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**10-MWe PILOT-PLANT-RECEIVER-PANEL
TEST-REQUIREMENTS DOCUMENT:
SOLAR THERMAL TEST FACILITY
JUNE 10, 1978**

AC03-76 ET 20417

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS

CORPORATION

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14 June 1978
A3-130-EP-JOP-161

Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

Attention: J. P. Littlehales

Subject: CONTRACT EY-76-C-03-1108, MODIFICATION
20-1, TEST REQUIREMENTS DOCUMENT

In accordance with Modification 21, Exhibit II, Reports and Deliverable Items, dated 24 April 1978 which was datafaxed to the undersigned on 12 June 1978, the Contractor submits herewith the subject document to the following addresses:

1 Draft Copy	Central Power Systems Branch Division of Solar Technology Department of Energy Washington, D.C. 20545
2 Draft Copies	Solar Energy Division Department of Energy 1333 Broadway Oakland, California 94612
2 Draft Copies	Technical Manager Contract No. xxxxxxxx Solar Projects Division Sandia Laboratories Livermore, California 94550

Should you have any questions relative to these submittals, please do not hesitate to contact the undersigned.

J. O. Peiffer
Branch Manager - Energy Contracts

Enclosure

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

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	ORIGINAL DATE OF DRAWING 2 SEP 1977				
	FIRST RELEASE OF PRINTS				
ODD DASH NUMBERS SHOWN DASH NUMBERS OPPOSITE OR IDENT NO.	PREPARED APPROVED <i>[Signature]</i> 6/8/78 CHECKED DESIGN ACTIVITY APPROVAL	RECEIVER/STTF TEST REQUIREMENTS	SIZE A	CODE IDENT NO. 18355	DRAWING NO. 1150721
FOR USAGE DATA SEE ENGINEERING RECORDS	CUSTOMER APPROVAL	SCALE	6/10/78	SHEET 1 OF	

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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.

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FIGURE 1-1
PHASE II STTF
TEST PROGRAM SCHEDULE

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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.

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(12) Investigate boiler panel tube wall fouling.

(13) Shakedown and calibrate test hardware.

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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.

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3.1.1-1

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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 shut-down sequences. With this arrangement, active control of the water flow through the preheater panels is not required.

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SHEET 3.1.1-3

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.

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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.

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Figure 3.1.2-1, Overall Test Configuration

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SHEET 3.1.2-2

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.

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Figure 3.1.2-1

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Figure 3.1.3-1, ASME Stamp on Test Panel

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.

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SHEET 3.1.4-1

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. x 0.68 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.

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Figure 3.2.1-1 SRE Receiver Panel

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3.2.1-2

3.2.1 (Cont.)

The tube bundle is supported by a bracket in the upper corner where the tubes are foled 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 AFTM C612-70, Classes IV and V (Ref: Rocketdyne drawings 99RS01501 and 99RS010519).

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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. The temperature control valve modulates the feedwater flow to the receiver panel to maintain the selected receiver steam outlet temperature despite diurnal and seasonal variations in heat load on the panel and regulates flow during the start and shutdown sequences.

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Table 3.2.2-1
SCHEMATIC SYMBOLS

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

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Table 3.2.2-1 (Continued)

SCHEMATIC SYMBOLS

PRESSURE REGULATOR

PRESSURE SWITCH

THERMOCOUPLE

THERMOCOUPLE IN WELL

RESISTANCE TEMP DETECTOR

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Table 3.2.2-2
SCHEMATIC NOMENCLATURE

LETTER/NUMERAL HARDWARE ID CODE:

Media (i.e., Water)

Location (i.e., Receiver
Preheater Panel)

Function (i.e., Relief)

R P W R V - 2 2 - 2

Component number if multiple components on
each major assembly.Assembly number if multiple major assemblies
(i.e., Receiver Panel 22).Component type or instrumentation parameter
(i.e., Valve).

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

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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

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To ensure the cleanliness of the feedwater immediately before it enters the boiler panel, flow next passes through the receiver boiler water filter (RBWF). Finally, the feedwater moves through the receiver boiler water inlet stop check valve (RBWISK) and enters the bottom of the receiver boiler panel (RB). 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 ensure absolutely dry steam and is then directed through the steam manifold and receiver downcomer steam inlet valve (RDSIV) to the receiver/STTF interface and the facility condenser.

During startup or shutdown when insolation is too low to produce the proper super-heat 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).

Under normal receiver 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.

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 discharge valves RADV, RMDV, and RFDV, and consequent liquid level control between upper and lower reference level settings.

Safety relief valves (RSRV and RFRV) and burst discs (RSBD and RFBD) are installed on the receiver discharge line and on the receiver flash tank for protection 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.

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6/8/78

SHEET 3.2.2-6

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.

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SHEET 3.2.2-7

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.

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SHEET 3.2.3-1

Figure 3.2.3-1, Electrical Control - STTF Receiver Installation

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SHEET 3.2.3-2

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.

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SHEET 3.2.3-3

FIGURE 3.2.3-2

STTF RECEIVER CONTROLLER

REV: 6/8/78
SHEET 3.2.3-4

FIGURE 3.2.3-3A
RECEIVER OPERATING CONSOLE

REV: 6/8/76
SHEET 3.2.3-5

FIGURE 3.2.3-3B
RECEIVER OPERATING CONSOLE

Figure 3.2.3-4

Controller Input/Output Diagram

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.

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SHEET 3.2.3-8

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SHEET

3.2.3-9

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_{REF}^1 , 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 commanded 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 a manual switch on the local operating console. With the manual switch and RS-2 in the conditions shown in Figure 3.2.3-5, the amplified signals from RBSOT-1 is the steam temperature feedback signal. As an alternate, the manual switch 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 signals 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.

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SHEET 3.2.3-10

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. The amplifier circuit that generates measurement signal Q_2 will have an adjustable gain. Calibration data will be provided so that the appropriate gain setting for each orifice size will be determined easily.

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.

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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 glove 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 milli-ampere 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 fully. 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 control configuration to RBTCV. Both valves close rapidly when their solenoid dump valves are deenergized.

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3.2.3-12

Figure 3.2.3-6, Boiler Temperature Control Valve Schematic

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3.2.3-13

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.

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SHEET 3.2.3-14

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SHEET 3.2.3-15

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.

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SHEET 3.2.3-16

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.

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SCALE

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SHEET 3.2.3-17

SCALE

SIZE
A

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DRAWING NO.

1750721

REV 6/8/78

SHEET 3.2.3-18

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

3.2.3.5 Feedwater Temperature Control

Figure 3.2.3-9 is a functional block diagram of the receiver feedwater temperature control loop that utilizes electrically-powered preheater RP.

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 local reference temperature signal, $T_{W,REF}$, is applied by means of a digital potentiometer on the operating console.

With relay switch RS-12 in the deenergized position shown, the preheater control loop is disabled. When RS-12 closes, as the result of a remote or local operator input, a proportional-plus-integral process controller delivers a control signal to a power controller. The power controller responds by delivering 0-24 amps DC, proportional to the control signal current as the control current for six saturable core reactors. The reactors respond by delivering AC power, as a function of the control current, to six preheater elements.

When RS-12 is closed or opened, the rate at which preheater electrical power is applied or removed is determined by the process controller integration (reset) gain setting. The process controller integrates any difference between T_{SET} and the feedback temperature measurement, for closed loop control or preheater electrical power input and 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 150 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.

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SHEET 3.2.3-19

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REV 6/8/78
SHEET 3,2,3-20

FIGURE 3.2.3-9

FUNCTIONAL BLOCK DIAGRAM - FEEDWATER TEMP CONTROL

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 discharge valve.

Outflow of water to the facility steam condenser is limited by an orifice. When the water level reduces to the low limit, the pilot valve is deenergized to close the discharge 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 3.2.3-9 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.

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SHEET 3.2.3-22

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 shown in Figure 3.2.2-1, the receiver test setup includes a normally-closed pneumatically actuated three-way shutoff valve RNHPV-1 in series with redundant check valves RNCK-1-1 and RNCK-1-2. When the solenoid pilot valve for RNHPV-1 is energized, nitrogen 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-generation operating conditions, the solenoid pilot valve for RNHPV-1 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 of steam-pressurized condensate through the check valves is thereby vented, to protect the nitrogen plumbing from entry of heated condensate or steam.

A manual two-way shutoff valve RNLPV is installed in series with redundant check valves RNCK-2-1 and RNCK-2-2. Pressure regulator RNPR-2 maintains 10 psig at the check valves. Whenever the receiver is shut down, an inert gas blanket is applied and maintained to prevent entry of ambient oxygen.

When the blanket gas check valve outlet pressure exceeds the 10 psig inlet pressure, leakage of condensate through the check valves is vented through a small bleed orifice, to protect the low-pressure nitrogen plumbing circuit.

There are four dual-pressure switches in the nitrogen plumbing circuits, with tag numbers RNPS-1 through 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 an alarm indication if any of the four regulated pressure are not within limits that are defined by the switch settings.

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SHEET 3.2.3-23

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. None of the alarm annunciations are transmitted to master control, however, master control is supplied with the instrumentation parameters required to initiate its own alarms.

Whenever an alarm condition is detected, a readily visible and specifically labeled annunciator light will attract the console operator's attention.

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

Fault 1 is detected by RWIP.

Fault 2 is detected by RWIP.

Fault 3 is detected with RWIP and the closed-position switch on RFIV.

Faults 4 and 5 are detected by RWFDP and RBWDP.

Fault 6 is detected by RSOP.

Fault 7 is detected by the RFSOP-1 and RFSOP-2 high-signal selector circuit.

Faults 9A and 9B are detected by RNPS-1, RNPS-2, RNPS-3, and RNPS-4.

Fault 10 is detected by RFMWT-1.

Fault 11 is detected by RFMWT-1.

Fault 12 is detected with T_{FB} and the closed-position switch on RDSIV.

Fault 13 is detected with feedback signal T_{FB} in the control loop of Figure 3.2.3-5 (RBSOT-1, -2, -3, -4, -5).

Faults 14 and 8 are detected within the controller signal conditioning circuits.

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SHEET 3.2.3-24

Fault 15 is detected with feedback signal Q_{FB} in the control loop of Figure 3.2.3-5 (RBWFR-1; RWODP).

Fault 16 is detected by a 4-20 ma differential-pressure transmitter in the heat-flux-sensing calorimeter cooling water plumbing.

Faults 17 through 19 are detected with the selected level measurement signal in Figure 3.2.3-10.

Fault 20 is detected with the valve closed position switches and command signals.

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SHEET 3.2.3-25

Table 3.2.3-1
ALARM CONDITIONS

<u>FAULT</u>	<u>INPUT</u>	<u>ANNUNCIATION</u>
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	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	RF Hi Press
8. RF pressure transducer error	RFSOP-1 RFSOP-2	Xdcr Out
9a/ Out-of-limits regulated nitrogen 9b	RNPS-1&2&4 RNPS-3	Nitrogen Out Valve GN ₂ Out
10. Feedwater temperature less than 400°F	RFMWT-1	Lo Water Temp
11. Feedwater temperature greater than 600°F	RFMWT-1	Hi Water Temp
12. Steam discharge temperature less than 625°F when RDSIV is open	RBSOT-1 thru 5	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 -4 -5	T/C Out

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MCDONNELL DOUGLAS

SIZE

A

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DRAWING NO.

1T50721

SCALE

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SHEET 3.2.3-26

Table 3.2.3-1 (Continued)

ALARM CONDITIONS

<u>FAULT</u>	<u>INPUT</u>	<u>ANNUNCIATION</u>
15. Feedwater flowrate less than 1b/sec	RBWFR-1 RWODP	Lo Water Flow
16. Calorimeter water flow less than 1b/sec	TBD	Lo Cal Flow
17. RA high water level	RAWL RAWLDP	RA Hi Water
18. RM high water level	RMWL RMWLDP	RM Hi Water
19. RF high water level	RFWL RFWLDP	RF Hi Water
20. Valve fails to respond to command	Closed Position Switches; Command Signals	Command/Position

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SHEET 3.2.3-27

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 causes and their annunciations.

As shown in the Figure 3.2.3-1 schematic diagram of the electrical control installation, the operator cutoff signal from the master control room to the receiver controller is via a normally-open manual switch and a direct wire that is 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 convertors.

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 console cutoff annunciation light is maintained until removed by a cutoff-reset switch on the console or by a cutoff-reset signal from the master control room.

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

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	A	18355	1T70521
SCALE		REV 6/8/78	SHEET 3.2.3-28

Table 3.2.3-2
SAFETY CUTOFF CONDITIONS

<u>FAULT</u>	<u>RC SIGNAL</u>	<u>RC SIGNAL TO MCS</u>
A. Controller console manual cutoff	RC Cutoff	RC Cutoff
B. Master control room manual cutoff	Remote Cutoff	-
C. Steam temperature greater than 1060°F	HI Steam Temp	RC Cutoff
D. Low quality steam	Lo Qual Steam	RC Cutoff
E. Valve position interlocks <ul style="list-style-type: none"> • RDSIV leaves closed before RSOT > RDT > 660°F • RFIV leaves closed when RSOP > 450 psig 	Valve Cutoff	RC Cutoff
F. Calorimeter water flow less than 1bs/sec.	Lo Cal Flow	RC Cutoff

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SHEET 3.2.3-29

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 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 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.

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SHEET 3.2.3- 30

3.2.3.10 Instrumentation (Continued)

The solenoid-actuated transducer isolation valves have 110 VAC coils. 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 wires connects the junction box to the tower computer room, via the galley. Solid state solenoid drivers are located in the receiver controller. A 10 VDC input to the driver circuit from master control results in an energize current output to all isolation valves simultaneously.

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	A	18355	1T50721
MCDONNELL DOUGLAS	SCALE	REV 6/8/78	SHEET 3.2.3-31

Table 3.2.3-3
Electrical Interfaces - Instrumentation

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

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CODE IDENT NO.
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SHEET 3.2.3 - 33

Table 3.2.3-3 (Cont'd)
Electrical Interfaces - Instrumentation

ITEM	SOURCE	MIN/MAX REQUIREMENTS		RECEIVER SUPPLIED CONNECTOR	ICD
		VOLTS	AMPS		
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		
Flowmeters				Unterminated Cable	(3)
• Excitation	RC	117V A.C.	-		
• Signal	—	-	1-5 MA		
Pressure Transmitter					
o Excitation	RC ⁽¹⁾	24 VDC			
o Signal	—	—	4-20 MA		
Diff. Press. Transmitter					
o Excitation	RC	24 VDC			
o Signal	—	—	4-20 ma		
Resistance Temp. Detector					
o Excitation	STTF				
o Signal	—				
(1) Receiver Controller					

FIGURE 3.2.3-11
INTERFACE - ELECTRICAL -
PRESSURE TRANSDUCER

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TABLE 3.2.3-4
INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	NORMAL RANGE	LIMITS		DATA ACCU-RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY (1)					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
											M	L			
	<u>PRESSURE</u>														
RBDP-1	Boiler Differential #1	psid													
RBDP-2	" " #2	"													
RBDP-3	" " #3	"													
RBDP-4	" " #4	"													
RBSMP	Boiler Steam Manifold	psig	0-1500										X		X
RBWFDP	Boiler Water Filter Diff.	psia	0-100	30									X	X	X
RBWIP	Boiler Water Inlet	psig	0-1500										X		
RBWMP	Boiler Water Inlet Manifold	"	"												
RDSIP	Downcomer Steam Inlet	"	"						-	X	-	-	X		X
RFSOP-1	Flash Tank Steam Outlet	"	0-400					X		X			X		X
RFSOP-2													X		
RFSOP-3		"						X	X	(2)	(2)		X		X
RSOP	Steam Outlet	"	"	1600	1660			X	X		X		X		X
RWIP	Water Inlet	"	0-1700	2300	--			X	X	X			X		X
RWFDP	Water Filter Differential	psid	0-100	30									X	X	X

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

- (1) All data recorded on magnetic tape
(2) P_{FB} (P_1 or P_2 , whichever is greater)

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TABLE 3.2.3- 4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
											M	L			
RWODP	Water Orifice ΔP	Psid	0-150					X			X		X	X	Δ P ₂ ; Q ₂ RBWFR-2
RBTCVDP	Temp Control Valve DP	Psid	0-500												
RFWLDP	Flash Tank Water Head	In-H ₂ O	0-90					X			X		X	X	
RMWLDP	Manifold Water Head	In-H ₂ O	0-160					X			X		X	X	
RAWLDP	Accumulator Water Head	In-H ₂ O	0-60					X			X		X	X	
RCCODP	Calorimeter Coolant Orifice	Psid	0-100					X			X		X	X	

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

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TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
											M	L			
	<u>Temperature</u>														
RBT-60C30	Receiver Boiler Panel (Cold Side)	°F	0-1500												Chrome Alumel (Type K) Thermocouples (Typical)
RBT-180C30															
RBT-180C40															
RBT-252C30															
RBT-324C30															
RBT-324C40															
RBT-360C30															
RBT-384C30															
RBT-384C40															
RBT-408C30															
RBT-432C5															
RBT-432C30															
RBT-432C40															
RBT-456C30															
RBT-480C1															
RBT-480C5															
RBT-480C30															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

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

Tube No. 30
Cold Side of Panel
60" Above 90° Tube Bend
Receiver Boiler Temp

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TABLE 3.2.3-4.

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU-RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
	<u>Temperature</u>														
RBT-480C40	Receiver Boiler Panel (Cold Side)	°F	0-1500												
RBT-480C65															
RBT-504C30															
RBT-504C40															
RBT-528C1															
RBT-528C5															
RBT-528C30															
RBT-528C65															
RBT-552C30															
RBT-576C1															
RBT-576C5															
RBT-576C30															
RBT-576C40															
RBT-576C65															
RBT-600C30															
RBT-624C1															
RBT-624C30															
RBT-648C30															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

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TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCURACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
RBT-672C1	Temperature														
RBT-672C5	Receiver Boiler Panel	°F	0-1500												
RBT-672C15	(Cold Side)														
RBT-672C30															
RBT-672C40															
RBT-672C55															
RBT-672C65															
RBT-672C70															
	Strongback T1		0-500												
	Strongback T2														
	Tower Ambient Lower														
	Tower Ambient Upper														

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
	<u>Temperature</u>														
RBT-480H40	Receiver Boiler Panel (Hot Side)	°F	0-1500												Chrome Alumel (Type K) Thermocouples (Typical)
RBT-480H65															
RBT-492H30															
RBT-504H30															
RBT-504H40															
RBT-516H30															
RBT-528H1															
RBT-528H5															
RBT-528H30															
RBT-528H65															
RBT-540H30															
RBT-552H30															
RBT-564H30															
RBT-576H1															
RBT-576H5															
RBT-576H30															
RBT-576H40															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

3.2.3-40

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TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU-RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
	<u>Temperature</u>														
RBT-576HG5	Receiver Boiler Panel (Hot Side)	°F	0-1500												
RBT-588H30															
RBT-600H30															
RBT-624H1															
RBT-624H30															
RBT-648H30															
RBT-648H40															
RBT-672H1															
RBT-60H30															
RBT-180H30															
RBT-180H40															
RBT-216H30															
RBT-252H30															
RBT-288H30															
RBT-324H30															
RBT-324H40															
RBT-360H30															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

3.2.3-41

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TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY						REF
				W	R			C	S	SC	PANEL		CRT	PTR		
											M	L				
	<u>Temperature</u>															
RBT-372H30	Receiver Boiler Panel (Hot Side)	°F	0-1500													
RBT-384H30																
RBT-384H40																
RBT-396H30																
RBT-408H30																
RBT-420H30																
RBT-432H5																
RBT-432H30																
RBT-432H40																
RBT-444H30																
RBT-456H30																
RBT-468H30																
RBT-480H1																
RBT-480H5																

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

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TABLE 3.2.3-4
INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	NORMAL RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY						REF
				W	R			C	S	SC	PANEL		CRT	PTR		
											M	L				
	<u>TEMPERATURE</u>															
RBSOT-1	Boiler Steam Outlet #1	°F	0-960	1000	1060			X	X	(3)	(3)		(3)	X	T ₁ T ₂ T ₃ T ₄ } T _{FB}	
RBSOT-2	Boiler Steam Outlet #2	"	"	"	"			X	X	↓	↓		↓	X		
RBSOT-3	Boiler Steam Outlet #3	"	"	"	"			X	X	↓	↓		↓	X		
RBSOT-4	Boiler Steam Outlet #4	"	"	"	"			X	X	↓	↓		↓	X		
RBSOT-5	Boiler Steam Outlet #5	"	"	(4)	-			X	X	↓	↓		↓	X		
RBT-XXXX	Boiler Panel Temperatures	(See Separate Listing)														
RFT	Flash Tank Temp	°F	0-960					X		X			X	X		
RFMWT-1	Flowmeter Water Temp	°F	0-550										X			
RFMWT-2	Flowmeter Water Temp	"	"													
RBSMT	Boiler Steam Manifold Temp	"	0-960													
RFSOT	Flash Tank Steam Outlet	"	"						X				X	X		
RPWOT-1	Preheater Water Outlet #1	"	0-550	585				X	-	X	X		X	X		
RPWOT-2	Preheater Water Outlet #2	"	"	"				X	-	?	?		X	X		

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

3.2.3-43

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

(4) Warning on erratic output (strip chart)

(5) H₂ counter warning - CRT flashing

TABLE 3.2.3-4 (Continued)

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	NORMAL RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
	<u>TEMPERATURE (Cont'd)</u>														
RSOT	Steam Outlet	°F	0-960							X	X		X	X	
RTSOT	Moisture Trap Outlet	"	0-960	(4)			High		X	X			(5)		
RWIT	Water Inlet	"	0-550										X		
RDT	Downcomer Temp	"	0-960					X		X			X	X	
	<u>FLOWRATE</u>														
RBWFR-1	Boiler Water	lb/sec	0 to 2.57					X		(7)	(7)		(7)	X	Q ₁
RBWFR-2	Boiler Water	lb/sec						X		(7)	(7)		(7)	X	Q ₂ (RWODP)
	<u>LEVEL</u>														
RFWL	Flash Tank Water	% full	0 to 100	TBD				X	X			(8)	X	X	L ₃
RMWL	Manifold Water	"	"	TBD				X	?			(8)	X	X	L ₂
RAWL	Moisture Accumulator Water	"	"	TBD	TBD			X	X			(8)	X	X	L ₁
	<u>POSITION-ANALOG</u>														
RBTCVX	Boiler Water Temp. Cont. Valve	% Open	5-100	TBD				X	X	X	X	TBD	X	X	X ₁

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

(7) QFB (manual selection of Q₁ or Q₂)

(8) See STATUS LIST: RFWLW, RMWLW and RTWLW

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TABLE 3.2.3-4 (Cont'd)

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	NORMAL RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
											M	L			
	<u>POSITION-ANALOG</u> (Cont'd)														
RFPCVX	Flashtank Pressure Control Valve	% Open	0-100	TBD				X		X	X	TBD	X	X	X ₃
RSVVX	Steam Press. Vent Valve	"	"	"				X	X	X	X	TBD	X	X	X ₂
RDSIVX	Downcomer Inlet Valve	"	"	"											
	<u>POSITION-DISCRETE</u>														
RDSIVC	Downcomer Steam Inlet Valve	Closed		TBD	TBD			X	X			X	X	X	
RFDVC	Flash Tank Drain Valve	"	N.C.					X				X	X	X	
RFIVC	Flash Tank Inlet Valve	"	"	TBD	TBD			X	X			X	X	X	
RMDVC	Manifold Drain Valve	"	"					X				X	X	X	
RADVC	Moisture Accumulator Drain Valve	"	"					X				X	X	X	
	<u>STATUS</u>														
CO-1	RC Cutoff	On-off	Off		(9)				X			X	X	X	
CO-2	Control Room Cutoff	"	"		(9)				X			X	X	X	

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

(9) Any observed redline condition

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TABLE 3.2.3-4 (Cont'd)

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	NORMAL RANGE	LIMITS		DATA ACCURACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
	<u>STATUS</u> (Cont'd)														
HSP	High Steam Pressure	On-Off	Off	TBD					X			X	X	X	
HST	High Steam Temperature	"	"	"					X			X	X	X	
LST	Low Steam Temperature	On-Off	Off	TBD					X			X	X	X	
RFWLW	Flash Tk. H ₂ O Level Warn.	On-Off	Off	TBD					X			X	X	X	
RMWLW	Manifold H ₂ O Level Warning	"	"	"					X			X	X	X	
RAWLW	M. Trap H ₂ O Level Warning	"	"	"					X			X	X	X	
RNPS-1&2	GN ₂ Press. Not Normal#1#2	"	"	"					X			X	X	X	
RNPS-2,3&4	GN ₂ Press. Not Normal#3#4	"	"	"					X			X	X	X	

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

(6) T/C Tag No. Code: 1st number (left) = inches above 90° bend at inlet
2nd number (right) = tube number
Letter (middle) = cold side (C), hot side (H)

Example: RBT-655C25

Receiver boiler temperature
655 inches above inlet
Cold side of tube
Tube No. 25

TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCURACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
21F1	Heat Flux**	MW/M ²	0-0.5												
21F35*															
21F70															
57F1															
57F35*															
57F70															
93F1															
93F35*															
93F70															
129F1															
129F18*															
129F35*															
129F52*															
129F70															
165F1															
165F35*															
165F70															
201F1															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PRT - PRINTER

* 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:

21F1

Tube 1
Flux Gage
21" Above Lower 90° Tube Bend

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3.2.3-47

TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCURACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
201F35*	Heat Flux**	MW/M ²	0-0.5												
201F70															
237F1															
237F35*															
237F70															
273F1															
273F78*															
273F35*															
273F52*															
273F70															
309F1															
309F35*															
309F70															
314F1*															
314F35*															
314F70*															
345F1															
345F35*															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

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3.2.3-4/8

TABLE 3.2.3-4.

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU- RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
345F70	Heat Flux**	MW/M ²	0-0.5												
381F1															
381F35*															
381F70															
417F1															
417F18*															
417F35*															
417F52*															
417F70															
453F1															
453F35*															
453F70															
489F1															
489F35*															
489F70															
525F1															
525F35*															
525F70															

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

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TABLE 3.2.3-4

INSTRUMENTATION LIST

TAG NO.	PARAMETER	UNITS	RANGE	LIMITS		DATA ACCU-RACY	FREQ RESP (Hz)	FUNCTION		DISPLAY					REF
				W	R			C	S	SC	PANEL		CRT	PTR	
561F1	Heat Flux**	MW/m ²	0-0.5												
561F17*	↓	↓	↓												
561F35*															
561F52*															
561F70															
597F1															
597F35															
597F70															
633F1															
633F35															
633F70	↓	↓	↓												

LIMITS: W - WARNING
R - REDLINE

FUNCTION: C - CONTROL
S - SAFETY

DISPLAY: SC - STRIPCHART
M - METER
L - LIGHT

CRT - CATHODE RAY TUBE
PTR - PRINTER

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3.2.3-50

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 3.2.3-20.

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. The temperature scale will be changeable,

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1TS0721

SCALE

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SHEET 3.2.3-51

on command, in order to improve resolution. 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.

In addition to the above, the ability will exist to call up the trend history of individual parameters in either tabulated digital or graphical format as shown in Figure 3.2.3-19.

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

Flux data will be displayed in a manner similar to Figure 3.2.3-20.

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REV 6/8/78

SHEET 3.2.3-52

FIGURE 3.2.3-12
SYSTEM CONTROL DISPLAY

REV: 6/8/78
3.2.3-53

FIGURE 3.2.3-13
SYSTEM PRESSURE PROFILE DISPLAY

3.2.3-54

REV: 6/8/78

FIGURE 3.2.3-14
SYSTEM TEMP PROFILE DISPLAY

3.2.3-55

Rev: 6/8/78

FIGURE 3.2.3-15
LEVELS/POSITIONS/STATUS DISPLAY

REV: 6/8/78
3.2.3-56

FIGURE 3.2.3-16
PANEL COLD SIDE VERTICAL TEMP PROFILE

6/8/78

3.2.3-57

FIGURE 3.2.3-17
PANEL COLD SIDE HORIZONTAL TEMP PROFILE

6/8/78

3.2.3-58

FIGURE 3.2.3-18
 PANEL HOT SIDE VERTICAL TEMP PROFILE

6/8/78

3.2.3-59

FIGURE 3.2.3-19
TYPICAL TREND HISTORY

6/8/78

3.2.3-60

FIGURE 3.2.3-20
PANEL VERTICAL FLUX PROFILE

60-0213-1A02 (06 AUG 71)

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SHEET 3.2.3-61

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 experiments (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.

	<u>Nonoperating</u>	<u>Operating</u>
° 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

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 SAFFIL type alumina insulation will be installed on the front of the tower (facing

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SHEET 3.2.4-1

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

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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 $\pm 45^\circ$ (Figure 3.2.4-2).

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

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SHEET 3.2.4-3

FIGURE 3.2.4-2, FLUX CONCENTRATOR

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SHEET 3.2.4-4

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.

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SHEET

3.3.1-1

Table 3.3.1-1
PIPING INTERFACES

PIPE TAG	CONTRACTOR INTERFACE CONNECTION	MIN/MAX RQMTS. (3)			EST. USAGE PER TEST	FLUID SPECS	ICD (2)
		TEMP (°F)	PRESS (PSIG)	FLOW RATE (GPM)			
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					(5)	

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

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SHEET 3.3.1-2

Table 3.3.1-2

FEEDWATER QUALITY REQUIREMENTS

<u>FACTOR</u>	<u>NORMAL LIMITS</u>	<u>MAXIMUM LIMIT*</u>
Silica	5-7 PPB	20 PPB
Sodium	1-2 PPB	5 PPB
Iron	3-5 PPB	10 PPB
Copper	1-2 PPB	2 PPB
Oxygen	Less than 2 PPB	2 PPB
Hydrazine	3-5 PPB	5 PPB
Conductivity (Straight)	N/A	10 Micro MHOS
Conductivity (Cation)	N/A	0.5 Micro MHOS
pH at 21°C (70°F)	N/A	9.45-9.60

*PPB - parts per billion

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SHEET 3.3.1-3

Table 3.3.1-3
NITROGEN REQUIREMENTS

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SHEET 3.3.1-4

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.

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SHEET 3.3.1-5

Table 3.3.1-5
Electrical Interfaces

<u>ITEM</u>	<u>SOURCE</u>	<u>MIN/MAX REQUIREMENTS</u>		<u>CONTRACTOR SUPPLIED CONNECTOR</u>	<u>ICD(2)</u>
		<u>VOLTS</u>	<u>AMPS</u>		
<u>POWER</u>					
RECEIVER CONTROLLER POWER () (1)	STTF	110/110 <u>±</u>			
RECEIVER PREHEATER POWER	STTF	480 <u>±</u>	(300 kw)		
<u>CONTROL</u>					
(REFERENCE FIGURE					
INPUTS TO STTF	REC	0 <u>±</u> /10 <u>±</u>			
OUTPUTS FROM STTF	STTF				

INSTRUMENTATION

(SEE SECTION 3.2.3.8, TABLE 3.2.3-3)

(1) STTF I.D.

(2) INTERFACE CONTROL DRAWING

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SHEET 3.3.1-6

Dan Ron
STTF
19 May 1978

Serial
Interface
with 'Master Control'
Figure 3.3.1-1

SIMPLIFIED INTERCONNECTION DIAGRAM

W. J. 1-7

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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.

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SHEET 3.3.2 -1

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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 $(Q/A)_{\max} - (Q/A)_{\min} \div (Q/A)_{\text{avg.}} \times \left[\begin{array}{l} \text{Fraction of nominal panel} \\ \text{width separating} \\ (Q/A)_{\max} \text{ from } (Q/A)_{\min} \end{array} \right]$	0.4	0.4
Power Transient Rate Limit	TBD	TBD

- (1) North Panel 12 or 13; Equinox Noon; 950 w/m²
 (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

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	A	18355	1T50721
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SHEET 3.3.2-2			

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SHEET 3.3.2 - 3			

Table 3.3.2-2
STTF RECEIVER TEST CONDITIONS

Flux Profiles

- ° Vertical
- ° Lateral

(Reference Figure 3.3.2-1)

(Reference Figure 3.3.2-2)

Test Receiver Characteristics

- ° Width
- ° Length
- ° Location
- ° Tilt (Degrees from Vertical)

.889m (2.9 feet)

12.5m (41 feet)⁽¹⁾

(Reference Figure 3.3.2-4)

Zero

Flux Concentrator

Winston Parabolic,
+ 45° Acceptance Angle⁽²⁾

Heliostats

- ° Number
- ° STTF Zone A = 78
- ° STTF Zone B = 144
- ° Heliostat Mirror Area Per Heliostat
- ° Facets per Heliostat
- ° Heliostat Alignment Point
- ° Heliostat Alignment Time
- ° Heliostat Aining Points
- ° Heliostat Locations

222

37.22m² (400 Ft.²)

25

Test Receiver Center Point⁽³⁾
(STTF Alignment State 2)

Day 80, Solar Noon

10 (Reference Figure 3.3.2-4)

(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 -

HEAT FLUX (MW/m²)

0.5

0.4

0.3

0.2

0.1

0

(Bottom)

VERTICAL DISTANCE ALONG RECEIVER
(m)

RECEIVER
CROSS SECTION

PANEL #13

PANEL #21

MAX STTF INCIDENT

MAX PILOT PLANT
INCIDENT (PANEL 13)

ABSORBED

MIN PILOT PLANT
INCIDENT (PANEL 21)

AIM POINT
LOCATIONS

STTF
Δ - FLUX DATA
POINTS
ALIGNMENT
STATE 1
DAY 80 - NOON
NO TERMINAL
CONCENTRATOR
10 AIM POINTS
DATA & AIM
POINTS ON
PANEL #
I = 0.1 W/cm²
ρ = 0.8

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3.3.2-4

(Top)

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

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SHEET 3.3.2-5

TABLE 4.4.3-4
STTF/MDAC SRE RECEIVER
POWER SUMMARY

Assumptions:

1. $I = 0.1 \text{ watt/cm}^2$ direct normal insolation
2. $\rho = 0.8$ 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

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SHEET 3.3.2-6

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

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SHEET 3.3.2-8

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)

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SHEET 3.3.3-1

from the transport truck and install it upon the elevating module with the exception of the truck mounted pivot mechanism required for the tower assembly.

3.3.6 Office/Assembly Space

Office space with typical furnishings and access to secretarial support will be required beginning December, 1977 to accommodate up to two contractor personnel for intermittent trips. From early January through July, 1978, 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. Accommodations for no more than two people on short trips should be required until Phase III installations begin in early 1979.

Approximately 100 cubic feet of secure storage space will be required for contractor equipment during the period from early February through July, 1978. In addition, temporary weather protected storage will be required for up to 10 reflector panels (each 10 feet by 4 feet by 3 feet) and 8 insulation panels (3 feet by 7 feet by 1 foot).

Since the plan is to assemble the majority of the test installation into the test tower prior to shipment to STTF, no assembly space should be required beyond the area on and immediately adjacent to the STTF elevating module.

3.3.7 Support Manpower/Schedule

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SHEET 3.3.6-1

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 are provided in the system to prevent excessive pressurization. The main system relief valve is set to 1,900 psig; the flash tank relief valve is set to 600 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.

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SHEET 4.0 - 1

5.0 PROCEDURES

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

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

5.1 ASSEMBLY

Current planning calls for essentially all fabrication/assembly to be accomplished at the contractor's facilities so that only the installation and hook-up of major subassemblies is required at STTF.

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 pre-fabricated 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 late May, 1978.

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SHEET 5.1 - 1

STEP 1

STEP 2

Step 3

Figure 5.2-1
Receiver Installation

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SHEET 5.2-1

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 CHECK-OUT

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.

The water/steam systems will subsequently be filled with water for cold flow functional checks. A combined test receiver/STTF system clean and flush operation will then be accomplished followed by a removal and cleaning of all filter elements.

Checkout will culminate in a series of "warm" check-out 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 insulation 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.

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SHEET 5.3-1

Table 5.4-1

PRELIMINARY STTF TEST REQUIREMENTS

Test Number	Test Description	Test Duration, Hours	Absorbed Power, MW	Flow Rate lb/sec	Panel Inlet Temp., F	Inlet Press. psia	Outlet Temp., F	Receiver Outlet Press. psia
1	System Shakedown and Calibration	3	0.2-4.2	0.4-6.1	Amb	1600-1800	550	~1500
2	System Shakedown and Calibration	3	0.2-4.2	0.4-6.1	Amb	1600-1800	550	~1500
3	Checkout of Electric Preheater and High Flow Characteristics	2	0.2-1.1	5.6-15.1*	400	1600-2000	550	1500
4	Minimum South Boiler Power, Start Sequence** Pilot Plant	1	0.2	0.28	550	1800	650	1515
5	Minimum South Boiler Power, Start Sequence** Pilot Plant	1	0.2	0.28	550	1800	650	1515
6	Minimum South Power, Rated and Derated Temps.	3	0.5	0.70, 0.53	550	1800	650, 960	1515
7	Maximum South Derated Power, Rated and Derated Temps.	3	0.74	1.02, 0.77	550	1800	650, 960	1515
8	Maximum South Rated Power, Rated and Derated Temps.	3	1.0	1.06	550	1800	650, 960	1515
9	Minimum South Power (Interface Press. Effects)	2	0.2	0.28	550	1750, 1850	650	1465, 1565
10	Minimum South Rated Power (Extremes of Control Valve ΔP)	3	0.5	0.7, .53	550	1750, 1850	650, 960	1465, 1565

* Or facility limit

** Conditions are for steady-state operation

Table 5.4-1

PRELIMINARY STTF TEST REQUIREMENTS (Continued)

Test Number	Test Description	Test Duration, Hours	Absorbed Power, MW	Flow Rate lb/sec	Panel Inlet Temp., F	Inlet Press. psia	Outlet Temp., F	Receiver Outlet Press. psia
11	Minimum South Rated Power (Extremes of Control Valve ΔP)	3	0.5	0.7, .53	550	1750, 1850	650, 960	1465, 1565
12	Minimum South Power (Inlet Temperature Effects)	4	0.2	0.48	500, 585	1800	650	1515
13	Minimum South Rated Power (Inlet Temperature Effects)	4	0.5	0.7, 0.53	500, 585	1800	650, 960	1515
14	Cloud Transients South Min. Cloud Transients South Max.	4	0.2 0.74	0.28 1.02	550 550	1800 1800	650 650	1515 1515
15	Emergency Shutdown Tests South Panel	4	1.0	1.06	550	1800	960	1515
16	East Boiler Characteristics****	3	TBD	TBD	550	1800	650, 960	1515
17	Emergency Shutdown, East Panel	4	TBD	TBD	550	1800	960	1515
18	North Boiler Characteristics ***	3	0.49-2.09	0.70-2.88	550	1800	650, 960	1515
19	Minimum North Power (Interface Pressure Effects)	1	0.5	0.7, .53	550	1750, 1850	650, 960	1465, 1565
20	Minimum North Rated Power (Extreme Control Valve ΔP)	2	1.23	1.70, 1.28	550	1750, 1850	650, 960	1465, 1565
21	Minimum North Power (Inlet Temperature Effects)	1	0.5	0.7, 0.53	500, 585	1800	650, 960	1515

***North and South boilers will use different valve trim and control gains

****Maximum lateral gradient

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Table 5.4-1

PRELIMINARY STTF TEST REQUIREMENTS (Continued)

Test Number	Test Description	Test Duration, Hours	Absorbed Power, MW	Flow Rate lb/sec	Panel Inlet Temp., F	Inlet Press. psia	Outlet Temp., F	Receiver Outlet Press. psia
22	Minimum North Rated Power (Inlet Temperature Effects)	2	1.23	1.70, 1.28	500, 585	1800	650, 960	1515
23	Cloud Transients North Min.	2	0.5	0.7	550	1800	650	1515
<u>REFLECTOR TESTS</u>								
24	System Shakedown and Calibration	3	TBD	TBD	550	1800	650, 960	1515
25	Maximum North Power	2	2.50	2.57	550	1800	960	1515
26	Maximum North Power (Extreme Control Valve ΔP)	2	2.50	2.57	550	1750, 1850	960	1465, 1565
27	Maximum North Power (Inlet Temperature Effects)	2	2.50	2.57	500, 585	1800	960	1515
28	Cloud Transients, North Max.	2	2.50	2.57	550	1800	960	1515
29	Emergency Shutdown Tests, North Panel	2	2.50	2.57	550	1800	960	1515
30	125 Percent Max. North Power	2	3.12	3.24	550	1900	960	1515

TABLE 5.4-2
TEST/TEST OBJECTIVE SUMMARY

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				
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

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SHEET 5.4-4

TABLE 5.4-3
TEST/TEST CONDITIONS SUMMARY

TEST OPERATING CONDITIONS	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
Steady State																														
Preheat Panel	✓	✓	✓																											
Rated Steam Conditions																														
Derated Steam Conditions																														
Transients																														
Startup																														
Shutdown																														
Emergency Shutdown																														
Cloud																														
Inlet Cond. Ramps																														
Temperature																														
Pressure																														
Outlet Cond. Ramps																														
Temperature																														
Pressure																														
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)																														
Max. Power (MW)																														
Nom. Power (MW)																														
1 First Set Point	X																													
2 Second Set Point	F																													
✓ Test Condition																														

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SHEET 5.4-5

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SHEET 5.4- 6

STTF PHASE II TEST SCHEDULE

TEST NUMBER OR ACTIVITY	TEST WEEK											
	1	2	3	4	5	6	7	8	9	10	11	12
TESTS 1, 2, 3												
ORIFICE AND RETRIM VALVE FOR SOUTH PANEL, CALIBRATE												
TESTS 4, 5, 6, 7												
TESTS 8, 9, 10, 11, 12												
TESTS 12, 13, 14, 15												
ORIFICE AND RETRIM VALVE FOR EAST PANEL, CALIBRATE												
TEST 16, 17												
ORIFICE AND RETRIM VALVE FOR NORTH PANEL, CALIBRATE												
TESTS 18, 19, 20												
TESTS 21, 22, 23												
INSTALL REFLECTORS												
TESTS 24, 25, 26												
TESTS 27, 28, 29, 30												

Figure 5.4-1 STTF Phase II Test Schedule

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,

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SHEET 5.4-7

STTF RECEIVER PANEL TEST NO. 1 & 2

Description: System Shakedown and Calibration

- Receiver panel to be operated as a preheater panel (no steam generated) for system checkout with inlet pressure variations.

Objectives:

- Determine control system response and stability
- Investigate preheater panel thermodynamic performance
- Investigate panel absorptive coating durability

Approach/Method: (Refer to Table 5.4-1 for specific operating values)

- Use modified start-up procedure to maintain liquid flow throughout system:
 - 1) Panel inlet temperature to be maintained at ambient.
 - 2) Panel outlet pressure to be maintained at 1500 psig.
 - 3) Increase incident power from heliostats in increments to increase water flowrate from minimum to maximum requirement.
 - 4) Panel outlet temperature to be maintained at 550°F.
 - 5) Panel inlet pressure to be varied between 1600 to 1800 psia.
- Flash tank may, or may not, be used during initial start-up
- Establish absorptive coating baseline condition prior to test

Success Criteria:

- Control system to respond properly (i.e., vary water flowrate) to variations in incident power
- Control system to maintain stable water flow at a given incident power level
- Instrumentation is operable and delivering usable data, especially for evaluation of absorbed power.

Performance Criteria Parameters:

- Boiler water flowrate
- Boiler steam outlet temperature and pressure
- Boiler water temperature control valve position
- Boiler panel differential pressure

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SHEET 5.4-8

STTF RECEIVER PANEL TEST NO. 1 & 2 (Continued)

Special Requirements:

- STTF and receiver preheaters off
- Pretest activities (leak and functional checks; flushing and purging; DAS checks, etc.) have been completed
- Problems identified during pretest activities have been corrected
- Pretest procedures have been successfully completed

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SHEET

5.4-9

STTF RECEIVER PANEL TEST NO. 3

Description: Checkout of Electric Preheater and High Flow Characteristics

- Receiver panel to be operated as a preheater panel as in Tests 1 & 2, but with panel inlet water heating.

Objectives:

- Demonstrate control system performance
- Investigate preheater panel thermodynamic performance

Approach/Method: (Refer to Table 5.4-1 for specific operating values)

- Same approach as Tests 1 & 2, but enable Receiver Preheater
- Receiver Preheater temperature set point to be adjusted to provide 400°F at water flowmeter inlet
- Water flowmeter inlet temperature to be stable at 400°F before application of incident power
- Incident power to be increased in increments to increase water flowrate from minimum to maximum requirement.

Success Criteria:

- Same success criteria as Tests 1 & 2

Performance Criteria Parameters:

- Same performance criteria parameters as Tests 1 & 2
- Receiver preheater outlet temperature or flowmeter water temperature

Special Requirements:

- If success criteria are satisfied, drain downcomer and connecting steam lines. Purge downcomer with GN₂ until dry.

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SHEET 5, 4-10

STTF RECEIVER PANEL TEST NO. 4 & 5

Description: Minimum South Boiler Power, Start Sequence Pilot Plant

- Operate receiver as a south boiler panel at 20% power and derated steam conditions

Objectives:

- Investigate control system performance (valve trim & control algorithms)
- Demonstrate control system capability to manage flowrate such that derated steam outlet conditions are established and maintained
- Demonstrate receiver panel ability to deliver steam at derated conditions
- Demonstrate delivery of dry steam

Approach/Method: (Refer to Table 5.4-1 for specific operating values)

- Use standard start-up procedure
- Apply incident power (by heliostats) to produce an absorbed power approximately 20% of south panel maximum (i.e., 0.2 MWt).
- Establish steady-state derated steam conditions
- Measure incident power and/or heat losses and use results for calculating total losses and/or incident power
- Measure boiler outlet temperature in steam manifold to detect moisture

Success Criteria:

- Control system to establish and maintain stabilized flowrate required to provide derated steam.
- Receiver panel to deliver absorbed power specified (0.2 - 1.1 MWt)
- No moisture indicated in steam outlet manifold

Performance Criteria Parameters:

- Same performance criteria parameters as Tests 1, 2 & 3
- Special heat loss and/or incident power instrumentation
- Moisture detection temperature

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SHEET 5.4-11

STTF RECEIVER PANEL TEST NO. 4 & 5 (Continued)

Special Requirements:

- Downcomer to be dry prior to test
- Check condition of surface coating post test
- Check panel expansion/contraction system post test
- South boiler panel control valve trim shall be installed prior to test

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SHEET 5.4-12

STTF RECEIVER PANEL TEST NO. 6, 7 & 8

Description: Minimum South Boiler Power, Rated and Derated Temperatures

- Operate receiver as a south boiler panel at 50, 75 and 100% power levels and derated/rated steam conditions

Objectives:

- Demonstrate receiver panel capability to deliver steam at derated and rated conditions over a wide range of incident powers.
- Investigate thermodynamic performance and heat losses
- Investigate control system performance (valve trim & control algorithms)
- Demonstrate delivery of dry steam

Approach/Method: (Refer to Table 5.4-1 for specific operating values)

- Use standard start-up procedure
- Apply incident power (by heliostats) to produce absorbed powers of 0.5, 0.75 and 1.0 MWt.
- Establish steady-state derated, or rated, steam conditions (at each power level)
- Measure incident power and/or heat losses as in Tests 4 & 5
- Measure boiler outlet temperature in steam manifold to detect moisture

Success Criteria:

- Receiver panel to deliver absorbed powers specified (0.5, 0.75 and 1.0 MWt)
- Control system to establish and maintain stabilized flowrates that result in derated and rated steam
- No moisture indicated in steam outlet manifold

Performance Criteria Parameters:

- Same performance criteria parameters as Tests 1-5

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SHEET 5.4-13

STTF RECEIVER PANEL TEST NO. 9

Description: Minimum South Power (Interface Pressure Effects)

- Operate receiver as a south boiler panel at minimum (20%) power with inlet and outlet pressure variations

Objectives:

- Demonstrate control system performance
- Demonstrate hydrodynamic flow stability
- Check flow distribution and uniformity
- Demonstrate delivery of dry steam

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply incident power to produce absorbed power at 0.2 MWt
- Establish steady-state derated steam conditions
- Vary inlet pressure and outlet pressure set points
- Measure panel front face temperatures
- Measure panel internal tube pressures
- Measure boiler outlet temperature in steam manifold for moisture

Success Criteria:

- Control system to respond such that derated steam temperature is maintained during pressure excursions
- No moisture detected in steam outlet manifold

Performance Criteria Parameters:

- Boiler outlet temperatures

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SHEET 5.4-14

STTF RECEIVER PANEL TEST NO. 10 & 11

Description: Minimum South Rated Power (Extremes of Control Valve ΔP)

- Operate receiver as a south boiler panel at 50% power with inlet and outlet pressure variations

Objectives:

- Investigate control system performance
- Demonstrate hydrodynamic stability
- Check flow distribution and uniformity
- Demonstrate delivery of dry steam

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply incident power to produce 0.5 Mwt absorbed power
- Establish steady-state derated; or rated, steam conditions
- Measure control valve inlet and outlet pressures (or ΔP)
- Vary inlet pressure and outlet pressure set points
- Reduce inlet pressure at operating condition to minimize control valve ΔP (to establish instability thresholds)

Success Criteria:

- Control system response to inlet and outlet pressure excursions to maintain derated and rated steam conditions as required
- No moisture detected.

Performance Criteria Parameters:

- Control valve ΔP

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SHEET 5.4-15

STTF RECEIVER PANEL TEST NO. 12 & 13

Description: Minimum South Rated Power (Inlet Temperature Effects)

- Operate receiver as a south boiler panel at 20% and 50% power with inlet temperature variations

Objectives:

- Measure panel losses and performance
- Demonstrate delivery of dry steam
- Demonstrate control system performance
- Investigate effects of varying feedwater temperature
- Investigate effects of varying outlet temperature ramp

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to produce 0.20 and 0.50 Mwt absorbed power
- Establish steady-state derated, or rated, steam condition
- Adjust feedwater temperature by varying receiver preheater set point

Success Criteria:

- Deliver dry steam at 0.20 and 0.50 Mwt power levels
- Operate at reduced inlet pressure to demonstrate control stability
- Demonstrate off design feedwater temperature operation

Performance Criteria Parameters:

- Water inlet temperature
- Water inlet pressure
- Water flow

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SHEET 5.4-16

STTF RECEIVER PANEL TEST NO. 14

Description: Cloud Transients - South Minimum & Maximum

- Operate receiver as a south boiler panel at 20% and 50% power and derated steam conditions

Objectives:

- Demonstrate control system performance
- Demonstrate delivery of dry steam
- Measure panel expansion and contraction to evaluate 30 year life
- Verify support system performance
- Demonstrate hydrodynamic stability
- Check flow distribution and uniformity

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to produce 0.20 and 0.75 Mwt absorbed power
- Establish steady-state derated steam condition
- Use modified start sequence to simulate cloud transient

Success Criteria:

- Conduct a simulated southern panel test at 0.2 to 0.74 Mwt absorbed power
- Introduce cloud transient simulation to confirm automatic control system control
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Control feedback is adequate to automatically operate with cloud transients
- Water entrainment data reflects only dry steam

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SHEET 5.4-17

STTF RECEIVER PANEL TEST NO. 15

Description: Emergency Shutdown Tests - South Panel

- Operate receiver as a south boiler panel at 100% power and rated steam conditions

Objectives:

- Demonstrate control system performance
- Verify support system performance
- Measure panel temperatures to evaluate life (30 year life)
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to produce 1.0 MWt absorbed power
- Establish steady-state rated steam conditions then initiate emergency shutdown

Success Criteria:

- Delivery of steam and test operations at 1.0 MWt absorbed power
- Enactment of emergency shutdown
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Measurement to indicate water entrainment in steam
- System control to indicate ability to accept shutdown without water entrainment in downcomer

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SHEET 5.4-18

STTF RECEIVER PANEL TEST NO. 16

Description: East Boiler Characteristics - Maximum Lateral Gradient

- Operate receiver as an east boiler panel at TBD% power and derated/rated steam conditions

Objectives:

- Measure panel wall temperatures to evaluate effects on lifetime
- Verify system performance during panel expansion and contraction
- Measure panel losses and performance
- Demonstrate delivery of dry steam
- Check flow distribution and uniformity
- Demonstrate hydrodynamic stability

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide TBD Mwt absorbed power
- Establish steady-state derated and rated steam conditions
- Lateral gradient may cause uniform expansion, which will require special monitoring

Success Criteria:

- Conduct satisfactory high lateral gradient test
- Demonstrate that thermal gradients do not damage receiver
- Confirm flow uniformity with high lateral gradient
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Heat flux transducers indicate gradient incident power
- Temperature profile reflects applied gradient
- DNB parameters (differential pressure and acoustic transducer) reflect steady interface levels

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SHEET 5,4-19

STTF RECEIVER PANEL TEST NO. 16 (Continued)

Special Requirements:

- Lateral gradient test

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SHEET 5.4-20

STTF RECEIVER PANEL TEST NO. 17

Description: Emergency Shutdown - East Panel

- Operate receiver as an east boiler panel at TBD% power and rated steam conditions

Objectives:

- Measure panel losses and performance
- Check flow distribution and uniformity
- Demonstrate hydrodynamic stability
- Demonstrate control system performance
- Verify support system performance
- Panel life evaluation

Approach/ Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to produce TBD MWt absorbed power
- Establish steady-state rated steam conditions
- Initiate emergency shutdowns to record data reflecting steam quality, response, and control

Success Criteria:

- Demonstrate satisfactory east panel test
- Demonstrate emergency shutdown
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Control Systems response adequately to prevent water entrainment in downcomer
- Recorded parameters reflect consistency in applied flux

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SHEET 5.4-21

STTF RECEIVER PANEL TEST NO. 18

Description: North Boiler Characteristics

- Operate receiver as a north boiler panel at 20 to 80% power and derated/rated steam conditions
- Retrim control valve for higher flow

Objectives:

- Investigate control system performance
- Measure panel losses and performance
- Demonstrate delivery of dry steam
- Check flow distribution and uniformity
- Demonstrate hydrodynamic stability

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Retrim receiver temperature control valve
- Use standard start-up procedure
- Apply heliostats to provide 0.5 MWt absorbed power
- Establish steady-state derated, or rated, steam conditions
- Increase absorbed power from 0.5 to 2.0 MWt by increasing heliostat application

Success Criteria:

- Maintain derated, and rated, steam outlet conditions as incident power is increased
- Confirm valve trim is satisfactory
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Valve ΔP and flow reflect stable control
- Flow dynamic and DNB parameters

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REV 6/8/78

SHEET 5.4-22

STTF RECEIVER PANEL TEST NO. 19

Description: Minimum North Power (Minimum Pressure Effects)

- Operate receiver as a north boiler panel at 20% power with inlet and outlet pressure variations

Objectives:

- Investigate control system performance
- Demonstrate hydrodynamic stability
- Check flow distribution and uniformity
- Measure panel losses and panel performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 0.5 Mwt absorbed power
- Establish steady-state derated, or rated, steam conditions
- Ramp outlet pressure and temperature profiles

Success Criteria:

- Maintain derated, and rated, steam conditions with variations in inlet and outlet pressures
- Demonstrate generation of steam and flow into downcomer
- Data acquisition is satisfactory
- Confirm controllability at off-design conditions

Performance Criteria Parameters:

- Demonstrate control with feedwater temperature variance

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SHEET 5, 4-23

STTF RECEIVER PANEL TEST NO. 20

Description: Minimum North Rated Power (Extreme Control Valve ΔP)

- Operate receiver as a north boiler panel at 50% power with inlet and outlet pressure variations

Objectives:

- Determine limits of valve trim, and minimum ΔP .
- Check flow distribution and uniformity
- Demonstrate hydrodynamic stability
- Support system performance
- Panel life evaluation
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 1.25 Mwt absorbed power
- Establish steady-state derated, or rated, steam conditions
- Modify procedure to vary inlet valve ΔP
- Outlet temperature and pressure profile controlled to meet design limits
- Upset steady-state with temperature and pressure changes

Success Criteria:

- Conduct a test cycle at 1.23 Mwt steam power
- Measure control valve ΔP and flow
- Vary control valve ΔP at steady state flow
- Data acquisition is satisfactory

Performance Criteria Parameters:

- H₂O valve minimum ΔP with control
- DNB measurements

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SHEET 5.4-24

STTF RECEIVER PANEL TEST NO. 21 & 22

Description: Minimum North Power (Inlet Temperature Effects)

- Operate receiver as a north boiler panel at 20 and at 50% with inlet temperature variations

Objectives:

- Demonstrate delivery of dry steam
- Hydrodynamic stability
- Control system performance
- Support system performance verification during thermal strain
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 0.5 and 1.25 MWt absorbed power as required
- Establish steady-state derated, or rated, steam conditions
- Vary inlet temperature
- Vary outlet temperature as required for derated or rated steam
- Design temperature profile to confirm satisfactory control at temperature limits

Success Criteria:

- Maintain derated, or rated, steam conditions with variations in feedwater temperature
- Satisfactorily conduct both tests at their respected levels of 0.5 and 1.23 MWt
- Demonstrate delivery of dry steam with various inlet temperature levels
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Steam pressure and temperature, with H₂O flow
- Dry steam determination

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SHEET 5.4-25

STTF RECEIVER PANEL TEST NO. 23

Description: Minimum North Power (Cloud Transients)

- Operate receiver as a north boiler panel at 20% power and derated steam condition

Objectives:

- Demonstrate control system performance
- Demonstrate delivery of dry steam with cloud transients
- Measure panel wall temperature to evaluate lifetime
- Confirm support system performance
- Hydrodynamic stability
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 0.5 MWt absorbed power
- Establish steady state derated steam condition
- Use modified procedure to introduce cloud transient perturbation simulation
- At steady-state induce partial transient levels to demonstrate flexibility of system to automatically react and control

Success Criteria:

- Conduct start-up/steady-state/shutdown at 0.5 MWt level
- Profile cloud cover transients to reflect system response and operation
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Demonstrate cloud perturbation response on flow, temperature, and water tank liquid level
- Confirm that only superheated steam flows into downcomer

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SHEET 5.4-26

STTF RECEIVER PANEL TEST NO. 24

Description: Reflector System Shakedown Test and Calibration-Reflector Test

- Operate receiver as a north boiler panel with reflector at TBD% power and derated/rated steam conditions

Objectives:

- Confirm operation of all components
- Confirm integrated operation with reflectors
- Conduct liquid flow calibration baseline test

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide TBD Mwt absorbed power
- Establish steady-state derated, or rated, steam conditions
- Using reflector procedure, establish and coordinate checkout
- Conduct water only calibration baseline test
- Confirm all components, and systems operate normally
- Reconfirm operation of all protective limits for reflectors

Success Criteria:

- Structural integrity of solar reflectors
- Ability to increase level of absorbed power
- Demonstrate integration of reflectors
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Reflector coolant system functions satisfactory
- Reflected incident power increases level to 2.5 Mwt
- Control system is satisfactory for increased power

Special Requirements:

- Activation of reflector array system

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SHEET 5.4-27

STTF RECEIVER PANEL TEST NO. 25

Description: Maximum North Power

- Operate receiver as a north boiler panel with reflector at 100% power and rated steam conditions

Objectives:

- Investigate effects of DNB
- Confirm support system performance
- Measure panel temperature to evaluate effect upon lifetime
- Demonstrate control system performance
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 2.5 MWt absorbed power
- Establish steady-state rated steam condition
- Initial steam test with reflector
- Establish reflector/panel operation mode

Success Criteria:

- Test cycle with power level to 2.5 MWt satisfactory
- Reflector operation satisfactory
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Complete test cycle at 2.5 MWt level
- Demonstrate operation with reflectors
- Data acquisition is satisfactory

Special Requirements:

- Confirm reflector operation

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SHEET 5.4-28

STTF RECEIVER PANEL TEST NO. 26

Description: Maximum North Power (Extreme Control Valve ΔP)

- Operate receiver as a north boiler panel with reflector at 100% power with inlet and outlet pressure variations

Objectives:

- Check flow uniformity and distribution
- Demonstrate hydrodynamic stability
- Determine minimum temperature control valve ΔP
- DNB phenomena effects
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Special Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 2.5 Mwt absorbed power
- Establish steady-state rated steam conditions
- Vary feedwater pressure to control valve ΔP
- If required, change trim on valve to establish optimum control characteristics
- At steady-state, reduce feedwater pressure to establish the lowest pump power requirements

Success Criteria:

- Test cycle with power level to 2.5 Mwt demonstrated
- Feedwater control valve ΔP is varied to determine minimum
- Recommended valve trim size is determined
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Steady resultant steam conditions with lower feedwater valve ΔP
- Differential pressure and acoustic measurements are satisfactory
- Steady-state operation

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SHEET 5.4-29

STTF RECEIVER PANEL TEST NO. 26 (Continued)

Special Requirements:

- Operate with lower feedwater pressure to conserve energy

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SHEET 5.4-30

STTF RECEIVER PANEL TEST NO. 27

Description: Maximum North Power (Inlet Temperature Effects)

- Operate receiver as north boiler panel with reflector at 100% power with inlet temperature variations

Objectives:

- Demonstrate delivery of dry steam
- Measure flow distribution and uniformity
- Demonstrate delivery of dry steam
- Hydrodynamic stability demonstration
- Control system performance
- Measure panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 2.5 MWt absorbed power
- Establish steady-state rated steam conditions
- Modify inlet temperature

Success Criteria:

- Test cycle with power to 25 MWt demonstrated
- The feedwater temperature control satisfactorily varied the temperature profile
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Demonstrate operation with feedwater temperature level changes
- Utilize all outlet temperature thermocouples for control

Special Requirements:

- Switch temperature control from thermocouple vote circuit to thermalwell

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SHEET 5.4-31

STTF RECEIVER PANEL TEST NO. 28

Description: Cloud Transients, Maximum North Power

- Operate receiver as a north boiler panel with reflector at 100% power and rated steam conditions

Objectives:

- Determine cloud transient effects
- Demonstrate control system performance during cloud transients
- Confirm delivery of dry steam with cloud interruptions
- Flow distribution and uniformity
- Panel losses and performance

Approach/Method: (Refer to Table 5.4-1 for Specific Operating Values)

- Use standard start-up procedure
- Apply heliostats to provide 2.5 MWt absorbed power
- Establish steady-state rated steam conditions
- Perturbate applied incident power to simulate cloud cover by defocusing heliostats

Success Criteria:

- Operation with cloud transient simulation
- Smooth control without water entrainment in downcomer
- Data acquisition to satisfactory

Performance Criteria Parameters:

- Absorbed power was 2.5 MWt
- Cloud transient profile reflected probable conditions of pilot plant
- Control of system flow was accomplished automatically without water entrainment in downcomer

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SHEET 5, 4-32

STTF RECEIVER PANEL TEST NO. 29

Description: Emergency Shutdown Tests, Maximum North Power

- Operate receiver as a north boiler panel with reflector at 100% power and rated steam conditions

Objectives:

- Establish emergency shutdown sequences based upon test results
- Demonstrate control system performance during shutdown
- Panel wall temperature effect upon life
- Panel thermal strain
- DiB phenomena
- Panel losses and panel performance

Approach/Method: (Refer to Table 5.4-1 for Special Operating Values)

- Use standard start-up procedure
- Apply incident power to establish 2.5 MWt absorbed
- Establish steady-state rated steam conditions
- Enact emergency shutdowns to demonstrate controls
- Continue test cycles to repeat to demonstrate dry steam

Success Criteria:

- Demonstrate shutdown modes which are satisfactory for pilot plant operations
- Performance data is satisfactory
- Data acquisition is satisfactory

Performance Criteria Parameters:

- Panel temperature to reflect transient heat transfer
- Full cycle with dry steam in downcomer
- Shutdowns to be smooth, without deleterious heating, or component interaction

Special Requirements:

- Introduce emergency shutdowns at various conditions

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SHEET 5.4-33

STTF RECEIVER PANEL TEST NO. 30

Description: 125% Maximum North Power

- Operate receiver as a north boiler panel with reflector at 125% power at rated steam conditions

Objectives:

- Effects of DNB phenomena
- Support system performance under extreme thermal strain
- Panel temperature to evaluate life expectancy
- Coating durability
- Fouling
- Panel losses and performance

Approach/Method: (Refer to Table 5.4-1. for Specific Operating Values)

- Use standard start-up procedure
- Apply incident power to produce 3.12 MWt absorbed power
- Establish steady-state rated steam conditions
- Monitor temperature limits to assure safe levels
- Conduct liquid flow calibration test at conclusion to determine if panel coating absorbtivity has changed

Success Criteria:

- Steady operation at 3.12 MWt
- Baseline calibration test data defines a method for panel efficiency determination
- High flux levels were not deleterious to panel
- Data acquisition is satisfactory

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SHEET 5.4-34

STTF RECEIVER PANEL TEST NO. 30 (Continued)

Performance Criteria Parameters:

- Differential pressure and acoustic measurement satisfactory
- Baseline calibration test indicates flux and absorbtivity
- Overall steam generation operation at high level is satisfactory

Special Requirements:

- Water flux calibration test at conclusion for baseline values

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SHEET 5.4-35

5.4.1 Receiver Prestart Procedure

<u>Action</u> By	<u>ACTION</u>
	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 = <u>TBD</u> to <u>TBD</u> psig
	RNPS-2 Normal range = <u>TBD</u> to <u>TBD</u> psig

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ction 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 $\begin{smallmatrix} +0 \\ -25 \end{smallmatrix}$ psig

RSRV 1700 $\begin{smallmatrix} +0 \\ -25 \end{smallmatrix}$ psig

RNHRV 300 $\begin{smallmatrix} +0 \\ -25 \end{smallmatrix}$ psig

RNLRV 25 $\begin{smallmatrix} +10 \\ -0 \end{smallmatrix}$ 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 GN₂ supply (above TBD psig) and record (___ psig).

RL B. Verify or position:

RWIV Closed

RBWISK Open

RBWDV Closed

RBSOV Open

RNMV Open

RNIV-1 Closed

RNLBV 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 GN₂ 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 GN₂. 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.

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5.4.1-2

Action By

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

<u>Valve</u>	<u>Switch</u>	<u>Indicator</u>
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.

<u>Valve</u>	<u>Switch</u>	<u>Indicator</u>
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:

<u>Valve</u>	<u>Enable Switch</u>	<u>Set Point Control</u>	<u>Indicator</u>
RADV	MOISTURE ACCUMULATOR LEVEL CONTROL	L ₁ ⁱ HIGH REF & L ₁ ⁱ LOW REF	RADV closed light on/off/on
RMDV	MANIFOLD LEVEL CONTROL	L ₂ ⁱ HIGH REF & L ₂ ⁱ LOW REF	RMDV closed light on/off/on
RFDV	FLASH TANK LEVEL CONTROL	L ₃ ⁱ HIGH REF & L ₃ ⁱ LOW REF	RFDV closed light on/off/on
RSVV	P CONTROL	P ⁱ REF	
	X ₂ CONTROL	X ₂ ⁱ REF	X ₂ position meter

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5.4.1-4

<u>tion By</u>	<u>Valve</u>	<u>Enable Switch</u>	<u>Set Point Control</u>	<u>Indicator</u>
	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 7. Engineering concurrence to proceed to start-up.
STTF

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5.4.1-5

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 <u>TBD</u> % open Q&T/C CONTROL off; Q LOW LIMIT set point at <u>TBD</u> lbm/sec; T REF set point at 500°F; VOTING CIRCUIT to <u>TBD</u> position; T/C SELECT to <u>TBD</u> 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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5.4.2 - 1

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

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

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
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RL E. System Blanket Pressure 10 ± 5 psig

STTF F. Heliostat System Ready

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5.4.2 - 2

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 <u>TBD</u> 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 $500 \pm$ TBD psig and RWIT at TBD°F.
RC/CC	G. Monitor filling of Moisture Trap and Receiver Manifold for <u>TBD</u> 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/sec² 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 $660 \pm \text{TBD } ^\circ\text{F}$.
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 $960 \pm \text{TBD } ^\circ\text{F}$ |
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/sec²
- 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

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5.4.2-1

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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5.4.3-2

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 1bm/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 X₁ 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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5.4.3-3

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 <u>close RBWDV</u> .
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 ± 5 psig for standby.
RC	N. Turn receiver controller operating console power OFF.
RL	O. Conduct engineering inspection of test assembly.

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5.4.3-4

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.

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SHEET 5.5-1

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

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SHEET **5.7-1**

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 I 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.

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SHEET 6.0-1

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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7.1-1

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.

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 GN₂ 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.

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7.2-4

TABL
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 Assembly (Moveable)	Electrical Control Harness Installation; Receiver to Controller
Vertical Flux Probe Installation and Details (Stationary)	Interface Drawing, Piping, Packaging Installation & Details	Electrical Control Harness Installation; Controller to STTF
Vertical Flux Probe Installation (Moveable)	Controller Wiring Diagram	Controller Component Locations
Handling Installation & Details	Console Layout	
Data Instrumentation Harness Installation		

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7.2-5

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.

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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 STTF 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.

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-1.2-8

3.0 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

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APPENDIX A
LIST OF DRAWINGS

<u>Drawing No.</u>	<u>Title</u>
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

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SHEET A-1

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

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SHEET A-2

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	NITROGEN	RNPS-1	UNITED ELECTRIC STOCK NO. J110A
-45B	DUAL-PRESSURE	RNPS-2	
-45C	SWITCHES	RNPS-3	
-45D		RNPS-4	

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