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10-MWe PILOT-PLANT-RECEIVER PANEL TEST REQUIREMENTS DOCUMENT SOLAR THERMAL TEST FACILITY

AUGUST 25,1978

AC 03-76ET20417

Revised Draft

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS CORPORATION

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CONTENTS (Cont'd.)

1.0 SCOPE

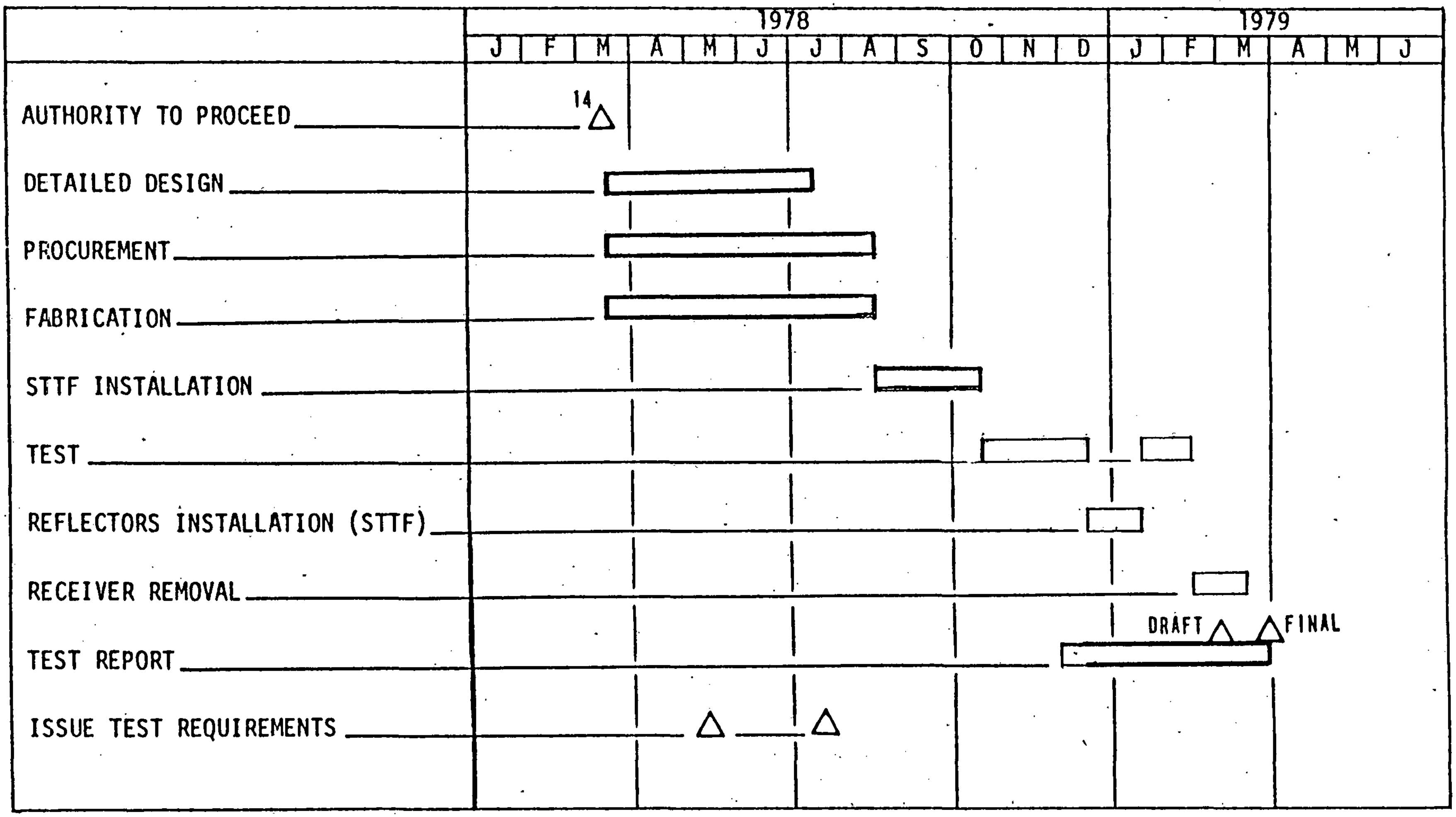
At the Solar Thermal Test Facility (STTF), insolation testing will be conducted on a full-scale test receiver panel and supporting hardware which essentially duplicate both physically and functionally, the design planned for the 10 MWe pilot plant. Testing will include operation during normal start and shutdown, intermittent cloud conditions, and emergencies to determine its transient and steady state operating characteristics and performance under conditions equal to or exceeding those expected in the pilot plant. The effects of variations of input and output conditions on receiver operation will also be investigated.

A summary schedule for the STTF test program is given in Figure 1-1. Discussion of the tests, operating conditions, and expected results is presented in Section 5.

FIGURE 1-1

PHASE II STTF

TEST PROGRAM SCHEDULE



SHEET 1-2 6/8/78

6/8/78

2.0 TEST OBJECTIVES

2.1 Phase II - Pilot Plant Tests

(1) Verify receiver panel thermodynamic performance and losses with heat flux and power levels from 20% to 125% of pilot plant requirements.

(2) Investigate effects of vertical flux profiles on panel losses and performance.

(3) Demonstrate the panel ability to deliver dry steam under rated or derated conditions over a power range from 20% to 125% of pilot plant requirements.

(4) Verify receiver flow distribution and uniformity.

(5) Verify receiver hydrodynamic stability.

(6) Verify receiver panel control system operational performance and stability under typical pilot plant timeline sequencing.

(7) Investigate control system steady state and transient performance limits.

- Intermittent clouds
- Feedwater transients
- Discharge transients
- Set point changes

(8) Investigate cyclic departure from nucleate boiling (DNB) phenomena at flux levels up to 125% of pilot plant conditions.

(9) Verify the ability of the panel thermal expansion/contraction design to prevent excessive thermal stresses.

(10) Demonstrate panel tube wall temperatures compatible with a 30-year life.

(11) Verify panel absorber surface coating durability under actual pilot plant conditions.

(12) Investigate boiler panel tube wall fouling.

(13) Shakedown and calibrate test hardware.

3.0 TEST HARDWARE

3.1 Summary Description

For purposes of orientation, a brief description of the pilot plant receiver subsystem is presented below, followed by a detailed description of the receiver assembly to be tested at STTF.

3.1.1 Pilot Plant Receiver

The mission of the pilot plant receiver subsystem (Figure 3.1.1-1) is to efficiently transfer the energy from the concentrated solar radiation reflected from the mirrors of the collector subsystem into the water supplied by the electrical power generation subsystem and deliver steam at precisely controlled superheat conditions to the plant turbine generator and/or the thermal storage subsystem.

Nominally, the receiver will be required to accept water from the flow distribution system at 13.8 MPa (2000 psia) and 205°C (401°F) and deliver superheated steam at rated conditions of 10.4 MPa (1515 psia) and 516°C (960°F) to the electrical generation subsystem. Any rated steam generated in excess of turbine power requirements will be diverted to the thermal storage subsystem.

The receiver subsystem must also be capable of delivering steam at 10.4 MPa (1515 psia) and 349°C (660°F) when it is required to charge the total receiver energy output into thermal storage.

The pilot plant receiver must safely and efficiently absorb incident solar radiation at a maximum flux of 0.30 MW/m^2. In addition, the receiver must be able to accept, without damage, thermal gradients imposed by radiation transients due to the intermittent passage of clouds over the collector field.

The major hardware assemblies comprising the pilot plant receiver subsystem are the receiver unit, the tower on which the receiver unit is mounted above the collector field, and the supporting control and instrumentation equipment.

The receiver unit is in turn made up of six modular preheater panels and 18 boiler panels, flow control and instrumentation equipment, and the supporting structure.

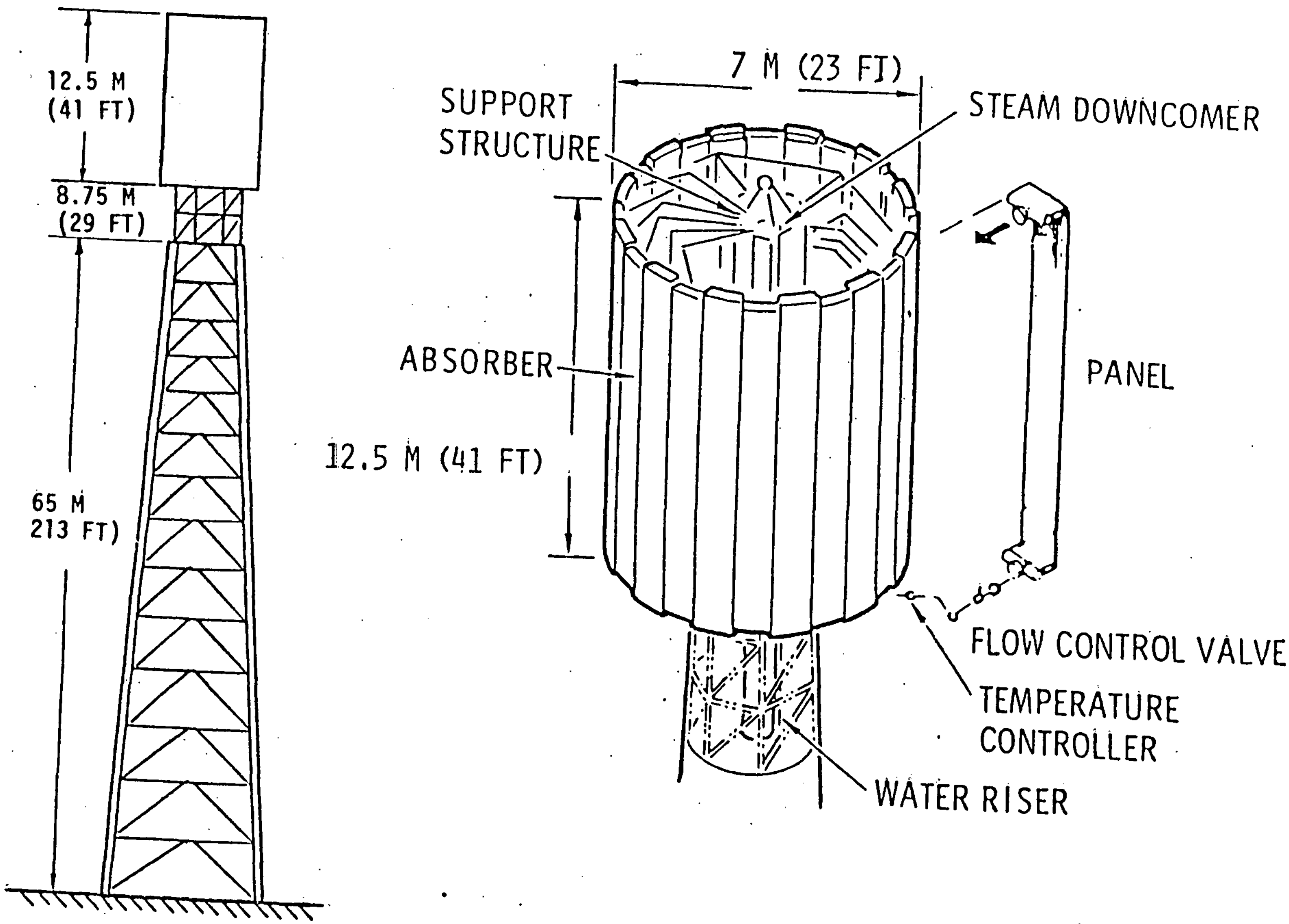


Figure 3.1.1-1, Pilot Plant Receiver

All panel subassemblies are constructed of 70 tubes [1.27 cm (0.50 IN) O.D. x .68 cm (.269 IN) I.D.] of high-strength corrosion-resistant Incoloy 800 laid side by side and joined together thermally and structurally and made opaque to incident light by full-length longitudinal seam welds.

The individual tubular panel assemblies of the receiver unit are mounted on a central core steel support structure to form a single large and essentially circular (24-sided) cylinder 7 m (23 ft.) in diameter by 12.5 m (41 ft.) long. The heliostats surrounding the receiver tower direct their collected insolation onto the full 360-degree external surface of the receiver unit.

The receiver tower is of steel construction and extends 65 meters (213 ft.) above grade to the interface with the receiver unit steel support structure which continues up through the receiver unit to an elevation of 86 meters (283 ft.) where it is crowned with a five ton capacity service crane. Mid-point of the receiver unit is 80 meters (262 ft.).

Functioning of the receiver can best be understood by following a typical day's operation.

To initiate startup, water from the water treatment equipment of the electrical power generation subsystem is forced up the receiver tower riser by the receiver feed pumps and into the receiver inlet filter assembly. Leaving the filter assembly, the water enters a manifold which distributes the flow into the inlets of the three parallel sets of two panels in series located on the south side of the receiver and designated to function as preheaters. The water absorbs heat as it flows through the preheater panels until it joins the flow from the other preheaters in a ring manifold supplying the remaining 18 panel assemblies designated as boiler panels. Passing through a modulating flow control valve located at the inlet to each boiler panel, the water flows vertically upward again absorbing heat from the incident solar radiation and leaving the upper end of the boiler panels as superheated steam. The individual boiler panel inlet valves provide the flow control necessary to maintain constant outlet temperature despite diurnal and seasonal variations in heat load at each panel. The control valves also control cloud-induced transients and regulate the startup and shutdown sequences. With this arrangement, active control of the water flow through the preheater panels is not required.

As the steam exits from each of the panel discharge manifolds, it passes through a cyclone-type water separator as a precautionary measure to ensure absolutely dry steam. The steam enters the steam downcomer collection manifold where it is mixed with the discharge flow from the other boiler panels and is finally carried away by the downcomer to the turbine of the electrical power generation subsystem or the thermal storage subsystem or both as directed by master control.

During startup or conditions when solar insolation is too low to produce the proper superheat conditions, a combination of valves is used to divert receiver discharge flow away from the downcomer and into a receiver flash tank assembly until proper superheat conditions are achieved.

A detailed description of the design of the receiver subsystem can be found in the McDonnell Douglas Central Receiver Solar Pilot Plant Preliminary Design Report (PDR), MDC G6776, Volume IV, dated May 1977.

3.1.2 Test Receiver Assembly

The test receiver assembly is comprised of the following subassemblies; panel, flow control, electrical control and instrumentation, and structure. The panel subassembly includes the tubes, insulation, thermal expansion provisions, backup structure, and manifolds. The function of the panel subassembly is to efficiently utilize incident thermal energy to convert ingested water into superheated steam.

The flow control subassembly includes the orifices, valves, filters, and plumbing. The function of this subassembly is to direct and control the flow of water to the various parts of the receiver as directed by the electrical control and instrumentation subassembly. This subassembly also provides for filtering, flushing, and purging of the receiver panel.

The electrical control and instrumentation subassembly includes the sensors, signal conditioning equipment, controller, and control valve actuators. This subassembly determines the condition of the receiver and utilizes the data to inform the test operators and to direct the flow control subassembly in conjunction with commands received from the test operators or facility master control.

The structural subassembly provides support for the other subassemblies with respect to gravity, wind, and seismic forces. These loads are transmitted by the structural subassembly to the tower.

The overall test configuration is shown in Figure 3.1.2.1. Each of the major subassemblies are described in Section 3.2. The drawings defining the overall test assembly are listed in Appendix A.

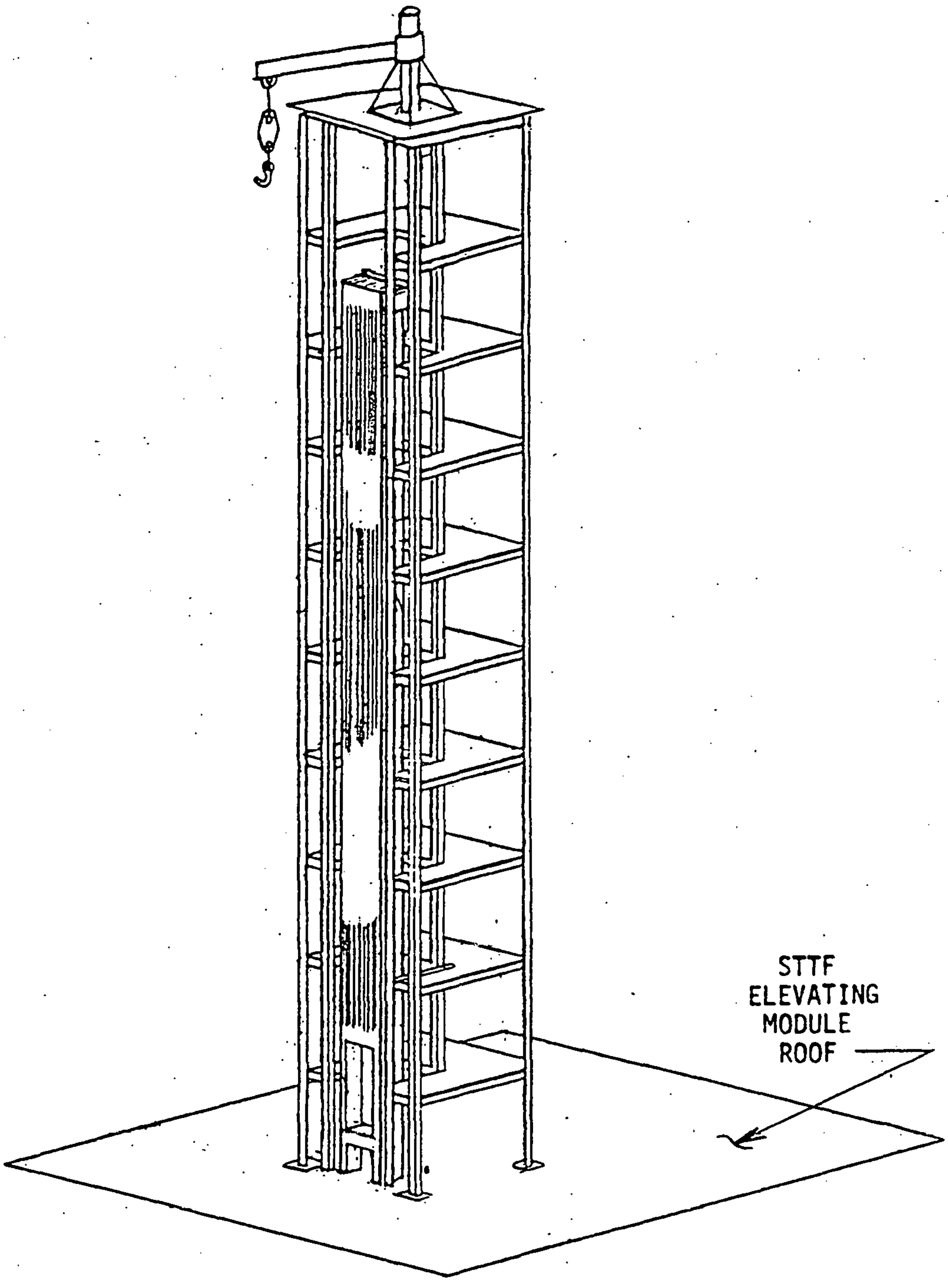


Figure 3.1.2-1, Overall Test Configuration

3.1.3 Design Specifications and Criteria

3.1.3.1 Mechanical

As a pressurized power boiler, the receiver unit from and including the receiver boiler panel water inlet valve (RBWISK; Ref. Figure 3.2.2-1), to and including the receiver boiler panel steam outlet valve (RBSOV) was designed and certified to the requirements of Section 1 of the ASME Boiler and Pressure Vessel Code (Ref. Figure 3.1.3-1). Fatigue life verification was made using the more sophisticated analysis techniques of Code Section VIII, Division 2. All pressure vessels (flash tank, moisture trap, receiver manifold) are designed to ASME Code Section VIII.

All valves and piping beyond the ASME Boiler Code jurisdiction will be designed, fabricated, or purchased in accordance with ANSI Power Piping Code B31.1.

All structural components will be designed to an ultimate load safety factor of 2.0.

3.1.3.2 Electrical

All electrical installations shall satisfy the requirements of the National Electric Code.

All low power signals shall be transmitted on shielded, twisted conductor pairs.

Figure 3.1.2-1

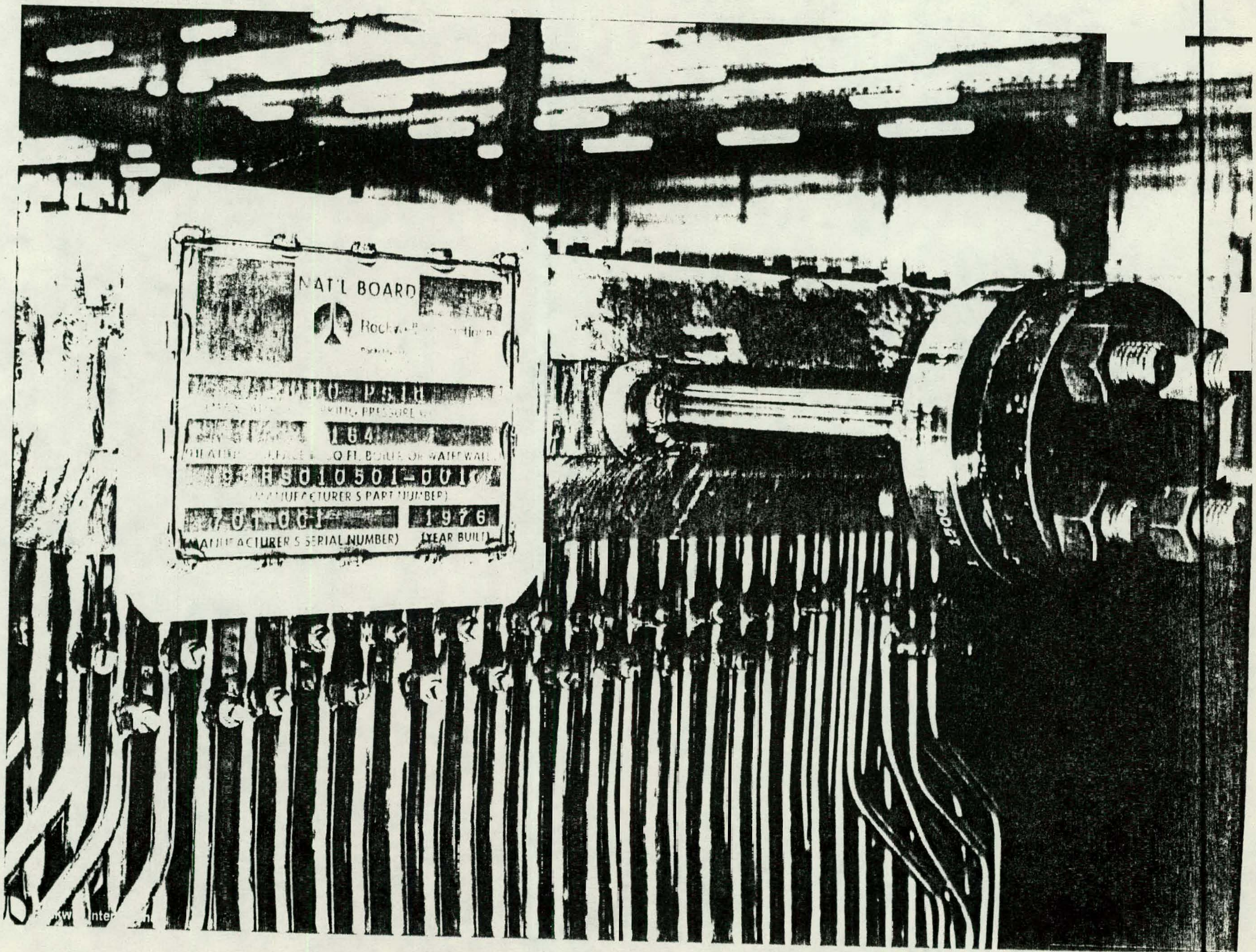


Figure 3.1.3-1, ASME Stamp on Test Panel

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MCDONNELL DOUGLAS

SIZE	CODE IDENT NO.	DRAWING NO.
A	18355	1T50721

SCALE | REV 6/8/78 | SHEET 3.1.3-2

3.1.4 Prior Test Experience

Prior to this STTF Test Program, the basic test receiver assembly successfully completed an extensive series of subsystem research experiments using radiant heaters to simulate solar flux. The SRE program is described in detail in the McDonnell Douglas Central Receiver Solar Pilot Plant Preliminary Design Report, MDC G6776, Volume IV, dated May, 1977.

3.2 MAJOR SUBASSEMBLY DESCRIPTIONS

3.2.1 Receiver Panel

The panel includes the tube bundle, manifolds, backup structure and insulation (Figure 3.2.1-1).

Tube Bundle

The tube bundle consists of 70 incoloy 800 seamless tubes. Each tube is 1.27 cm (0.500 inch) O.D.X0.68 cm (.269 inch) I.D. x 18.5 meters (726 inches) long. The length includes a .9 meter (36 inch) length folded over at the bottom to protect the water manifold and lower steel structure from radiation and a 0.4 meter (17 inch) length folded over on top to protect the steam manifold from isolation. Only the upper 12.5 meters of the straight section of the tube bundle will be exposed to concentrated insolation to duplicate the shorter pilot plant panel length.

The surface of the tubes exposed to solar radiation are coated with Pyromark paint which has demonstrated an absorptivity of 95 per cent over a wide range of wavelengths.

Backup Structure

The functions of the panel backup structure are to maintain the panel in its proper shape and to hold it to the structural subassembly in proper location while allowing for thermal growth and providing support for wind and seismic loads.

The panel is rigidly attached to the structural subassembly at the top (steam) manifold. The remainder of the structure allows for axial and lateral thermal expansion. Two fixed Tie beams engage sliding blocks at several axial stations on the panel to provide for axial expansion.

Each pair of sliding blocks (at a given axial station) are fastened to a channel having a hat-shaped cross section. Clips welded to the tubes slide on the above mentioned channels to permit lateral expansion of the panel. In addition to providing panel support, the transverse channels are used to mount thermal insulation on the back of the panel.

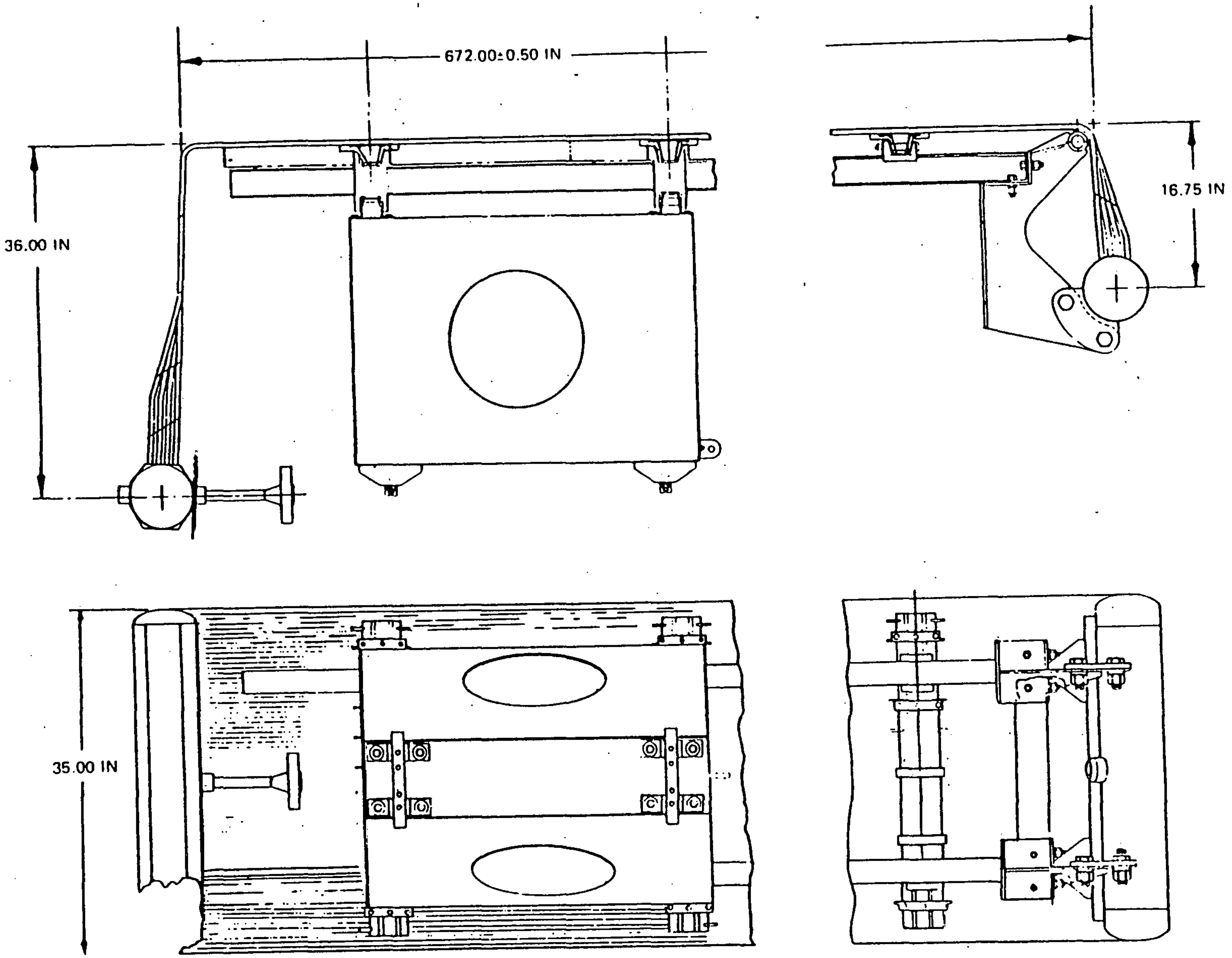


Figure 3.2.1-1 SRE Receiver Panel

3.2.1 (Cont.)

The tube bundle is supported by a bracket in the upper corner where the tubes are bent approximately 90° from the vertical. The bracket is tied to the panel's main rails which are in turn fastened to the main panel support structure. The panel suspended in this manner is allowed to expand downward.

Manifolds

The steam manifold is located at the uppermost portion of the receiver panel. All structural welds are full penetration butt welds. The tubes enter the manifold in four rows where they are mechanically expanded into the manifold and seal-welded. The tubes are slightly sloped such that they are self draining. Two brackets are welded to the manifold which are used for handling and attaching the panel to the support structure. The manifold material is Incoloy 800.

The water manifold is similar in construction to the steam manifold and is designed to uniformly distribute water to the tubes over the complete range of panel flow rates.

Insulation

Insulation is required behind the panel to reduce heat losses from the back side of the tubes and to protect structure and equipment behind the panel. The insulation consists of a bonded mineral fiber meeting the requirements of ASTM C612-70, Classes IV and V (Ref: Rocketdyne drawings 99RS01501 and 99RS010519).

3.2.2 Flow Control

The general requirements for flow control are: (1) modulate receiver panel inflow from the test facility feedwater riser in a dynamically stable manner, for consequent regulation of steam discharge temperature; (2) modulate steam outflow from the flash tank in a dynamically stable manner, for consequent regulation of steam discharge pressure under start-up and shutdown conditions; (3) control transitions between operating conditions; and (4) provide filtration, vent, relief, and nitrogen pressurant functions.

The relative arrangement of flow control components is presented schematically in Figures 3.2.2-1, with components identified by generic names or by tag numbers. Component symbols and nomenclature are defined in Tables 3.2.2-1 and 3.2.2-2. Components are further identified in the Appendix B equipment list.

Incoming polished water passes through manual stop valve RWIV and filter RWF, and through receiver preheater RP wherein, during a receiver startup, it is heated electrically to regulate the RB water inlet temperature. When sufficient steam heat energy becomes available in a start sequence for operation of the STTF feedwater preheater, all feedwater heating is accomplished by the STTF steam-heated preheater and RP heating is terminated. Preheated feedwater passes through fluid metering orifice RWO, vortex-shedding flowmeter RFM (which is the primary flow measurement device), steam discharge temperature control valve RBTCV, filter RBWF, and stop-check valve RBWISK en route to the RB water manifold.

RWO and RFM provide for alternate flow measurement techniques, for use in flow control and for data acquisition throughout all anticipated flowrate ranges. Various RWO orifice sizes will be used for STTF test conditions that impose a range in feedwater flowrates that is beyond the normal capability of the flowmeter (RFM). The flowmeter has sufficient rated flowrate range for compliance with pilot plant flowrate measurement requirements, and the flowmeter will be evaluated

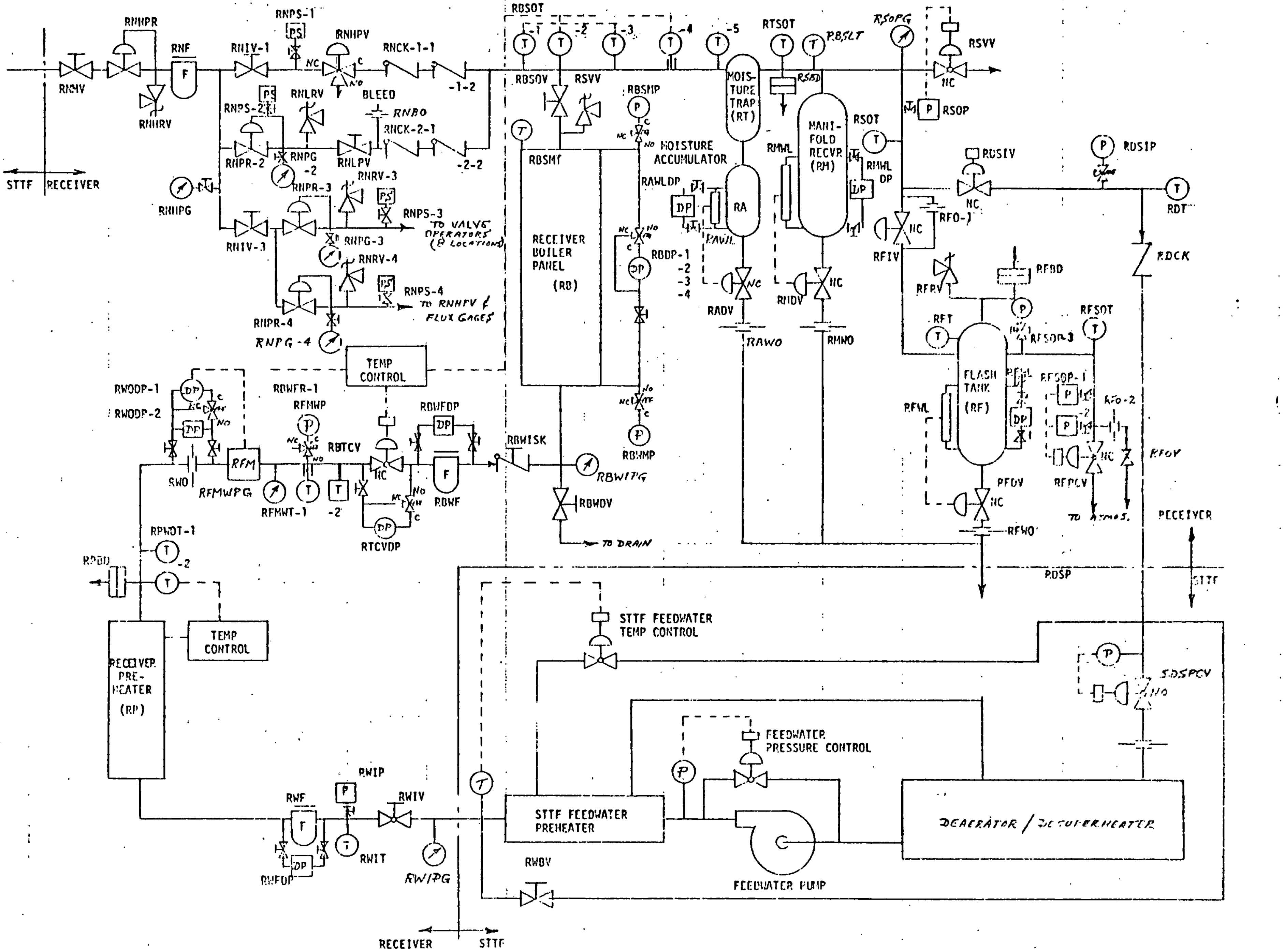


FIGURE 3.2.2-1
TEST SCHEMATIC
8/25/78

Table 3.2.2-1

SCHEMATIC SYMBOLS

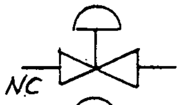
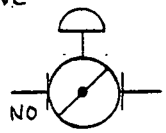
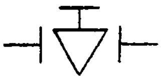
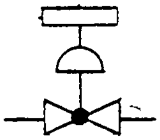
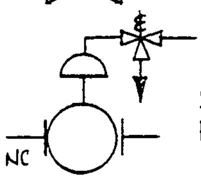
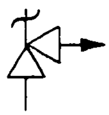
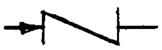
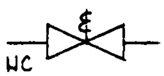
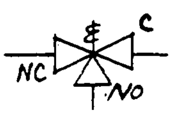
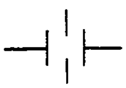
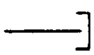
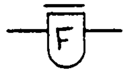
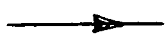
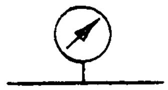
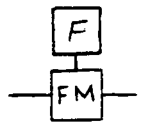
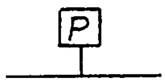
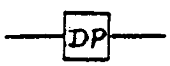
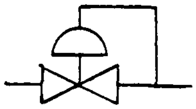
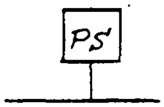
	MANUAL GATE VALVE
	PNEUMATIC GATE VALVE (NORMALLY CLOSED)
	PNEUMATIC BUTTERFLY VALVE (NORMALLY OPEN)
	MANUAL PLUG VALVE
	PNEUMATICALLY ACTUATED MODULATING GLOBE VALVE WITH ACTUATOR POSITIONER
	SOLENOID OPERATED PNEUMATIC BALL VALVE (NORMALLY CLOSED)
	MECHANICAL RELIEF VALVE
	CHECK VALVE (FLOW DIRECTION INDICATED)
	MANUAL STOP-CHECK VALVE
	2 WAY SOLENOID VALVE (NORMALLY CLOSED)
	3 WAY SOLENOID VALVE
	ORIFICE
	CAP
	WYE STRAINER
	FILTER
	FLOW DIRECTION
	LEVEL INDICATOR
	CONTROL CONNECTION
	BURST DISC
	LOCAL PRESSURE GAGE
	FLOWMETER WITH FLOW TRANSMITTER
	PRESSURE TRANSMITTER (CURRENT OUTPUT)
	PRESSURE TRANSDUCER (VOLTAGE OUTPUT + R-CAL)
	DIFFERENTIAL PRESSURE TRANSDUCER
	DIFFERENTIAL PRESSURE TRANSMITTER

Table 3.2.2-1 (Continued)

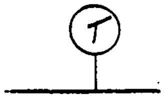
SCHEMATIC SYMBOLS



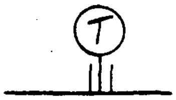
PRESSURE REGULATOR



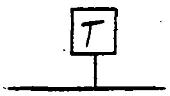
PRESSURE SWITCH



THERMOCOUPLE



THERMOCOUPLE IN WELL



RESISTANCE TEMP DETECTOR

McDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.
MCDONNELL DOUGLAS

Table 3.2.2-2

SCHEMATIC NOMENCLATURE

LETTER/NUMERAL HARDWARE ID CODE:

RPWRV-22-2

- Media (i.e., Water) → W
- Location (i.e., Receiver Preheater Panel) → RP
- Function (i.e., Relief) → R
- Component type or instrumentation parameter (i.e., Valve) → V
- Assembly number if multiple major assemblies (i.e., Receiver Panel 22) → 22
- Component number if multiple components on each major assembly → 2

Location	Media	Function	Component or Parameter
			Burst Disc = BD
Condenser = C	Heat Transfer Fluid=F	Bypass = B	Boost Pump = BP
CHW = Condenser Hot Well	Nitrogen = N	Charging = C	Controller = C
Deaerator = DA	Oil = O	Drain = D	Check Valve = CK
			Boost Pump = BP
High Pressure Heater = HPH	Steam = S	Extraction = E	Charging Pump = CP
			Differential Pressure = DP
Low Pressure Heater = LPH	Water = W	Inlet = I	Extraction Pump = EP
Receiver = R	AIR = A	Level Control = LC	Filter = F
Receiver Boiler Panel = RB	METAL = M	Main = M	Feed Pump = FP
Receiver Downcomer = RD		Outlet = O	Flow Rate = FR
Receiver Flash Tank = RF		Pressure Control = PC	Flow Transmitter = FT
Receiver Flux Gage = RFG			
Receiver Downcomer Manifold = RM			Gage = G
Receiver Preheater Panel = RP		Relief = R	Level Transmitter = LT
Receiver Moisture Trap = RT		Temp. Control = TC	Outlet Pressure = OP
Support Structure = S			
Thermal Storage = T		Throttle Stop Valve = TSV	Pressure = P
			Pressure Regulator = PR
Thermal Storage Desuperheater=TD		Vent = V	Inlet Pressure - IP
Thermal Storage Heater = TH		Warmup = W	Pressure Switch = PS
			Solenoid = S

Table 3.2.2-2

SCHEMATIC NOMENCLATURE (Cont'd.)

Location	Media	Function	Component or Parameter
Thermal Storage Unit = TU			Stop/Check Valve = SK Temperature = T Temperature Switch = TS Temperature Transmitter = TT Valve = V

MCDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.
MCDONNELL DOUGLAS
SIZE A
CODE IDENT NO. 18355
DRAWING NO. 107521
SCALE
REV 6/8/78
SHEET 3.2.2-5
60-0213-1A02 (06 AUG 71)

for that application.

RBTCV modulates the feedwater flow to the receiver panel to maintain the selected receiver steam outlet temperature despite diurnal and seasonal variations in heat input to the panel and also regulates flow during the start and shutdown sequences.

To ensure the cleanliness of the feedwater immediately before it enters the boiler panel, flow next passes through the receiver boiler water filter (RBWF) which provides for finer filtration than filter RWF at the RP inlet. Finally, the feedwater moves through the receiver boiler water inlet stop check valve (RBWISK) and enters the bottom of the receiver boiler panel (RB). Stop-check valve RBWISK is the interface between the feedwater plumbing and the ASME Boiler Code Section I portion of the RB and Code Section VIII components.

Under normal operating conditions, the feedwater flows upward through the receiver boiler panel, absorbs heat from the incident solar radiation, and leaves the upper end of the panel as superheated steam. As the steam exits from the receiver panel discharge manifold, it passes through a flow turbulator (swirler) and a cyclone type receiver moisture trap (RT) as a precautionary measure to prevent water carryover and is then directed through the steam manifold and receiver downcomer steam inlet valve (RDSIV) to the receiver/STTF interface and the facility condenser. Water removed by RT is collected in accumulator RA.

Liquid levels in moisture accumulator RA, receiver manifold RM, and flash tank RF are each monitored redundantly. Liquid level measurements are obtained with submerged probe capacitance-type transducers and with differential-pressure transducers. Either measurement method can be selected for automatic on-off operation of drain valves RADV, RMDV, and RFDV, and consequent liquid level control between upper and lower reference level settings.

During startup, shutdown, and when insolation is too low to produce the proper superheat conditions, RDSIV is closed and receiver two-phase flow is diverted through the receiver flash tank inlet valve (RFIV) to the receiver flash tank (RF). Steam flows through pressure control valve RFPCV to the atmosphere.

Under operating conditions with steam flow through the downcomer and with flash tank valves RFIV and RFPCV closed, orifices RFO-1 and RFO-2 provide a path for a small flow of steam through the flash tank. The flash tank is thereby kept warm to minimize thermal transients in a shutdown sequence when steam flow is transferred from the downcomer to the tank. When manual shutoff valve RFOV is closed, the receiver installation can be pressure tested without pressurizing the facility condenser.

Safety relief valves (RSRV and RFRV) and burst discs (RSBD and RFBD) project the steam discharge line and the flash tank against overpressure. A pneumatically actuated valve (RSVV) also provides the ability to relieve or vent receiver steam pressure if necessary during test operations and provides an alternate method for steam pressure control by discharge of steam flow the atmosphere.

Test facility nitrogen is regulated at four different pressure levels. Regulator RNHPR provides nitrogen for pressurizing the receiver installation during startup. Regulator RNPR-2 provides low pressure nitrogen to maintain an inert gas blanket pressure in the receiver under shutdown conditions. Regulators RNPR-3 and RNPR-4 provide nitrogen for pneumatically actuated valves. Relief valves RNHRV, RNPR-2, RNPR-3, and RNPR-4 provide protection against overpressure.

3.2.3 Electrical Control and Instrumentation

3.2.3.1 Summary

The general requirements for electrical control and instrumentation are: 1) provide an interface between the master control room and the RB installation for remote control and supervision; 2) provide for operator local manual control and supervision of RB checkout and test operations; 3) monitor and record the operational parameters that are required for subsystem control, evaluation, and protection.

The electrical control and instrumentation installation (Figure 3.2.3-1) includes the receiver controller (RC) which is located in the STTF tower computer room. The RC contains the electronics that are required for receiver manual checkout and control and for control instrument signal conditioning. In addition to normal pilot plant control functions, the STTF control and instrumentation installation includes control loops for control of panel discharge pressure and the feedwater electric preheater. Wiring will be provided to interconnect the subassembly components and the STTF computer control network.

Under normal operating conditions, the controller functions in response to master control commands, and provides the control room with supervisory operational data. However, the controller includes an operating console, and when the "local control enable" switch is closed at the console, the controller responds to operator manual inputs. The console provides for receiver checkout and operation that is independent of master control.

Instrument signals that are used for control purposes, as well as for data acquisition, are processed by the controller. Instrument signals that are used only for data acquisition purposes are processed directly by STTF equipment.

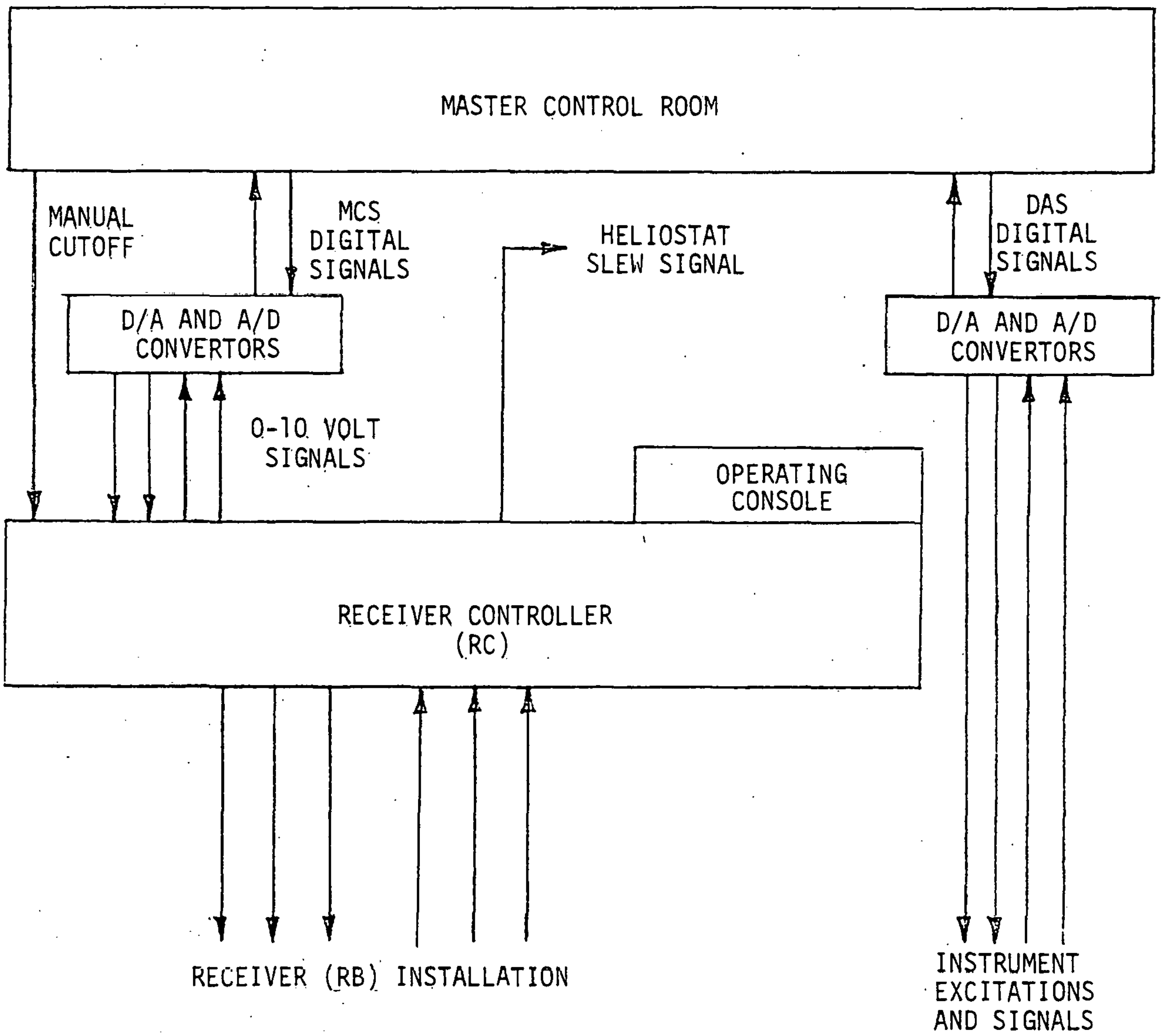


Figure 3.2.3-1 Electrical Control and Instrumentation - STTF Receiver Installation

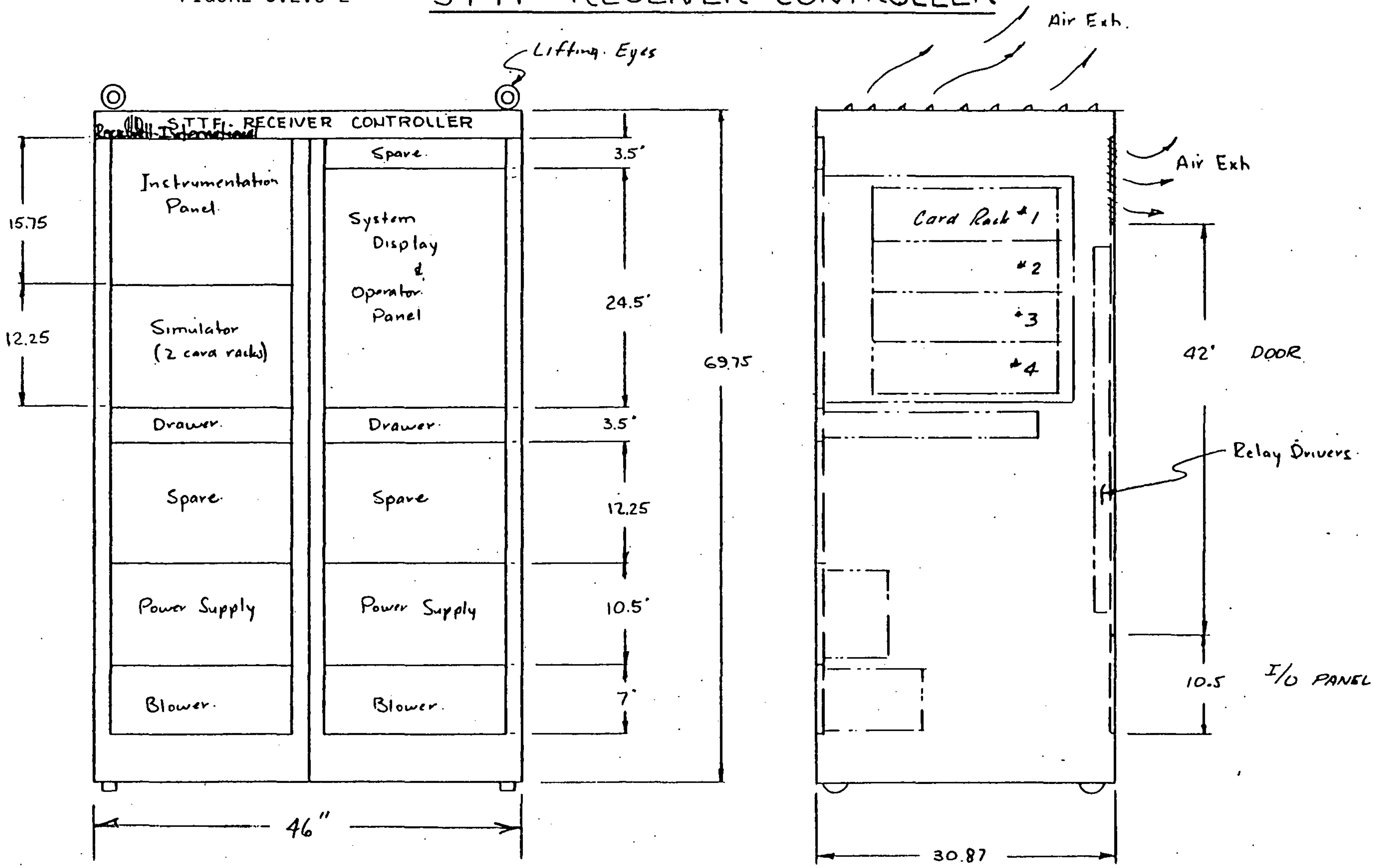
The receiver controller is housed in a standard rack enclosure (Figure 3.2.3-2) and is designed for installation in the controlled-environment computer room in the test tower elevator module. The controller operating console input and display features are shown in Figure 3.2.3-3.

The controller requires 110 volt 60 Hz electrical power from the test facility.

As indicated in Figure 3.2.3-1, all communication between controller RC and the master control room will be through digital to analog (D/A) and analog to digital (A/D) convertors located in the tower computer room. As indicated in Figure 3.2.3-1, and in the controller input-output diagram of Figure 3.2.3-4, all control signals back and forth between the A/D and D/A convertors and RC will be 0-10 volts DC, whether analog or on-off. One exception to digital data link communication is a direct link between RC and the master control room via a shielded twisted pair of wires, for operator manual safety cutoff that is independent of master control. Such cutoff is accomplished by closure of a normally open switch.

The various receiver installation control loops are described further below in Sections 3.2.3.2 through 3.2.3.9. Instrumentation is discussed in Section 3.2.3.10.

FIGURE 3.2.3-2 STTF RECEIVER CONTROLLER

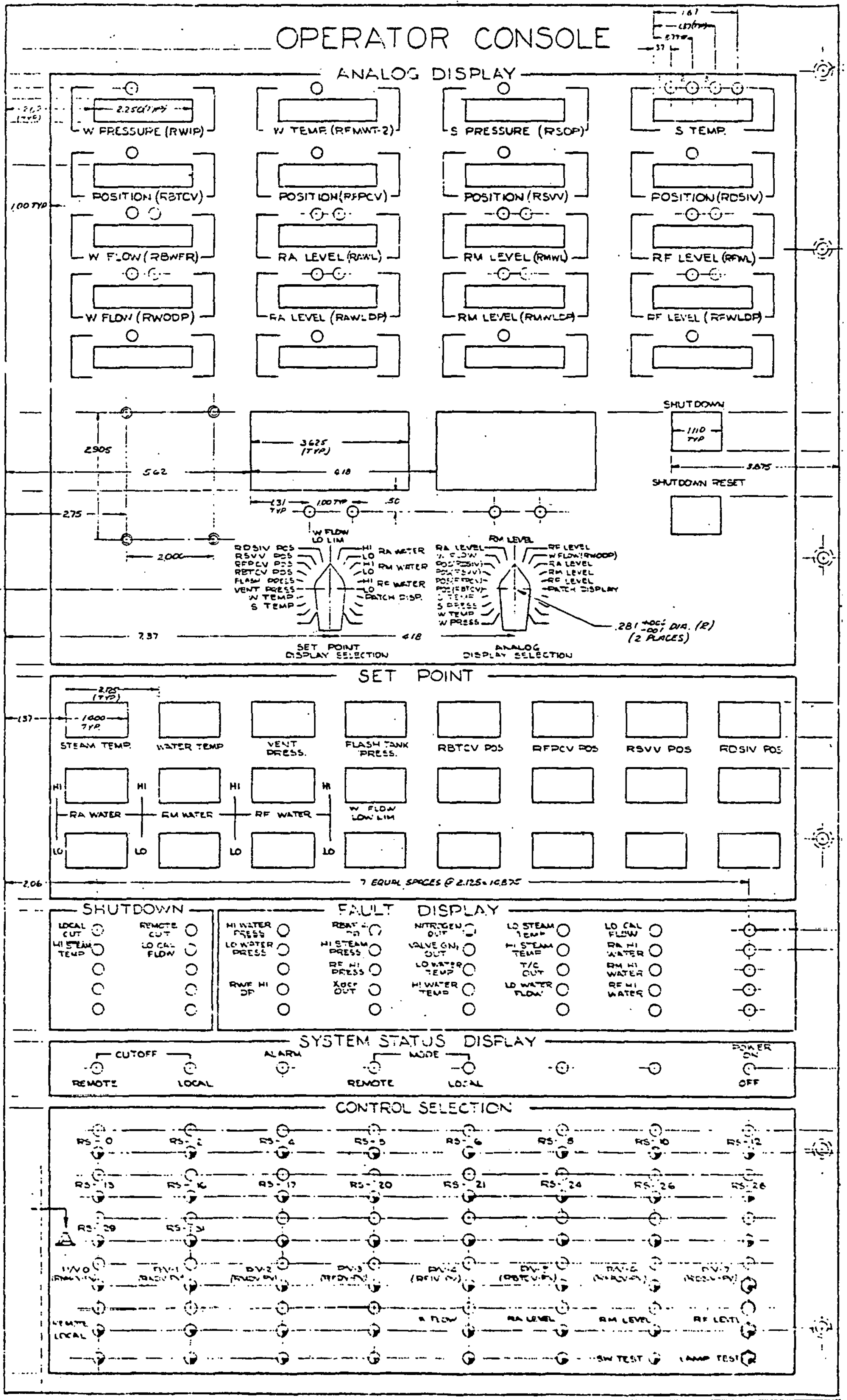


REV. 8/25/78 SHEET 3.2.3-4

Estimated Weight = 1,000 lbs.

"C" REV. Wendland 5-25-78

FIGURE 3.2.3-3



REV: 8/25/78
SHEET 3.2.3-5 & 6

FIGURE 3.2.3-4
CONTROLLER INPUT/OUTPUT DIAGRAM

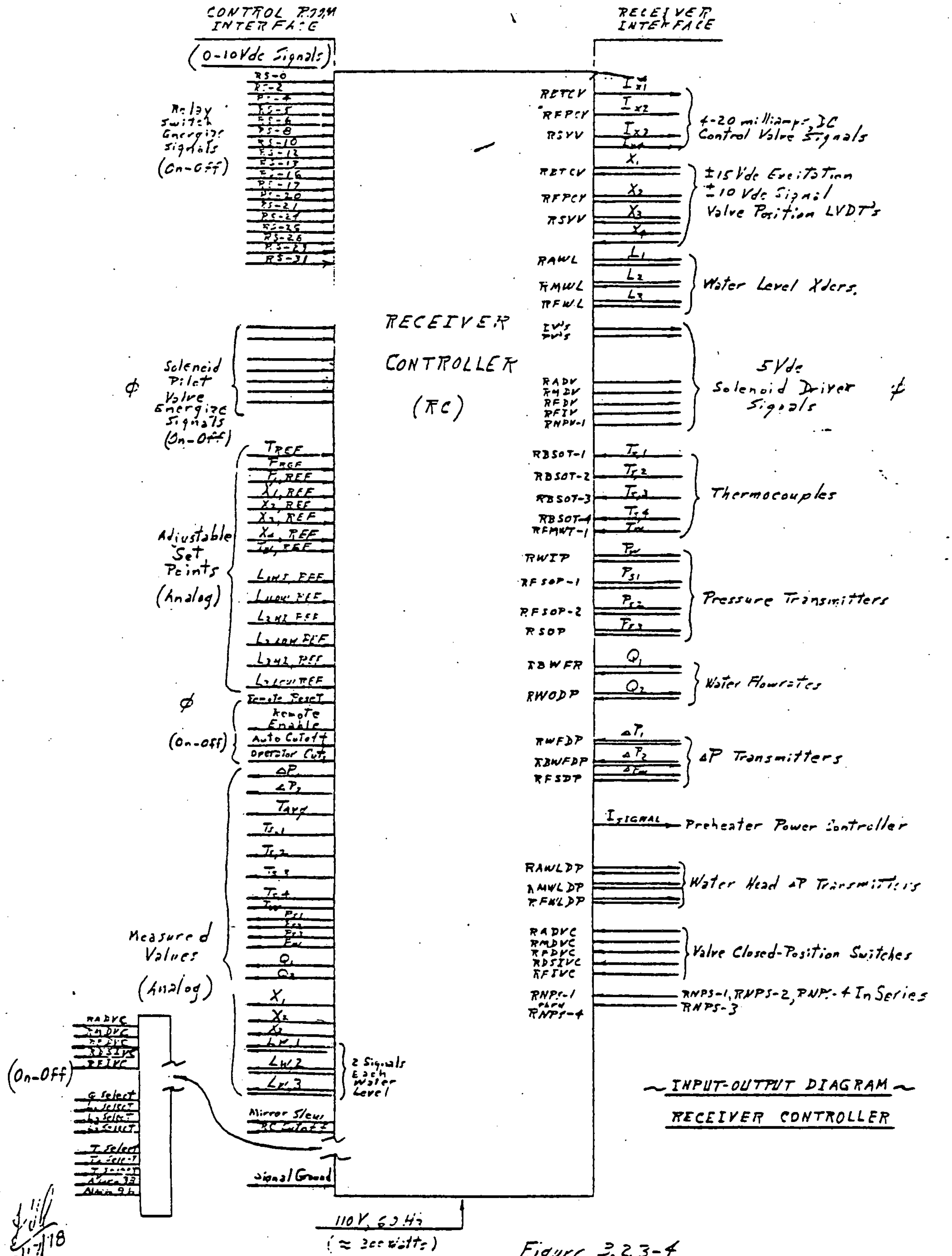


Figure 3.2.3-4

REV: 8/25/78
SHEET: 3.2.3-7

3.2.3.2 Steam Temperature Control

Figure 3.2.3-5 is a block diagram of the steam temperature control loops. Relay switches RS-1 through RS-6 are delineated symbolically as mechanical switches; however, the intent is to identify their functions, not their physical configurations.

With the switches in Figure 3.2.3-5 in the conditions shown, a reference temperature signal, T_{REF}, and a reference feedwater control valve position signal, $X_{1,REF}$, are applied to the controller as master control room interface signals. With switches RS-4 and RS-5 in the conditions shown, the temperature control loop is open and the valve position control loop is closed.

Under boiler startup conditions, a fixed temperature control valve (RBTCV) position is initially commanded. That valve has a mechanical stop which is set to ensure that the valve remains partially open to preclude feedwater inadvertent shutoff under any operating condition. The feedwater control valve assembly and its characteristics are described in greater detail later in this discussion.

Prior to onset of insolation, as the receiver startup sequence continues, relay switch RS-5 is closed to enable the temperature control loop, maintaining RS-4 in the condition shown. Because there is no insolation at that time, the control loop attempts to reduce the feedwater flowrate in attempting to increase the discharge temperature to the reference setpoint. An amplifier low limit, which is adjustable at the local operating console or in response to a master control room signal, becomes the water flowrate command signal. Any difference between the flowrate command signal, Q_{REF}, and the measured flowrate feedback signal, Q_{FB}, is integrated in generating a signal E_2. Signal E_2 then adds to or subtracts from signal E_1. A current amplifier output signal, I_{X1}, is proportional to the sum of E_1 and E_2. Feedwater control valve position in steady state is a linear function of the signal current. When RS-5 closes, E_2 is initially zero, and thereafter changes plus-or-minus at a rate which is limited by the gain of the integrating amplifier. Smooth transfer from feedwater valve position control to feedwater flowrate control is thereby obtained.

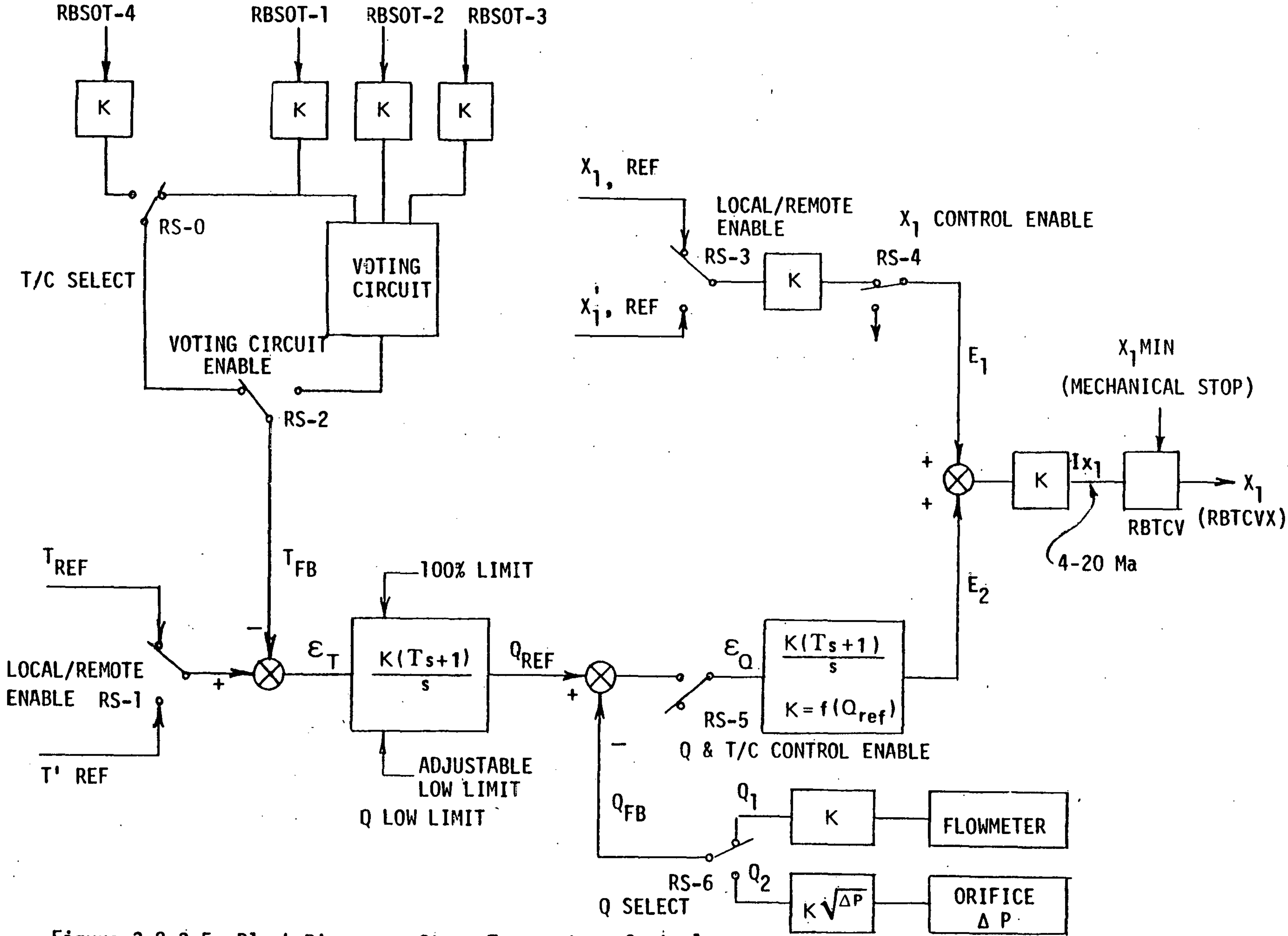


Figure 3.2.3-5, Block Diagram - Steam Temperature Control

3.2.3.2 Steam Temperature Control (Continued)

When insolation heat energy input is applied and the receiver discharge temperature increases to T_{REF} or T^1_{REF}, the temperature control loop automatically increases the feedwater flowrate as required for absorbing the heat input and regulating the discharge temperature.

As noted in Figure 3.2.3-5, the gain of the integration block that generates E_2 is a function of the commanded feedwater flowrate. The controller circuitry is designed so that alternate gain functions can be inserted, as required in optimizing control performance.

The amplifier that generates Q_{REF} has an adjustable low limit, as previously discussed. In the event that the sensed steam temperature is less than the commended temperature, normally resulting in a commanded reduction in feedwater flowrate, a minimum flowrate limit is imposed. The amplifier has a 100% limit to preclude amplifier overload saturation when RS-5 is open and T_{FB} is not equal to T_{REF}.

Steam temperature signals from sheathed thermocouples RBSOT-1, RBSOT-2, and RBSOT-3 are amplified and delivered to a voting circuit. The voting circuit delivers an average of the two signals that are closest together. If the third signal differs from the average of the other two by more than the equivalent of 50F, operation continues, but a T/C OUT fault signal is displayed at the local operating panel and is delivered to the master control room.

The amplified signal from RBSOT-1 is also delivered to relay switch RS-0. With RS-0 and RS-2 in the conditions shown in Figure 3.2.3-5, the amplified signal from RBSOT-1 is the steam temperature feedback signal. As an alternate, RS-0 can be positioned so that an amplified signal from RBSOT-4, a thermocouple in a well in the steam discharge line, can be selected as the feedback signal. Relay switch RS-2 can be positioned locally or remotely to accept the voting circuit output signal as the feedback signal. All four thermocouple amplified signals are delivered through the controller interface with the master control room, for system supervision and data acquisition.

3.2.3.2 Steam Temperature Control (Cont.)

The thermocouple circuit concept permits steam temperature control with a fast-response sheathed thermocouple, RBSOT-1, with a slower responding thermocouple in a well, RBSOT-4, or with a redundant circuit which permits operation in the event of a thermocouple failure. These options provide flexibility in a receiver testing, and will be used in determining the option that will be recommended for pilot plant control.

Relay switch RS-6 in Figure 3.2.3-5 permits selection of alternate feedwater flowrate feedback signals. The primary selection is the signal from a vortex-shedding type of flowmeter. The secondary feedback signal selection is the signal from a controller circuit that monitors pressure differential through a feedwater metering orifice. As discussed in Section 3.2.2, Flow Control, alternate orifice sizes will be used for tests with flowrate ranges beyond the anticipated ranges for the pilot plant.

Small green indicating lights on the controller operating console, and corresponding indicating signals to the master control room, indicate which of the three temperature sensing options and which of the two flowrate sensing options are in use for closed loop control.

When a local-control-enable switch is closed at the operating console, relay switches RS-1 and RS-3 are positioned for the input of steam temperature reference and valve position reference command signals which result from potentiometer settings at the console.

The relay switches in Figure 3.2.3-5 are shown in their normal conditions; e.g., none of the relays are energized. Relay switch positions are changed upon receipt of energize signals from the master control room, or by operating console switch settings under manual-input control when a local-control-enable signal is present.

3.2.3.2 Steam Temperature Control (Cont.)

Figure 3.2.3-6 is a schematic diagram of temperature control valve RBTCV. The normally-closed globe valve has a stainless steel body with 1 inch 1500 lb. raised-face flanges and stellite-faced equal-percentage-contour trim. The valve has an adjustable minimum-position stop to preclude inadvertent shutoff of feedwater flow. The assembly includes a double-acting spring-biased piston actuator. The actuator is controlled by a mechanical-feedback servo-positioner which is adjusted so that a 3 to 15 psig input signal to the positioner results in 0 to 100% poppet lift. The positioner operates with 125 psig nitrogen supply pressure for the piston actuation. The positioner input signal is obtained from an electric/pneumatic transducer which is adjusted so that a 4 to 20 milliampere input signal from the receiver controller results in 3 to 15 psig output pressure. The valve assembly includes a 20 psig pressure regulator for the transducer pneumatic supply. The valve assembly also includes a three-way solenoid dump valve in the pneumatic line to the opening side of the piston actuator. When the solenoid valve is in its deenergized normally-closed condition it vents the opening side of the actuator, and the spring-biased control valve closes rapidly. The dump valve is deenergized upon loss of electrical power, for automatic fast closing of RBTCV, and is also deenergized in an emergency shutdown procedure. The assembly includes an LVDT type of position transducer which has integral electronics so that it operates with a DC excitation and a DC output signal. The transducer is used for position indication only, not for closed loop control.

The downcomer steam inlet valve (RDSIV) is similar in configuration to RBTCV. Both valves close rapidly when their solenoid dump valves are deenergized.

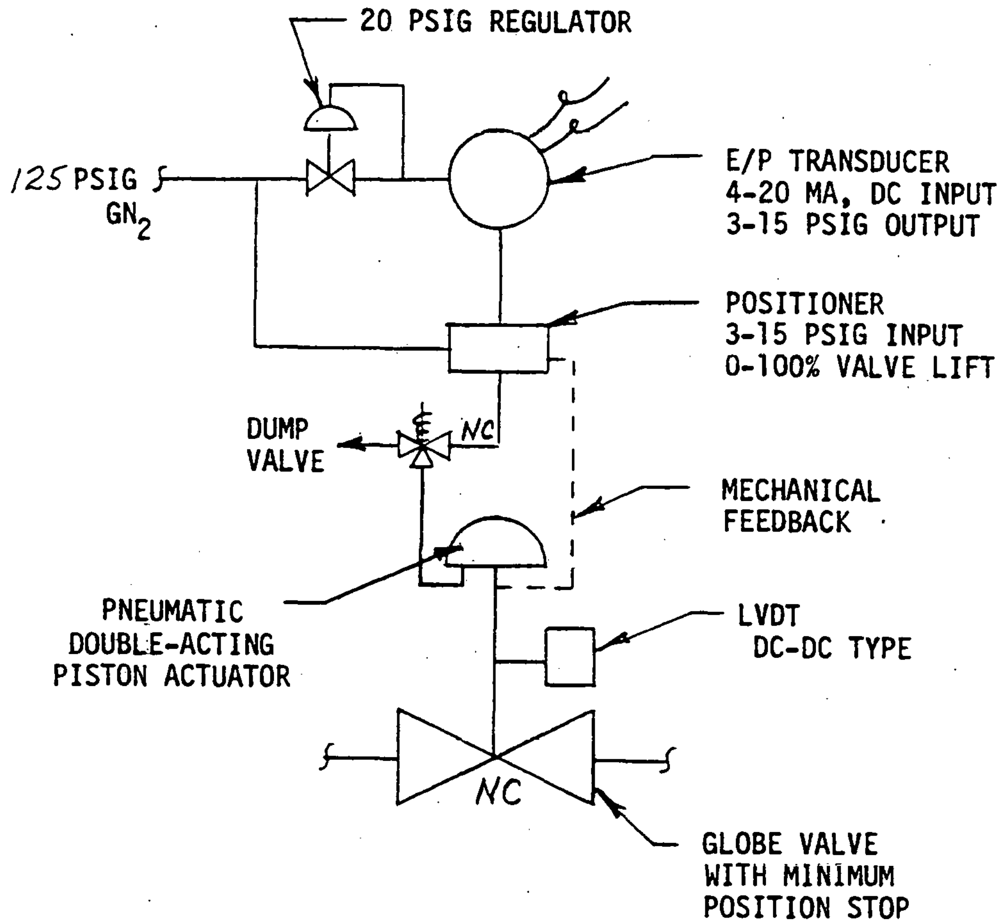


Figure 3.2.3-6, Boiler Temperature Control Valve Schematic

3.2.3.3 Flash Tank Steam Pressure Control

In the receiver startup and shutdown modes of operation, or at any time insolation is insufficient for the generation of dry superheated steam, steam downcomer inlet valve RDSIV is closed to prevent entry of water into the downcomer. Under those conditions the steam flow path is through shutoff valve RFIV, flash tank RF, and modulating control valve RFPCV to the facility condenser.

Figure 3.2.3-7 is functional block diagram of the flash tank steam pressure control circuit that is incorporated into the receiver controller. This circuit utilizes control valve RFPCV in open loop position control or closed loop pressure regulating control modes of operation.

With the relay switches in the conditions shown, a reference pressure signal, P_{REF}, and a reference steam pressure control valve position signal, $X_{2,REF}$, are applied to the controller as master control room interface signals. With switches RS-8 and RS-10 in the conditions shown, the pressure control loop and the valve position control loop are open and disabled.

Under boiler startup conditions with the Figure 3.2.3-7 control loops, RS-8 is closed and a scheduled steam pressure control valve position is commanded. Subsequently, in the startup sequence of operations, there is an event in which RS-10 closes to enable the pressure control loop, maintaining RS-8 in its closed condition. Any difference between the commanded pressure signal, P_{REF} and the sensed pressure feedback signal, P_{FB}, is integrated in generating a signal E_4. Signal E_4 adds to or subtracts from signal E_3. A current amplifier output signal, I_{X2}, is proportional to the sum of E_3 and E_4. Steam pressure control valve position is a function of the signal current.

When RS-10 closes, E_4 is initially zero, and thereafter changes plus-or-minus at a rate which is limited by the gain of the integrating amplifier. Smooth transfer from valve position control to steam pressure control is thereby obtained.

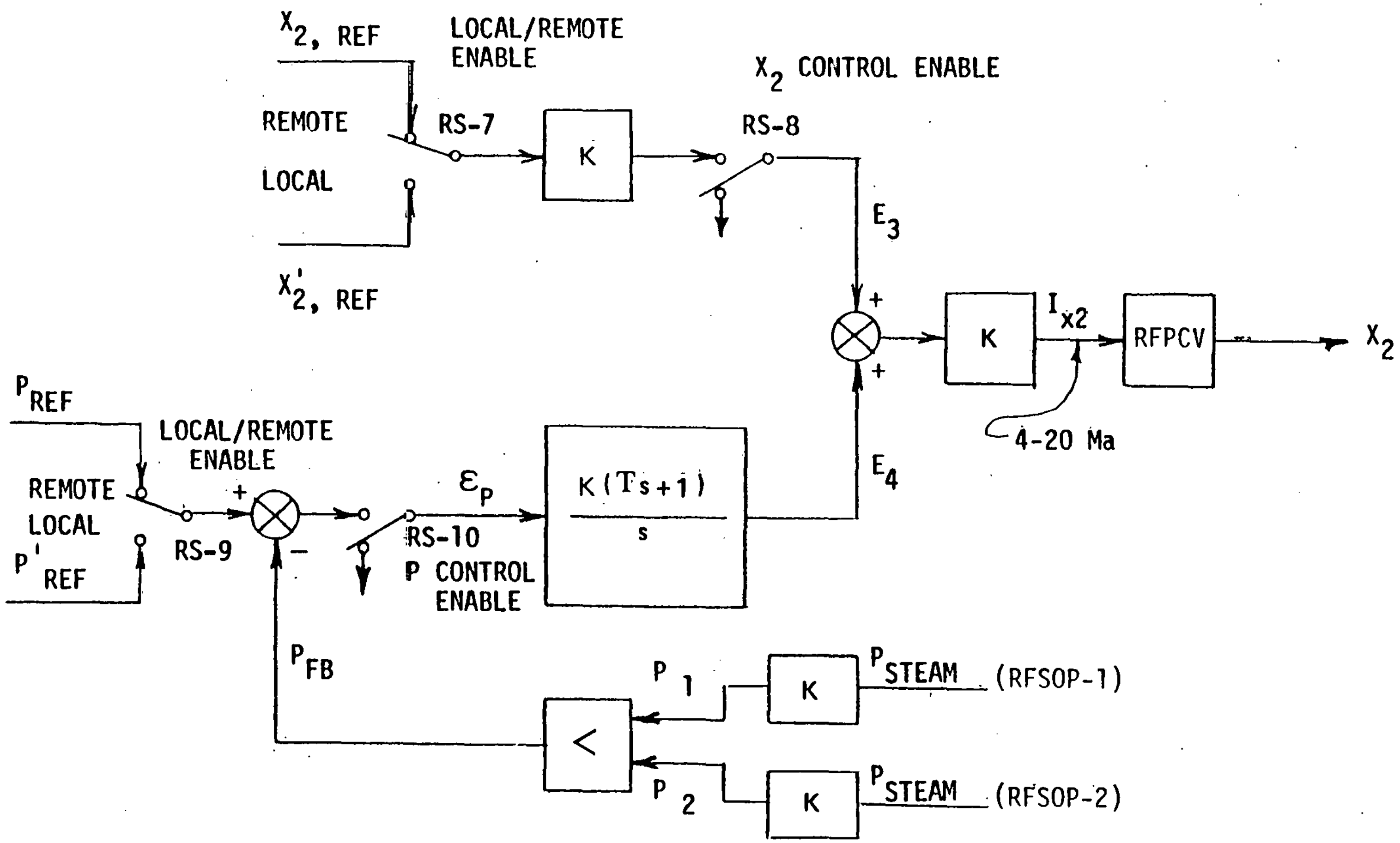


Figure 3.2.3-7, Block Diagram - Flash Tank Pressure Control

3.2.3.3 (Cont.)

Steam pressure signals from transducers RFSOP-1 and RFSOP-2 are amplified and delivered to a signal selector. The greater pressure indication is passed along as the sensed pressure feedback signal, P_{FB}. If the pressure signals differ by more than the equivalent of 50 psig, operation continues, but an XDCR OUT fault signal is displayed at the local operating panel and is delivered to the master control room.

The steam pressure sensing circuit concept provides redundancy in the measurement of this critical operating parameter. Both amplified pressure signals are delivered to the local operating console and to the master control room for system supervision and data acquisition.

When the local-control-enable switch is closed at the local operating console, relay switches RS-7 and RS-9 are positioned for the input of steam pressure reference and valve position reference command signals which result from potentiometer settings at the console.

3.2.3.4 Vent Valve Steam Pressure Control

Figure 3.2.3-8 is a functional block diagram of an alternate receiver steam discharge pressure control circuit that is incorporated into the receiver controller to provide flexibility in test operations. With this circuitry, steam vent valve (RSVV) can be utilized to control steam discharge pressure by controlling receiver steam outflow to the atmosphere.

With the relay switches in the conditions shown, a reference pressure signal, $P_{1,REF}$, and a reference vent valve position signal, $X_{3,REF}$, are applied to the controller as master control room interface signals, and the control loops are disabled.

In the local-control-enable mode of controller operation, switches RS-23 and RS-25 are positioned so that the $P'_{1,REF}$ and $X'_{3,REF}$ signals result from manual input potentiometer settings at the operating console.

When switch RS-24 closes in response to a command signal, local or remote, valve RSVV opens to the commanded position. This circuit provides for operator control of the RSVV position command signal, and consequent control of vent flow and receiver steam discharge pressure.

When switch RS-26 closes in response to a command signal, local or remote, a proportional-plus-integral control loop is closed for automatic regulation of the steam pressure that is sensed by transducer RSOP. This circuit provides for operator manual input setpoint control of regulated steam discharge pressure.

Vent valve RSVV is a normally closed valve. However, in an emergency shutdown this valve is commanded to its full open position. Additionally, a normally closed solenoid pilot valve is de-energized to vent the closing side of the control valve double-acting piston actuator so that the valve opens at its maximum rate.

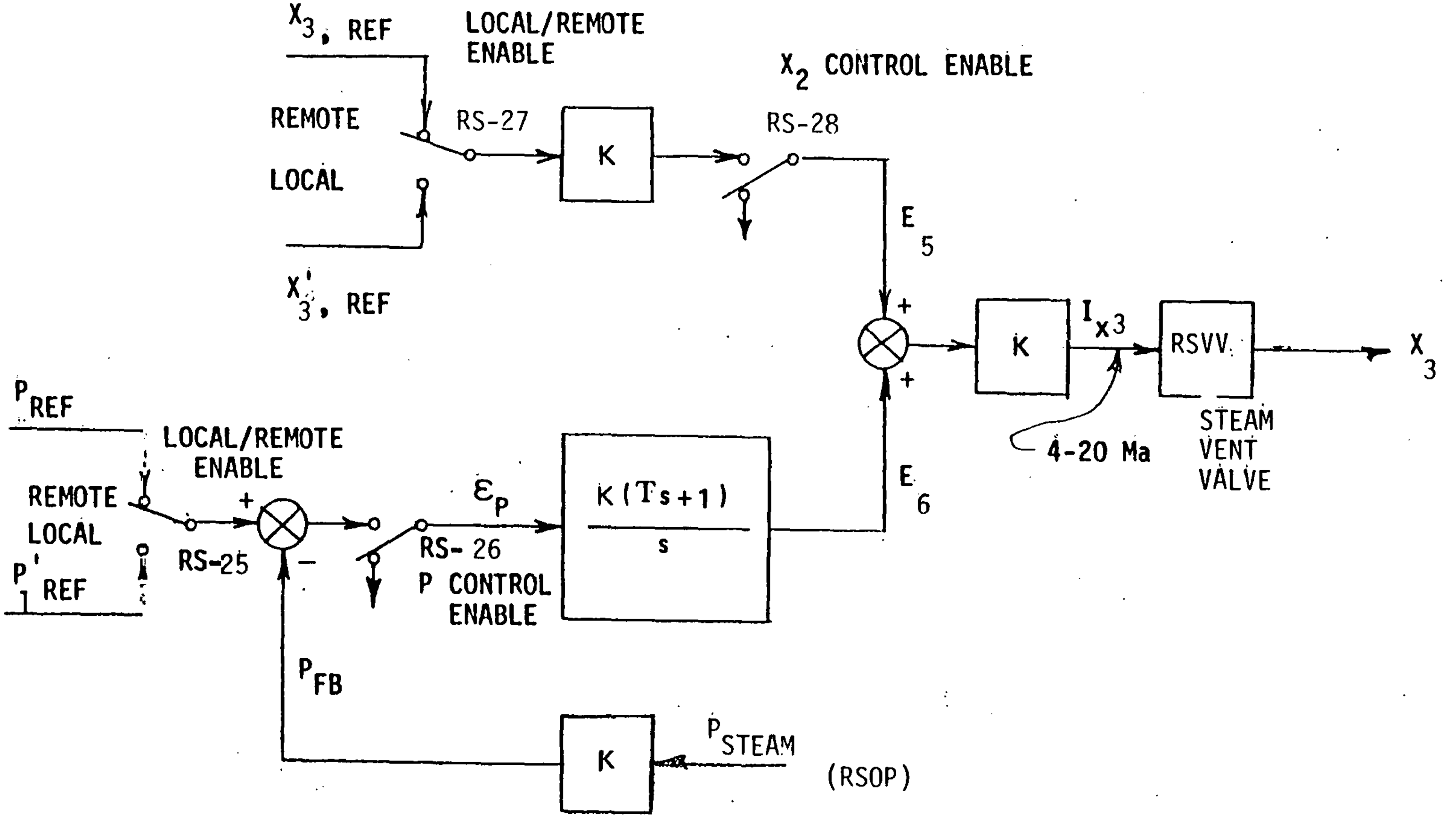


Figure 3.2.3-8, Block Diagram - Vent Valve Steam Pressure Control

3.2.3.4-a Downcomer Steam Inlet Valve Control

Modulating valve RDSIV controls steam flow from the receiver to the STTF downcomer. Figure 3.2.3-8a is a functional block diagram of the position control loop for that valve.

In transition modes of operation, when receiver steam discharge flow is diverted from the flash tank to the downcomer, or vice versa, RDSIV can be opened or closed gradually, or in incremental steps, to obtain smooth transitions without thermal shocks.

With RS-30 in the condition shown in Figure 3.2.3-8A, valve position command signal $X_{4,REF}$ is a receiver controller interface signal from master control. In the local-control-enable mode of controller operation, RS-30 is positioned for response to the $X^1_{4,REF}$ signal that results from a manual input potentiometer setting at the controller operating console.

When RS-31 is energized to close, the control circuit is enabled. In the event of a safety cutoff, RS-31 is returned to its normally-open condition and the control circuit responds by commanding the valve-closed position. (Reference 3.2.3.9 Emergency Control.)

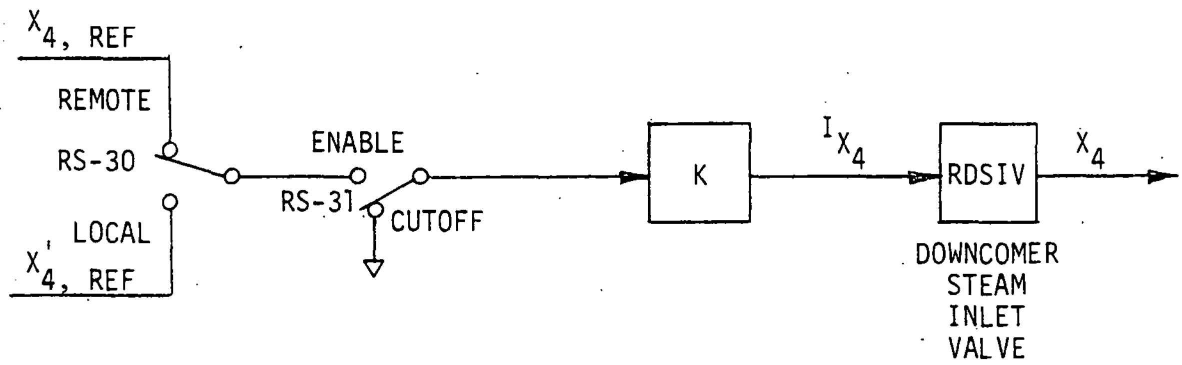


Figure 3.2.3-8a Functional Block Diagram - Downcomer Steam Inlet Valve Control

3.2.3.5 Feedwater Temperature Control

Figure 3.2.3-9 is a functional block diagram of the receiver feedwater temperature control loops that utilize an electrically-powered preheater (RF).

A manually operated switch, located internally within the receiver controller (RC), can be positioned to select automatic closed loop temperature control or manual open loop temperature control.

During operation in the manual mode of control, a digital potentiometer on the RC operator console is used to input an RP manual command. This input is conditioned and the RC delivers a signal current to the power controller. The power controller delivers signal current to six saturable core reactors which in turn deliver electrical power to six RP heater units. The operator observes the feedwater temperature display on the RC operator console and adjusts the potentiometer for manual control of RF electrical power input and consequent control of feedwater temperature.

During operation in the automatic mode of control, the temperature setpoint can be input at the RC operator console or as an interface signal from the master control room.

With relay switch RS-32 in the deenergized position shown, both control loops are disabled. RS-32 remains energized when a safety cutoff condition does not exist. If a safety cutoff occurs, RS-32 is then deenergized to terminate RP operation. Subsequent to a safety cutoff, RS-32 is returned to its energized condition when the cutoff reset pushbutton is depressed by the operator.

With relay switch RS-11 in the deenergized position shown, a reference temperature signal, $T_{W,REF}$, is applied to the receiver controller via the tower D/A converters, as a master control room input. When the operating console local-control-enable switch is closed, and consequently RS-11 is energized, a reference temperature signal, $T^{1}_{W,REF}$, is applied by means of a digital potentiometer on the local operator console.

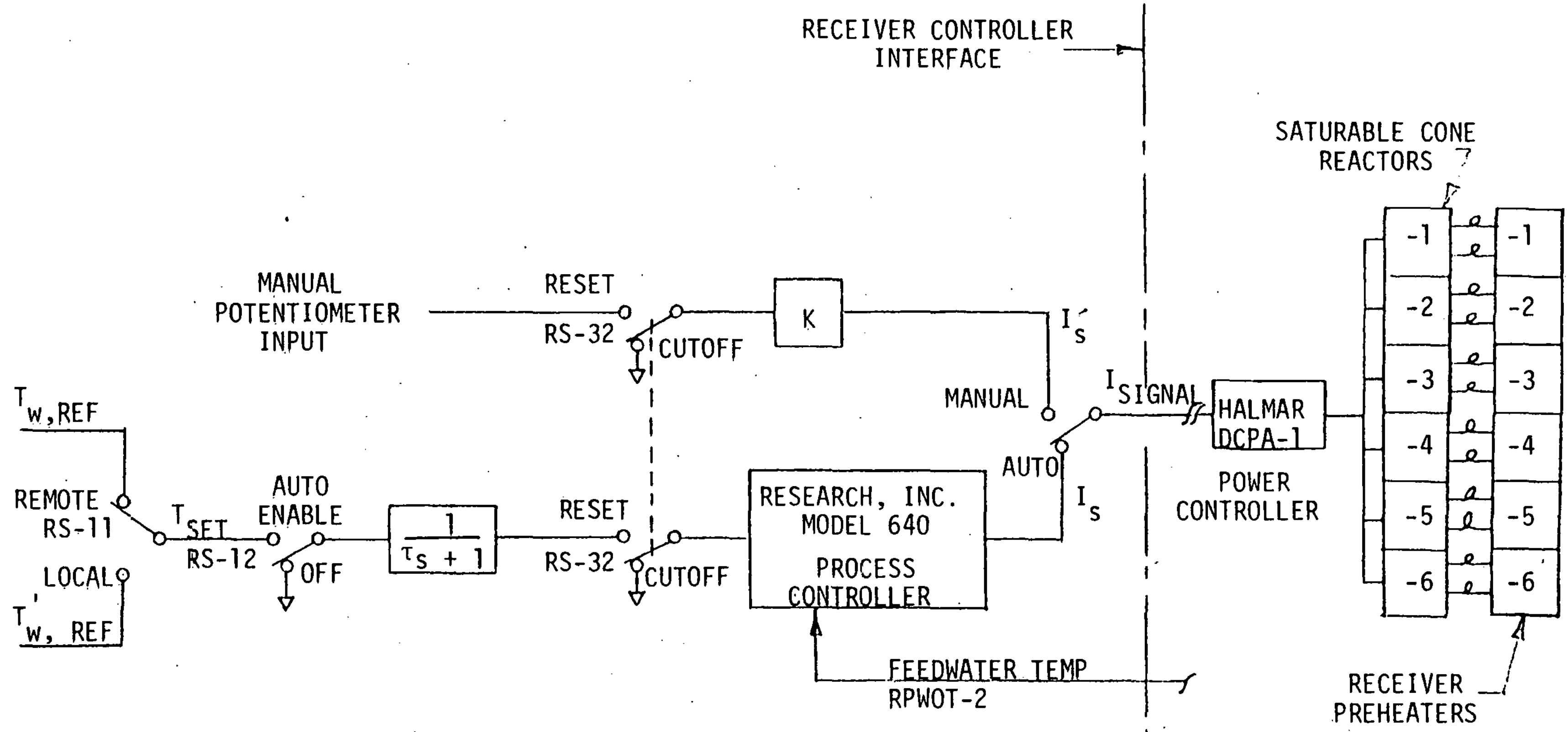


Figure 3.2.3.9   Functional Block Diagram - Feedwater Temeprature Control

MCDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.

MCDONNELL DOUGLAS

SIZE A | CODE IDENT NO. 18355 | DRAWING NO. 1T50721

SCALE | REV 8/25/78 | SHEET 3.2.3-22

60-0213 1A02 (06 AUG 71)

3.2.3.5 (Continued)

With relay switch RS-12 in the deenergized position shown, the RP automatic control loop is disabled. When RS-12 is closed, as the result of a remote or local operator input, a proportional-plus-integral process controller delivers the power controller signal current. When RS-12 closes, the rate at which T_{SET} is applied as a process controller input is limited by a first-order time lag. The result is a smooth increase in RP power. Power can be terminated by RS-12, with a time lag, or it can be terminated suddenly by RS-32. The process controller integrates any difference between T_{SET} and the feedback temperature measurement for closed loop regulation of feedwater temperature.

The input gain of the power controller will be matched to the process controller I_{SIGNAL} output range so that the preheater maximum electrical power at controller maximum signal is within the 200 KVA capability of the STTF interface.

When the receiver is generating steam to an extent that is sufficient for operation of the steam-heated STTF feedwater preheater, that heater regulates water temperature at a set point that is higher than the RP regulation set point. As facility preheater operation becomes effective and the water temperature exceeds the RP set point, process controller output I_{SIGNAL} goes to zero and the RP control loop automatically ceases active operation.

3.2.3.6 Water Level Control

Figure 3.2.3-10 is a functional block diagram of the flash tank water level control loop. With the relay switches in the conditions shown, high-level and low-level limit signals are applied to the controller as master control room interface signals, and the capacitance-type liquid level transducer signal is selected for use as the comparator measurement signal.

When the local-control-enable switch is closed at the local operating console, relay switches RS-14 and RS-15 are positioned for input of water-level limit signals which result from potentiometer settings at the controller operating console. Relay switch RS-13 can be positioned to select the differential pressure transducer signal as the comparator measurement signal.

Small green indicating lights on the controller operating console, and corresponding indicating signals to the master control room, indicate which of the level measurement signals is in use for water level control.

When normally-open RS-16 is energized to close, if the flash tank water level measurement signal is equal to or greater than the high limit signal, a solenoid pilot valve is energized to open the flash tank drain valve.

Outflow of water to a facility blowdown line is limited by an orifice. When the water level reduces to the low limit, the pilot valve is deenergized to close the drain valve. The cycle is repeated each time the water level increases to the high limit. When RS-16 is deenergized, the flash tank water level control loop is disabled.

The water level control loop shown in Figure 3.2.3-10 will be duplicated, with appropriate changes in identifying notation, for water level control in the moisture trap and in the receiver manifold, with component tag numbers as identified in Figure 3.2.2-1.

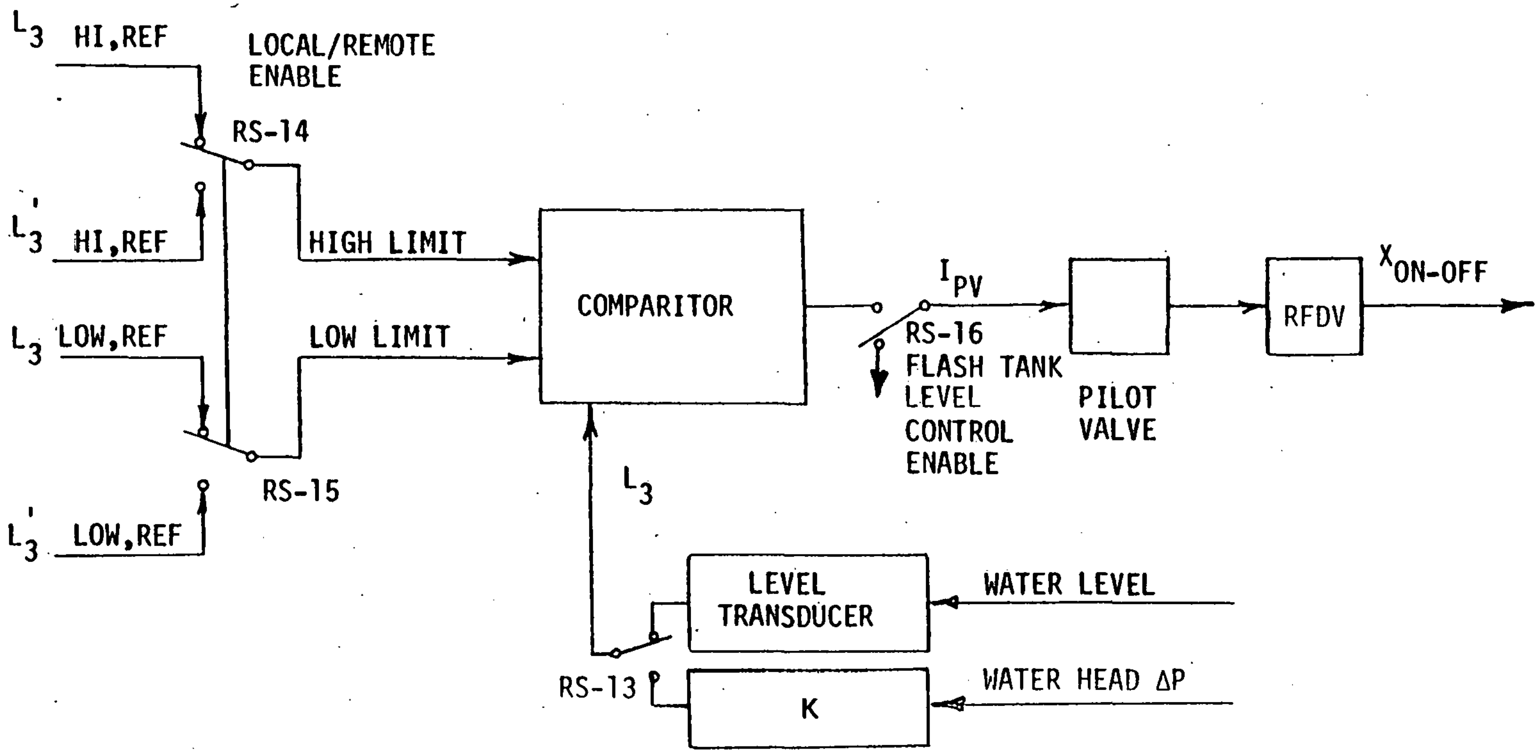


Figure 3.2.3-10, Block Diagram - Flash Tank Water Level Control
(Typical for Receiver/Moisture Accumulator and Receiver Manifold Level Controls)

3.2.3.7 Nitrogen Pressure Control

As discussed in 3.2.2 Flow Control, and as indicated in Figure 3.2.2-1, the receiver STTF installation includes a nitrogen gas pressure control subsystem.

Manual stop valve RNMV is located at the STTF/Receiver nitrogen gas interface. Nitrogen inflow through RNMV passes through pressure regulator RNHPR and through filter RNF.

Manual stop valve RNIV-1 is open during system operation, and nitrogen pressure is delivered to a normally-closed pneumatically-actuated three-way shutoff valve RNHPV in series with redundant check valves RNCK-1-1 and RNCK-1-2. When the solenoid pilot valve for RNHPV is energized, nitrogen pressurant is applied to the receiver in preparation for a startup. This nitrogen is regulated at a pressure that is greater than the saturation pressure of the heated feedwater to prevent the water from prematurely flashing into steam.

Under steam-generating operating conditions, the solenoid pilot valve for RNHPV is deenergized and the three-way valve is returned to its normal condition, with its inlet port closed and its outlet port open to its vent port. Leakage through the check valves is thereby vented, to protect the nitrogen supply circuits from the entry of heated condensate or steam.

Pressure regulator RNPR-2 delivers nitrogen through manual stop valve RNLPV to series-redundant check valves RNCK-2-1 and RNCK-2-2. This pressure is maintained continuously at the check valves when RNMV is open. Whenever the receiver is shut down, an internal inert gas blanket is maintained to prevent entry of ambient oxygen. When the blanket gas check valve outlet pressure exceeds the nitrogen inlet pressure, any leakage of condensate through the check valves is vented through a small bleed orifice (RNBO) to protect the low-pressure nitrogen plumbing circuit.

Manual stop valve RNIV-3 is open during system operation, and pressure regulator RNPR-3 delivers nitrogen as the operating fluid for piston-actuated modulating and on-off valves. Pressure regulator RNPR-4 delivers nitrogen as the operating fluid for diaphragm-actuated valve RNHPV and as a flux sensor coolant.

3.2.3.7 (Continued)

The four regulated pressures are indicated by pressure gages, with tag numbers RNHPG, RNPG-2, RNPG-3 and RNPG-4. Overpressure protection is provided by relief valves with tag numbers RNHRV, RNRV-2, RNRV-3 and RNRV-4. The flowrate capacities of the relief valves are sufficient to limit pressures within safe limits under conditions of the maximum flowrates that can be obtained with failed-open regulators and maximum regulator inlet pressures.

There are four dual-pressure switches in the nitrogen plumbing circuits, with tag numbers RNPS-1 thru RNPS-4, one for each regulated pressure setting. Each switch assembly has two double-throw single-pole mechanical switches, with switch set points above and below the corresponding monitored pressure setting. These switches are used for alarm indications if any of the four regulated pressure are not within limits that are defined by the switch settings, as discussed in Section 3.2.3.8, Alarm Control.

3.2.3.8 Alarm Control

The receiver controller provides the local operating console with alarm annunciations when an out-of-limits condition is detected. The alarm annunciator circuitry is continuously enabled at the operating console in both local and remote modes of operation. Except for out-of-limits regulated pressure faults (9a and 9b), none of the alarm annunciations are transmitted to master control; however, master control is supplied with measurements of the parameters that are required for its own alarm condition detection.

Whenever an alarm condition is detected, a readily visible alarm status light will attract the operator's attention. Small lights, with annunciator labels identify the specific alarm conditions.

Table 3.2.3-1 lists the alarm-condition faults, their input data sources, and annunciations.

Table 3.2.3-1

ALARM CONDITIONS

	FAULT	INPUT	ANNUNCIATION
1.	Feedwater pressure greater than 2000 psig	RWIP	Hi Water Press
2.	Feedwater pressure less than 1000 psig	RWIP	Lo Water Press
3.	Feedwater inlet pressure less than 1800 psig when RFIV is closed	RWIP RFIVC	Lo Water Press
4.	RWFDP greater than 30 psig	RWFDP	RWFDP Hi
5.	RBWFDP greater than 30 psig	RBWFDP	RBWFDP Hi
6.	Steam header pressure greater than 1600 psig	RSOP	Hi Steam Press
7.	RF pressure greater than 500 psig	RFSOP-1 RFSOP-2 RFSOP-3	RF Hi Press
8.	RF pressure transducer error	RFSOP-1 RFSOP-2 RFSOP-3	Xdcr Out
9a/ 9b	Out-of-limits regulated nitrogen	RNPS-1&2&4 RNPS-3	Nitrogen Out Valve GN_2 Out
10.	Feedwater temperature less than 400°F	RFMWT-1 RFMWT-2	Lo Water Temp
11.	Feedwater temperature greater than 600°F	RFMWT-1 RFMWT-2	Hi Water Temp
12.	Steam discharge temperature less than 625°F when RDSIV is open	RBSOT-1 thru 5 RDSIVC	Lo Steam Temp
13.	Steam discharge temperature greater than 1000°F	RBSOT-1 -2 -3 -4 -5	Hi Steam Temp
14.	Thermocouple voting circuit error	RBSOT-1 -2 -3	T/C Out

Table 3.2.3-1 (Continued)

ALARM CONDITIONS

	FAULT	INPUT	ANNUNCIATION
15.	High Panel Tube Temp*	RBT-216H30 -252H30 -360H30 -456H30 -408H30 RBT-324H40 -432H40 -384H40	Hi Tube Temp
16.	Feedwater flowrate less than lb/sec	RBWFR-1 RWODP-1	Lo Water Flow
17.	Flux Gage water flow less than TBD lb/sec	RFGWODP	Lo Flux Flow
18.	RA high water level	RAWL RAWLDP	RA Hi Water
19.	RM high water level	RMWL RMWLDP	RM Hi Water
20.	RF high water level	RFWL RFWLDP	RF Hi Water
21.	Valve fails to respond to command*	Closed Position Switches; Command Signals	Valve Fault

*STTF computer generated only

3.2.3.9 Emergency Control

The receiver controller incorporates emergency control features for safe shutdown of the receiver and the heliostat field in the event of an operator-initiated cutoff or in the event that certain out-of-limit conditions are detected. Table 3.2.3-2 lists the safety-cutoff faults and the operating console annunciations.

As indicated in the Figure 3.2.3-1, electrical control and instrumentation schematic diagram, the operator manual cutoff signal from the master control room to the receiver controller is via wires that are independent of master control. Additionally, an automatic cutoff signal from the master control room to the receiver is via the D/A and A/D converters. In the event of an RC-initiated safety cutoff, the controller sends a signal to the test facility, via wires that are also independent of master control, to slew the heliostats away from the receiver panel. Additionally, a cutoff signal is sent to the master control room via the D/A and A/D converters.

The receiver controller annunciator circuitry has "first-out" capability, i.e., the cause of the cutoff is annunciated, and any subsequent out-of-limits conditions that may occur are not. A cutoff annunciation, with operating console lights and identifying lables, is maintained until removed by a cutoff-reset push-button on the console or by a cutoff-reset signal from the master control room.

The manual cutoff switch on the receiver controller operating console and the manual cutoff switch in the master control room are both continuously enabled, with the controller in either the local or remote modes of operation.

The events that occur in response to a cutoff signal are identified in Section 5.5, Emergency Shutdown Procedure.

Control valves RBTCV, RDSIV, and RSVV have safety cutoff solenoid-actuated pilot valves that function as discussed in Section 5.5, Emergency Shutdown Procedure. The normally-closed pilot valves have 110 VAC coils and are controlled as indicated in Figure 3.2.3-10A. The three pilot valves are wired into a common junction box in the receiver structure. Within the junction box the solenoid wiring is interconnected so that the pilot valves are in parallel electrically. A single pair of

Table 3.2.3-2

EMERGENCY SHUTDOWN

	FAULT	RC ANNUNCIATION	RC SIGNAL TO MCS
1.	Controller operating console manual cutoff	Local Cutoff	RC Cutoff
2.	Master control room manual cutoff	Remote Cutoff	-
3.	Steam discharge temperature (RBSOT) greater than 1060F	Hi Steam Temp	RC Cutoff
4.	Calorimeter water flow less than TBD 1B/sec	Lo Cal Flow	RC Cutoff
5.	RDSIV leaves closed position when * RDT indicates temperature greater than 660F and RBSOT indicates a steam temperature less than the down-comer temperature by 100F	Lo Steam Temp	*
6.	Low quality steam *	Lo Qual Steam	*
7.	RFIV leaves closed position * when RSPO indicates steam pressure greater than 450 psig	RF Inlet	*

*STTF computer generated only

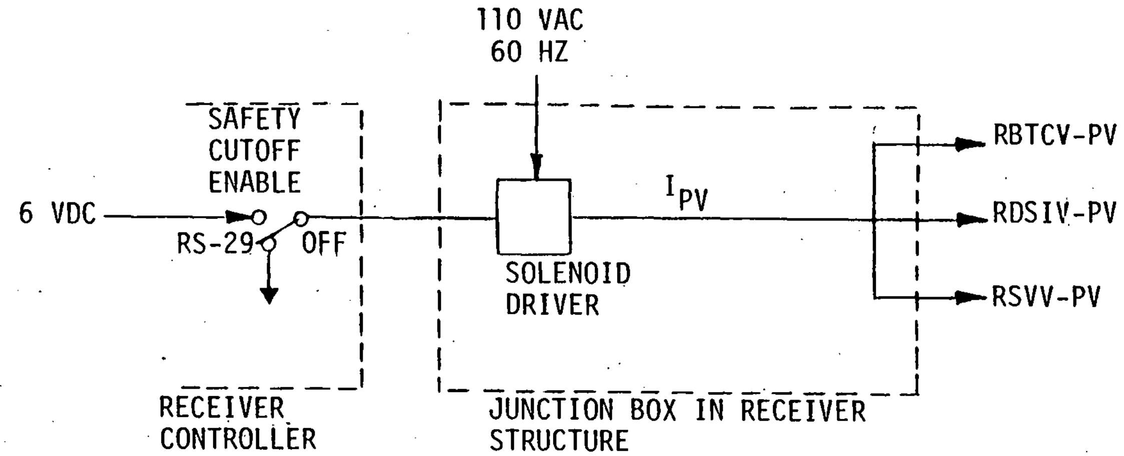


Figure 3.2.3-10A Safety Cutoff Solenoid Pilot Valve Control

3.2.3.9 (Continued)

Direct current signal wires connect the junction box to the tower computer room. A solid state solenoid driver circuit is located in the junction box. In the event of a safety cutoff, relay switch RS-29 is returned to its normally-open condition, and solenoid driver output current I_{PV} decays to zero. When the CUTOFF RESET pushbutton is depressed subsequent to a cutoff, relay switch RS-29 is closed, and the solenoid pilot valves are again energized.

3.2.3.10 Instrumentation

All receiver test instrumentation parameters are listed in Table 3.2.3-4 along with their intended functions, limits, sampling rates, and recording and/or display requirements. In addition to the recording requirements noted, all data is to be recorded digitally on magnetic tape.

All instrumentation signals required for control purposes will be conditioned within the receiver controller console and supplied to the facility A/D converters as 0-10 VDC signals. STTF will provide signal conditioning for all other instrumentation and will record and display, as required, all data directed from the test installation to the master control room.

All recorded data must be time referenced for event correlation purposes.

Instrumentation electrical interface requirements are identified in Table 3.2.3-3.

All pressure gages, pressure transmitters and differential-pressure transmitters are installed with manual shutoff valves that permit instrument isolation or replacement without opening the receiver to atmosphere. These transmitters are two-wire industrial process types that are energized with 24 volts DC from the RC and transmit pressure signals with an output of 4-20 milliamperes on the excitation wires.

Selected pressure and differential-pressure measurements, for data acquisition purposes only, are obtained with bridge-circuit voltage-output transducers that are wired as shown in Figure 3.2.3-11, and that have in-place calibration capability. These transducers are installed with 3-way solenoid-actuated isolation valves. The transducers are operational when the isolation valves are in their normally-open condition. When the isolation valves are energized to close, the pressure transducers are vented to ambient pressure, and differential pressures are equalized, to provide zero reference points for calibration. Regulated 10 volt DC excitation is applied for calibration, as it is for normal operation. While the transducers are vented, the R-Cal switch is closed, and the output is a second calibration point.

3.2.3.10 Instrumentation (Cont.)

The solenoid-actuated transducer isolation valves have 110 VAC coils, and are controlled as indicated in Figure 3.2.3-11A. All of these valves are wired into a common junction box in the receiver structure. Within the junction box the solenoid wiring is interconnected so that all of these valves are in parallel electrically. A single pair of direct current signal wires connects the junction box to the tower computer room, via the galley. Solid state solenoid drivers are located in the junction box. A 10 VDC input to the driver circuit from master control results in an energize current output to the isolation valves.

Figure 3.2.3-11B is a functional block diagram of the receiver panel heat flux transducer coolant circuits.

Liquid coolant, water with ethylene glycol, is circulated through a closed sensor-cooling circuit by a booster pump (RFGWBP) that is hydraulically in series with a pump in the STTF-furnished chiller unit. The booster pump maintains a pressure that is sufficient to prevent boiling within the sensors.

Water pressure is indicated locally by a pressure gage (RFGWPG) that is upstream from a filter (RFGWF). A trimming orifice (RFGWO-1) adds flow resistance to one leg of the parallel flow paths and is sized for the flowrate division that is indicated in the schematic diagram. A metering orifice (RFGWO-2) is sized to provide the indicated pressure distribution. A differential-pressure transmitter is used as a flowrate indicator.

As discussed in 3.2.3.9 Emergency Control, if water flowrate decreases below a preset minimum value during system operation, an automatic emergency shutdown occurs.

Nitrogen purge flow is applied, through a manual shutoff valve (RFGNV), to the sapphire windows of the radiometers. A trimming orifice (RFGNO) is sized for the indicated nitrogen flowrate.

Table 3.2.3-3

Electrical Interfaces - Instrumentation

ITEM	SOURCE	MIN/MAX REQUIREMENTS VOLTS	MIN/MAX REQUIREMENTS AMPS	CONTRACTOR SUPPLIED CONNECTOR	ICD[1]
Thermocouples		-	-	2 Pin Male Connectors (Not Installed)	(3)
• Excitation	(Self)	-	-		
• Signal	—	-3.0 to +10 MV D.C. -3.0 to +15 MV D.C. -3.0 to +25 MV D.C.	- - -		
Heat Flux Gauges				Calibrated Twisted Pairs With Floating Shields	(3)
• Excitation	(Self)	-	-	Unterminated	
• Signal	—	0-12 MV D.C.	-		
Pressure Transducers				8 Wire Cables Unterminated	(3)
• Excitation	STTF	10V D.C.	-	-	
• Signal	—	0-30 MV	-		
Diff. Pressure Transducers				8 Wire Cables Unterminated	(3)
• Excitation	STTF	28V D.C.	-		
• Signal	—	0-500 MV	-		

(1) Interface Control Drawing
(2) Referenced to 150°F
(3) Terminate instrument wires 8 feet below top of elevating module (TBD X & y coordinates).

Table 3.2.3-3 (Cont'd)

Electrical Interfaces - Instrumentation

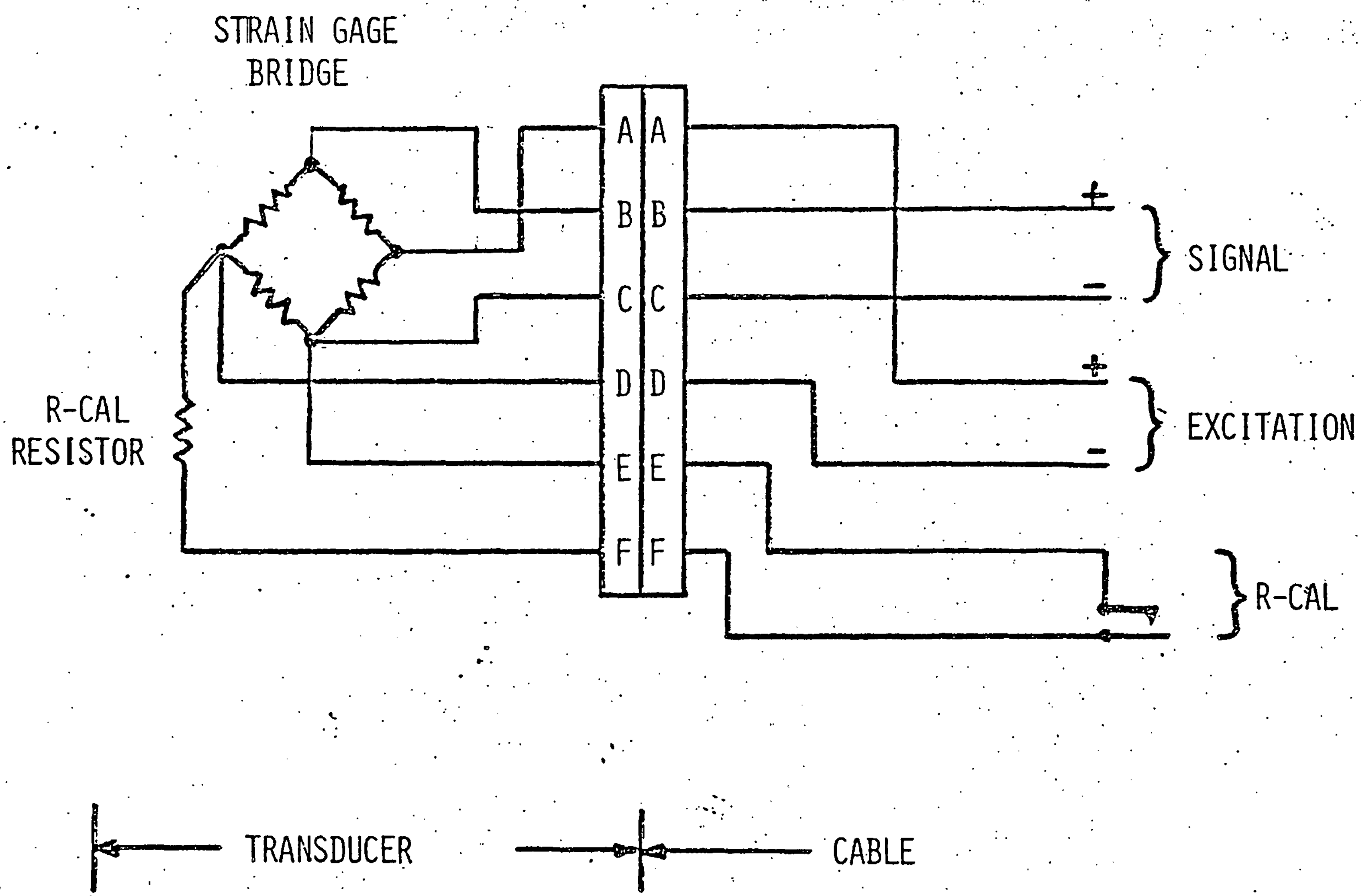
ITEM	SOURCE	MIN/MAX REQUIREMENTS VOLTS	AMPS	RECEIVER SUPPLIED CONNECTOR	ICD
Displacement Transducers (LVDT)				8 Wire Cable Unterminated	(3)
● Excitation	STTF	± 15 VDC	—		
● Signal	—	± 10 VDC	—		
Liquid Level Transducers				Unterminated Cable	(3)
● Excitation	RC	117V A.C.	-		(3)
● Signal	—	-	4-20 MA(5)		
Flowmeters				Unterminated Cable	(3)
● Excitation	RC	117V A.C.	-		
● Signal	—	-	1-5 MA(5)		
Pressure Transmitter					
o Excitation	RC(4)	24 VDC			
o Signal	—	—	4-20 MA(5)		
Diff. Press. Transmitter					
o Excitation	RC	24 VDC			
o Signal	—	—	4-20 ma(5)		
Resistance Temp. Detector					
o Excitation	STTF				
o Signal	—				

(4) Receiver Controller

(5) Output as 0-10 VDC to STTF A/D converters

FIGURE 3.2.3-11

INTERFACE - ELECTRICAL - PRESSURE TRANSDUCER



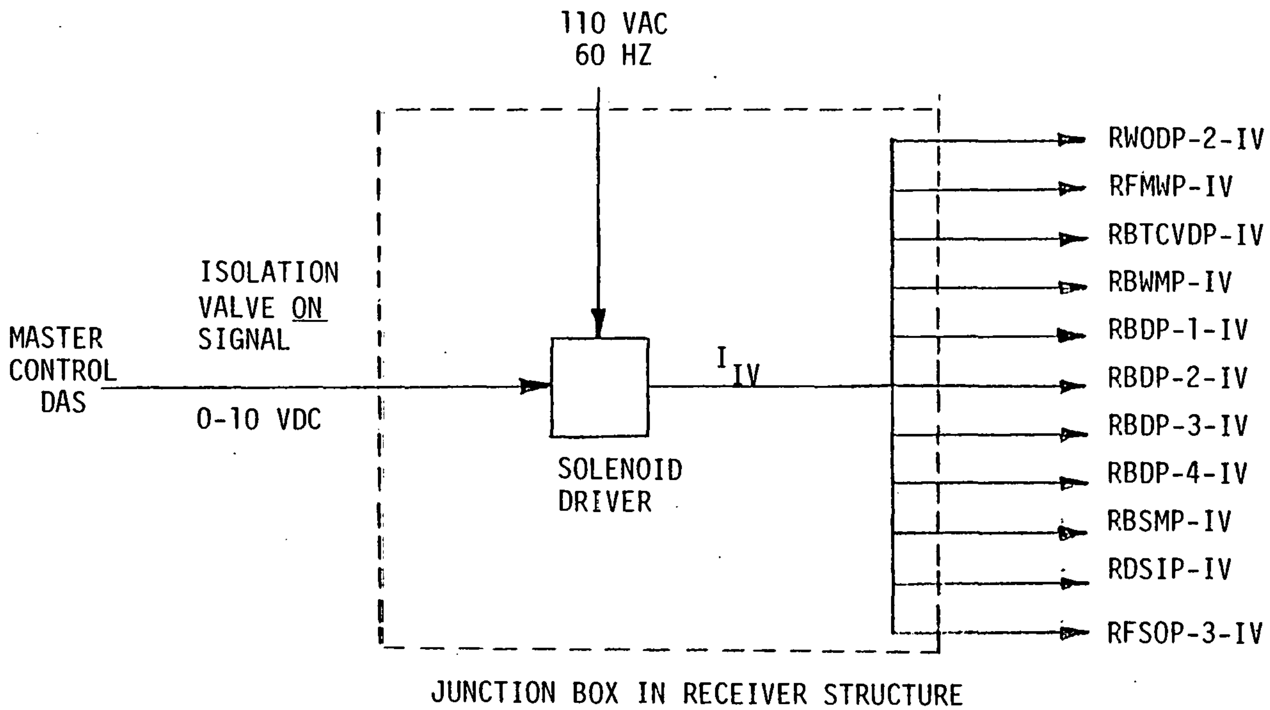


Figure 3.2.3-11A Transducer Isolation Valve Control

MCDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.
MCDONNELL DOUGLAS
SIZE A | CODE IDENT NO. 18355 | DRAWING NO. 1T50721
SCALE | REV 8/25/78 | SHEET 3.2.3-40
60-0213-1A02 (06 AUG 71)

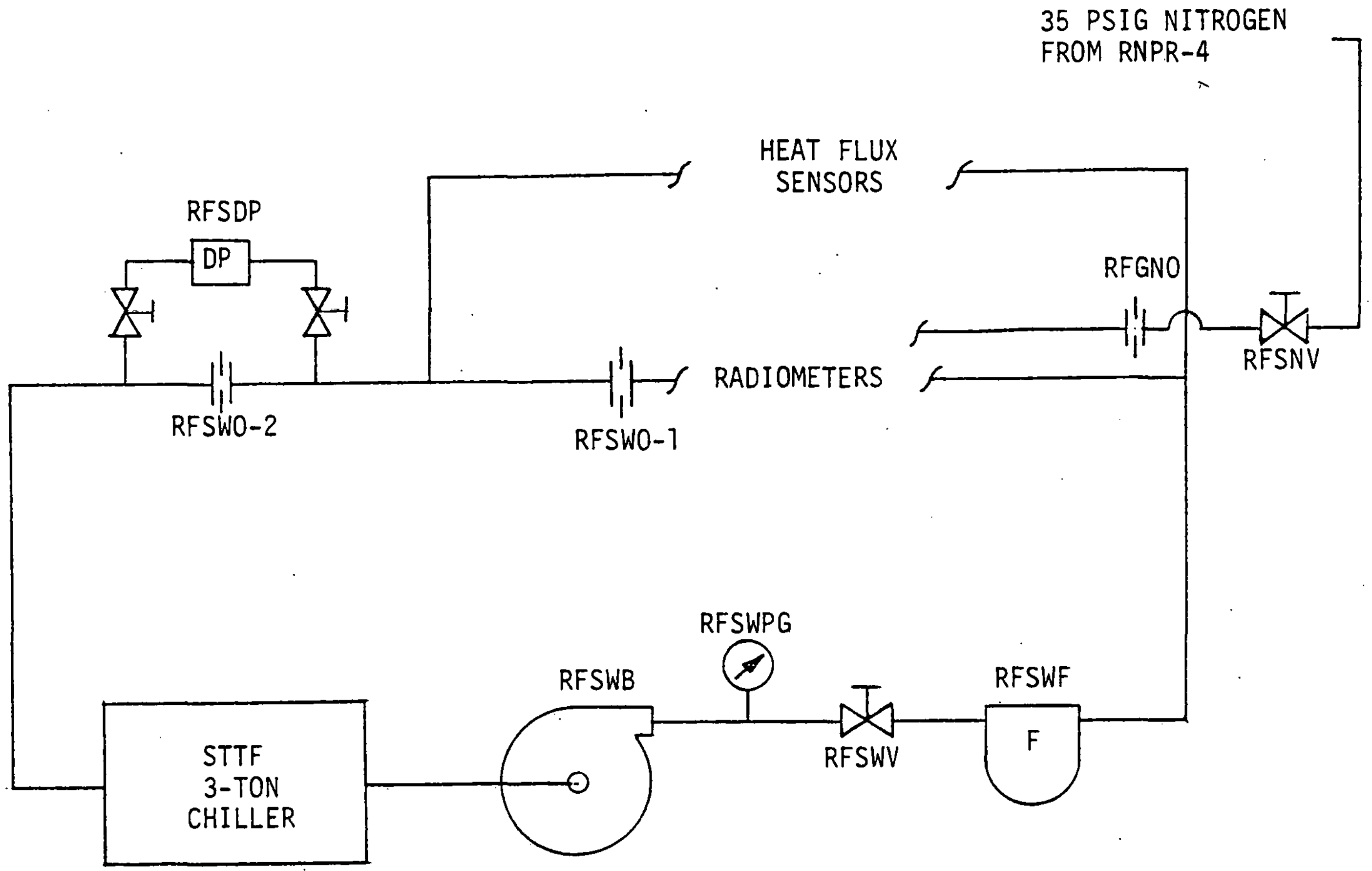


Figure 3.2.3-11b Functional Block Diagram - Heat Flux Transducer Coolant Circuits

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Pressures														
RAWLDP	Accumulator Water Head	In-H_2O	0-60	5.0	1	X	TBD	-	-	X	X	A/G	X	-	Backup to RAWL
RBDP-5	Boiler Delta P - Tube #5	psid	0-100	0.25	5	-	-	-	-	-	-	A/G	X	X	
RBDP-30	" " " #30	"	"	"	"	-	-	-	X	-	-	A/G	-	X	
RBDP-40	" " " #40	"	"	"	"	-	-	-	-	-	-	A/G	X	X	
RBDP-70	" " " #70	"	"	"	"	-	-	-	-	-	-	A/G	-	X	
RBSMP	Boiler Steam Manifold	psig	0-2000	0.5	1	-	-	-	-	-	-	A	X	-	
RBTCVDP	Temp Control Valve DP	psid	0-500	1.0	1	-	-	-	-	-	-	A	X	-	
RBWFDP	Boiler Water Filter Diff.	psid	0-100	1.0	0.1	-	30	-	-	-	X	A/G	X	-	ΔP_1
RBWIP	Boiler Water Inlet	psig	0-2000	0.5	1	-	-	-	-	-	-	A	X	-	
RBWMP	Boiler Water Inlet Manifold	psig	"	"	"	-	-	-	X	-	-	A	X	-	
RDSIP	Downcomer Steam Inlet	"	"	"	"	-	-	-	X	-	-	A/G	X		
RFGWODP	Flux Gage Water Orifice ΔP	psid	0-100	2.0	"	-	TBD	TBD	-	-	X	A/G	X	-	
RFMWP	Flowmeter Water	psig	0-2000	1.0	"	-	-	-	-	-	-	A	X	-	
RFSOP-1	Flash Tank Steam Outlet	"	0-600	1.0	"	X	500	-	-	(3)	-	A/G	X	-	P_1
RFSOP-2	" " " "	"	"	"	"	X	500	-	-	(3)	-	A/G	X	-	P_2
RFSOP-3	" " " "	"	"	"	"	-	500	-	X		-	A/G	X		

W - Warning
C/O - Cut-off
Print - Printer
Plot - Plotter

SC - Strip Chart
RC - Receiver Controller
M - Meter
L - Light

CRT - Cathode Ray Tube
A - Alpha Numeric
G - Color Graphic
F - Flux Color Graphic

(1) All data recorded on magnetic tape
(2) Percent of required range
(3) P_{FB} (P_1 or P_2, whichever is greater

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits		Display						Ref.
							W	C/O	SC	RC M	RC L	CRT	Print	Plot	
RFWLDP	Flash Tank Water Head	In-H_2O	0-90	5.0	1	X	TBD	-	-	X	X	A/G	X	-	Backup to RFWL
RMWLDP	Manifold Water Head	In-H_2O	0-160	"	"	X	"	-	-	X	X	"	X	-	Backup to RMWL
RSOP	Steam Outlet	psig	0-2000	0.5	"	X	1600	-	X	X	X	"	X	-	
RWFDP	Water Filter Differential	psid	0-100	1.0	0.1	-	30	-	-	-	X	"	X	-	
RWIP	Water Inlet	psig	0-2500	0.5	1		$<$ 2000 $>$ 1000	-	X	X	X	"	X	-	
RWODP-1	Water Orifice ΔP (Transmitter)	psid	0-150	0.5	1	X	TBD	-	-	X	X	A	X	-	ΔP_2; Q_2 = RBWFR-2
RWODP-2	" " " (Transducer)	"	0-150	0.25	1	-	TBD	-	-	-	X	"	X	-	

W - Warning
C/O - Cut-off
Print - Printer
Plot - Plotter

SC - Strip Chart
RC - Receiver Controller
M - Meter
L - Light

CRT - Cathode Ray Tube
A - Alpha Numeric
G - Color Graphic
F - Flux Color Graphic

(1) All data recorded on magnetic tape
(2) Percent of required range
(3) P_{FB} (P_1 or P_2, whichever is greater

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Temperature														
RBT-0C1	Receiver Boiler Panel (Cold Side)	°F	0-1500	0.5	1	-	-	-	-	-	-	A	X	-	Chrome Alumel (Type K) Thermocouples (Typical)
RBT-0C30												A	X	X	
RBT-0C70												A	X	X	
RBT-60C1												A	X	-	
RBT-60C30												A	X	X	
RBT-60C70												A	X	-	
RBT-120C1												A	X	-	
RBT-120C30												A	X	X	
RBT-120C70												A	X	-	
RBT-150C1												A	X	-	
RBT-150C70												A	X	-	
RBT-180C5												A	X	-	
RBT-180C30												A	X	X	
RBT-180C40												A	X	X	
RBT-180C70												A	X	-	
RBT-252C5												A	X	X	
RBT-252C30												A	X	X	

Tag No. Code: 1st Number (left) = Inches Above Panel Lower 90° Tube Bend
Letter (middle) = Cold Side (C); Hot Side (H)
2nd Number (right) = Tube Number

Example: R B T - 6 0 C 3 0
- 3 0 — Tube No. 30
- C — Cold Side of Panel
- 6 0 — 60" Above 90° Tube Bend
- R B T — Receiver Boiler Temp.

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	<u>Temperature</u> (Cont'd)														
RBT-252C70	Receiver Boiler Panel (Cold Side)	°F	0-1500									A	X	-	
RBT-324C5												A	X	X	
RBT-324C30												A	X	X	
RBT-324C40												A	X	X	
RBT-324C70												A	X	-	
RBT-360C30												A	X	X	
RBT-384C5												A	X	X	
RBT-384C30												A	X	X	
RBT-384C40												A	X	-	
RBT-384C70												A	X	-	
RBT-408C30												A	X	X	
RBT-432C5												A	X	X	
RBT-432C30												A	X	X	
RBT-432C40												A	X	X	
RBT-432C70												A	X	-	
RBT-456C30												A	X	X	
RBT-480C1												A	X	-	

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	<u>Temperature</u> (Cont'd)														
RBT-480C5	Receiver Boiler Panel (Cold Side)	°F	0-1500	0.5	1	-	-	-	-	-	-	A	X	X	
RBT-480C30												A	X	X	
RBT-480C40												A	X	-	
RBT-480C55												A	X	-	
RBT-504C30												A	X	X	
RBT-504C40												A	X	-	
RBT-528C1												A	X	X	
RBT-528C5												A	X	X	
RBT-528C30												A	X	X	
RBT-528C65												A	X	X	
RBT-528C70												A	X	-	
RBT-552C30												A	X	X	
RBT-576C1												A	X	-	
RBT-576C5												A	X	X	
RBT-576C30												A	X	X	
RBT-576C40												A	X	-	

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Temperature (Cont'd)														
RBT-576C65	Receiver Boiler Panel (Cold Side)	°F	0-1500									A	X	-	
RBT-600C30												A	X	X	
RBT-624C1												A	X	-	
RBT-624C30												A	X	X	
RBT-624C70												A	X	-	
RBT-648C30												A	X	-	
RBT-668C1				0.5	1	-	-	-	-	-	-	A	X	X	
RBT-668C5												A	X	X	
RBT-668C12												A	X	X	
RBT-668C30												A	X	X	
RBT-668C40												A	X	X	
RBT-668C58												A	X	X	
RBT-668C65												A	X	X	
RBT-668C70												A	X	X	
RCT-432	Structure Corrugation at Station 432		0-500									A	X	-	

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	<u>Temperature</u> (Cont'd)														
RIBT-432	Insulation Back - Sta 432	°F	0-500	0.5								A	X	-	
RSAT-432	Structure Ambient - Sta. 432											A	X	-	
RSBT-432	Strongback Temp - Sta. 432											A	X	-	
RSTRT-432	NE Corner Beam at Sta. 432											A	X	-	

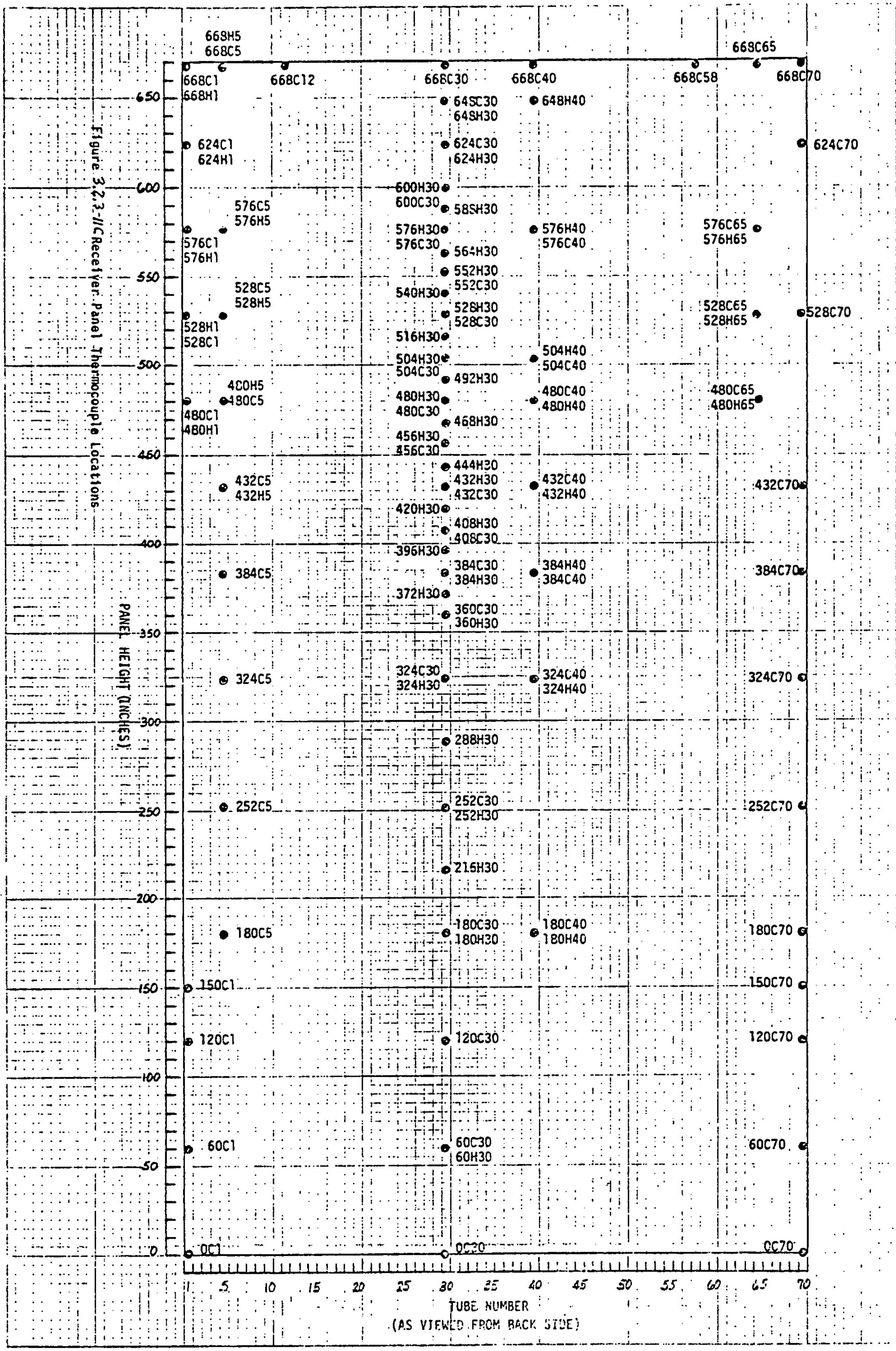

Figure 3.2.3-11C Receiver Panel Thermocouple Locations

FIGURE 3.2.3-11C
RECEIVER PANEL THERMOCOUPLE LOCATIONS

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	<u>Temperature</u>														
RBT-480H40	Receiver Boiler Panel (Hot Side)	°F	0-1500	0.5	1	-		-	-	-		A	X	X	Chrome Alumel (Type K) Thermocouples (Typical)
RBT-480H55		↓	↓	↓	↓	-		-	-	-	-	A	X	X	
RBT-492H30		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	
RBT-504H30		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	
RBT-504H40		↓	↓	-	-	↓		↓	-	-		A	X	-	
RBT-516H30		↓	↓			↓		↓	-	-	-	A	X	X	
RBT-528H1		↓	↓	↓	↓	↓		↓	-	-	-	A	X	-	
RBT-528H5		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	
RBT-528H30		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	
RBT-528H65		↓	↓	↓	↓	↓		↓	-	-	-	A	X	-	
RBT-540H30		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	
RBT-552H30		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	
RBT-564H30		↓	↓	↓	↓	↓		↓	-	-	-	A	X	X	

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Temperature (Cont'd)														
RBT-576H1	Receiver Boiler Panel (Hot Side)	°F	0-1500	0.5	1	-		-	-	-	-	A	X	X	
RBT-576H5									-	-	-	A	X	X	
RBT-576H30									-	-	-	A	X	X	
RBT-576H40									-	-	-	A	X	X	
RBT-576H65							-	-	-	-	-	A	X	X	
RBT-588H30									-	-	-	A	X	X	
RBT-600H30									-	-	-	A	X	X	
RBT-624H1									-	-	-	A	X	-	
RBT-624H30									-	-	-	A	X	X	
RBT-648H30									-	-	-	A	X	X	
RBT-648H40									-	-	-	A	X	-	
RBT-668H1									-	-	-	A	X	-	
RBT-60H30									-	-	-	A	X	X	
RBT-180H30									-	-	-	A	X	X	
RBT-180H40									-	-	-	A	X	-	
RBT-216H30							TBD		-	-	X	A/G	X	X	

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Temperature (Cont'd)														
RBT-252H30	Receiver Boiler Panel (Hot Side)	°F	0-1500		1	-	TBD	-	-	-	X	A/G	X	X	
RBT-288H30									-	-	-	A	X	X	
RBT-324H30									-	-	-	A	X	X	
RBT-324H40							TBD		-	-	X	A/G	X	-	
RBT-360H30							TBD		-	-	X	A/G	X	X	
RBT-372H30				0.5	1	-	-	-	-	-	-	A	X	X	
RBT-384H30							-	-	-	-	-	A	X	X	
RBT-384H40							TBD	-	-	-	X	A/G	X	-	
RBT-396H30							-		-	-	-	A	X	X	
RBT-408H30							TBD		-	-	X	A/G	X	X	
BT-420H30							-		-	-	-	A	X	X	
RBT-432H5							-		-	-	-	A	X	X	
RBT-432H30							-		-	-	-	A	X	X	
RBT-432H40							TBD		-	-	X	A/G	X	-	
RBT-444H30							-		-	-	-	A	X	X	

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Temperature (Cont'd)														
RBT-456H30	Receiver Boiler Panel (Hot Side)	°F	0-1500	0.5	1	-	TBD	-	-	-	X	A/G	X	X	
RBT-468H30							-		-	-		A	X	X	
RBT-480H1							-		-	-	-	A	X	X	
RBT-480H5							-		-	-	-	A	X	X	
RBT-480H30								-	-	-		A	X	X	
RBST-1	Boiler Steam Temp-Tube #1	°F	0-1500	0.5	5	-	-	-	-	-	-	A	X	X	
-5	" " " " #5													X	
-12	" " " " #12													X	
-30	" " " " #30													X	
-40	" " " " #40													X	
-58	" " " " #58													X	
-66	" " " " #66													X	
-70	" " " " #70													X	
RBSMT	Boiler Steam Manifold Surface			0.5	1	-	-	-	-	-	-	A	X	-	
RBSOT-1	Boiler Steam Outlet #1				5	X	1000	1060	(4)	(4)	X	A/G	X	(4)	

(4) T_{FB} (result of manual selection or voting circuit)

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (%)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Temperature (Cont'd)														
RBSOT-2	Boiler Steam Outlet #2	°F	0-1500	0.5	5	X	1000	1060	(4)	(4)	X	A/G	X	(4)	T_2
RBSOT-3	" " " #3					X	|	|							T_3 T_{FB}
RBSOT-4	" " " #4					X	|	|							T_4
RBSOT-5	" " " #5	°F	0-1500	0.5	5	-	(5)	-	-	-	-	A/G	X	(4)	
RBT-XXXX	Boiler Panel Temperatures (See Separate Listing)														
RFT	Flash Tank Temp	°F	0-1500	0.5	1	X	-	-	X	-	-	A/G	X	-	
RFMWT-1	Flowmeter Water Temp		0-750	0.5	1	-	< 400 > 600	-	-	X	X	A	X	-	
RFMWT-2	" " " (RTD)		"	.25	1	-	< 400 > 600	-	-	X	X	A	X	-	
RFSOT	Flash Tank Steam Outlet		0-1500	0.5	1	-	-	-	X	-	-	A	X	-	
RPWOT-1	Preheater Water Outlet #1		0-750	0.5	1		585	-	-	-	-	A	X	-	
RPWOT-2	" " " #2			0.5	1	X	585	-	X	-	-	A	X	-	
RSOT	Steam Outlet		0-1500	0.5	1	-	-	-	X	X	-	A/G	X	-	
RTSOT	Moisture Trap Outlet		0-1500	1.0	(5)	-	(5)	-	X	-	-	A/G	X	-	
RWIT	Water Inlet		0-750	1.0	1	-			X			A/G	X	-	
RDT	Downcomer Surface Temp		0-1500	0.5	1	X	TBD	TBD	X	X	X	A/G	X	-	

(4) T_{FB} (result of manual selection or voting circuit)

(5) Warning on erratic output (strip chart)

(6) Cycle counter warning - CRT flashing

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits		Display						Ref.
							W	C/O	SC	RC M	RC L	CRT	Print	Plot	
	<u>Flowrate</u>														
RBWFR-1	Boiler Water	lb/sec	0 to 2.57	0.5	1	-	TBD	-	(7)	(7)	X	A/G	X	-	Q_1 ($RWODP = Q_2$)
	<u>Level</u>														
RFWL	Flash Tank Water	% full	0 to 100	5.0	1	X	TBD	-	-	X	(8)	A/G	X	-	L_3
RMWL	Manifold Water	"	"	5.0	1	X	TBD	-	-	X	(8)	A/G	X	-	L_2
RAWL	Moisture Accumulator Water	"	"	5.0	1	X	TBD	-	-	X	(8)	A/G	X	-	L_1
	<u>Position-Analog</u>														
RBTCVX	Boiler Water Temp. Cont. Valve	% Open	5-100	2.0	2	X	-	-	X	X	-	A/G	X	-	X_1
RBX-N/S-250	Boiler Expansion-North/South at Station 250	Inches	0-5	2.0	1	-	-	-	-	-	-	A	X	-	
RBX-E/W-268	Boiler Expansion-East/West at Station 268	"	0-2	2.0	1	-	-	-	-	-	-	A	X	-	
RBX-V-0	Boiler Expansion-Vertical at Station 0	"	0-5	2.0	1	-	-	-	-	-	-	A	X	-	

(7) Q_{FB} (manual selection of Q_1 or Q_2)

(8) See Fault List: RFWLW, RMWLW and RTWLW

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	Position-Analog (Cont'd)														
RFPCVX	Flashtank Pressure Control Control Valve	% Open	0-100	2.0	2	-	-	-	-	X	-	A/G	X	-	X_3
RSVVX	Steam Press. Vent Valve	"	"	"	2	-	-	-	-	X	-	A/G	X	-	X_2
RDSIVX	Downcomer Inlet Valve	"	"	"	2	-	-	-	-	X	-	A/G	X	-	
	Position-Discrete														
RDSIVC	Downcomer Steam Inlet Valve	Closed	DNA	DNA	2	X	TBD	TBD	-	-	X	A/G	X	-	
RFDVC	Flash Tank Drain Valve	"				-	-	-	-	-	X	A/G	X	-	
RFIVC	Flash Tank Inlet Valve	"				X	TBD	TBD	-	-	X	A/G	X	-	
RMDVC	Manifold Drain Valve	"				-	-	-	-	-	X	A/G	X	-	
RADVC	Moisture Accumulator Drain Valve	"				-	-	-	-	-	X	A/G	X	-	
	Faults														
CO-1	RC Cutoff	On-Off			5	-	-	(9)	-	-	X	A/G	X	-	
CO-2	Control Room Cutoff	"			5	-	-	(9)	-	-	X	A/G	X	-	

(9) Any observed redline condition

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
	<u>Faults</u>														
HSP	High Steam Pressure	On-Off	DNA	DNA	2	-	TBD	-	-	-	X	A/G	X	-	
HST	High Steam Temperature	"				-	"	-	-	-	X	A/G	X	-	
LST	Low Steam Temperature	"				-	"	-	-	-	X	A/G	X	-	
RFWLW	Flash Tk. H_2O Level Warn.	On-Off				-	"	-	-	-	X	A/G	X	-	
RMWLW	Manifold H_2O Level Warning	"	DNA			-	"	-	-	-	X	A/G	X	-	
RAWLW	M. Trap H_2O Level Warning	"	"			-	"	-	-	-	X	A/G	X	-	
RNPS-1/2/4	GN_2 Press. 1,2 or 4. Not Normal	"	"			-	"	-	-	-	X	A/G	X	-	
RNPS-3	GN_2 Press. #3. Not Normal	"	"			-	"	-	-	-	X	A/G	X	-	
24F1##	Heat Flux**	MW/M^2	0-0.5	0.5	1	-	-	-	-	-	-	A/F	-	-	
24F35*	" "											A/F	X	X	
24F70												A/F	X	X	
60F1												A/F	-	-	
60F35*												A/F	X	X	
60F70												A/F	X	X	

* 1/16" Diameter Gage
** Tag No. Code

1st Number (Left) = Inches Above Lower 90° Tube Bend
Letter F = Flux Gage
2nd Number (Right) = Tube Number

Example: 2 1 F 1
- 1 — Tube 1
- F — Flux Gage
- 21 — 21" Above Lower 90° Tube Bend

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
96F1	Heat Flux** (Cont'd)	MW/M^2	0-0.5	0.5	1	-	-	-	-	-	-	A/F	-	-	
96F35*												A/F	X	X	
96F70												A/F	X	X	
132F1												A/F	X	X	
132F21*												A/F	-	-	
132F35*												A/F	X	X	
132F49*												A/F	X	X	
132F70												A/F	X	X	
168F1												A/F	-	-	
168F35*												A/F	X	X	
168F70												A/F	X	X	
204F1												A/F	-	-	
204F35*						-	-	-	-	-	-	A/F	X	X	
204F70												A/F	X	X	
240F1												A/F	-	-	
240F35*												A/F	X	X	
240F70												A/F	X	X	

* 1/16" Diameter Gage
**Tag No. Code

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
276F1	Heat Flux** (Cont'd)	MW/M^2	0-0.5	0.5	1	-	-	-	-	-	-	A/F	X	X	
276F21*												A/F	X	X	
276F35*												A/F	X	X	
276F49*												A/F	X	X	
276F70												A/F	X	X	
312F1												A/F	-	-	
312F35*												A/F	X	X	
312F70												A/F	X	X	
330F1												A/F	-	-	
330F35*												A/F	X	X	
330F70												A/F	X	X	
348F0												A/F	X	X	
348F1*												A/F	X	X	
348F35*												A/F	X	X	
348F70												A/F	X	X	
384F1												A/F	X	X	
384F21*												A/F	X	X	

* 1/16" Diameter Gage
**Tag No. Code

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TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
384F35*	Heat Flux** (Cont'd)	MW/M^2	0-0.5	-	-	-	-	-	-	-	-	A/F	X	X	
384F49*												A/F	X	X	
384F70												A/F	X	X	
420F1												A/F	-	-	
420F21*												A/F	-	-	
420F35*												A/F	X	X	
420F49*												A/F	-	-	
420F70												A/F	-	-	
456F1												A/F	X	X	
456F21												A/F	X	X	
456F35*												A/F	X	X	
456F49*												A/F	X	X	
456F70												A/F	X	X	
492F1												A/F	X	X	
492F21*												A/F	-	-	
492F35*												A/F	X	X	
492F49*												A/F	-	-	

* 1/16" Diameter Gage

**Tag No. Code

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
492F70	Heat Flux** (Cont'd)	MW/M^2	0-0.5			-			-	-	-	A/F	X	X	-
528F1												A/F	X	X	
528F21*												A/F	X	X	
528F35*												A/F	X	X	
528F49*												A/F	X	X	
528F70												A/F	X	X	
564F1												A/F	-	-	
564F21*												A/F	-	-	
564F35*												A/F	X	X	
564F49*												A/F	-	-	
564F70												A/F	X	X	
600F1												A/F	X	X	
600F21*												A/F	X	X	
600F35*												A/F	X	X	
600F49*												A/F	X	X	
600F70												A/F	X	X	
636F1												A/F	X	X	

* 1/16" Diameter Gage
**Tag No. Code

8/25/78

TABLE 3.2.3-4

INSTRUMENTATION LIST

Tag No.	Parameter	Units	Required Range	Req'd Accuracy (2)	Samples Per Second	Control Function	Safety Limits W	Safety Limits C/O	Display SC	Display RC M	Display RC L	Display CRT	Display Print	Display Plot	Ref.
636F35*	Heat Flux**	MW/M^2	0-0.5									A/F	X	X	
636F70												A/F	X	X	

* 1/16" Diameter Gage
**Tag No. Code

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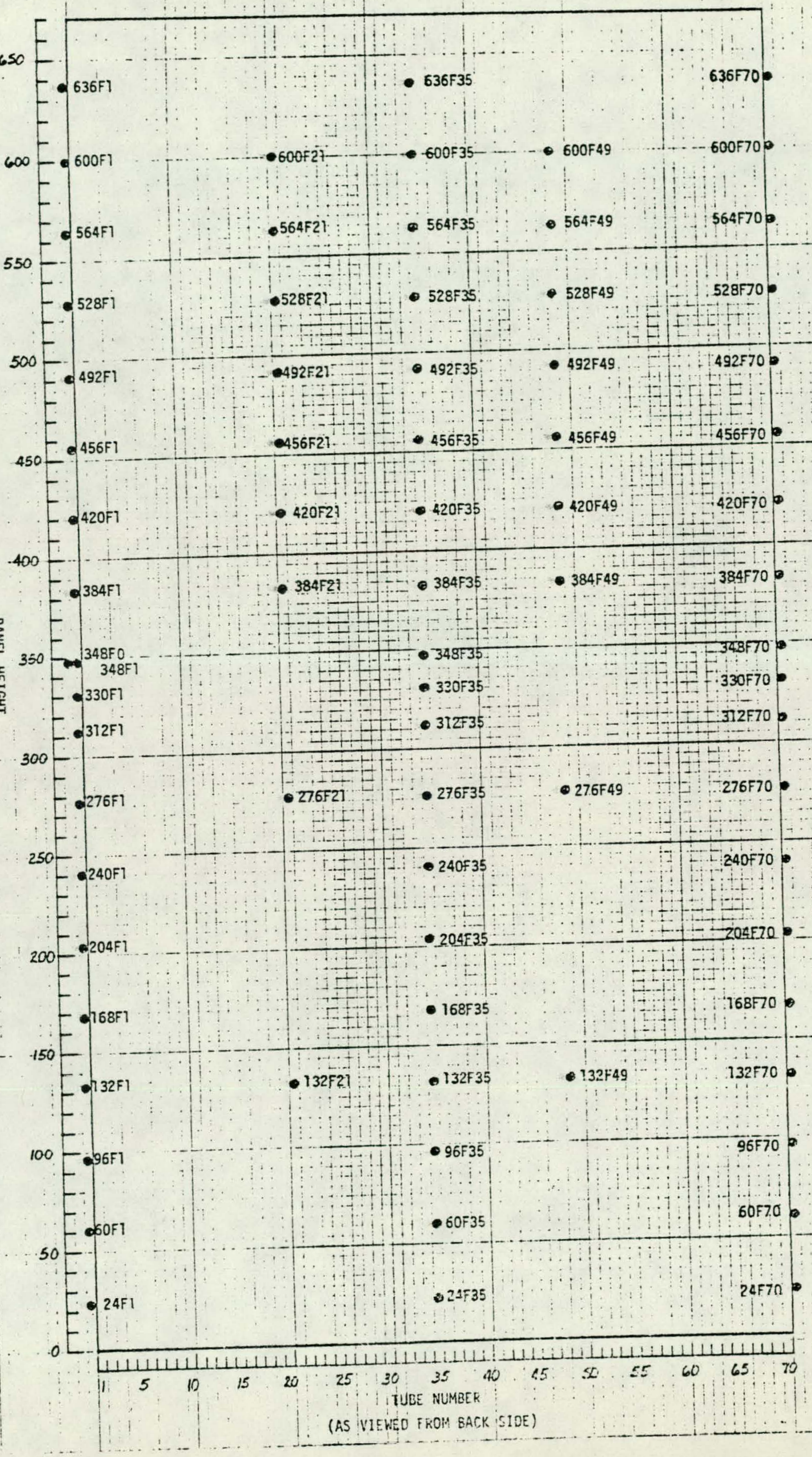

Figure Heat Flux Gages - STTF Receiver Panel Instrumentation

FIGURE 3.2.3-11D
STTF RECEIVER FLUX GAGE LOCATIONS

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3.2.3.11 CRT Data and Control Display

The receiver console display in the central control room is an essential to operation of the experiment. The display presents, in analog formats, the receiver pressures, temperatures, flows, and valve positions which are being controlled. Set points are also shown on the display.

The CRT data display formats necessary to evaluate the safety and performance of the test hardware in real time are presented in Figures 3.2.3-12 through 3.2.3-19.

When parameters exceed predetermined warning values, the parameter display will be emphasized by flashing yellow. When a valve position and its commanded position do not agree, the valve position display will be emphasized in flashing yellow. When cut-off limits are exceeded, an audible signal will be given and the parameter display will be emphasized in flashing red. In addition, the type of cutoff (i.e., high steam temperature, high steam pressure, etc.) will be displayed in flashing red.

System pressure profile data will be displayed as shown in Figure 3.2.3-13. Alternate high and low pressure ranges for better resolution are shown. Pressure measurement nomenclature is keyed to the system schematic. The pressures are displayed in bar graph format. The pressure difference between transducers is displayed digitally. In some case absolute pressures (e.g., RWFMP and RCVOP) are measured and the ΔP is calculated. At other locations the ΔP is measured (e.g., RWFDP) and an absolute pressure is derived based on the ΔP and another absolute pressure.

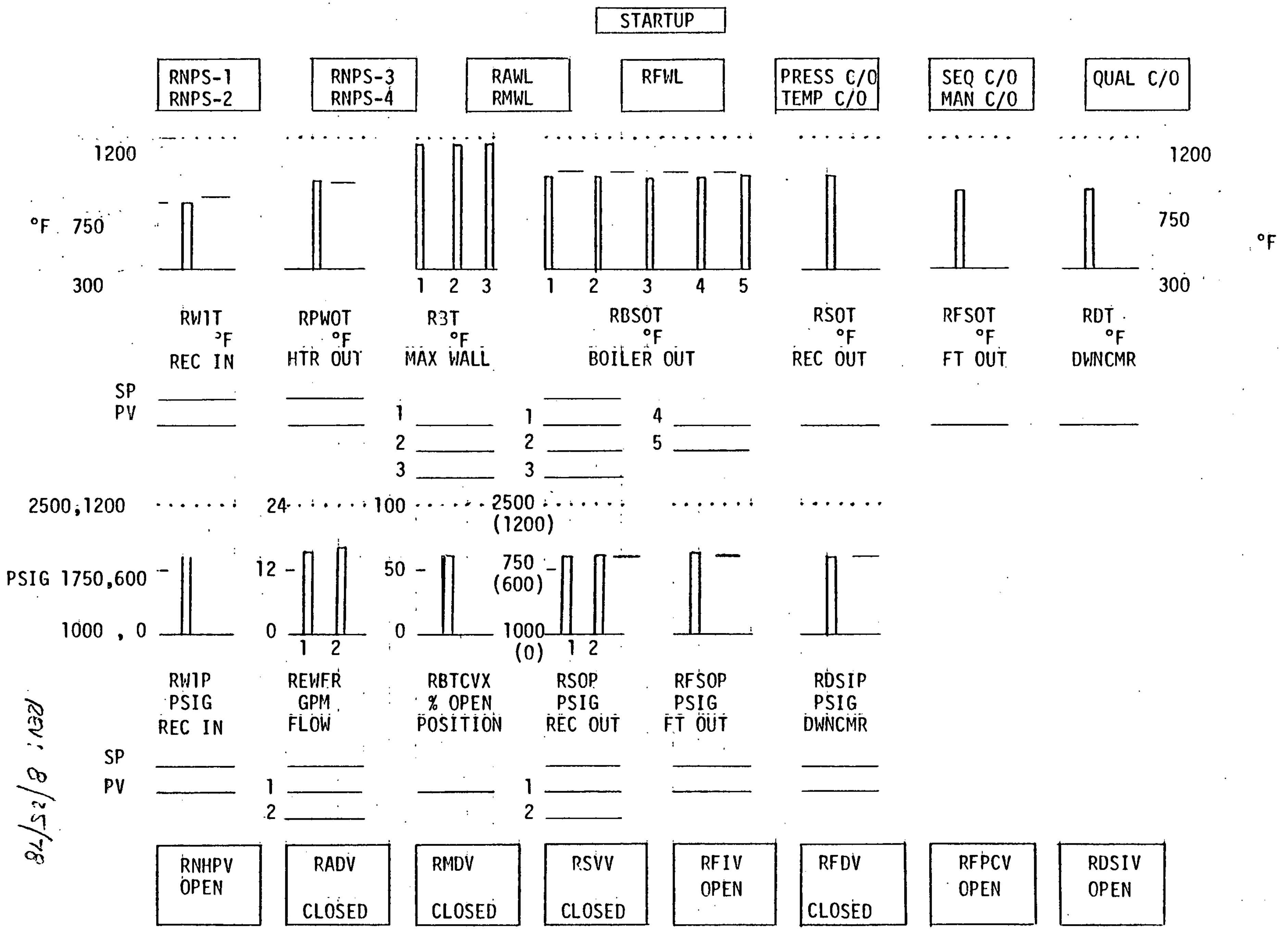
Temperatures of the fluid throughout the system will be displayed in a manner similar to that shown in Figure 3.2.3-14. All temperatures are measured directly and displayed as bars. The ΔT values are calculated and displayed digitally.

Temperatures measured on the back side of the panel will be displayed in the format shown in Figure 3.2.3-18. Temperatures measured near the tube outlets will be displayed as shown in Figure 5.2.3-17. Temperatures measured on the hot side of the panel will be displayed as shown in Figure 3.2.3-18.

Hard copies of CRT displays will be available in real time upon request.

Flux data will be displayed in a manner similar to Figure 3.2.3-19.

FIGURE 3.2.3-12
SYSTEM CONTROL DISPLAY



REV: 8/25/78

FIGURE 3.2.3-13
SYSTEM PRESSURE PROFILE DISPLAY

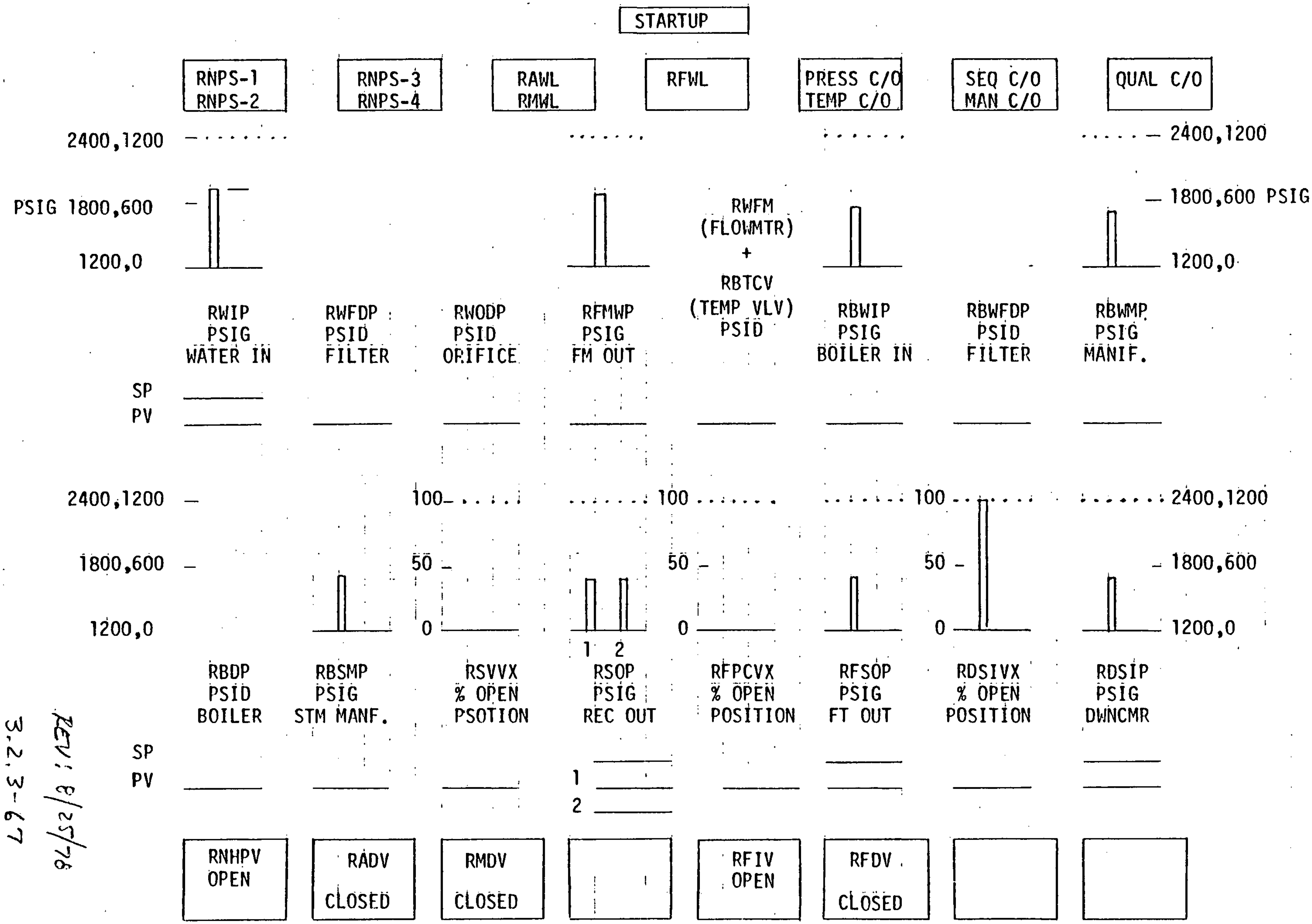


FIGURE 3.2.3-14
SYSTEM TEMP PROFILE DISPLAY

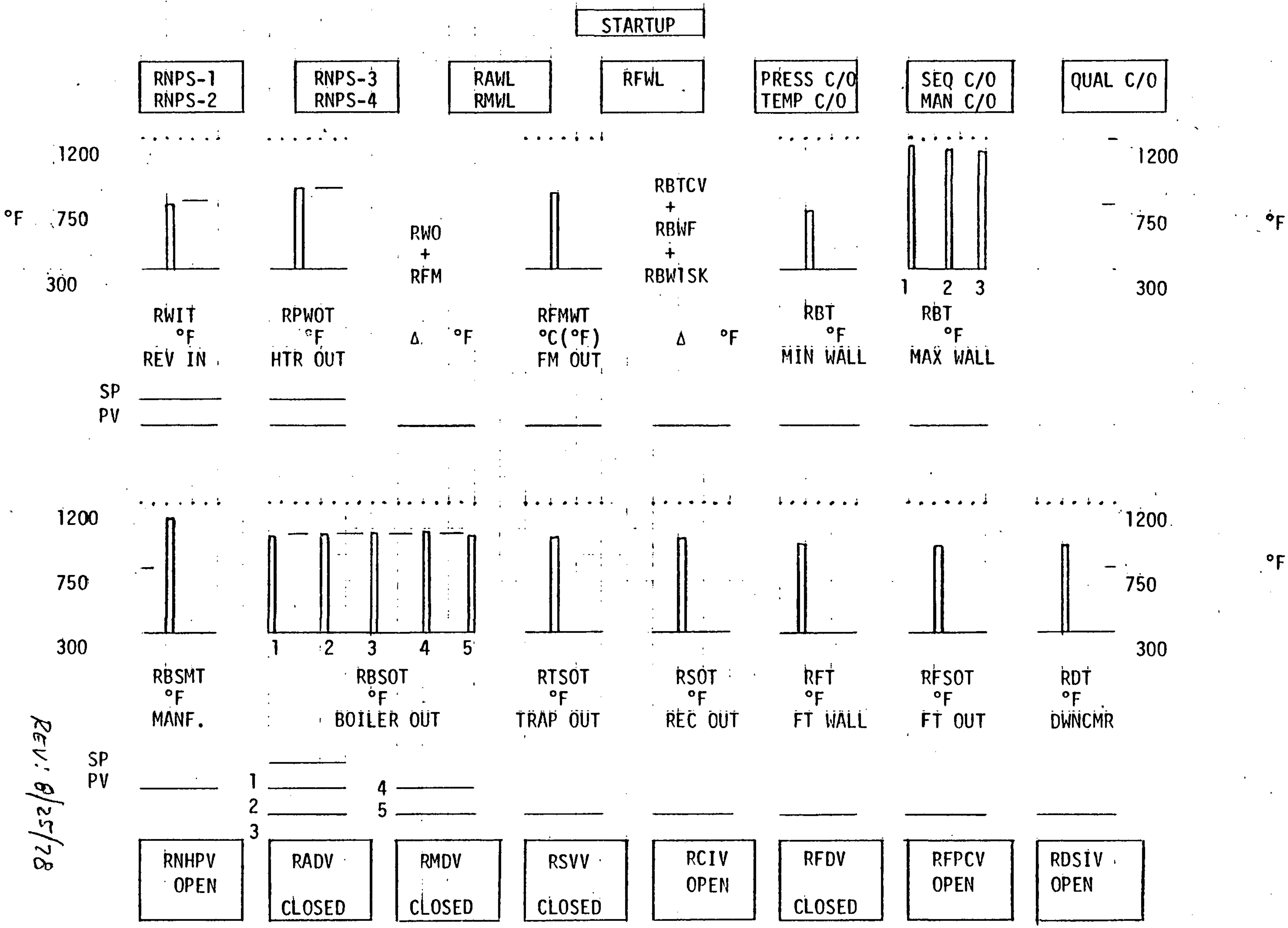


FIGURE 3.2.3-15
LEVELS/POSITIONS/STATUS DISPLAY

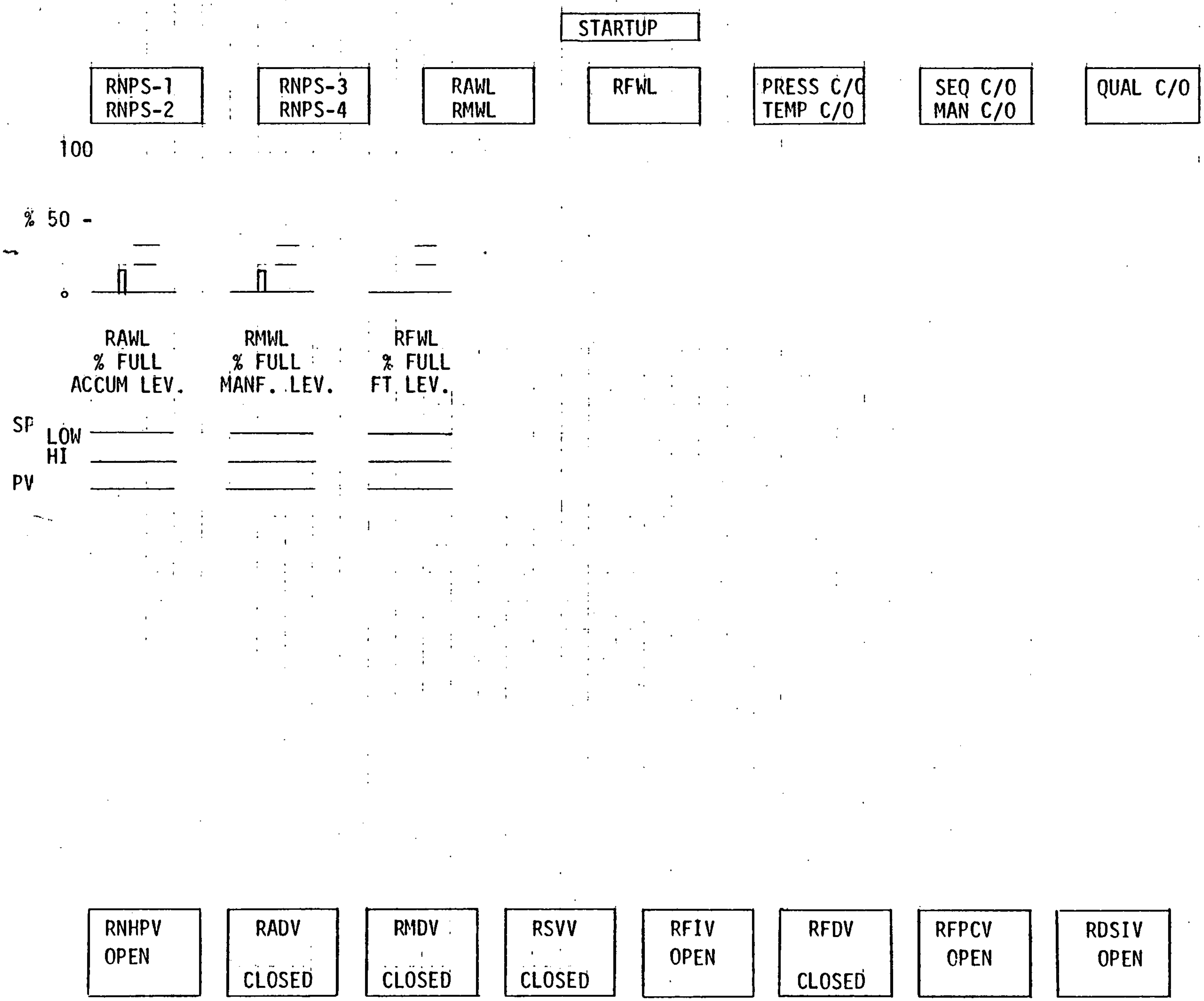


FIGURE 3.2.3-16
PANEL COLD SIDE VERTICAL TEMP PROFILE

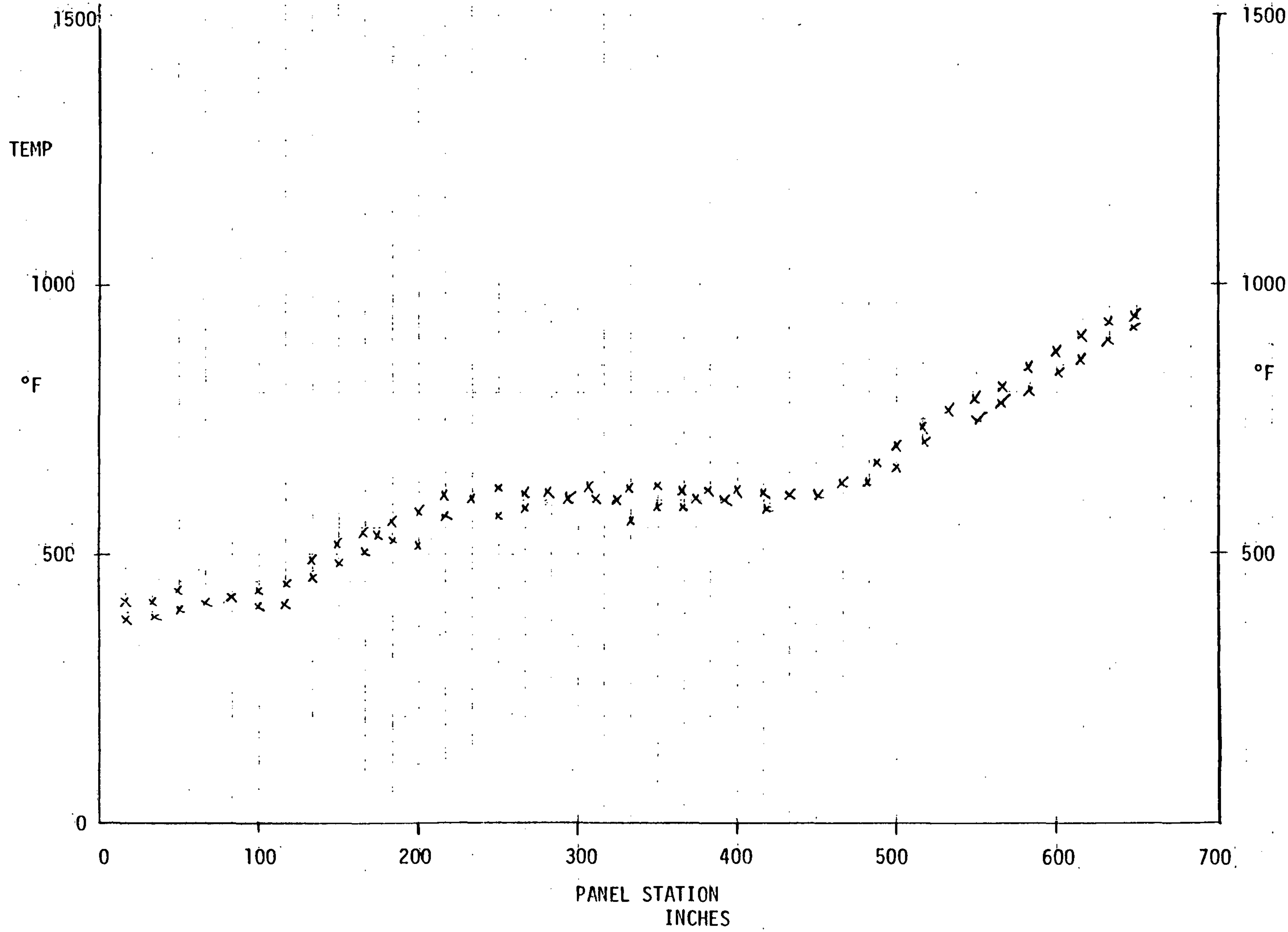


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FIGURE 3.2.3-17
PANEL COLD SIDE HORIZONTAL TEMP PROFILE

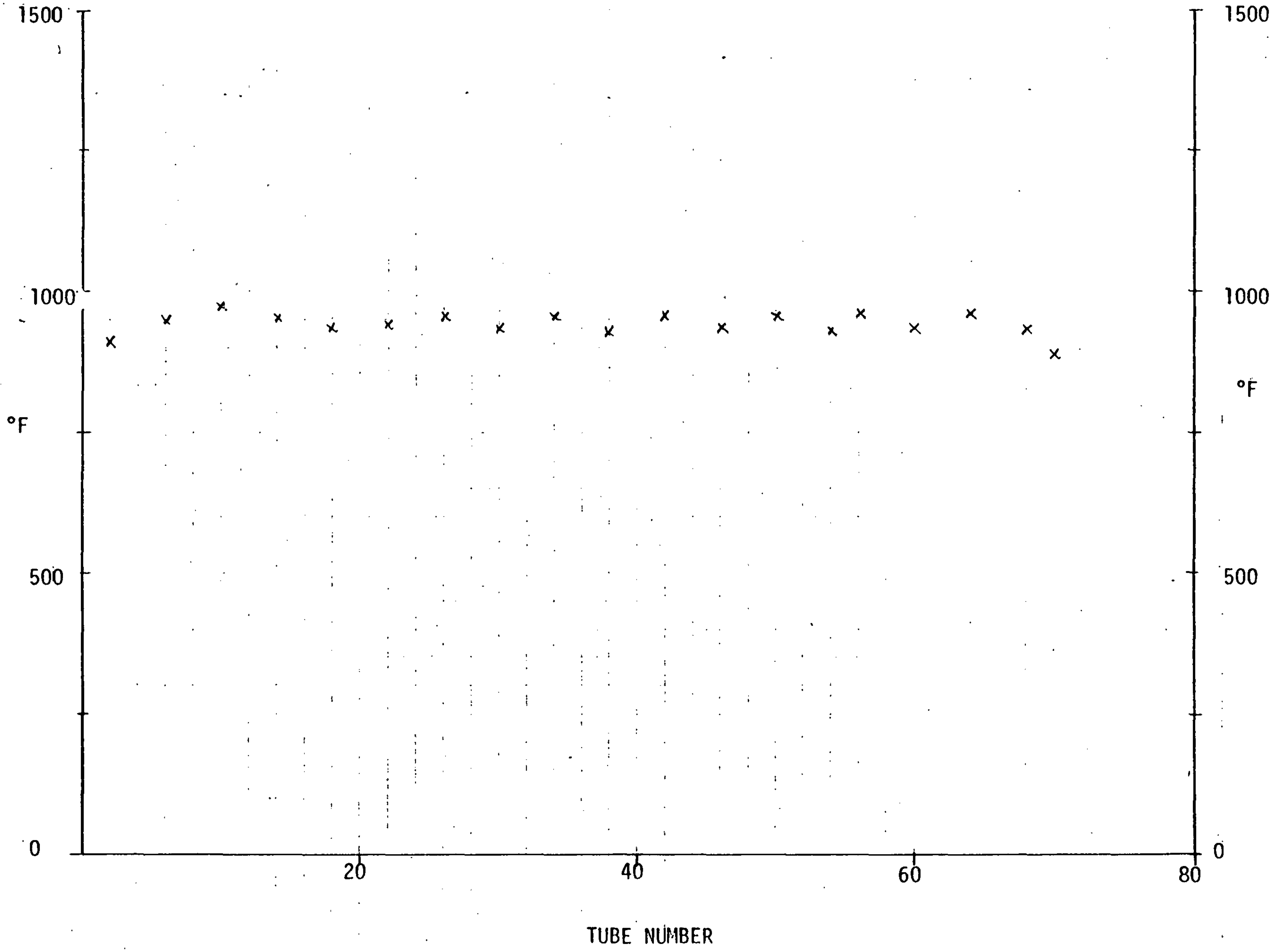

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FIGURE 3.2.3-18
PANEL HOT SIDE VERTICAL TEMP PROFILE

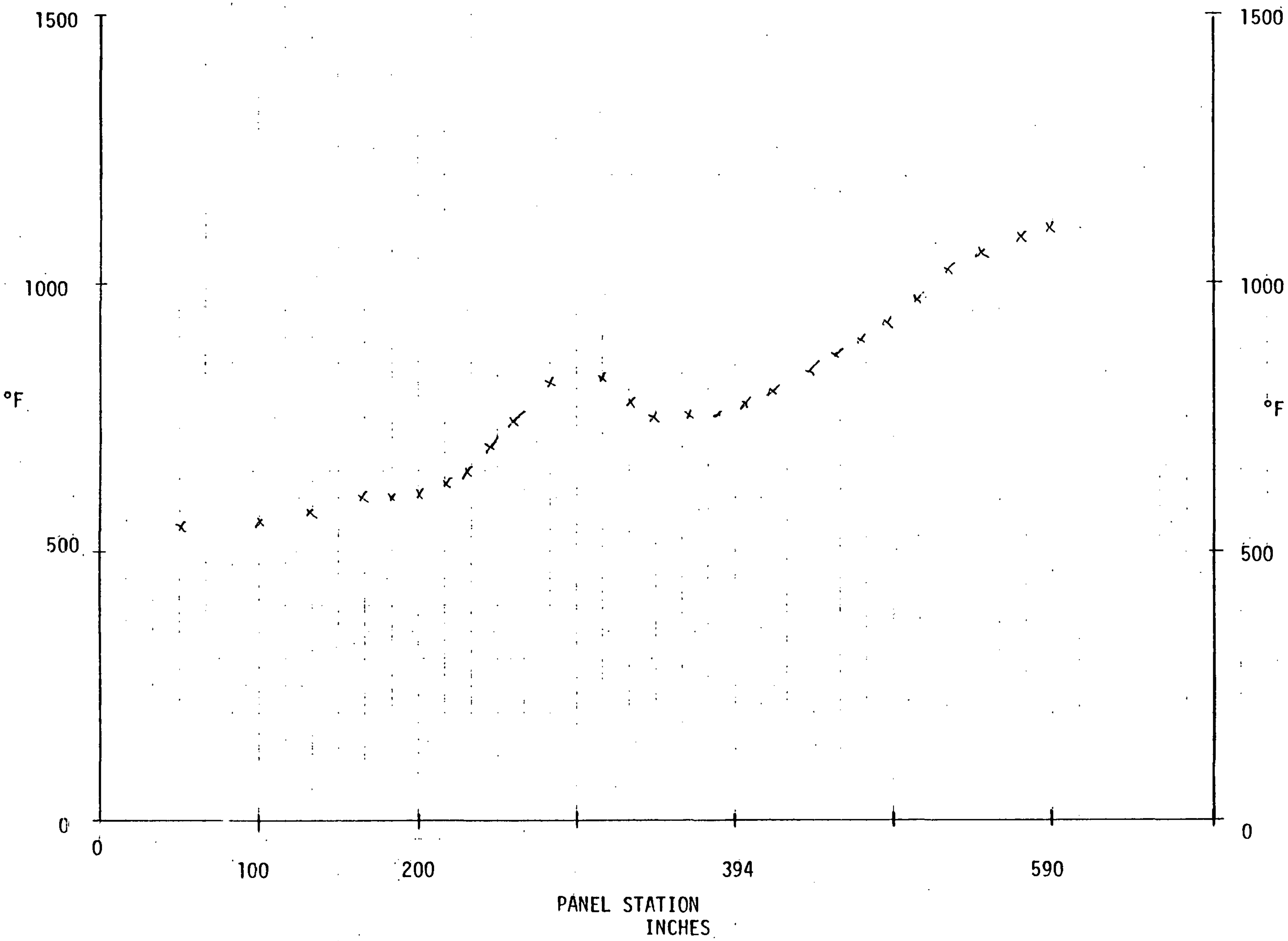

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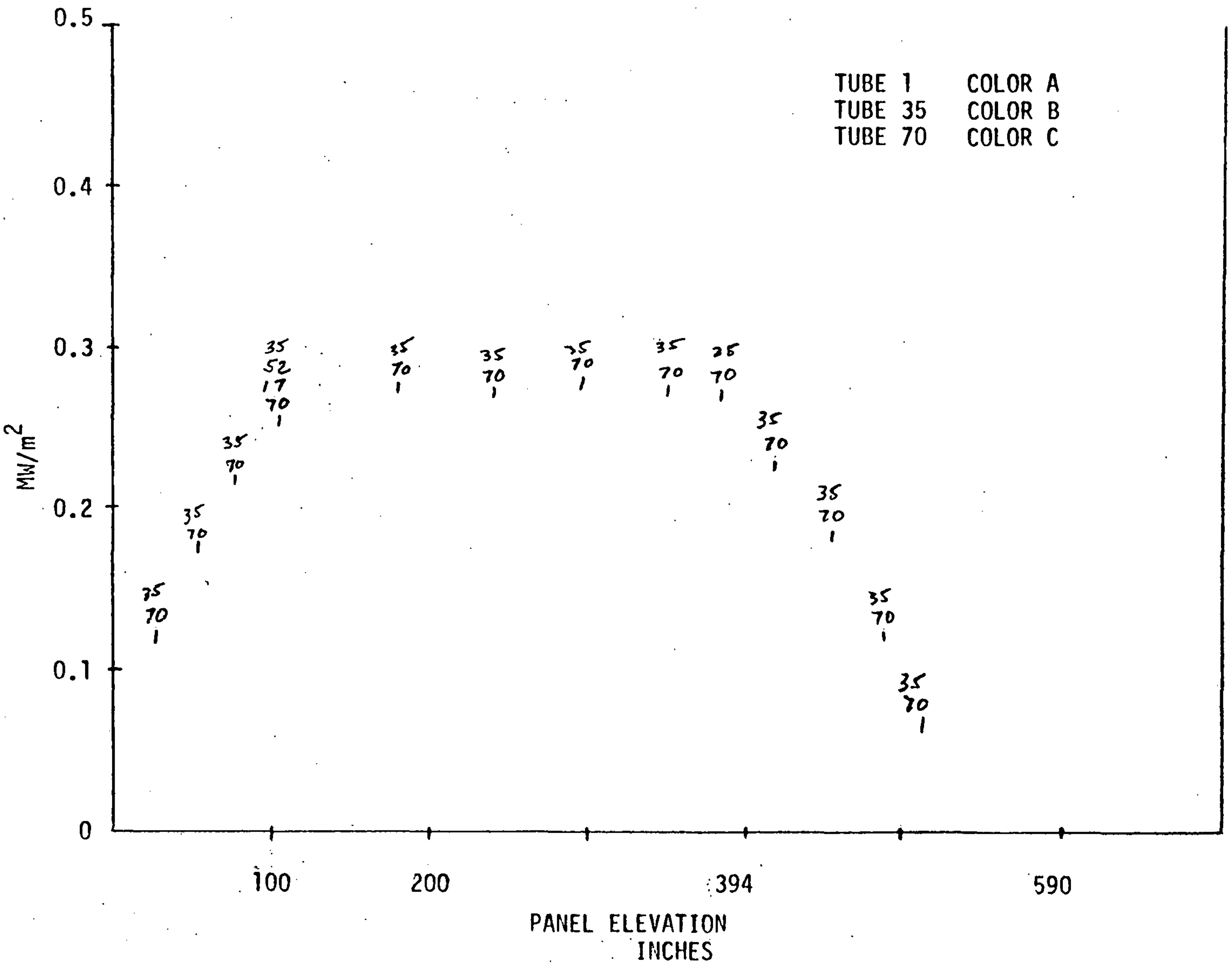
FIGURE 3.2.3-19

PANEL VERTICAL FLUX PROFILE



McDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.
MCDONNELL DOUGLAS

SIZE	CODE IDENT NO.	DRAWING NO.
A	18355	1T50721

SCALE

REV 8/25/78

SHEET 3.2.3-73

60-0213-1A02 (06 AUG 71)

3.2.4 Structural Subassembly

The structural subassembly consists primarily of a tower to support the receiver test panel, insulation to protect the test tower from concentrated solar flux, and an optical concentrator to enhance receiver panel flux levels.

3.2.4.1 Receiver Tower

For reasons of economy, the tower used to support the receiver test panel during the Pilot Plant Phase I subsystem research experiements (SRE) will be modified for use at STTF (Ref. Figure 3.1.2-1). The receiver tower is approximately 9 feet square and 65 feet tall exclusive of the I-beam base, which attaches to the STTF tower elevating module, and a 1,000 pound capacity job crane atop the receiver tower. During test operations, the STTF elevating module will be located at the 61 m (200 Feet) level.

To increase the resistance of the receiver tower to more severe environmental conditions at STTF, additional horizontal trusses and diagonal bracing will be added to increase tower stiffness and torsional strength. As modified, the structural subassembly will survive the following conditions with an ultimate load safety factor of two.

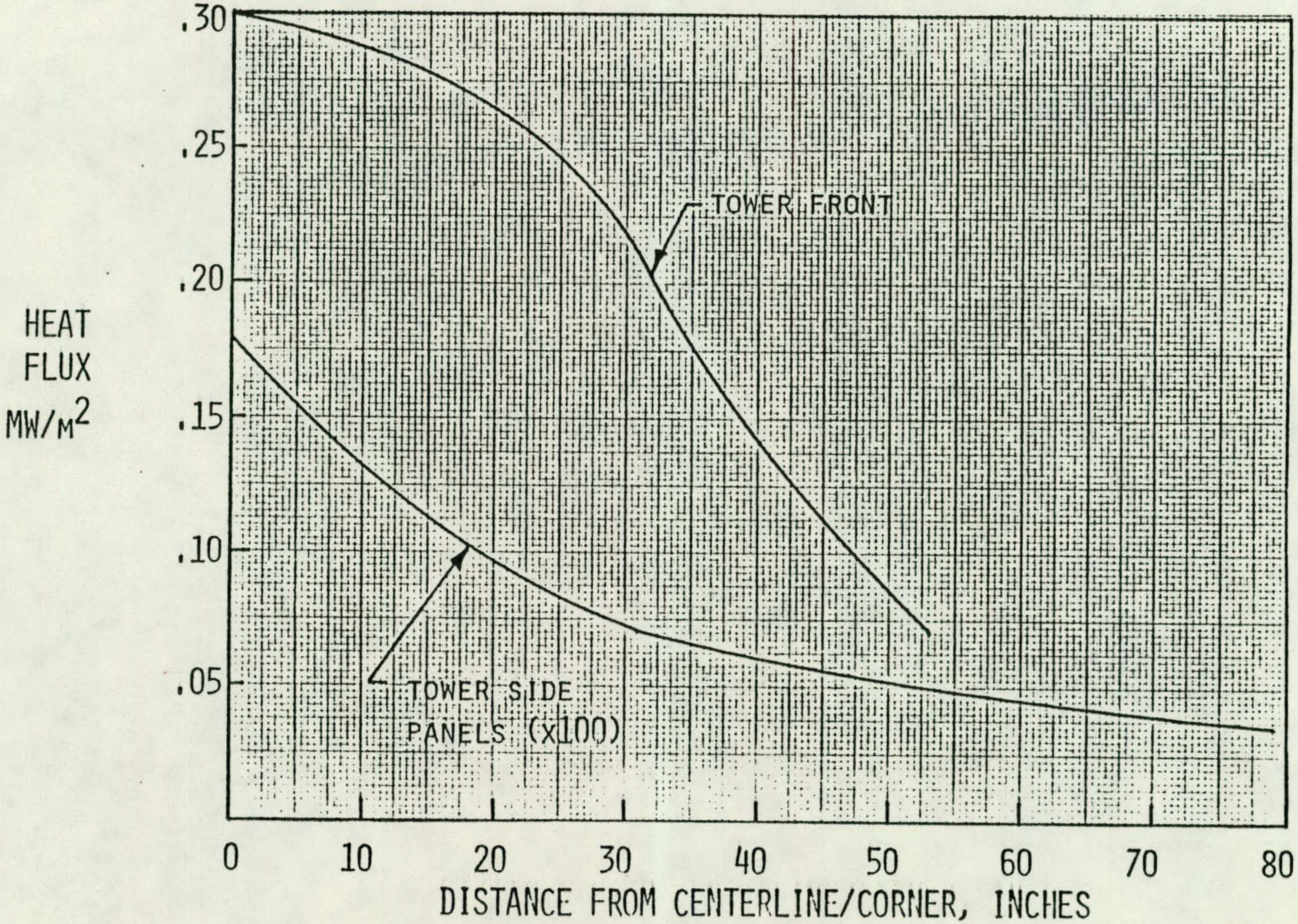
	Nonoperating	Operating
° Maximum allowable wind velocity at 250 feet elevation	100 MPH	40 MPH
° Maximum allowable wind velocity at 33 feet elevation	74 MPH	30 MPH
° Maximum allowable structure temp	150°F	300°F
° Maximum allowable seismic acceleration	0.5 g	0.2 g

"Slack" guy wires will provide added tower protection.

3.2.4.2 Shielding Insulation

The receiver test tower is constructed primarily of aluminum and will be subjected to the solar flux profile shown in Figure 3.2.4-1. To ensure that the temperature of the aluminum structure does not exceed 300°F, approximately six inches of KAOWOOL type insulation will be installed on the front of the tower (facing

FIGURE 3.2.4-1, HEAT FLUX PROFILE ON TOWER (MAXIMUM)



SIZE	CODE IDENT NO.	DRAWING NO.
A	18355	1T50721
SCALE	REV 6/8/78	SHEET 3.2.4-2

the heliostat field). Approximately one inch of insulation will be required on the sides of the test tower.

3.2.4.3 Flux Concentrator

To maximize the solar flux on the test receiver panel a flux concentrator will be installed on the test tower during the latter part of the test program to maximize the incident flux on the test receiver. The flux concentrator will consist of five modular reflective units installed on each side of the test receiver (ten units total). When installed, the reflective units will form a Winston parabolic shape in horizontal cross section with an insolation acceptance angle of $\pm$ 45° (Figure 3.2.4-2).

The concentrator reflective units will be cooled by a facility supplied water-glycol system capable of absorbing 7 mwt.

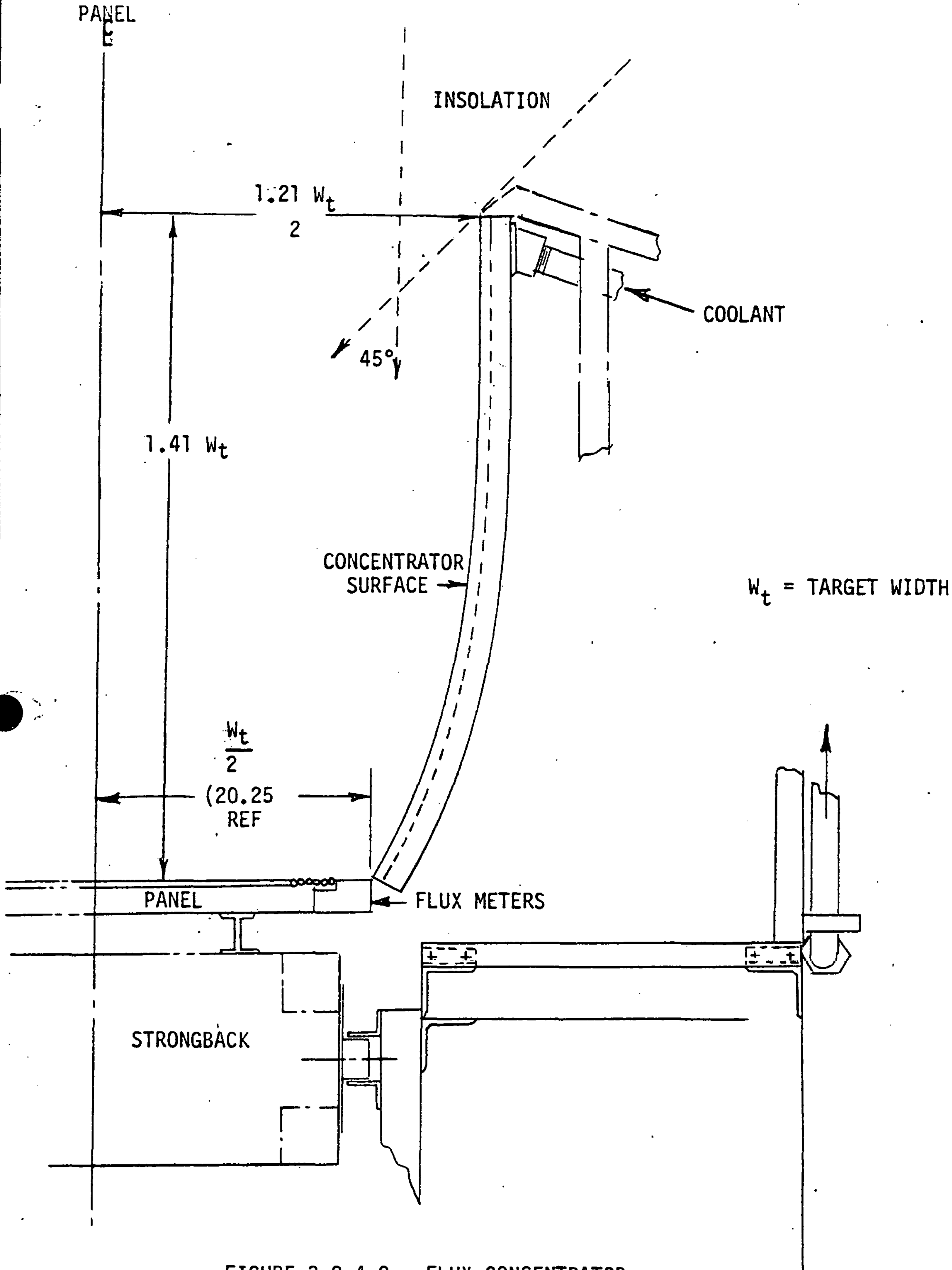


FIGURE 3.2.4-2, FLUX CONCENTRATOR

3.3 Facility Requirements

3.3.1 Interfaces

3.3.1.1 Piping

STTF to test installation piping interfaces are summarized by Table 3.3.1-1 and defined in detail by the interface control drawings listed thereon.

3.3.1.2 Structural

STTF to test installation structural interfaces are defined by interface control drawings.

3.3.1.3 Electrical

STTF to test installation electrical interfaces are summarized in Table 3.3.1-5 and defined in detail by the interface control drawings listed thereon.

Table 3.3.1-1

PIPING INTERFACES

PIPE TAG	CONTRACTOR INTERFACE CONNECTION	MIN/MAX RQMTS.[3] TEMP (°F)	PRESS (PSIG)	FLOW RATE (GPM)	EST. USAGE PER TEST	FLUID SPECS	ICD[2]
Receiver Feedwater Supply (FW)[1]	1" Sch 80 ANSI 2500 Bolted Flange	450 ± ?	400 ± _/2200 ± _	2.5/37		(4)	
Condensate Return (RBD)	1" Sch 80			2.5/			
High Pressure (HPS) Steam Discharge	2" XX Stg ANSI 2500 Bolted Flange	(6)					
Drain (D Vent)	1" Sch 80						
GN_2 Supply ($HPGN_2$)	3/4" Sch						

(1) STTF I.D.
(2) Interface Control Drawings
(3) Mechanical Loads Limited Only by Pipe Capabilities
(4) Reference Table 3.3.1-2
(5)
(6) Reference Table 3.3.1-4 (Max. Temp Rates)

Table 3.3.1-2

FEEDWATER QUALITY REQUIREMENTS

FACTOR	NORMAL LIMITS	MAXIMUM LIMIT*
Total Disolved Solids	-	50 PPB
Silica	5-7 PPB	20 PPB
Iron	3-5 PPB	10 PPB
Copper	1-2 PPB	2 PPB
Oxygen	Less than 2 PPB	7 PPB
pH at 21°C (70°F)	N/A	9.2-9.5

*PPB - parts per billion

Table 3.3.1-4
MDAC SRE Receiver/STTF

Downcomer Temperature Ramp Rates

1. If the downcomer is stabilized at 650°F (i.e., several degrees above saturation temperature), the incoming steam temperature can be ramped to 950-1000°F in five minutes.

2. If the downcomer is stabilized at 400°F (i.e., maximum STTF feedwater supply temperature), the input to the downcomer can be ramped to 650°F in thirty minutes, but must be done at low flow velocities to prevent damage from any localized condensation. Such condensation would most likely occur near the massive tee flanges in the downcomer.

3. If the downcomer is stabilized at 550°F by using feedwater output from MDAC's electric preheater, the input to the downcomer can be ramped to 650°F in 10-15 minutes. The above concern about condensate particles still applies.

Table 3.3.1-5

Electrical Interfaces

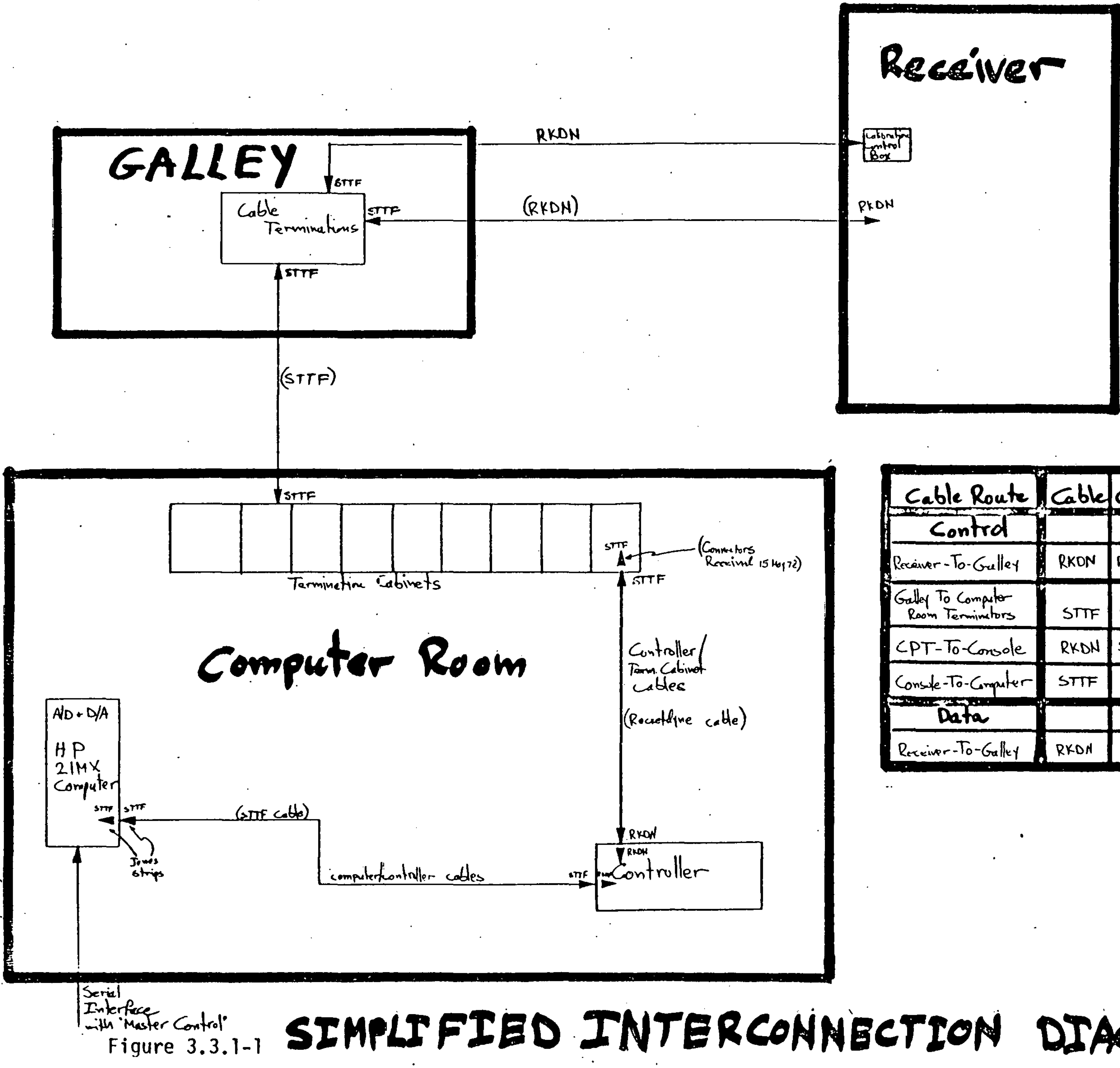
ITEM	SOURCE	MIN/MAX REQUIREMENTS VOLTS	AMPS	CONTRACTOR SUPPLIED CONNECTOR	ICD (2)
POWER					
RECEIVER CONTROLLER POWER ( )(1)	STTF	110/110 ±			
RECEIVER PREHEATER POWER	STTF	480 ±	(200 KW) (225 AMPS/PHASE)		
FLUX GAGE COOLANT BOOST PUMP POWER	STTF	480 ±	(1.5 KW)		
CONTROL					
(REFERENCE FIGURE					
INPUTS TO STTF	REC	0/10 ±			
OUTPUTS FROM STTF	STTF				

INSTRUMENTATION

(SEE SECTION 3.2.3.8, TABLE 3.2.3-3)

(1) STTF I.D.

(2) INTERFACE CONTROL DRAWING



Cable Route	Cable	Connector	Termination
Control			
Receiver-To-Galley	RKDN	RKDN-STTF	RKDN-RKDN
Galley To Computer Room Terminators	STTF	STTF-STTF	STTF-STTF
CPT-To-Console	RKDN	STTF-RKDN	RKDN-RKDN
Console-To-Computer	STTF	STTF-STTF	STTF-STTF
Data			
Receiver-To-Galley	RKDN	RKDN-STTF	RKDN-RKDN

Dan Ron
STTF
19 May 1978

8/25/78

Figure 3.3.1-1 SIMPLIFIED INTERCONNECTION DIAGRAM

3.3.2 Insolation

Table 3.3.2-1 summarizes the pilot plant and STTF test program insolation requirements. Table 3.3.2-2 summarizes the selected test conditions for the STTF program.

Figures 3.3.2-1 and 3.3.2-2 compare the expected pilot plant and STTF vertical and lateral flux profiles. Since the test receiver panel is .889m (2.9 feet) wide by 17m (56 feet) long and the pilot plant panel is expected to be .889m by only 12.5m (41 feet) long, the STTF flux will be targeted only on the top 12.5m of the test receiver.

Table 3.3.2-3 presents the expected STTF power levels. Comparison with Table 3.3.2-1 shows that flux concentrator is required to achieve power and flux levels above expected maximum pilot plant values.

Table 3.3.2-1

Insolation Requirements

	Pilot Plant	STTF
Maximum Boiler Panel Incident Power, Mwt	2.9 (1)	3.6 (3)
Maximum Boiler Panel Absorbed Power, Mwt	2.5	3.2
Maximum Boiler Panel Incident Flux, Mwt/m^2	0.30 (4)	0.375
Maximum Boiler Panel Absorbed Flux, Mwt/m^2	0.25 (4)	0.32
Maximum Boiler Panel Flow Rate, Kg/Sec (Lbs/Sec)	1.18 (2.6)	1.51 (3.33)
Minimum Boiler Panel Incident Power (into steam), Mwt	0.52 (2)	0.52
Minimum Boiler Panel Absorbed Power, Mwt	0.24	0.24
Minimum Boiler Panel Incident Flux, Mwt/m^2	0.053 (4)	0.053
Minimum Boiler Panel Absorbed Flux, Mwt/m^2	0.024 (4)	0.024
Minimum Boiler Panel Flow Rate, Kg/Sec (Lbs/Sec)	0.11 (0.24)	0.11 (0.24)
Maximum Absorbed Heat Flux Lateral Gradient $(Q/A)_{max} - (Q/A)_{min} \div (Q/A)_{avg.} \times \left[\text{Fraction of nominal panel width separating } (Q/A)_{max} \text{ from } (Q/A)_{min}\right]$	0.4	0.4
Power Transient Rate Limit	TBD	TBD

(1) North Panel 12 or 13; Equinox Noon; 950 w/m^2

(2) Southeast Panel 21; Equinox Morning; 15° Sun Elevation

(3) Pilot Plant Level Times 1.25

(4) Reference Figure 3.3.2-1 for Vertical Flux Profile

(5) Reference Figure 3.3.2-2 for Horizontal Flux Profile

Table 3.3.2-2

STTF RECEIVER TEST CONDITIONS

Flux Profiles	
° Vertical	(Reference Figure 3.3.2-1)
° Lateral	(Reference Figure 3.3.2-2)
Test Receiver Characteristics	
° Width	.889m (2.9 feet)
° Length	12.5m (41 feet)(1)
° Location	(Reference Figure 3.3.2-4)
° Tilt (Degrees from Vertical)	Zero
Flux Concentrator	Winston Parabolic, $\pm$ 45° Acceptance Angle(2)
Heliostats	
° Number	222
° STTF Zone A = 78	
° STTF Zone B = 144	
° Heliostat Mirror Area Per Heliostat	37.22m^2 (400 Ft.^{2})
° Facets per Heliostat	25
° Heliostat Alignment Point	Test Receiver Center Point(3) (STTF Alignment State 2)
° Heliostat Alignment Time	Day 80, Solar Noon
° Heliostat Aiming Points	10 (Reference Figure 3.3.2-4)
° Heliostat Locations	(Reference Figure 3.3.2-3)

(1) The Top 12.5m of the 17m SRE Receiver Panel, Ref. Figure 3.3.2-4

(2) Reference Section 3.2.4.3

(3) Reference Figure 3.3.2-4

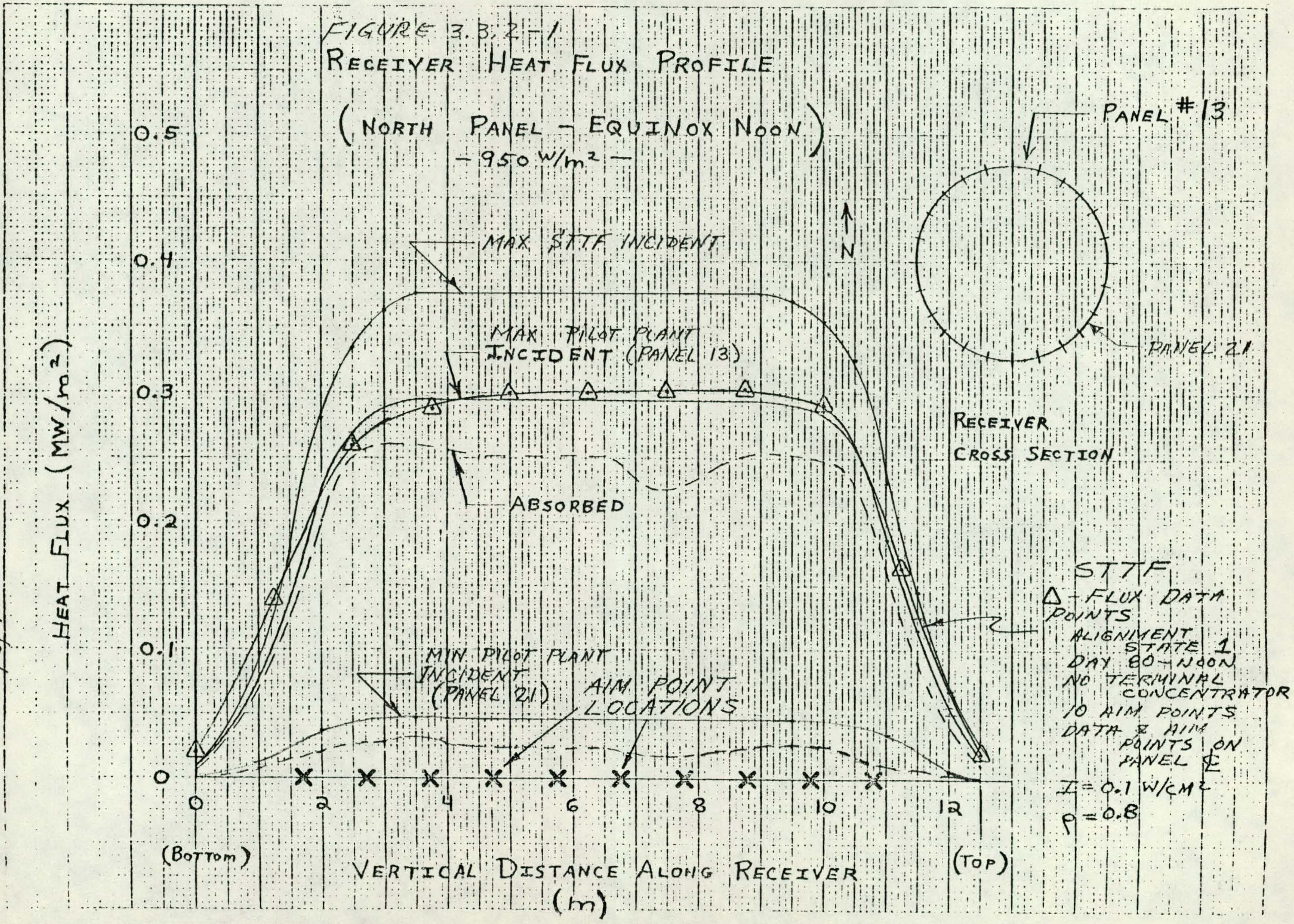


FIGURE 3.3.2-1
RECEIVER HEAT FLUX PROFILE
(NORTH PANEL - EQUINOX NOON)
- 950 W/m² -

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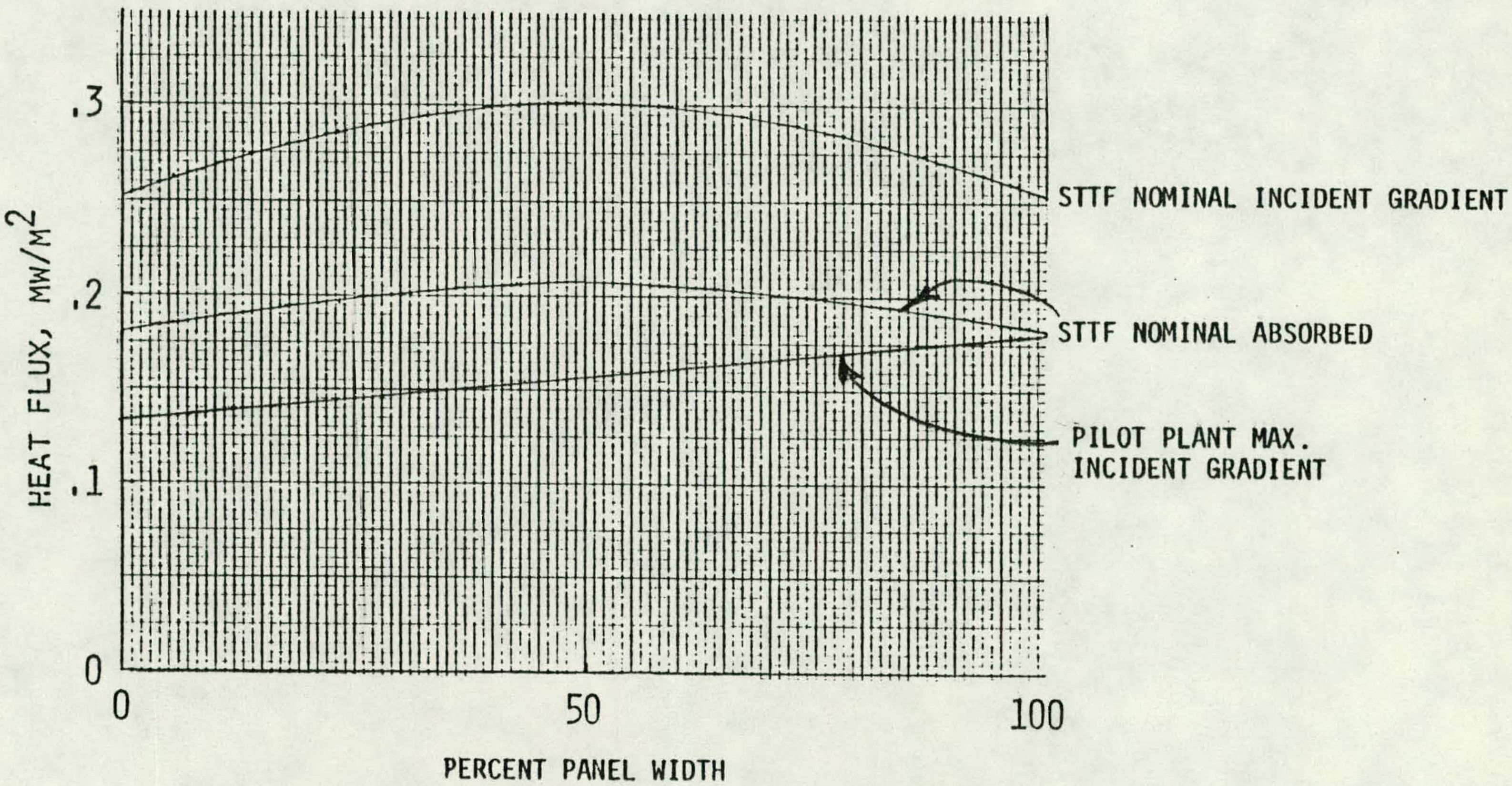


Figure 3.3.2-2 STTF Lateral Heat Flux Characteristics (No Flux Concentrator)

TABLE 4.4.3-4

STTF/MDAC SRE RECEIVER
POWER SUMMARY

Assumptions:

1. I = 0.1 watt/cm^2 direct normal insolation
2. ρ = 0.8 mirror reflectivity
3. 12.5 meter vertical flux profile length
4. Day 80, solar noon alignment time
5. No concentrators/reflectors

Alignment State	Panel Tilt Angle (Degrees)	Incident Power (MW)				Target Width (m)	Error Distribution Half Angle (mrad)	Heliostat Alignment Time (Day)
		Day 80		Day 172				
		10 AM	Noon	10 AM	Noon			
1	0	2.33	2.52	2.25	2.45	.889	3	80
1	0	3.05	3.29	2.93	3.18	1.2	3	80
1	0			3.51		1.5	3	80
1	0			4.01		1.8	3	80
1	0			4.55		2.2	3	80
1	0			5.03		2.7	3	80
3	0		2.94			.889	3	80
2	0	2.72	2.92	2.55	2.71	.889	3	80
2	0			3.26		1.2	3	80
2	0			3.83		1.5	3	80
2	0			4.30		1.8	3	80
2	0				2.77	.889	3	172
2	0		4.65		4.20	.889	0	80
1	0		3.76		3.66	.889	0	80
2	0				2.74	.889	3	172 & 80
2	0		4.27		3.87	.889	1	80
1	0		3.51		3.40	.889	1	80
2	0		3.50		3.21	.889	2	80
1	0		2.95		2.86	.889	2	80

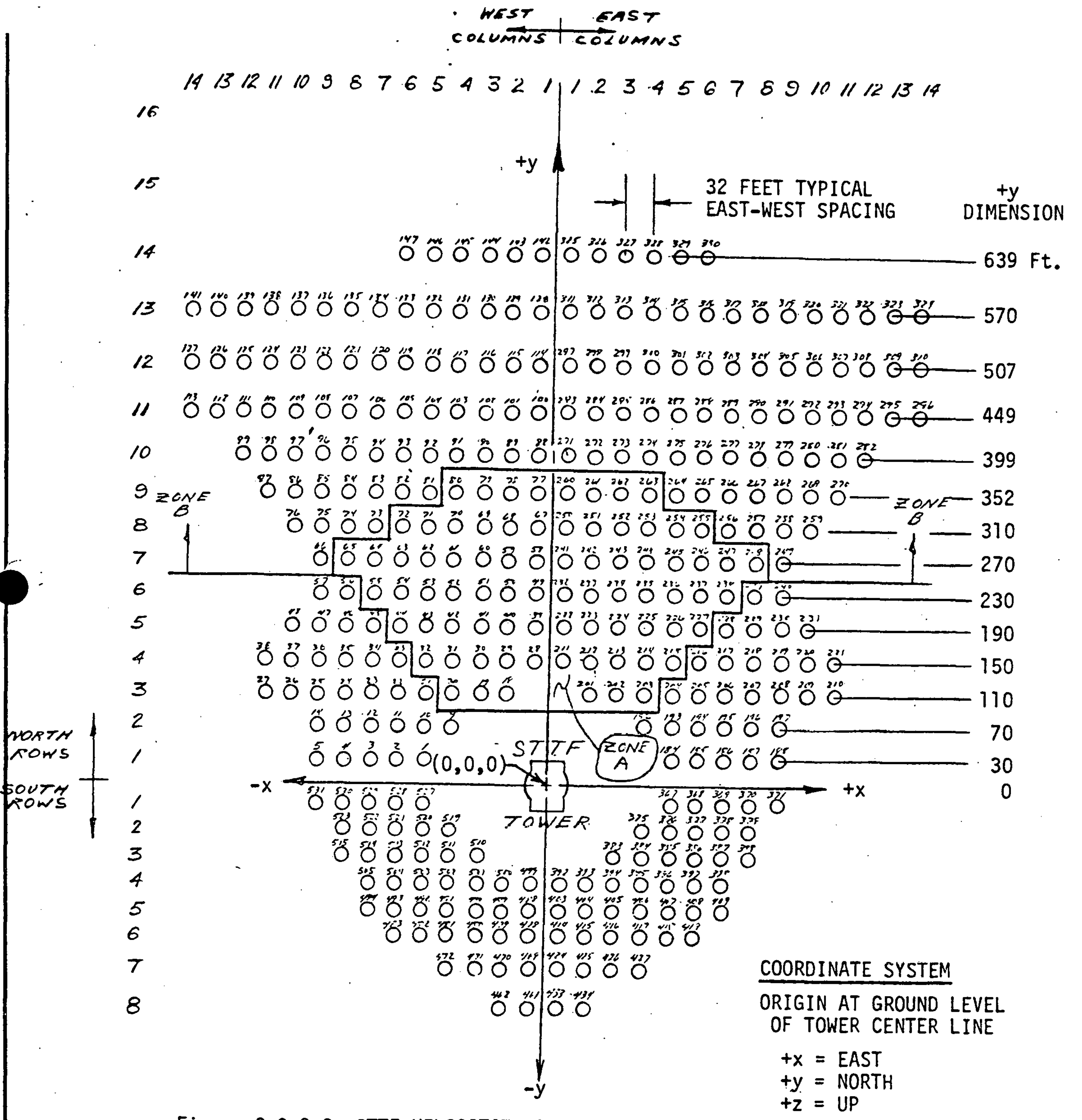
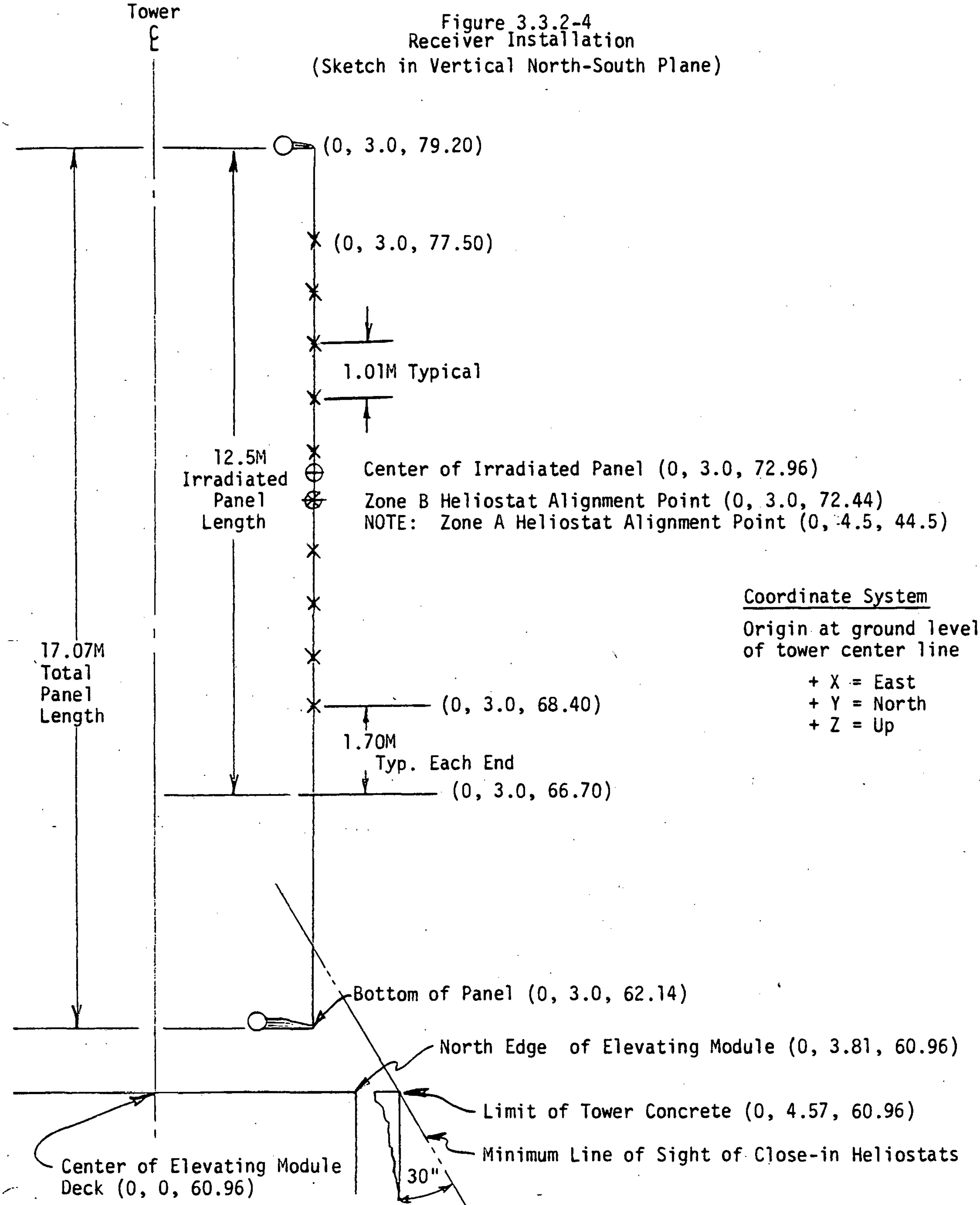


Figure 3.3.2-3, STTF HELIOSTAT LAYOUT

MCDONNELL DOUGLAS ASTRONAUTICS CO. HUNTINGTON BEACH, CALIF. MCDONNELL DOUGLAS	SIZE A	CODE IDENT NO. 18355	DRAWING NO. 1T50721	
	SCALE	REV 6/8/78	SHEET 3.3.2-7	

Figure 3.3.2-4
Receiver Installation
(Sketch in Vertical North-South Plane)



3.3.3 Utility Requirements

All fluids, gases and electrical requirements are specified in Section 3.3.1.

3.3.4 Instrumentation/Data Support Requirements

Instrumentation/data support requirements are specified in Section 3.2.3.

3.3.5 Special Tools and Equipment

3.3.5.1 Photographic

Still and movie coverage for general documentation of installation and test activities.

3.3.5.2 TV

General test area surveillance during test for problem detection (desirable).

3.3.5.3 Communication

Full time audio communication should be provided between the central control building, the receiver controller console, and test area monitors during test operations. Time referenced audio recording of test operation communications is desirable.

3.3.5.4 Tools

STTF will provide all general purpose mechanical and electronic equipment required for assembly, installation, checkout, operation and maintenance of the test installation.

In the electronic area this will specifically include an oscilloscope for controls checkout.

3.3.5.5 Handling Equipment

STTF will provide all handling equipment (hoists, rigging, jacks, etc.) required to remove the test tower and receiver assembly (approximately 40,000 pounds) from the transport truck and install it upon the elevating module.

3.3.6 Office/Assembly Space

Office space with typical furnisheings and access to secretarial support will be required beginning September, 1978 to accommodate up to two contractor personnel for intermittent trips. From early October through February, 1979, it is planned that one contractor engineer will be located essentially full time at STTF. As many as three additional transient personnel could also be at STTF for short periods during this time.

Approximately 100 cubic feet of secure storage space will be required for contractor equipment during the period from early September through February, 1979.

3.3.7 Support Manpower/Schedule

4.0 SAFETY

System safety is assured by the design and fabrication methods and by the use of operating procedures to control potentially hazardous operations.

Structure, plumbing, and pressure vessels are designed and fabricated to meet or exceed the requirements of applicable safety codes as noted in the section on Quality Control. This includes the ASME certification of the boiler and all pressure vessels. All plumbing for the water and steam systems is hydrostatically tested to 3,000 psig. All welds are inspected as required by the applicable codes.

Safety relief valves and burst discs are provided in the system to prevent excessive pressurization. The main system relief valve is set to 1,700 psig; the flash tank relief valve is set to 475 psig.

Instrumentation is provided to indicate abnormal test conditions (Ref. Table 3.2.3-1 and 3.2.3-2). These signals will be used in automatic cut-off circuits and/or as sequence interlocks to prevent unsafe sequences from being executed.

The structure was designed to conform to OSHA safety standards. Provisions will be made for an aircraft warning light and lightning protection.

As a final safety precaution, personnel access to the test area will be limited and controlled during high pressure/high temperature tests of the system.

5.0 PROCEDURES

The contractor will provide the drawings, procedures, and engineering support necessary to assemble, install, checkout, operate, maintain and remove the contractor supplied hardware.

STTF will provide all other support personnel required to accomplish the above tasks.

5.1 ASSEMBLY

The test receiver and its control and instrumentation support plumbing and wiring will be assembled into the basic test tower structure and shipped to STTF as one unit. Due to shipping limitations, the tower base, jib crane, tower protective insulation, and some instrumentation such as level sensors and flux gauges will have to be installed at STTF. Interconnecting plumbing and wiring will be prefabricated wherever practical to minimize cut-to-fit activities at STTF.

All assembly at STTF will be accomplished using standard engineering drawings and engineering support provided by the contractor.

5.2 INSTALLATION

Installations at STTF will begin with the placement of the receiver test tower base into the elevating module deck. Erection of the test tower assembly of the test tower jib crane will follow immediately to permit its use in subsequent installations. The receiver feedwater electric pre-heater and controller console installations will be accomplished soon thereafter. The installation of plumbing and wiring interconnecting the test hardware and STTF can then begin.

Delivery and installation of the flux concentrator panels and their interconnecting plumbing are not planned until December, 1978.

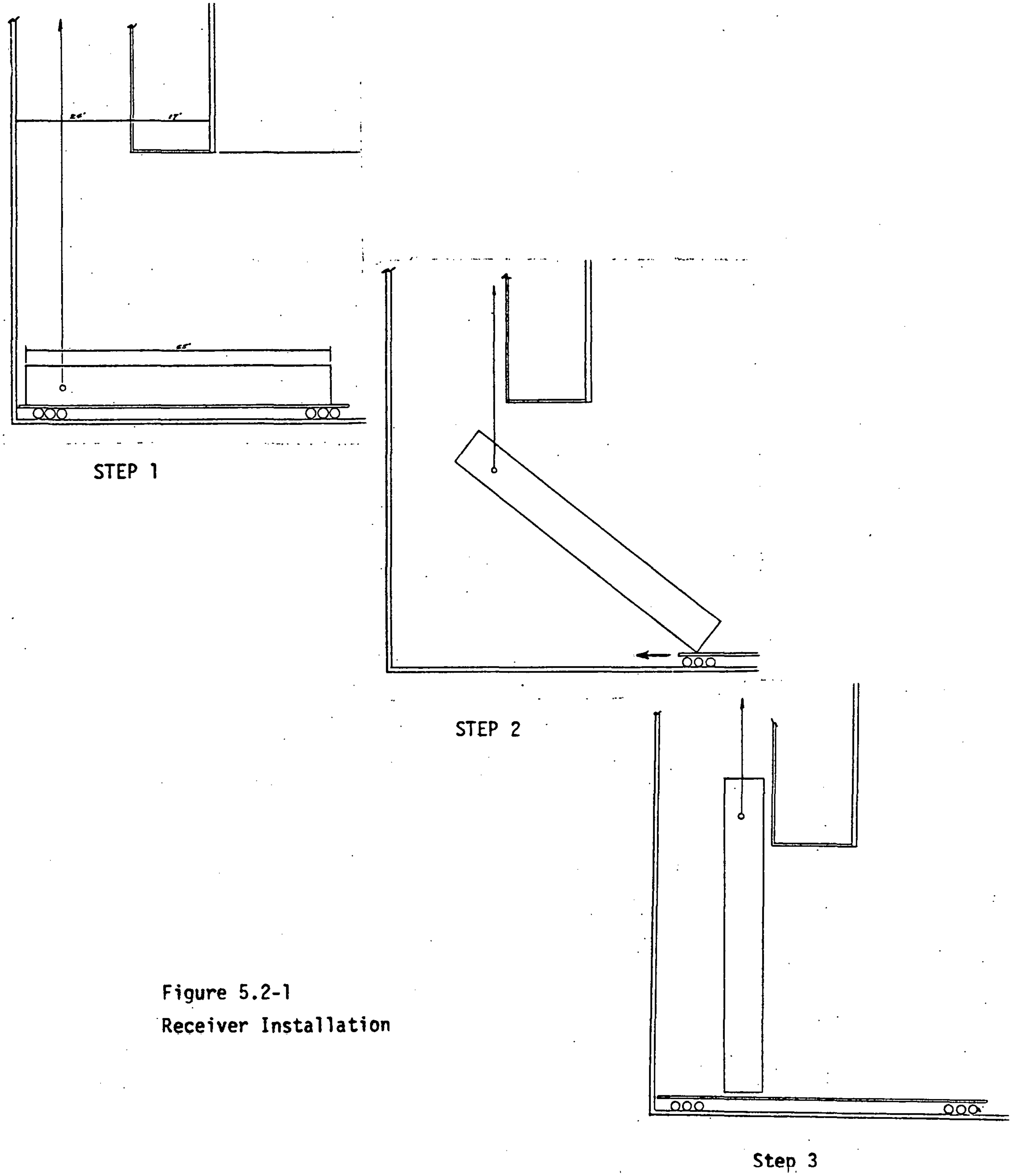


Figure 5.2-1
Receiver Installation

All STTF installations will be primarily accomplished using standard engineering drawings and engineering support provided by the contractor. Written work control procedures will be used where required by the criticality and/or complexity of the task (i.e., test tower erection onto the elevating module).

5.3 CHECKOUT

As hardware installations are completed, wiring continuity and control and instrumentation component functional checks will begin. Once electrical control integrity has been established from both the manual control panel and the central control room computer system, pneumatic control systems will be activated and leak checked. All control valves will then be functionally exercised and gaseous nitrogen leak checks of all water steam plumbing will be accomplished.

Checkout will culminate in a series of "warm" checkout flows to verify the integrity of the system at temperatures and pressures up to 550°F and 2,000 psia.

Written test control procedures provided by the contractor will be used where required by the criticality and/or complexity of the checkout task.

5.4 NORMAL TEST OPERATIONS

Tables 5.4-1, 5.4-2 and 5.4-3 and Figure 5.4-1 summarize the series of tests planned for the STTF receiver Phase II Pilot Plant test program to accomplish the test objectives given in Section 2.0.

It is anticipated that initial testing will be nonsteaming runs to shake down the test hardware and test procedures, calibrate the flux power profiles, and simulate pilot plant preheater panel operation.

Steaming tests will begin with insolation duplicating the lower power conditions to be expected on a southerly pilot plant receiver panel and then increase with each test until maximum pilot plant power conditions are achieved.

Table 5.4-1

STTF TEST REQUIREMENTS SUMMARY (SHEET 1 OF 4)

Test Number	Test Description	Test Duration, Hours	Incident Pwr, MW	Flow Rate lb/sec	Panel Inlet Temp, F	Inlet Press, psig	Outlet Temp, F	Receiver Outlet Press, psig
1	Receiver Panel Heat Capacity	3	0.1-0.4	0	DNA	DNA	DNA	DNA
2	Preheater Verification	3	0.4-2.0	0.4-15.0*	400	2250	550	1550
3	Pilot Plant Start Sequence; Max/Min South Pwr, Derated Operation	2	0.65-1.25	0.35-1.15	400	2250	660	1550
4	Max/Min South Panel Power, Rated/Derated Operation	3	0.65-1.25	0.35-1.15	400	2250	660-960	1550
5	Min South Panel Power; Inlet Temp & Discharge Press Effects on Derated Operation	3	0.65-1.25	0.35-1.15	250-600	2250	660-960	1300-1750
6	Max South Power; Feedwater Press Effects on Derated Operation; Cloud Transients	3	0.65-1.25	0.35-1.15	550	2250	660-960	1550
7	Max/Min South Panel Power, Rated Operation	3	0.65-1.25	0.35-0.92	AMB-400	1800-2500	660-960	1550
8	Min South Panel Power; Inlet Temp & Discharge Pressure Effects	3	0.65-1.25	0.35-1.15	250-550	2250	660-960	1300-1750

*Or facility limit

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Table 5.4-1

STTF TEST REQUIREMENTS SUMMARY (SHEET 2 OF4)

Test Number	Test Description	Test Duration, Hours	Incident Pwr, MW	Flow Rate lb/sec	Panel Inlet Temp, F	Inlet Press, psig	Outlet Temp, F	Receiver Outlet Press, psig
9/10	Min South Pwr, Feedwater Press Effects; Cloud Transients; Emergency Shutdown	3	0.25-.75	0.11-0.67	250-550	1800-2500	660-960	1550
11	Typical Pilot Plant Day, South Panel	Full Day	0.65-1.25	0.35-0.92	250-550	2250	660-960	1550
12	Min/Max East Panel Pwr; Inlet Temp & Discharge Press Effects on Derated Operation at Max Power	4	0.65-2.55	0.35-2.78	250-600	1800-2500	660-960	1300-1750
13	Max East Panel Pwr; Feedwater Press Effects on Derated Operation; Cloud Transients	4	0.35-2.78	0.35-2.78	550	1800-2500	660-960	1550
14	Min East Panel Pwr; Inlet Temp & Discharge Press Effects	4	0.65-2.55	0.35-2.78	250-600	2250	660-960	1300-1750
15/16	Min East Panel Pwr; Inlet Press Effects; Cloud Transients; Emergency Shutdown	4	0.38-1.28	0.08-1.28	550	1800-2500	660-960	1550
17	Typical Pilot Plant Day, East Panel	Full Day	0.65-2.55	0.35-2.78	250-550	2250	660-960	1550

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Table 5.4-1

STTF TEST REQUIREMENTS SUMMARY (SHEET 3 OF 4)

Test Number	Test Description	Test Duration, Hours	Incident Pwr, MW	Flow Rate lb/sec	Panel Inlet Temp, F	Inlet Press, psig	Outlet Temp, F	Receiver Outlet Press, psig
18	Min/Max North Panel; Inlet Temp & Discharge Press Effects on Derated Operation at Max Power	4	1.13-3.22	0.78-3.56	250-600	2250	660-960	1300-1750
19	Max North Pwr; Inlet Press Effects; Cloud Transients	4	1.13-3.22	0.78-3.56	550	1800-2500	660-960	1550
20	Min North Pwr; Inlet Temp & Discharge Press Effects	4	1.13-3.22	0.78-3.56	250-600	2250	660-960	1300-1750
21/22	Min North Pwr; Inlet Press Effects; Cloud Transients; Emergency Shutdown	4	0.72-1.61	0.42-1.67	550	1800-2500	660-960	1550
23	Typical Pilot Plant Day, North Panel	Full Day	1.13-3.22	0.78-3.56	250-550	2250	660-960	1550
	REFLECTOR TESTS							
24	Sys Shakedown; Min/Max North Panel Pwr Operation	3	1.13-3.22	0.78-3.56	400	2250	660-960	1550

Table 5.4-1

STTF TEST REQUIREMENTS SUMMARY (SHEET 4 OF 4)

Test Number	Test Description	Test Duration, Hours	Incident Pwr, MW	Flow Rate lb/sec	Panel Inlet Temp, F	Inlet Press, psig	Outlet Temp, F	Receiver Outlet Press, psig
25	Min/Max North Pwr; Inlet Temp & Discharge Press Effects	4	1.13-3.22	0.78-3.56	250-600	2250	660-960	1300-1750
26	Max North Pwr; Inlet Press Effects; Cloud Transients	4	1.13-3.22	0.78-3.56	550	1800-2500	660-960	1550
27	125% Max North Pwr; Inlet Temp & Discharge Pressure Effects	4	1.13-4.03	0.78-4.47	250-600	2250	660-960	1300-1750
28	125% Max North Power; Inlet Press Effects; Cloud Transients	4	1.13-4.03	0.78-4.47	550	1800-2500	660-960	1550
29	125% Max North Power Typical Operating Day	Full Day	1.13-4.03	0.78-4.47	250-550	2250	660-960	1550
30	Max Flux Test	4	TBD	TBD	550	2250	660-960	1550

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TABLE 5.4-2

TEST/TEST OBJECTIVE SUMMARY

TO BE REVISED

TEST OBJECTIVES	STTF TEST NUMBER																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Measure Panel Losses and Panel Perf.			X	✓	✓	X	X	X	✓	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	✓	✓	✓		X	✓	✓	✓	✓	X
2. Investigate Effects of Vert. Flux Profile on Panel Losses and Perf.																														
3. Demonstrate Delivery of Dry Steam				✓	✓	✓	✓	✓	✓	✓	✓	X	X	X		X	✓	✓	✓	✓	X	X	X		✓	✓	X	X		✓
4. Check Flow Distribution and Uniformity				✓	✓	✓	✓	✓	✓	X	X	✓	✓	✓		X	X	✓	✓	X	✓	✓	✓		✓	X	✓	✓		✓
5. Demonstrate Hydrodynamic Stability				✓	✓	✓	✓	✓	✓	X	X	X	X	✓		X	X	✓	✓	X	X	X	✓		✓	X	X	✓		✓
6. Demonstrate Control Sys. Perf.			✓	X	X		✓		X			✓	✓	X	X		X		X		✓	✓	X		✓		✓	X	X	✓
7. Investigate Control Sys. Perf.																														
Effects of Valve Trim				X	X	X										X		X												
Min. Valve ΔP										X	X									X						X				
Control Algorithms				X	X	X										X		X												
8. Investigate Effects of DNB Phenomena																									X	✓	✓	✓	✓	X
9. Verify Panel Support System Perf. During Panel Therm. Exp. & Contr.			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	✓	✓	✓	✓		X	✓	✓	✓	X	X
10. Meas. Panel Wall Temp. to Evaluate Effects on Lifetime (Verify 30 Yr Life)			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	X	✓	✓	✓	✓	✓	✓		X	✓	✓	✓	X	X
11. Verify Panel Coating Durability	C																													C
12. Check Tube Fouling	C																													C
13. Syst. Shakedown and Calibration	X	X																						X						

X = Primary Test Objective
✓ = Gather Data
C = Check

TABLE 5.4-3

TEST/TEST CONDITIONS SUMMARY

TEST OPERATING CONDITIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	STTF TEST NUMBER																													
Steady State																														
Preheat Panel	✓	✓	✓																											
Rated Steam Conditions						2	2	2		2	2		2		I	2	I	2	2	2	2	2		2	✓	✓	✓	✓	I	✓
Derated Steam Conditions				F	F	1	1	1	✓	1	1	✓	1	✓		1		1	1	1	1	1	✓	1						
Transients																														
Startup				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Shutdown															X		X												X	
Emergency Shutdown														X									X							
Cloud																														
Inlet Cond. Ramps																														
Temperature												V	V								V	V					V			
Pressure									V	✓	✓								V	✓						✓				
Outlet Cond. Ramps																														
Temperature						✓	✓	✓			✓		✓			✓		✓	✓	✓	✓	✓				✓				
Pressure									V	✓									V	✓						✓				
Fluctuations to Simulate Interactions between Panels																														
Test Panel Simulated Location																														
South				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓															
North																		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
East (Lateral Flux Gradients)																✓	✓													
Test Power Level (%Max. Nom. Absorbed)																														
Min. Power (MW)	.2	.2	.2											.2				.49												
Max. Power (MW)	4.2	4.2	1.1											.74				2.09												
Nom. Power (MW)					.2	.2	.5	.74	1.0	.2	.5	.5	.2	.5	1.0				.5	1.23	.5	1.23	.5		2.5	2.5	2.5	2.5	3.12	

1 First Set Point
2 Second Set Point
✓ Test Condition
X Major Operating Transient
F Final
I Initial
V Vary

TO BE REVISED

MCDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.
MCDONNELL DOUGLAS

SIZE	CODE IDENT NO.	DRAWING NO.
A	18355	1T50721
SCALE	REV 6/10/78	SHEET 5.4-5

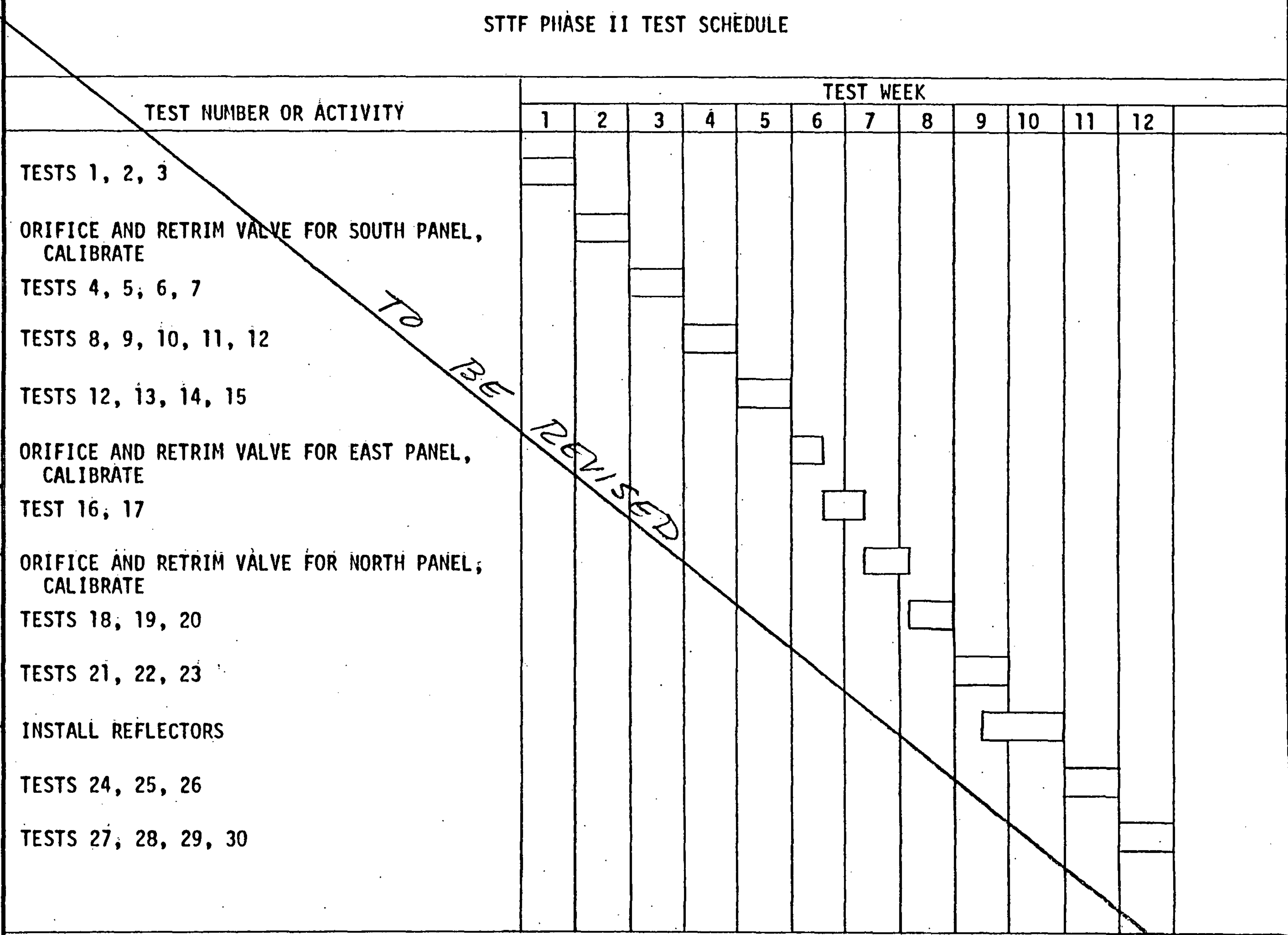

Figure 5.4-1 STTF Phase II Test Schedule

MCDONNELL DOUGLAS ASTRONAUTICS CO.
HUNTINGTON BEACH, CALIF.
MCDONNELL DOUGLAS

SIZE	CODE IDENT NO.	DRAWING NO.
A	18355	1T50721

SCALE REV 6/8/78 SHEET 5.4-6

60-0213-1A02 (06 AUG 71)

Following the demonstration of successful receiver panel operation under steady state conditions, a series of tests will be run to investigate the effect of normally expected variations in receiver input and output conditions on receiver performance and stability (i.e., cloud transients, feedwater transients, etc.).

Written procedures provided by the contractor and coordinated with STTF will be used to control all "hot" tests. Pre-start, start, transition, shut-down and standby procedures and sequences will duplicate those planned for the pilot plant wherever practical. Typical prestart, start, normal shutdown, and emergency shutdown procedures are presented in Sections 5.4.1, 5.4.2, 5.4.3 and 5.5.

The following test description sheets indicate the individual differences, and similarities, between planned tests at STTF. All tests are similar in that the same hardware and instrumentation are utilized throughout the program--only conditions are to be changed. These tests are designed to provide a data base for pilot plant receiver design and operations.

"Performance criteria parameters," indicate the primary instrumentation required for satisfying test objectives. Other instrumentation parameters otherwise monitored for each test are not included. For instance, temperature, pressures, heat flux, acoustic, flow and panel position, control levels and control signals will be recorded for every test. Performance and other characteristics will be evaluated from this data.

Test records shall be retained as permanent data on tape for analysis

The parameter listing and other related general items to be conducted every test have been omitted from the test description sheets for the sake of room.

PILOT PLANT RECEIVER TEST NO. 1

DESCRIPTION: RECEIVER PANEL HEAT CAPACITY

- ILLUMINATE DRY RECEIVER PANEL WITH LOW POWER INSOLATION

OBJECTIVES

- SYSTEM SHAKEDOWN AND CALIBRATION
  - DETERMINE RECEIVER THERMAL MASS
  - CHECK PANEL THERMAL AND FLUX INSTRUMENTATION
  - TEST CREW FAMILIARIZATION AND PROCEDURE VALIDATION

TEST CONDITIONS

- RECEIVER DRY AND PRESSURIZED WITH GN_2 TO 10 PSIG.
- TOP 41 FEET OF RECEIVER BOILER PANEL FACE EXPOSED FOR TEST: REMAINDER INSULATED FROM FLUX.
- NO CLOUDS, MINIMUM WIND.

TEST SEQUENCE

- NORMAL PRE-START PROCEDURE
- ILLUMINATE RECEIVER WITH HELIOSTATS IN INCIDENT POWER INCREMENTS NOT TO EXCEED 0.1 MWT UP TO A MAXIMUM TOTAL INCIDENT POWER OF 0.4 MWT.
- MONITOR PANEL TEMPS FOR STABILIZATION BETWEEN THE APPLICATION OF EACH POWER INCREMENT. (MAINTAIN CONSTANT POWER AS CLOSE AS POSSIBLE DURING STABILIZATION PERIODS).
- REMOVE ALL INSOLATION AND MONITOR PANEL TEMP DECAY

SUCCESS CRITERIA

- SUCCESSFUL MEASUREMENT OF RECEIVER PANEL TEMPS, INCIDENT FLUX LEVELS AND WEATHER CONDITIONS

PRIMARY DATA REQUIREMENTS

- FLUX GAGES
- PANEL TEMPS (HOT AND COLD SIDES)

SPECIAL REQUIREMENTS

- NO FEEDWATER REQUIRED

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PILOT PLANT RECEIVER TEST #2

DESCRIPTION: PREHEATER VERIFICATION

- MAINTAINING SUB-COOLED WATER CONDITIONS THROUGHOUT THE TEST, ILLUMINATE THE TEST RECEIVER AT INCREMENTAL POWER LEVELS UP TO MAXIMUM PILOT PLANT PREHEATER FLOW AND TEMPERATURE CONDITIONS.
- VERIFY ELECTRIC PREHEATER OPERATION.

OBJECTIVES:

- PANEL PRE-HEATER FLOW CHARACTERIZATION
- ELECTRIC PREHEATER PERFORMANCE VERIFICATION.
- SYSTEM SHAKEDOWN AND CALIBRATION
  - PILOT PLANT PRE-START/START PROCEDURE VERIFICATION
  - CONTROL SYSTEM VERIFICATION
  - INSTRUMENTATION SYSTEM VERIFICATION
  - CREW FAMILIARIZATION AND PROCEDURE VALIDATION
- FLUX GAGE CALIBRATION

TEST CONDITIONS:

- TOP 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX.
- NO STEAM GENERATION
- FEEDWATER TEMP FROM STTF
  - INITIALLY AMBIENT
  - FINALLY 400°F
- MAINTAIN ALL LIQUID CONDITIONS THROUGH THE TEST.

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TEST SEQUENCE

- NORMAL PRESTART PROCEDURE (TR PARA. 5.4.1)
- NORMAL START PROCEDURE (TR PARA 5.4.2) THROUGH 5.4.2.3 [RECEIVER PREHEATER (RP) CHECK].
- NORMAL START PROCEDURE (TR PARA 5.4.2) UP TO SECTION 3, "RECEIVER PREHEATER CHECK".
- RECEIVER PREHEATER OFF
- INCREASE RBTCV Q LOW LIMIT SET POINT INCREMENTALLY UNTIL RFDV CANNOT CONTROL FLASH TANK WATER LEVEL OR RFPCV BEGINS TO OPEN TO MAINTAIN FLASH TANK PRESSURE BELOW 425 PSIG
- INCREASE RWIP TO 675 IN COORDINATION WITH RISE OF RFSOP (MAINTAIN MIMIMUM RBTCV ΔP OF 250 PSIG).
- WITH RDSPCV SET TO 425 PSIG, SLOWLY OPEN RDSIV AND ESTABLISH LIQUID FLOW TO FILL THE STTF DOWNCOMER.
- WHEN RDSIV IS FULLY OPEN, CLOSE RFIV.
- MAINTAINING A MINIMUM RBTCVDP OF 250 PSIG, INCREASE RWIP TO 2250 PSIG (USING RFW RECIRC VALVE) AND RSOP TO 1550 PSIG (BY INCREASING RDSPCV SET POINT AS REQUIRED).
- MONITOR SYSTEM PRESSURES AND INCREASE RBTCV Q LOW LIMIT SET POINT INCREMENTALLY TO 15 POUNDS PER SECOND OR UNTIL RELIEF VALVE LIMITS ARE APPROACHED OR FACILITY FLOW CAPACITY IS REACHED.
- REDUCE RBTCV Q LOW LIMIT SET POINT TO _______.
- WITH RBTCV TEMP SET POINTS OF 550, 500, and 450°F, ILLUMINATE THE TEST PANEL WITH HELIOSTATS IN INCIDENT POWER INCREMENTS NOT TO EXCEED 0.4 MWT UP TO A TOTAL INCIDENT POWER LEVEL OF 2.0 MWT OR A FLOW RATE OF 15 POUNDS PER SECOND OR FACILITY FLOW CAPACITY IS REACHED. (MAINTAIN CONSTANT POWER AS CLOSELY AS POSSIBLE AT EACH POWER LEVEL.)

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- REMOVE HELIOSTATS FROM RECEIVER.
- REDUCE RBTCV Q LOW LIMIT SET POINT TO _________ LBS/SEC.
- ACTIVATE STTF DEAERATOR/DESUPERHEATER (DA/DSH) IMMERSION HEATERS AND VERIFY PROPER OPERATION AT VARIOUS SET POINTS.
- ACTIVATE RECEIVER ELECTRIC PREHEATER (RP) AND VERIFY OPERATION AT VARIOUS SET POINTS.
- WITH BOTH DA/DSH HEATERS (AT 400°F SET POINT) AND RP (AT 550°F SET POINT) ACTIVE, INCREASE RECEIVER FLOW UNTIL RP OUTPUT TEMP OF 550°F CANNOT BE MAINTAINED.

SUCCESS CRITERIA

- SUCCESSFUL MEASUREMENT OF RECEIVER PANEL TEMPS, INCIDENT FLUX LEVELS AND WATER FLOW RATES.
- SUCCESSFUL DETERMINATION OF ABSORBED POWER AT VARIOUS INCIDENT POWER LEVELS.
- SUCCESSFUL DETERMINATION OF RECEIVER PANEL PREHEATER CHARACTERISTICS UP TO TEMP OF 550°F AND FLOW RATE UP TO 15 LBS/SECOND (OR FACILITY FLOW LIMIT).
- SUCCESSFUL OPERATION OF TEST PANEL CONTROL SYSTEM.
  - FLOW RATE CONTROL
  - PANEL OUTLET TEMP CONTROL
- FEEDWATER PREHEATERS MEET MAXIMUM FLOWRATE REQUIREMENTS.
- DATA SYSTEM OPERATION IS RELIABLE AND REPEATABLE.

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM PRESSURES AND TEMPS
- WATER FLOW RATES
- PANEL TEMPS AND PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS
- PREHEATER TEMPS
- VALVE POSITIONS

SPECIAL REQUIREMENTS

- STTF DOWNCOMER MUST ACCEPT WATER FLOW UP TO FACILITY FLOW LIMIT AT 550°F AND 1700 PSIG.

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PILOT PLANT RECEIVER TEST #3

DESCRIPTION: PILOT PLANT START SEQUENCE VERIFICATION; MAXIMUM/MINIMUM SOUTH PANEL POWER DERATED STEAM OPERATION

- ACCOMPLISH "COLD" RECEIVER START TO DERATED STEAM CONDITIONS AT APPROXIMATELY 50 PERCENT OF SOUTH PANEL MAXIMUM POWER; INCREASE INCIDENT POWER TO 100 PERCENT OF SOUTH PANEL MAXIMUM; DECREASE INCIDENT POWER TO MINIMUM STABLE OPERATING LEVEL AT DERATED CONDITIONS.

OBJECTIVES

- SYSTEM SHAKEDOWN AND CALIBRATION
- VERIFY PILOT PLANT RECEIVER "COLD" START PROCEDURE TO DERATED STEAM CONDITIONS
- VERIFY RECEIVER OPERATION FROM MAXIMUM TO MINIMUM SOUTH PANEL POWER AT DERATED STEAM CONDITIONS
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- TOP 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX
- FEEDWATER TEMP FROM STTF INITIALLY AMBIENT
- RECEIVER PREHEATER OFF
- INCIDENT INSOLATION UP TO 1.25 MWT
- SOUTH PANEL RBTCV TRIM INSTALLED

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE (TR SECTION 5.4.1)
- NORMAL PILOT PLANT START PROCEDURE (TR SECTION 5.4.2) TO DERATED STEAM CONDITIONS (660°F, 1550 PSIG)
- TRANSITION FROM FLASH TANK TO DOWNCOMER AT 0.65 MWT INCIDENT (≈ 50 PERCENT MAXIMUM SOUTHERN POWER)
- AFTER TRANSITION TO DOWNCOMER, INCREMENTALLY INCREASE INCIDENT POWER TO A MAXIMUM OF 1.25 MWT (MAXIMUM SOUTHERN PANEL POWER).
- INCREMENTALLY DECREASE INCIDENT POWER UNTIL DERATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE (TR SECTION 5.4.3)

PILOT PLANT RECEIVER TEST #3 (CONTINUED)

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, START, AND SHUTDOWN PROCEDURES
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT DERATED STEAM CONDITIONS AT POWER LEVELS FROM 100 PERCENT TO 40 PERCENT OF MAXIMUM SOUTH PANEL POWER

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM INTERNAL PRESSURES AND TEMPERATURES
- WATER FLOW RATES
- PANEL HOT AND COLD TEMPERATURES AND DELTA PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS

SPECIAL REQUIREMENTS

- NONE

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PILOT PLANT RECEIVER TEST #4

DESCRIPTION: MAXIMUM/MINIMUM SOUTH PANEL POWER OPERATION AT DERATED/RATED CONDITIONS

° ACCOMPLISH "WARM" RECEIVER START AT DERATED STEAM CONDITIONS AT APPROXIMATELY 50 PERCENT OF SOUTH PANEL MAXIMUM POWER; TRANSITION TO RATED STEAM CONDITIONS; INCREASE INCIDENT POWER TO 100 PERCENT OF SOUTH MAXIMUM; DECREASE POWER TO MINIMUM STABLE OPERATING LEVEL AT RATED CONDITIONS

OBJECTIVES

° SYSTEM SHAKEDOWN AND CALIBRATION

° VERIFY NORMAL PILOT PLANT PRESTART, START AND SHUTDOWN PROCEDURES

° DEMONSTRATE RECEIVER RATED STEAM CONDITION OPERATION FROM MAXIMUM TO MINIMUM SOUTH PANEL POWER

° INVESTIGATE CONTROL SYSTEM PERFORMANCE

° DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

° TOP 41 FEET OF PANEL EXPOSED FOR TEST

° STTF FEEDWATER TEMPERATURE 400°F

° INCIDENT INSOLATION UP TO 1.25 MWT

TEST SEQUENCE

° NORMAL PILOT PLANT PRESTART PROCEDURE

° NORMAL PILOT PLANT WARM START PROCEDURE TO DERATED CONDITIONS

° TRANSITION TO DOWNCOMER AT 50 PERCENT MAXIMUM SOUTH POWER

° TRANSITION FROM DERATED TO RATED CONDITIONS

° INCREMENTALLY INCREASE INCIDENT POWER TO MAXIMUM SOUTH POWER

° INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTANED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F

° NORMAL PILOT PLANT SHUTDOWN PROCEDURE

SUCCESS CRITERIA

° SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, WARM START, AND NORMAL SHUTDOWN

° SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 100 PERCENT to 40 PERCENT OF MAXIMUM SOUTH POWER

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PILOT PLANT RECEIVER TEST #4 (CONTINUED)

PRIMARY DATA REQUIREMENTS

(SAME AS TEST #3)

SPECIAL REQUIREMENTS

° NONE

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PILOT PLANT RECEIVER TEST #5

DESCRIPTION: MINIMUM SOUTH PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON DERATED OPERATION AT MAXIMUM SOUTH POWER

- ACCOMPLISH MINIMUM SOUTH POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM SOUTH TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT 100 PERCENT MAXIMUM SOUTH POWER AND DERATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- SHUTDOWN FROM MAXIMUM SOUTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- TOP 41 FEET OF PANEL EXPOSED FOR TEST
- SOUTH PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 1.25 MWT
- FEEDWATER FROM STTF INITIALLY AT 250°F, 400°F AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO DERATED STEAM CONDITIONS AT MINIMUM SOUTH POWER
- TRANSITION TO RATED STEAM CONDITIONS AT MINIMUM SOUTH POWER
- INCREASE INCIDENT POWER TO 50 PERCENT OF SOUTH MAXIMUM
- TRANSITION BACK TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF SOUTH MAXIMUM
- TRANSITION TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF SOUTH MAXIMUM
- TRANSITION TO DERATED CONDITIONS

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PILOT PLANT RECEIVER TEST #5 (CONTINUED)

- HOLDING INCIDENT POWER AT 1.25 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F. IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 550°F.
- HOLDING INCIDENT POWER AT 1.25 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- SHUTDOWN FROM SOUTH MAXIMUM POWER

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN ± 25°F OF SET POINT DURING STEADY STATE AND WITHIN ± 35°F DURING TRANSITION PERIODS.
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED.
- DRY STEAM PRODUCED AND MAINTAINED.
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #3 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST #6

DESCRIPTION: SOUTH MAXIMUM POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM SOUTH POWER HOT START TO RATED CONDITIONS, INCREASE INCIDENT POWER TO MAXIMUM SOUTH AND TRANSITION TO DERATED STEAM CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS.
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS.
- NORMAL SHUTDOWN FROM MAXIMUM SOUTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- TOP 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 1.25 MWT
    - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- SOUTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED.

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM SOUTH POWER
- INCREASE INCIDENT POWER TO 100 PERCENT OF MAXIMUM SOUTH
- TRANSITION TO DERATED CONDITIONS
- HOLDING INCIDENT POWER AT 1.25 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

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PILOT PLANT RECEIVER TEST #6 (CONTINUED)

- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- TRANSITION TO STEADY STATE RATED CONDITIONS AT MAXIMUM SOUTH POWER.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 75 PERCENT OF SOUTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF SOUTH MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 50 PERCENT OF SOUTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF SOUTH MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE 25 PERCENT AND 50 PERCENT POWER REDUCTIONS/REAPPLICATIONS.
- NORMAL CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #5 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #5.

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS OF ± 25 AND ± 50 PERCENT OF MAXIMUM SOUTH POWER.

PILOT PLANT RECEIVER TEST #7

DESCRIPTION: MAXIMUM/MINIMUM SOUTH PANEL POWER RATED STEAM OPERATION

- ACCOMPLISH "COLD" RECEIVER START TO RATED STEAM CONDITIONS AT APPROXIMATELY 50 PERCENT OF SOUTH PANEL MAXIMUM POWER; INCREASE INCIDENT POWER TO 100 PERCENT OF SOUTH PANEL MAXIMUM; DECREASE INCIDENT POWER TO MINIMUM STABLE OPERATING LEVEL AT RATED CONDITIONS.

OBJECTIVES

- SYSTEM SHAKEDOWN AND CALIBRATION
- VERIFY PILOT PLANT RECEIVER "COLD" START PROCEDURE TO RATED STEAM CONDITIONS
- VERIFY RECEIVER OPERATION FROM MAXIMUM TO MINIMUM SOUTH PANEL POWER AT RATED STEAM CONDITIONS
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX
- FEEDWATER TEMP FROM STTF INITIALLY AMBIENT
- RECEIVER PREHEATER OFF
- INCIDENT INSOLATION UP TO 1.25 MWT
- SOUTH PANEL RBTCV TRIM INSTALLED

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE (TR SECTION 5.4.1)
- NORMAL PILOT PLANT START PROCEDURE (TR SECTION 5.4.2) TO RATED STEAM CONDITIONS (960°F, 1550 PSIG)
- TRANSITION FROM FLASH TANK TO DOWNCOMER AT 0.65 MWT INCIDENT (≈ 50 PERCENT MAXIMUM SOUTHERN POWER)
- AFTER TRANSITION TO DOWNCOMER, INCREMENTALLY INCREASE INCIDENT POWER TO A MAXIMUM OF 1.25 MWT (MAXIMUM SOUTHERN PANEL POWER).
- INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE (TR SECTION 5.4.3)

PILOT PLANT RECEIVER TEST #7 (CONTINUED)

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, START, AND SHUTDOWN PROCEDURES
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 100 PERCENT TO 40 PERCENT OF MAXIMUM SOUTH PANEL POWER

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM INTERNAL PRESSURES AND TEMPERATURES
- WATER FLOW RATES
- PANEL HOT AND COLD TEMPERATURES AND DELTA PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS

SPECIAL REQUIREMENTS

- NONE

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PILOT PLANT RECEIVER TEST #8

DESCRIPTION: MINIMUM SOUTH PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON RATED OPERATION AT MINIMUM SOUTH POWER

- ACCOMPLISH MINIMUM SOUTH POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM SOUTH, TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- DECREASE INCIDENT POWER TO MINIMUM SOUTH POWER AND TRANSITION TO RATED CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT MINIMUM SOUTH POWER AND RATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- DECREASE POWER TO MINIMUM STABLE OPERATING LEVEL AT RATED CONDITIONS
- NORMAL SHUTDOWN FROM MINIMUM SOUTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- SOUTH PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 1.25 MWT
- FEEDWATER FROM STTF AT 250°F, 400°F AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO RATED STEAM CONDITIONS AT MINIMUM SOUTH POWER
- TRANSITION TO DERATED STEAM CONDITIONS AT MINIMUM SOUTH POWER
- INCREASE INCIDENT POWER TO 50 PERCENT OF SOUTH MAXIMUM
- TRANSITION BACK TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF SOUTH MAXIMUM
- TRANSITION TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF SOUTH MAXIMUM

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PILOT PLANT RECEIVER TEST #8 (CONTINUED)

TEST SEQUENCE (CONT'D)

- TRANSITION TO RATED CONDITIONS
- DECREASE INCIDENT POWER TO 40 PERCENT OF SOUTH MAXIMUM
- HOLDING INCIDENT POWER AT 0.50 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 550°F.
- HOLDING INCIDENT POWER AT 0.50 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE MAINTAINED WITHIN ± 25°F OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN + 25°F OF SET POINT DURING STEADY STATE AND WITHIN + 35°F DURING TRANSITION PERIODS FROM 40 TO 100 PERCENT OF MAXIMUM SOUTH POWER
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED FROM 40 TO 100 PERCENT OF MAXIMUM SOUTH POWER
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #3 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST #9/10

DESCRIPTION: SOUTH MINIMUM POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM SOUTH POWER HOT START TO RATED CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS
- EMERGENCY SHUTDOWN FROM MINIMUM SOUTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 0.75 MWT
    - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- SOUTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM SOUTH POWER
- HOLDING INCIDENT POWER AT 0.5 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

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PILOT PLANT RECEIVER TEST #9/10 (CONTINUED)

- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- INCREASE INCIDENT POWER TO 60 PERCENT OF MAXIMUM SOUTH
- STEP CHANGE INCIDENT POWER FROM 60 PERCENT TO 40 PERCENT OF SOUTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 60 PERCENT OF SOUTH MAXIMUM.
- DECREASE INCIDENT POWER TO 40 PERCENT OF SOUTH MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 40 PERCENT TO 20 PERCENT OF SOUTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 40 PERCENT OF SOUTH MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE ABOVE POWER REDUCTIONS/ REAPPLICATIONS.
- DECREASE INCIDENT POWER UNTIL DERATED CONDITIONS CAN NO LONGER BE MAINTAINED WITHIN ± 25°F OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- EMERGENCY CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #5 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.
- SUCCESSFUL EMERGENCY CUTOFF.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #5.

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS FROM 20 TO 60 PERCENT OF MAXIMUM SOUTH POWER.

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PILOT PLANT RECEIVER TEST #11

DESCRIPTION: TYPICAL PILOT PLANT DAY, SOUTH PANEL

- ACCOMPLISH WARM RECEIVER START TO RATED STEAM CONDITIONS AT MINIMUM SOUTH PANEL POWER; NORMAL DIURNAL INCREASE IN INCIDENT POWER TO 100 PERCENT OF SOUTH PANEL MAXIMUM; EMERGENCY SHUTDOWN AT MAXIMUM SOUTH POWER AND RESTART; NORMAL DIURNAL DECREASE IN INCIDENT POWER TO MINIMUM SOUTH OPERATING LEVEL AT RATED CONDITIONS.

OBJECTIVES

- DEMONSTRATE NORMAL PILOT PLANT DIURNAL CYCLE
- DEMONSTRATE SUCCESSFUL EMERGENCY SHUTDOWN AND HOT RESTART
- VERIFY RECEIVER OPERATION FROM MAXIMUM TO MINIMUM SOUTH PANEL POWER AT RATED STEAM CONDITIONS
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- EARLY MORNING START, FULL DAY RUN.
- LOWER 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX
- FEEDWATER TEMPERATURE FROM STTF INITIALLY 250°F, FINAL 550°F.
- INCIDENT INSOLATION FROM .5 UP TO 1.25 MWT (NORMAL DAILY CYCLE)
- SOUTH PANEL RBTCV TRIM INSTALLED

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE (TR SECTION 5.4.1)
- NORMAL PILOT PLANT START PROCEDURE (TR SECTION 5.4.2) TO DERATED STEAM CONDITIONS (660°F, 1550 PSIG) AT MINIMUM SOUTH POWER.
- TRANSITION TO RATED POWER AFTER ONE HOUR.
- ALLOW NORMAL DIURNAL INCREASE IN INCIDENT POWER TO A MAXIMUM OF 1.25 MWT (MAXIMUM SOUTHERN PANEL POWER).
- EMERGENCY SHUTDOWN AT MAXIMUM SOUTH POWER.
- IMMEDIATE "HOT" RESTART TO RATED CONDITIONS.
- SIMULATE CLOUD PASSAGES
- ALLOW NORMAL DIURNAL POWER DECREASE TO MINIMUM SOUTH POWER.
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE (TR SECTION 5.4.3).

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PILOT PLANT RECEIVER TEST #11 (CONTINUED)

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, START, EMERGENCY SHUTDOWN, RESTART, AND NORMAL SHUTDOWN PROCEDURES
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 100 PERCENT TO 40 PERCENT OF MAXIMUM SOUTH PANEL POWER

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM INTERNAL PRESSURES AND TEMPERATURES
- WATER FLOW RATES
- PANEL HOT AND COLD TEMPERATURES AND DELTA PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS

SPECIAL REQUIREMENTS

- FULL DAY RUN
- STEP REMOVAL/APPLICATION OF INSOLATION REQUIRED.

PILOT PLANT RECEIVER TEST #12

DESCRIPTION: MINIMUM EAST PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON DERATED OPERATION AT MAXIMUM EAST POWER

- ACCOMPLISH MINIMUM EAST POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM EAST TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT 100 PERCENT MAXIMUM EAST POWER AND DERATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLEY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL SHUTDOWN

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- EAST PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 2.55 MWT
- FEEDWATER FROM STTF INITIALLY AT 250°F, 400°F, AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO DERATED STEAM CONDITIONS AT MINIMUM EAST POWER
- TRANSITION TO RATED STEAM CONDITIONS AT MINIMUM EAST MAXIMUM
- INCREASE INCIDENT POWER TO 50 PERCENT OF EAST MAXIMUM
- TRANSITION BACK TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF EAST MAXIMUM
- TRANSITION TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF EAST MAXIMUM
- TRANSITION TO DERATED CONDITIONS

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PILOT PLANT RECEIVER TEST #12
(CONTINUED)

- HOLDING INCIDENT POWER AT 2.55 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F. IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 500°F.
- HOLDING INCIDENT POWER AT 2.55 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE STABLEY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- NORMAL SHUTDOWN

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN ±25°F OF SET POINT DURING STEADY STATE AND WITHIN ± 35°F DURING TRANSITION PERIODS.
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #3 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST #13

DESCRIPTION: EAST MAXIMUM POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM EAST POWER HOT START TO RATED CONDITIONS, INCREASE INCIDENT POWER TO MAXIMUM EAST AND TRANSITION TO DERATED STEAM CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS.
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS.
- NORMAL SHUTDOWN FROM MAXIMUM EAST POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 2.55 MWT
    - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- EAST PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED.

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM EAST POWER
- INCREASE INCIDENT POWER TO 100 PERCENT OF MAXIMUM EAST
- TRANSITION TO DERATED CONDITIONS
- HOLDING INCIDENT POWER AT 2.55 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

PILOT PLANT RECEIVER TEST #13(CONTINUED)

- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- TRANSITION TO STEADY STATE RATED CONDITIONS AT MAXIMUM EAST POWER.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 75 PERCENT OF EAST MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF EAST MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 50 PERCENT OF EAST MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF EAST MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE 25 PERCENT AND 50 PERCENT POWER REDUCTIONS/REAPPLICATIONS.
- NORMAL CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #12 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #12

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS OF ± 25 AND ± 50 PERCENT OF MAXIMUM EAST POWER.

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PILOT PLANT RECEIVER TEST #14

DESCRIPTION: MINIMUM EAST PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON RATED OPERATION AT MINIMUM EAST POWER

- ACCOMPLISH MINIMUM EAST POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM EAST, TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- DECREASE INCIDENT POWER TO MINIMUM EAST POWER AND TRANSITION TO RATED CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT MINIMUM EAST POWER AND RATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- DECREASE POWER TO MINIMUM STABLE OPERATING LEVEL AT RATED CONDITIONS
- NORMAL SHUTDOWN FROM MINIMUM EAST POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- EAST PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 2.55 MWT
- FEEDWATER FROM STTF AT 250°F, 400°F AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO RATED STEAM CONDITIONS AT MINIMUM EAST POWER
- TRANSITION TO DERATED STEAM CONDITIONS AT MINIMUM EAST POWER
- INCREASE INCIDENT POWER TO 50 PERCENT OF EAST MAXIMUM
- TRANSITION BACK TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF EAST MAXIMUM
- TRANSITION TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF EAST MAXIMUM

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PILOT PLANT RECEIVER TEST #14(CONTINUED)

TEST SEQUENCE (CONT'D)

- TRANSITION TO RATED CONDITIONS
- DECREASE INCIDENT POWER TO 25 PERCENT OF EAST MAXIMUM
- HOLDING INCIDENT POWER AT 0.65 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 550°F.
- HOLDING INCIDENT POWER AT 0.65 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE MAINTAINED WITHIN ± 25°F OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN + 25°F OF SET POINT DURING STEADY STATE AND WITHIN + 35°F DURING TRANSITION PERIODS FROM 25 TO 100 PERCENT OF MAXIMUM EAST POWER
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED FROM 25 TO 100 PERCENT OF MAXIMUM EAST POWER
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST # 13 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST #15/#16

DESCRIPTION: EAST MINIMUM POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM EAST POWER HOT START TO RATED CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS
- EMERGENCY SHUTDOWN FROM MINIMUM EAST POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 1.28 MWT
  - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- SOUTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM SOUTH POWER
- HOLDING INCIDENT POWER AT 0.5 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

PILOT PLANT RECEIVER TEST #15/16 (CONTINUED)

- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- INCREASE INCIDENT POWER TO 50 PERCENT OF MAXIMUM EAST
- STEP CHANGE INCIDENT POWER FROM 50 PERCENT TO 25 PERCENT OF EAST MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 50 PERCENT OF SOUTH MAXIMUM.
- DECREASE INCIDENT POWER TO 25 PERCENT OF EAST MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 25 PERCENT TO 15 PERCENT OF EAST MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 25 PERCENT OF EAST MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE ABOVE POWER REDUCTIONS/ REAPPLICATIONS.
- DECREASE INCIDENT POWER UNTIL DERATED CONDITIONS CAN NO LONGER BE MAINTAINED WITHIN ± 25°F OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- EMERGENCY CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #14 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.
- SUCCESSFUL EMERGENCY CUTOFF.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #14.

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS FROM 15 TO 50 PERCENT OF MAXIMUM EAST POWER.

PILOT PLANT RECEIVER TEST #17

DESCRIPTION: TYPICAL PILOT PLANT DAY, EAST PANEL

- ACCOMPLISH WARM RECEIVER START TO RATED STEAM CONDITIONS AT MINIMUM EAST PANEL POWER; NORMAL DIURNAL INCREASE IN INCIDENT POWER TO 100 PERCENT OF EAST PANEL MAXIMUM; EMERGENCY SHUTDOWN AT MAXIMUM EAST POWER AND RESTART; NORMAL DIURNAL DECREASE IN INCIDENT POWER TO MINIMUM EAST OPERATING LEVEL AT RATED CONDITIONS.

OBJECTIVES

- DEMONSTRATE NORMAL PILOT PLANT DIURNAL CYCLE
- DEMONSTRATE SUCCESSFUL EMERGENCY SHUTDOWN AND HOT RESTART
- VERIFY RECEIVER OPERATION FROM MAXIMUM TO MINIMUM EAST PANEL POWER AT RATED STEAM CONDITIONS
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- EARLY MORNING START, FULL DAY RUN.
- LOWER 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX
- FEEDWATER TEMPERATURE FROM STTF INITIALLY 250°F, FINAL 550°F.
- INCIDENT INSOLATION FROM 0.65 UP TO 2.55 MWT (NORMAL DAILY CYCLE)
- EAST PANEL RBTCV TRIM INSTALLED

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE (TR SECTION 5.4.1)
- NORMAL PILOT PLANT START PROCEDURE (TR SECTION 5.4.2) TO DERATED STEAM CONDITIONS (660°F, 1550 PSIG) AT MINIMUM EAST POWER.
- TRANSITION TO RATED POWER AFTER ONE HOUR.
- ALLOW NORMAL DIURNAL INCREASE IN INCIDENT POWER TO A MAXIMUM OF 2.55 MWT (MAXIMUM EAST PANEL POWER).
- EMERGENCY SHUTDOWN AT MAXIMUM EAST POWER.
- IMMEDIATE "HOT" RESTART TO RATED CONDITIONS.
- SIMULATE CLOUD PASSAGES
- ALLOW NORMAL DIURNAL POWER DECREASE TO MINIMUM EAST POWER.
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE (TR SECTION 5.4.3).

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PILOT PLANT RECEIVER TEST #17 (CONTINUED)

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, START, EMERGENCY SHUTDOWN, RESTART, AND NORMAL SHUTDOWN PROCEDURES
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 100 PERCENT TO 25 PERCENT OF MAXIMUM EAST PANEL POWER

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM INTERNAL PRESSURES AND TEMPERATURES
- WATER FLOW RATES
- PANEL HOT AND COLD TEMPERATURES AND DELTA PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS

SPECIAL REQUIREMENTS

- FULL DAY RUN
- STEP REMOVAL/APPLICATION OF INSOLATION REQUIRED.

PILOT PLANT RECEIVER TEST #18

DESCRIPTION: MINIMUM NORTH PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON DERATED OPERATION AT MAXIMUM NORTH POWER

- ACCOMPLISH MINIMUM NORTH POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM NORTH TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT 100 PERCENT MAXIMUM NORTH POWER AND DERATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL SHUTDOWN

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- NORTH PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 3.22 MWT
- FEEDWATER FROM STTF INITIALLY AT 250°F, 400°F, AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO DERATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- TRANSITION TO RATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- INCREASE INCIDENT POWER TO 50 PERCENT OF NORTH MAXIMUM
- TRANSITION BACK TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF NORTH MAXIMUM
- TRANSITION TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF NORTH MAXIMUM
- TRANSITION TO DERATED CONDITIONS

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PILOT PLANT RECEIVER TEST #18
(CONTINUED)

- HOLDING INCIDENT POWER AT 3.22 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F. IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 500°F.
- HOLDING INCIDENT POWER AT 3.22 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE STABLEY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- NORMAL SHUTDOWN

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN ±25°F OF SET POINT DURING STEADY STATE AND WITHIN ± 35°F DURING TRANSITION PERIODS.
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #12 PLUS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST # 19

DESCRIPTION: MAXIMUM NORTH POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM NORTH POWER HOT START TO RATED CONDITIONS, INCREASE INCIDENT POWER TO MAXIMUM NORTH AND TRANSITION TO DERATED STEAM CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS.
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS.
- NORMAL SHUTDOWN FROM MAXIMUM NORTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 3.22 MWT
  - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- NORTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED.

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM NORTH
- INCREASE INCIDENT POWER TO 100 PERCENT OF MAXIMUM NORTH
- TRANSITION TO DERATED CONDITIONS
- HOLDING INCIDENT POWER AT 3.22 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

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PILOT PLANT RECEIVER TEST #19(CONTINUED)

- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- TRANSITION TO STEADY STATE RATED CONDITIONS AT MAXIMUM NORTH POWER.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 75 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF NORTH MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 50 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF NORTH MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE 25 PERCENT AND 50 PERCENT POWER REDUCTIONS/REAPPLICATIONS.
- NORMAL CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #18 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #18

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS OF ± 25 AND ± 50 PERCENT OF MAXIMUM NORTH POWER.

PILOT PLANT RECEIVER TEST # 20

DESCRIPTION: MINIMUM NORTH PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON RATED OPERATION AT MINIMUM NORTH POWER

- ACCOMPLISH MINIMUM NORTH POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM NORTH TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- DECREASE INCIDENT POWER TO MINIMUM NORTH POWER AND TRANSITION TO RATED CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT MINIMUM NORTH POWER AND RATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- DECREASE POWER TO MINIMUM STABLE OPERATING LEVEL AT RATED CONDITIONS
- NORMAL SHUTDOWN FROM MINIMUM NORTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- NORTH PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 3.22 MWT
- FEEDWATER FROM STTF AT 250°F, 400°F AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO RATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- TRANSITION TO DERATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- INCREASE INCIDENT POWER TO 50 PERCENT OF MAXIMUM NORTH
- TRANSITION BACK TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF MAXIMUM NORTH
- TRANSITION TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF MAXIMUM NORTH

PILOT PLANT RECEIVER TEST #20 (CONTINUED)

TEST SEQUENCE (CONT'D)

- TRANSITION TO RATED CONDITIONS
- DECREASE INCIDENT POWER TO 35 PERCENT OF MAXIMUM NORTH
- HOLDING INCIDENT POWER AT 1.13 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 550°F.
- HOLDING INCIDENT POWER AT 1.13 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE MAINTAINED WITHIN ± 25°F OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN + 25°F OF SET POINT DURING STEADY STATE AND WITHIN + 35°F DURING TRANSITION PERIODS FROM 35 TO 100 PERCENT OF MAXIMUM NORTH POWER
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED FROM 35 TO 100 PERCENT OF MAXIMUM NORTH POWER
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #19 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST #21/#22

DESCRIPTION: NORTH MINIMUM POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM NORTH POWER HOT START TO RATED CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS
- EMERGENCY SHUTDOWN FROM MINIMUM NORTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 1.61 MWT
  - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- NORTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM NORTH POWER
- HOLDING INCIDENT POWER AT 1.13 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

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- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- INCREASE INCIDENT POWER TO 50 PERCENT OF MAXIMUM NORTH
- STEP CHANGE INCIDENT POWER FROM 50 PERCENT TO 35 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 50 PERCENT OF NORTH MAXIMUM.
- DECREASE INCIDENT POWER TO 35 PERCENT OF NORTH MAXIMUM
- STEP CHANGE INCIDENT POWER FROM 35 PERCENT TO 15 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 35 PERCENT OF NORTH MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE ABOVE POWER REDUCTIONS/ REAPPLICATIONS.
- DECREASE INCIDENT POWER UNTIL DERATED CONDITIONS CAN NO LONGER BE MAINTAINED WITHIN ± 25°F OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- EMERGENCY CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #20 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.
- SUCCESSFUL EMERGENCY CUTOFF.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #20

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS FROM 15 TO 50 PERCENT OF MAXIMUM NORTH POWER.

PILOT PLANT RECEIVER TEST # 23

DESCRIPTION: TYPICAL PILOT PLANT DAY, NORTH PANEL

- ACCOMPLISH WARM RECEIVER START TO RATED STEAM CONDITIONS AT MINIMUM NORTH PANEL POWER; NORMAL DIURNAL INCREASE IN INCIDENT POWER TO 100 PERCENT OF NORTH PANEL MAXIMUM; EMERGENCY SHUTDOWN AT MAXIMUM NORTH POWER AND RESTART; NORMAL DIURNAL DECREASE IN INCIDENT POWER TO MINIMUM NORTH OPERATING LEVEL AT RATED CONDITIONS.

OBJECTIVES

- DEMONSTRATE NORMAL PILOT PLANT DIURNAL CYCLE
- DEMONSTRATE SUCCESSFUL EMERGENCY SHUTDOWN AND HOT RESTART
- VERIFY RECEIVER OPERATION FROM MAXIMUM TO MINIMUM NORTH PANEL POWER AT RATED STEAM CONDITIONS
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- EARLY MORNING START, FULL DAY RUN.
- LOWER 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX
- FEEDWATER TEMPERATURE FROM STTF INITIALLY 250°F, FINAL 550°F.
- INCIDENT INSOLATION FROM 1.13 UP TO 3.22 MWT (NORMAL DAILY CYCLE)
- NORTH PANEL RBTCV TRIM INSTALLED

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE (TR SECTION 5.4.1)
- NORMAL PILOT PLANT START PROCEDURE (TR SECTION 5.4.2) TO DERATED STEAM CONDITIONS (660°F, 1550 PSIG) AT MINIMUM NORTH POWER.
- TRANSITION TO RATED POWER AFTER ONE HOUR.
- ALLOW NORMAL DIURNAL INCREASE IN INCIDENT POWER TO A MAXIMUM OF 3.22 MWT (MAXIMUM NORTH PANEL POWER).
- EMERGENCY SHUTDOWN AT MAXIMUM NORTH POWER.
- IMMEDIATE "HOT" RESTART TO RATED CONDITIONS.
- SIMULATE CLOUD PASSAGES
- ALLOW NORMAL DIURNAL POWER DECREASE TO MINIMUM NORTH POWER.
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE (TR SECTION 5.4.3).

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PILOT PLANT RECEIVER TEST #23 (CONTINUED)

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, START, EMERGENCY SHUTDOWN, RESTART, AND NORMAL SHUTDOWN PROCEDURES
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 35 PERCENT TO 100 PERCENT OF MAXIMUM NORTH PANEL POWER

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM INTERNAL PRESSURES AND TEMPERATURES
- WATER FLOW RATES
- PANEL HOT AND COLD TEMPERATURES AND DELTA PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS

SPECIAL REQUIREMENTS

- FULL DAY RUN
- STEP REMOVAL/APPLICATION OF INSOLATION REQUIRED.

PILOT PLANT RECEIVER TEST #24

DESCRIPTION: INITIAL FLUX CONCENTRATOR TEST; MINIMUM/MAXIMUM NORTH PANEL POWER OPERATION AT DERATED/RATED CONDITIONS

- ACCOMPLISH "WARM" RECEIVER START AT DERATED STEAM CONDITIONS AT MINIMUM NORTH PANEL POWER; TRANSITION TO RATED STEAM CONDITIONS; INCREASE INCIDENT POWER TO 100 PERCENT OF NORTH MAXIMUM; DECREASE POWER TO MINIMUM STABLE OPERATING LEVEL AT RATED CONDITIONS

OBJECTIVES

- SYSTEM SHAKEDOWN AND CALIBRATION WITH FLUX CONCENTRATORS.
- VERIFY NORMAL PILOT PLANT PRESTART, START AND SHUTDOWN PROCEDURES
- DEMONSTRATE RECEIVER RATED STEAM CONDITION OPERATION FROM MAXIMUM TO MINIMUM NORTH PANEL POWER
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- STTF FEEDWATER TEMPERATURE 400°F
- INCIDENT INSOLATION UP TO 3.22 MWT

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE
- NORMAL PILOT PLANT WARM START PROCEDURE TO DERATED CONDITIONS
- TRANSITION FROM DERATED TO RATED CONDITIONS
- INCREMENTALLY INCREASE INCIDENT POWER TO MAXIMUM NORTH POWER
- INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, WARM START, AND NORMAL SHUTDOWN
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 35 PERCENT TO 100 PERCENT OF MAXIMUM NORTH POWER

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PILOT PLANT RECEIVER TEST #24 (CONTINUED)

PRIMARY DATA REQUIREMENTS

(SAME AS TEST #23)

SPECIAL REQUIREMENTS

° ADDITION OF FLUX CONCENTRATORS

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PILOT PLANT RECEIVER TEST #25

DESCRIPTION: MINIMUM NORTH PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON DERATED OPERATION AT MAXIMUM NORTH POWER

- ACCOMPLISH MINIMUM NORTH POWER WARM START, INCREASE INCIDENT POWER TO 50, 75, AND 100 PERCENT OF MAXIMUM NORTH TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT 100 PERCENT MAXIMUM NORTH POWER AND DERATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL SHUTDOWN

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- NORTH PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 3.22 MWT
- FEEDWATER FROM STTF INITIALLY AT 250°F, 400°F, AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO DERATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- TRANSITION TO RATED STEAM CONDITIONS AT MINIMUM NORTH MAXIMUM
- INCREASE INCIDENT POWER TO 50 PERCENT OF NORTH MAXIMUM
- TRANSITION BACK TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 75 PERCENT OF NORTH MAXIMUM
- TRANSITION TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF NORTH MAXIMUM
- TRANSITION TO DERATED CONDITIONS

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PILOT PLANT RECEIVER TEST #25
(CONTINUED)

- HOLDING INCIDENT POWER AT 3.22 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F. IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 500°F.
- HOLDING INCIDENT POWER AT 3.22 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- NORMAL SHUTDOWN

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN ±25°F OF SET POINT DURING STEADY STATE AND WITHIN ± 35°F DURING TRANSITION PERIODS.
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #18 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

PILOT PLANT RECEIVER TEST # 26

DESCRIPTION: NORTH MAXIMUM POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM NORTH POWER HOT START TO RATED CONDITIONS, INCREASE INCIDENT POWER TO MAXIMUM NORTH AND TRANSITION TO DERATED STEAM CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS.
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS.
- NORMAL SHUTDOWN FROM MAXIMUM NORTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 3.22 MWT
    - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- NORTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED.

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM NORTH POWER
- INCREASE INCIDENT POWER TO 100 PERCENT OF MAXIMUM NORTH
- TRANSITION TO DERATED CONDITIONS
- HOLDING INCIDENT POWER AT 3.22 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

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- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- TRANSITION TO STEADY STATE RATED CONDITIONS AT MAXIMUM NORTH POWER.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 75 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF NORTH MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 100 PERCENT TO 50 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 100 PERCENT OF NORTH MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE 25 PERCENT AND 50 PERCENT POWER REDUCTIONS/REAPPLICATIONS.
- NORMAL CUTOFF

SUCCESS CRITERIA

- SAME AS TEST # 25 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST # 25

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS OF ± 25 AND ± 50 PERCENT OF MAXIMUM NORTH POWER.

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PILOT PLANT RECEIVER TEST #27

DESCRIPTION: MINIMUM NORTH PANEL POWER START SEQUENCE; INTERFACE EFFECTS ON DERATED OPERATION AT 125 PERCENT OF MAXIMUM NORTH POWER

- ACCOMPLISH MINIMUM NORTH POWER WARM START, INCREASE INCIDENT POWER TO 50, 100, AND 125 PERCENT OF MAXIMUM NORTH TRANSITIONING BACK AND FORTH BETWEEN RATED AND DERATED STEAM CONDITIONS
- WITH STEADY STATE OPERATION ESTABLISHED AT 125 PERCENT MAXIMUM NORTH POWER AND DERATED STEAM CONDITIONS, INCREMENTALLY VARY STEAM DISCHARGE PRESSURE, AND FEEDWATER TEMPERATURE
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED STEAM CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F
- NORMAL SHUTDOWN

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- VERIFY PANEL THERMAL EXPANSION/CONTRACTION
- CHECK FLOW DISTRIBUTION AND UNIFORMITY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- NORTH PANEL RBTCV TRIM INSTALLED
- INCIDENT INSOLATION UP TO 4.03 MWT
- FEEDWATER FROM STTF INITIALLY AT 250°F, 400°F, AND 550°F
- RECEIVER PREHEATER OUTLET TEMPERATURES TO VARY FROM 400 TO 600°F
- STTF TO VARY DISCHARGE PRESSURE FROM 1300 TO 1750 PSIG

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL WARM START TO DERATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- TRANSITION TO RATED STEAM CONDITIONS AT MINIMUM NORTH POWER
- INCREASE INCIDENT POWER TO 50 PERCENT OF NORTH MAXIMUM
- TRANSITION BACK TO DERATED CONDITIONS
- INCREASE INCIDENT POWER TO 100 PERCENT OF NORTH MAXIMUM
- TRANSITION TO RATED CONDITIONS
- INCREASE INCIDENT POWER TO 125 PERCENT OF NORTH MAXIMUM
- TRANSITION TO DERATED CONDITIONS

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PILOT PLANT RECEIVER TEST # 27
(CONTINUED)

- HOLDING INCIDENT POWER AT 4.03 MWT, INLET PRESSURE AT 2250 PSIG, AND DISCHARGE PRESSURE AT 1550 PSIG, USING THE STTF AND RECEIVER PREHEATERS STEP PREHEATER WATER OUTLET TEMPERATURE (RPWOT) FROM 250 TO 400 TO 550°F. IF STABILITY AND CONTROL ARE MAINTAINED AT 550°F, SLOWLY INCREASE RPWOT TO 600°F OR UNTIL CONTROL IS LOST AND THEN REDUCE RPWOT TO 500°F.
- HOLDING INCIDENT POWER AT 4.03 MWT, INLET PRESSURE AT 2250 PSIG, AND INLET TEMPERATURE AT 550°F, STTF INCREMENTALLY STEP DOWNCOMER PRESSURE FROM 1550 PSIG TO 1300 PSIG TO 1650 PSIG (OR UNTIL RSVV RELIEF) USING THE STTF DOWNCOMER STEAM PRESSURE CONTROL VALVE (SDSPCV). REDUCE DISCHARGE PRESSURE TO 1550 PSIG.
- TRANSITION TO RATED CONDITIONS AND INCREMENTALLY DECREASE INCIDENT POWER UNTIL RATED CONDITIONS CAN NO LONGER BE STABLY MAINTAINED OR UNTIL MAXIMUM PANEL TEMPERATURE REACHES 1200°F.
- NORMAL SHUTDOWN

SUCCESS CRITERIA

- STEAM TEMPERATURE CONTROL MAINTAINED WITHIN ±25°F OF SET POINT DURING STEADY STATE AND WITHIN ± 35°F DURING TRANSITION PERIODS.
- NO UNDAMPED THERMAL OR HYDRODYNAMIC INSTABILITIES DETECTED
- SUCCESSFUL PILOT PLANT START AND SHUTDOWN ACHIEVED
- DRY STEAM PRODUCED AND MAINTAINED
- NORMAL PANEL EXPANSION/CONTRACTION ACHIEVED

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #25 PLUS
- PANEL EXPANSION/CONTRACTION POSITION TRANSDUCERS

SPECIAL REQUIREMENTS

- VARY FEEDWATER TEMPERATURE FROM 250 TO 400 TO 550 TO 600°F
- STTF VARY STEAM DOWNCOMER PRESSURE FROM 1300 TO 1650 PSIG

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PILOT PLANT RECEIVER TEST #28

DESCRIPTION: 125 PERCENT OF MAXIMUM NORTH POWER FEEDWATER PRESSURE INTERFACE EFFECTS; CLOUD TRANSIENT EFFECTS

- ACCOMPLISH MINIMUM NORTH POWER HOT START TO RATED CONDITIONS, INCREASE INCIDENT POWER TO 125 PERCENT OF MAXIMUM NORTH AND TRANSITION TO DERATED STEAM CONDITIONS.
- INCREMENTALLY AND SINUSOIDALLY VARY FEEDWATER INLET PRESSURE TO DETERMINE INTERFACE EFFECTS.
- SIMULATE CLOUD PASSAGE AT BOTH RATED AND DERATED STEAM CONDITIONS.
- NORMAL SHUTDOWN FROM 125 PERCENT OF MAXIMUM NORTH POWER

OBJECTIVES

- DEMONSTRATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE HYDRODYNAMIC STABILITY
- CHECK FLOW DISTRIBUTION AND UNIFORMITY
- DEMONSTRATE DRY STEAM DELIVERY

TEST CONDITIONS

- LOWER 41 FEET OF PANEL EXPOSED FOR TEST
- 400°F FEEDWATER TEMPERATURE FROM STTF
- RECEIVER PREHEAT TO 550°F
- INCIDENT INSOLATION UP TO 4.03 MWT
  - STEP REMOVAL/REAPPLICATION OF INSOLATION REQUIRED
- NORTH PANEL RBTCV TRIM
- INCREMENTAL AND SINUSOIDAL CONTROL OF FEEDWATER PRESSURE BY STTF AND RBTCV REQUIRED.

TEST SEQUENCE

- NORMAL PRESTART
- NORMAL "HOT" (550°F) START TO RATED CONDITIONS AT MINIMUM NORTH POWER
- INCREASE INCIDENT POWER TO 125 PERCENT OF MAXIMUM NORTH POWER
- TRANSITION TO DERATED CONDITIONS
- HOLDING INCIDENT POWER AT 4.03 MWT, DISCHARGE PRESSURE AT 1550 PSIG, AND INLET WATER TEMPERATURE AT 550°F, INCREMENTALLY STEP RECEIVER WATER INLET PRESSURE (RWIP) FROM 2250 PSIG TO 2500 PSIG AND DOWN TO 2000 PSIG. IF STABILITY AND CONTROL ARE MAINTAINED AT 2000 PSIG, SLOWLY DECREASE RWIP TO 1800 PSIG OR UNTIL CONTROL IS LOST AND THEN RETURN RWIP TO 2250 PSIG.

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PILOT PLANT RECEIVER TEST #28 (CONTINUED)

- STTF SINUSOIDALLY VARY RWIP OVER A RANGE OF 2250 ± PSIG WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- USING RBTCV, IMPOSE A SINUSOIDAL ± LB/SECOND FLOW VARIATION INTO THE RECEIVER PANEL INLET WITH PEAK TO PEAK PERIODS OF 36 AND 95 SECONDS.
- TRANSITION TO STEADY STATE RATED CONDITIONS AT 125 PERCENT MAXIMUM NORTH POWER.
- STEP CHANGE INCIDENT POWER FROM 125 PERCENT TO 75 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 125 PERCENT OF NORTH MAXIMUM.
- STEP CHANGE INCIDENT POWER FROM 125 PERCENT TO 50 PERCENT OF NORTH MAXIMUM, WAIT ONE MINUTE AND INCREASE BACK TO 125 PERCENT OF NORTH MAXIMUM.
- TRANSITION TO DERATED CONDITIONS AND REPEAT THE 50 PERCENT AND 75 PERCENT POWER REDUCTIONS/REAPPLICATIONS.
- NORMAL CUTOFF

SUCCESS CRITERIA

- SAME AS TEST #27 PLUS
- SUPERHEAT CONDITIONS MAINTAINED DURING SIMULATED CLOUD TRANSIENTS.

PRIMARY DATA REQUIREMENTS

- SAME AS TEST #27

SPECIAL REQUIREMENTS

- VARY STTF FEEDWATER PRESSURES INCREMENTALLY AND SINUSOIDALLY OVER A RANGE FROM 1800 TO 2500 PSIG.
- VARY RBTCV FLOWRATE SINUSOIDALLY ± LBS/SECOND
- REMOVE/REAPPLY INCIDENT INSOLATION IN INCREMENTS OF ± 50 AND ± 75 PERCENT OF 125 PERCENT OF MAXIMUM NORTH POWER

8/25/78
5.4-58

PILOT PLANT RECEIVER TEST #29

DESCRIPTION: TYPICAL PILOT PLANT DAY, 125 PERCENT OF MAXIMUM NORTH POWER

- ACCOMPLISH WARM RECEIVER START TO RATED STEAM CONDITIONS AT MINIMUM NORTH PANEL POWER; NORMAL DIURNAL INCREASE IN INCIDENT POWER TO 125 PERCENT OF NORTH PANEL MAXIMUM; EMERGENCY SHUTDOWN AT 125 PERCENT OF MAXIMUM NORTH POWER AND RESTART; NORMAL DIURNAL DECREASE IN INCIDENT POWER TO MINIMUM NORTH OPERATING LEVEL AT RATED CONDITIONS.

OBJECTIVES

- DEMONSTRATE 125 PERCENT OF NORMAL PILOT PLANT DIURNAL CYCLE
- DEMONSTRATE SUCCESSFUL EMERGENCY SHUTDOWN AND HOT RESTART
- VERIFY RECEIVER OPERATION FROM 125 PERCENT OF MAXIMUM TO MINIMUM NORTH PANEL POWER AT RATED STEAM CONDITIONS
- INVESTIGATE CONTROL SYSTEM PERFORMANCE
- DEMONSTRATE DELIVERY OF DRY STEAM

TEST CONDITIONS

- EARLY MORNING START, FULL DAY RUN
- LOWER 41 FEET OF PANEL EXPOSED FOR TEST, REMAINDER INSULATED FROM FLUX
- FEEDWATER TEMPERATURE FROM STTF INITIALLY 250°F, FINAL 550°F.
- INCIDENT INSOLATION FROM 1.13 UP TO 4.03 MWT (125 PERCENT OF NORMAL DAILY CYCLE)
- NORTH PANEL RBTCV TRIM INSTALLED

TEST SEQUENCE

- NORMAL PILOT PLANT PRESTART PROCEDURE (TR SECTION 5.4.1)
- NORMAL PILOT PLANT START PROCEDURE (TR SECTION 5.4.2) TO DERATED STEAM CONDITIONS (660°F, 1550 PSIG) AT MINIMUM NORTH POWER.
- TRANSITION TO RATED POWER AFTER ONE HOUR.
- ALLOW NORMAL DIURNAL INCREASE IN INCIDENT POWER TO A MAXIMUM OF 4.03 MWT (125 PERCENT OF MAXIMUM NORTH PANEL POWER).
- EMERGENCY SHUTDOWN AT 125 PERCENT OF MAXIMUM NORTH POWER.
- IMMEDIATE "HOT" RESTART TO RATED CONDITIONS.
- SIMULATED CLOUD PASSAGES
- ALLOW NORMAL DIURNAL POWER DECREASE TO MINIMUM NORTH POWER
- NORMAL PILOT PLANT SHUTDOWN PROCEDURE (TR SECTION 5.4.3).

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PILOT PLANT RECEIVER TEST #29 (CONTINUED)

SUCCESS CRITERIA

- SUCCESSFUL ACCOMPLISHMENT OF PILOT PLANT PRESTART, START, EMERGENCY SHUTDOWN, RESTART, AND NORMAL SHUTDOWN PROCEDURES
- SUCCESSFUL RECEIVER CONTROL, STABILITY, AND THERMODYNAMIC PERFORMANCE AT RATED STEAM CONDITIONS AT POWER LEVELS FROM 25 PERCENT TO 40 PERCENT OF MAXIMUM NORTH PANEL POWER

PRIMARY DATA REQUIREMENTS

- WATER/STEAM SYSTEM INTERNAL PRESSURES AND TEMPERATURES
- WATER FLOW RATES
- PANEL HOT AND COLD TEMPERATURES AND DELTA PRESSURES
- FLUX GAGES
- TOTAL INCIDENT AND ABSORBED POWER CALCULATIONS

SPECIAL REQUIREMENTS

- FULL DAY RUN
- STEP REMOVAL/APPLICATION OF INSOLATION REQUIRED.

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5.4.1 Receiver Prestart Procedure

ion By	ACTION
	1. After completion of the Securing Procedure from the previous test operation (where the receiver boiler panel and connecting water/steam lines have been drained), perform the following:
	A. Systems Integrity Verification
RL (Receiver test level)	1) All lines are connected, all transducers installed, all wiring properly connected, and all maintenance/repair items complete.
STTF/RC/CC	2) Computer Control (CC), Receiver Controller (RC), and data acquisition systems interface checks are complete.
RC	3) Receiver control to sensor/control element interface checks are complete.
RL	4) Calibrations of gages, meters, transducers and data acquisition system are in date and complete.
RL	5) Verify

a. Filters and elements are clean and installed:

RWF	TBD Mesh/micron
RBWF	TBD Mech/micron
RNF	TBD Micron

b. Burst disks are installed, intact and properly burst rated:

RPBD	TBD psig
RFBD	TBD psig
RSBD	TBD psig

c. Pressure switches are installed and set at:

RNPS-1	Normal range = TBD to TBD psig
RNPS-2	Normal range = TBD to TBD psig

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Action By

RNPS-3 Normal Range = TBD to TBD psig
RNPS-4 Normal Range = TBD to TBD psig

d. Relief valves are installed and set at:

RFRV	475 psig
RSVV	1650 $^{+0}_{-25}$ psig
RSRV	1700 $^{+0}_{-25}$ psig
RNHRV	300 $^{+0}_{-25}$ psig
RNLRV	25 $^{+10}_{-0}$ psig
RNRV-3	TBD
RNRV-4	TBD

RL 2. Engineering inspection complete and concurrence to proceed

STTF A. STTF ready to proceed.

3. System preparation for functional checkouts

RL A. Verify adequate GN_2 supply (above TBD psig) and record (___ psig).

RL B. Verify or position:

RWIV	Closed	RNMV	Open
RBWISK	Open	RNIV-1	Closed
RBWDV	Closed	RNLBV	Open
RBSOV	Open	RNIV-3	Closed

RC C. Set up receiver controller (RC) operating console electrical power systems:

a. Verify that switches are in off/closed position and set points adjusted to prevent control valve movement.

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Action By

b. LOCAL/REMOTE ENABLE switch to LOCAL position

c. Turn on controller power.

d. Verify:

1) POWER ON and LOCAL CONTROL ENABLED lights ON

2) All valve energized lights OFF

3) Verify control valve normal positions.

RL/RC D. Set up receiver GN_2 system

a. Verify or adjust RNHPR to 250 ± 25 psig

b. Verify RNPS-3 and -4 NOT NORMAL lights ON.

c. Open RNIV-3 and verify or adjust RNPR-3 to 125 ± 15 psig and verify RNPS-3 NOT NORMAL light goes OFF.

d. Verify or adjust RNPR-4 to 35 ± 5 psig and verify RNPS-4 NOT NORMAL light goes OFF.

e. Verify RNPS-1 NOT NORMAL light ON.

f. Open RNIV-1; verify RNHPV closed and not flowing GN_2. Verify RNPS-1 NOT NORMAL light goes OFF.

g. Verify or adjust RNPR-2 to 10 ± 5 psig. Verify RNPS-2 NOT NORMAL light OFF

4. Control Valve Functional Checks - LOCAL CONTROL

RC A. Verify LOCAL/REMOTE ENABLE switch in LOCAL position.

Action By

B. Obtain clearance from receiver level. Cycle open/closed control valves open and closed and verify operation of valves and position indicators.

Valve	Switch	Indicator
RNHPV		-
RFIV		RFIV closed light on/off/on
RADV		RADV " " "
RMDV		RMDV " " "
RFDV		RFDV " " "

RC/STTF — C. Cycle proportional control valves open and closed. Verify open/closed or position status.

Valve	Switch	Indicator
SDSPCV		
Feedwater Pressure		
Feedwater Temperature		
RBTCV		X_1 position meter
RDSIV		Closed light on/off/on
RSVV		X_2 position meter
RFPCV		X_3 position meter

RC — D. Cycle open/closed and proportional control valves by set point control excursions:

Valve	Enable Switch	Set Point Control	Indicator
RADV	MOISTURE ACCUMULATOR LEVEL CONTROL	L_1' HIGH REF & L_1' LOW REF	RADV closed light on/off/on
RMDV	MANIFOLD LEVEL CONTROL	L_2' HIGH REF & L_2' LOW REF	RMDV closed light on/off/on
RFDV	FLASH TANK LEVEL CONTROL	L_3' HIGH REF & L_3' LOW REF	RFDV closed light on/off/on
RSVV	P CONTROL	P' REF	
	X_2 CONTROL	X_2' REF	X_2 position meter

A ...on By	Valve	Enable Switch	Set Point Control	Indicator
	RBTCV	Q&T/C CONTROL	Q LOW LIMIT & T' REF	
		X_1 CONTROL	X_1' REF	X_1 position meter
	RFPCV			X_3 position meter
	RDSIV			
	SDSPCV			
	Feedwater Pressure			
	Feedwater Temperature			

5. Control Valve Functional checks - REMOTE CONTROL

RC A. Verify local control panel switches off/closed

RC B. LOCAL/REMOTE ENABLE switch to REMOTE position

CC C. Repeat 4.B, C, and D using computer control.

STTF 6. Verify heliostats ready for start-up.

RL/RC/CC STTF 7. Engineering concurrence to proceed to start-up.

Action By	5.4.2 Receiver Startup Procedure

1. Verify or position the following:

   A. Valve Positions

Receiver Level (RL) — 1) Hand Valves

RWIV	Closed	RNMV	Open
RBWISK	Open	RNIV-1	Open
RBWDV	Closed	RNLBV	Open
RBSOV	Open	RNIV-3	Open

Receiver Controller/ Computer Control (RC/CC) — 2) Control Valves (open/closed)

RMDV	Open	Level control off
RADV	Open	Level control off
RFDV	Open	Level control off
RFIV	Open	
RNHPV	Closed	

3) Proportional Control Valves

STTF	STTF Feedwater Pressure	Open	Pressure control on; pressure set point at 500 psig
RC/CC	RBTCV	Open	X_1 CONTROL ON; X_{REF} set point at TBD% open Q&T/C CONTROL off; Q LOW LIMIT set point at TBD lbm/sec; T REF set point at 500°F; VOTING CIRCUIT to TBD position; T/C SELECT to TBD position.
RC/CC	RSVV	Closed	P CONTROL on; P REF set point at 1600 ± 25 psig; X_2 CONTROL off
RC/CC	RFPCV	Closed	Pressure control on; pressure set point at 425 psig

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Action By			
STTF	SDSPCV	Closed	Pressure control on; pressure set point at 250 psig
RC/CC	RDSIV	Closed	

RL — B. Regulator Settings

RNHPR	250 ± 25 psig
RNPR-2	10 ± 5 psig
RNPR-3	125 ± 15 psig
RNPR-4	35 ± 5 psig

C. Water Levels and Controls

Action By		
STTF	Verify facility water system ready.	
RC/CC	RAWL	Level control off; set point L_1 HIGH REF at TBD%; L_1 LOW REF at TBD%; valve RADV OPEN
RC/CC	RMWL	Level control off; set point L_2 HIGH REF at TBD%; L_2 LOW REF at TBD%; valve RMDV OPEN
RC/CC	RFWL	FLASH TANK LEVEL CONTROL off; set point L_3 HIGH REF at TBD%; L_3 LOW REF at TBD%; valve RFDV open

D. Feedwater Preheater Controls

Action By		
STTF	Condenser Preheater	TEMP CONTROL ON, set point at TBD°F
STTF	Facility Steam Preheater	TEMP CONTROL TBD, set point at TBD°F
RC/CC	Receiver Preheater	Disabled; T WATER, HIGH set point at TBD°F; T WATER, LOW set point at TBD°F

RL — E. System Blanket Pressure 10 ± 5 psig

STTF — F. Heliostat System Ready

Action By		
	2.	Water Fill
RL	A.	Verify RWIV closed.
STTF	B.	Open receiver water by-pass valve (RWBV) and start STTF feedwater pump to begin riser flush.
STTF	C.	After flushing riser for TBD minutes, verify water quality acceptable.
RC/CC	D.	Monitor flowmeter and pressure indications (TBD) and OPEN RWIV to begin flow to receiver.
STTF	E.	Close RWBV.
RC/CC	F.	Verify RWIP at 500 ± TBD psig and RWIT at TBD°F.
RC/CC	G.	Monitor filling of Moisture Trap and Receiver Manifold for TBD minutes.
RC/CC	H.	Turn on and monitor Flash Tank, receiver manifold, and moisture accumulator level controls.
RC/CC	I.	Turn RBTCV Q&T/C control ON.
RC/CC	J.	Open RNHPV (pressurizes Flash Tank to 250 psig)
RC/CC	K.	Verify RBTCV flow remains constant during flash tank pressurization.
RL/STTF	L.	Check for leaks
RC/CC	M.	Verify acceptable feedwater flow, temp, and pressure and level controls normal
	3.	Receiver Preheater Check
RC/CC	A.	Momentarily turn on receiver preheater and monitor temperature indicators to verify preheater operation.
RC/CC	B.	Turn receiver preheater TBD (OFF or ON as required) for the test.

Action By		
STTF/RC/CC		C. Verify ready to proceed to steaming operation.
RL		D. Clear the receiver test level of all personnel.
	4.	Water/Steam Transition Phase (Heliostat Activation)
RC/CC		A. Verify RBTCV temperature control enabled; set point 500°F
RC/CC		B. Verify RSOP-1 = between 250 and 425 psig
RC/CC		C. Verify RSOT = TBD °F and reasonably stable
RC/CC		D. Verify flowrate = TBD lbm/sec and stable
RC/CC		E. Verify RFPCV pressure control with set point at 425 psig
STTF		F. Bring receiver insolation up at a rate of TBD Btu/sec^2 to a maximum heat input = TBD Btu/sec
STTF		G. Verify SDSPCV pressure control enabled with set point at 250 psig
RC/CC		H. Monitor RBSOT and RFSOT rise to 500°F
STTF		I. Increase RWIP to 675 psig in coordination with rise of RFSOP to 425 psig (maintain relative ΔP of 250 psig).
RC/CC		J. Verify RFPCV pressure control maintains RFSOP at 425 psig
RC/CC		K. Verify stable system operation at 500°F and 425 psig
RC/CC		L. Momentarily OPEN RADV and RMDV to drain RA and RM and then return to automatic level control.
RC/CC		M. Increase RBTCV temp set point to 660°F.
RC/CC		N. Monitor RBSOT and RFSOT rise to 660°F.
RC/CC		O. Verify RFPCV maintains RFSOP at 425 psig.
RC/CC		O. Verify stable system operation at 660°F and 425 psig.

Action By		
	5.	Flash Tank to Downcomer Transition.
RC/CC	A.	Determine the initial receiver steam outlet conditions required.
RC/CC	B.	Determine downcomer wall temperature (RDT)
RC/CC	C.	If the required initial receiver steam outlet temperature is derated (600°F) and downcomer wall temperature is 1) above TBD °F or 2) below TBD °F, position RDSIV to provide the allowable downcomer 1) cooling or 2) heating rate until the downcomer wall temperature is 660 ± TBD °F.
RC/CC	D.	If the required initial receiver steam outlet temperature is rated (960°F) and downcomer wall temperature is above 660°F,
		1) Begin ramping RBTCV temperature set point to 960°F at TBD °F/sec
		2) When RBSOT is equal to or greater than downcomer wall temperature, position RDSIV to provide the allowable downcomer heating rate until the downcomer wall temperature is 960 ± TBD °F
STTF	E.	Increase SDSPCV pressure set point to 400 ± 25 psig
RC/CC	F.	Open RDSIV to full open
RC/CC	G.	Close RFIV
RC/CC	H.	Secure flash tank
		1) Maintain RFPCV set point at 425 psig; maintain pressure control enabled
		2) Maintain level control enabled
		3) Verify RNHPV open
STTF	I.	Increase receiver feedwater pressure (RWIP) set point to TBD psig (nominal 2250 psig) at a rate of TBD psig/min.

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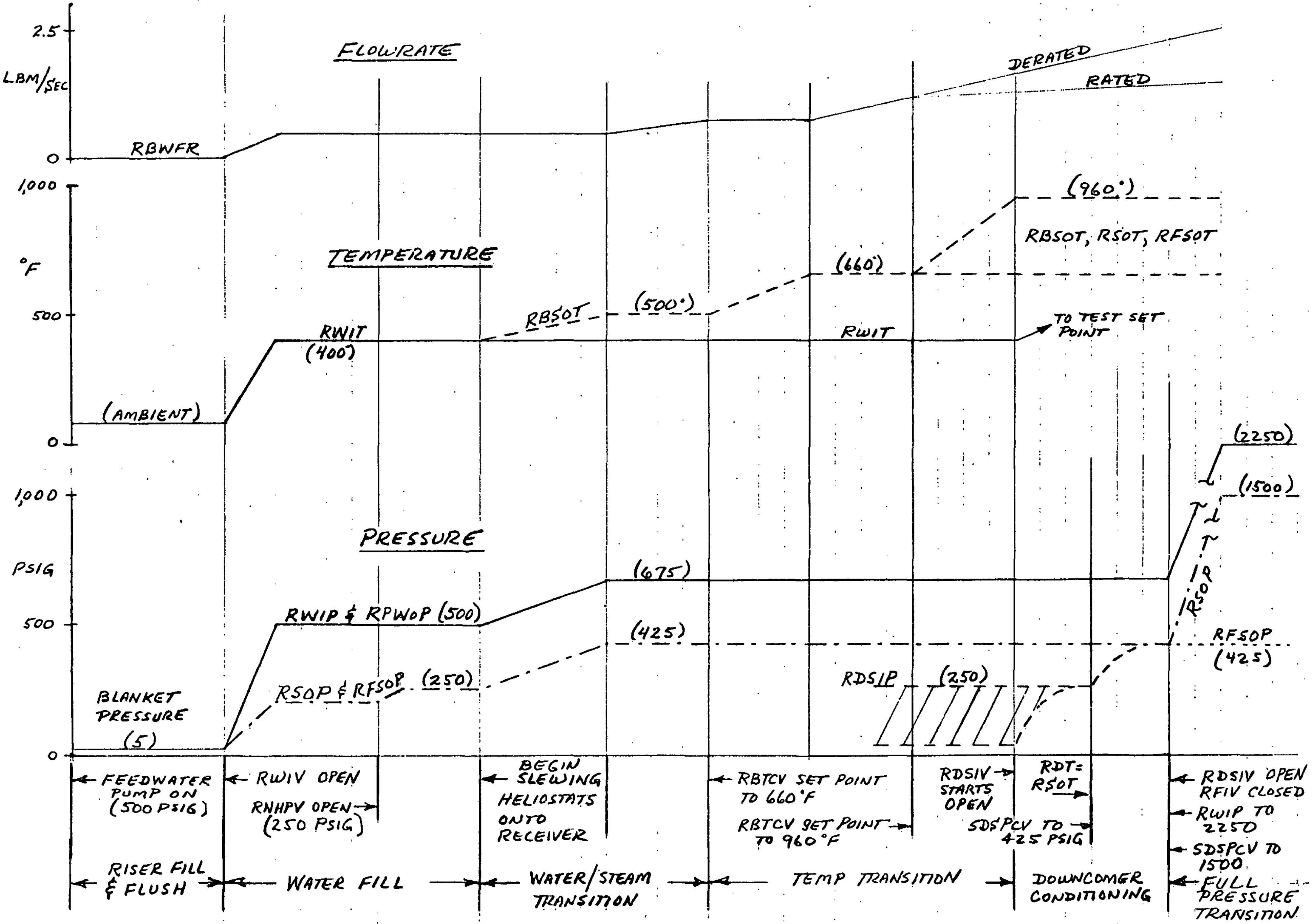
Action By

STTF	J.	In coordination with rise of RWIP, increase downcomer pressure control (SDSPCV) set point to TBD psig (nominal 1500 psig) at a rate of TBD psig/min.
RC/CC	K.	When receiver steam outlet conditions are achieved, indicate ready to accept heat input at a rate of TBD Btu/sec^2
RC/CC	L.	Reduce or cut off preheater heat as required

6. Steam Condition Transitions

RC/CC	A.	For derated to rated steam, increase RBTCV temperature set point at a rate of TBD °F/min.
RC/CC	B.	For rated to derated steam, decrease RBTCV temperature set point at a rate of TBD °F/min.



RECEIVER START-UP

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5.4.2-7

Action By

5.4.3 Receiver Shutdown Procedure (Normal)

RC/CC

1. After completion of the Test Procedure (where normal steam conditions are assumed to exist; that is, steam temperature between 660°F and 960°F at 1500 psig), verify or perform the following:

   A. Valve Positions

      1) Control Valves (Open/Closed)

RMDV	Closed	Level control on
RADV	Closed	Level control on
RFDV	Closed	Level control on
RFIV	Closed	
RNHPV	Open	

      2) Proportional Control Valves

STTF Feedwater Pressure	Open	Pressure control on; pressure set point at 2250 psig
RBTCV	-	X_1 control ON, X_1 set point at TBD% OPEN; Q&T/C CONTROL ON; Q LOW LIMIT set point at TBD lbm/sec; T REF set point at 660 to 960°F; Voting circuit in TBD position; T/C SELECT in TBD position
TSVV	Closed	P CONTROL ON; P REF set point at 1600 ± 25 psig; X_2 CONTROL OFF
RFPCV	Closed	Pressure control on; pressure set point at 425 psig
SDSPCV	Open	Pressure control on; pressure set point at 1500 psig
RDSIV	Open	

   B. Nitrogen Pressure Switches (RNPS-1, -2, -3, -4) NOT NORMAL lights OFF

Action By

C. Water Levels and Controls

RAWL	Level control on; set point L_1 HIGH REF at TBD%; L_1 LOW REF at TBD%; valve RADV closed
RMWL	Level control on; set point L_2 HIGH REF at TBD%; L_2 LOW REF at TBD%; valve RMDV closed
RFWL	FLASH TANK LEVEL CONTROL on; set point L_3 HIGH REF at TBD%; L_3 LOW REF at TBD%; valve RFDV closed

D. Receiver Feedwater Preheater Control — On or off, as the test required

2. Transition from Existing Steam Conditions

RC/CC — A. Verify all stations ready for normal receiver shutdown.

STTF — B. Begin reduction of heliostat heat input to approximately TBD Btu/sec at a decreasing rate not to exceed TBD Btu/sec^2.

RC/CC — C. Maintain RBTCV T REF set point at final test condition.

RC/CC/STTF — D. When receiver heat input rate drops below TBD Btu/sec and/or flow rate drops below TBD lbm/sec, begin decrease of RWIP to 500 psig at a rate not to exceed TBD psig/min.

STTF — E. In coordination with the drop of RWIP, decrease SDSPCV pressure set point and downcomer pressure to 250 psig at a rate not to exceed TBD psig/min.

3. Transition from Downcomer to Flash Tank

RC/CC — A. Verify

1) RFPCV pressure control enabled and set point = 425 psig

2) RFDV level control enabled

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Action By

3) RNHPV open

RC/CC — B. Determine Flash Tank temperature (RFT) and when RDSIP is at or below 400 psig and flow rate is equal to or less than TBD lbm/sec; open RFIV.

RC/CC — C. Close RDSIV at a rate permitted by the allowable flash tank heating rate.

RC/CC — D. When RDSIV is fully closed, decrease RBTCV T REF set point to 500°F.

4. Transition from Steam to Water

RC/CC/STTF — A. When all heliostat heat input stops, cut off Receiver and STTF preheaters (if on).

RC/CC — B. When RBSOT is less than TBD °F, RBTCV Q&T/C CONTROL OFF.

RC/CC — C. When RBSOT is less than TBD °F, RBTCV X_1 control OFF.

STTF — D. When RBSOT is less than TBD °F, stop STTF feedwater pump.

RC/CC — E. Close RNHPV

RC/CC — F. When RSOP is less than 200 psig, close RFIV.

5. Securing

RC/CC — A. RADV and RMDV level controls OFF.

RC/CC — B. Open RADV and RMDV as required to drain receiver Moisture Accumulator and/or manifold, and reduce system pressure below TBD psig.

RC/CC — C. RFDV level control OFF and open RFDV as required to drain Flash Tank and reduce Flash Tank pressure below TBD psig.

RL — D. Clear personnel to return to test level.

E. Verify off or turn OFF:

STTF — 1) STTF feedwater pressure control

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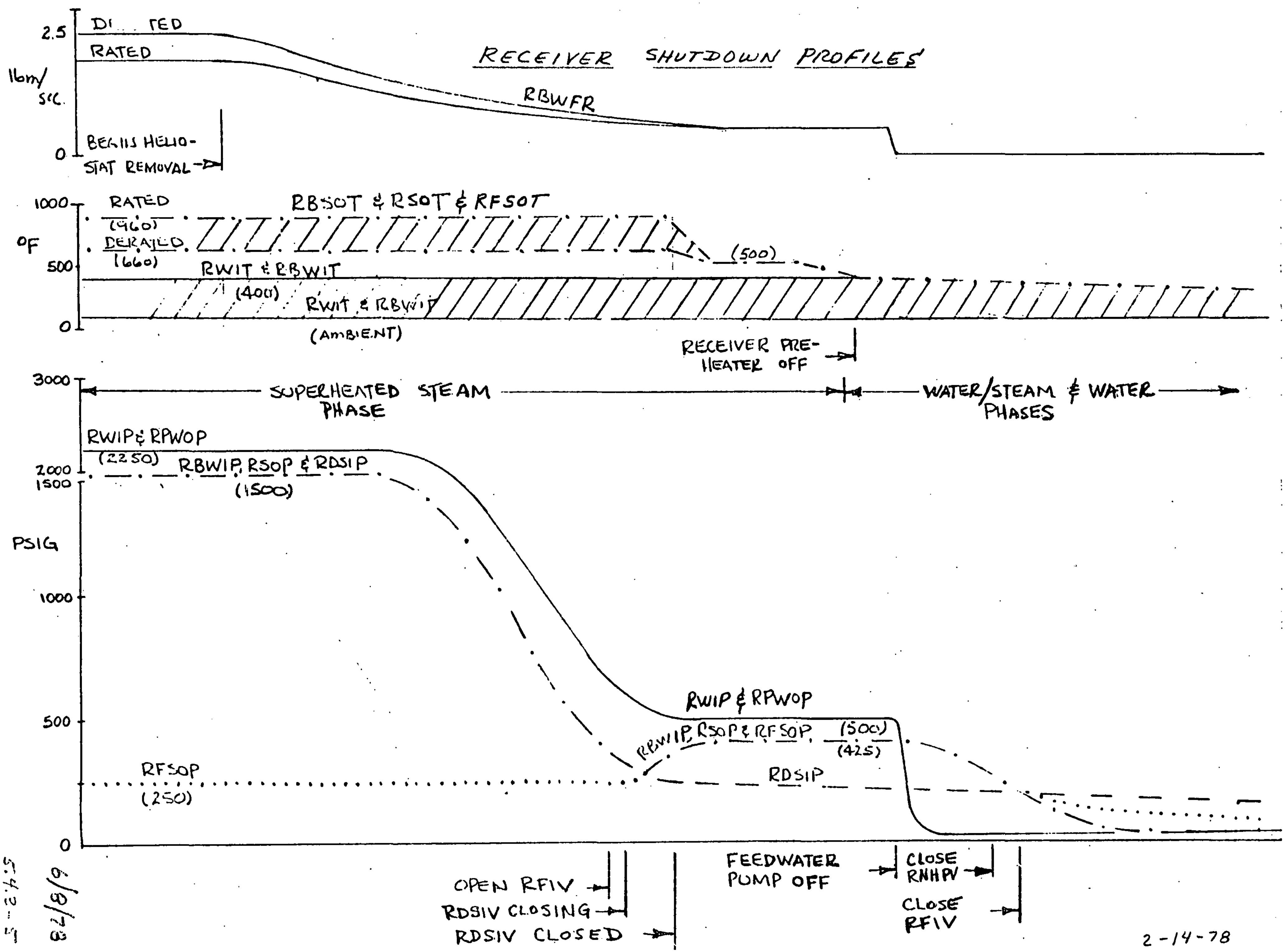
Action By	
RC/CC	2) RBTCV temp control
RC/CC	3) RSVV pressure control
STTF	4) SDSPCV pressure control
RL	F. Close RWIV
RL	G. Open RBWDV if expected ambient temperature conditions require receiver drain and then close RBWDV.
RC	H. Receiver controller operating console LOCAL/REMOTE ENABLE switch in LOCAL
RC	I. Verify or position all switches to off/closed and verify position talkbacks normal.
RL	J. Close RNIV-3 and reduce RNPR-3 and RNPR-4 to zero.
RC	K. Verify RNPS-3 and -4 not normal lights go ON.
RL	L. Close RNIV-1
RL	M. Verify RNMV open, RNLBV open, and RNPR-2 set for 10 $\pm$ 5 psig for standby.
RC	N. Turn receiver controller operating console power OFF.
RL	O. Conduct engineering inspection of test assembly.


RECEIVER SHUTDOWN PROFILES
2.5
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BEGINS HELIOSTAT REMOVAL
1000
500
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°F
RATED (960)
DERATED (660)
RBSOT & RSOT & RFSOT
(500)
RWIT & RBWIT (400)
RWIT & RBWIT (AMBIENT)
RECEIVER PREHEATER OFF
3000
2000
1500
1000
500
0
PSIG
SUPERHEATED STEAM PHASE
WATER/STEAM & WATER PHASES
RWIP & RPWOP (2250)
RBWIP, RSOP & RDSIP (1500)
RWIP & RPWOP
RBWIP, RSOP & RFSOP
(500)
(425)
RDSIP
RFSOP (250)
OPEN RFIV
RDSIV CLOSING
RDSIV CLOSED
FEEDWATER PUMP OFF
CLOSE RNHPV
CLOSE RFIV
2-14-78

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5-42-5

5.5 RECEIVER SHUTDOWN PROCEDURES (EMERGENCY)

Section 3.2.3.9 discusses emergency control. Safety cutoff causes and their annunciations are identified in Table 3.2.3-2.

Receiver controller simultaneous responses in an emergency shutdown are as follows:

1) Send command signals to close RDSIV and RBTCV and de-energize cutoff pilot valves in those valve assemblies to dump opening pressure.

2) Send command signal to open RSVV and de-energize the RSVV cutoff pilot valve to dump closing pressure.

3) Send signal to master control to slew the heliostats away from the receiver panel.

4) Send command signal to close RFIV

5) Send command signals to open RFPCV and RFDV.

6) Disable control loops for RP temperature control, and for RA, RM, and RF water level control.

7) Annunciate cutoff cause at the local operating console.

5.7 DISPOSITION OF TEST HARDWARE

Disposition of the test hardware will be coordinated by STTF. Following disassembly and preparation for shipment by STTF, the hardware will be shipped by STTF to

6.0 QUALITY ASSURANCE

Structures were originally designed and inspected to meet the local building codes at the Los Angeles Division facility. The structure was subsequently strengthened to meet the more severe wind and seismic loads at STTF.

The boiler panel is designed, fabricated, and certified per Section 1 of the ASME Boiler Code. All pressure vessels (moisture separator, receiver manifold, flash tank) are designed and will be certified to Section VIII of the Boiler Code. Plumbing and feed system components are designed, specified, and fabricated in accordance with ANSI B31.1.

Electric wiring for lighting and 110 VAC outlets is per the National Electric Code. Instrumentation and controls wiring is furnished in twisted pairs or coaxial cable as applicable.

Fabrication activities will be controlled by engineering drawings and procedures with critical items inspected and documented by ASME certified inspectors and/or contractor quality control or engineering personnel. During installations at STTF, contractor engineering personnel will monitor the activities and accomplish and document inspections required to ensure conformity to drawings.

7.0 RESPONSIBILITIES

7.1 PHASE 1 CONTRACTOR TASKS

The Contractor will perform Phase I, consisting of the below listed tasks, over a 2-1/2 month period ending November 4, 1977. Phase I will culminate with a definitive plan for Phase II.

1. Test Requirements

Test objectives will be defined which take advantage of the unique capabilities of the Solar Thermal Test Facility as compared with the Radiant Heat Facility in which the SRE Receiver has been previously tested. These objectives include the actual use of solar energy and the extended duration capabilities of the STTF. A test plan will be prepared describing the specific tests to be conducted based on these objectives. Test requirements will be derived in terms of operating conditions for the experiments.

2. Interface

The Contractor will perform definition of all hardware and operational interfaces for STTF. This will include defining the responsibility for supplying the equipment and/or services. At present, the responsibilities assumed by the Contractor include the design and fabrication (or procurement) of all structure, plumbing, instrumentation and control equipment from the panel to the facility interface at the top of the STTF tower. The presently defined operational responsibilities of the Contractor are to design and ensure delivery of the above-mentioned hardware to the STTF; to provide on-site engineering capabilities as required during the buildup period; and to provide engineering manpower as required during the testing program. The foregoing definition of responsibility will be refined and expanded during performance of this task.

3. STTF Data Package

The Contractor will prepare a data package that will include the following items:

Scope and objectives
Design description
Safety analyses
Operating procedures
Quality Assurance
Maintenance procedures
Spare parts list
Functional wire list
Interface drawings
Special tool & equipment list
Facility requirements

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4. Preliminary Design

A preliminary design of the equipment required to interface the SRE receiver panel to the STTF will be carried out.

The design will include overall design descriptions of the structure required to attach the receiver to the facility, including the capability of pointing the normal to the panel at an angle of 30 degrees below the horizontal to receive maximum solar intensity. It will include the plumbing of the feedwater, steam, and pressurant lines, and the instrumentation and controls wiring. The shielding to protect components from spill-over thermal radiation from the heliostats will also be designed.

5. Early Procurement Items

As a result of the preliminary design, items requiring early procurement (prior) to Phase II ATP) will be defined. Orders will be placed for the following items: a water filter, spare trim parts for control valves, and pressure differential transducers.

6. Phase II Costs

A firm cost quote for Phase II activities will be prepared. The quote will be based on the results of the foregoing tasks in terms of detail design, hardware fabrication/procurement, installation in STTF, testing, removal, and reporting requirements, and will further define Phase II responsibilities.

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7.2 PHASE II CONTRACTOR TASKS

INTRODUCTION

This Work Statement Revision "H" defines the Subcontractors additional effort to conduct a Phase II program which will consist of modification of the Subsystem Research Experiment (SRE) Receiver Panel, and Receiver Test Support at the Solar Thermal Test Facility (STTF) and is to be conducted in accordance with Tasks 1 through 4 noted below.

One panel, typical of 24 boiler/preheaters in a solar pilot plant receiver, has been built and tested by the subcontractor. The testing included basic control elements and radiant electric heaters were used to simulate the solar energy input. With the completion of the STTF and the selection of the once-thru boiler/external receiver concept, it is desirable to expand the previous testing.

PURPOSE

The purpose of the program is to broaden the existing data base. The tests will demonstrate performance and operation using additional controls components to more closely simulate the entire pilot plant receiver subassembly. Closed steamloop operation with heliostat-focused solar energy will also provide closer duplication of pilot plant operation.

GENERAL INFORMATION

This statement of work assumes the following will be provided by the DOE in a timely manner:

1. All reflectors and supporting equipment, design, fabrication and installation, except for attachment provisions on the receiver support structure.
2. Assembled receiver system cleaning and flushing materials, equipment, and labor at STTF.

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GENERAL INFORMATION:

3. Fabrication, assembly, installation, and test support, labor and equipment at STTF.

4. Office, assembly and storage space at STTF.

5. Acoustical Transducer system except for attachment of mounts.

NOTE: Figure I identifies Phase II schedule activities.

WORK PACKAGE

TEST AND EVALUATION

Task 1, Detailed Design

Detailed designs will be conducted in the following areas: panel, Receiver Support Structure, plumbing, controls components, controls electronics, instrumentation, and system aspects.

Detailed design in the area of panel modifications will consist of the specification of thermocouple locations on the panel and specification of installation procedures for these thermocouples. The effort will also include specifications of pressure boss and acoustical transducer mount locations and installation procedures. Mechanical design for the installation of panel deflection sensors will also be made.

WORK PACKAGE (Continued)

Task 1 (Cont'd)

The structural detail design will include drawings and specifications to define the modifications to the existing structure which was used during the previous SRE program. Detailed structural analysis of the system, both in the vertical (operating) orientation and the horizontal (shipping) orientation will be made. Thermal analysis of the structure under operating conditions will also be conducted. Included in this structural design area is the structure itself, insulation for the structure, cooled heat flux sensors, shipping fixtures, and a jib crane. Coordination of the structural interfaces is also a part of this task.

The plumbing detail design effort will include preparation of drawings and material requirements and procurement specifications for the water, steam, and GN_2 plumbing. The installation drawings of the valves and components, as well as the pipe hangers and insulation, will be included in this effort. Applicable hydraulic, stress, and thermal analyses will be conducted for this subsystem. Cleaning specifications for components and the entire receiver system will be defined. Conformance with STTF interfaces will be verified.

The specifications for the controls components will be finalized and a detailed list of spares and alternative valve trim requirements will be prepared. Definition of component sizes, weights, and interfaces will be made. The checkout and operating procedures for those components will be defined.

The detailed design effort in the area of controls electronics will include a definition of the component-to-controller wiring and connectors and the STTF-to-controller wiring and connectors.

WORK PACKAGE (Continued)

Task I (Cont'd)

New logic circuits for the controller will be designed as required. Circuit diagrams and component locations in the controller will be defined and the components and spares requirements will be established. Console configuration and interface drawings will be made. Checkout and operating procedures will be defined.

Detailed design for instrumentation will include a definition of the sensor-to-controller wiring and connectors for STTF. The location and configuration of installations for sensors will be specified. The sensor specifications and requirements, including spares, will be finalized. Calibration procedures for the instrumentation will be defined. Detailed design efforts in the area of the receiver system will include specification of initial and daily system checkout procedures including the configuration, the required STTF inputs, signals sent to STTF from the controller, and operating limits. Conditions at critical points throughout the receiver system will be evaluated during start and run. Dynamic control simulations will be accomplished to predict control settings for initial tests and to provide a means for relating test results to expected pilot plant conditions. Detailed packing, shipping and erection procedures will be specified for the complete system. A listing of the drawings expected for the Phase 2 effort is given in Table 1.

Task 2, Procurement/Fabrication

The following components will be procured during this effort: instrumentation sensors, control components, electronic components, wire and connectors, structural members, insulation for the panel, plumbing and structure, pipe, fittings, hangers, jib crane, shipping and handling fixtures. Engineering inspection for all materiel will be provided.

All subassembly fabrication efforts will be accomplished at the subcontractors facility.

TABLE -

PHASE II DRAWINGS EXPECTED

Receiver - Structure Test Assembly Drawing	Interface Frame Assembly Tower to Elevator	Tower Reinforcement Installation Drawing
Tower Reinforcement Detail Drawing	Strongback Installation and Details Drawing	Insulation Installation and Details Drawing
Steam System Installation	Water Inlet System Installation	Receiver Installation
Steam Separator Installation	Receiver Manifold Installation	Flash Tank Installation
Valves Installation	Filter Installation	Preheater Pallet Assembly
Preheater Installation	Pneumatic System Installation	Instrumentation Installation
	Reflector Support Structure Interface	Vertical Flux Probe Assembly (Stationary)
Vertical Flux Probe Installation and Details (Stationary)	Vertical Flux Probe Assembly (Moveable)	Electrical Control Harness Installation; Receiver to Controller
Vertical Flux Probe Installation (Moveable)	Interface Drawing, Piping, Packaging Installation & Details	Electrical Control Harness Installation; Controller to STTF
Handling Installation & Details	Controller Wiring Diagram	Controller Component Locations
Data Instrumentation Harness Installation	Console Layout	

WORK PACKAGE (Cont'd)

Task 2 (Cont'd)

The panel and strongback assembly will be removed from the receiver support structure and set in a horizontal orientation with the tube bundle facing upward. The tube bundle will be prepared for installation of thermocouples. A maximum of 80 thermocouples will be attached to the panel. All thermocouples will be checked and defective thermocouples replaced. The panel will be grit-blasted and coated with Pyromark and cured. Pressure bosses and acoustical transducer mounts will be installed and inspected. The panel will be hydro-tested and purged with dry GN_2. Insulation on the back of the panel will be refurbished as required.

The receiver support structure will be reinforced as required and attachments put in place for the reflectors. The base which interfaces the receiver support structure and the STTF facility will be fabricated. A jib crane will be fabricated and attached to the top of the receiver support structure.

The pipe sections will be fabricated, hydro-tested, and cleaned. All controls components will be inspected, and cleaned if necessary. Valves will be functionally checked and the existing flowmeter will be calibrated. The controls components and instrumentation sensors will be assembled into the piping and the structure. Upon completion of the plumbing assembly a leak check will be performed and the system cleaned and dried and an ultrasonic inspection of the panel performed. Pipe, components, and the receiver support structure will be insulated.

Basic wire harnesses between the subcontractor supplied hardware and STTF will be provided. The controller components and console will be fabricated, wired and functionally checked.

WORK PACKAGE (Cont'd)

Task 2 (Cont'd)

The structure/plumbing assembly will be mated with the panel/strongback assembly and temporary reinforcements for shipping will be added as necessary. The assembly will be shipped to STTF.

Task 3, Facility/Test Support

Continuous interface coordination will be accomplished by telephone and by trips to STTF as required. The subcontractor will supply a test requirements document which will include detailed descriptions of the hardware and components, a listing of the functional and physical interfaces, requirements for data and data reduction, procedures for installing, checkout and operating subcontractor equipment, and a specification of all tests to be performed.

The subcontractor will supply engineering support at STFF to accomplish the following activities. The condition of subcontractor components upon arrival at STTF will be checked. A spares inventory will be maintained. Engineering assistance will be provided for the installation, checkout, and removal of all subcontractor components, as well as troubleshooting. Operation of the receiver test control consoles will be performed by subcontractor engineering personnel.

In addition, the subcontractor will perform the following on-site engineering activities at STTF. Daily test requirements will be specified including minor changes to the hardware. On-site evaluation of test data will be performed. Data recording or presentation requirements specific to an individual test or group of tests will be specified.

Engineering effort at the subcontractor's facility will include analysis of the data and evaluation of component performance with application to pilot plant performance.

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WORK PACKAGE (Cont'd)

Task 4, Program Management and Documentation

Management surveillance to assure adherence to budget, schedules, and technical requirements will be provided. Informal progress reviews will be provided at reasonable intervals. Monthly progress reports indicating technical progress and budget expenditures, as well as intended near-future effort will be written. A final report summarizing all design, fabrication, test and analysis activities and results, will be presented. The schedule for these activities is shown in Figure 1.

The Contract Data Requirements are as follows:

1. Test Requirements
2. Monthly Progress Reports (input to existing reports)
3. Final Test Report.

8.0 TEST DOCUMENTATION

8.1 Test Records and Daily Log

The Test Conductor shall maintain a chronological and historical record of all significant events that transpire during the test. Events are to be recorded on the spot and later extracted to become part of the test report. The Test Conductor shall also keep a daily log with details of test progress, anomalies, deviations, significant results, etc. Log entries shall be made on a continual basis while tests are in progress, and daily during test downtime.

8.1.2 Preparation of Technical Memorandum

A test report documenting the results of the tests shall be prepared by the contractor and include, but not be limited to, the following:

A. Test hardware description

B. Test objectives

C. Description of test sequences

D. List of equipment used

E. Significant test data

F. Copies of photographs

G. Analysis of test data

APPENDIX A

LIST OF DRAWINGS

Drawing No.	Title
99RS010501	Panel Assy - Solar Receiver
99RS010502	Panel, Solar Receiver
99RS010503	Tube Bundle, Solar Receiver
99RS010504	Manifold, Feedwater Inlet
99RS010505	Manifold, Steam Outlet
99RS010506	Rail, Panel Support
99RS010507	Slide and Spacer, Solar Receiver
99RS010508	Beam, Transverse, Solar Receiver
99RS010509	Beam, Intermediate, Transverse, Solar Receiver
99RS010510	Yoke, Upper, Solar Receiver
99RS010515	Block, Stand Off, Feedwater Line, Solar Receiver
99RS010517	Block, Insulator, Upper, Solar Receiver
99RS010518	Block, Insulator, Lower, Solar Receiver
99RS010519	Block, Insulator, Upper Intermediate, Solar Receiver
99RS010520	Block, Insulator, Solar Receiver
99RS010521	Strap, Tie, Insulation, Solar Receiver
99RS010522	Line, Feedwater Supply, Solar Receiver
99RS010523	Coupling, Expansion, Feedwater
99RS010524	Line, Flowmeter to Throttle Valve, Solar Receiver
99RS010525	Line, Shutoff Valve to Flowmeter, Solar Receiver
99RS010526	Line, Throttle Valve to Expansion Coupling
99RS010527	Line, Steam Discharge, Solar Receiver
99RS010528	Receiver Segment Assembly
	Receiver - Structure Test Assembly
	Interface Frame Assembly Tower to Elevator
	Tower Reinforcement Installation
	Tower Reinforcement Details
	Strongback Installation and Details
	Insulation Installation and Details
	Steam System Installation

Drawing No.	Title
	Water Inlet System Installation
	Receiver Installation
	Steam Purifier Installation
	Receiver Manifold Installation
	Flash Tank Installation
	Valves Installation
	Filter Installation
	Preheater Pallet Assembly
	Preheater Installation
	Pneumatic System Installation
	Instrumentation Installation
	Reflector Assembly
	Reflector Support Structure Assembly
	Reflector Installation
	Reflector Coolant Installation
	Vertical Flux Probe Assembly (Stationary)
	Vertical Flux Probe Installation and Details
	Vertical Flux Probe Assembly (Movable)
	Vertical Flux Probe Installation (Movable)
	Horizontal Flux Probe Assembly
	Horizontal Flux Probe Installation and Details
	Interface Drawing, Piping, Packaging Installation and Details
	Handling Installation and Details
	Electrical Control Harness Installation
	Data Instrumentation Harness Installation
	Controller Wiring Diagram
	Controller Component Locations
	Console Layout

TABLE B

STTF RECEIVER CONTROL COMPONENTS

SPEC NO.	COMPONENT	TAG NO.	IDENTIFICATION
STTFC-1	FEEDWATER INLET VALVE	RWIV	ROCKWELL EDWARD FIGURE 1028
-2	DISCHARGE VALVE	RADV RMDV	VALTEK
-3	FLASH TANK DISCHARGE VALVE	RFDV	VALTEK
-4	FLASH TANK INLET VALVE	RFIV	VALTEK
-5	FLASH TANK PRESSURE CONTROL VALVE	RFPCV	VALTEK
-6	DOWNCOMER STEAM INLET VALVE	RDSIV	VALTEK
-8	FLASH TANK RELIEF VALVE	RFRV	CROSBY, 1E2-J0-46-STM-D
-9	FLASH TANK BURST DISC	RFBD	FIKE, ASSY. F WITH 6 BURST DISCS
-10	NITROGEN CHECK VALVE	RNCK-1-1 THRU RNCK-2-2	ROCKWELL EDWARD FIGURE 6674, 1/2"
-11	NITROGEN PRESSURE VALVE	RNPV-1	SINCLAIR-COLLINS, C264-2005
-12	NITROGEN BLANKET PRESSURE VALVE	RNBV	ROCKWELL-EDWARD
-13	PREHEATER FEEDWATER FILTER	RWF	CAPITAL WESTWARD
-14	BOILER FEEDWATER FILTER	RBWF	CAPITAL WESTWARD
-15	BOILER TEMPERATURE CONTROL VALVE	RBTCV	VALTEK

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TABLE B (Continued)

STTF RECEIVER CONTROL COMPONENTS

SPEC NO.	COMPONENT	TAG NO.	IDENTIFICATION
STTFC-16	STEAM VENT VALVE	RSVV	VALTEK
-17	STEAM RELIEF VALVE	RSRV	CROSBY, RCA-78, 1 1/2"-F-3
-18	STEAM BURST DISC	RSBD	FIKE
-19	BOILER INLET STOP-CHECK VALVE	RBWISK	ROCKWELL-EDWARD, FIGURE 3664
-20	BOILER WATER DRAIN VALVE	RBWDV	ROCKWELL-EDWARD, FIGURE 1048Y
-21	BOILER STEAM OUTLET VALVE	RBSOV	ROCKWELL-EDWARD, FIGURE 6626
-22	INSTRUMENT SHUTOFF VALVE		ROCKWELL-EDWARD, FIGURE 4152
-23	INSTRUMENT ISOLATION VALVE		MAROTTA SCIENTIFIC CONTROLS P/N 207663
-24	FLASH TANK CHECK VALVE	RFCK	ROCKWELL-EDWARD FIGURE 3674
-25	SOLENOID PILOT VALVE		ASCO CAT. NO. 8320A20
-26	RECEIVER PREHEATER BURST DISC	RPBD	FIKE, ASSEMBLY F WITH 6 BURST DISCS

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TABLE B (Continued)

STTF RECEIVER CONTROL COMPONENTS

SPEC NO.	COMPONENT	TAG NO.	IDENTIFICATION
STTFC-31	NITROGEN INLET SHUTOFF VALVE	RNMV	ROCKWELL-EDWARD FIGURE 1048
-32	NITROGEN SHUTOFF VALVES	RNIV-1, RNIV-3	ROCKWELL-EDWARD FIGURE 848
-34	RECEIVER NITROGEN FILTER	RNF	
-35	NITROGEN HIGH PRESS. REGULATOR	RNHPR	FISHER TYPE 1301G
-36	NITROGEN LOW PRESS. REGULATOR	RNPR-2, RNPR-4	FISHER TYPE 1301F
-37	NITROGEN OPER. PRESS. REGULATOR	RNPR-3	FISHER TYPE 1301F
-38	NITROGEN HIGH PRESS. GAGE	RNHPG	ASHCROFT
-39	NITROGEN LOW PRESS. GAGE	RNPG-2 RNPG-4	ASHCROFT
-40	NITROGEN OPER. PRESS. GAGE	RNRG-3	ASHCROFT
-41	NITROGEN HIGH PRESS. RELIEF	RNHRV	CROSBY-SAGE SERIES 300
-42	NITROGEN LOW PRESS. RELIEF VALVE	RNRV-2, RNRV-4	CROSBY-SAGE SERIES 300
-43	NITROGEN OPER. PRESS. RELIEF VALVE	RNRV-3	CROSBY-SAGE SERIES 300
-45A -45B -45C -45D	NITROGEN DUAL-PRESSURE SWITCHES	RNPS-1 RNPS-2 RNPS-3 RNPS-4	UNITED ELECTRIC STOCK NO. J110A

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