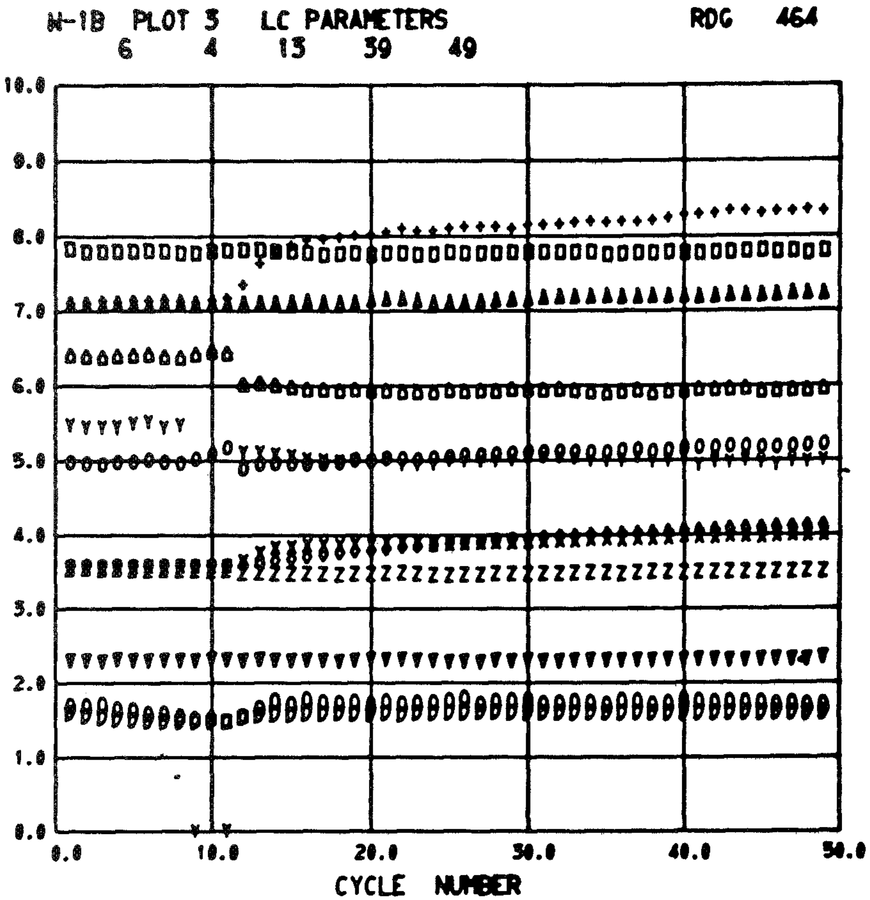


W-1B PLOT 2 HRL PARAMETERS RDG 464
6 4 13 39 49

□	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

FIGURE 9(b).- STARTUP 58. HRL PARAMETERS.



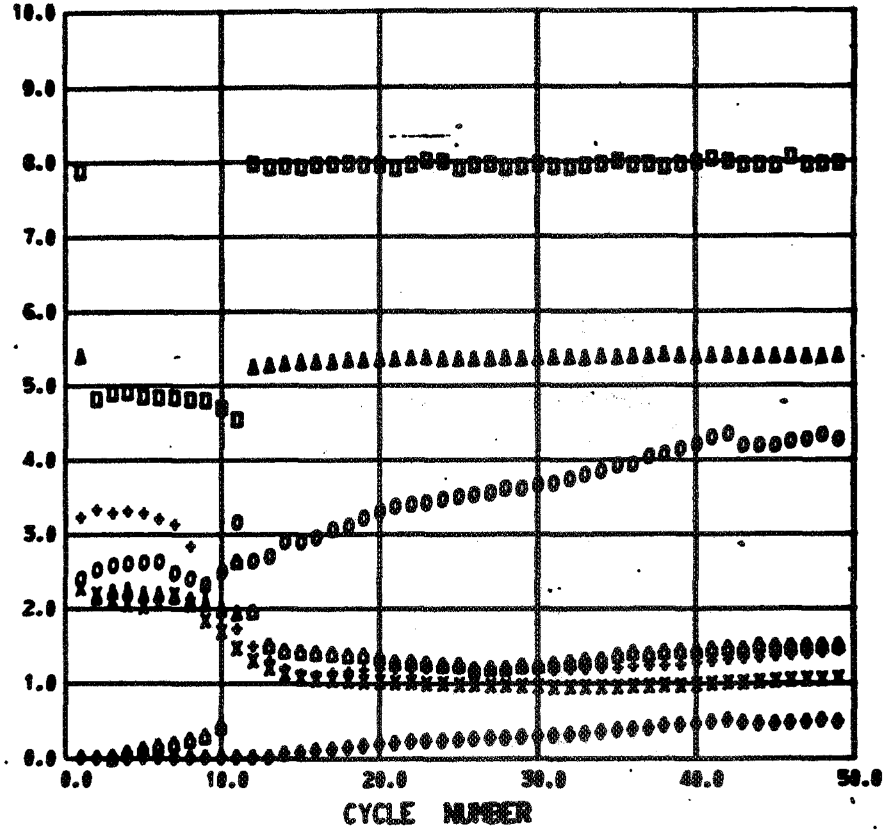
W-1B PLOT 3 LC PARAMETERS RDG 464
6 4 13 39 49

□	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
Ω	HG PMA MHE OUTLET TEMP	X	100 F

11.43 SECONDS BETWEEN CYCLES

FIGURE 9(c). – STARTUP 58. L/C PARAMETERS.

H-1B PLOT 4 HG PARAMETERS RDG 464
6 4 15 39 49

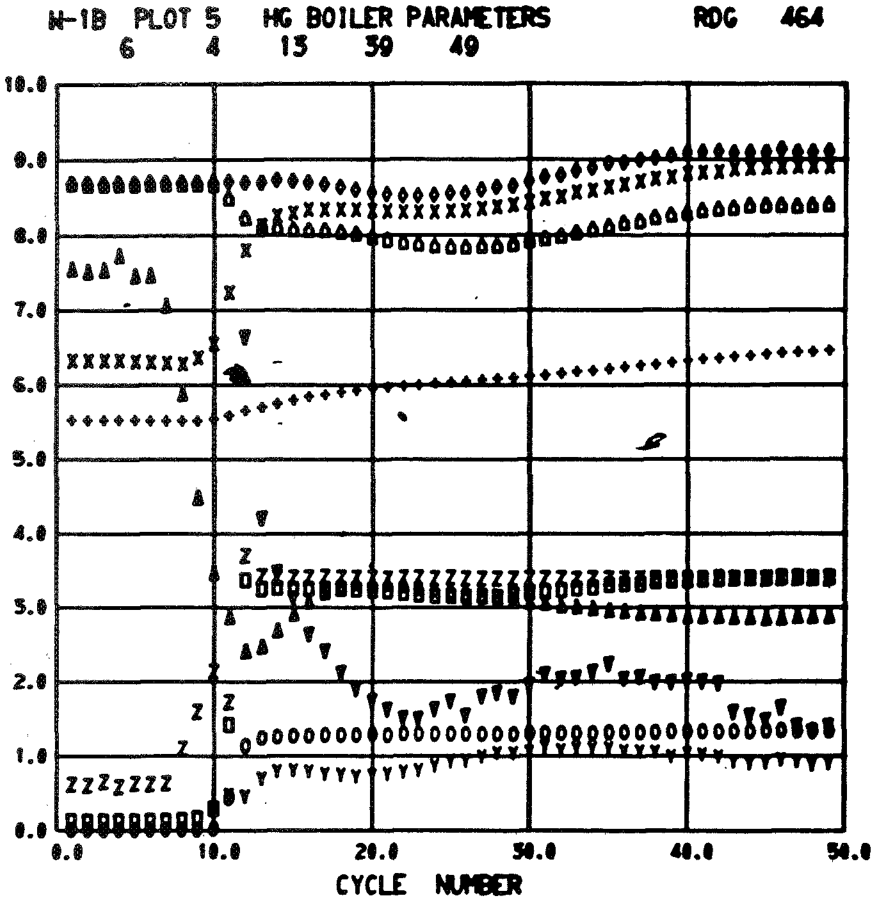


H-1B PLOT 4 HG PARAMETERS RDG 464
6 4 15 39 49

□	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 0/0

11.43 SECONDS BETWEEN CYCLES

FIGURE 9(d). - STARTUP 58. HG PARAMETERS.

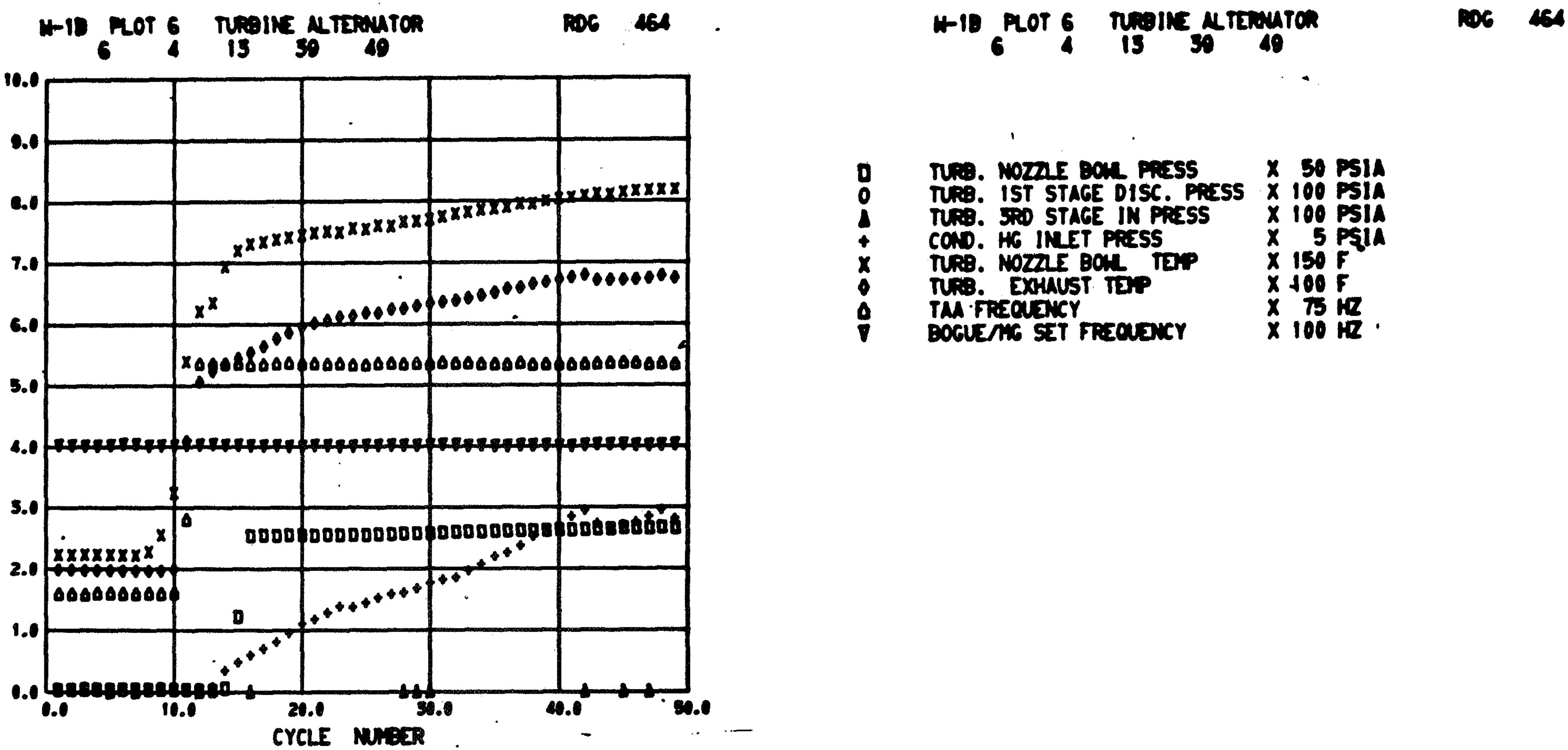


W-1B PLOT 5 HG BOILER PARAMETERS RDG 464
6 4 13 39 49

□	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		

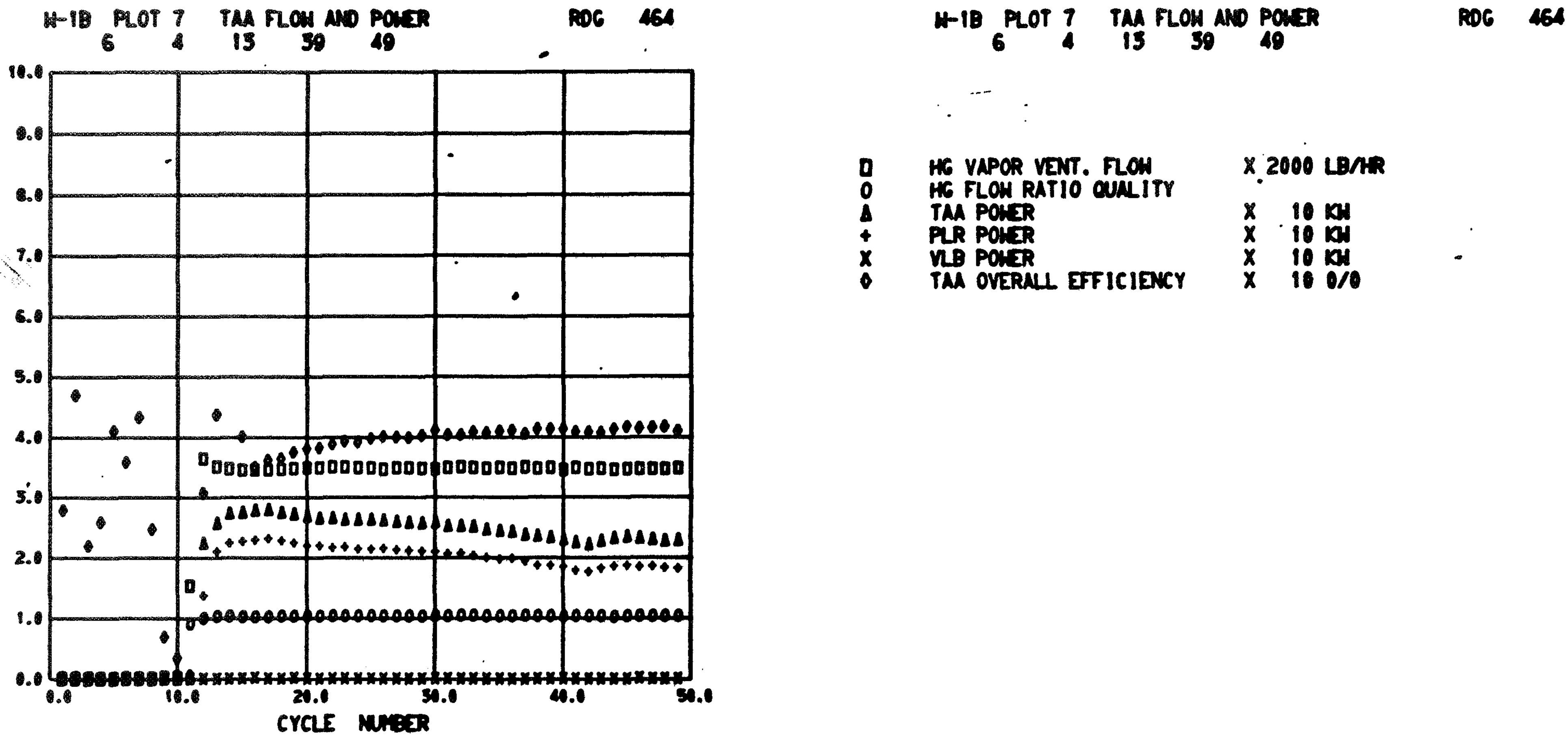
11.43 SECONDS BETWEEN CYCLES

FIGURE 9(e). - STARTUP 58. HG BOILER PARAMETERS.



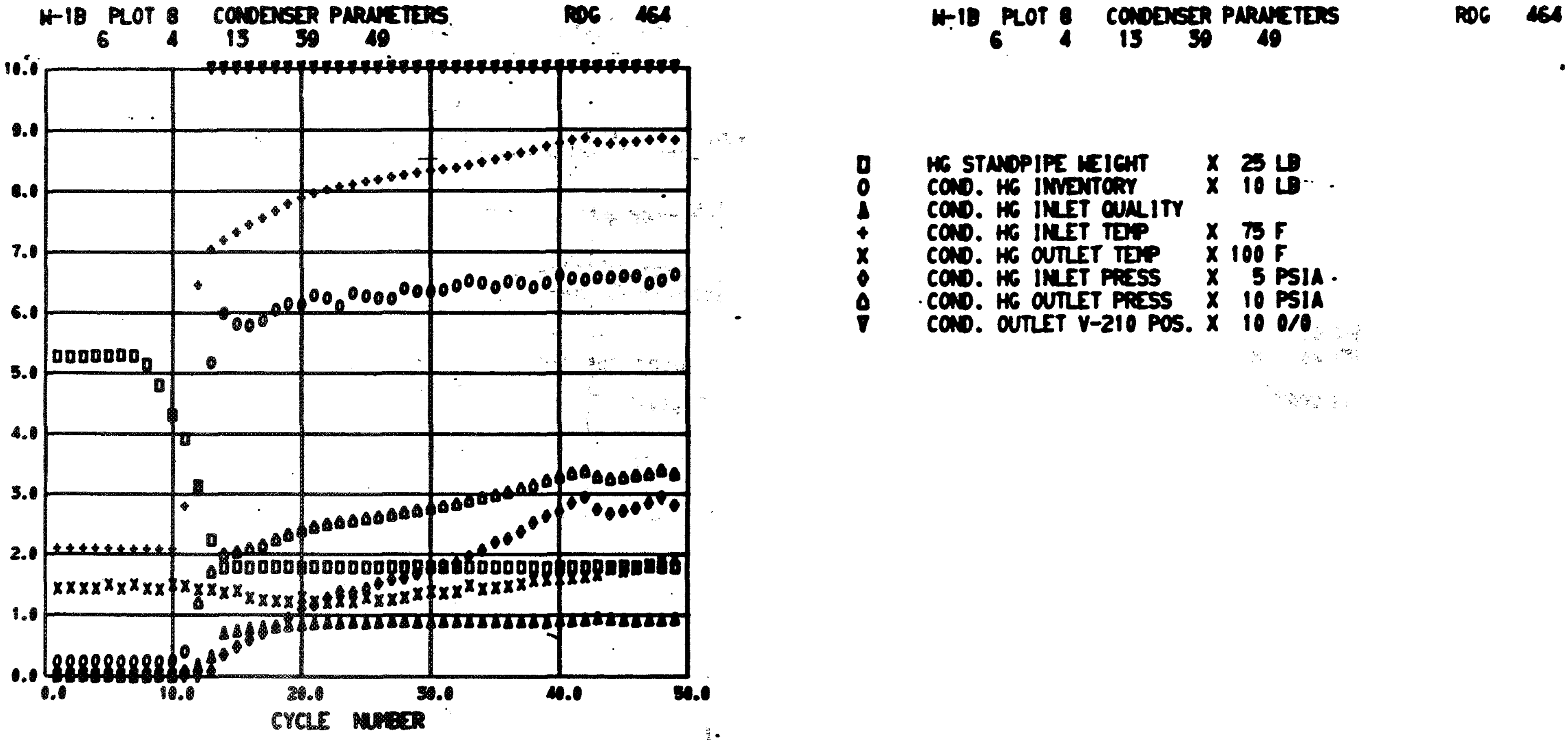
11.43 SECONDS BETWEEN CYCLES

FIGURE 9(f). - STARTUP 58. TURBINE-ALTERNATOR PARAMETERS.



11.43 SECONDS BETWEEN CYCLES

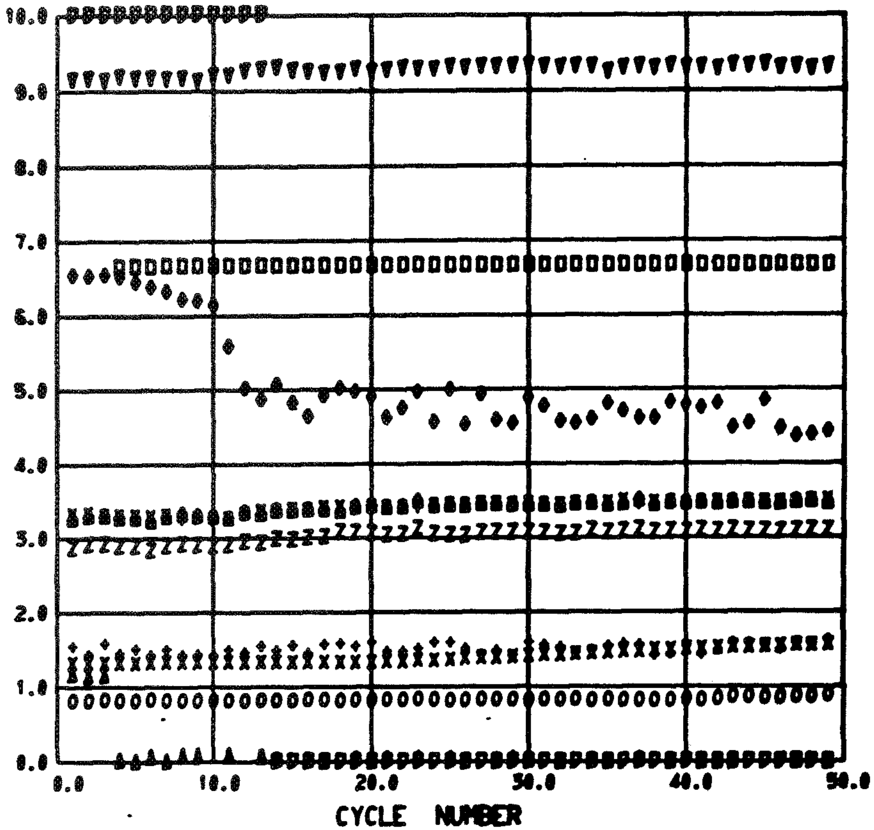
FIGURE 9(g). - STARTUP 58. TAA FLOW AND POWER PARAMETERS.



11.43 SECONDS BETWEEN CYCLES

FIGURE 9(h). - STARTUP 58. CONDENSER PARAMETERS.

N-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 464
6 4 13 39 49

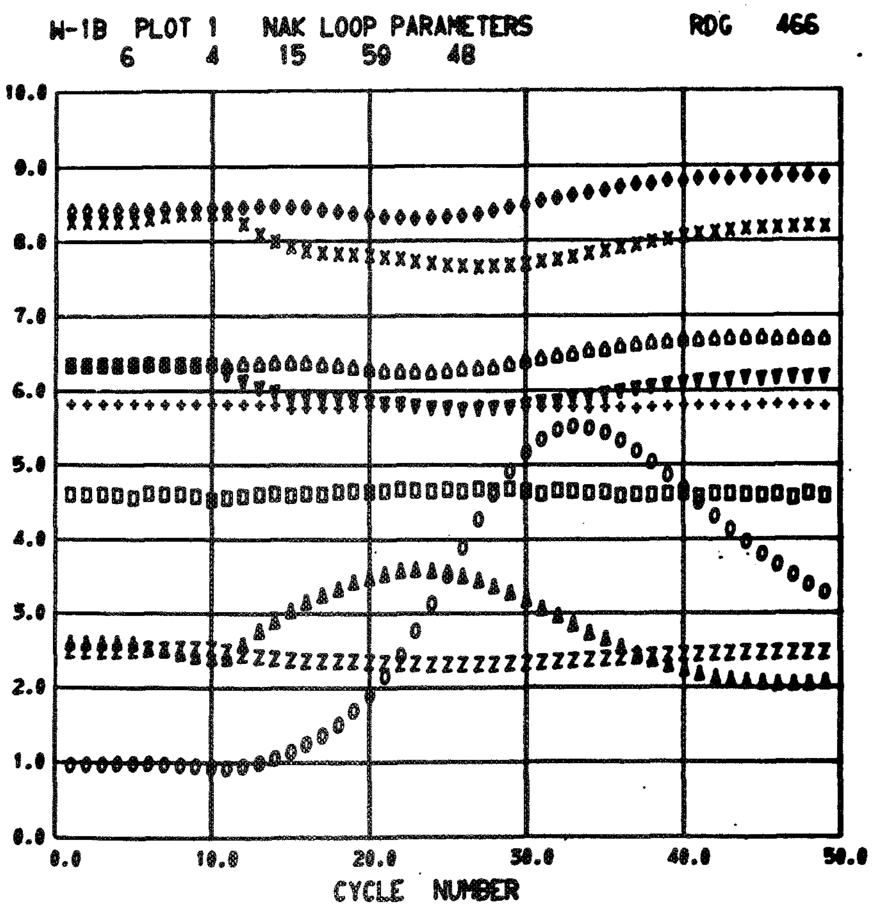


11.43 SECONDS BETWEEN CYCLES

N-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 464
6 4 13 39 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

FIGURE 9(i).- STARTUP 58. HG-HRL-AUX. LOOP PARAMETERS.

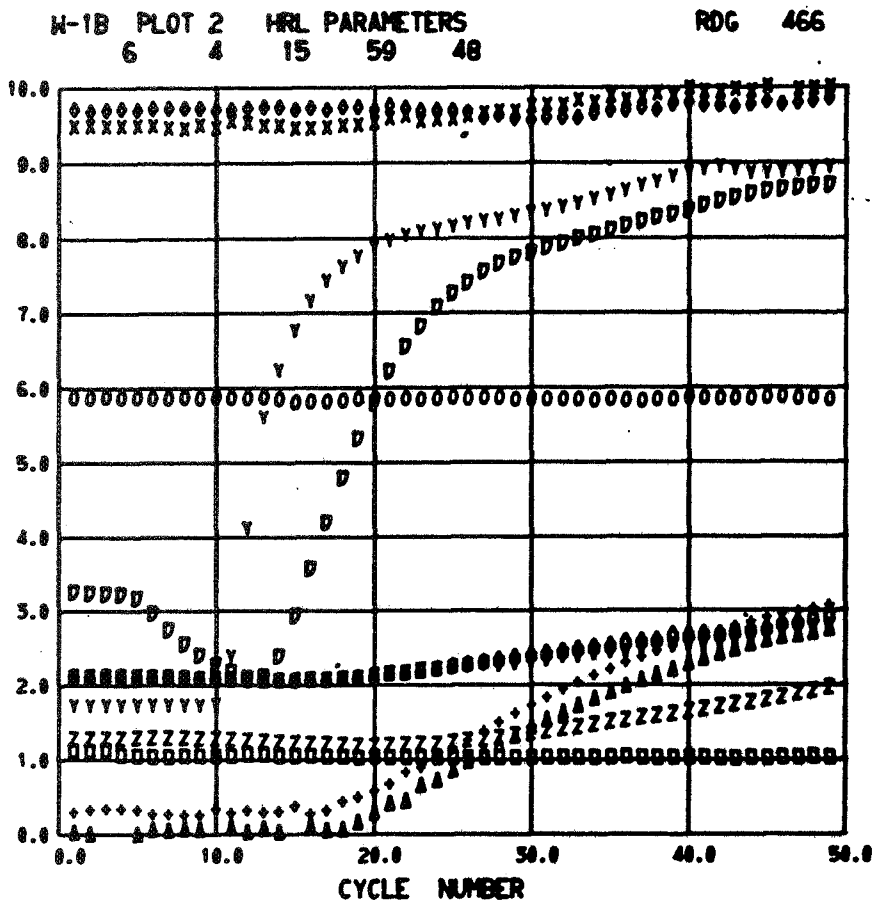


W-1B PLOT 1 NAK LOOP PARAMETERS RDG 466
6 4 15 59 48

□	PRI NAK FLOW	X	10000	LB/HR
O	IGNITRON PWR	X	100	KW
▲	EXCESS REACT	X	10 -25	CENT
+	PMPMA 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	PMPMA INLET TEMP	X	500	F

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(2). - STARTUP 60. NAK LOOP PARAMETERS.

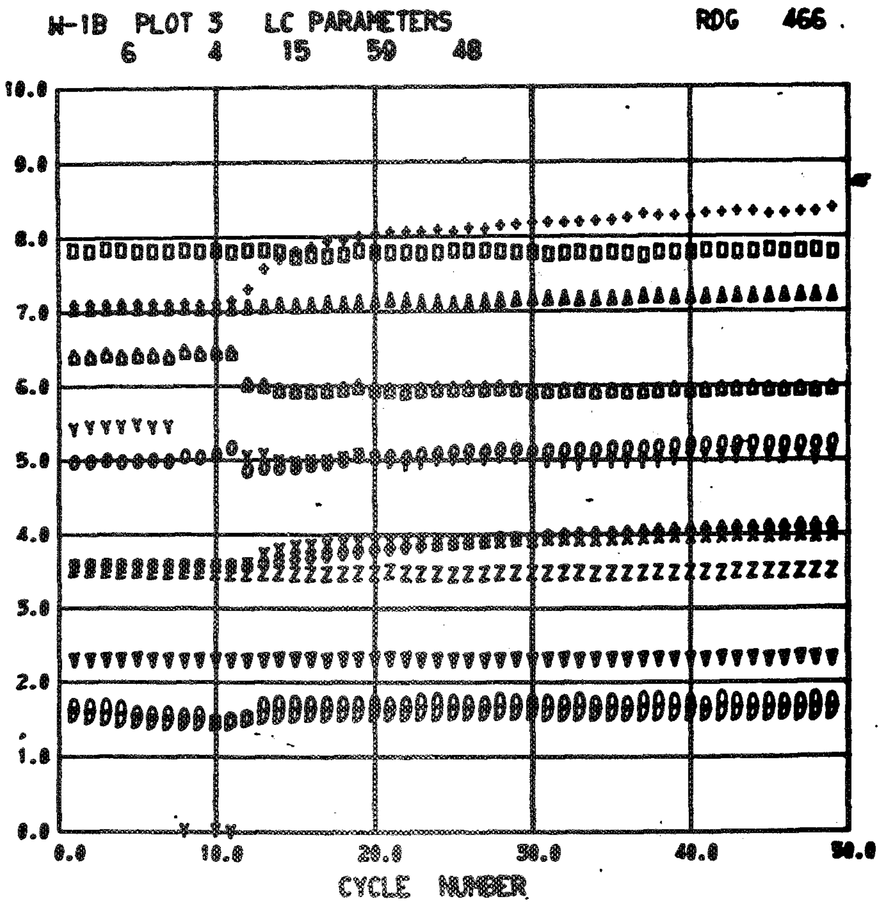


W-1B PLOT 2 HRL PARAMETERS RDG 466
6 4 15 59 48

□	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

FIGURE 10(b). - STARTUP 60. HRL PARAMETERS.

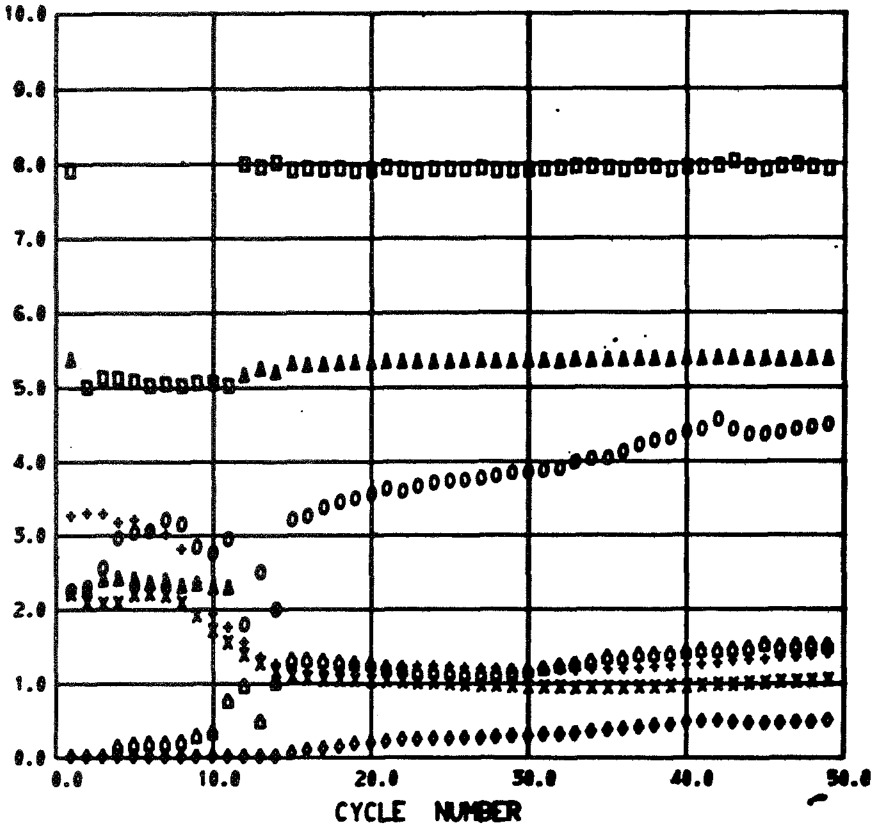


H-1B PLOT 3 LC PARAMETERS RDG 466
6 4 15 59 48

□	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
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

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(c). – STARTUP 60. L/C PARAMETERS.

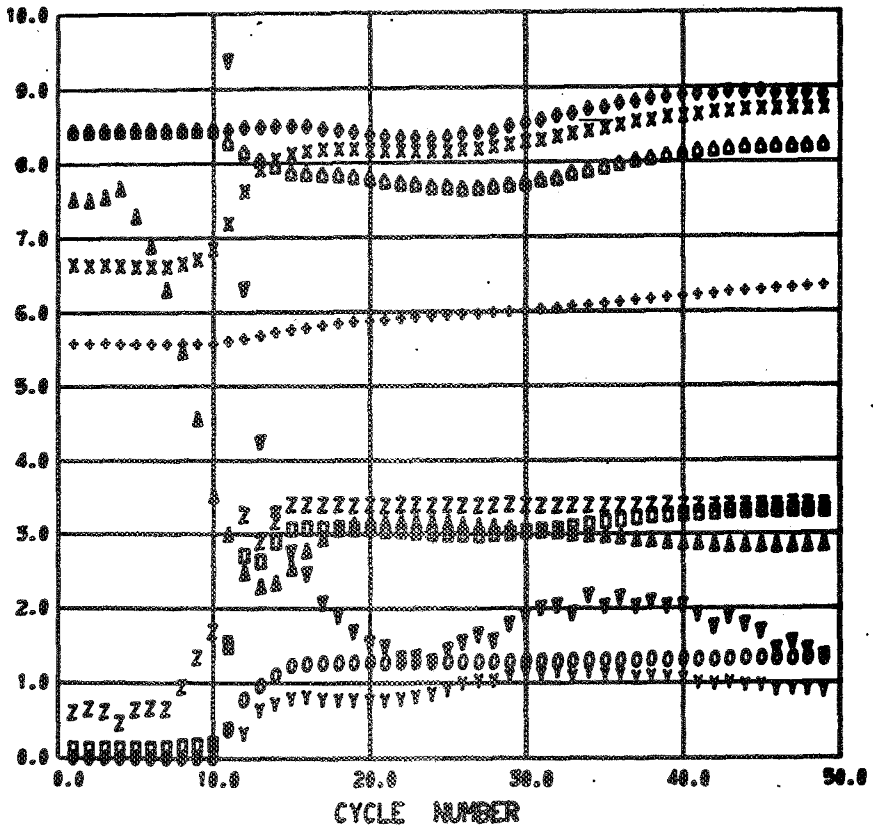


W-1B PLOT 4 HG PARAMETERS RDG 466
6 4 15 59 48

□	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
Δ	HG FCV POSITION	X	10 0/0

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(d).- STARTUP 60. HG LOOP PARAMETERS.

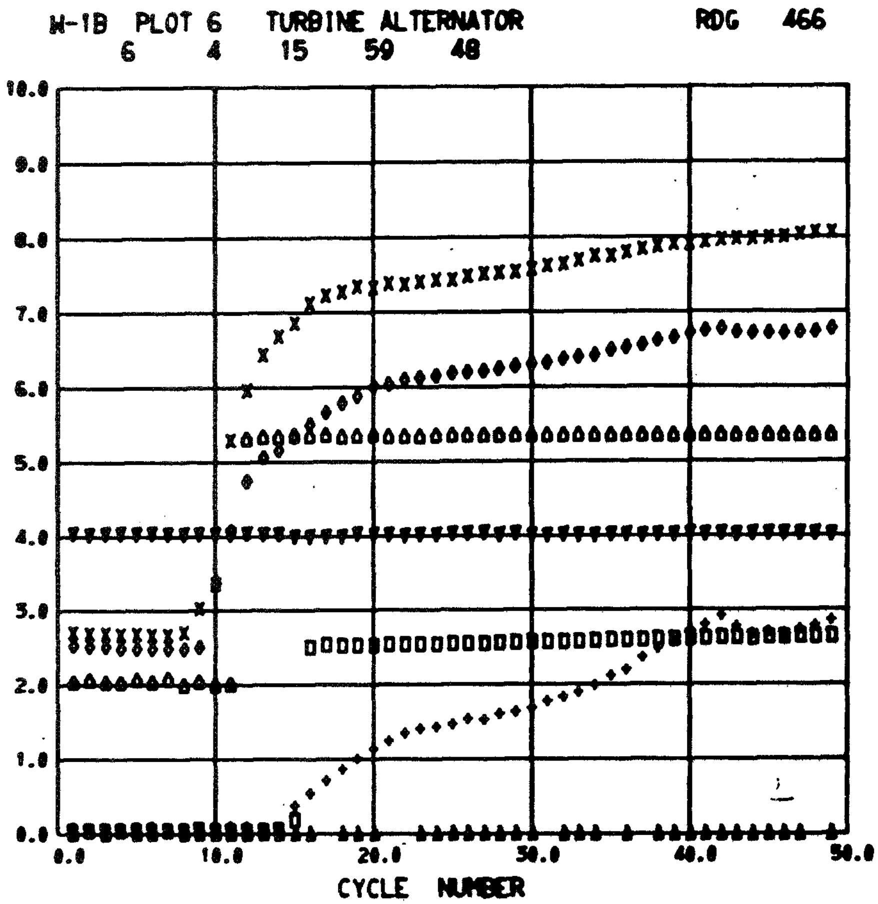


W-1B PLOT 5 HG BOILER PARAMETERS RDG 466
6 4 15 59 48

□	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		

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(e).- STARTUP 60. HG BOILER PARAMETERS.



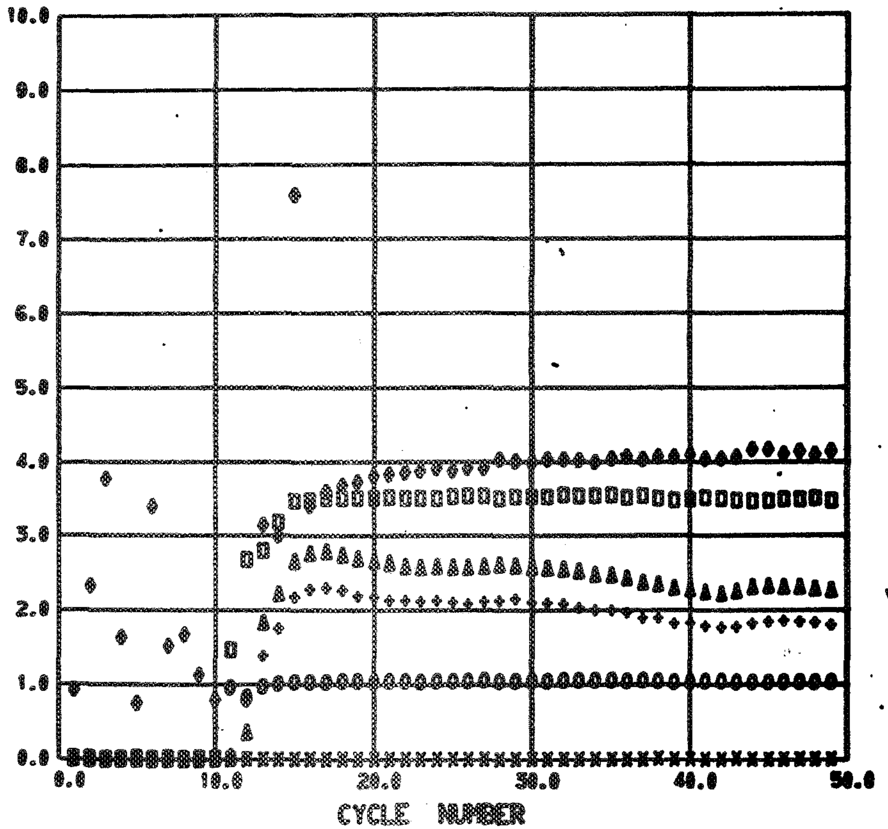
H-1B PLOT 6 TURBINE ALTERNATOR RDG 466
6 4 15 59 48

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(f).- STARTUP 60. TURBINE- ALTERNATOR PARAMETERS.

W-1B PLOT 7 TAA FLOW AND POWER RDG 466
6 4 15 59 48

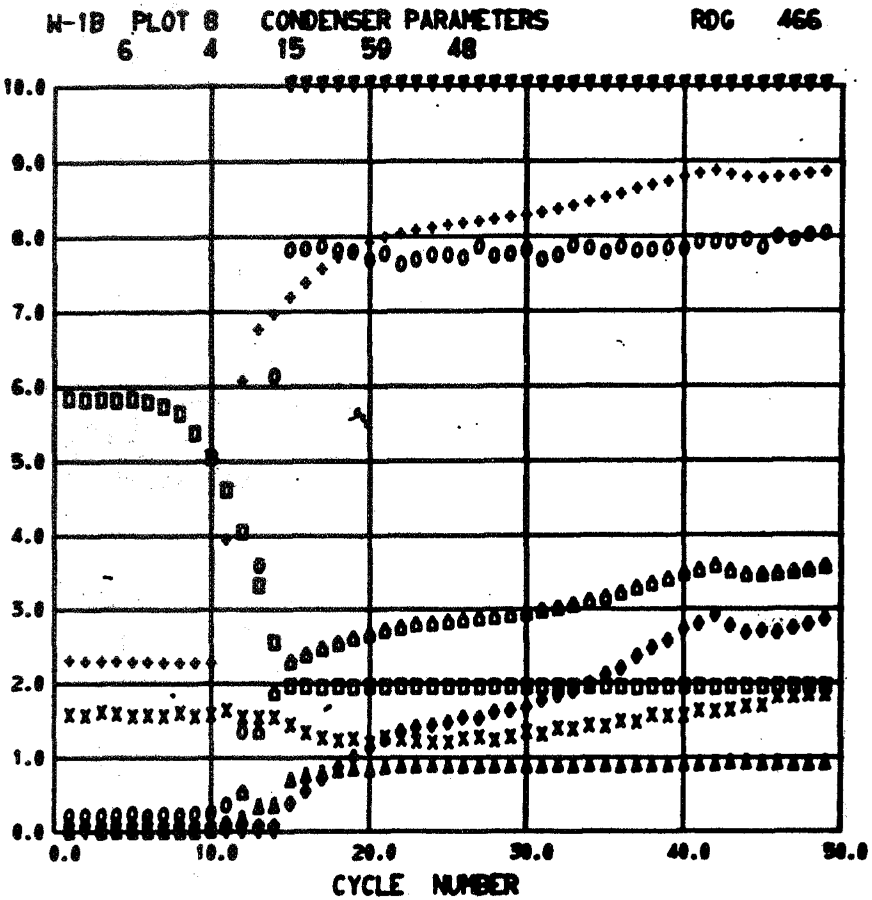


W-1B PLOT 7 TAA FLOW AND POWER RDG 466
6 4 15 59 48

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(g). - STARTUP 60: TAA FLOW AND POWER PARAMETERS.

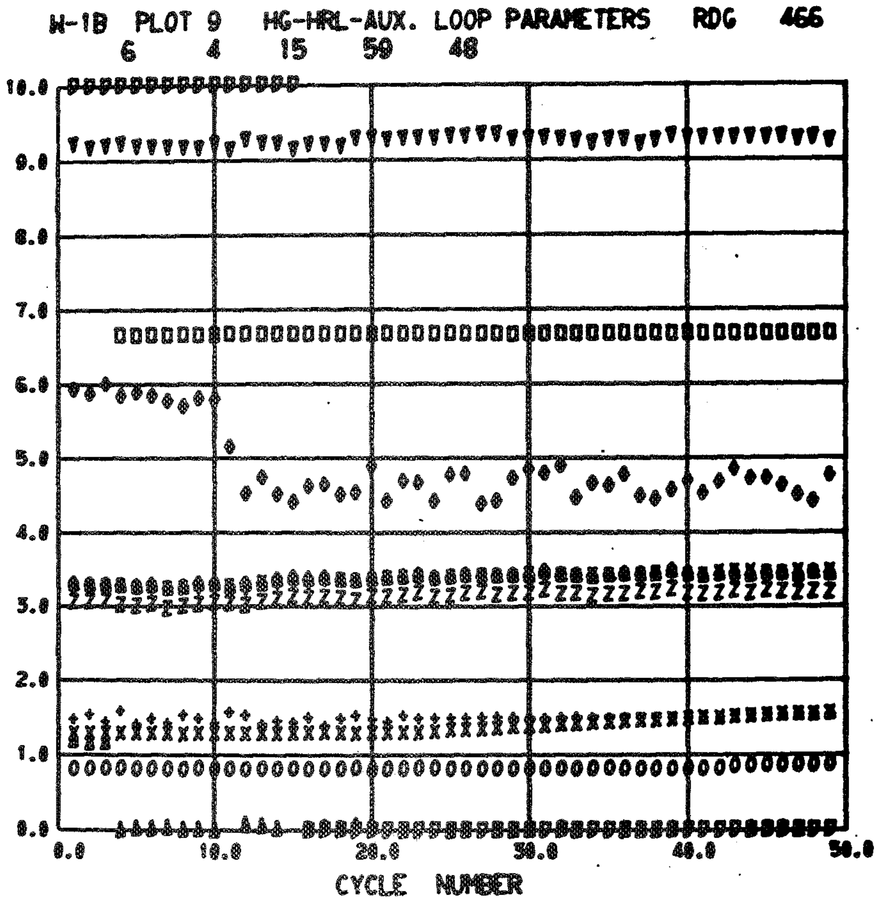


W-1B PLOT 8 CONDENSER PARAMETERS RDG 466
6 4 15 59 48

□	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

FIGURE 10(h). – STARTUP 60. CONDENSER PARAMETERS.

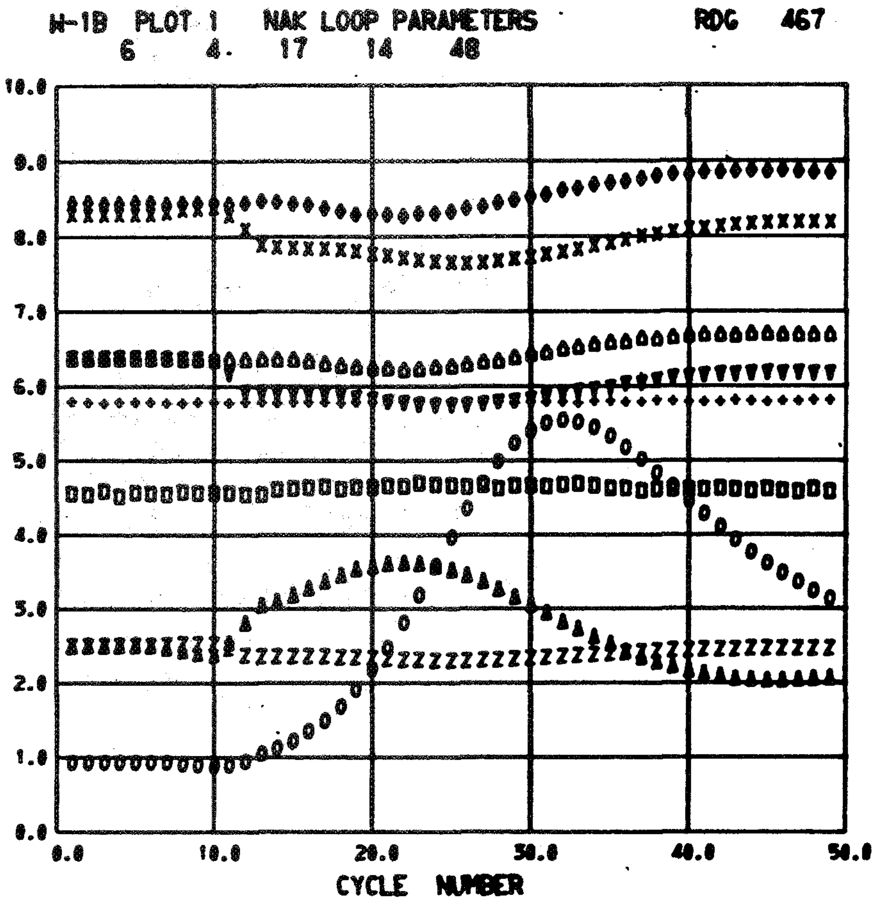


W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 466
6 4 15 59 48

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 10(i). - STARTUP 60. HG-HRL-AUX LOOP PARAMETERS.



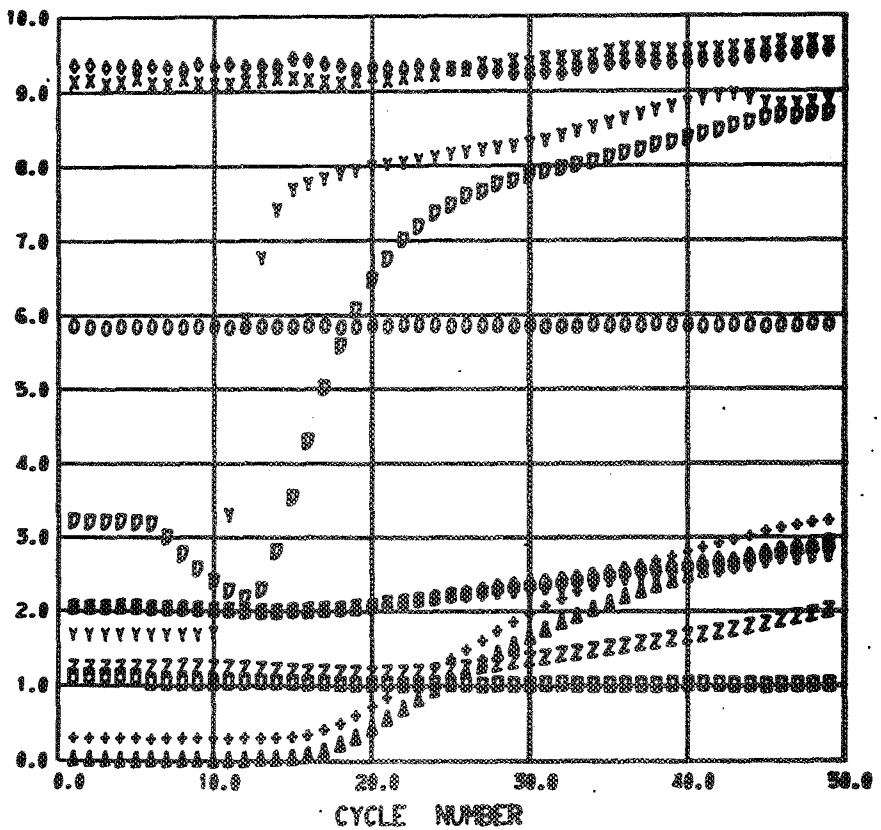
W-1B PLOT 1 NAK LOOP PARAMETERS RDG 467
6 4 17 14 48

□	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
Δ	BOILER INLET TEMP	X	200 F
∇	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

11.43 SECONDS BETWEEN CYCLES

FIGURE 11 (2). - STARTUP 61. NAK LOOP PARAMETERS.

W-1B PLOT 2 HRL PARAMETERS RDG 467
6 4 17 14 48



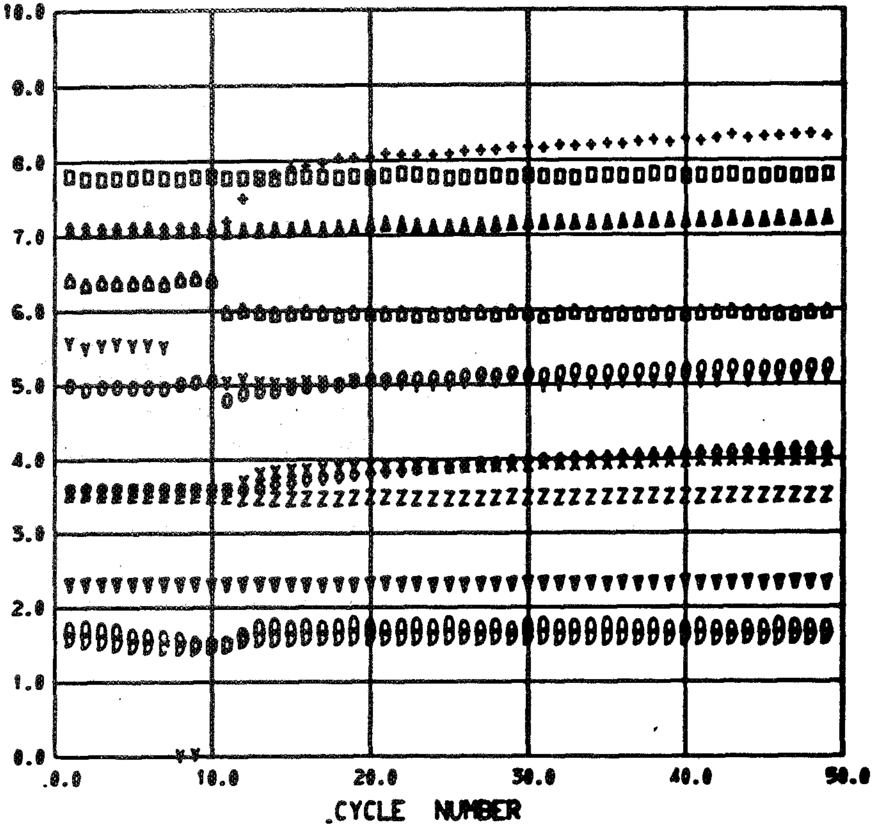
W-1B PLOT 2 HRL PARAMETERS RDG 467
6 4 17 14 48

D	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

FIGURE 11(b). - STARTUP 61. HRL PARAMETERS.

W-1B PLOT 3 LC PARAMETERS RDG 467
6 4 17 14 48



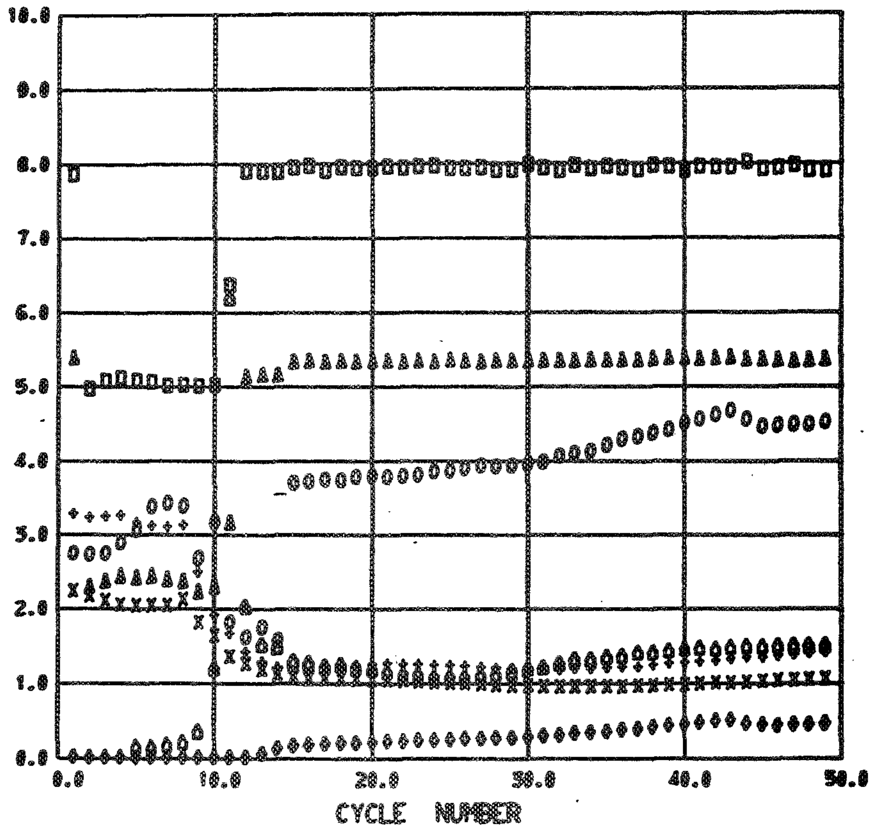
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 3 LC PARAMETERS RDG 467
6 4 17 14 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
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

FIGURE 11(a). - STARTUP 61. L/C PARAMETERS.

W-1B PLOT 4 HG PARAMETERS RDG 467
6 4 17 14 48



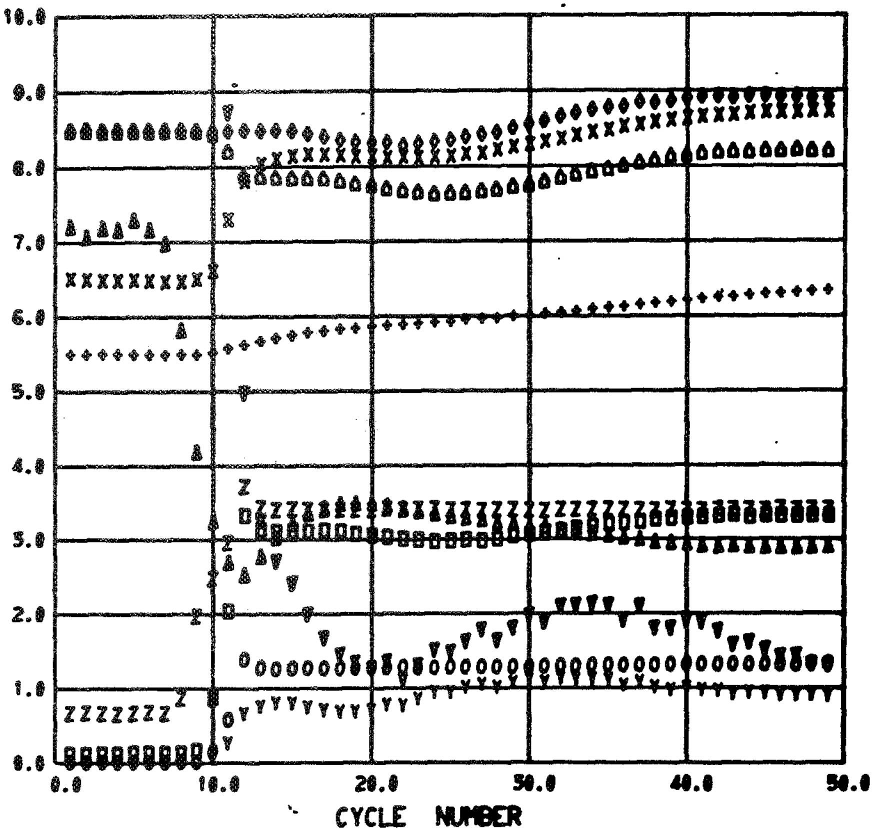
W-1B PLOT 4 HG PARAMETERS RDG 467
6 4 17 14 48

□	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
Δ	HG FCV POSITION	X	10 0/0

1.643 SECONDS BETWEEN CYCLES

FIGURE 11 (d). - STARTUP 61. HG LOOP PARAMETERS.

W-1B PLOT 5 HG BOILER PARAMETERS RDG 467
6 4 17 14 48

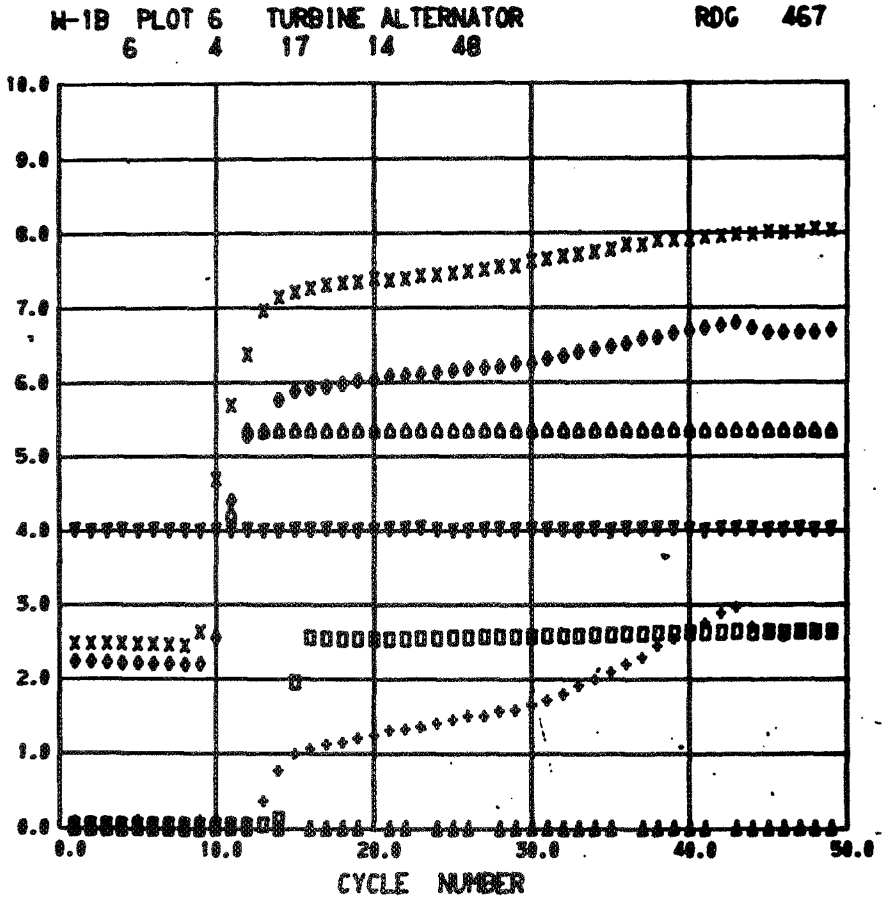


W-1B PLOT 5 HG BOILER PARAMETERS RDG 467
6 4 17 14 48

□	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		

11.43 SECONDS BETWEEN CYCLES

FIGURE 11 (e). - STARTUP 61. HG BOILER PARAMETERS.



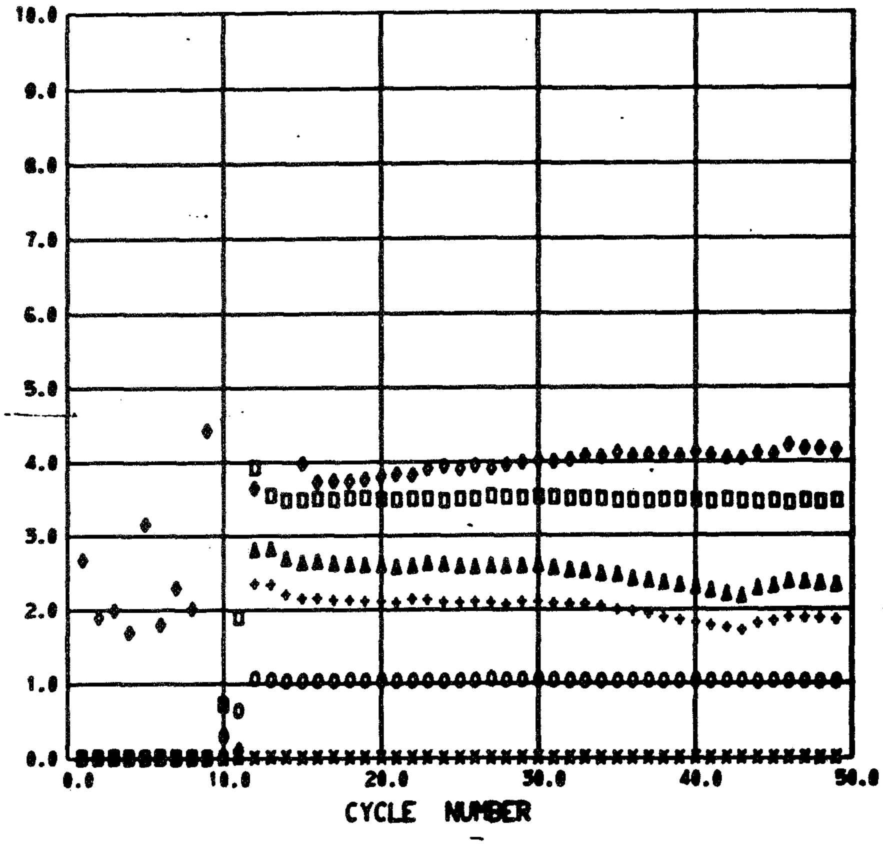
W-1B PLOT 6 TURBINE ALTERNATOR RDG 467
6 4 17 14 48

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 11(f). - STARTUP 61. TURBINE - ALTERNATOR PARAMETERS.

W-1B PLOT 7 TAA FLOW AND POWER RDG 467
6 4 17 14 48

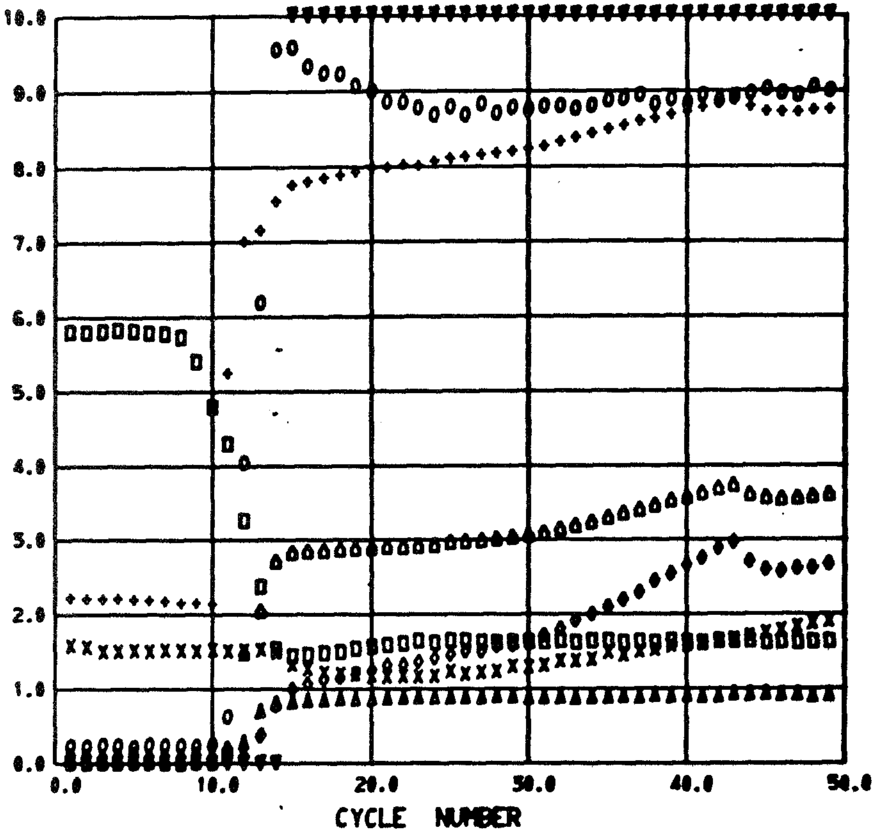


W-1B PLOT 7 TAA FLOW AND POWER RDG 467
6 4 17 14 48

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 11(8).- STARTUP 61. TAA FLOW AND POWER PARAMETERS.



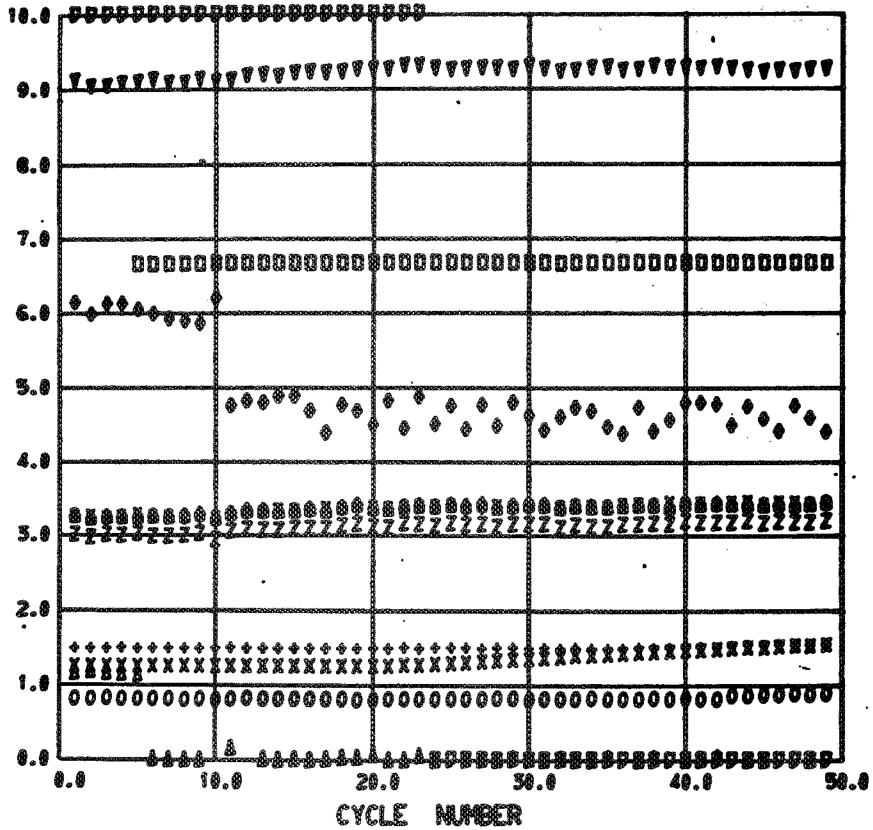
W-1B PLOT 8 CONDENSER PARAMETERS RDG 467
6 4 17 14 48

□	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
Δ	COND. HG OUTLET PRESS	X	10 PSIA
∇	COND. OUTLET V-210 POS.	X	10 0/0

11.43 SECONDS BETWEEN CYCLES

FIGURE 11(h). - STARTUP 61. CONDENSER PARAMETERS.

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 467
6 4 17 14 48

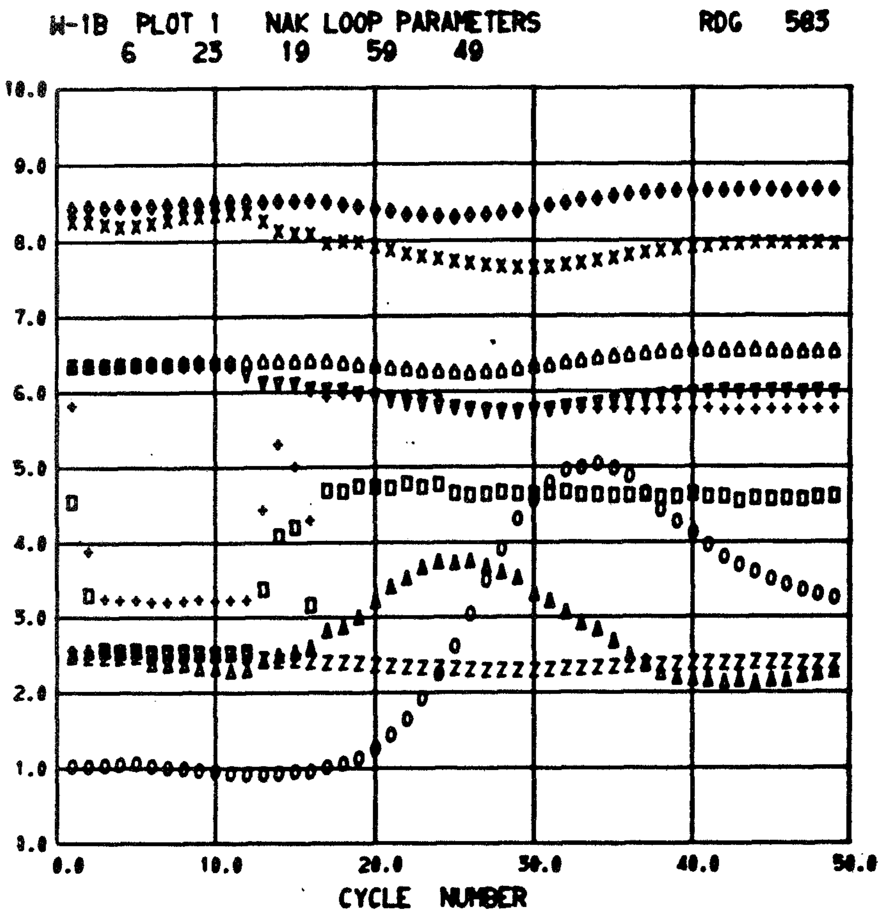


W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 467
6 4 17 14 48

□	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

FIGURE 11(i). - STARTUP 61. HG-HRL-AUX. LOOP PARAMETERS.



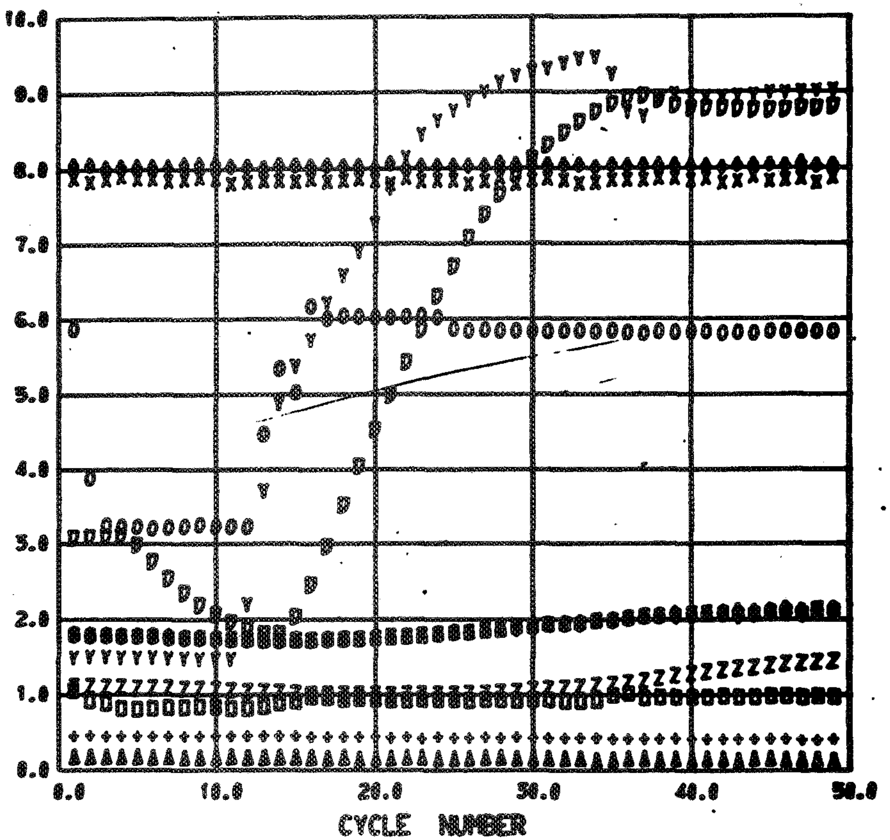
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 1 NAK LOOP PARAMETERS RDG 583
6 23 19 59 49

□	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

FIGURE 12 (a). - STARTUP 115. NAK LOOP PARAMETERS.

H-1B PLOT 2 HRL PARAMETERS RDG 585
6 25 19 59 49



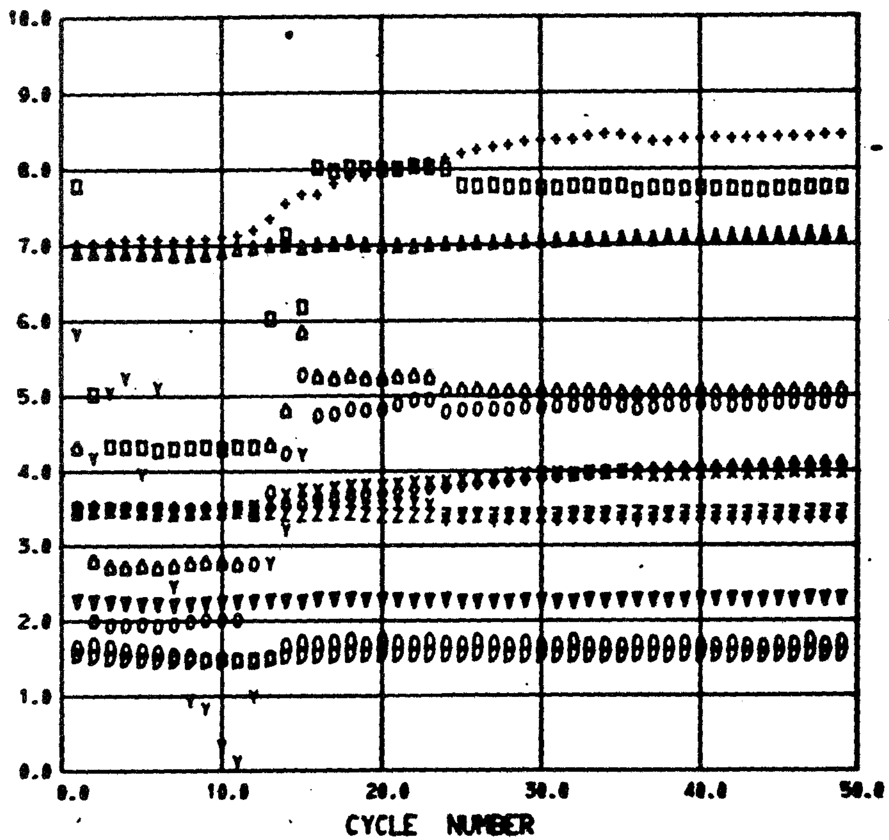
11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 2 HRL PARAMETERS RDG 585
6 25 19 59 49

□	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 12 (b). - STARTUP 115. HRL PARAMETERS.

W-1B PLOT 3 LC PARAMETERS RDG 583
6 23 19 59 49



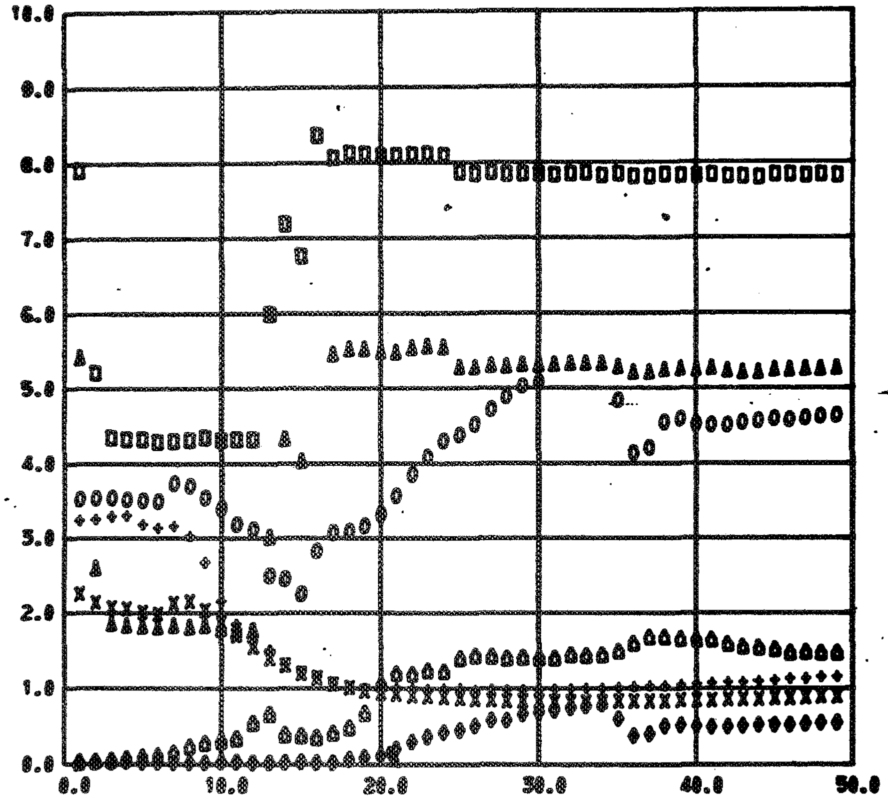
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 3 LC PARAMETERS RDG 583
6 23 19 59 49

□	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
O	HG PMA MHE OUTLET TEMP	X	100 F

FIGURE 12(c).- STARTUP 115. L/C PARAMETERS.

W-1B PLOT 4 HG PARAMETERS ROG 583
6 25 19 59 49



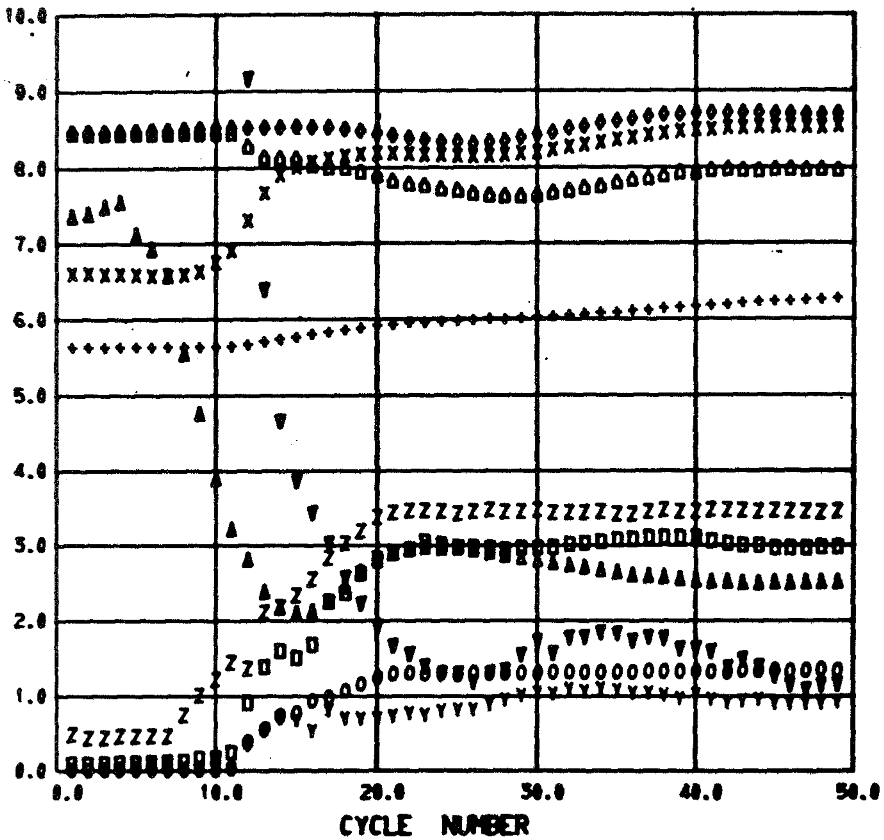
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 4 HG PARAMETERS ROG 583
6 25 19 59 49

□	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

FIGURE 12 (d). - STARTUP 115. HG LOOP PARAMETERS.

W-1B PLOT 5 HG BOILER PARAMETERS RDG 583
6 25 19 59 49

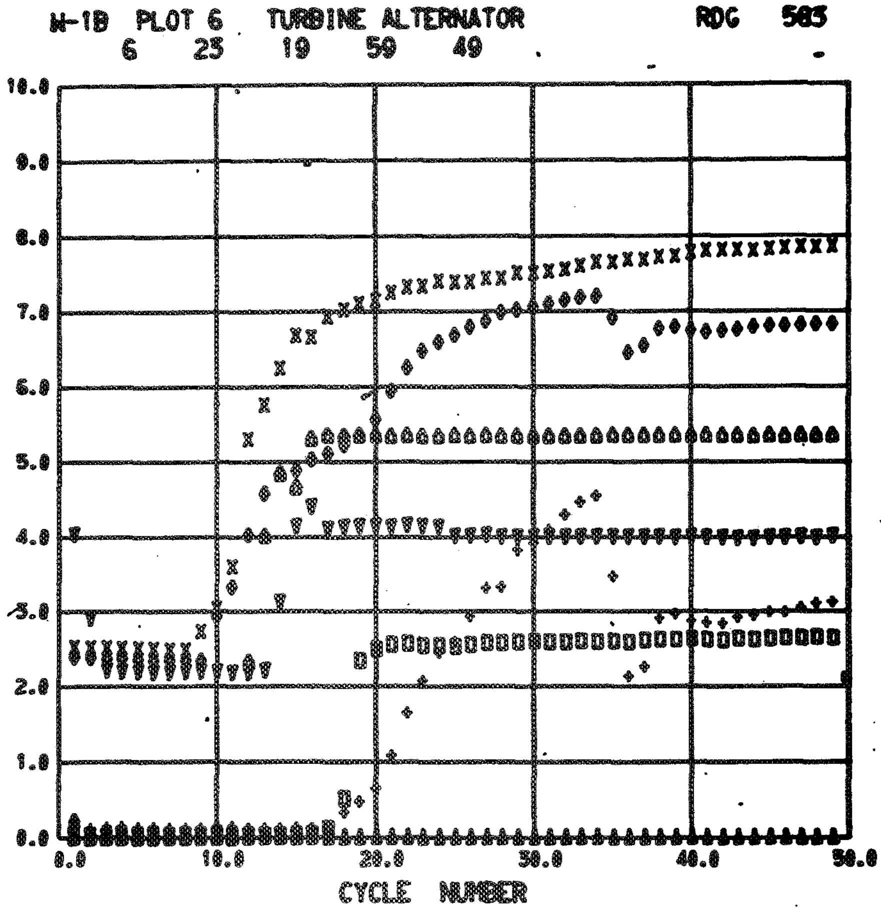


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 5 HG BOILER PARAMETERS RDG 583
6 25 19 59 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
Δ	BOILER NAK OUTLET TEMP	X	150	F
▽	BOILER TERM. TEMP DIFF.	X	20	F
Z	BOILER HG LIQUID FLOW	X	2000	L
Y	BOILER HT. BAL. QUALITY			

FIGURE 12 (e).- STARTUP 115. HG BOILER PARAMETERS.

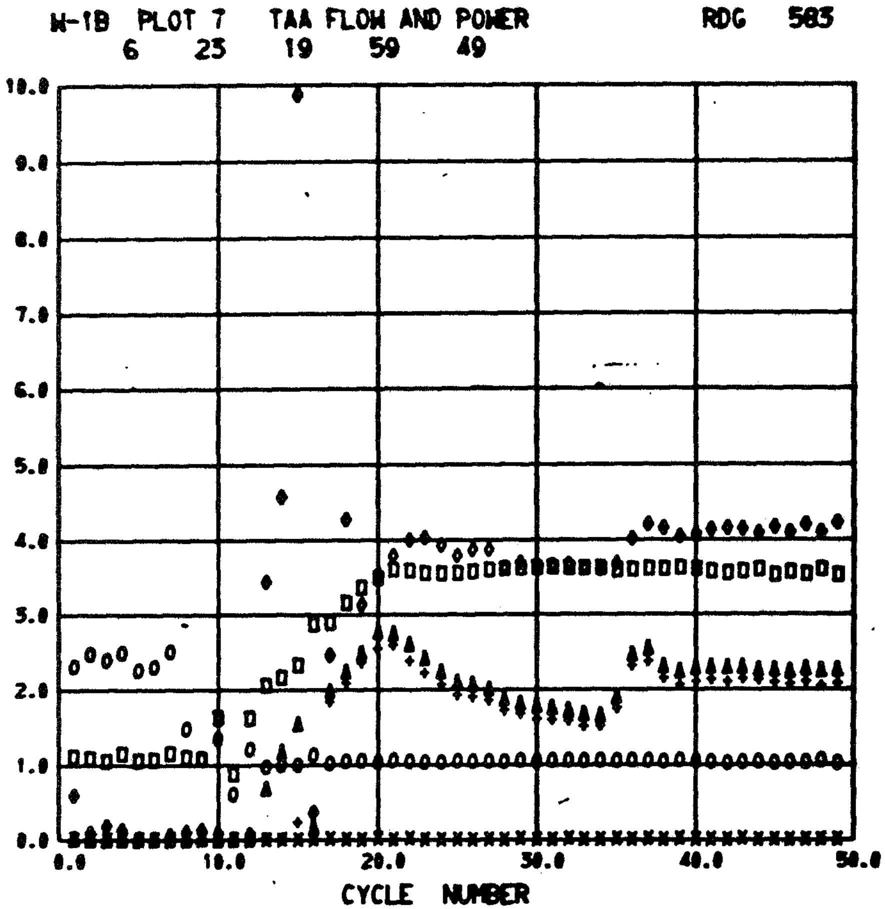


11.43 SECONDS BETWEEN CYCLES

N-1B PLOT 6 TURBINE ALTERNATOR RDG 583
6 25 19 59 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
Δ	TAA FREQUENCY	X 75 HZ
∇	BOGUE/MG SET FREQUENCY	X 100 HZ

FIGURE 12(f).- STARTUP 115. TURBINE-ALTERNATOR PARAMETERS.

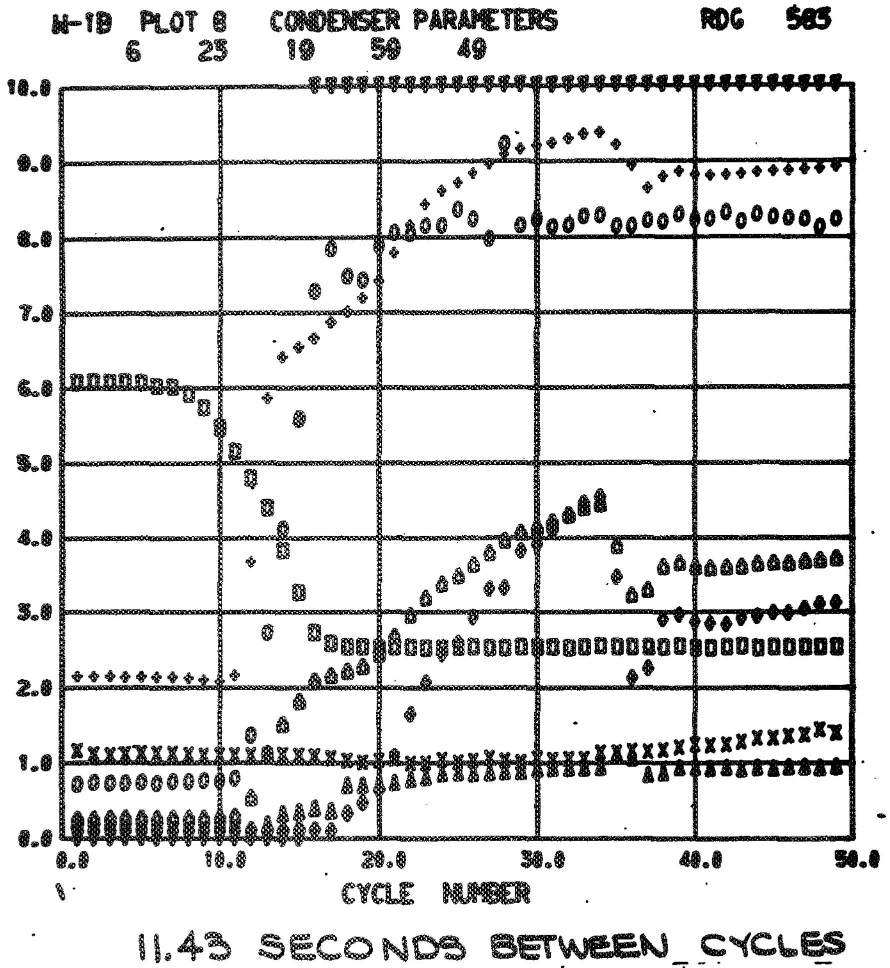


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 7 TAA FLOW AND POWER RDG 583
6 25 19 59 49

□	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

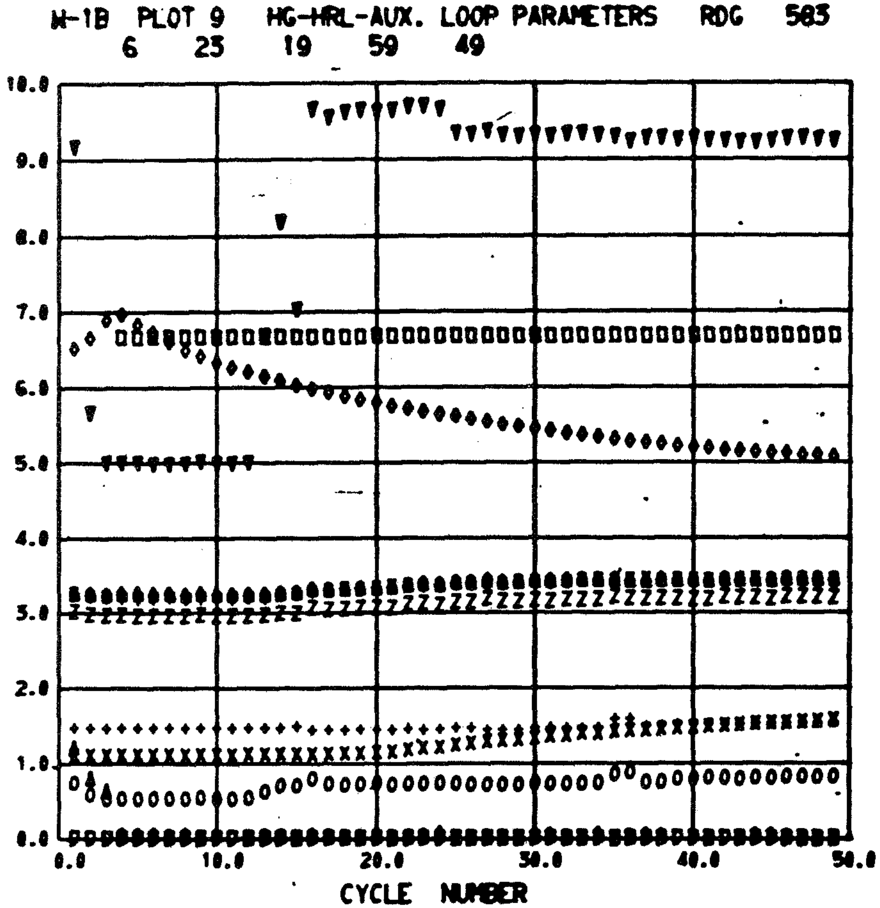
FIGURE 12 (g). - STARTUP 115. TAA FLOW AND POWER PARAMETERS.



W-1B PLOT 8 CONDENSER PARAMETERS RDG 585
6 25 19 59 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
Δ	COND. HG OUTLET PRESS	X 10 PSIA
∇	COND. OUTLET V-210 POS.	X 10 0/0

FIGURE 12(h). - STARTUP 115. CONDENSER PARAMETERS.

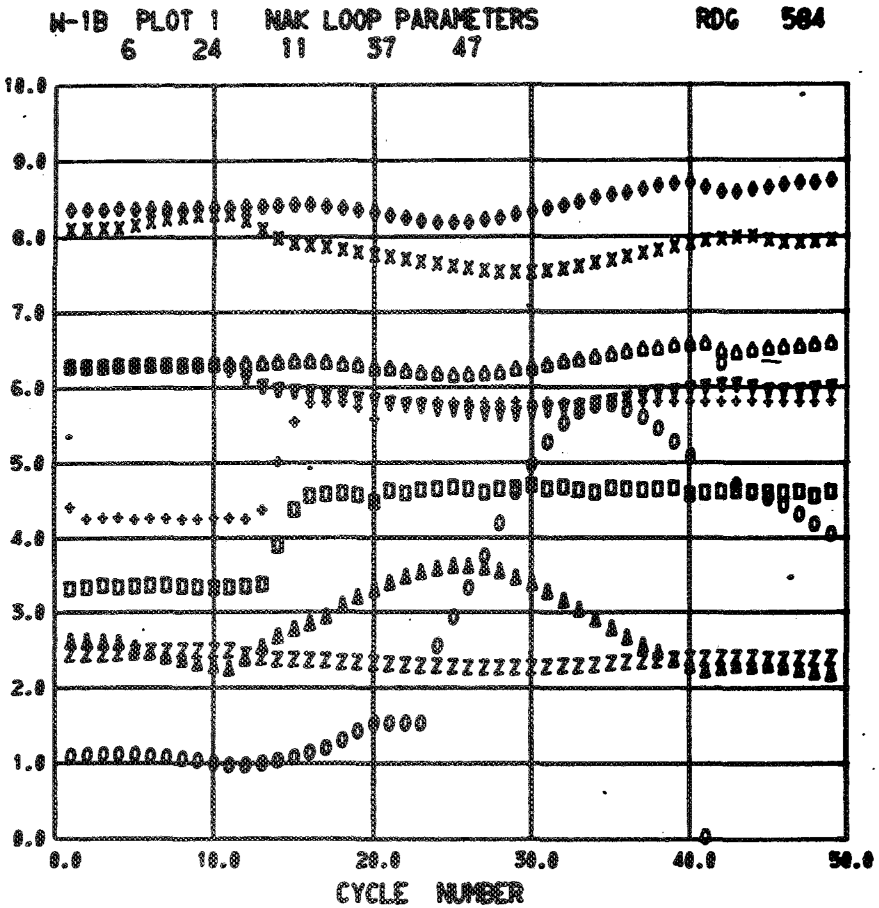


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 583
6 23 19 59 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

FIGURE 12 (i). - STARTUP 115. HG-HRL-AUX. LOOP PARAMETERS.

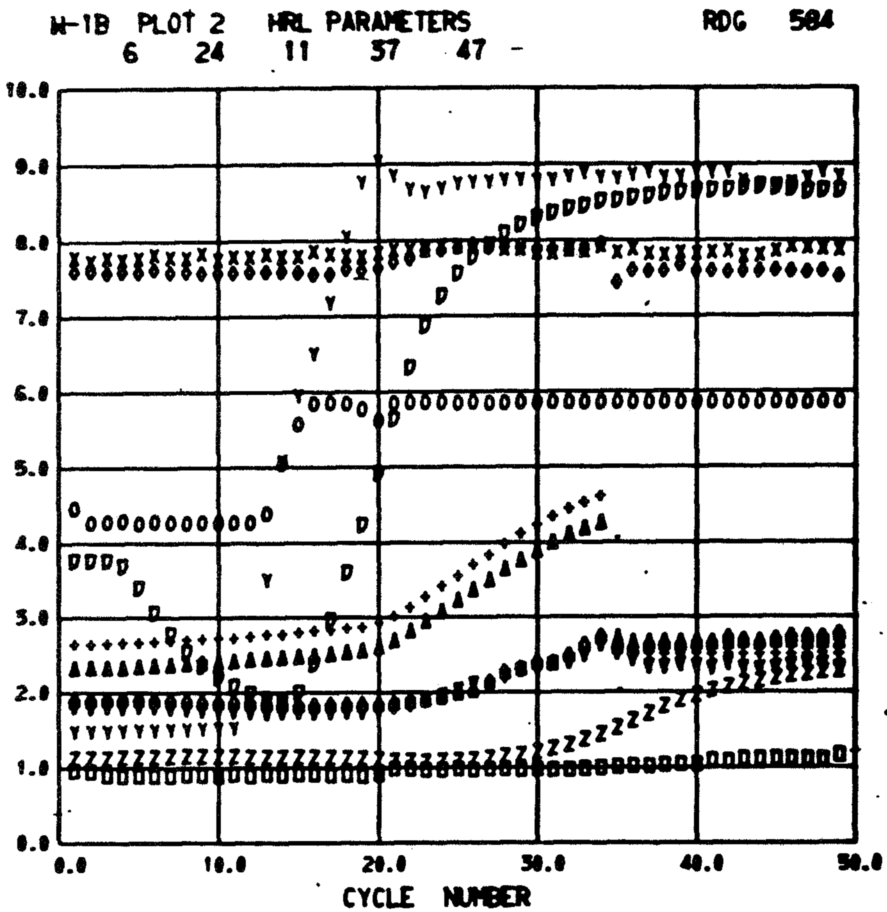


W-1B PLOT 1 NAK LOOP PARAMETERS RDG 584
6 24 11 37 47

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 13(2). - STARTUP 116. NAK LOOP PARAMETERS.



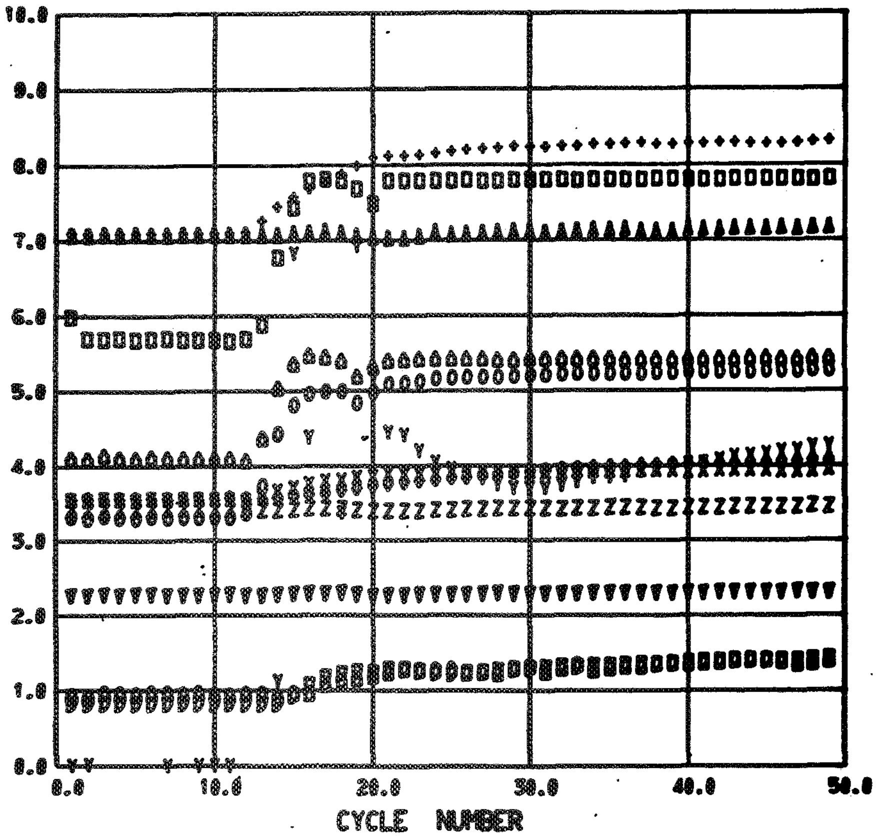
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 2 HRL PARAMETERS RDG 584
6 24 11 37 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 13(b). - STARTUP 116. HRL PARAMETERS.

W-1B PLOT 3 LC PARAMETERS RDG 504
6 24 11 37 47

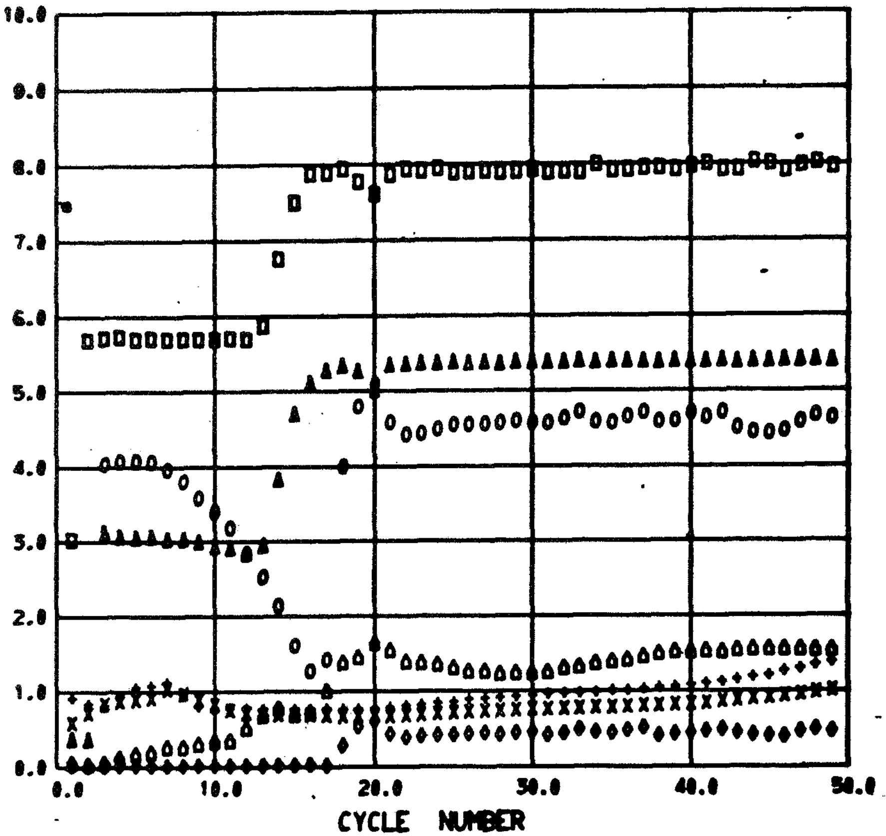


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 3. LC PARAMETERS RDG 504
6 24 11 37 - 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

FIGURE 13(e). - STARTUP 1.16. L/C PARAMETERS.



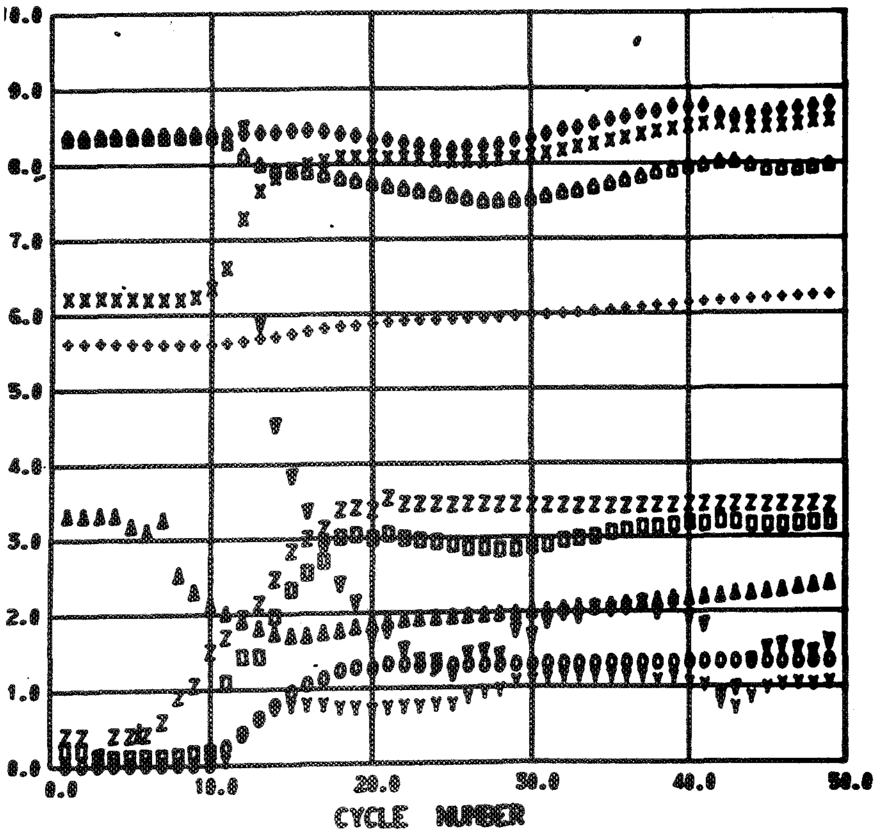
11.43 SECONDS BETWEEN CYCLES

N-1B PLOT 4 HG PARAMETERS RDG 584
6 24 11 37 47

□	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 0/0

FIGURE 13 (d). - STARTUP 116. HG LOOP PARAMETERS.

W-1B PLOT 5 HG BOILER PARAMETERS RDG 584
6 24 11 57 47

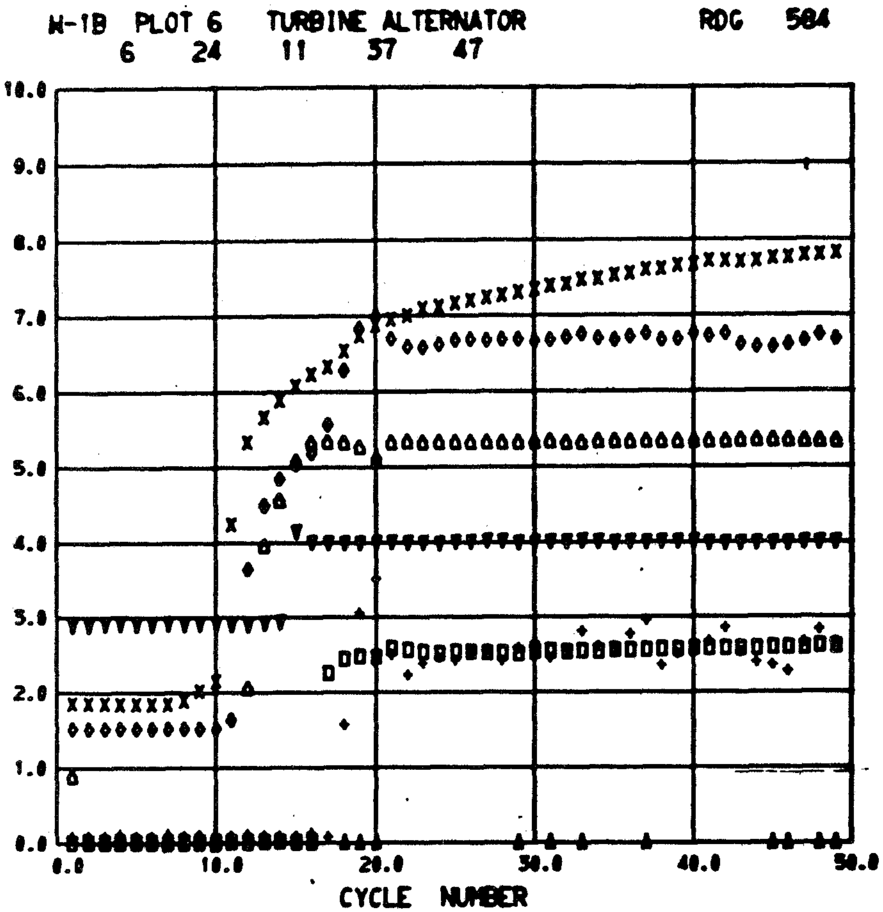


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 5 HG BOILER PARAMETERS RDG 584
6 24 11 57 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		

FIGURE 13(e). – STARTUP 116. HG BOILER PARAMETERS.



11.43 SECONDS, BETWEEN CYCLES

H-1B PLOT 6 TURBINE ALTERNATOR RDG 584
6 24 11 57 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

FIGURE 13(f). - STARTUP 116. TURBINE- ALTERNATOR PARAMETERS.

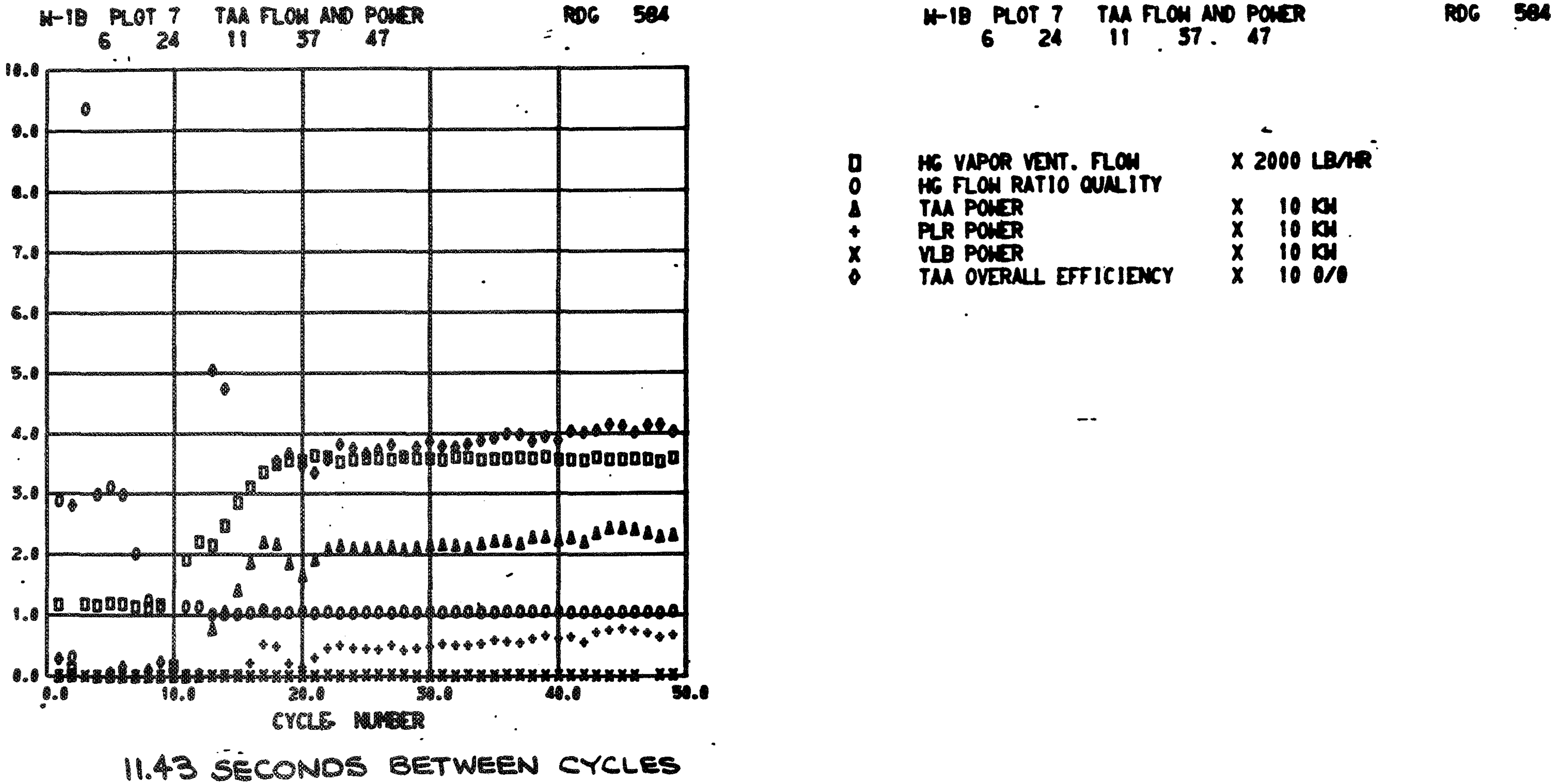
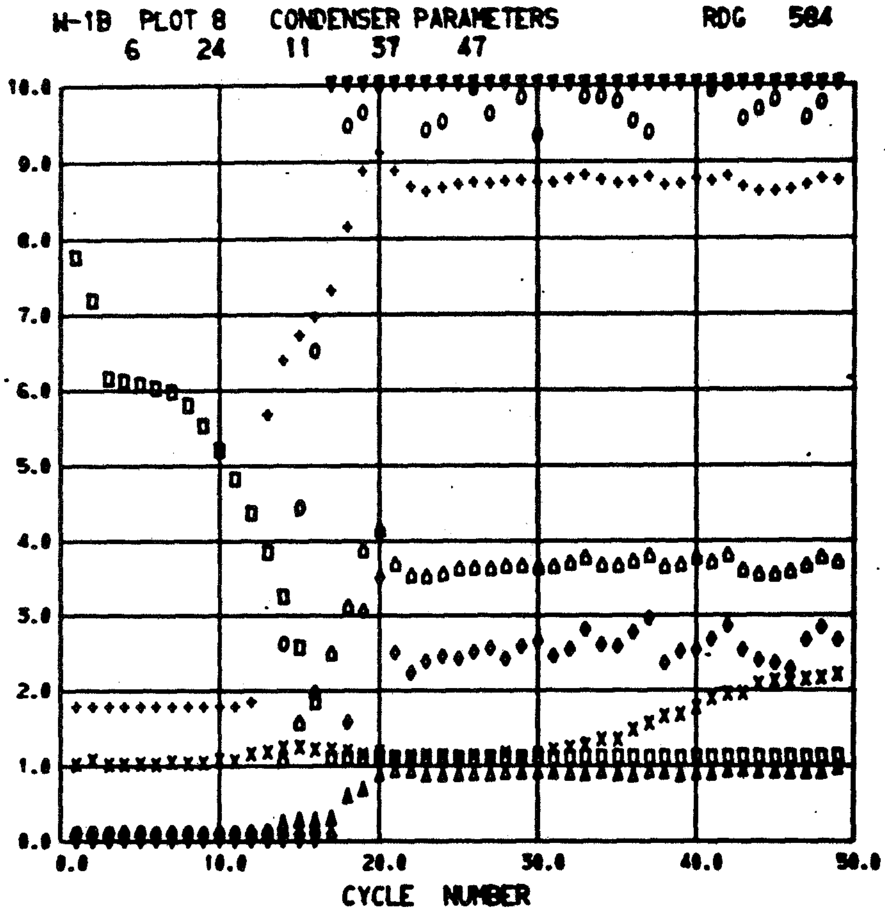


FIGURE 13 (g). - STARTUP 116. TAA FLOW AND POWER PARAMETERS.



W-1B PLOT 8 CONDENSER PARAMETERS RDG 584
6 24 11 37 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

11.43 SECONDS BETWEEN CYCLES

FIGURE 13(h). - STARTUP 116. CONDENSER PARAMETERS.

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 584
6 24 11 37 47

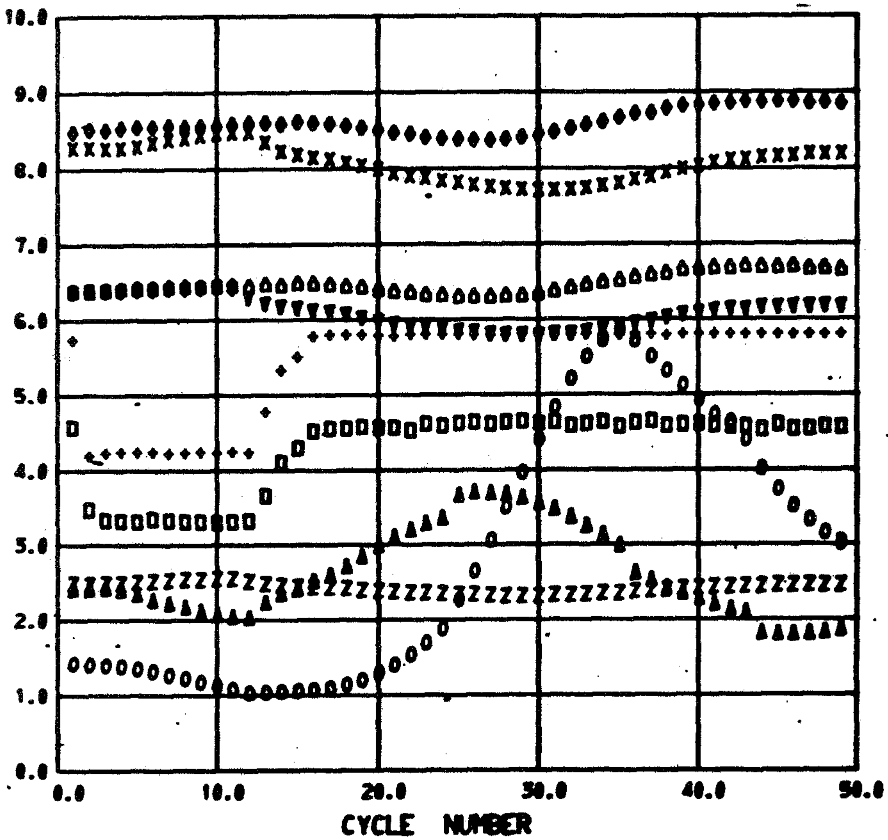
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 584
6 24 11 37 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

FIGURE 13(i).- STARTUP 116. HG-HRL-AUX LOOP PARAMETERS.

N-1B PLOT 1 NAK LOOP PARAMETERS RDG 585
6 24 12 44 48

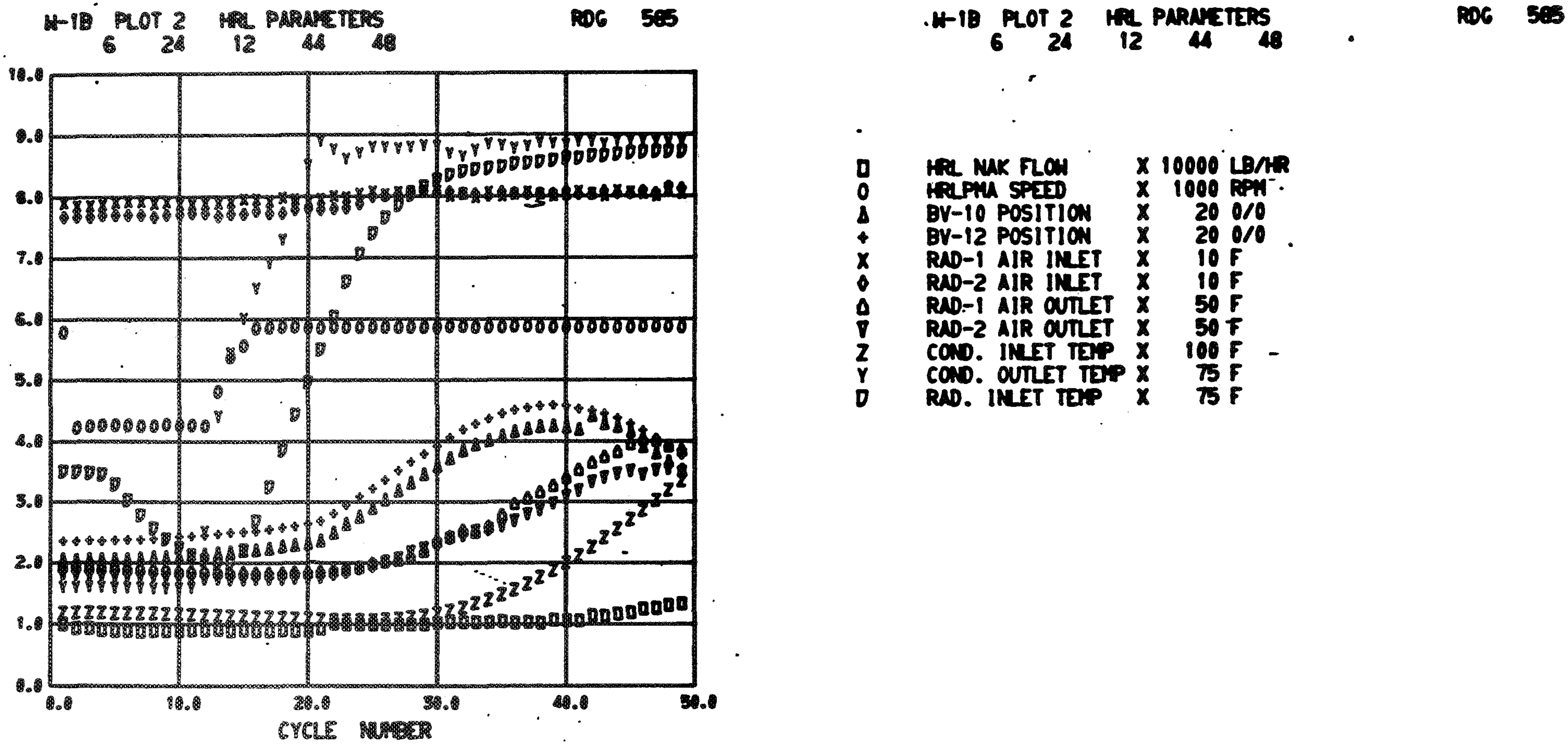


11.43 SECONDS BETWEEN CYCLES

N-1B PLOT 1 NAK LOOP PARAMETERS RDG 585
6 24 12 44 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
Δ	BOILER INLET TEMP	X	200 F
∇	BOILER OUTLET TEMP	X	200 F
Z	PNPMA INLET TEMP	X	500 F

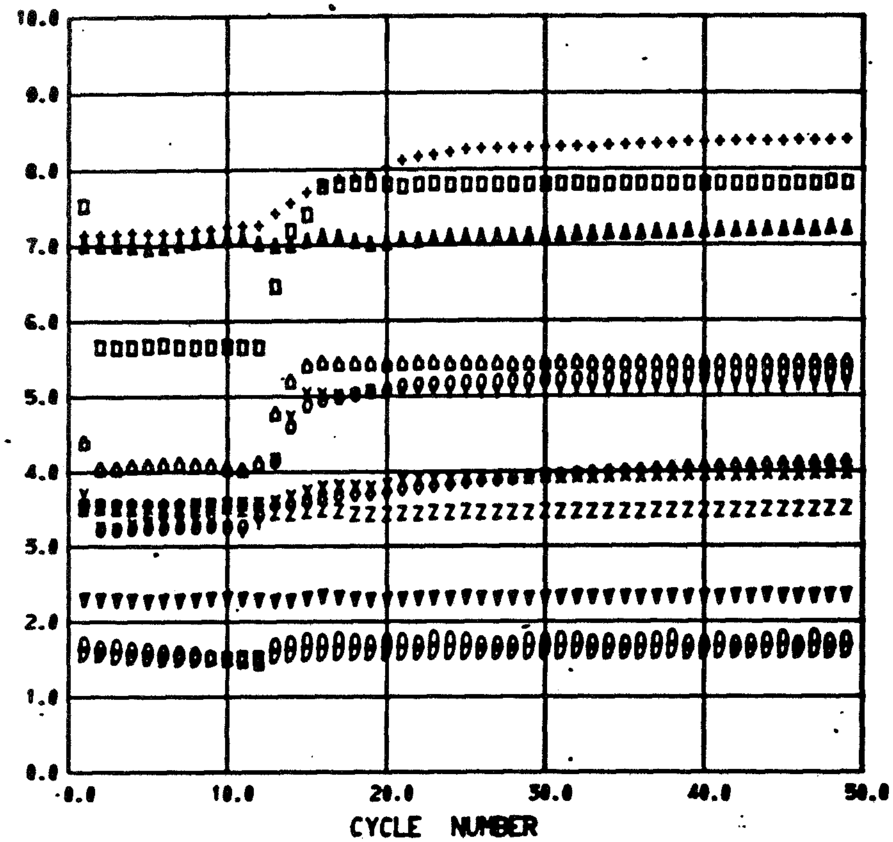
FIGURE 14(2). - STARTUP 117. NAK LOOP PARAMETERS.



11.43 SECONDS BETWEEN CYCLES

FIGURE 14 (b).- STARTUP 117. HRL PARAMETERS.

H-1B PLOT 3 LC PARAMETERS RDG 585
6 24 12 44 48



11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 3 LC PARAMETERS RDG 585
6 24 12 44 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
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

FIGURE 14 (c). - STARTUP 117. L/C PARAMETERS.

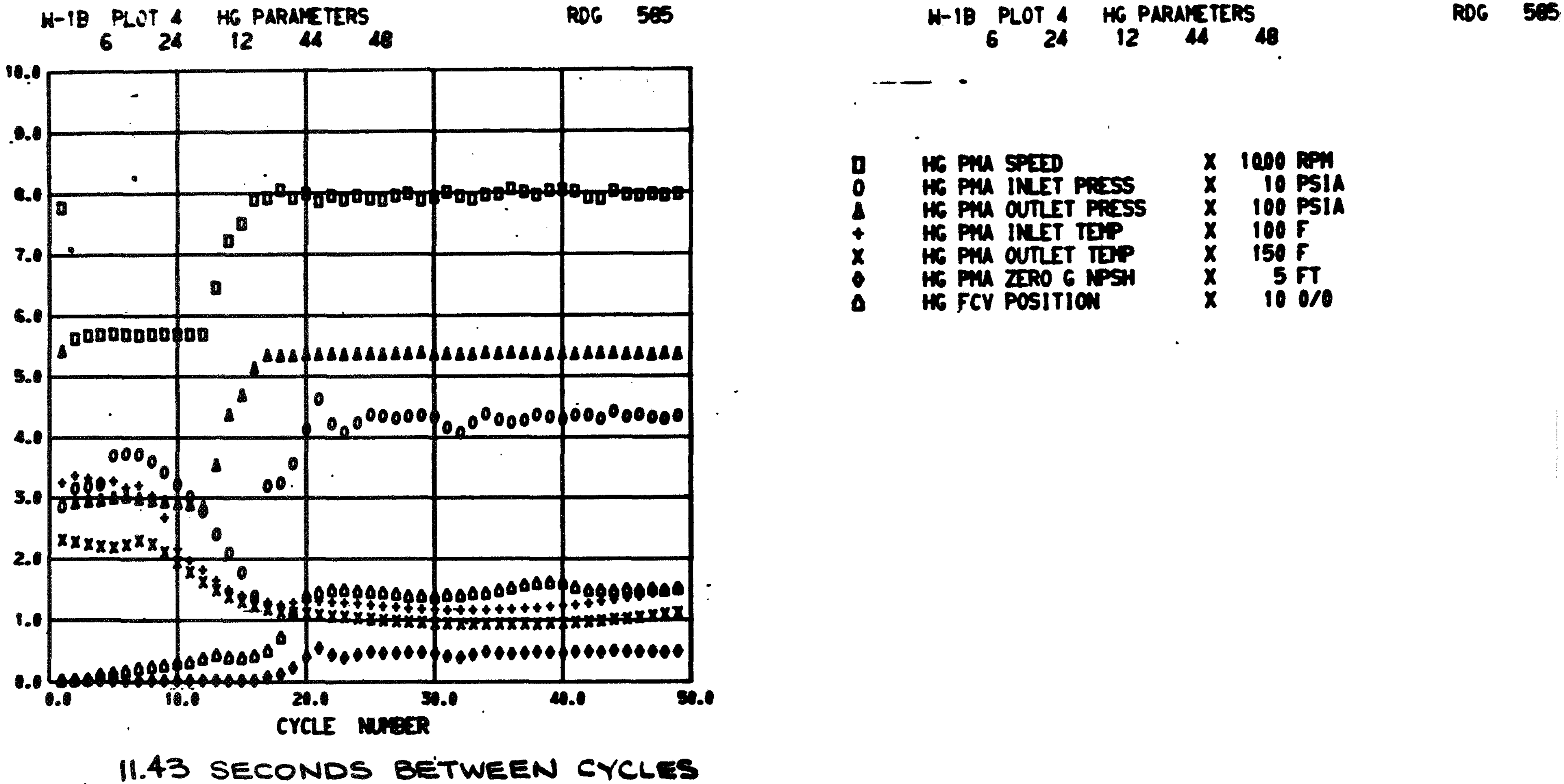
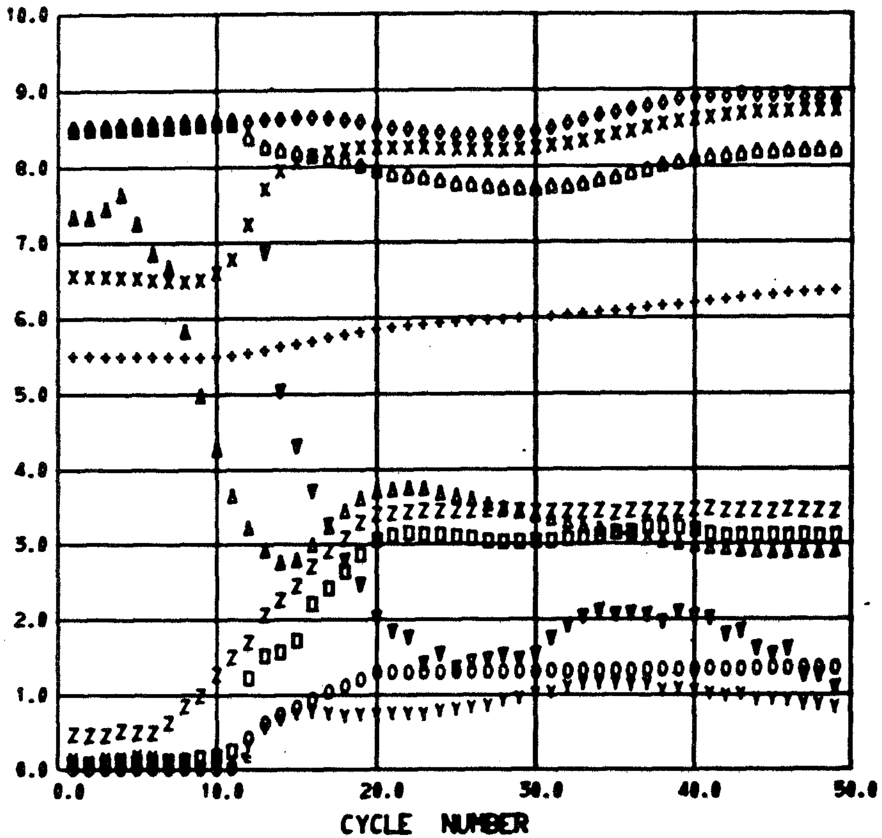


FIGURE 14(d). - STARTUP 117. HG LOOP PARAMETERS.

W-1B PLOT 5 HG BOILER PARAMETERS RDG 585
6 24 12 44 48



11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 5 HG BOILER PARAMETERS RDG 585
6 24 12 44 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			

FIGURE 14(e). - STARTUP 117. HG BOILER PARAMETERS.

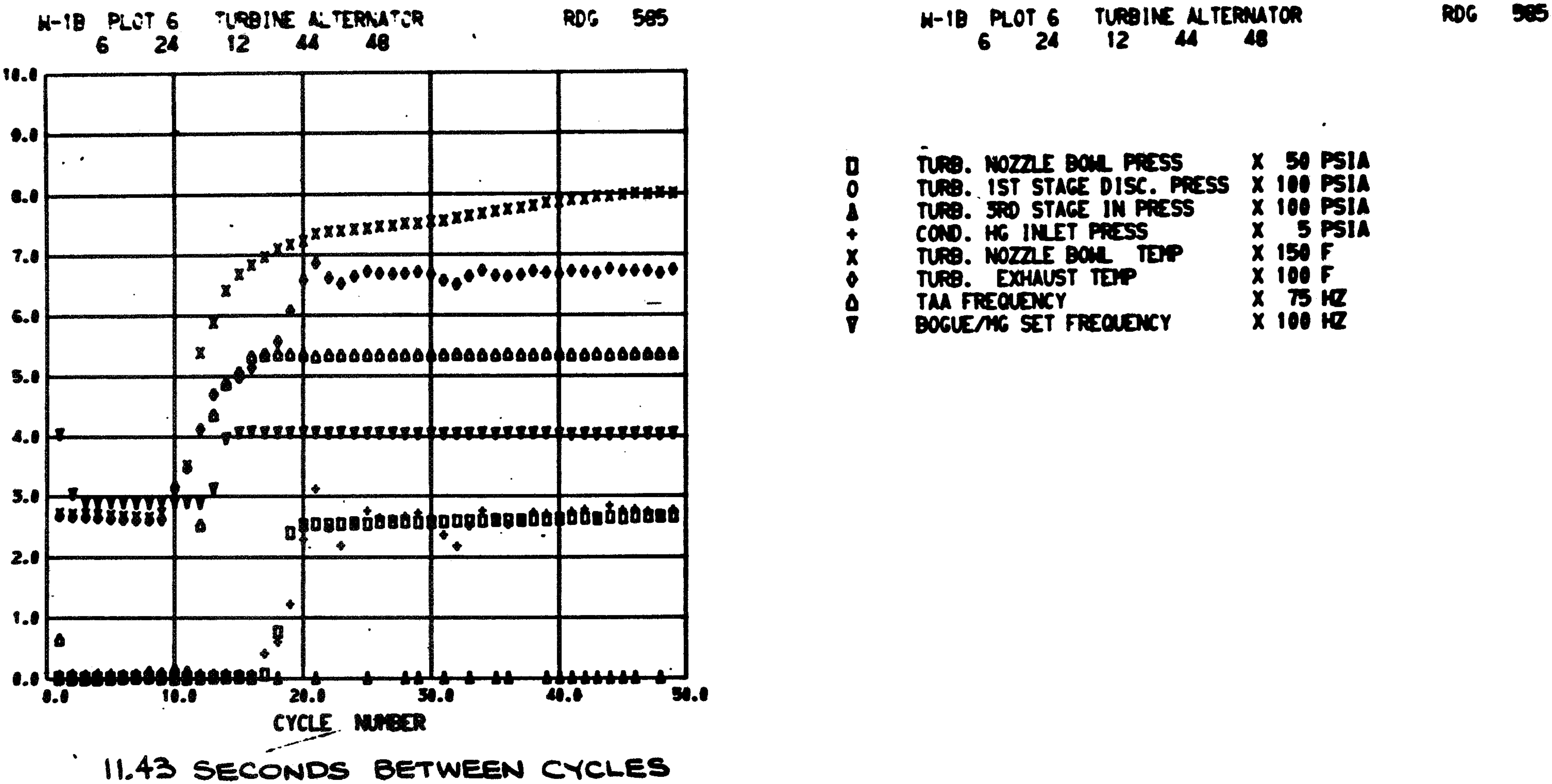
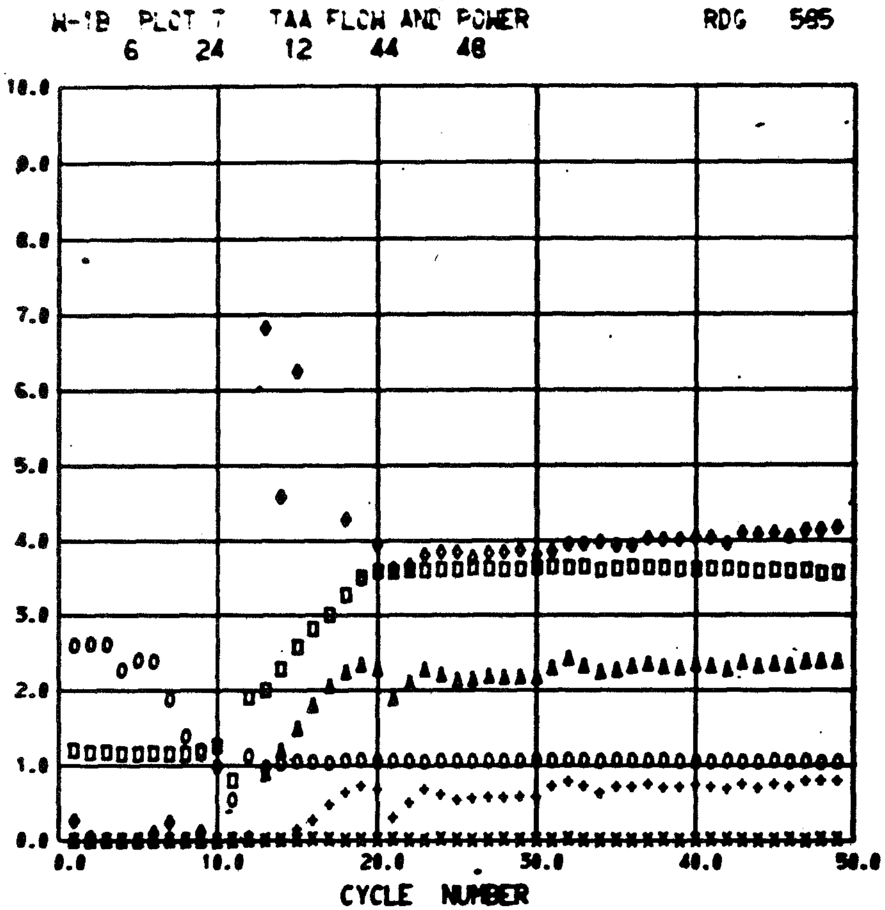


FIGURE 14(f). - STARTUP 117. TURBINE-ALTERNATOR PARAMETERS.

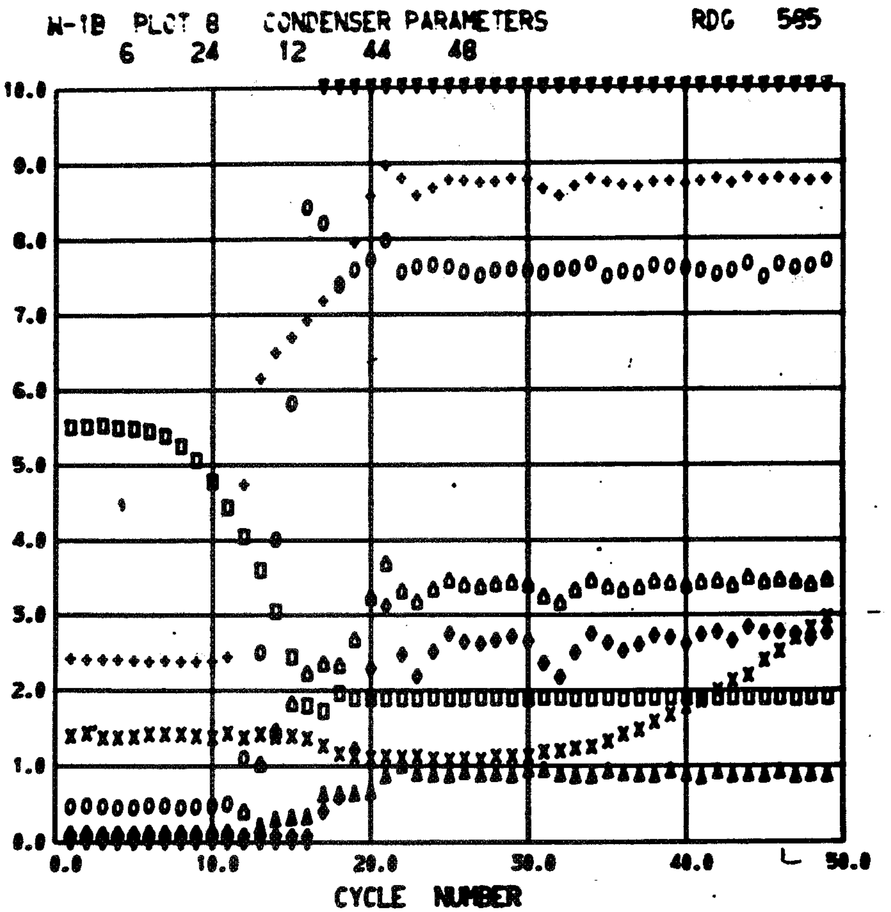


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 7 TAA FLOW AND POWER RDG 585
6 24 12 44 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

FIGURE 14(g). - STARTUP 117. TAA FLOW AND POWER PARAMETERS.



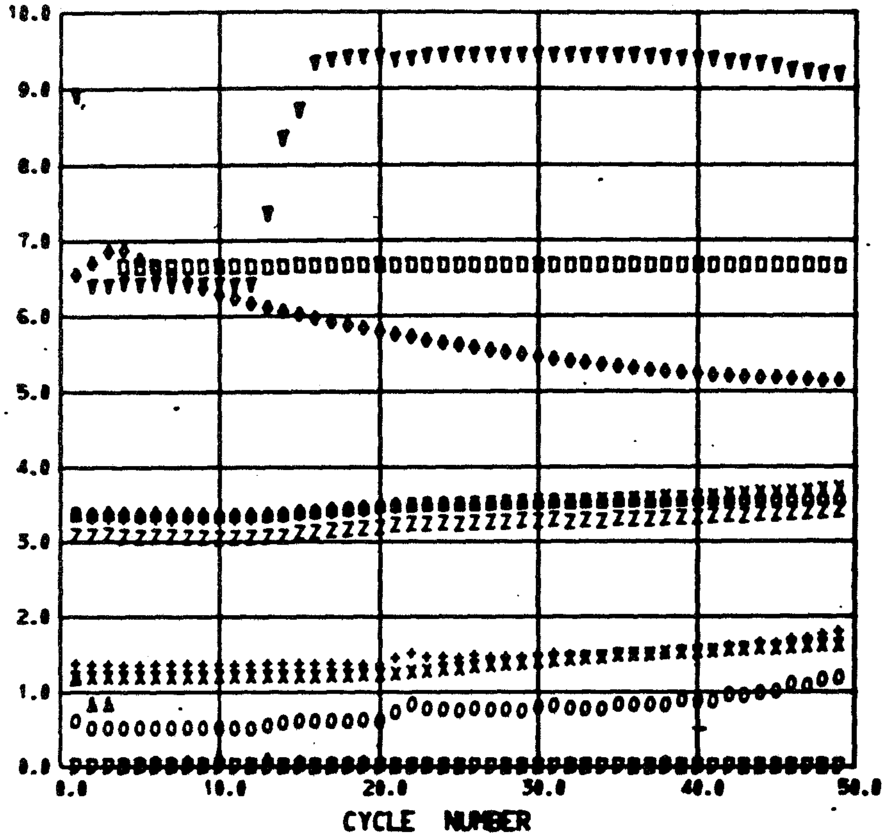
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 8 CONDENSER PARAMETERS RDG 585
6 24 12 44 48

□	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
Δ	COND. HG OUTLET PRESS	X	10 PSIA
▼	COND. OUTLET V-210 POS.	X	10 0/0

FIGURE 14-(h). - STARTUP 117. CONDENSER PARAMETERS.

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 585
6 24 12 44 48

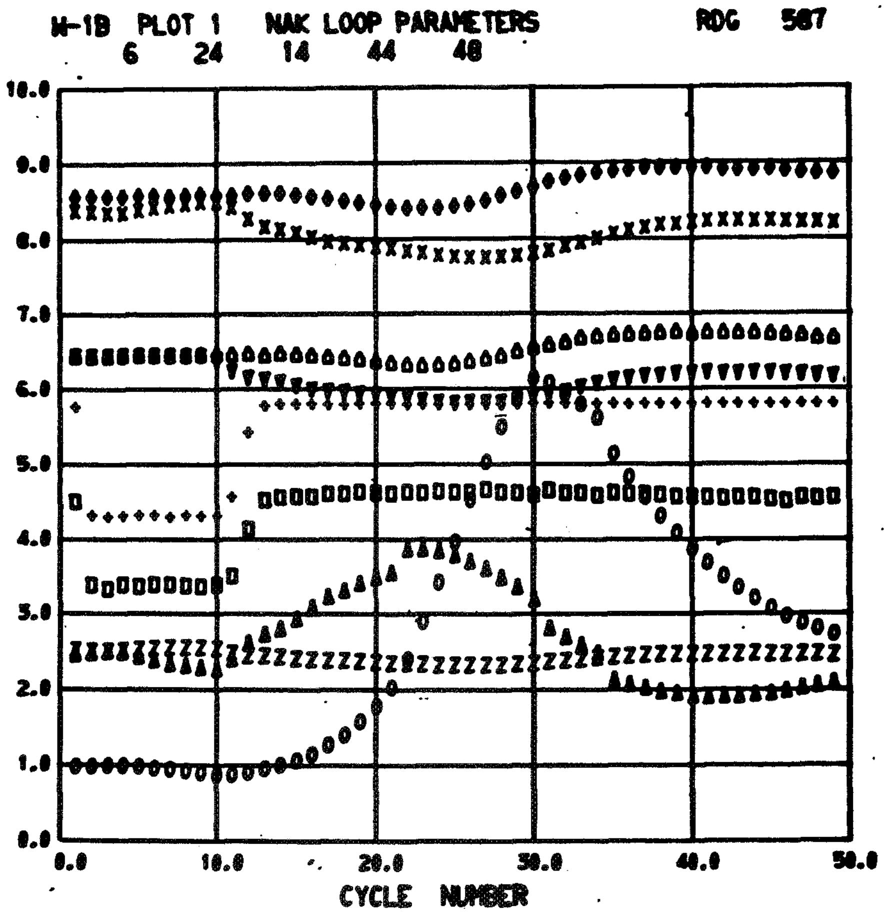


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 585
6 24 12 44 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

FIGURE 14 (i). - STARTUP 117 HG - HRL - AUX. LOOP PARAMETERS.

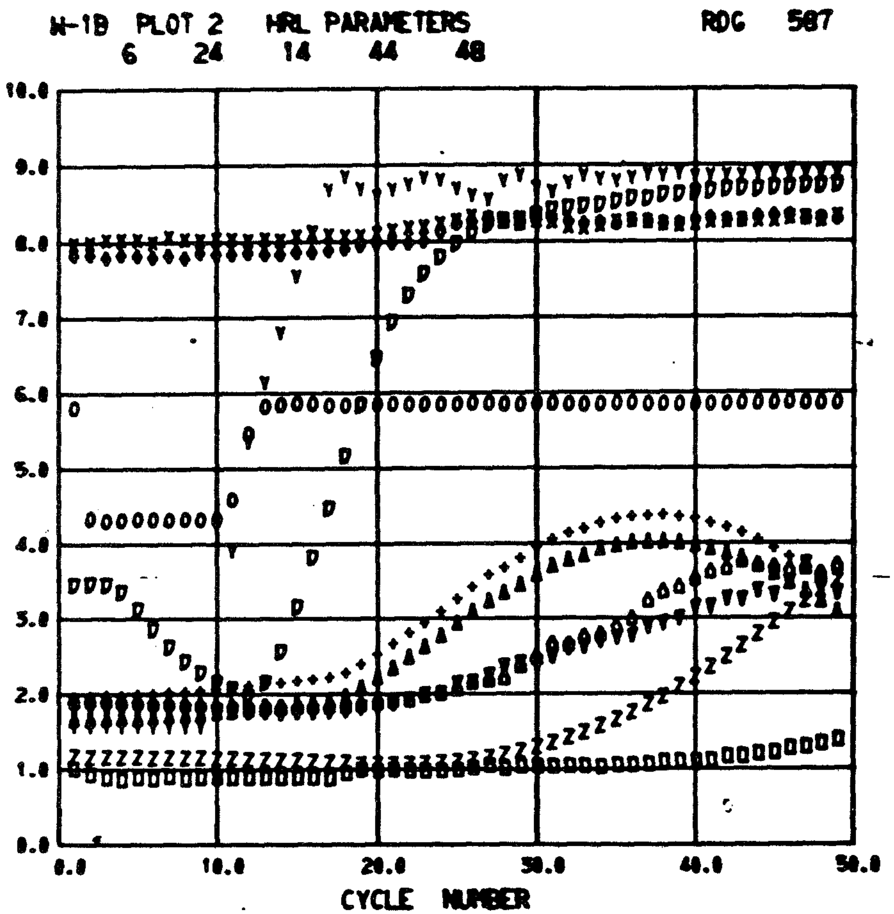


W-1B PLOT 1 NAK LOOP PARAMETERS RDG 587
6 24 14 44 48

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 15(a).-STARTUP 119. NAK LOOP PARAMETERS.

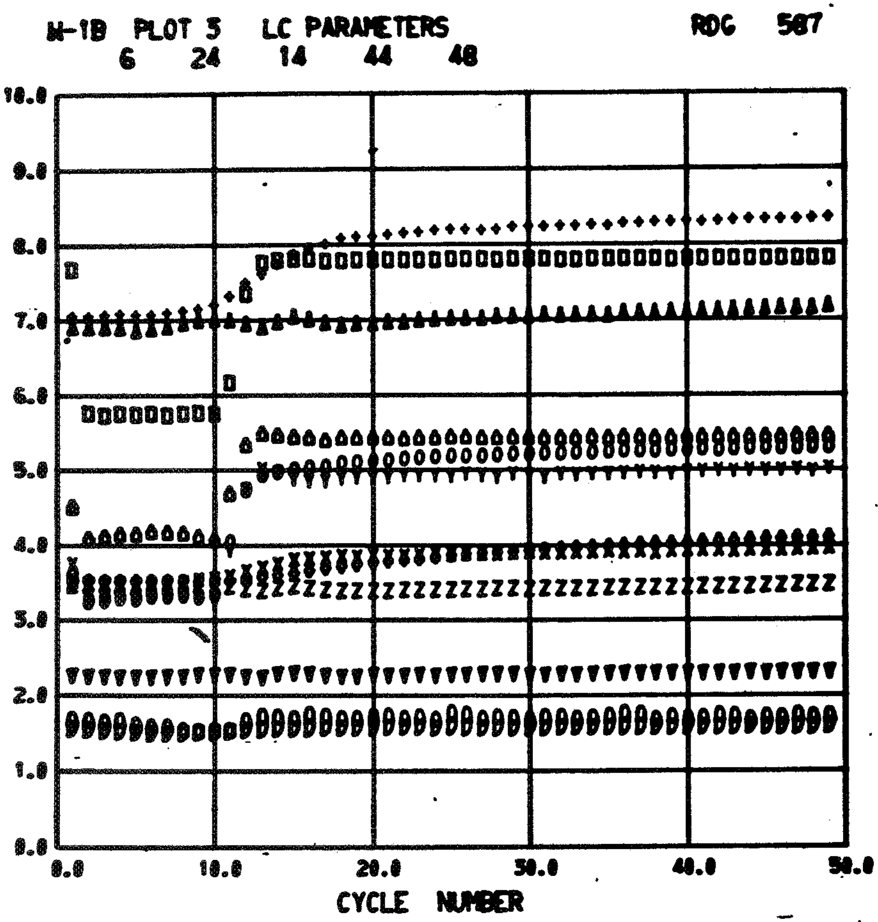


W-1B PLOT 2 HRL PARAMETERS RDG 587
6 24 14 44 48

□	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

FIGURE 15(b). - STARTUP 119. HRL PARAMETERS.

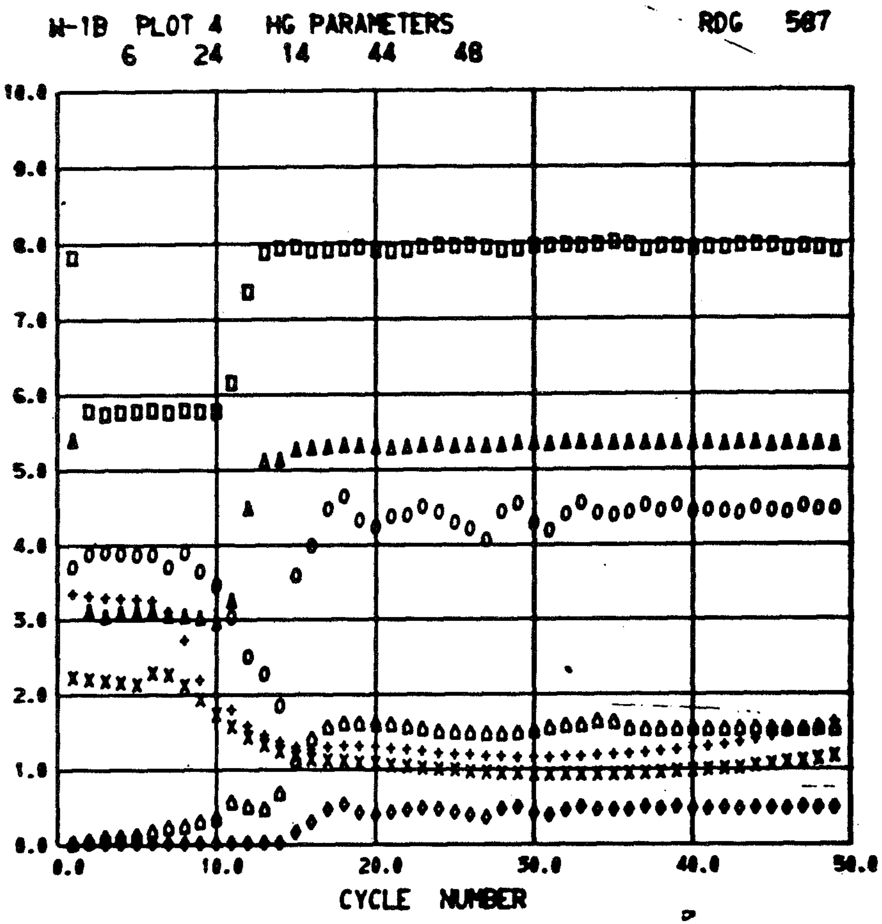


11.43 SECONDS BETWEEN CYCLES

N-1B PLOT 3 LC PARAMETERS RDG 507
6 24 14 44 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
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

FIGURE 15 (c). - STARTUP 119. L/C PARAMETERS

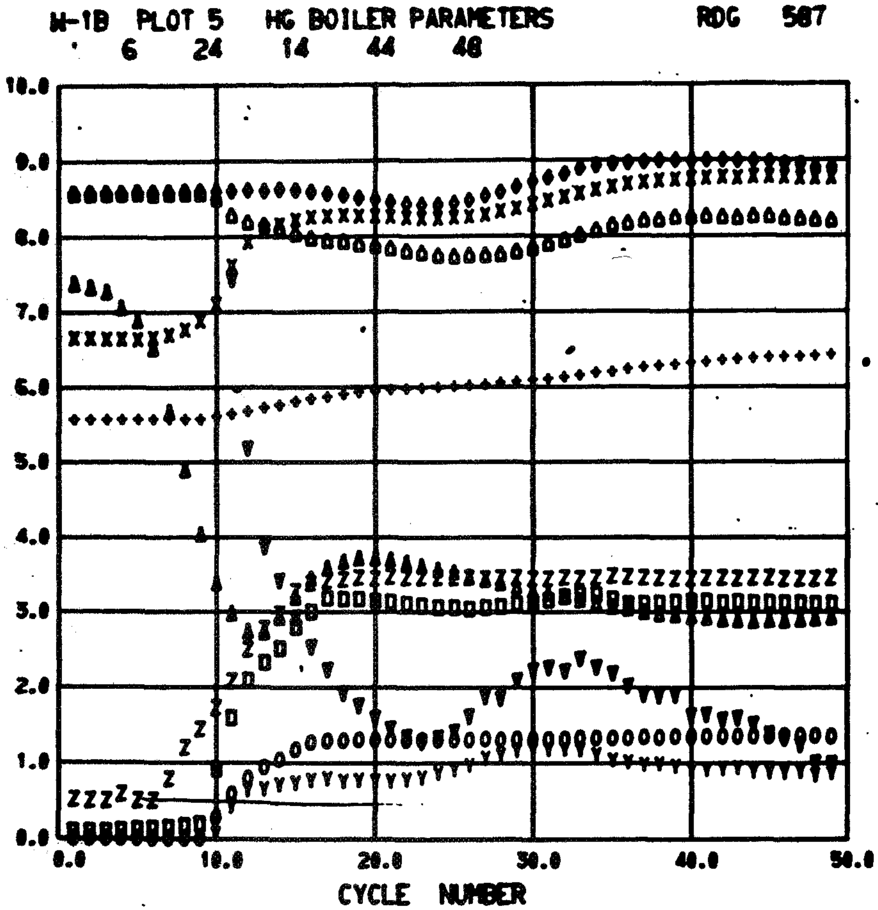


11.43 SECONDS BETWEEN CYCLES

N-1B PLOT 4 HG PARAMETERS RDG 587
6 24 14 44 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
Δ	HG FCV POSITION	X	10 0/0

FIGURE 15 (d).- STARTUP 119. HG LOOP PARAMETERS



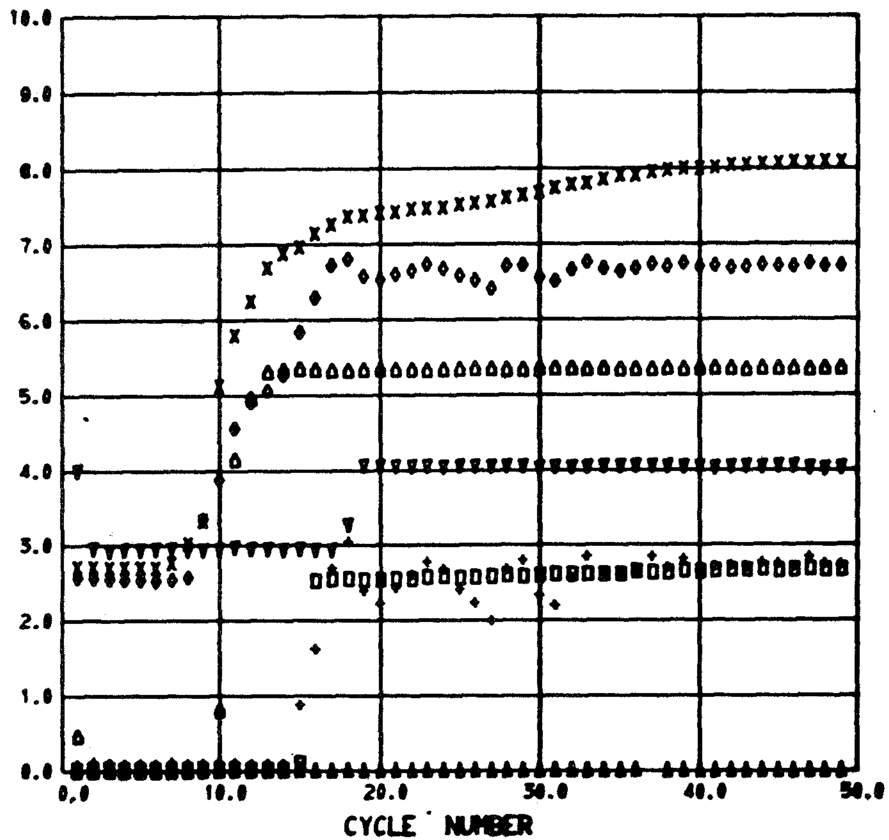
W-1B PLOT 5 HG BOILER PARAMETERS RDG 587
6 24 14 44 48

□	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
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

FIGURE 15(e).- STARTUP 119. HG BOILER PARAMETERS

W-1B PLOT 6 TURBINE ALTERNATOR RDG 587
6 24 14 44 48

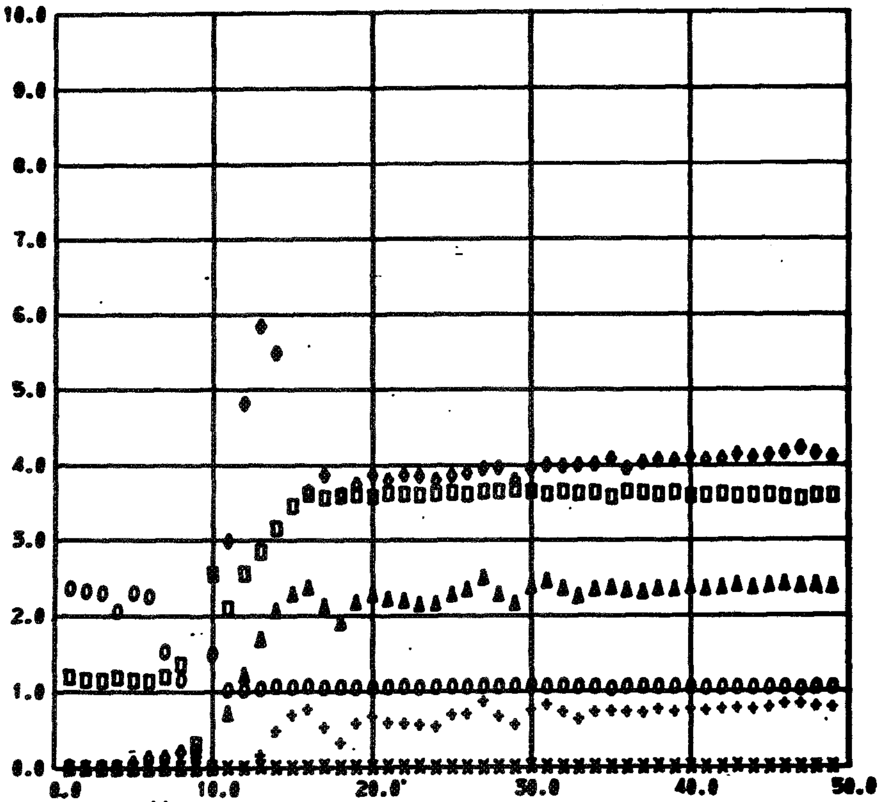


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 6 TURBINE ALTERNATOR RDG 587
6 24 14 44 48

□	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

FIGURE 15(f).- STARTUP 119. TURBINE ALTERNATOR PARAMETERS

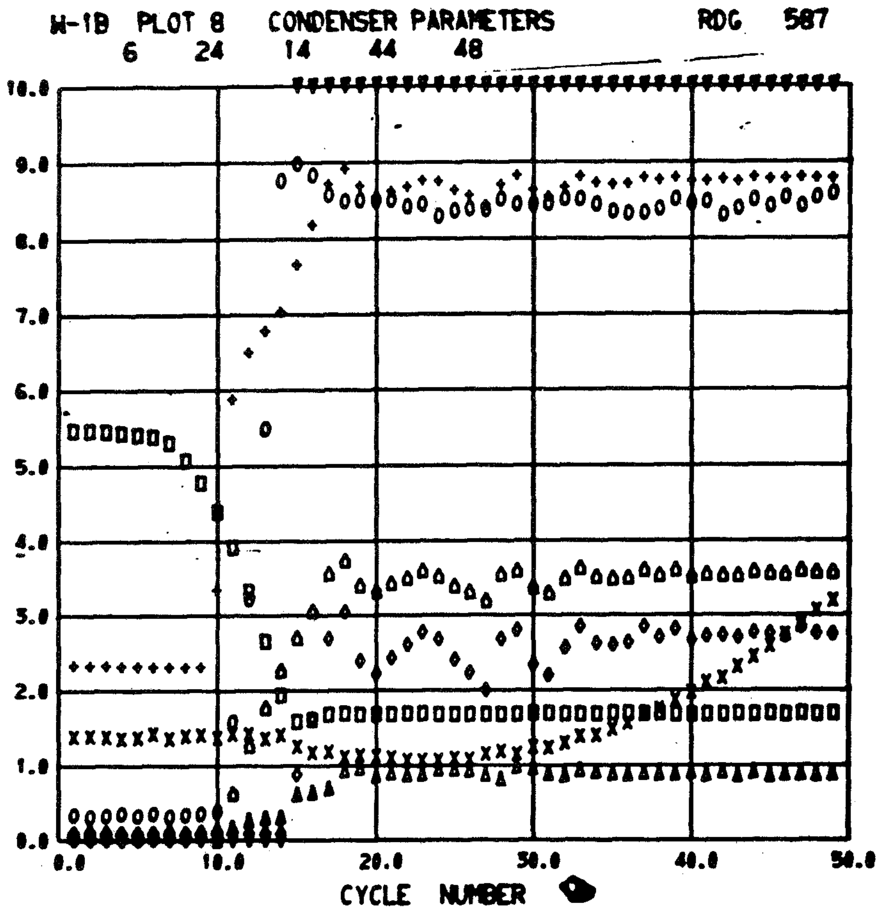


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 7 TAA FLOW AND POWER RDG 587
6 24 14 44 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 O/O

FIGURE 15(g).-STARTUP 119. TAA FLOW AND POWER PARAMETERS



11.43 SECONDS BETWEEN CYCLES

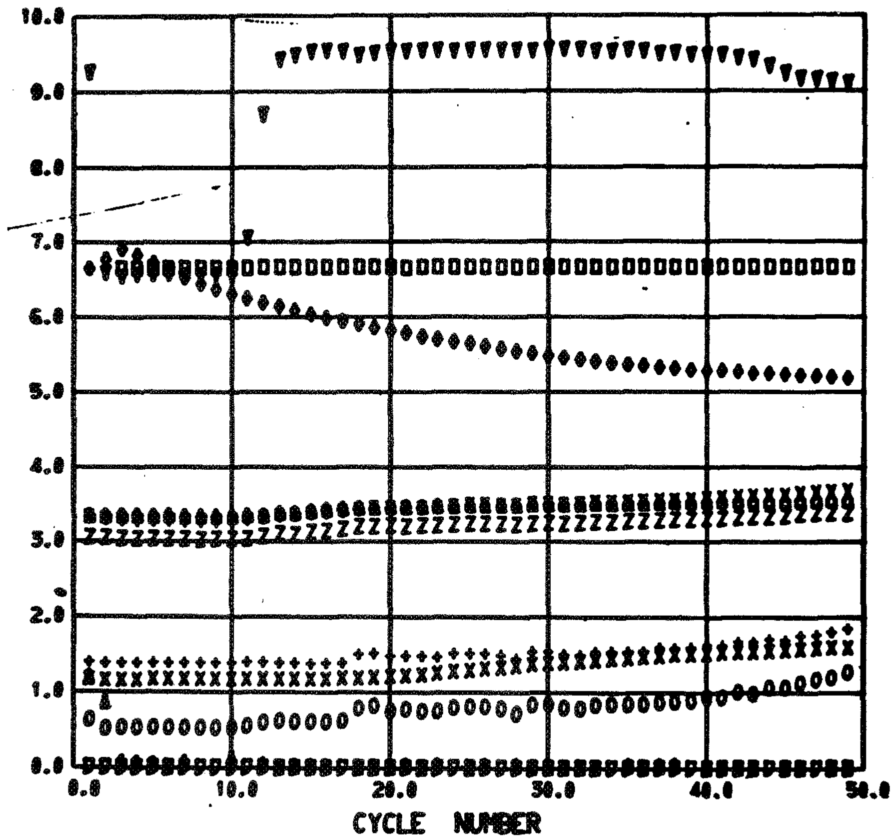
W-1B PLOT 8 CONDENSER PARAMETERS RDG 587

6 24 14 44 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~~

FIGURE 15 (h).- STARTUP 119. CONDENSER PARAMETERS.

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 587
6 24 14 44 48

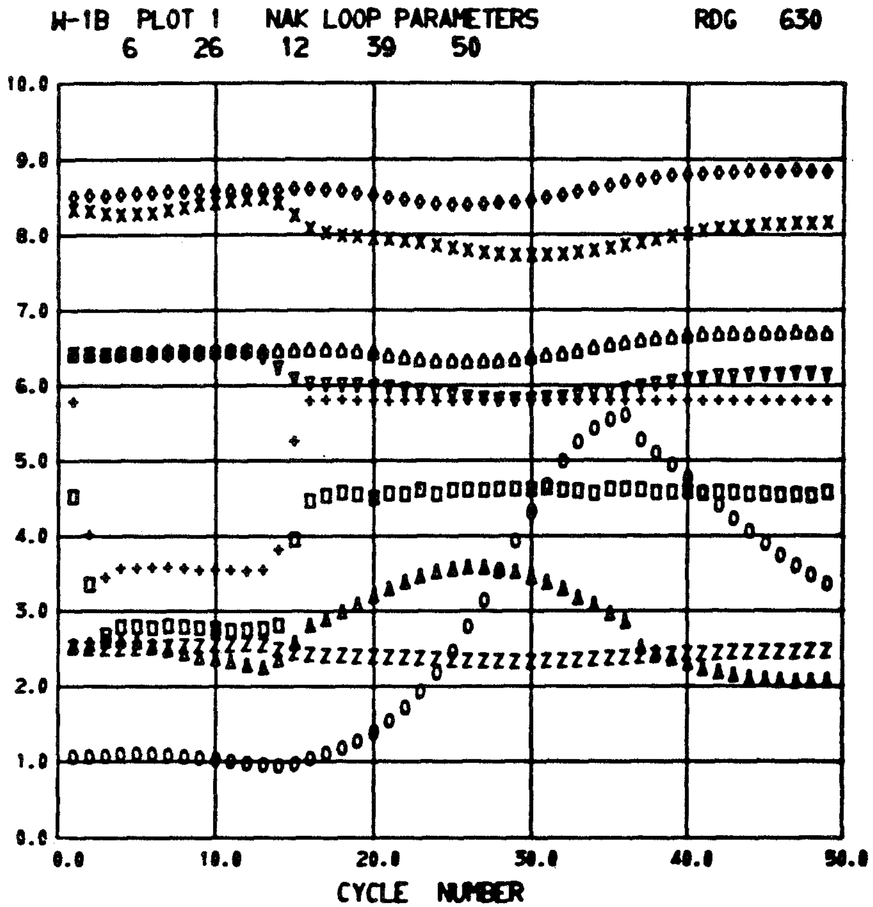


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 587
6 24 14 44 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

FIGURE 15(i).- STARTUP 119: HG-HRL-AUX. LOOP PARAMETERS



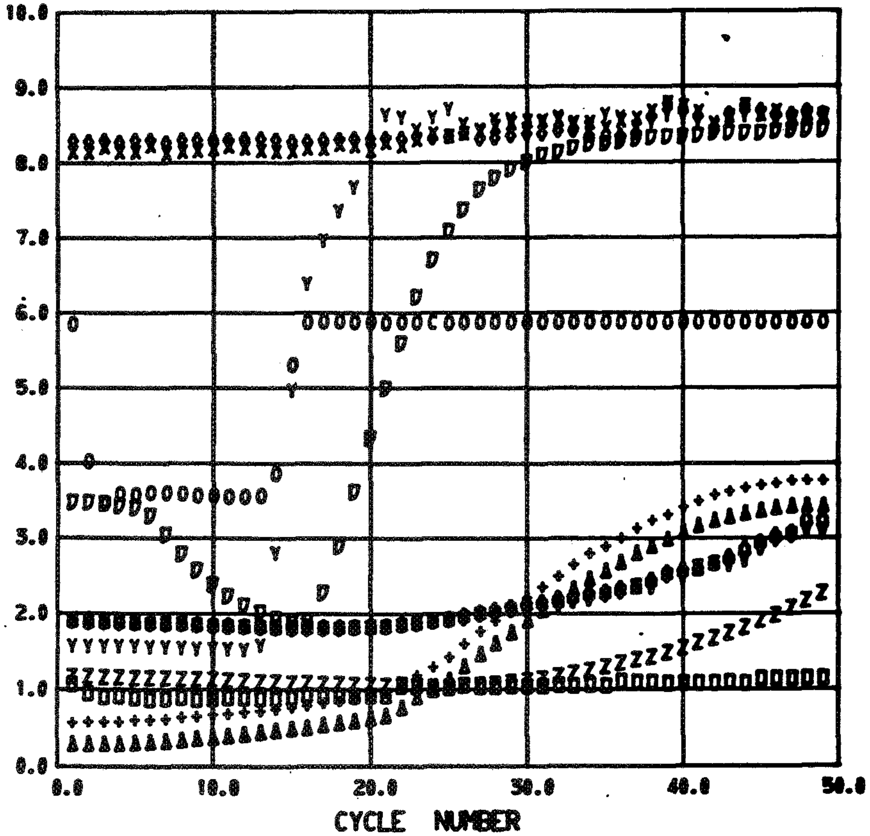
H-1B PLOT 1 NAK LOOP PARAMETERS RDG 630
6 26 12 39 50

□	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

11.43 SECONDS BETWEEN CYCLES

FIGURE 16(2). - STARTUP 126. NAK LOOP PARAMETERS.

H-1B PLOT 2 HRL PARAMETERS RDG 630
6 26 12 39 50



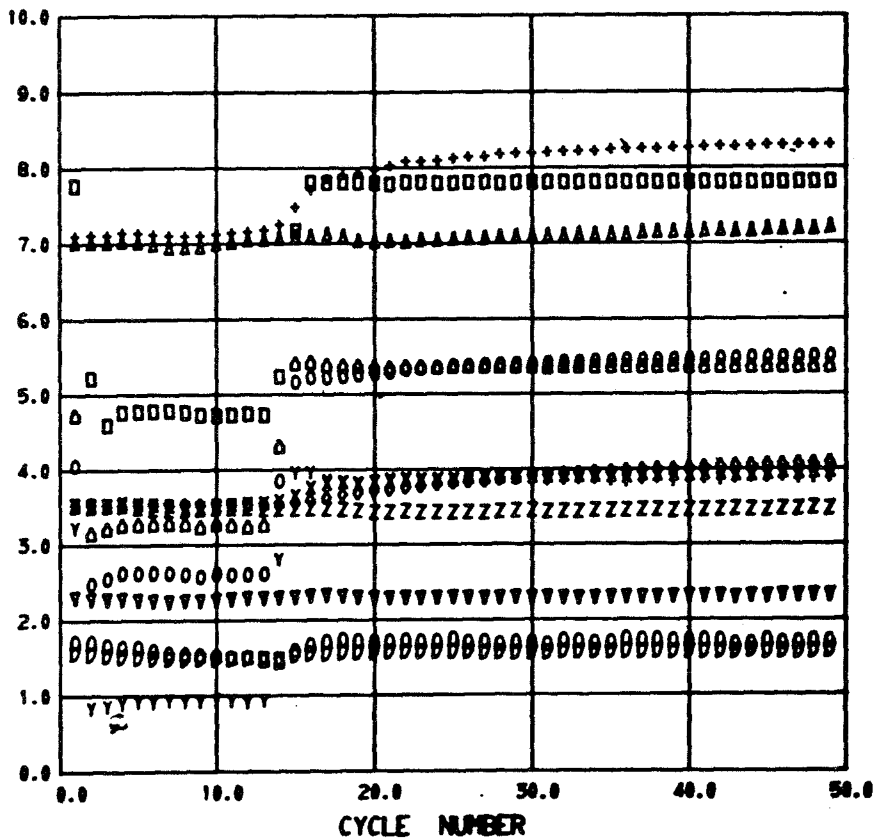
H-1B PLOT 2 HRL PARAMETERS RDG 630
6 26 12 39 50

□	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

FIGURE 16(b). - STARTUP 126. HRL PARAMETERS.

H-1B PLOT 3 LC PARAMETERS RDG 630
6 26 12 39 50

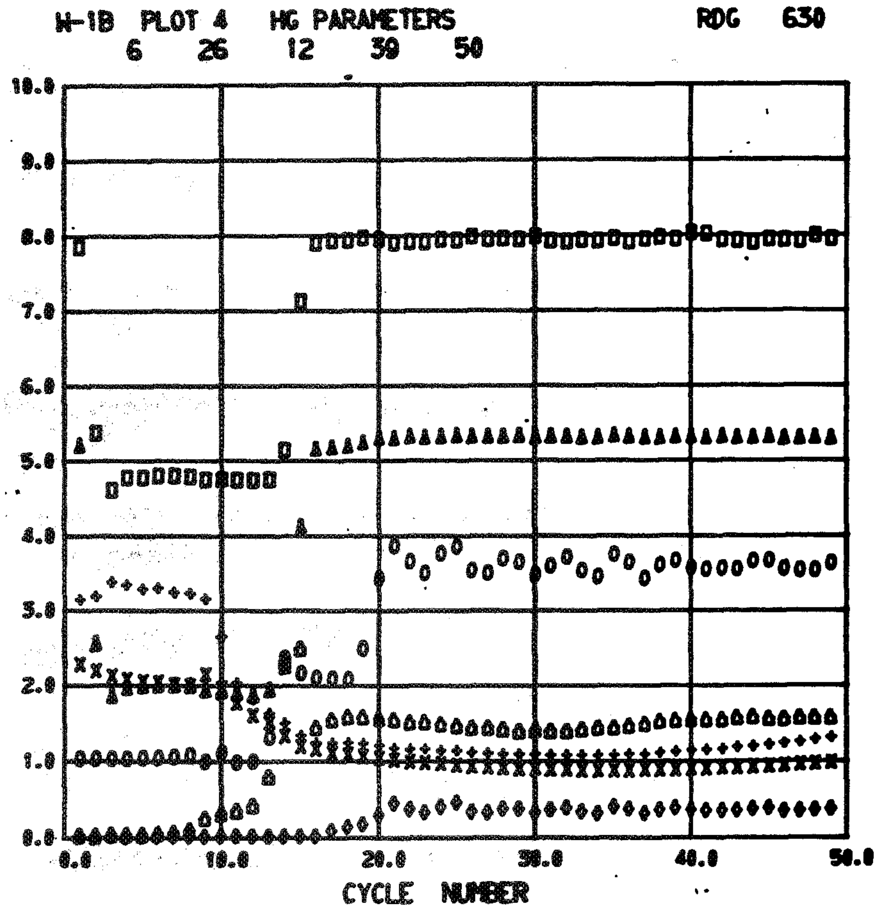


11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 3 LC PARAMETERS RDG 630
6 26 12 39 50

□	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
Ω	HG PMA MHE OUTLET TEMP	X	100 F

FIGURE 16(c). - STARTUP 126. L/C PARAMETERS.



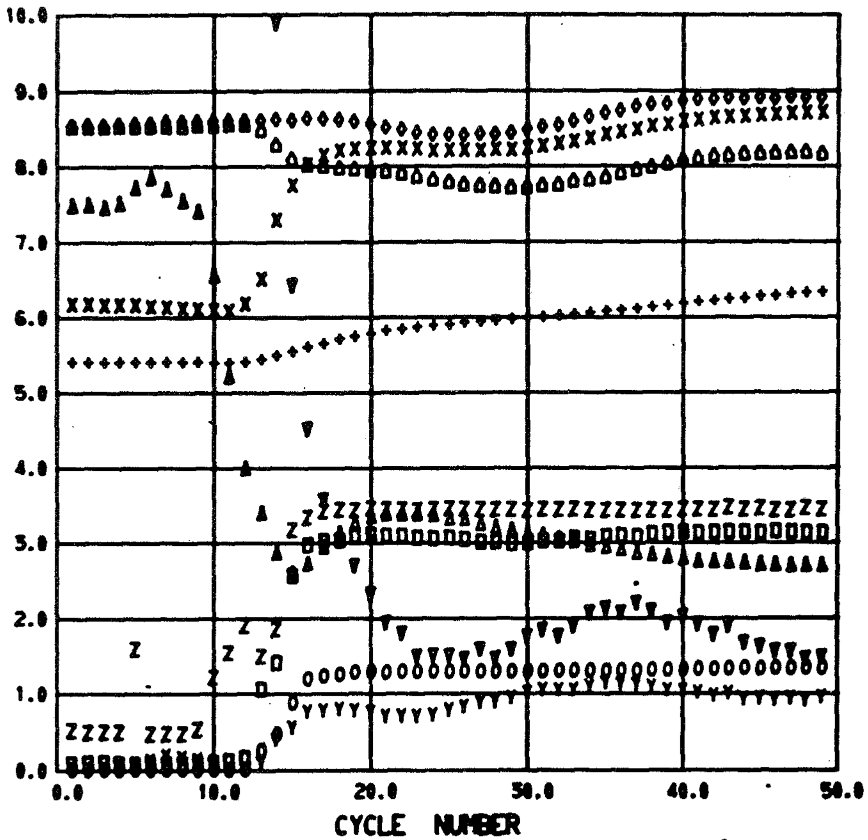
W-1B PLOT 4 HG PARAMETERS RDG 630
6 26 12 39 50

□	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 0/0

11.43 SECONDS BETWEEN CYCLES

FIGURE 16 (d).— STARTUP 1.26. HG LOOP PARAMETERS.

W-1B PLOT 5 HG BOILER PARAMETERS RDG 630
6 26 12 39 50

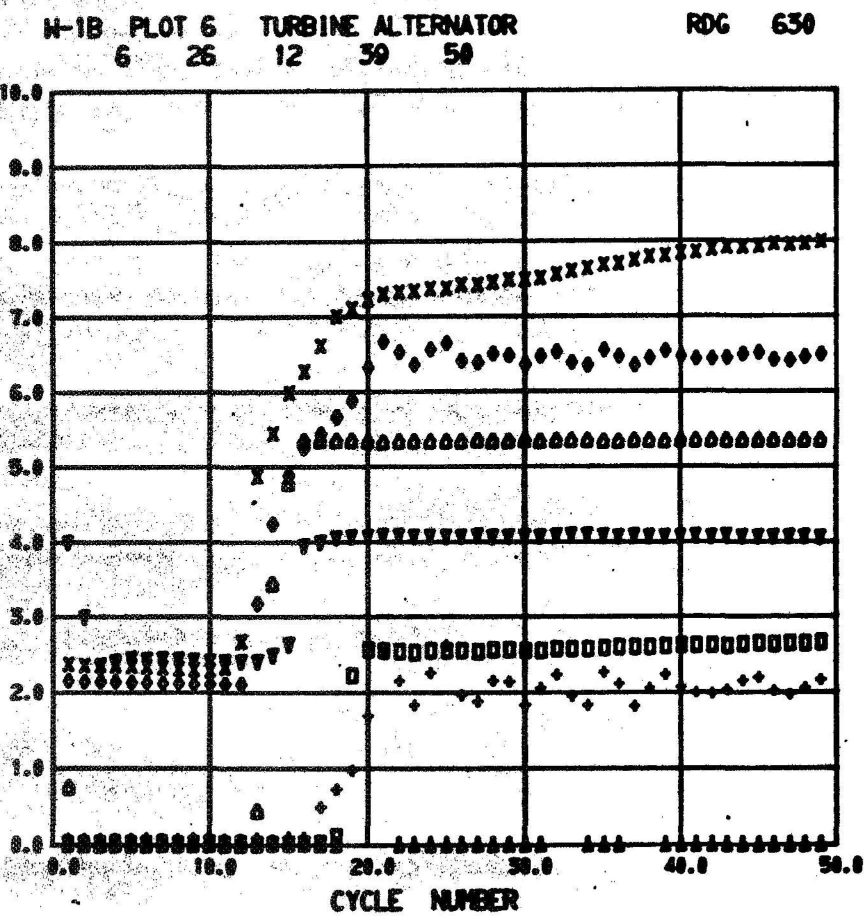


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 5 HG BOILER PARAMETERS RDG 630
6 26 12 39 50

□	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
⌂	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		

FIGURE 16 (e). - STARTUP 126. HG BOILER PARAMETERS



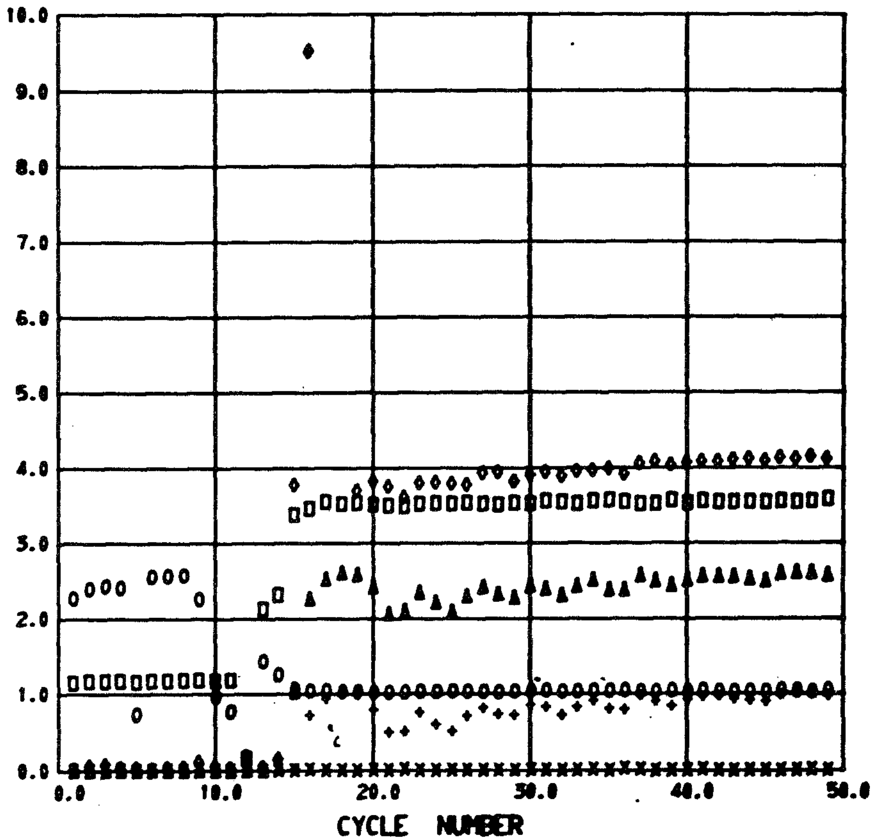
W-1B PLOT 6 TURBINE ALTERNATOR RDG 630
6 26 12 39 50

□	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
Δ	TAA FREQUENCY	X 75 HZ
▼	BOGUE/MG SET FREQUENCY	X 100 HZ

11.43 SECONDS BETWEEN CYCLES

FIGURE 16 (f).- STARTUP 126. TURBINE ALTERNATOR PARAMETERS

W-1B PLOT 7 TAA FLOW AND POWER RDG 630
6 26 12 39 50



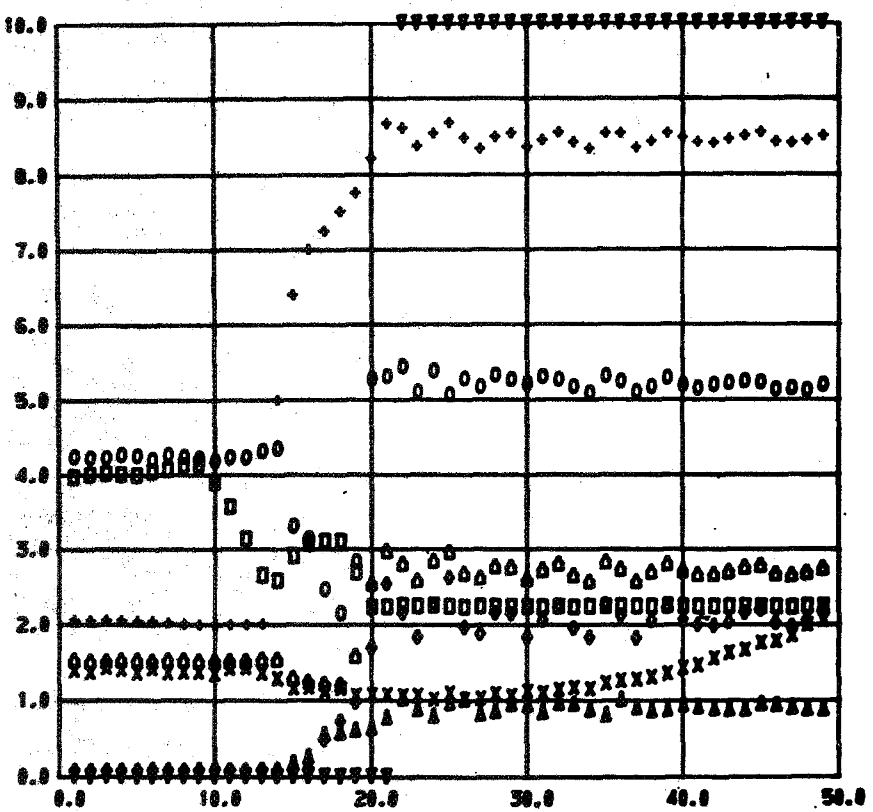
11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 7 TAA FLOW AND POWER RDG 630
6 26 12 39 50

□	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

FIGURE 16(g).- STARTUP 126. TAA FLOW AND POWER PARAMETERS

W-1B PLOT 8 CONDENSER PARAMETERS RDG 630
6 26 12 39 50

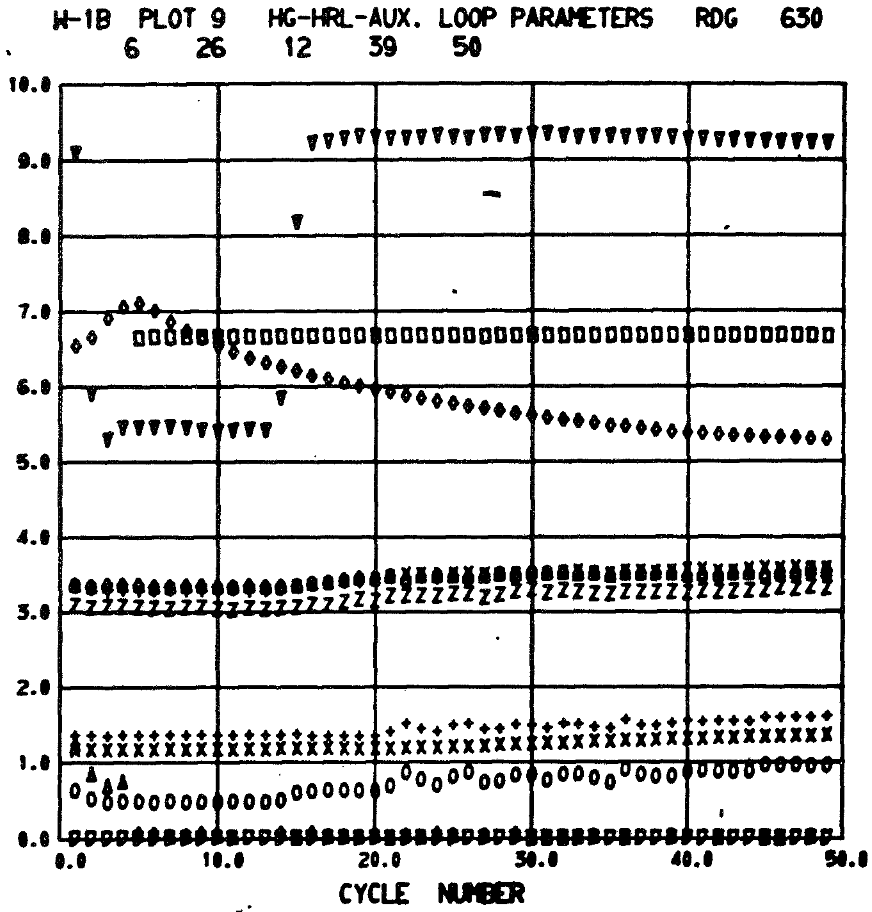


11.43 SECONDS BETWEEN CYCLES

W-1B PLOT 8 CONDENSER PARAMETERS RDG 630
6 26 12 39 50

□	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
Δ	COND. HG OUTLET PRESS	X 10 PSIA
▼	COND. OUTLET V-210 POS.	X 10 0/0

FIGURE 16(h).- STARTUP 126. CONDENSER PARMETERS



11.43 SECONDS BETWEEN CYCLES

H-1B PLOT 9 HG-HRL-AUX. LOOP PARAMETERS RDG 630
6 26 12 39 50

□	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

FIGURE 16(i).- STARTUP 126. HG-HRL-AUX. LOOP PARAMETERS