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LMFBR DEMONSTRATION PLANT STEAM GENERATING SYSTEM

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The following pages are an exact representation of what is in the original document folder.

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SPECIFICATION FOR STEAM GENERATOR WATER/STEAM CIRCULATION SYSTEM

FOR

LMFBR DEMONSTRATION PLANT

SPECIFICATION

FOR

THE STEAM GENERATOR WATER/STEAM CIRCULATION SYSTEM

FOR

THE 1000 MEGAWATT LMFBR DEMONSTRATION PLANT

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1.0 SCOPE

This specification defines the requirements for the design, material selection, fabrication, testing, inspection and installation of the sodium heated steam generator water/steam circulation system (SGWCS) for the 1000 MWt LMFBR Demonstration Plant and specifies the CE SGWCS Design in compliance with these requirements.

1.1 ABBREVIATIONS AND ACRONYMS

A. LMFBR - Liquid Metal Fast Breeder Reactor

B. SGWCS - Steam Generator Water/Steam Circulation System

C. ASME - American Society Mechanical Engineers

D. ANSI - American National Standards Institute

E. RDT - Reactor Development Technology

F. AEC - Atomic Energy Commission

G. MCR - Maximum Continuous Rating

H. CR - Circulation Ratio

1.2 PURPOSE OF EQUIPMENT

SGWCS equipment is an integral part of a 1000 MWt LMFBR Demonstration Plant design. As part of the Demonstration Plant design, the SGWCS delivers superheated steam to drive a turbine-generator system.

A. The reactor shall use three (3) primary and three (3) secondary sodium loops. One SGWCS will be connected to each secondary loop. A total of three (3) Steam Generator Water/Steam Systems (SGWCS) shall be used in the LMFBR Demonstration Plant design.

B. The SGWCS covered by this specification is designed to absorb reactor generated heat from the secondary sodium loop by means of producing steam in the evaporators and superheaters. The SGWCS, using the principle of water recirculation in the water evaporator section of the steam generator, shall produce a reliable supply of superheated steam to a turbine and remove decay heat during shutdown.

Each SGWCS contains three (3) sodium heated evaporators, three (3) sodium heated superheaters, steam drum, three (3) recirculating pumps, valves and connecting piping.

(See SGWCS Schematic Arrangement - Appendix "C")

1.3 COMPONENTS AND SERVICES TO BE PROVIDED

A. The design of the SGWCS contains several related systems that are part of the SGWCS but are not included in this specification;

they are:

(1) The evaporator and superheater vessels (to ends of nozzles).

(2) Evaporator and superheater vessel inlet and outlet isolation valves.

(3) Evaporator and superheater vessel dump valves.

(4) The water/steam dump system.

(5) The SGWCS control system.

B. The pressure part terminal points of the SGWCS are (but not including):

(1) The feedwater stop and check valve arrangement.

(2) The evaporator inlet nozzles.

(3) The evaporator dump valves.

(4) The evaporator outlet nozzles.

(5) The superheater inlet nozzles.

(6) The superheater dump valves.

(7) The superheater outlet nozzles.

(8) The common superheater steam lead to the turbine.

C. Components and services that shall be supplied include the following:

(1) Three (3) complete steam generator water/steam circulation systems as described in Sections 11.0 and 1.3 A and B.

(2) Instrumentation with connections.

(3) Thermal insulation.

(4) Circulating pump miscellaneous high pressure piping.

(5) Structural attachments and lifting lugs.

(6) Drain and vent connections with double valves.

(7) Safety valves.

(8) Terminal point connections with butt welded ends.

(9) Drawings and instruction manuals.

(10) RDT and Code Procedure Committments, such as reports, certifications, tests, etc.

(11) Special tools and spare parts, if they are required, for maintaining the SGWCS.

(12) Services of an engineer to supervise the Steam Generator Water/Steam installation and to instruct personnel in operation and maintenance of the system.

(13) Delivery of equipment to the plant site.

D. Components and services that shall not be supplied include the following:

(1) All piping external to the SGWCS such as piping downstream of the drain vent double valves, safety valve discharge piping and silences, etc.

(2) Circulating pump miscellaneous low pressure piping.

(3) All unloading, storage, field erection labor, crane service, rigging and logging, and tools, except those special tools furnished with the SGWCS.

(4) Foundation and structure for supporting the SGWCS.

2.0 APPLICABLE DOCUMENTS

The following documents are a part of this specification except where specified herein. Those amendments in effect on specification date issue, shall only apply unless otherwise specified. Where the specification appears to conflict with the requirements of the referenced document, such conflict shall be brought to the attention of the specification issuer for resolution.

2.1 REACTOR DEVELOPMENT AND TECHNOLOGY (RDT) STANDARDS

RDT C 7-2T*	Thermocouple Material, Iron-Constantan, Magnesium-Oxide Insulated, Sheathed
RDT C 7-4T*	Thermocouple Material, Iron-Constantan, Magnesium-Oxide Insulated, Sheathed
RDT C 7-6T*	Thermocouple Assembly, Nuclear Grade, Chromel-P vs Alumel, Stainless Steel Sheathed, Magnesium-Oxide Insulated
RDT E 15-2T*	Requirements for nuclear components (supplement to ASME Boiler and Pressure Vessel Code, Section III).
RDT F 2-2T*	Quality Assurance Program Requirements
RDT F 3-6T*	Non-Destructive Examination
RDT F 3-37T*	Special Requirements for Metal Products
RDT F 4-20T*	Operation and Maintenance Manuals

Identification No.	
RDT F 5-11*	Cleaning and Cleanliness Requirements for Nuclear Requirements
RDT F 6-5T*	Welding Qualifications (Supplement to ASME Boiler & Pressure Vessel Code, Section IX)
RDT F 6-7T*	Requirements Concerning Welding
RDT F-6-10T*	Repair of Materials by Welding
RDT F 6-11T*	Requirements for Subassembly Fabrication and Marking
RDT F 7-2T*	Preparation for Sealing, Packaging, Packing and Marking of Components for Shipment and Storage
RDT F 7-3T*	Requirements for Identification marking of Reactor Plant Components and Piping
RDT F8-1T*	Pre-loading Threaded Fasteners and closures*
RDT F 8-6T*	Requirements for Hoisting and Rigging.
RDT F 9-1T*	Requirements for Nuclear Components at Elevated Temperatures (Supplement to ASME Elevated Temperature Code 1331)
RDT 2-4T*	Requirements for establishing and execution of a program by the contractor to verify the quality of items and services
RDT 3-4T*	Calibration System to Control Accuracy of Measurement and Test Equipment

All material RDT Standards that are applic-able to the SGWCS design (to be provided later).

* "T" which appear at the end of RDT Standard numbers designates approval for use as "Tentative" standard

2.2 AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) CODES

The SGWCS shall be designed to ASME Boiler and Pressure Vessel Code with Addenda and applicable Code Cases:

NOTE - The design of the SGWCS will require various sections of the Code to apply; see Schematic SGWCS Code Responsibility Sketch in Appendix "C".

Section III Class 1	Power Boilers
Section III Code Case 1331-7	Power Boilers
Section I	Power Boilers
Section IX	Welding Qualifications

2.3 AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) STANDARDS

ANSI B1.1	Unified Screw Threads
ANSI B16.9	Wrought Steel Butt Welding Fittings
ANSI B16.26	Buttwelding Ends for Pipe, Valves, Flanges and Fittings
ANSI B31.1.0	Power Piping
ANSI B46.1	Surface Texture
ANSI Y14	Drafting Manual

3.0 REQUIRED TECHNICAL FUNCTIONS AND DESIGN FEATURES

3.1 REQUIRED TECHNICAL FUNCTIONS

The SGWCS shall:

A. Absorb reactor generated heat from the secondary sodium loop by means of evaporators and superheaters to produce a stable supply of superheated steam to the turbine.

B. Remove decay reactor generator heat from the secondary sodium loop during shutdown and emergency conditions.

C. Ensure proper boilerwater recirculation supply to the evaporators and steam flow to the superheaters at normal and upset, emergency and faulted operations.

D. Minimize the effects of a possible water - to - sodium leak.

E. Provide design rated superheated steam, from evaporators and superheaters inservice, to the turbine throttle consistent with the number of evapoartor and superheater modules that may be out of service for repair.

3.2 REQUIRED TECHNICAL DESIGN FEATURES

3.2.1 Required Process Parameters

The SGWCS shall be designed to meet the following process parameters:

A. The SGWCS shall be designed to meet Maximum Continuous Rating (MCR) conditions listed in Table 1:

TABLE 1

Maximum Continuous Rating (100% Load) Design Process Parameters

Note: The LMFBR Plant has three (3) steam generator water/steam circulation systems. This table is for one (1) SGWCS.

	100% Load Design Conditions
Steam Flow - Lb/Hr - (rounded)	1,200,000
Steam Drum Pressure - psig	2,700
Superheater Outlet Pressure - psig	2,500
Superheater Outlet Temperature - F	900
Feed Water Drum Inlet Temperature - F	460
Thermal Rating - MWt	330

(Partial Listing - remainder to be provided at a later date)

B. Physical Properties and Purity of Feed Water

The Feed Water purity limits are given in Table II.

TABLE II

Properties	PPB
(1) Total dissolved solids	50 (max)
(2) Silica	20
(3) Iron	10
(4) Copper	2
(5) Oxygen	5
(6) Hydrazine	10
(7) PH	9.2 - 9.4

C. Physical Properties and purity of circulating water shall be held to feedwater properties and purity.

3.2.2 Required System Configuration

The LMFBR Demonstration Plant shall contain three (3) duplicate steam generator water/steam circulation systems(SGWCS) - one for each secondary sodium loop.

NOTE - See SGWCS Schematic Arrangement in Appendix "C".

A. Each system will contain three (3) evaporators and three (3) superheaters, steam drum, three (3) recirculating pumps, valves, piping, etc.

B. There shall be no piping interconnections between independent systems; however, the feedwater for all three (3) systems will come from a common source and the superheater steam leads from all three (3) systems will be tied together for steam delivery to the turbine.

3.2.3 Flow Distribution

Each SGWCS produces high pressure superheated steam to the turbine generator in the following manner:

A. Feedwater is fed to the steam drum and recirculated with the boiler water by recirculating pumps to the evaporators.

B. Heat is transferred in the evaporators from the sodium to the water where it becomes partially vaporized.

C. The steam water mixture is separated into saturated steam and water in the steam drum.

D. The saturated water is recirculated with incoming feed water; the saturated steam is passed through the superheaters. where saturated steam is superheated to turbine conditions.

3.2.4 Evaporator Section Recirculation Requirements

The evaporator recirculation section of the SGWCS shall be designed to:

A. Produce an ample, predictable and stable circulation for normal operation over the load range and for upset, emergency, and faulted operating conditions.

NOTE - For operating definitions see Appendix "K".

B. Provide hydraulic flexibility to permit:

(1) Adjustment of circulation to individual evaporators.

(2) Increase in total water circulation flow.

(3) Incorporation of orifices at the inlet of the evaporators for operating stability.

C. Produce saturated steam of (to be provided later) quality to the superheaters to minimize unpredicable operation of the superheaters.

D. Supply water recirculation flow that does not contain entrained steam which may act as an internal feedwater heating device thus undermining the basic design parameters upon which the evaporators were designed.

E. Provide sufficient piping flexibility to permit temperature changes from 80 F - 690F without damage to piping and components.

3.2.5 <u>Superheater Section Requirements</u>

The superheater section of the SGWCS shall be designed to:

A. Provide ample and predictable steam flow for normal operation over the load range and for upset, emergency and faulted operating conditions.

B. Provide sufficient piping flexibility to permit temperature changes from 80F to 960F without damage to piping and components.

3.2.6 Structural Requirements

3.2.6.1 Design Objectives

Structural requirement details of the circulation system shall be evaluated for adequacy of heat transfer and structural integrity, through the design life time of 30 years and under all the steady state and transient conditions.

Structural design shall consider the effect of pressure, thermal and cyclic loadings for the design at normal and upset, emergency and faulted conditions.

Pressure parts shall be designed to withstand a full vacuum at operating temperature.

A. See Operating and Design Parameters - Appendix "B"

B. See Operational Descriptions and Thermal Transients in Appendix "K".

3.2.6.2 Stress Limits

Allowable stress limits for all materials used in the fabrication of the circulation system components and stress analysis procedures shall be in accordance with the applicable section of the ASME Boiler Pressure and Vessel Code and applicable RDT Standards.

3.2.6.3 Seismic Considerations

Static analysis shall be performed on Class 2 components.

A. Earthquake Zone 3

B. OBE Acceleration .2G Horizontal
.1G Vertical
acting simultaneously

3.2.6.4 Vibration

The SGWCS and all its parts shall be designed so that they shall not be damaged or caused to malfunction either by internally generated vibrations, such as, flow- induced vibrations, mechanical vibrations derived from pump operation and check valve slam action or by inpact loads caused by shipping.

3.2.6.5 Differential Thermal Expansion

The SGWCS shall accomodate differential thermal expansion for piping, tubing, and structural supports in a circulation system in accordance to applicable Sections of the ASME Codes.

3.2.6.6 Thermal Transients

Major pressure parts and piping components shall be designed to withstand the operating transients at normal and upset, emergency and faulted conditions using stress criteria of Section III of the ASME Boiler and Pressure Vessel Code.

A. See Operating Descriptions and Thermal Transients in Appendix "K".

3.2.6.7 Drum and Nozzle Loads

SGWCS drum and nozzles shall be designed to accommodate the piping loads to meet:

A. Maximum design flexibility requirements for normal and maximum upset operating conditions.

B. Operating transients at normal and upset, emergency and faulted conditions using criteria of Section III of the ASME Boiler and Pressure Vessel Code.

(1) See Operating Description & Transients - Appendix "K"

3.2.6.8 Sodium to Water Reaction

The SGWCS shall be designed to accommodate the shock forces caused by the quick isolation and dump of the steam/water side of the SGWCS during a water-to-sodium leak.

3.2.6.9 Deformation and Deflections

Deformations and deflections from all causes, including inelastic behavior, creep and ratchetting, shall be determined for all components, their supports and appurtenances in a manner consistent with excepted stress and structural analysis.

These deformations shall be evaluated for their effect on:

A. Functional requirements and assumed loading requirements.

B. Interface requirements for supports and appurtenances.

C. Safety and rupture.

D. Acceptability of visible deformations in subsequent service inspections.

3.2.6.10 Corrosion Allowances

A corrosion allowance for all pressure boundaries of the steam generator of the SGWCS shall be (to be provided later)

The allowance shall include compensation for the loss or degradation of material resulting from erosion, corrosion, intergranual penetration, chemical cleaning, and other environmental affects.

3.2.6.11 Failure Analysis

A failure and effects analysis evaluating the safety of the SGWCS design shall be performed.

The results of studies, analyses and evaluations shall be documented in a design report.

A. If a pipe rupture should occur, the loadings transmitted to the vessel by the broken pipe shall not impair structural integrity of the SGWCS and its supports.

3.2.7 Materials of Construction Requirements

Materials to be used in the construction of the SGWCS shall be selected from the RDT materials standards listed in paragraph 2.1 of this specification. In addition to the requirements of these standards, the selected materials shall conform to the requirements of the applicable ASME Code. Any materials proposed for use in the construction of the SGWCS which are not in accordance with the above requirements will be approved by the Specification issuer. All materials used in the construction of the SGWCS shall be (to be provided later).

The following factors shall be considered in order to obtain the optimum selection of materials used in constructing the steam generator:

A. Strength and creep properties at the operating temperature.

B. Resistance to stress-corrosion cracking.

C. Consistant with service requirements.

D. Resistance to the operating environment, including weld materials, cleaning agents, and inspection and testing agents, in addition to water-steam.

3.2.8 Instrumentation and Controls

A. Process instrumentation and controls shall be provided to monitor and control the steam generator for normal operation over the load range and for upset, emergency and faulted operating conditions. A list of instrumentation and controls is provided in Appendix "D" (to be provided later).

B. The SGWCS shall include provision for periodic inspection and calibration of control instrumentation.

C. The SGWCS shall include provision for removal and replacement of control instrumentation. Critical operating control instrumentation shall include redundancy, wherever possible, to minimize unscheduled shutdown of the unit.

3.2.9 Design Life

An expected service life of 30 years shall be used as a basis for the design. Components for which a 30 year life expectation cannot be reasonable assured shall be designed and installed to permit convenient replacement.

3.2.10 Safety Requirements

The design of the SGWCS shall meet the safety requirements of:

A. Applicable, local, state and national safety requirements.

B. Applicable sections of the LMFBR Demonstration Plant PSAR.

3.2.11. Required Maintenance and Operation Design

3.2.11.1 Maintenance Requirements

The following maintenance criteria shall apply to the design of the SGWCS:

A. The design shall permit access for removal, replacement and maintenance of system components.

3.2.11.1 MAINTENANCE REQUIREMENTS (continued)

B. The system shall be capable of complete drainage of pressure parts except in the bayonet tubes.

C. There shall be a capability for isolation of circulating pumps (no double valves) while the unit is in operation.

D. The system shall be designed for surveillance and in-service inspection of critical components as listed in (to be added).

3.2.11.2 Operation Requirements

The SGWCS shall be designed to provide:

A. Heating of the system from dry (inert gas) at ambient temperature to water/steam filled at 400°F at a rate of 50F/hr.

B. Satisfactory operation under normal and upset, emergency and faulted operating conditions as provided in Appendix "K":

C. Sufficient superheated steam to the turbine consistent with the number of evaporator and superheater modules in operation.

3.2.12 General Feature Requirements

A. The design of the SGWCS shall contain isolation valves to permit quick isolation and dump of the water/steam side of an evaporator and superheater following a water-to-sodium leak. The SGWCS shall be isolated and depressurized in (time-to be provided later).

The design shall permit physical removal of the failed component and permit steam generator operation with remaining components.

NOTE: This specification refers to but does not cover the steam/water side quick isolation valves, dump valves and dump system.

B. The SGWCS shall be capable of operation with one or two steam generating sets our of service.

Note: A steam generating set consists of one evaporator and one superheater-sodium connected.

C. The SGWCS design shall have the capability to remove reactor generated heat at shutdown and emergency conditions.

D. The SGWCS shall contain provision for relief of pressure caused by mal-operation using pressure relief valves installed on major components.

E. Venting, drain connections, connections for relief and safety valves, internal chemical feed lines, instrumentation taps, and any additional connections and appurtenances required shall be (to be provided later).

F. Clips and rings for supporting insulation shall be provided prior to final heat treatment. Requirements for insulation shall be (to be provided later).

4.0 FABRICATION REQUIREMENTS

Fabrication shall be in accordance with applicable RDT Standards and ASME Codes listed in Section 2.0 - Applicable Documents.

5.0 INSTALLATION AND FIELD SERVICE REQUIREMENTS

Installation and field service requirements shall be in accordance with applicable RDT Standards and ASME Codes listed in Section 2.0 - Applicable Documents.

6.0 REPORTS AND DOCUMENTATION REQUIREMENTS

Reports and documentation shall be in accordance with applicable RDT Standards and Codes listed in Section 2.0 - Applicable Documents.

7.0 DRAWING AND MANUAL REQUIREMENTS

Drawings and manuals shall be in accordance with RDT Standards and Codes listed in Section 2.0 - Applicable Documents.

8.0 QUALITY ASSURANCE REQUIREMENTS

Quality assurance requirements shall be in accordance with applicable RDT Standards and Codes listed in Section 2.0 - Applicable Documents.

9.0 PREPARATION FOR DELIVERY REQUIREMENT

Preparation for delivery shall be inaccordance with applicable RDT Standards and Codes listed in Section 2.0 - Applicable Documents.

10.0 GENERAL REQUIREMENTS

A. Services of an engineer to supervise the SGWCS installation and to instruct personnel in operation and maintenance shall be provided.

11.0 SPECIFICATIONS

The following information provides specific details of the CE design of the SGWCS for the 1000 MWt LMFBR Demonstration Plant in compliance with requirements outlined in Sections 1.0 to 10.0 of this specification.

11.1 System Arrangement

A. The SGWCS arrangement information is found in Appendix "C" in the following items:

(1) A schematic sketch of the evaporator and superheater water and steam side pressure parts.

(a) The SGWCS has three (3) evaporators, three (3) superheaters, one (1) steam drum and three (3) recirculating pumps, valves and connecting piping.

(b) The complete LMFBR Demonstrator Plant has nine (9) evaporators, nine (9) superheaters, three (3) drums and nine (9) recirculating pumps.

(2) Layout drawings - ND-723114, ND-723115 and ND-723116.

(3) A three-page summary of pressure parts - number, size and material.

Note - See Section 1.3 as not all components are included, provided, etc. by this specification.

B. The SGWCS piping arrangement from steam drum to circulating pumps makes use of C-E standard Controlled Circulation Boiler arrangement.

(1) Height of steam drum above recirculating pumps allows the design to meet all NPSH requirements.

(2) Flexibility loops have been installed in the supply piping from steam drum feeding the anchored evaporators.

11.2 <u>System Features</u>

11.2.1 <u>Steam Generator Water/Steam Circulation System Description</u>

The flow path is as follows (See Appendix "C" for drawings and pressure part size listings):

A. Feedwater flow is brought to the 60" ID steam drum through a 10-3/4" O.D. feedwater stop and check arrangement where it is fed through two (2) 8-5/8" O.D. lines into the drum.

B. The mixture leaves the drum (equal flow) through four (4) 12-3/4" O.D. downcomers.

C. The mixed fluid enters the 20" O.D. pump suction manifold where it is equally distributed to two (2) operating pumps, through 20" x 16" O.D. reducers and 16" O.D. pump suction valves.

D. Boiler water is discharged from the two (2) operating pumps, through 12-3/4" O.D. discharge valves and 14" O.D. discharge lines, to the 18" O.D. pump discharge manifold where it flows by means of two (2) 18" O.D. lines (with orifices) to the 16" O.D. evaporator inlet header.

E. The mixed water is fed equally to the three (3) individual evaporators through 16" O.D. isolation valves, where fluid is heated to a design steam/water mixture.

F. The steam/water mixture leaves the three (3) evaporators by 16" O.D. discharge lines with outlet isolation valves. The lines swage to 20" OD distribution bottles where the mixture is delivered uniformly over the drum length by means of 60-5" O.D. tubes.

G. The steam/water mixture enters C-E standard controlled circulation 60" I.D. drum internals where the steam and saturated water are separated.

H. The separated boiler water is reservoired in the drum and mixes with the incoming feedwater, and the mixture begins the recirculation flow path just described.

I. The separated saturated steam leaves the drum evenly over the drum length by 18-5" O.D. tubes where it enters a 14" O.D. saturated steam collection header.

J. The saturated steam proceeds by a 12-3/4" O.D. satchel handle and single 16" O.D. lead to a distribution bottle where it is fed equally, through 15-5" O.D. tubes, to the three (3) 14" O.D. superheater inlet leads.

K. The steam enters the three (3) individual superheaters, through 14" O.D. isolation valves, where it is heated to superheated steam.

L. The superheated steam discharges from the superheater, through three (3) 14" O.D. leads with isolation valves, to a 14" O.D. discharge manifold where it is fed by a 12-3/4" O.D. satchel handle to a single 16" O.D. superheater outlet lead.

M. Although it is not shown on drawings and sketches, the single superheater outlet leads from each independent SGWCS are tied together for steam delivery to the turbine throttle.

11.2.2 <u>SGWCS and Reactor Decay Heat Details</u>

In a manner similar to that described above the SGWCS is capable of removing reactor decay heat during shutdown and emergency conditions.

11.2.3 <u>SGWCS and Steam/Water Isolation and Dump</u>

A. The SGWCS is designed to quickly isolate and dump the water or steam from an evaporator or superheater component following a water-to-sodium tube leak in approximately (time- to be provided later).

B. The return to operation of the SGWCS a water-to-sodium leak, is described in Section 11.8.1.

NOTE: Isolation valves, dump valves and dump system are built into the SGWCS. However, they are not provided by this specification.

11.3 DETAIL SYSTEM PERFORMANCE CHARACTERISTICS AND GENERAL FEATURES

11.3.1 Evaporator Recirculation System

A. The design of the SGWCS shall use three (3) circulating pumps. Two (2) pumps are maintained in continuous operation while the third pump is maintained on hot standby.

(1) The recirculating pumps are placed on automatic control operation. The spare pump will be on hot standby service and will be placed into service in (to be added) seconds.

(2) Each pump has a suction and discharge valve for isolating a pump for repair. The other pumps are maintained in normal operation.

B. Two (2) circulating pumps provide a constant, stable and predictable water recirculation flow over the load range. The design of the pumps provide a circulation ratio (C.R.) of 3.5 for Maximum Continuous Rating (MCR) (CR increases as the load is decreased). The following features describe the performance of the recirculating pumps:

(1) The circulation system is designed to provide additional circulation capability to a CR of 4.0 at MCR on a permanent basis for two (2) circulating pump operation (See paragraph 11.3.1-D)

11.3.1 Evaporator Recirculation System (Continued)

B. (2) Pump performance curves are provided in Appendix "C" for two pump designs operating over a range of 3.5 and 4.0 CR.

(3) Operation of three (3) pumps will increase circulation by approximately 10% over the design flow. In a similar manner one pump operation produces approximately 68% of the design flow.

C. The design of the SGWCS permits the operation of any two of the three recirculating pumps without affecting the water distribution throughout the system.

D. The design of the SGWCS incorporates an orifice installed at the pump discharge side of the circulation system. The orifice provides a pressure drop into the system that can be removed or adjusted to increase boiler water circulation, to adjust the evaporator fluid distribution and to add stability to heated circuitry if it is required.
The orifice is installed in the lines feeding the evaporator inlet header form the pump discharge. However, the design of the evaporator may permit the installation of the orifice inside the evaporator units.

E. The design of the SGWCS uses a 60" I.D. conventional controlled circulation C-E steam drum with standard internals and associated system design. The steam drum design has proven successful application on units operating at the same pressure and temperature conditions. The steam drum shall be designed to provide the following conditions:

11.3

11.3.1 Evaporator Recirculation System (continued)

E. (1) The steam drum will provide steam of (to be provided later) quality and boiler water that is free from carryunder of entrained generator steam.

(2) Steam and water mixtures entering the drum internals and boiler water leaving the drum are uniformly distributed over the drum length to insure even water level and satisfactory drum internal operation regardless of which circulating pumps or evaporators are in operation.

11.3.2 Superheater Section

A. The design of the SGWCS shall provide stable and predictable steam distribution to the superheater units regardless of which superheater modules are in service.

B. Saturated steam leaves the steam drum uniformly over the drum length regardless of which superheaters are in service.

11.3.3 SGWCS General

Based on the definition and application of the ASME Code Documents as identified in Section 2.2, the design of the SGWCS shall provide:

A. Check and stop valves at the feedwater inlet of each steam drum.

B. Quick closing valves acting as stop valves at the outlet of each superheater.

11.4 DETAIL PROCESS PARAMETERS

The design of the SGWCS shall meet the required process parameters provided in Section 3.2.1.

11.5 COMPONENT DETAILS

11.5.1 Piping

The pipe sizing and arrangement for the SGWCS is based on stress, hydraulic analysis and operational requirements. Piping design and material are consistant with service requirements. The design of the piping for the SGWCS is provided in Appendix "C" and consists of:

A. Three (3) page summary of pressure parts piping.

(1) The SGWCS piping sizes are based on limiting the fluid and steam velocities to less than:

(a) 19 ft/sec for water

(b) 25 ft/sec for water/steam mixture

(c) 41 ft/sec for saturated steam

(d) 120 ft/sec for superheated steam

(2) Operating and design parameters listed in Appendix "B".

B. Process piping arrangement drawings ND-723114, ND-723115, and ND723-116.

11.5.2 Steam Drum

See Appendix "G" for steam drum sub-specification.

11.5.3 Recirculating Pump

See Appendix "H" for recirculating pumps sub-specification.

11.5.4 Recirculating Pump Suction and Discharge Valves

See Appendix "J" for recirculating pump suction and discharge valve specification.

11.5.5 SGWCS Protection Against Over-pressure - Safety Valves

11.5.5.1 Evaporator and Superheater Vessels

Safety relief valves for protection of the sodium heated SGWCS components against over-pressure will be provided.

11.5.5.1 Evaporator and Superheater Vessels (continued)

Safety relief valves will be selected in accordance with the requirements of Section I of ASME Boiler & Pressure Vessel Code. In general, the requirements of Para. PG-67.2 of Section I, will be followed in that the safety valve capacity shall be such that the valves will discharge all the steam that can be generated without allowing the pressure to rise more than 6% above the highest pressure at which the valve is set, and in no case to more than 6% above the maximum allowable working pressure (design pressure). Also, since each heat absorbing component of the sodium heated steam generator system is completely isolatable by quick closing valves, over-pressure protection is required in each of these components. Section I also requires at least two safety valves be installed on steam generating units of more than 500 sq. ft. of heating surface. Since both the evaporator and superheater components are much larger than this, at least two safety valves will be incorporated on each component.

In determining the relieving capacity for each evaporator and superheater component, the following logic was applied since there are no precise rules to follow in Section I. Each component was considered to be isolated on the steam/water side, while the sodium flow continues to transfer heat to the isolated component. For this condition, the relief capacity was calculated in order to prevent the pressure rise exceeding six (6%) percent above the design pressure, which is also the set pressure of the safety valves. This results, for the evaporator operating CR of 3.5; in a relieving capacity of 270,000 lbs/hr; whereas for the superheater filled with saturated steam, this results in a relieving capacity of 116,000 lbs/hr. Though the capacities may appear large, the corresponding valve required are the smallest standard

11.5.5.1 Evaporator and Superheater Vessels (continued)

Section I valves available at this pressure and temperature ratings. A CR of 4.0 requires negligible change in the size of the safety valves. The safety relief capacity of each valve installed in the evaporator shall be 135,000 lb/hr. The safety relief capacity of each superheater valve shall be 58,000 lbs/hr.

11.5.5.2 Steam Drum

For the steam drum relieving capacity, considering only the input for the three (3) evaporators, was calculated according to Appendix A-12 of Section I. this formula states that the relieving capacity shall equal 75% of the heat input divided by 1,100. This results in a required relief capacity of 510,000 lbs/hr for the steam drum. One 2-1/2" power operated control valve will be installed on the steam drum for operational control.

11.5.5.3 Evaporator Section

The relief capacity of the SGWCS evaporator section includes the relief capacity of three (3) evaporators and a steam drum. As a result, the total relief capacity is 1,320,000 lbs/hr (three evaporator units plus steam drum equals 270,000 lbs/hr x 3 plus 510,000 lbs/hr) which is greater than the 1,200,000 lbs/hr steam generator capacity for the three (3) evaporators. This does not include the capacity of the superheater safety valves which are not permitted by Para. CG 68.2 of Section I, because there are intervening valves between the evaporator and superheater components.

(1) Drawings of typical safety valves are in Appendix "C".

(2) Valves are listed in Appendix "E".

11.5.6 Steam/Water Isolation and Dump Valves

Steam/water isolation and dump valves are not covered by this specification.

11.5.7 Evaporator

Evaporators are not covered by this specification.

11.5.8 Superheater

Superheaters are not covered by this specification.

11.6 DETAIL INSTRUMENTATION AND CONTROLS

Process instrumentation, logic and controls for the SGWCS interface with the overall plant control system of the LMFBR Demonstration Plant. The following instrumentation and controls will be provided for the SGWCS:

A. Instrumentation for measuring and recording SGWCS process parameters and equipment operation such as flows, pressures, temperatures, drum level and steam conductivity.

(1) A list of instrumentation for the SGWCS is included (to be added).

(2) Process Parameters are included in Appendix "C".

(3) Back up instrumentation sensors are provided when such equipment is inaccessible for convenient maintenance. (A list to be provided later).

B. Following functions are performed by controls instrumentation but are not included in this specification:

(1) Steam drum water level control to hold water level within the required limits.

(2) Circulating pump controls for placing hot standby pump into operation following the loss of an operating pump, pump protection system pump start up and shut down.

11.6 DETAIL INSTRUMENTATION AND CONTROLS (Continued)

B. (3) Steam generator controls such as feedwater flow, steam flow, superheater outlet pressure, superheater outlet temperature controllers.

11.7 DETAILS OF FEATURES TO REDUCE THE EFFECTS OF HAZARDOUS CONDITIONS

The design of the SGWCS shall reduce the effects of a hazardoux condition:

A. Live steam problems are minimized by:

(1) Checking various parts of the system for leaks as the system pressure is increased during start up.

(2) Providing safety relief valves equipped with exhaust stacks which deflect any steam relief to inaccessible areas.

B. Water-to-sodium tube leak reaction is minimized by:

(1) Providing a steam generator water/steam isolation and dump system which isolates and dumps water/steam from evaporator-superheater combination into an inert gas blanketed collection chamber.

(2) Providing capability to relieve the pressure and reaction products generated on the steam generator sodium side.

NOTE: The systems in item (1) and (2) above are not covered by this specification.

C. Overpressure of pressure parts is minimized by:

(1) Providing an electrically operated actuator relief valve on the steam drum. This valve will be remotely operated from the control room, to relieve steam generator pressure.

(2) Providing self actuated relief valves in the SGWCS to maintain line and vessel pressures below design limits.

D. A list of operating alarms and corresponding corrective actions associated with the operation of the SGWCS and its components is included (to be added).

11.8 DETAIL OPERATION AND MAINTENANCE

11.8.1 Operation

The operation of the SGWCS shall meet the requirements established for upset, emergency and faulted conditions as outlined in 3.2.11.2.

A. Operating limitations of the SGWCS are provided as follows (partial listing-remainder to follow):

(1) Feedwater must be made available to the SGWCS in order to maintain water in the system to remove reactor decay heat during plant shutdown.

(2) The water level must be maintained within a tolerable limit in the drum if the circulating pumps are to function properly to prevent shutdown.

B. Operating steps for a recovery and return to normal operation are as follows:

(1) The entire system is shutdown, and the component requiring major repairs is cut out of the water and sodium pressure parts.

(2) The open end pressure parts are capped, and the remaining system is placed back into normal operation.

11.8.2 Maintenance

A. Routine maintenance activities will be performed during reactor outages. The SGWCS is designed to perform the following maintenance activities:

(1) Adjust and repair equipment in place.

(2) Replace components with spare unit (repair the disabled unit).

The design of the SGWCS shall provide the following maintenance features:

11.8.2 Maintenance (Continued)

B. The design of the SGWCS shall provide the following maintenance features:

(1) Items, such as motors, valves, actuators, sensors, etc. are designed and arranged to permit inspection, adjustment and repair.

(2) Sufficient space, handling equipment, and accessibility are provided to minimize maintenance activities.

(3) Critical operating items are designed to have redundancy to prevent unscheduled shutdown of the system.

(4) Provision to move large components from the building to a maintenance facility will be provided for such items as circulating pump motors, etc.

(Partial listing - additional listing to be added)

PAGES 32 to 33

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APPENDIX "A"

REFERENCES

(To be provided later)

APPENDIX "B"

Parameter List

This section contains engineering parameters for the SGWCS. (Page 35-A, 35-B, 35-C, 35-D and 35-E are a partial listing - the remainder to be added)

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER AEC STEAM GENERATOR CONT. NO. 7670 MADE BY — DATE —
LOCATION DWG. NO. ND723 114-0 CHK'D BY AP DATE 11/2/72

ΔP SUMMARY RECIRCULATION SYSTEM

	CR=3.5	CR=4.0
	ΔP	ΔP
ΔP DRUM TO PUMP –	2.55	3.33
ΔP PUMP TO DISCHARGE HDR –	1.83	2.43
ΔP DISCHARGE HDR TO EVAP IN –	5.67	7.48
ΔP ORIFICE –	23.80	8.41
ΔP EVAPORATOR –	25.00	32.80
ΔP MIXTURE TO DRUM –	7.51	8.92
TOTAL –	66.36 PSI	63.37 PSI
NHH –	2.17	1.98
TOTAL	64.19 PSI	61.39 PSI

PUMP DESIGN	CR = 3.5	CR = 4.0
HEAD – PSI	USE 64 PSI	USE 61 PSI
HEAD – FT	(64)(3.6) = 232 FT	(61)(3.66) = 224
GPM	6550	7600
HEAD PROVIDED BY IR & HT	* 247 FT @ 6550 GPM	224 FT @ 7600 GPM
PUMP DESIGN POINT DESIGNATION SYMBOLS ON ATTACHED IR & HT PUMP CURVES	A	B

* HIGHER THAN DESIGN HEAD MEANS ORIFICE ΔP AT CR OF 3.5 IS NOW 28.21 PSI (INSTEAD OF 23.8 PSI)

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER AEC STEAM GENERATOR CONT. NO. 7670 MADE BY — DATE —
LOCATION ________ DWG. NO. ND723119-0 CHK'D BY M.D DATE 11/2/72

APPROXIMATE WATER/STEAM WATER PRESSURES

	OPERATING PSIG	DESIGN PSIG	& TEMP
DRUM	2700	2840	688F
PUMP SUCTION	2720	2860	↓
PUMP DISCH.	2789	2910	↓
PUMP DISCH HDR	2782	↓	↓
EVAP INLET	2764	↓	↓
EVAP OUTLET	2710	↓	↓
DRUM INLET	2701	2840	↓
DRUM	2700	2840	↓

APPROXIMATE SAT AND SH'T'R STEAM PRESSURES

	OPERATING PSIG	DESIGN PSIG	& TEMP
DRUM	2700	2840	688F
S'H'T'R OUTLET "T"	2537	↓	960F
S'H'T'R OUTLET JUNCTION	2500	↓	960F
TURBINE THROTTLE	2400		

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY — DATE —
LOCATION DWG. No. ND723114-0 CHK'D BY [illegible] DATE 11/2/72

ΔP SUMMARY DRUM TO S'H'TR INLET

	ΔP
18-5" x 0.500 MWT SAT STEAM LINE -	3.32
14" x 11.125" ID SAT STEAM COLLECTION HDR-	—
2-12 3/4" x 1 1/4" AVG SAT STEAM INLET SATCHEL HANDLE	1.47
1-16" x 1 9/16 AVG SAT STEAM INLET LEAD	4.15
1-22" x 17.375" ID SAT STEAM DISTRIBUTION BOTTLE-	—
15-5" x 0.500 MWT SAT STEAM INLET LINE	4.05
3-14" x 1 5/16" AVG SAT STEAM SH'T'R INLET-	0.25
3-14" SH'T'R INLET QUICK CLOSING VALVE -	5.00
	18.24 PSI

ΔP SUMMARY S'H'T'R OUTLET TO S'H'T'R OUTLET "T"

	ΔP
~~3-14" SH'T'R OUTLET QUICK CLOSING VALVE~~	~~30.00~~
3-14" x 10.25" ID S'H'T'R OUTLETS	2.36
1-14" x 9.75" ID S'H'T'R OUTLET MANIFOLD —	—
2-12 3/4 x 9.25" ID S'H'T'R OUTLET SATCHEL HANDLE -	6.05
1-16" x 11.75" ID S'H'T'R OUT LEAD "T" —	5.90
	44.31 PSI

S'H'T'R ΔP SUMMARY

	ΔP
DRUM TO S'H'T'R INLET -	18.2
S'H'TR DROP	100.0
S'H'TR OUTLET TO LEAD "T"	44.3
	162.5 PSI

3.7.3.1 COMBUSTION ENGINEERING

CONTROLLED CIRCULATION BOILER — COMBUSTION ENGINEERING, INC.

PURCHASER AEC STEAM GENERATOR — CONTRACT NO. 7670

PLANT ______ DWG. NO. ______ DATE 10/4/72 BY DP

CIRCULATING PUMP PERFORMANCE & NPSH

A. Evaporation,	lb/hr	1,200,000	F. Drum operating press,	psig	2700
B. Pump head,	psi	61.4 (224 Ft)	G. Sat. temp. in drum,	deg F	680.3
C. Pump efficiency,	pct	82	H. Enthalpy, sat. water,	btu/lb	[illegible]
D. Motor efficiency,	pct		I. Temp., feedwtr. to drum,	deg F	460
E. Number of pumps operating		2 of 3	J. Enthalpy, feedwater,	btu/lb	442

ITEM	UNITS	CALCULATING STEP	NORMAL OPERATION	MAXIMUM DESIGN
1. Drum pressure	psig		2700	2840 *
2. Circulation Ratio, CR			4.0	SATURATED WATER
3. Total circulation	lb/hr	CR x Item A	4,800,000	
4. Circulation per pump	lb/hr	Item 3 ÷ Item E	2,400,000	
5. Heat in (CR-1) lb sat. water	btu	(CR-1) x Item H	2280	
6. Heat in CR lb mixed water	btu	Item 5 + Item J	2722	
7. Enthalpy mixed water	btu/lb	Item 6 ÷ CR	680	
8. Mixed water temperature	deg F		645	687.9
9. Mixed water specific volume	cu ft/lb	(DT-94-0)	0.0254	0.03205
10. Volume flow per pump	cfs	Item 4 x Item 9(Norm. Oper.) / 3600	16.9	
11. Volume flow per pump	gpm	449 x Item 10	7600	
12. Feet mixed water per psi	ft/psi	144 x Item 9	3.66	4.61
13. Elevation, pump to drum level	ft		80	80
14. Elevation head	psi	Item 13 ÷ Item 12	21.80	17.30
15. Diam. at pump suction	in.		12.875	12.875
16. Flow area at pump suction	sq ft		0.90	0.90
17. Velocity at pump suction	fps	Item 10 ÷ Item 16	18.8	18.8
18. Velocity head at pump suction	psi	(Item 17)^2 ÷ (Item 12x64.4)	1.5	1.19
19. Static suction head	psi	Item 14 - Item 18	20.30	16.11
20. Losses, drum to pump	psi		3.32	2.66
21. Static head - losses	psi	Item 19 - Item 20	16.97	13.45
22. Pump suction pressure	psig	Item 1 + Item 21	2717	2854
23. Sat. temp. at suction press.	deg F		681.3	688.6
24. Sat. press. at mixed water temp.	psig		2119	2840 *
25. Available NPSH	psi	Items (1-24 + 14-20)	592.47	14.64
26. Available NPSH	ft	Items 25 x Item 12	22.00	67.50
27. Mixed water specific gravity		0.016 ÷ Item 9	0.63	* Denotes Common Entry
28. Water horsepower, normal oper.	hp	Item 11 x Item B ÷ 1715	272	
29. Water horsepower, cold water	hp	Item 28 ÷ Item 27	431	
30. Pump brake horsepower, normal	hp	Item 28 ÷ Item C	332	
31. Pump brake horsepower, cold water	hp	Item 29 ÷ Item C	526	
32. Motor elec. power, normal oper.	kw	Item 30 ÷ (Item D x 1.341)		
33. Motor elec. power, cold water	kw	Item 31 ÷ (Item D x 1.341)		
34. Pump head at max. design press.	psi	Item B x Item 9(Norm. Oper.) / Item 9(Max. Des.)		48.8
35. Pump design pressure	psig	Items (1 + [illegible])		2905
36. Pump hydrostatic test press.	psig	1.5 x Item 35		4360

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3.7.3.1

COMBUSTION ENGINEERING

CONTROLLED CIRCULATION BOILER
PURCHASER AEC STEAM GENERATOR
PLANT ____________ DWG. NO. ND723114-0

COMBUSTION ENGINEERING, INC.
CONTRACT NO. 7670
DATE 10/4/72 BY DP

CIRCULATING PUMP PERFORMANCE & NPSH

A. Evaporation,	lb/hr	1,200,000	F. Drum operating press,	psig	2700
B. Pump head,	psi	68.6 (247 Ft)	G. Sat. temp. in drum,	deg F	680.3
C. Pump efficiency,	pct	0.81	H. Enthalpy, sat. water,	btu/lb	759.3
D. Motor efficiency,	pct		I. Temp., feedwtr. to drum,	deg F	460
E. Number of pumps operating		2 of 3	J. Enthalpy, feedwater,	btu/lb	442

ITEM	UNITS	CALCULATING STEP	NORMAL OPERATION	MAXIMUM DESIGN
1. Drum pressure	psig		2700	2840 *
2. Circulation Ratio, CR			3.5	SATURATED WATER
3. Total circulation	lb/hr	CR x Item A	4,200,000	
4. Circulation per pump	lb/hr	Item 3 ÷ Item E	2,100,000	
5. Heat in (CR-1) lb sat. water	btu	(CR-1) x Item H	1900	
6. Heat in CR lb mixed water	btu	Item 5 + Item J	2342	
7. Enthalpy mixed water	btu/lb	Item 6 ÷ CR	668	
8. Mixed water temperature	deg F		639	637.9
9. Mixed water specific volume	cu ft/lb	(DV-94-0)	0.025	.03205
10. Volume flow per pump	cfs	Item 4 x Item 9 (Norm. Oper.) / [illegible]	14.6	
11. Volume flow per pump	gpm	449 x Item 10	6550	
12. Feet mixed water per psi	ft/psi	144 x Item 9	3.6	4.61
13. Elevation, pump to drum level	ft		80	80
14. Elevation head	psi	Item 13 ÷ Item 12	22.2	17.3
15. Diam. at pump suction	in.		12.875	12.875
16. Flow area at pump suction	sq ft		0.90	0.90
17. Velocity at pump suction	fps	Item 10 ÷ Item 16	16.3	16.3
18. Velocity head at pump suction	psi	$(\text{Item } 17)^2$ ÷ (Item 12x64.4)	1.15	0.90
19. Static suction head	psi	Item 14 - Item 18	21.05	16.40
20. Losses, drum to pump	psi		2.55	2.00
21. Static head - losses	psi	Item 19 - Item 20	18.50	14.40
22. Pump suction pressure	psig	Item 1 + Item 21	2719	2954
23. Sat. temp. at suction press.	deg F		681.4	682.6
24. Sat. press. at mixed water temp.	psig		2031	2840 *
25. Available NPSH	psi	Items (1-24 + 14-20)	688.65	15.30
26. Available NPSH	ft	Items 25 x Item 12	2480	70.50
27. Mixed water specific gravity		0.016 ÷ Item 9	0.64	* Denotes Common Entry
28. Water horsepower, normal oper.	hp	Item 11 x Item B ÷ 1715	262	
29. Water horsepower, cold water	hp	Item 28 ÷ Item 27	408	
30. Pump brake horsepower, normal	hp	Item 28 ÷ Item C	324	
31. Pump brake horsepower, cold water	hp	Item 29 ÷ Item C	505	
32. Motor elec. power, normal oper.	kw	Item 30 ÷ (Item D x 1.341)		
33. Motor elec. power, cold water	kw	Item 31 ÷ (Item D x 1.341)		
34. Pump head at max. design press.	psi	Item B x Item 9 (Norm. Oper.) / Item 9 (Max. Design)		53.5
35. Pump design pressure	psig	Items (1 + [illegible])		2910
36. Pump hydrostatic test press.	psig	1.5 x Item 35		4370

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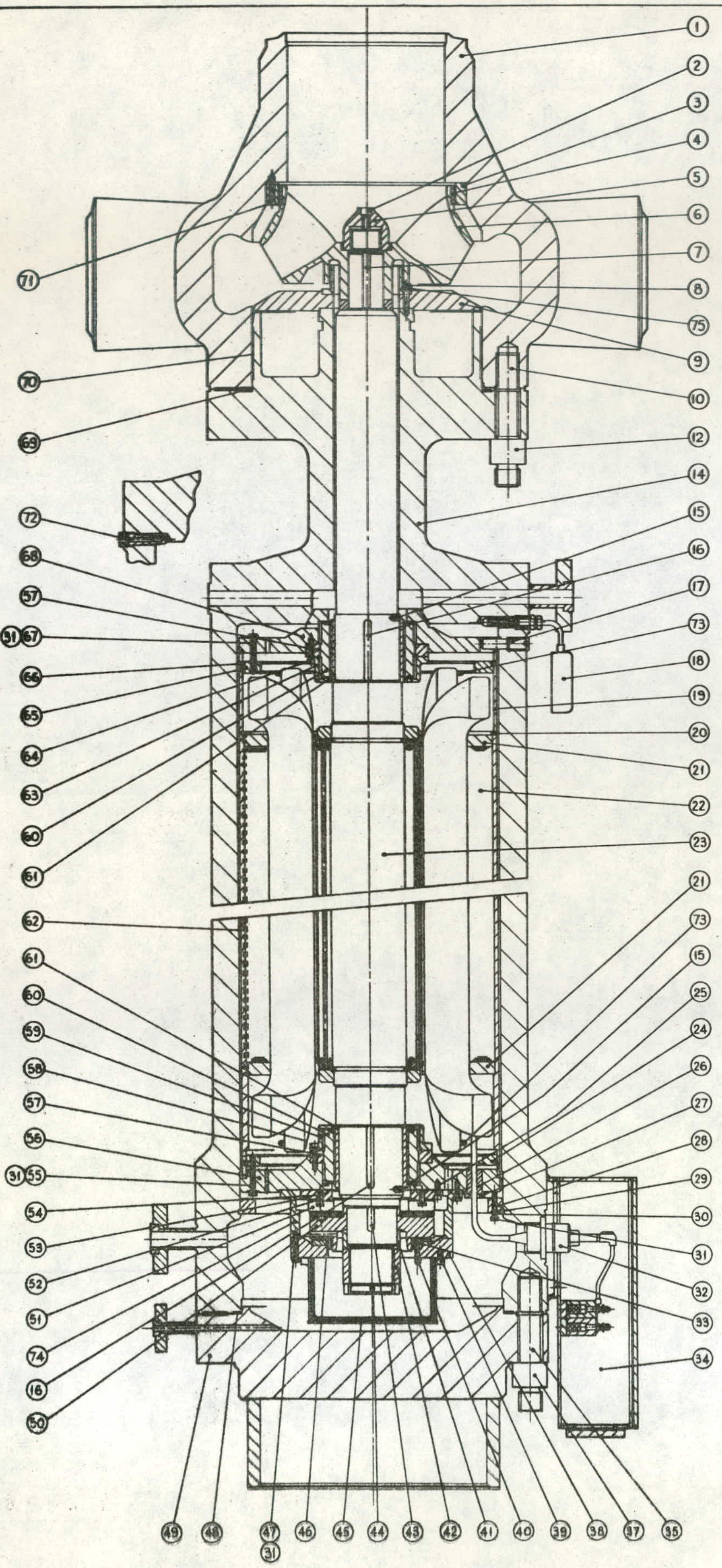
Appendix C

Drawings

1.	DEV 1293	Schematic Code Responsibility Sketch
2.	ND-723114-0	Water/Steam Circulation System Elevation
3.	ND-723115-0	Water/Steam Circulation System - Plan View
4.	ND-723116-0	Water/Steam Circulation System - View A-A
5.	DEV 1289	Steam Generator Water/Steam Circulation System Schematic Arrangement
6.	DEV 1290-a 1290-b 1290-c	Three (3) page summary of SGWCS Pressure Parts
7.	DEV 1292-a 1292-b	Two (2) Estimated Recirculating Pump Performance Curves (1292-a = Hayward Tyler and 1292-b = Ingersoll Rand)
8.	40745/D/2	Circulating Pump Drawing
9.		Safety Valve Drawings (to be provided later)
10.		Recirculating Pump Suction and Discharge Valve Drawings (to be provided later)
11.	DEV 1294	Typical Arrangement of Internal 60" Steam Drum
12.	7670-1E 1402 7670-1E 1407 7670-1E 1408 7670-1B 1457 7670-1B 1458 767 -1C 1446	Drum and Drum Detail Drawings
13.	SK #07670273-0	Drum Internal Analysis Sheet
14.	E-679-677-2	Flow Diagram For Circulating Pumps

ISSUE G7280



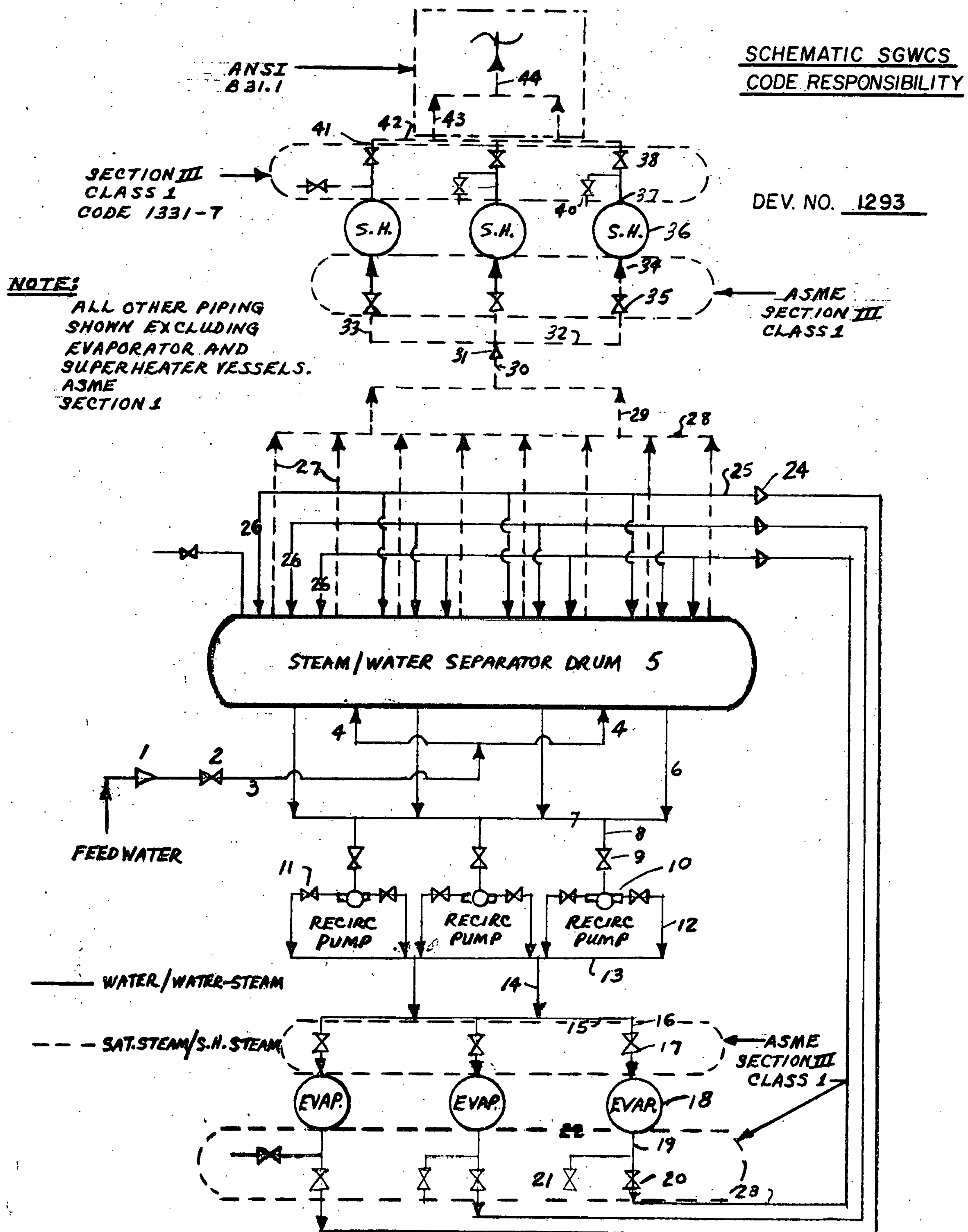
REF.	DESCRIPTION	Nº OFF	MATERIAL
1	PUMP CASE	1	S.A.216 GRD. W.C.B.
2	SKT. HD. CAP SCREW 5/8" U.N.C.	1	A.I.S.I. TYPE 413
3	CASE WEAR RING	1	S.A.57 GRD. C6
4	IMPELLER WEAR RING	1	S.A.351 GRD. CF8C STELLITED
5	IMPELLER NUT	1	A.I.S.I. TYPE 431
6	IMPELLER	1	S.A.351 GRD. CF 8C
7	IMPELLER KEY	1	A.I.S.I. TYPE 431
8	SECURING SCREW 1/2" U.N.C. HEX. HD.	6	A.I.S.I. TYPE 1020
9	BAFFLE PLATE	1	S.A.306 GRD.60
10	STUD	24	S.A.540 GRD. B21 CLASS 5
11			
12	NUT	24	S.A.194 GRD.7
13			
14	MOTOR CASE	1	S.A.105 GRD.2 WELDABLE
15	JOURNAL LOCKING SCREW	2	S.A.306 GRD.60
16	JOURNAL KEY	2	S.A.306 GRD.60
17	BTM. BRG. STOP PEG	1	S.A.306 GRD.60
18	THERMOMETER	1	——
19	STATOR SHELL	1	S.A.306 GRD.60
20	SPLIT RING	1	S.A.306 GRD.60
21	STATOR END PLATE	1	A.S.T.M. A351 GRD. CF 8C
22	STATOR LAMINATION	42"	FERROSIL 158
23	ROTOR ASSY.	1	——
24	CLAMP RING STATOR SHELL COVER END	1	S.A.306 GRD.60
25	SKT. HD. CAP SCREW 3/8" U.N.C.	6	A.I.S.I. TYPE 431
26	SPLIT BUSH	3	FEROBESTOS
27	SKT. HD. CAP SCREW	12	A.I.S.I. TYPE 431
28	LOCK RING MOTOR CASE	1	S.A.306 GRD.60
29	SPLIT RING MOTOR CASE	1	S.A.306 GRD.60
30	LOCK RING SCREW 5/8" U.N.C.	12	S.A.193 GRD. B7
31	LOCKING WIRE	—	——
32	CABLE SEAL ASSY.	3	——
33	SKT. HD. CAP SCREW	6	A.I.S.I. TYPE 431
34	TERMINAL BOX ASSY.	1	
35	STUD	24	S.A.540 GRD. B21 CLASS 5
36			
37	NUT	24	S.A.194 GRD.7
38	REVERSE THRUST SEAT	1	S.A.306 GRD.60
39	SKT. HD. CAP SCREW	4	A.I.S.I. TYPE 431
40	PHILADAS NUT	6	S.A.306 GRD.60
41	THRUST DISC SPACER SAVE	1	S.A.306 GRD.60
42	THRUST NUT	1	S.A.306 GRD.60
43	THRUST DISC KEY	1	S.A.306 GRD.60
44	SPLIT COTTER PIN	1	S.A.306 GRD.60
45	FILTER ASSY.	1	——
46	REVERSE THRUST PLATE	1	FEROBESTOS
47	HEX. HEAD SCREW 3/8" U.N.C.	6	S.A.193 GRD. B7
48	GASKET - FLEXITALLIC	1	TYPE 304 S.S. & ASBESTOS
49	MOTOR COVER	1	S.A.105 GRD.2 WELDABLE
50	THRUST DISC	1	S.A.306 GRD.60 & FEROBESTOS
51	THRUST PADS	10	A.I.S.I. TYPE 431
52	THRUST PAD STOP	10	A.I.S.I. TYPE 431
53	THRUST SEAT	1	A.I.S.I. TYPE 431
54	SPLIT COTTER PIN	10	S.A.306 GRD.60
55	HEX. HEAD SCREW 1/2" U.N.C.	12	S.A.193 GRD. B7
56	BEARING HOUSING - COVER END	1	S.A.306 GRD.60
57	BEARING RING	2	A.I.S.I. TYPE 431
58	SKT. HD. CAP SCREW 3/8" U.N.C.	4	A.I.S.I. TYPE 431
59	SECURING RING - COVER END	1	S.A.306 GRD.60
60	TILTING PAD	2 SETS 6 EACH	A.I.S.I. TYPE 431
61	JOURNAL SLEEVE	2	S.A.306 GRD.60 & FEROBESTOS
62	STATOR KEY	1	CARBON STEEL
63	SECURING RING - PUMP END	1	S.A.306 GRD.60
64	SKT. HD. CAP SCREW 3/8" U.N.C.	6	A.I.S.I. TYPE 431
65	CLAMP RING - STATOR SHELL PUMP END	1	S.A.306 GRD.60
66	SPLIT RING - STATOR SHELL	2	S.A.306 GRD.60
67	HEX. HEAD SCREW 1/2" U.N.C.	12	S.A.193 GRD. B7
68	BEARING HOUSING - PUMP END	1	S.A.306 GRD.60
69	GASKET - FLEXITALLIC	1	TYPE 304 S.S. & ASBESTOS
70	IMPELLER WASHER	1	S.A.306 GRD.60
71	SKT. HD. CAP SCREW 5/16" U.N.C.	6	A.I.S.I. TYPE 431
72	THERMOWELL	1	A.I.S.I. TYPE 347
73	WINDING SUPPORT	2	BRASS BAR & PERBUNAN
74	BEARING HOUSING CYLINDER	1	S.A.306 GRD.60
75	TAB WASHER	6	A.I.S.I. TYPE 1020

C.E.I. PURCHASE ORDER Nº 1003025
C.E.I. CONTRACT Nº 7869 - BCC
C.E.I. CUSTOMER - PUBLIC SERVICE OF COLORADO
USE - BOILER WATER CIRCULATING PUMPS WITH MOTORS - HAYWARD TYLER

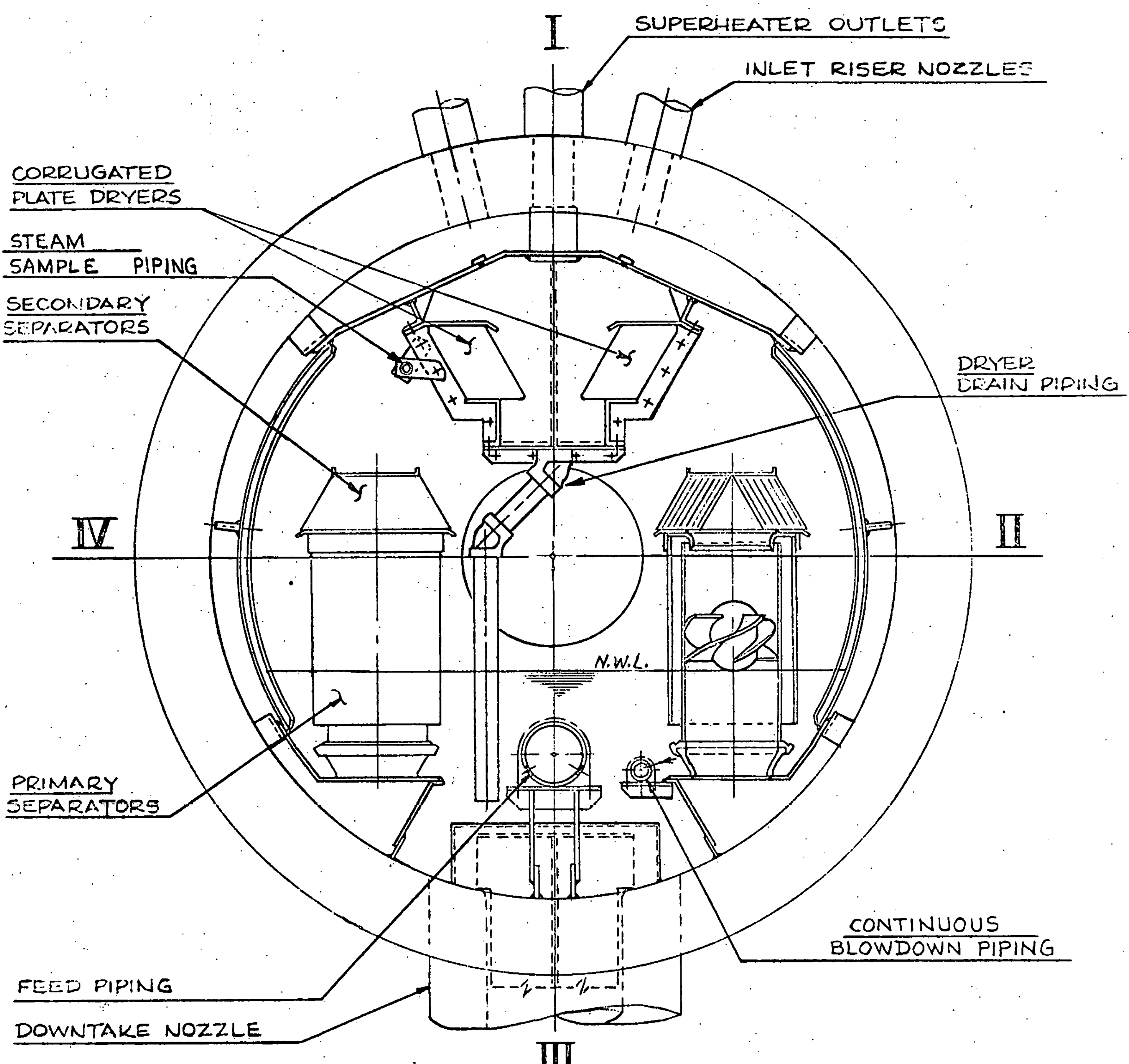
NOTE:
FOR TRUE RADIAL POSITIONS OF CONNECTIONS & TERMINAL BOX SEE DRG. Nº 40745/1

HAYWARD TYLER G.M.P.U. TYPE Y. 750. H.4.70.

DRAWING Nº 40745/D/2

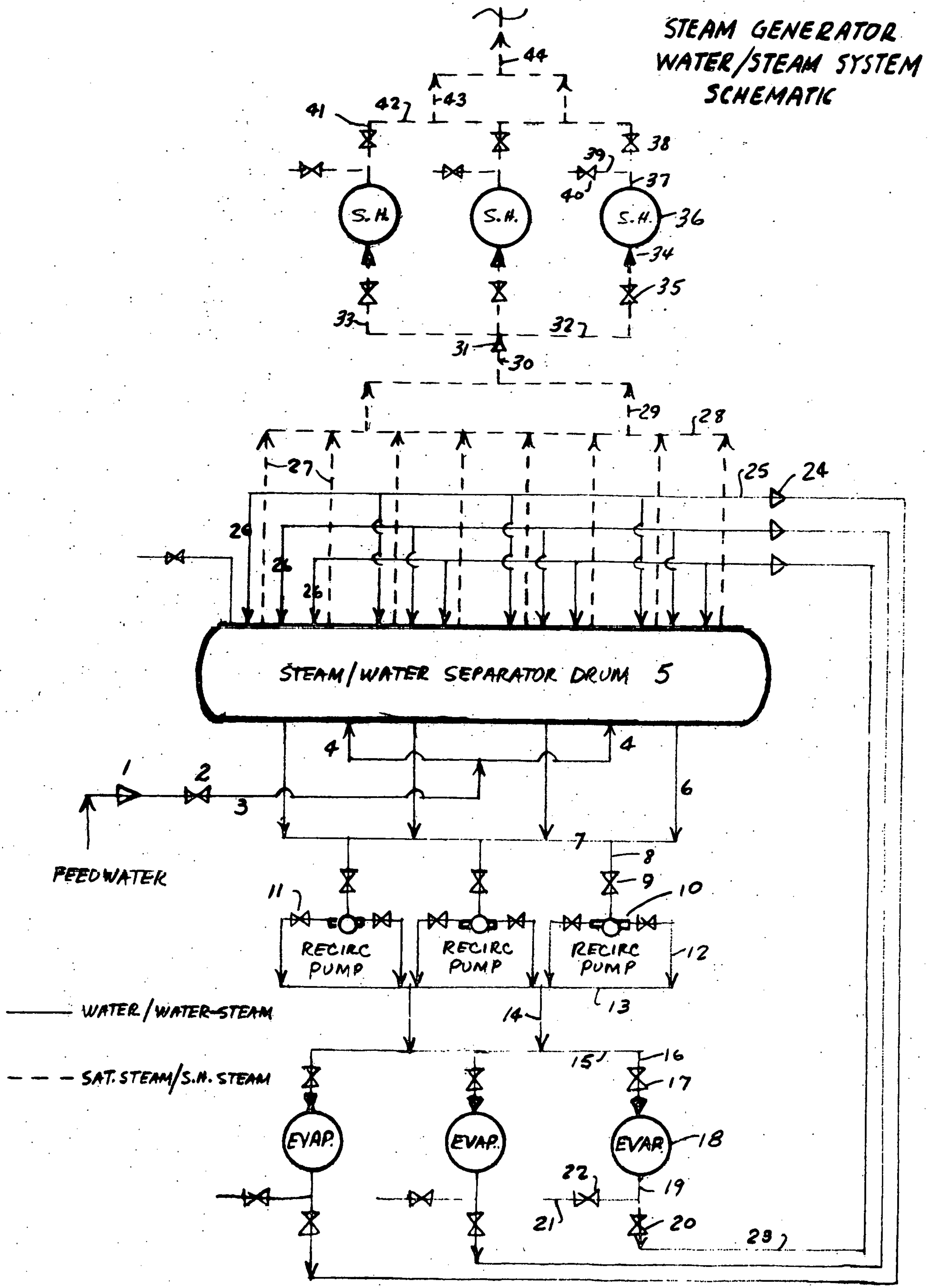

SCHEMATIC SGWCS
CODE RESPONSIBILITY
DEV. NO. 1293
ANSI B31.1
SECTION III CLASS 1 CODE 1331-7
NOTE: ALL OTHER PIPING SHOWN EXCLUDING EVAPORATOR AND SUPERHEATER VESSELS. ASME SECTION 1
S.H.
S.H.
S.H.
ASME SECTION III CLASS 1
STEAM/WATER SEPARATOR DRUM 5
FEEDWATER
RECIRC PUMP
RECIRC PUMP
RECIRC PUMP
WATER/WATER-STEAM
SAT. STEAM/S.H. STEAM
ASME SECTION III CLASS 1
EVAP.
EVAP.
EVAP.

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.



TYPICAL ARR'GT. OF INTERNALS
60" STEAM DRUM

DEV. NO. 1294



STEAM GENERATOR
WATER/STEAM SYSTEM
SCHEMATIC
S.H.
S.H.
S.H.
STEAM/WATER SEPARATOR DRUM 5
FEEDWATER
RECIRC PUMP
RECIRC PUMP
RECIRC PUMP
EVAP.
EVAP.
EVAP.
WATER/WATER-STEAM
SAT. STEAM/S.H. STEAM

DEV. 1289

Component STEAM/WATER CIRC. SYSTEM **LIST OF MATERIAL (Estimate Form)** Sheet 1 of 3

Product DEMO PLANT STEAM GEN. Negotiation No. D51100 Ref. Drawing No. FIGURE 3.1.7-2

Purchaser ______ No. Units 3 Quantities for 1 Unit By LP Date 10-19-72

E-2524

Item	Qty.	Description	Mat'l Spec. P-Spec.	Finished Size	Finished Wt.	Blank Size	Blank Wt.	Unit Cost	Total Cost
1	1	F.W. CHECK VALVE	—	10 3/4"					
2	1	F.W. STOP VALVE	—	10 3/4"					
3	1	F.W. LINE	SA-106 C	10 3/4" x 1 1/8" THK					
4	2	〃	〃	8 5/8" x 15/16" THK					
5	1	STEAM DRUM	SA-299	60" I.D.					
6	4	DOWNCOMERS	SA-106 C	12 3/4" x 1 3/16" THK					
7	1	SUCTION MANIFOLD	SA-515-70	20" OD x 2" THK					
8	3	SUCTION MANIFOLD TO VALVE REDUCER	〃	20" x 16"					
9	3	SUCTION VALVE	—	16" x 16" x 16"					
10	3	CIRCULATION PUMP	—	—					
11	6	DISCHARGE VALVE	—	12 3/4" x 12 3/4" x 12 3/4"					
12	6	DISCHARGE LINES	SA-106-C	14" x 1 3/8" THK					
13	1	DISCHARGE MANIFOLD	SA-515-70	18" x 1 13/16" THK					
14	2	DISCHARGE LINES TO EVAPORATOR	〃	18" x 1 1/16" THK					
15	1	EVAPORATOR INLET HEADER	〃	16" Φ x 1 5/8" THK					

Component STEAM/WATER CIRC SYSTEM

LIST OF MATERIAL (Estimate Form)

Sheet 2 of 3

Product DEMO PLANT STEAM GEN

Negotiation No. D51100

Ref. Drawing No. FIGURE 3.1.7-2

~~Purchaser~~ LIST OF MATERIAL

No. Units 3

Quantities for 1 Unit By LP

Date 10-19-72

E-2524

Item	Qty.	Description	Mat'l Spec. P-Spec.	Finished OD Size THK	Finished Wt.	Blank Size	Blank Wt.	Unit Cost	Total Cost
16	3	EVAP. INLET LINES	SA-106-C	16" x 1 9/16" THK					
17	3	EVAP. INLET QUICK CLOSING VALUE							
18	3	EVAPORATOR							
19	3	EVAP. MIXTURE OUTLET	SA-106-C	16" x 1 9/16" THK					
20	3	EVAP. OUTLET QUICK CLOSING VALVE							
21	3	EVAP. OUTLET DUMP LINE	SA-106-C	16" x 1 9/16" THK					
22	3	EVAP OUTLET QUICK OPENING VALVE							
23	3	EVAP OUTLET LEADS TO DRUM	SA-106-C	16" x 1 9/16" THK					
24	3	OUTLET LEAD REDUCER	SA-515-70	20 x 16					
25	3	MIXTURE DISTRIBUTION BOTTLE	|	20" x 2" THK					
26	60	MIXTURE DISTRIBUTION LINES	SA-106 B	5" x 1/2" THK					
27	13	STEAM OUTLET LINES FROM DRUM	|	5" x 1/2" THK					
28	1	SATURATED STEAM COLLECTION HDR	SA-515-70	14" x 1 15/16" THK					
29	2	SUPERHEATER INLET LEAD SATCHEL HANDLE	SA-106-C	12 3/4" x 1 1/4" THK					
30	1	SUPERHEATER INLET LEAD	|	16" x 1 9/16" THK					

Component STEAM/WATER CIRC SYSTEM — LIST OF MATERIAL (Estimate Form) — Sheet 3 of 3

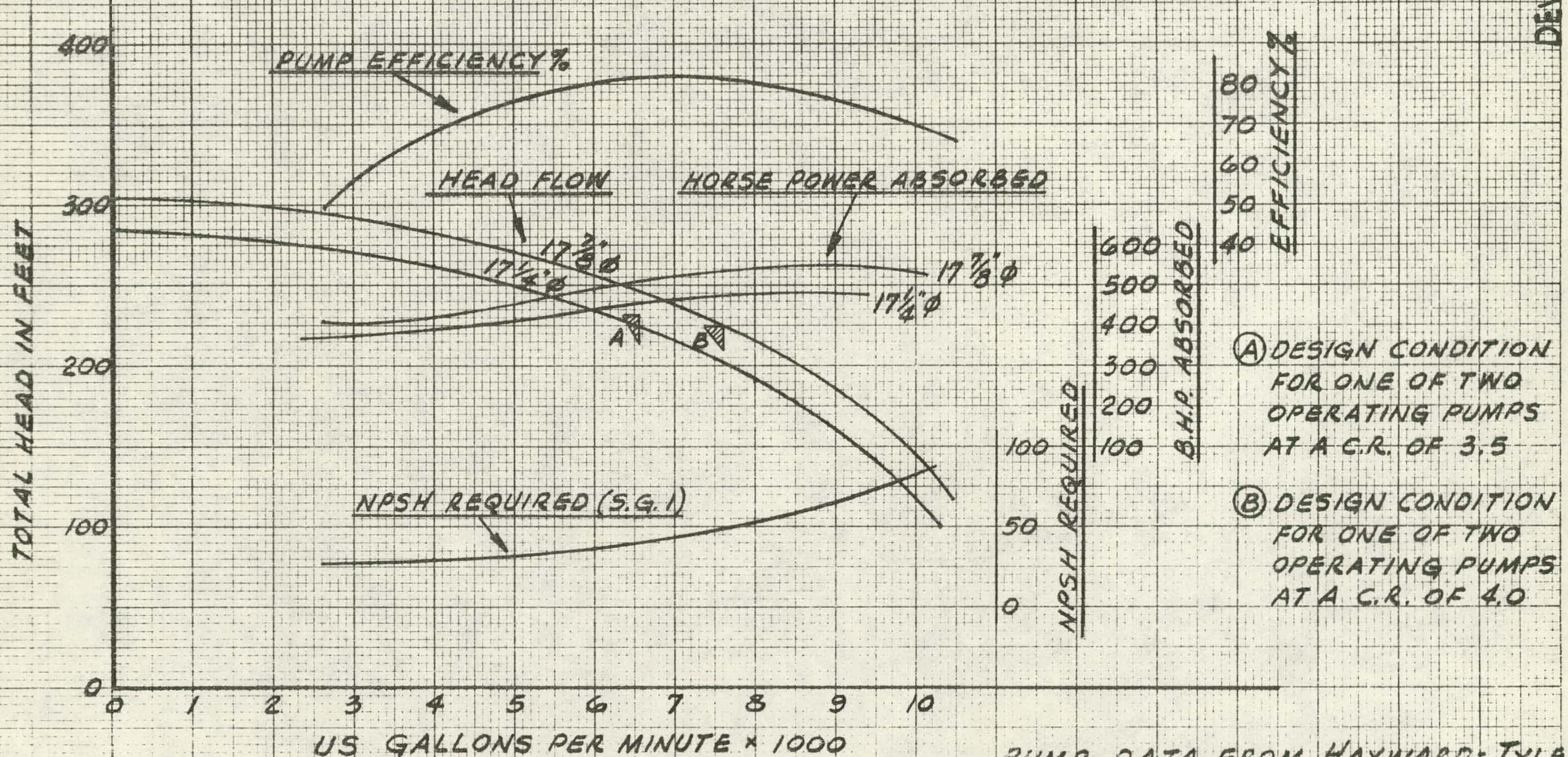
Product DEMO PLANT — Negotiation No. 051100 — Ref. Drawing No. FIGURE 3.1.7-2

Purchaser ______ — No. Units 3 — Quantities for 1 Unit By LP — Date 10-19-72

E-2524

Item	Qty.	Description	Mat'l Spec. P-Spec.	Finished Size	Finished Wt.	Blank Size	Blank Wt.	Unit Cost	Total Cost
31	1	SUPERHEATER INLET LEAD REDUCER	SA-515-70	22" x 16"					
32	1	S.H. INLET DISTRIBUTION BOTTLE	″	22" x 2 5/16" THK					
33	15	S.H. INLET LINES	SA-106-B	5" x 1/2" THK					
34	3	S.H. INLET	SA-106-C	14" x 1 5/16" THK					
35	3	S.H. INLET QUICK CLOSING VALVE	—						
36	3	SUPERHEATER	—						
37	3	S.H. OUTLET	SA-387 B	14" x 1 7/8" THK					
38	3	S.H. OUTLET QUICK CLOSING VALVE	″	14" x 1 7/8" THK					
39	3	S.H. OUTLET DUMP LINE	″	14" x 1 7/8" THK					
40	3	S.H. OUTLET QUICK OPENING VALVE	—						
41	3	S.H. OUTLET LEAD	SA-387B	14" x 1 7/8" THK					
42	1	S.H. OUTLET MANIFOLD	″	14" x 2 1/8" THK					
43	2	S.H. LEAD SATCHEL HANDLE	″	12 3/4" x 1 3/4" THK					
44	1	S.H. LEAD	″	16" x 2 1/8" THK					

DEV 1292-a



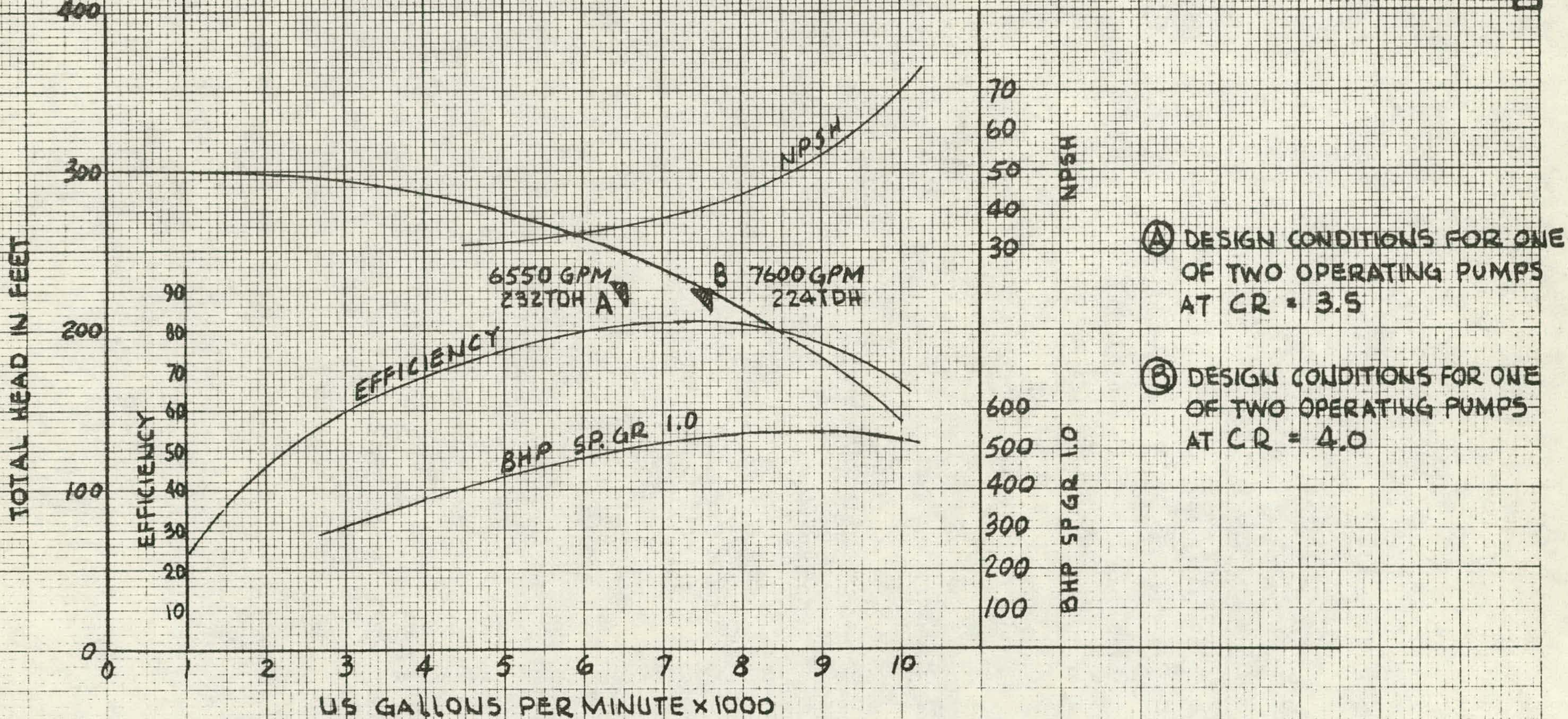
PUMP DATA FROM HAYWARD-TYLER

PUMP SIZE & TYPE 10×12×19 1750 R.P.M. - GLANDLESS CIRCULATOR

ESTIMATED PERFORMANCE - WATER CIRCULATING PUMPS

DEV 1292-a

DEV 1292-6



PUMP SIZE & TYPE 14 VEH W 1750 RPM - IMPELLER PUMP DATA FROM INGERSOLL RAND

ESTIMATED PERFORMANCE - WATER CIRCULATING PUMPS

DEV 1292-6

APPENDIX "D"

INSTRUMENT LIST

(to be provided later)

APPENDIX "E"

VALUE LIST

(to be provided later)

APPENDIX "F"

EQUIPMENT LIST

(to be provided later)

APPENDIX "G"

SUBSPECIFICATION

FOR

STEAM DRUM

APPENDIX "G" - CONTENTS

G1.0 SCOPE

This specification defines the requirements for the design, material selection, fabrication, testing, inspection and installation of a steam drum for the SGWCS and specifies a typical drum normally supplied by C-E for this type of duty in compliance with these requirements.

G1.1 INTENTION

This drum sub-specification is part of the base SGWCS Specification where the entire system behavior, design, etc. is outlined in detail.

It is not the intention of this specification issuer to needlessly or legalistically repeat base specification information that is applicable to the steam drum such as general description, operation, maintenance, structural design, transients, etc.

The intention is to provide additional steam drum information, major departures, etc. from the base SGWCS specification knowing that applicable sections of the base specification apply without written record.

G2.0 REQUIRED TECHNICAL FUNCTIONS AND DESIGN FEATURES

G2.1 REQUIRED TECHNICAL FUNCTIONS

The steam drum shall:

A. Separate the steam/water mixture entering the drum from the evaporators into saturated water and saturated steam.

  (1) The steam shall be of acceptable purity.

  (2) Saturated water shall be free enough from entrained steam so that entering feedwater is not heated by any entrained steam.

B. Provide proper amount of water storage in the drum with a horizontal and straight water level.

  (1) Proper in the extent that the water level can be contained within certain specified physical (vertical height within drum) limits for normal operation.

G2.1 REQUIRED TECHNICAL FUNCTIONS (continued)

C. Contain proper internals to allow the drum to be heated and cooled quickly and uniformly with temperature change of fluid or steam/water mixture.

D. Be such that inlets to the downcomer shall prevent vortexing and large foreign objects from entering the downcomer.

E. Provide proper feedwater inlet and mixing within the drum:

(1) Proper in the sense that the mixed water temperature for each downcomer shall have the same temperature and subcooling.

F. Provide a means of controlling impurity concentration within the SGWCS from the drum which normally has a higher impurity level than other parts of the SGWCS.

G. Be designed so that there is a low pressure drop for the mixed fluid leaving the drum. This is required for saturated water operating conditions when the water level in the drum is the only means of keeping the saturated liquid from flashing.

G2.2 REQUIRED TECHNICAL DESIGN FEATURES

G2.2.1 REQUIRED PROCESS PARAMETERS

The drum shall be designed to meet Maximum Continuous Rating (MCR) conditions listed in Table 4.

TABLE 4

	Maximum Continuous Rating (MCR) Design Process Parameter	100% Load Design Conditions
(1)	Saturated steam flow - lbs/hr (rounded)	1,200,000
(2)	Drum operating pressure - psig	2,700
(3)	C.R.	3.5
(4)	Entering feedwater temperature - °F	460
(5)	Drum design pressure - psig	2840
(6)	Drum design temperature - °F	688

(Partial Listing - remainder to be added - All parameters listed in Appendix "B").

G2.2.1 REQUIRED PROCESS PARAMETERS (continued)

B. Additional operating and design parameters are found in Appendix "B".

G2.2.2 REQUIRED DRUM CONFIGURATION

A. The LMFBR Demonstration Plant shall contain three (3) steam generator water/steam systems; there shall be a steam drum for each SGWCS - a total of three (3) drums for the plant.

B. Each drum shall contain drum internals, feedwater piping, downcomer vortex breakers and screens, blowdown piping, etc.

G2.2.3 DESCRIPTION OF REQUIRED STEAM, STEAM AND STEAM WATER MIXTURE FLOW

Each drum shall operate in the following manner:

A. Steam/water mixture is fed to the drum from evaporators.

B. Steam/water mixture is separated into saturated steam and saturated water.

C. Separated saturated water is reservoired in the drum and mixes with feedwater being fed into the drum.

D. The mixture of saturated water and feedwater leaves the drum by means of downcomers for delivery to the circulating pumps.

E. The saturated steam leaves the drum by saturated steam tubes for delivery to the superheater modules.

G2.2.4 REQUIRED DRUM INTERNAL REQUIREMENTS

Drum internals shall:

A. Separate the steam/water mixture into saturated steam and saturated water using the principles of centrifugal separation and plate driers.

B. Provide steam of acceptable purity so that carryover does not undermine the parameters upon which the superheater modules were designed.

G2.2.4 REQUIRED DRUM INTERNAL REQUIREMENTS (continued)

C. Provide saturated water that is free enough from entrained steam so that entering feedwater is not heated by any entrained steam. Loss of subcooling, due to entrained steam, undermines the design parameters upon which the evaporator modules were designed.

D. Heat and cool the drum metal quickly and uniformly during start-up, cool down, transients, etc.

E. The distribution of the steam/water mixture entering the drum, of saturated steam leaving the drum and of mixed water leaving the drum must be uniform over the drum length regardless of which circulating pumps or superheater modules are in operation. Steam and steam/water mixture cross flow is minimized with proper distribution resulting in proper drum internal loading.

G2.2.5 REQUIRED DRUM WATER STORAGE

The drum water storage shall be ample, and have a straight and horizontal water level so that for normal control and feedwater regulation, the level of the drum can be held within (vertical height) limits in the steam drum because high level produces steam carryover and low level influences the operation of the circulating pumps. This requires that:

A. The relationships of the drum diameter, location of normal water level height in the drum, available longitudinal mixed water flow area to downcomers, etc. shall be such that the quantity of water stored in the drum is sufficient and that the water flow to downcomers is such that the level is straight and horizontal.

G2.2.5 REQUIRED DRUM WATER STORAGE (continued)

B. The distribution of the steam/water mixture entering the drum, of saturated steam leaving the drum and of mixed water leaving the drum must be kept uniform over the drum length regardless of which circulating pumps or superheater modules are in operation so that cross flow of steam and water is minimized within the drum keeping the level straight and horizontal.

G2.2.6 REQUIRED DRUM FEATURES GENERAL

A. A low pressure drop vortex breaker shall be installed in the inlet to each downcomer, and the downcomer entrance shall be sized to prevent:

(1) Vortexing of the entering fluid.

(2) Flashing of fluid leaving the drum at operating conditions where the fluid is saturated for normal water level range.

B. A screen shall be provided over each downcomer to prevent large foreign objects from entering the pumps and jamming the pump impellers.

C. Feedwater shall be fed into the drum at (2) two points and mixed with the reservoired saturated water over the downcomer entrances so that:

(1) The feedwater is not heated by any possible entrained steam.

(2) The feedwater is well mixed with the saturated water being recirculated.

D. A continuous blowdown pipe shall be provided to hold the impurity of the reservoired drum water within specified limits.

E. The drum shall be provided with vents, drains, relief, instruments, and any additional connections and appurtenances that shall be required for proper filling, draining, installation and operation of the drum.

G3.0 DETAILED SPECIFICATIONS

The following information specifies those C-E designs for the steam drum in compliance with requirements outlined in Sections 1.0 and 2.0.

A. Omission of certain verification statements in the following paragraphs, regarding adherence to certain requirements listed in Section 1 and 2, was made intentionally for simplicity and avoidance of needless repetition.

The intention is to provide additional detailed information for the C-E steam drum design knowing that requirements in Section 1 and 2 apply without written record.

G3.1 DETAILED SYSTEM CONFIGURATION

A. One steam drum per SGWCS - three (3) drums per plant.

B. The following steam drum drawing information is found in Appendix "C".

(1) A Schematic Sketch of 60" Drum Internal Arrangement.

(2) A three (3) page summary of pressure parts giving number, size and material of pressure parts.

(3) The following drawings were made for the steam drum and internals for the 30 MW SCTI Model for the 1000 MW Demonstration Plant; the drum for the SGWCS is similar in design. - only longer in length. The drawings are:

(a) 7670-1E1402 Detail Assembly of 60" I.D. Steam Drum

(b) 7670-1E1407 Arrangement of Internals for 60" Steam Drum

(c) 7670-1E1408 Detail of Internal HD Panel Pl.-Drum

(d) 7670-1B1457 Material for 60" I.D. Steam Drum

(e) 7670-1B1458 16" O.D. Manhole Cover

(f) 7670-1C1446 Detail of 8" Downcomer Nozzle

(g) SK#07670273-0 Drum Internal Analysis Sheet

G3.2 REQUIRED DESIGN PARAMETERS

The steam drum is designed to meet the required parameters listed in Section 2.2.1.

G3.3 DETAILED SYSTEM PERFORMANCE CHARACTERISTICS AND GENERAL FEATURES

G3.3.1 COMPONENTS

G3.3.1.1 DRUM SHELL

A. The steam drum of the SGWCS is designed in accordance with proven procedures established in designing steam drums for controlled circulation boilers covering a period of over twenty (20) years for over 250 boilers.

Thus, the relationships between shell drum diameter, location of normal water level, available longitudinal fluid flow area to downcomers, etc. for the establishment of proper water storage and horizontal and straight water level design is set from both analysis and experience.

B. The 60" inside diameter drum is 42' long between head shell welds.

(1) Drum plate will be established similar to the method shown for the 30 MW Drum Material Sheet in Appendix "C".

(2) Drum plate material is included in pressure part summary in Appendix "C".

(3) See 30 MW Drawings for steam drum head arrangement, manholes, etc; they are similar for the 1000 MW constructed drum.

G3.3.1.2 INTERNALS

A. The steam water separation equipment is collectively known as drum internals. They consist of primary and secondary separators and corrugated plate drier. The primary-secondary separator assemblies have been a standard and used successfully on 250 Controlled Circulation boilers. The corrugated plate drier has been used for over 10 years.

G3.3.1.2 INTERNALS (continued)

A. continued

The 60" drum is equipped with two (2) rows of primary-secondary separator assemblies and a corrugated plate drier. Each row of separators has twenty-six (26) assemblies on 18-1/2" centers. For the maximum steam flow of 1,200,000 lb/hr, each assembly is rated at 23,000 lb/hr. The steam released per foot of affected drum internals is 28,600 lb/hr. With the recirculation ratio of 4 and an operating pressure of 2700 psig, these ratings are within limits of operating control circulation boilers and assure satisfactory performance.

With the above mentioned drum internals separation of water/steam in the drum is completed in three stages. See Schematic Sketch of 60" Drum Internal Arrangement in Appendix "C"; the water and steam mixture from the evaporator is introduced at the top of the drum on both sides of the centerline and sweeps the drum shell on its path to the bottom. This water tight compartment, that encloses the mixture against the drum shell, is called - the shroud. This flow pattern promotes quick metal heating and uniform drum metal temperature. The mixture then enters the primary separators.

A centrifugal separating force is created by vanes which give the mixture a spinning action as it travels upward through the separator. The concentrated layer of water, flowing upward along the surface of the primary tube is skimmed off at the top and directed downward through the outer concentric tube. It is discharged below the water line with the minimum disturbance to the water level. This completes the first stage of separation.

G3.3.1.2 INTERNALS (continued)

A. (continued)

The steam and small quantity of entrained water, in the separator beyond the vanes, continues upward to a steam collector nozzle and turns horizontally into the secondary separator. This consists of a closely spaced corrugated plates and is designed to force out the entrained water from the steam. The velocity at this point is relatively low, and the water can not be re-entrained from the wetted surfaces. It runs off the plates away from the steam outlets. The steam then leaves the separator and flows upward and through the corrugated plate drier located at the top of the drum. This completes the third and final stage of separation before the steam leaves the drum for the superheaters. The separated water from the three stages of separation combined with incoming feedwater and recirculated saturated water to provide subcooled downcomer flow.

(1) In order to obtain maximum effectiveness of drum internal performance, uniform flow distribution is required and is accomplished by considering the flow and location of risers, downcomers, steam outlets and feedwater piping. The drum has four (4) rows of risers with an equal number of risers in each row. There are eighteen (18) steam - steam outlets in a single row, four (4) downcomers and two (2) feedwater inlet nozzles with internal piping; all are located to provide the desired distribution.

(2) Flow velocities through the drum internals will be similar to those shown for the 30 MW drum internals on Drum Internal Data Sheet found in Appendix "C".

G3.3.1.3 FEEDWATER LINES

A. Feedwater enters the drum at two (2) points and divides into four (4) branches that feed feedwater directly into downcomer inlet nozzles.

(1) See 30 MW drawings in Appendix "C"; arrangement for 1000MW is similar.

G3.3.1.4 DOWNCOMER VORTEX BREAKER AND SCREEN

A. A standard C-E vortex breaker is installed at the inlet to each downcomer.

(1) Division plates divide the downcomer inlet into four (4) equal compartments.

(2) The plates extend from the downcomer into the drum proper.

(3) There is a plate on top of the extended division plates which forces the recirculated water to enter from the sides of the vortex breaker into the divided compartments.

B. There is a standard C-E screen box over the vortex breaker to keep large pieces of foreign matter form entering the downcomer.

G3.3.1.5 CONTINUOUS BLOWDOWN

A standard C-E continuous blowdown line is provided in the steam drum.

A. It is properly located and designed to prevent blowing down feedwater but to remove highly concentrated water within the drum.

G3.3.2.1 DETAILED FEATURES

A. The above drum internals are guaranteed to provide steam with a maximum of 0.2% moisture carryover.

B. The drum is provided with vent, drain, relief, test, instrument, etc. connections and appurtenances for venting, draining, installation and operation of the drum.

G3.3.2.1 DETAILED FEATURES (continued)

C. A test instrumentation is provided in the drum to check actual water level.

(1) Details of test installation (later).

D. Steam sampling probes are located in the drum and at steam outlet for steam purity tests.

(1) Details of installation (later).

G3.4 DETAILED INSTRUMENTATION AND CONTROLS

Process instrumentation, logic and controls for the steam drum interfaced with the overall plant control system of the LMFBR Demonstration Plant; note the following:

A. Instrumentation is provided to measure and record drum process parameters and equipment operation such as flows, pressures, drum metal temperature, drum level, steam conductivity, etc.

(1) A detailed list of provided instrumentation for the steam drum is included (to be added).

(2) Process parameters are included in Appendix "B".

(3) Backup senses for the instruments are provided when such equipment is inaccessible for convenient maintenance.

B. Drum and Demonstration Plant logic and controls are required to perform the following functions but are not covered by this specification:

(1) Steam drum water level control to hold water level within required limits.

(2) Normal expected drum pressure, steam flow, etc. controls.

G3.5 DRUM OPERATING LIMITATIONS DETAILS (Partial List - Remainder to follow)

A. A list of operating alarms and corresponding corrective actions associated with the drum and its components is included (to be added later).

B. Feedwater must be available to the drum to maintain water in the drum if the SGWCS is to handle the reactor decay heat during plant shutdown.

C. Water level must be maintained within the drum if the circulating pumps are to function properly and not be required to be shutdown.

D. Drum level must not exceed far above the upper normal water level operating limit because there is the possibility of carryover.

APPENDIX "H"

SUBSPECIFICATION

FOR

RECIRCULATING PUMP

APPENDIX "H" - CONTENTS

H 1.0 SCOPE

This specification defines requirements for the design, material selection, fabrication, testing, inspection and installation of a recirculating pump for the SGWCS and specifies a typical pump design normally chosen by C-E for this type of duty in compliance with these requirements.

H 1.1 INTENTIONS

A. It is not the specification issuer's intention to design the inner workings of a recirculating pump; the intention is to present general design requirements to the pump manufacturer and allow him the freedom to design, select materials, etc. (within limits) and assume the responsibility for the inner workings of the recirculating pump.

B. It is the specification issuer's intent to ask pump manufacturers to meet RDT Standards. However, if RDT Standards cannot be met, it must be so stated, and the pump manufacturer must strive to reach and state the highest level of the spirit of RDT Standards that he can reach.

C. The pump subspecification is part of the general base SGWCS specification where information on the entire system has been outlined in detail. As the pump is an integral part of the SGWCS specification, there is information that is applicable to the pump in the base specification, such as Codes, transients, operation, maintenance, general description, etc.

It is not the intention of the specification issuer to needlessly repeat base specification information in the pump subspecification. The intention is to provide additional pump information, indicate major departures, etc., from the base specification knowing that applicable sections of the base specification apply without written record.

H 2.0 REQUIRED TECHNICAL FUNCTIONS AND DESIGN FEATURES

H 2.1 REQUIRED TECHNICAL FUNCTIONS

The recirculating pump shall:

A. Recirculate boiler water mixed with feedwater from the steam drum, through the evaporators and steam/water mixture back to the steam drum.

B. Be able, if required, to circulate chemical cleaning solutions within specified limits without pump damage.

H 2.2 REQUIRED TECHNICAL DESIGN FEATURES

H 2.2.1 REQUIRED SYSTEM CONFIGURATION

A. There are three (3) recirculating pumps per SGWCS - a total of nine (9) pumps per plant.

(1) See Appendix "C" for schematic arrangement of SGWCS which shows typical pump arrangement.

(a) Any two (2) operating pumps shall be capable of operating in parallel to provide design process requirements.

(b) Any one (1) (idle) pump shall be a complete spare and be capable of operating in parallel with the other pumps.

(2) The height of the steam drum above the recirculating pumps shall permit the design to meet all NPSH requirements.

H 2.2.2 REQUIRED PROCESS PARAMETERS

Any two (2) pumps, operating in parallel, shall be designed to meet the following process parameters.

A. Provisions shall be provided to increase SGWCS design circulation ratio (CR) from 3.5 to 4.0 at MCR; therefore, two (2) pumps process design parameters at MCR shall be provided; they are listed in Table 3.

H 2.2.2 REQUIRED PROCESS PARAMETERS (continued)

TABLE 3

REQUIRED DESIGN PARAMETERS
At Maximum Continuous Rating
2 Pumps Operating - Performance of One of the Pumps

	100% Load Design Conditions	
(1) Design C. R.	3.5	4.0
(2) Flow GPM	6550	7600
(3) Head Ft.	247	224
(4) Head PSI	69	61
(5) Fluid Temperature - °F	639	645
(6) Approx. Pump Suction Pressure - PSIG	2719	2717
(7) SG of Fluid	0.64	0.63

(Partial Listing - Remainder to be provided)

B. Operating parameters listed in Appendix "B".

H 2.2.3 GENERAL REQUIRED PUMP FEATURES

A. Pump shall be vertical, single stage with vertical top suction and dual tangential horizontal discharge and shall be designed to be suspended from the suction nozzle with the motor down.

(1) Length of center line displacement of tangential discharge nozzles and length of suction nozzles will be established by the specification issuer.

(2) The pump shall be designed for counterclockwise rotation when viewed from the driver end.

(3) Suction and discharge nozzles shall be finished for welding to SGWCS piping or valves. Approximate O.D. of connection nozzles shall be:

(a) Suction - 16" O.D.
Dual Discharge - 12-3/4" O.D.

H 2.2.3 GENERAL REQUIRED PUMP FEATURES (Continued)

B. The drive shall be a can-motor or electronersible type motor. This differs from a conventional unit in that the drive is caned or wet motor housed within the pump case and may be subject to full pump pressure. The required motor characteristics shall be: three-phase, 60 Hz, *rpm, 4160 volts. The nominal rating of the motor shall be HP* with a continuous overload capacity based on 1.15 maximum service factor.

* Provided by pump manufacturer.

(1) During boiler start-up and shutdown the pump will be delivering cold water for a limited period. During this period the pump load will be substantially higher than normal. The motor selected shall be capable of operating in this manner without impairing its life or performance.

(2) While the motor cavity is initially filled with cold feedwater, the motor parts may eventually be in contact with boiler water. The motor shall be able to operate equally satisfactory with boiler water. Maximum property and impurity limits are (to be added).

(3) All motor windings and terminals shall be water tight.

(4) All pump motors shall be interchangeable with all pump casings furnished for the SGWCS.

C. This type of pump does not require a shaft seal since it is totally enclosed in the pump casing. An auxiliary impeller is generally provided to insure high pressure cooled water circulation through the shaft sleeves, bearings and motor parts while the pump is in service. An external cooler shall be provided to keep the high pressure circulation fluid from exceeding (to be added) °F.

H 2.2.3 GENERAL REQUIRED PUMP FEATURES (Continued)

C. (continued)

(1) The cooler is a vital attachment to the pump and can or cannot be supplied with the pump. It will be referred to in the pump write-up; however, the pump cooler is not covered, not provided, etc., by this specification.

D. The pump shall be suitable for the hot or cold standby service conditions without impairing its performance. During the hot standby condition the pump will be idle and subjected to full pressure and temperature. During the cold standby condition, the pump is idle and subjected to low pressure and ambient temperature.

When a pump is held on hot standby it will be kpet hot by allowing water to bypass the pump valves. In a cold condition, with valves closed, it must be preheated before starting. The maximum permissible temperature difference between pump casing and boiler water for normal starting shall be specified (to be added).

E. The pump shall be provided with the necessary thermometers, with alarm and trip contacts, to protect motor/pump from excessive temperature. The normal motor temperature and the alarm and trip settings shall be specified in a report.

F. The pump shall have connections to properly fill, vent, drain and purge the pump and motor, if necessary, with clean water.

G. Water for filling motor cavity shall not exceed property and impurity limits found in (to be added).

H 2.2.4 PUMP PERFORMANCE REQUIREMENTS GENERAL

A. Two (2) pump process circulation parameters shall be designed for the SGWCS at MCR, see Section 2.2.2.

H 2.2.4 PUMP PERFORMANCE REQUIREMENTS GENERAL (continued)

A. (Continued)

(1) At either design point for one pump operation, the pump shall be capable of delivering approximately 50% over rated capacity at the reduced head; the pumps shall be designed for continuous operation in this manner.

(2) The pump performance shall be guaranteed so that each pump shall be capable of continuous operation at rated capacity and head of the conditions specified in 2.2.2. for the SGWCS CR of 4.0 process parameters; however, the pump performance requirements for the SGWCS CR of 3.5 shall be exceeded.

H 2.2.5 REQUIRED PUMP TESTS

Required pump tests shall be as follows:

A. A complete hydraulic test on water and at low suction pressure on one unit on the SGWCS to obtain complete performance characteristic curves. The required characteristics include head, NPSH, power input and overall efficiency versus capacity.

B. A mechanical run at low pressure with water on the remaining units.

C. Electrical tests. Routine test outlines shall be specified in a report.

D. Six (6) copies of the pump performance curves shall be furnished to the specification issuer.

H 2.2.6 IMPORTANT REQUIRED INTERFACES NOT COVERED BY THIS SUBSPECIFICATION

The following interfaces are required and discussed, but they are not covered, not provided, etc., by this subspecification.

A. Pump cooler which cools high pressure water that is circulated through inner pump parts for lubrication and cooling effect, see Section 2.2.3.

H 2.2.6 IMPORTANT REQUIRED INTERFACES NOT COVERED BY THIS SUBSPECIFICATION (Continued)

B. Low pressure cooling water which is vital to pump operation.

(1) It cools pump coolers.

(2) It cools, by other coolers, pump water used to fill pump motor cavity and pump, if required.

(3) It cools purge water so that pump is purged clean with cool water, if required.

(4) This system is so vital that both a primary and emergency (second) source is required.

C. Low and high pressure fill and purge which is used to fill and purge, if required, a motor/pump.

D. Fill, vent and drain systems which are required for filling and draining a pump.

H 2.2.7 REQUIRED MATERIALS OF CONSTRUCTION

A. The pump shall be capable of, if required, to circulate chemical cleaning solutions, including such items as impellers, impeller seal rings, shaft, casing, casing cover, consideration shall be given to the materials which will withstand the action of the chemical cleaning solution. For the following chemical cleaning operation:

(1) The circulation of chemical cleaning solution approximately 30 minutes at times when the boiler is being chemically cleaned. However, this circulation is not to exceed one hour total time per year. Total time exposed to the chemical solution will not exceed 10 hours time per year.

H 2.2.8 REQUIRED INSTRUMENTS AND CONTROLS

A. The spare pump shall be on hot standby and shall be capable of being placed automatically into service in (to be added) seconds, if required.

B. Instrumentation shall be provided so that the boiler operator will know that a recirculating pump is in operation.

C. Process instrumentation and controls shall be provided to monitor and control a circulating pump for normal and upset, emergency and faulted operation and shutdown conditions.

H 3.0 DETAILED SPECIFICATIONS

The following information specifies a typical pump design normally chosen by C-E for this type of duty in accordance with requirements outlined in Section 1.0 and 2.0 of this subspecification and applicable requirements of the base specification.

A. There are many available pump manufacturers; however, Hayward-Tyler is used in this subspecification as typical equipment.

H 3.1 DETAILED SYSTEM CONFIGURATION

The pump arrangement, found in drawings ND 723114, ND 723115 and ND 723116 (Appendix "C"), meets the system requirements of Section 2.2.1.

H 3.2 DETAILED PROCESS PARAMETERS

The circulating pump is designed to meet the process parameters outlined in 2.2.2.

H 3.3 DETAILED PUMP CONSTRUCTION

The following is a typical construction for a Hayward-Tyler (HTG) Glandless Motor Pump.

Note: See cross section Hayward-Tyler Pump in Appendix "C".

A. General

The unit consists of a single stage centrifugal pump driven by an

H 3.3 DETAILED PUMP CONSTRUCTION (Continued)

A. (Continued)

induction motor of the wet stator type.

The interior of the motor pump unit is filled with cool water at system working pressure. There is no stuffing box on the rotating pump shaft. The motor casing is built to withstand the full pressure of the system and the motor is wound with special pressure tight submersible cable. The electrical supply is fed through pressure tight cable inlets.

To keep the motor cool its water content is circulated through the external heat exchanger by an auxiliary impeller integral with the thrust disc located at the base of the motor.

The design also includes a thermal barrier for minimising the flow of heat from the pump to motor.

B. Unit Construction

The construction of the unit is shown in the sectional arrangement drawing contained in Appendix "C".

The unit is designed for vertical mounting with the pump case positioned uppermost. The pump and motor have a common shaft, which carries a rotor on the lower portion and a key located impeller at the upper end.

There are three main pressure tight components, namely the pump case, motor case and motor cover. Refer to the sectional arrangement drawing contained in Appendix "C" for component material specification.

The pump case is welded into the pipework of the boiler system at the suction and delivery branches and contains all the volutes and passages of the pump. Twin delivery branches are employed and

H 3.3 DETAILED PUMP CONSTRUCTION (Continued)

B. (Continued)

must be arranged to ensure that there is an equal flow from each.

The motor and pump cases are connected by means of a flanged pressure tight joint secured by high tensile studs and nuts. The studs are so designed that hydraulic tensioners may be used to assist tightening the main flange nuts. A flexitallic gasket recessed into the stainless steel overlays at the joint face provides the pressure seal.

The motor case contains all the moving parts of the unit other than the impeller. The pressure tight shell is completed by the motor cover, secured and sealed in a similar manner to the pump case joint. The impeller of the shrouded type is fitted with a renewable wearing ring. The wearing ring runs within another ring located in the pump casing.

Below the impeller is located a heat baffle, which reduces the flow of heat down the unit by convection and conduction. A sleeve provided above the heat baffle forms a labyrinth with the under side of the impeller to limit sediment penetration into the motor. If any foreign matter should pass into the motor enclosure, it is filtered out by a strainer located at the base of the motor.

The stator shell complete with the stator pack, the rotor shaft, the journal bearing housings and the thrust assembly can be withdrawn from the pressure tight motor case in sequence for maintenance.

The motor is of the squirrel cage induction type wound with special watertight Polyvinyl-chloride (P.V.C.) covered cable in the stator. Phase joints and connections to the leads are molded in solid P.V.C.

The stator core is made of electrical quality sheet steel stampings compressed between end plates, and secured by means of a split ring.

H 3.3 DETAILED PUMP CONSTRUCTION (Continued)

B. (Continued)

The rotor cage is of de-oxidized copper and electrical quality bronze bars, used in conjunction with a laminated pack of electrical quality steel (Ferosil).

C. Motor Cooling Circuit

The auxiliary impeller circulates the H.P. internal water content of the motor so long as the motor is energized. The water is circulated continuously through the bearings, motor windings and heat exchanger on a closed circuit.

When the motor is stationary thermo-syphon circulation takes place to remove conducted heat from the pump end. Thus there is no waste of treated boiler water with this design of unit.

D. Heat Exchanger (Not covered, not provided by the specification)

The heat exchanger dissipates the heat generated in the motor windings.

Brackets are provided on the motor case to mount the heat exchanger. Flanges with raised type faces at the head of the heat exchanger provide connection for the external LP cooling water supply.

Interconnecting pipework is purposely made short and direct, with the heat exchanger mounted as high as practicable, in order to promote good thermo-syphon circulation when unit is on hot stand-by.

The heat exchanger is of the shell and tube type, having high pressure boiler water on the shell side and low pressure cooling water on the tube side.

The low pressure cooling water must be lean and from a reliable source.

H 3.4 DETAILED SYSTEM PERFORMANCE CHARACTERISTIC AND GENERAL FEATURES

H 3.4.1 PUMP PERFORMANCE DETAILS

Hayward-Tyler pump performance curve, which meets the required pump design parameters, is provided in Appendix "C".

H 3.4.2 COMPONENT DETAILS

H 3.4.2.1 INTERFACE MISCELLANEOUS PIPING SYSTEMS

A. Drawing E 679-677-2 (Flow Diagram Boiler for Circulating Pump) is found in Appendix "C".

(1) This drawing shows typical miscellaneous piping systems that interface with a circulating pump, but are not covered by this specification. It shows typical piping systems for:

(a) High and low pressure pump fill.

(b) Vent piping.

(c) Drain piping.

(d) Low pressure cooling water piping.

H 3.4.2.2 LOW PRESSURE COOLER

This is a commercial tubular cooler which is not covered, not provided by this subspecification.

H 3.5 DETAILED INSTRUMENTATION

Instrumentation is provided to measure and record pump process parameters.

A. A detail list of provided instrumentation is included in (to be added).

B. Circulating pump logic and controls are required to perform the following functions, but they are not covered by this subspecification.

(1) Pump automation to start up, shut down, place into operation a hot standby pump, etc.

(2) Pump differential manometer control to establish whether a pump is or is not in operation.

H 3.6 DETAILED OPERATION AND MAINTENANCE

H 3.6.1 DETAIL OPERATION

A. Pump is designed to operate at normal and upset, emergency and faulted operations and shutdown conditions.

B. Design operating limitations (partial list - remainder to follow).

(1) The pump must not be run unless the motor is completely filled with circuit liquid.

(2) The pump must not run with reverse rotation for long periods or bearing damage will result.

(3) Temperature difference between the pump case and steam drum must not exceed 100°F prior to starting of the pump.

(4) The pump must not be run with the pump suction valve closed. Every effort should be made to achieve a balance flow from the delivery branches, i.e., delivery valves equally open. A period, not exceeding 15 minutes, is permissible with unbalance flow, providing flow unbalance does not exceed 10%.

(5) If it becomes necessary to drain the boiler, the pump/motor unit should be subsequently isolated by closing the suction, discharge and the bypass valves; this is done to keep the motor, pump branches full of water at all times.

(6) Continuous purge water must be supplied during acid cleaning, if necessary.

(7) There are stringent limitations on pump operation and pump on hot standby without cooling water to pump coolers. So that the pump motor windings are not damaged; the following limitations must be followed: (to be added)

H 3.6.1 DETAIL OPERATION (Continued)

B. (Continued)

(8) A high temperature of the internal high pressure cooling water, flowing from the motor to the pump cooler, automatically trips the circulating pump. The pump must be tripped when cooling water reaches (to be added) °F.

H 3.6.2 DETAIL MAINTENANCE

Listing of required tools and spare parts are listed in (to be added).

H 3.7 DETAILED SPECIFICATION GENERAL

A. The omission of certain verification statements, regarding the adherence to certain requirements listed in earlier subsections, was intentional for simplicity and avoidance of needless repetition.

APPENDIX "J"

SUBSPECIFICATION

FOR

RECIRCULATING PUMP

SUCTION AND DISCHARGE

VALVES

APPENDIX "J" - CONTENTS

J1.0 SCOPE

This specification defines requirements for the design, material selection, fabrication, testing, inspection and installation of recirculating pump suction and discharge valves of the SGWCS and specifies typical suction and discharge valve design normally chosen by CE for this type of duty in compliance with these requirements.

J1.1 INTENTIONS

A. It is not the intention of the specification issuer to design inner workings of suction and discharge valves. The intention is to present general design requirements to the pump manufacturer and allow him the freedom to design, select materials, etc. (within certain limits) and assume the responsibility of the inner workings of the valves.

B. It is the specification issuer's intent to ask a valve manufacturer to meet RDT Standards. However, if RDT Standards cannot be met, it must be so stated, and the valve manufacturer must strive to reach and state the highest level of the spirit of RDT Standards that he can reach.

C. This valve sub-specification is part of the base SGWCS specification where the entire system behavior, design, etc. is outlined in detail. It is not the intention of the specification issuer to needlessly or legalistically repeat base specification information that is applicable to the steam suction and discharge valve such as general description, operation, maintenance, structural design, transients, etc. The intention is to provide additional suction and discharge valve information, major departures, etc. from the base SGWCS specification knowing that applicable sections of the base specification apply without written record.

J2.0 REQUIRED TECHNICAL FUNCTIONS AND DESIGN FEATURES

J2.1 TECHNICAL FUNCTIONS

A. A discharge valve shall:

(1) Function as a stop check valve.

(2) Be capable of opening and closing by motor operator or by manual operation.

(3) Have a low pressure drop design.

B. A suction valve shall:

(1) Function as a gate valve.

(2) Be capable of opening and closing by motor operator or by manual operation.

(3) Have a low pressure drop design.

J2.2 TECHNICAL FEATURES

J2.2.1 PROCESS PARAMETERS

A circulating pump suction valve shall be designed to meet the MCR Process parameters in Table 5.

TABLE 5

CIRCULATING PUMP SUCTION VALVE MCR PROCESS PARAMETERS

Description:	Quantity	Size Desig.	Press. Class
Circulating Pump Suction (gate)	9	16	MSS-SP-66

Type of Operation:

Electric Motor: 440 Volts - 3 Phase - 60 Cycles - 1800 Motor RPM

Port Dimension (I.D. of Seat) - 11-3/4" Approx. inches

Connecting Pipe Data:	Inlet	Outlet
Nominal Size (inches)	16	16

Design Conditions: 2910 psig at 688°F

Maximum Differential Pressure against which valve is to be operated - 50 PSI (upstream Pressure: 2910 PSIG)

J2.2.1 PROCESS PARAMETERS (Continued)

TABLE 5 (continued)

Flow at Operating Conditions:

*	Normal	- 2,400,000 lb/hr	SP. Vol. 0.0254 cu. ft/lb.
**	Minimum	- 1,550,000 lb/hr	Sp. Vol. 0.0250@cu. ft/lb.
***	Maximum	- 5,150,000 lb/hr	Sp. Vol. 0.01607 cu. ft/lb.

Test Requirements: (In accordance with MSS-SP-66 Part II and/or MSS-SP-61, but not less than the following minimum requirements)

	Gate
Hydrostatic Seat Test Pressure, PSIG	
a) Each Side of Wedge	4500

* 2 pump operating CR 4.0 Design - Hot
** 3 pumps operating CR 3.5 Design - Hot
*** 1 Pump operating CR 4.0 Design - Cold

NOTE: (partial listing - remainder to be followed at a later date)

B. The circulating pump discharge valve shall be designed to meet the MCR Process Parameters in Table 6.

TABLE 6

CIRCULATING PUMP DISCHARGE VALVE MCR PROCESS PARAMETERS

Description:	Quantity	Size Desig.	Press. Class
Circulating Pump Discharge	18	12-3/4"	MSS-SP-66

Type of Operation:

Electric Motor: 440 Volts - 3 Phase - 60 Cycles - 1800 Motor RPM

Port Dimension (I.D. of Seat) - 10-3/8" Approx. inches

Connecting Pipe Data:	Inlet	Outlet
Nominal Size (inches)	12-3/4	14

Design Conditions: 2910 PSIG at 688 °F

Maximum Differential Pressure against which valve is to be operated - 50 PSI (Upstream Pressure: 2910 PSIG)

J2.2.1 PROCESS PARAMETERS (Continued)

TABLE 6 (Continued)

Flow at Operating Conditions:

*	Normal -	1,200,000 lb/hr	Sp. Vol.	0.0254 cu. ft/lb
**	Minimum -	775,000 lb/hr	Sp. Vol.	0.0250 @cu. ft/lb
***	Maximum -	2,575,000 lb/hr	Sp. Vol.	0.01607 cu. ft/lb

Test Requirements: (In accordance with MSS-SP-66 Part II and/or MSS-SP-61, but not less than the following minimum requirements)

	Elbow Down St. Ck.
a) Above Disc	4500
b) Under Disc	2910

* 2 Pumps operating CR 4.0 Design - Hot
** 3 Pumps operating CR 3.5 Design - Hot
*** 1 Pump operating CR 4.0 Design - Cold

(partial listing - remainder to be provided later)

J2.2.2 SYSTEM CONFIGURATIONS

There are three (3) recirculating pumps per SGWCS and nine (9) recirculating pumps per Demonstration Plant.

A. There are two (2) discharge valves and one (1) suction valve per recirculating pump.

B. There are six (6) discharge valves and three (3) suction valves per SGWCS.

C. There are eighteen (18) discharge valves and nine (9) suction valves per Demonstration Plant.

J2.2.3 GENERAL FEATURES

A. The suction and discharge valves shall be used to isolate a recirculating pump for maintenance, under pressure and temperature conditions, cold standby, etc.

B. Discharges valves on a hot standby recirculating pump shall prevent backflow through this pump from the high pressure discharge manifold to the low pressure suction manifold by means of the stop-check feature.

J2.2.3 GENERAL FEATURES (Continued)

C. Because the suction and discharge valves are part of the recirculating pump system, they shall have a low pressure drop design.

D. The above requires a discharge stop check valve that shall have:

(1) a floating disc.

(2) a pressure seal

(3) a bypass

E. The above required requires a suction gate valve that shall have:

(1) a flexible wedge

(2) a pressure seal

(3) a bypass

F. As the recirculating pump shall be automatically started up, shut down, hot standby pump placed automatically into operation, etc. the suction and discharge valves are to be motor operated with provision for hand operation.

J3.0 DETAIL SPECIFICATIONS

The following information specifies typical suction and discharge valve design normally chosen by C-E for this type of duty in accordance with requirements outlined in Sections 1.0 and 2.0 of this sub-specification and applicable requirements of the base specification.

A. The omission of certain verification statements, regarding the adherence to certain listed requirements in the Sections 1.0 and 2.0, was intentional for simplicity and avoidance of needless repetition.

B. There are many available valve manufacturers; however, Powell Valves and Limitorque Operators are used in this specification as typical equipment.

J3.1 SYSTEM CONFIGURATION

Arrangement drawings ND 723114, ND 723115, and ND 723116 show suction and discharge valve location in the SGWCS. (See Appendix "C").

J3.2 PROCESS PARAMETERS

The valves are designed for the process parameters outlined in Section 2.1.

J3.3 GENERAL FEATURES

Both the suction and discharge valves are classified as standard hardware. The valves can be purchased from any Power Valve Catalogue.

The motor operators are also classified as standard hardware. They can be purchased from any Limitorque Catalogue.

A. Discharge Valve

Powell 1500 lb. Y globe valve, pressure seal bonnet, Delta seal gasket Stellite Seating Surfaces, motor operated, welded ends, WCB Body material, Seat ID 10-3/8", figure 11351-YWE (See Powell Valve Catalogue for further information).

Limitorque SMB 4-60, stem speed four inch/minute, 1800 RPM motor, double torque switch, class B insulation, four (4) trained geared limit switch, 40% run motor (See Limitorque Catalogue for further information).

B. Suction Feed Valves

Powell 1500 lb OS&Y gate valve pressure, seal product, Delta seal gasket, Stellite Seating Surfaces, motor operated, WCB Body, Stellited Pack under pressure, flexible wedge, weld ends, Seat I.D. 11-3/4" similar to Figure 11323 WE (See Powell Valve Catalogue for further information).

Limitorque SMB 1-40, stem speed 12"/minute, 40% run motor, four (4) trained geared limit switch, double torque, class B installation, 1800 RPM motor (See Limitorque Catalogue for further information).

APPENDIX "K"

DEMONSTRATION PLANT STEAM

GENERATOR RDT STANDARD

SPECIFICATION SECTION 3.6,

OPERATING CONDITIONS

(partial information - remainder to follow)

NOTE: This write up pertains to the evaporator and superheater vessels. However, their performances directly relate to the SGWCS, and provide background information for preliminary analysis work. Transient temperatures throughout the SGWCS will be established and added later in this or another appendix.

3.6 Operating Conditions

Note: (The information and criteria in this section is of a preliminary nature and is not in the form that will be contained in the final specification. Some of the notations and discussions are included for preliminary information only and will be deleted in the final spec. Tables will replace the curves shown in figures 4 through 11).

3.6.1 Types of Operating Conditions - The steam generator shall be designed and fabricated for satisfactory operations under the normal, upset, emergency and faulted conditions as defined in paragraph NB-3113 of Section III of the ASME Code and as specified below in Sections 3.6.2 and 3.6.3. These operating condition categories are defined in summary in the following paragraphs.

3.6.1.1 Normal Conditions - Normal conditions are any conditions experienced in the course of system startup, operation in the design power range, hot standby and system shutdown, other than Upset, Emergency, Faulted or Testing Conditions.

3.6.1.2 Upset Conditions - Any deviations from Normal Conditions anticipated to occur often enough that design should include a capability to withstand the conditions without operational impairment are called Upset Conditions. The Upset Conditions include those transients which result from any single operator error or control malfunction, transients caused by a fault in a system component requiring its isolation from the system and transients due to loss of load or power. Upset Conditions include any abnormal incidents not resulting in a forced outage and also forced outages for which the corrective action does not include any repair of mechanical damage.

3.6.1.3 Emergency Conditions - Emergency Conditions are those deviations from Normal Conditions which require shutdown for correction of the conditions or repair of damage in the system. The conditions have a

2

3.6.1.3 Emergency Conditions continued

low probability of occurrence but are included to provide assurance that no gross loss of structural integrity will result as a concomitant effect of any damage developed in the system. The total number of postulated occurences for such events shall not cause more than 25 stress cycles having an Sa value greater than that for 10^6 cycles from the applicable fatigue design curves.

3.6.1.4 Faulted Conditions - Faulted conditions are those combinations of conditions associated with extremely-low-probability, postulated events whose consequences are such that the integrity and operability of the nuclear energy system may be impaired to the extent that considerations of public health and safety are involved. Such considerations require compliance with safety criteria as may be specified by jurisdictional authorities.

3.6.2 Steady-State and Transient Operation - The steam generator shall perform under steady-state operational and environmental conditions, including transients induced by varying loads. It shall also operate under other operational transients which are not steady-state conditions. All of these operating conditions are defined in the following paragraphs.

3.6.2.1 Normal Conditions

1. Full Power Stead-State Operating Conditions - The steam generator full power steady state operating conditions are shown in Table 3.6.1.

2. Part Load Steady-State Operating Conditions - The steam generator part load steady-state operating conditions of temperature flow and pressure are shown in Table 3.6.1 and the curves on Figures 3.6.1, 3.6.2, and 3.6.3.

3.6.2.1 Normal Conditions continued

3. Dry Heatup and Cooldown - Dry heatup and cooldown rates of the steam generator shell are shown in the following table. Heatup of the shell is accomplished by trace heating prior to filling with sodium.

Event	Location	Temp. °F Start	End	No. of Occurrences	Temperature Change
Dry Heatup	Shell	Ambient	400°F	10	+5°F/hr.
Dry	Shell	400°F	Ambient	10	-5°F/hr.

4. Normal Startup and Shutdown - The normal startup and shutdown temperature transient conditions are specified in the following tables. The temperature change rates shown in the first table apply specifically to the inlet nozzles on both the sodium and water/steam sides.

Event	Location	Temp. °F Start	End	No. of Occurrences	Max. Rate of Temp. Change
Startup	Sodium Inlet Nozzle	400°F	924°F	600	+ 100°F/hr.
	FW Inlet Nozzle & Drum	100°F	370°F		
Shutdown	Sodium Inlet Nozzle	924°F	400°F	250	- 100°F/hr.
	FW Inlet Nozzle & Drum	370°F	100°F		

During the startup transient sodium flow is held constant at 30% to 35% power and then increased lineraly to 40% flow at 40% power. Feedwater flow, pressure and temperature are given by the following table.

3.6.2.1 NORMAL CONDITIONS (continued)

PLANT CONDITION	CORE POWER, %	TIME	F W FLOW RATE, %	F W PRESSURE PSIA	F W TEMP. °F
Shutdown	0	0	~ 0	250	~ 100
Start Heating	5	30 min.	~ 0 to 5	250	~ 100
Turbine Takes 5% Load	5	2 hr. 30 min.	~ 5	1500	~ 150
Design Steam Condition Achieved	35	5 hrs.	~ 37	~ 2560	~ 290
Low Power End of Normal Control Range	40	5 hrs. 15 min.	42	2563	370
Full Power	100	6 hrs.	100	2666	460

The flow, temperature, pressure and power transients during shutdown are the reverse of those given for startup. The transient conditions given in the above tables are summarized in the curves shown on figure 3.6.4.

5. Load Changes Over the 40 - 100% Power Range -

The steam generator will be subjected to two types of load changes, i.e. step changes in load and ramps.

a. Normal Ramp Change - Normal ramp load changes will vary linearly between the end conditions at 40% and 100% full power with a power ramp rate of 3%/min. Temperature change rates are shown in the table below. Sodium and feedwater flows vary from 39.5% to 100% and 37% to 100% respectively over this power range. This information is summarized in Figure 3.6.5 for a normal load decrease from 100% to 40%. A load increase over the same range is simply the reverse of these curves.

Additional temperature ramps over different load ranges can be obtained from the part load operation curves shown in Figures 3.6.1, 3.6.2 and 3.6.3.

3.6.2.1 NORMAL CONDITIONS (Continued)

Event	Location*	Temp., °F Start	End	No. of Occurrences	Max. Rate of Temp. Change
Normal Power Increase	Sodium Inlet Nozzle	924	960	9000	1.8°F/min.
	FW Inlet Nozzle @ Drum	370	460		4.5°F/min.
Normal Power Decrease	Sodium Inlet Nozzle	960	924	9000	-1.8°F/min.
	FW Inlet Nozzle @ Drum	460	370		-4.5°F/min.

*Temperature transients at other locations within the steam generator will be available later.

b. Step Changes - It is assumed that the demonstration plant must be capable of performing step changes in power which are at least equivalent to those provided for in current water reactor plants. Therefore, the step change is based on a ± 10% instantaneous change in power from any power level over the 40% - 100% power range. The response of the plant to these steps should be as quickly as possible. However, the rate of change of temperature, pressure and flow has not been determined and will be supplied later. The C-E PWR's specify that these step changes exhibit temperature and pressure fluctuations within the range of their normal specified plant variations. The normal demonstration plant variations are not available, therefore, this information will be supplied later. The number of occurrences is estimated to be 1500, equally divided between upswings and downswings.

c. Fast or Emergency Ramp Power Changes - (Later)

6. Other Normal Operating Conditions - There are several other operating conditions that are considered normal but are not included here because it is felt that they are similar in transient response to some of those already listed. These operating conditions would include such things as: Hot Restart after Scram, Shutdown after Scram, or the Return to Power from Hot Standby or the reverse, i.e., going to Hot Standby

3.6.2.1 NORMAL CONDITIONS (Continued)

condition from Power Operation. All of these transient conditions are similar to or a combination of either normal startup and normal power increases over the load range or the reverse, which is normal power decreases and normal shutdown. Therefore, they have been accounted for by increasing the number of occurrences of the appropriate normal operating condition.

3.6.2.2 Upset Conditions - The following transients are defined as upset conditions and are considered to be representative of most of the group of possible upset events. Included are curves showing the expected thermal transients in the fluid at the sodium and feedwater inlet nozzles and their estimated number of occurrences. The thermal transients at other locations throughout the steam generator are currently being evaluated.

1. Normal Reactor Plant Scram - (Number of Lifetime Occurrences = 350) Reactor plant scram is an operating procedure for very quickly reducing the power output of the reactor to a low level of ~2-5% as determined by fission product decay heat. This scram might be a result of a false spurious electrical signal or a desired response from one of many protective system signals or an operator-initiated signal. The reactor scram primarily consists of reducing the reactor power by dropping all control rods, and simultaneously reducing the heat transfer system flows by tripping the primary and secondary sodium pumps and feedwater pumps. The secondary sodium flow coasts down to ~5% while the feedwater flow coasts down to ~4%. These flow decay curves and the sodium and feedwater inlet temperature transients for the first 300 seconds following scram are shown in Figure 3.6.6. Also shown is the feedwater inlet pressure drop of 200 psi which varies with the square of the flow. Furthermore, when scram occurs, the turbine-generator is also tripped. After the 300 seconds shown on the curves, the transient is assumed to follow the normal shutdown transient.

3.6.2.2 Upset Conditions continued

2. Loss of Recirculation Pump Flow - (Number of lifetime occurrences = 2 pump) Definition of transient - (Later)

3. Other Upset Operating Conditions - It is recognized that there are a number of other operational events that are considered to be Upset Conditions. However, at this time since they all would very quickly cause a reactor scram, it is assumed that the transients would be similar to a scram transient. Therefore, allowance has been made for these events by appropriately adjusting the number of occurrences of the normal scram. Some of the other Upset Conditions include events such as: positive reactivity insertion with scram; loss of electrical power to one primary, secondary or feedwater pump with scram, loss of plant power with scram, control rod drop with scram, and turbine trip with scram. It is recognized that the scram following some of these events might be delayed somewhat and therefore, momentary up or down temperature transients could be initiated. However, from past experience these have been found to be quite short in time and have very little effect on the overall temperature transient used for structural analysis. Therefore, since these delays were not identified at this time, no attempt was made to include them and all such events are assumed to be similar to a normal scram. It should be pointed out that as additional plant system design information becomes available, these Upset Conditions will be reconsidered and if this assumption appears invalid in any of the cases the transient will be considered separately.

3.6.3 Abnormal Conditions - Abnormal conditions are classifiable as occurring after a failure or malfunction of a component or system. Although no longer stated as an operating category in the ASME Code, the events under this section in the RDT Standards include events which now fall under Faulted, Emergency and in some cases, Upset Condition categories of the ASME Code. Since some Upset Conditions were also listed under section 3.6.2

3.6.3 Abnormal Conditions continued

- "Steady-State and Transient Operation" of the RDT Standards above, e.g., reactor scram, it was decided to include all Upset Conditions under that category. Therefore, only Emergency and Faulted Conditions will be included in this section.

3.6.3.1 Emergency Conditions - The following transients are defined as Emergency Conditions and are representative of a group of possible events but do not include all such events. Included here, similar to what was done previously for Upset Conditions, are curves showing the expected thermal transients in the fluid at the sodium and feedwater inlet nozzles and their estimated number of occurrences. The transients at other locations throughout the steam generator are currently being determined and will be available in the near future.

1. Single Secondary Sodium Pump Seizure with Scram - (Number of Lifetime Occurrences = 3 per loop) The seizure of one secondary sodium pump is quite similar to a normal scram, with the exception of the flow coastdown in the affected loop. Since the pump shaft is assumed to seize quickly, the impellar stops rotating and therefore creates an additional resistance in the loop flow. This is assumed to cause a flow coastdown twice as fast as a normal loop coastdown. The sodium inlet temperature to the steam generator of the affected loop will remain constant over the first 300 seconds. Feedwater parameters are identical to those occurring during normal scram. All of these steam generator inlet parameters for the affected loop are shown in Figure 3.6.7. Parameters in the other two secondary sodium loops and associated feedwater systems are identical to normal reactor scram, since scram is assumed to occur a few instants after pump seizure. After the 300 sec. shown on the curves, the transient is assumed to follow the normal shutdown transient.

3.6.3.1 EMERGENCY CONDITIONS (Continued)

2. Single Primary Sodium Pump Seizure with Scram - (Number of Lifetime Occurrences - 3 per loop) The steam generator inlet conditions for the first 300 seconds of this transient are shown in Figure 3.6.8. Everything is the same as normal scram with the important exception of sodium inlet temperature which eventually decreases at a rather high rate of -3°F/sec. This temperature ramp is caused by the stoppage of the primary flow in the seized loop as a result of closure of the check valve. That is, once flow in the primary loop is essentially stopped, the secondary sodium loop, even at low decay heat flows, rapidly removes the stored heat in the IHX primary sodium. The reduction in primary sodium temperature causes a similar reduction in secondary sodium temperature which eventually levels out near the steam saturation temperature. Sodium and feedwater flows, temperatures and pressures in the two other main heat transfer loops are the same as for normal scram. Furthermore, after the 300 seconds shown on the curves of Figure 3.6.8, the transient is assumed to follow the normal shutdown transient.

3. Activation of Na/H_2O Protection System - (Number of Lifetime Occurrences - 2 per component - evaporator/superheat pair) This event consists of an emergency isolation and dump of the water/steam side of an evaporator/superheater module pair during power operation. Following the initiation of such an event, a reactor plant scram will occur, probably triggered by a loss of pressure signal of the effected steam generator. For this transient, a delay of 5 seconds is assumed before scram occurs. The sodium inlet nozzle temperature and flow transients are therefore similar to normal scram and are illustrated in Figure 3.6.9. The feedwater parameters will also vary according to normal scram conditions with a 5 second delay; however, this transient is not influenced by feedwater conditions since the

water/steam sides are isolated. Instead, when the isolation valves close and the dump valve opens, the water/steam mixtures will quickly blow down. This occurs in both the evaporator and superheater modules simultaneously since the protection system of each pair is tied together. These blowdown flows are currently being determined and are not yet available. Therefore, the internal temperature transients in the steam generator during and after blowdown have not been determined. They will be supplied in the near future. Again, as before, after the first 300 seconds, the transient is assumed to be similar to the normal scram transient.

4. Loss of Feedwater Flow Via Feedwater Control Valve Closure with Scram - (Number of Lifetime Occurrences = 2 valves) Although the operating philosophy for this event has not been completely defined yet, it is included and briefly discussed here because of the possible effects it might have on the steam drum, the evaporator, and recirculation pump designs. This event is different from the loss of feedwater pump power event in that the closing of the feedwater control valve stops all feedwater flow whereas 4% natural convection flow still remained after loss of pump power. With the complete loss of feedwater flow to the steam drum, the drum level can drop, possibly to a point where the recirculation pumps began to cavitate. This condition could damage the pumps. Furthermore, with no low temperature feedwater entering the drum, the drum water temperatures will begin to rise as a function of the recirculation water temperature only. This will cause temperature transients on the drum as well as the evaporator. It is probably possible to eliminate this transient by proper operating procedures and/or a backup feedwater supply, however, this has not yet been determined. Therefore, the transient, if any, during this event will be defined later.

3.6.3.1 EMERGENCY CONDITIONS (Continued)

5. Sodium-Water Reaction Due to A Design Basis Leak - The pressure, flow and temperature transients during this event will be defined later.

6. Steam Line Rupture (Loss of Pressure) - This transient has not been defined yet and will be supplied later.

7. Other Emergency Operating Conditions - Several other events which might be considered to fall within this category by some designers are briefly discussed in this section. The RDT Standard lists four additional events including: loss of primary sodium, loss of secondary sodium, loss of operating power, and scram with sodium flow continuing. The first two events could include two initiating conditions, both of which have been already discussed and specified. That is, the loss of primary or secondary flow can be caused by power failure to the pumps which is similar in transient response to reactor scram and is included under Upset Conditions. This event could also be caused by seizure of a pump as was discussed above under Emergency Conditions. The third event, loss of operating power is similar in response to reactor scram and is included under Upset Conditions. The last event, i.e., scram with sodium flow continuing, has been precluded by the control philosophy of the demonstration plant. That is, sufficient backup trip circuits will be provided to insure that all pumps trip whenever scram occurs.

3.6.3.2 Faulted Conditions - Only one event of this nature has been identified thus far for the steam generator and even this is uncertain. This event is a major sodium-water reaction due to complete circumferential rupture of multiple tubes. Since the sodium-water reaction relief system is designed to handle this event, it is questionable whether it should be classified as an Emergency rather than a Faulted Condition. A faulted

3.6.3.2 Faulted Conditions continued

condition requires that the integrity and operability of the nuclear energy system may be impaired to the extent that considerations of public health and safety are involved. It is very unlikely that this would be the case following a multiple tube rupture. However, if the sodium-water reaction relief system failed, it is uncertain as to what the results would be. Work is currently underway on large sodium-water reactions and their influence on the design of the plant. The classification of this event will be re-evaluated when this is completed and the resulting effects included.

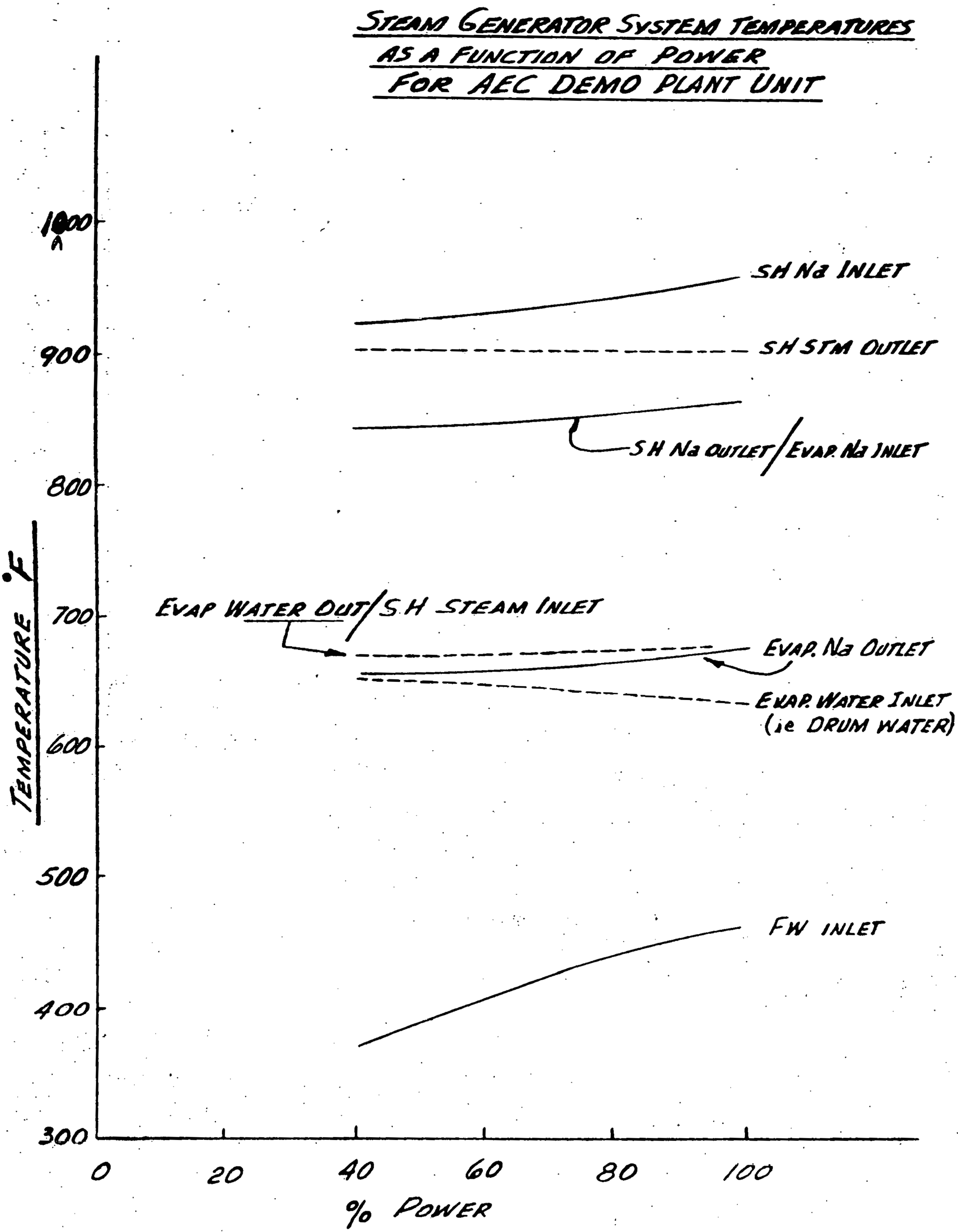

STEAM GENERATOR SYSTEM TEMPERATURES
AS A FUNCTION OF POWER
FOR AEC DEMO PLANT UNIT
1000
900
800
700
600
500
400
300
TEMPERATURE °F
SH Na INLET
SH STM OUTLET
SH Na OUTLET/EVAP. Na INLET
EVAP WATER OUT/S.H STEAM INLET
EVAP. Na OUTLET
EVAP. WATER INLET
(ie DRUM WATER)
FW INLET
0
20
40
60
80
100
% POWER

FIG. 3.6.1

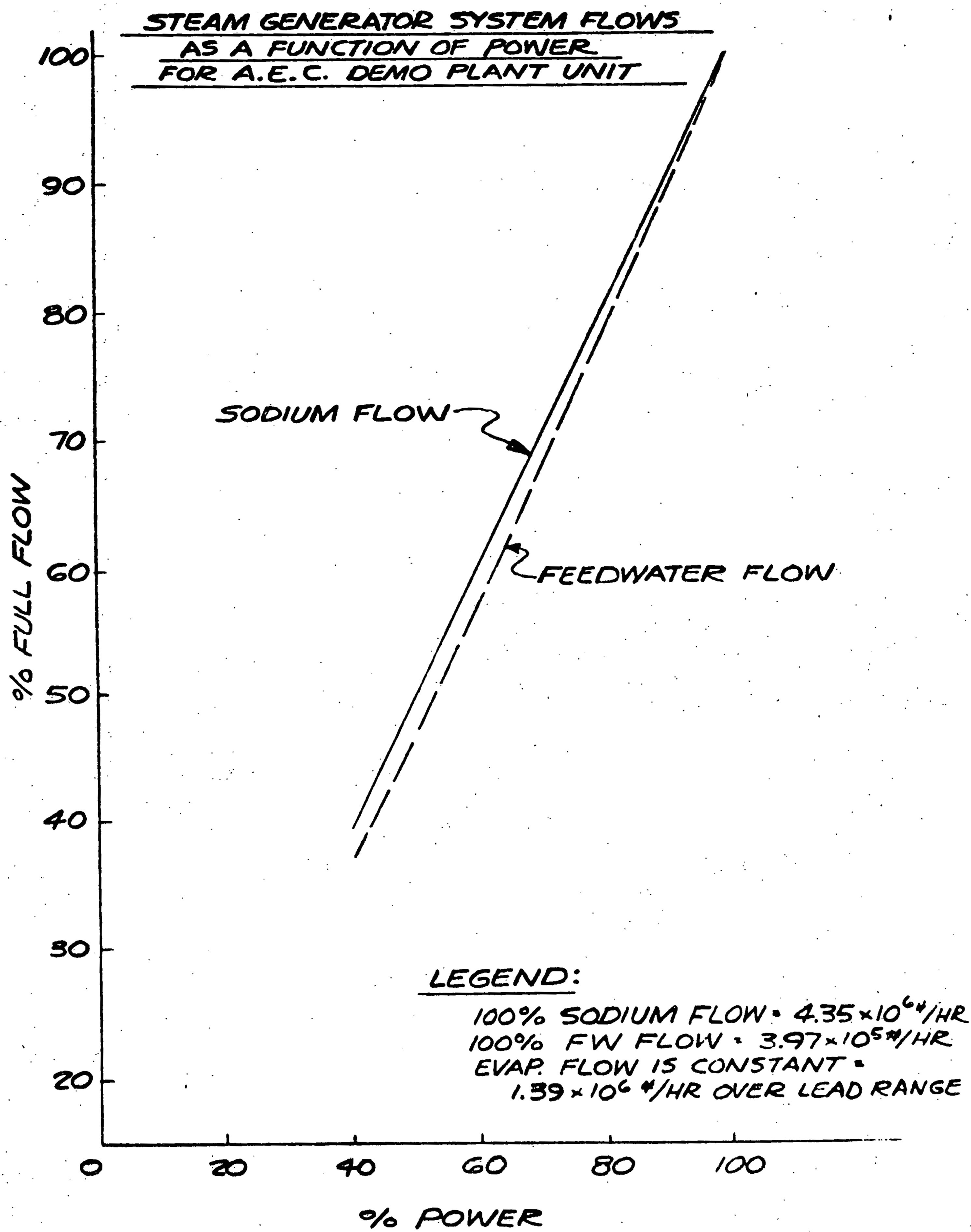

STEAM GENERATOR SYSTEM FLOWS
AS A FUNCTION OF POWER
FOR A.E.C. DEMO PLANT UNIT
100
90
80
70
60
50
40
30
20
% FULL FLOW
SODIUM FLOW
FEEDWATER FLOW
LEGEND:
100% SODIUM FLOW = 4.35×10⁶ #/HR
100% FW FLOW = 3.97×10⁵ #/HR
EVAP. FLOW IS CONSTANT =
1.39×10⁶ #/HR OVER LEAD RANGE
0
20
40
60
80
100
% POWER

FIG. 3.6.2

STEAM GENERATOR SYSTEM PRESSURES AS A FUNCTION OF POWER FOR A.E.C. DEMO PLANT UNIT

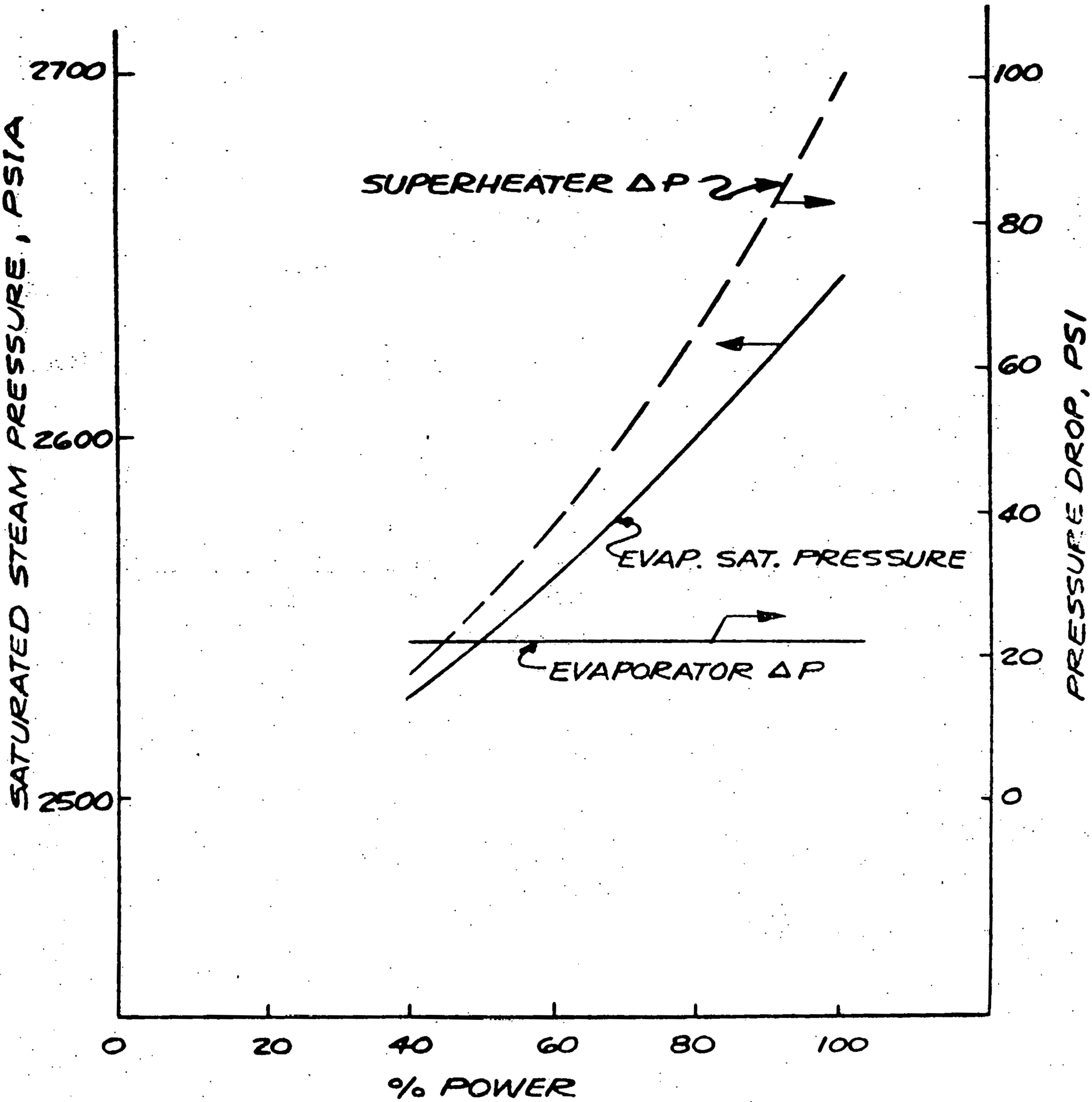


FIG. 3.6.3

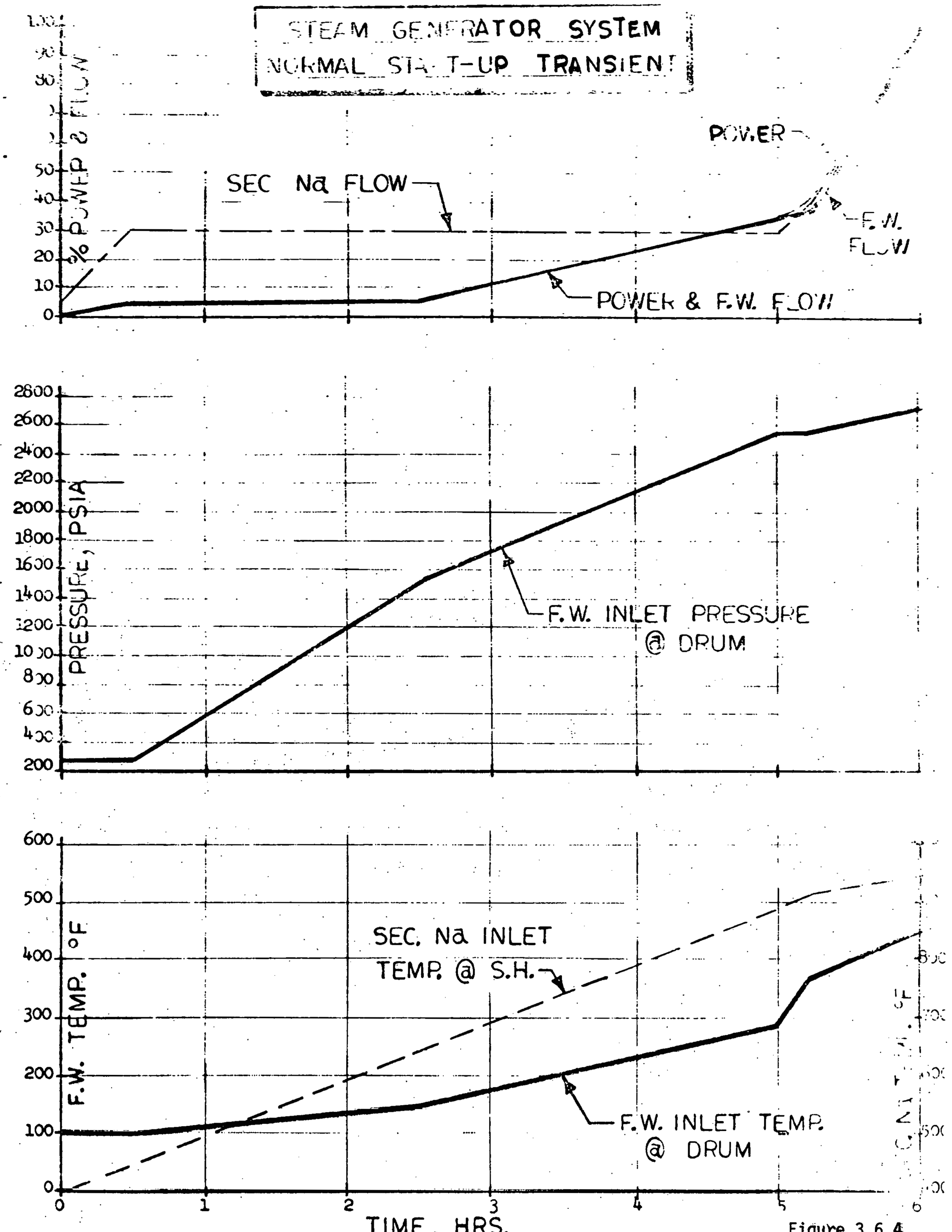

STEAM GENERATOR SYSTEM
NORMAL START-UP TRANSIENT
% POWER & FLOW
SEC Na FLOW
POWER
F.W. FLOW
POWER & F.W. FLOW
PRESSURE, PSIA
F.W. INLET PRESSURE @ DRUM
F.W. TEMP. °F
SEC. Na INLET TEMP. @ S.H.
F.W. INLET TEMP. @ DRUM
TIME, HRS.

Figure 3.6.4

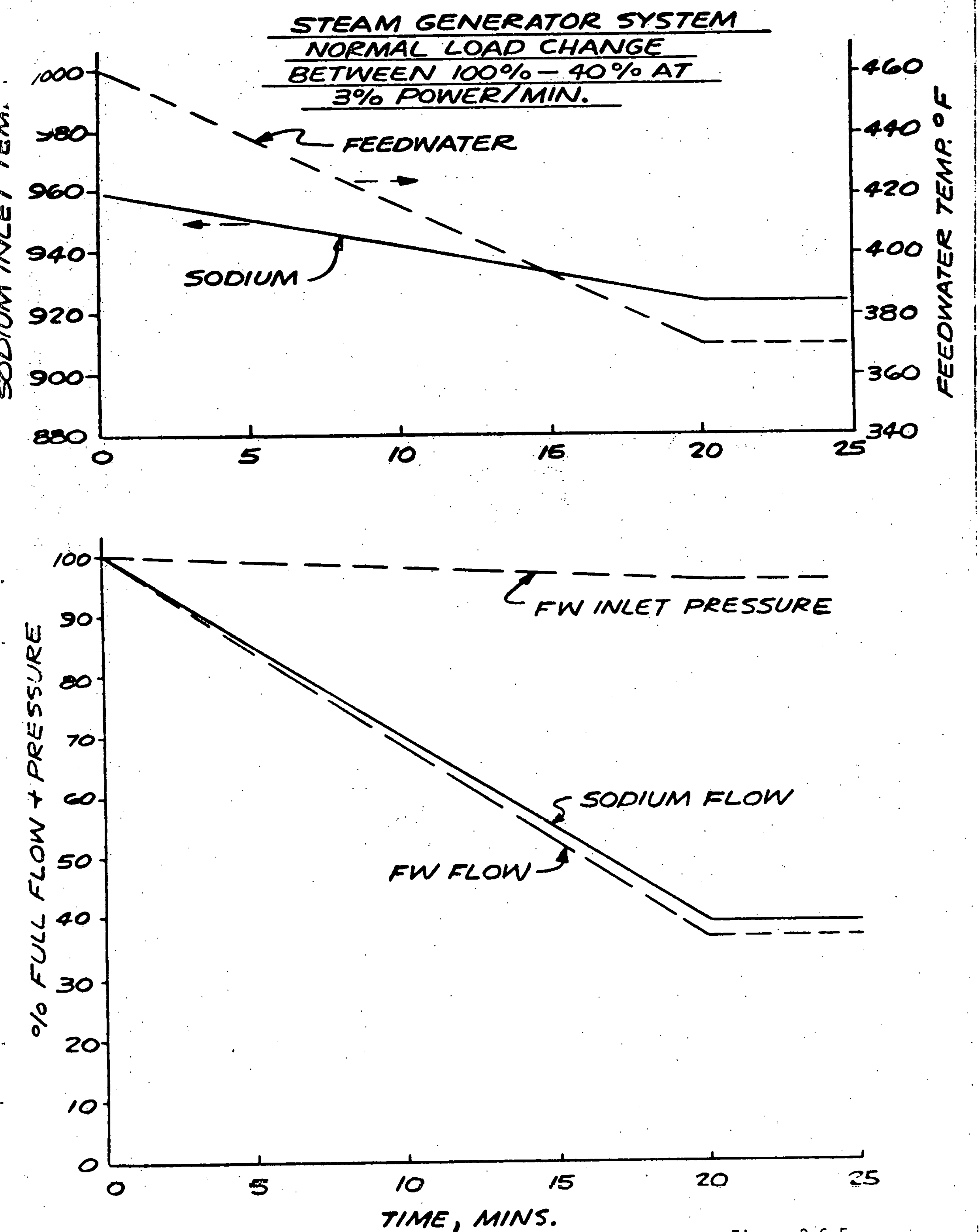

STEAM GENERATOR SYSTEM
NORMAL LOAD CHANGE
BETWEEN 100% – 40% AT
3% POWER/MIN.
FEEDWATER
SODIUM
FEEDWATER TEMP. °F
1000
980
960
940
920
900
880
460
440
420
400
380
360
340
0
5
10
15
20
25
FW INLET PRESSURE
SODIUM FLOW
FW FLOW
% FULL FLOW + PRESSURE
100
90
80
70
60
50
40
30
20
10
0
TIME, MINS.

Figure 3.6.5

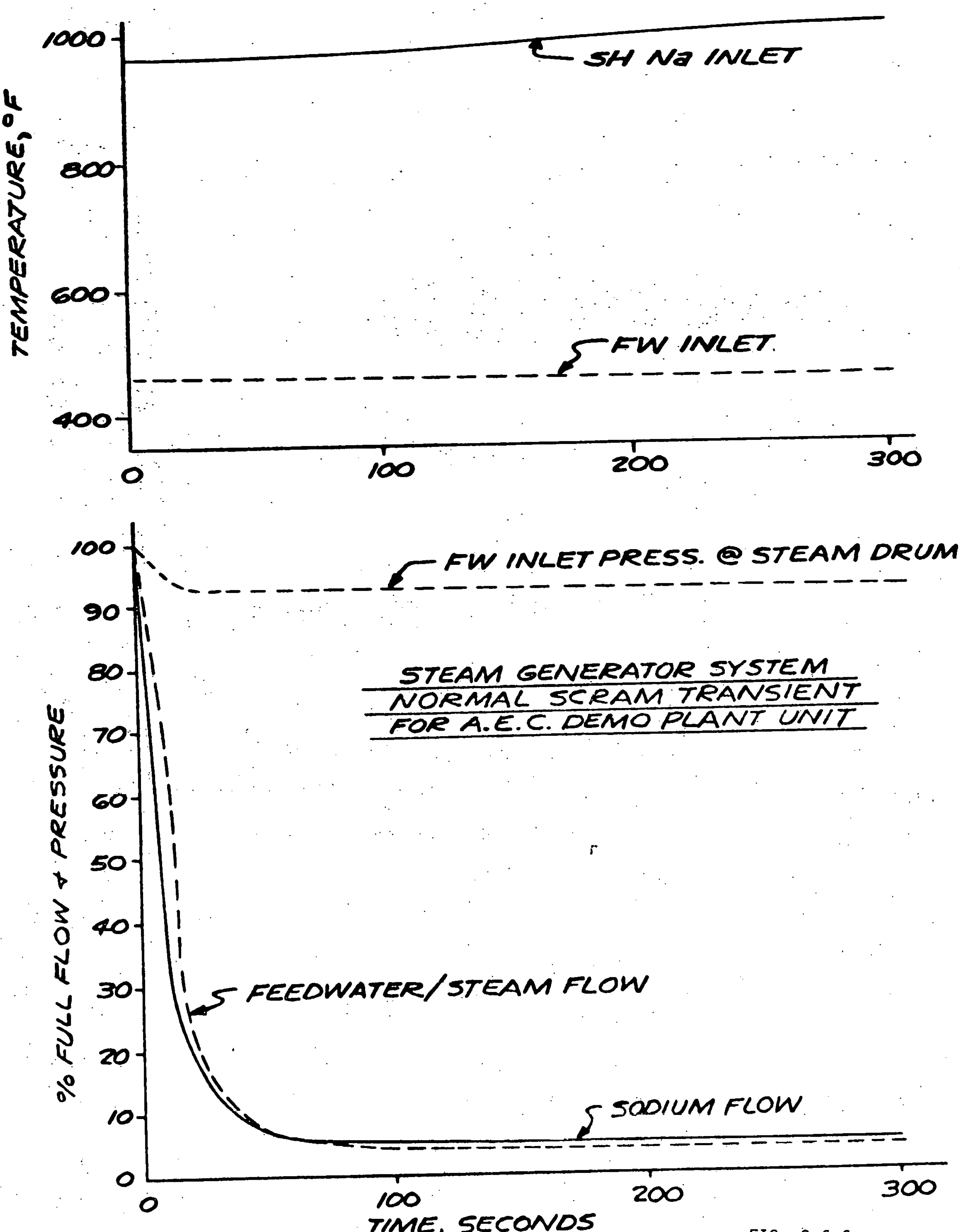
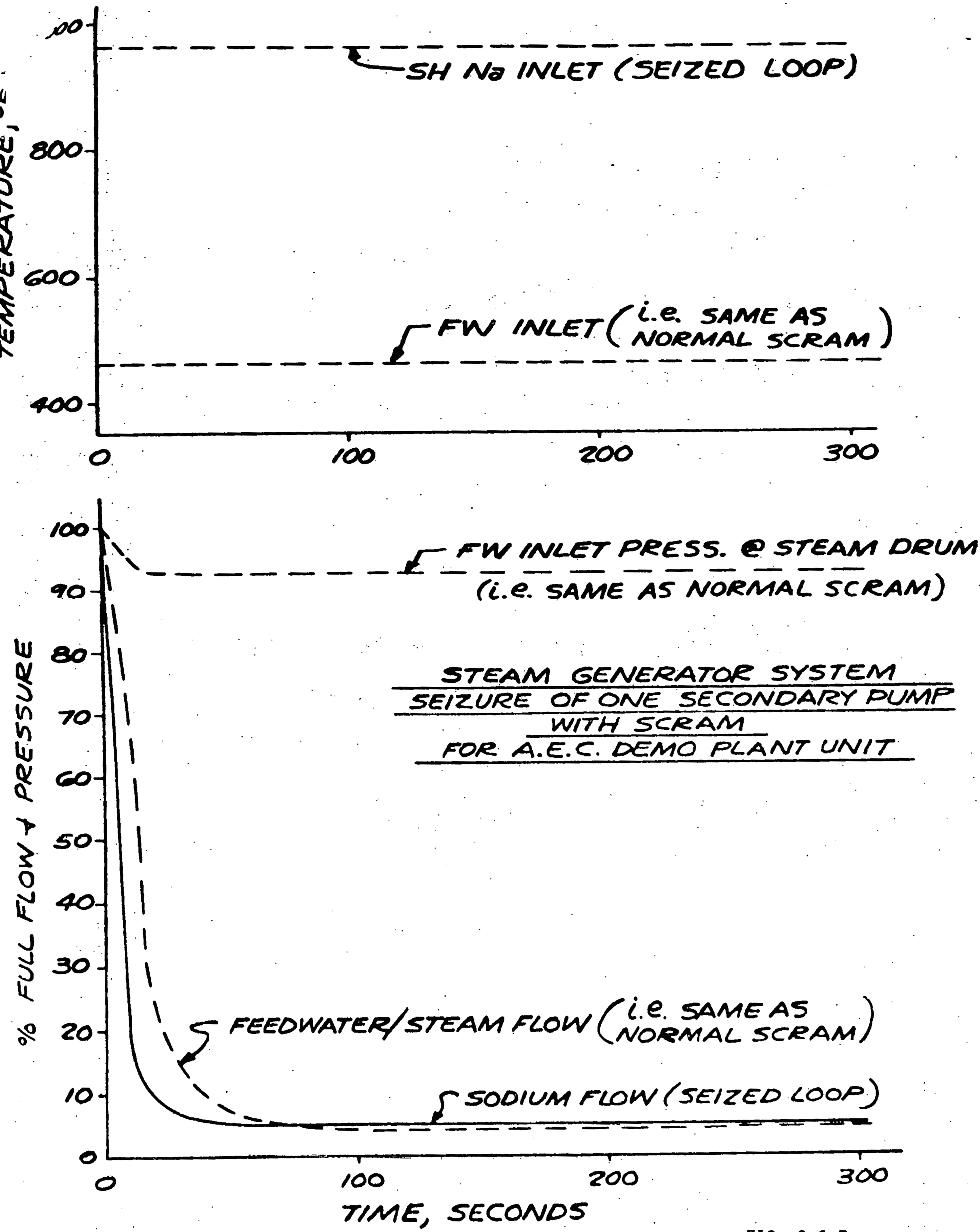

SH Na INLET
TEMPERATURE, °F
1000
800
600
400
FW INLET
0
100
200
300
FW INLET PRESS. @ STEAM DRUM
STEAM GENERATOR SYSTEM
NORMAL SCRAM TRANSIENT
FOR A.E.C. DEMO PLANT UNIT
% FULL FLOW + PRESSURE
100
90
80
70
60
50
40
30
20
10
0
FEEDWATER/STEAM FLOW
SODIUM FLOW
TIME, SECONDS

FIG. 3.6.6



SH Na INLET (SEIZED LOOP)
FW INLET (i.e. SAME AS NORMAL SCRAM)
TEMPERATURE, °F
800
600
400
0
100
200
300
FW INLET PRESS. @ STEAM DRUM (i.e. SAME AS NORMAL SCRAM)
STEAM GENERATOR SYSTEM
SEIZURE OF ONE SECONDARY PUMP
WITH SCRAM
FOR A.E.C. DEMO PLANT UNIT
% FULL FLOW + PRESSURE
100
90
80
70
60
50
40
30
20
10
0
FEEDWATER/STEAM FLOW (i.e. SAME AS NORMAL SCRAM)
SODIUM FLOW (SEIZED LOOP)
TIME, SECONDS

FIG. 3.6.7

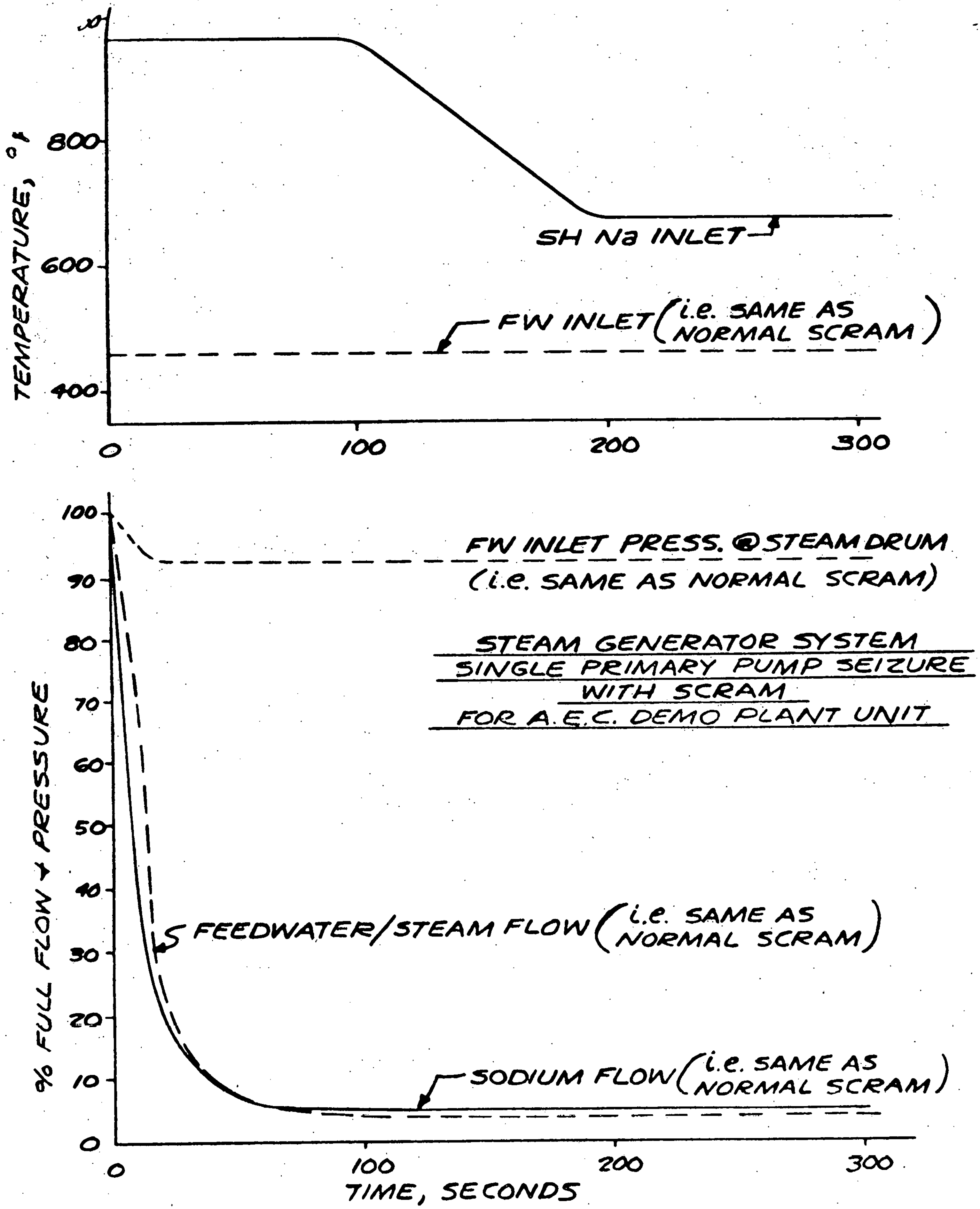
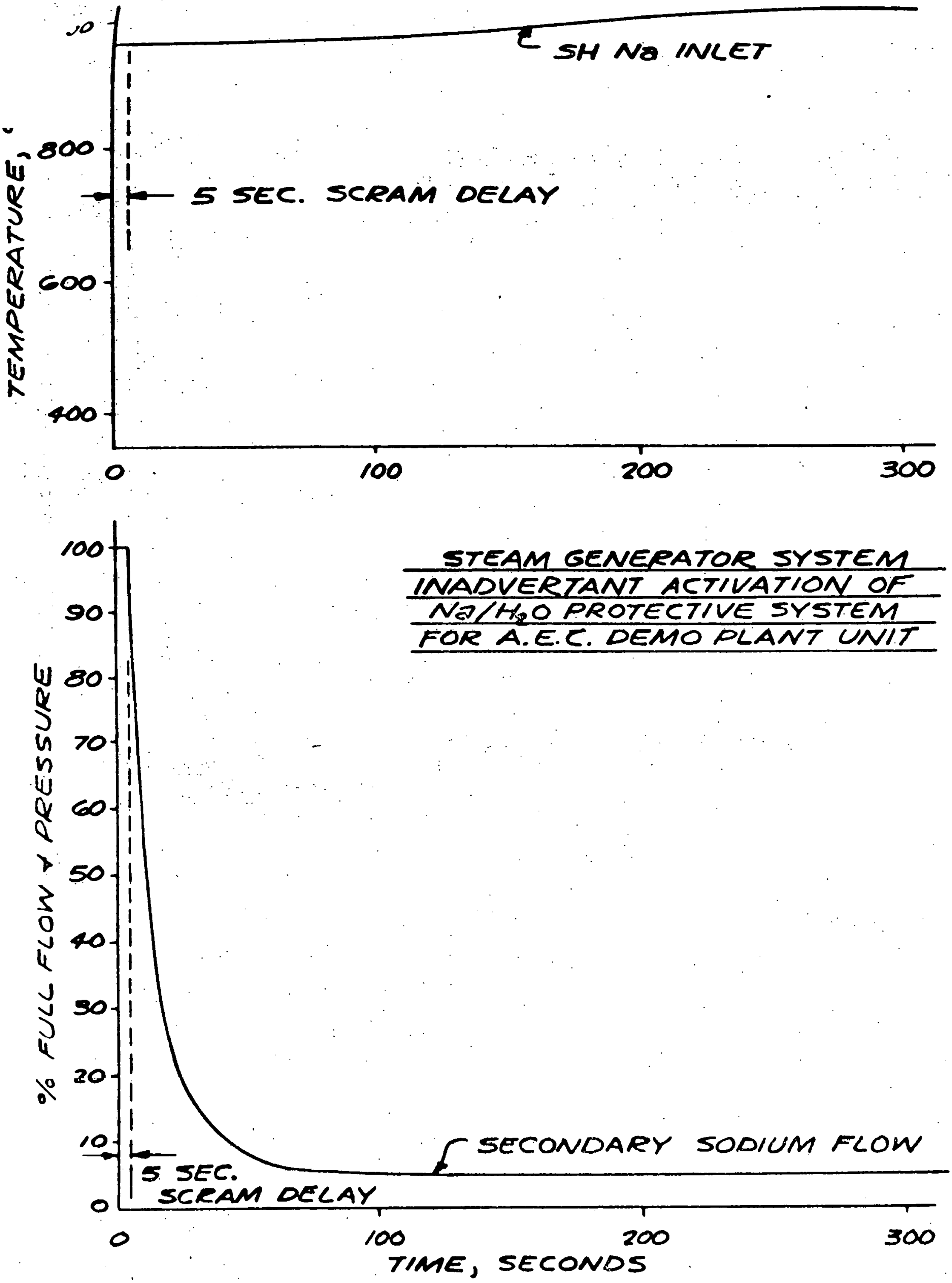

TEMPERATURE, °F
800
600
400
SH Na INLET
FW INLET (i.e. SAME AS NORMAL SCRAM)
0
100
200
300
% FULL FLOW + PRESSURE
100
90
80
70
60
50
40
30
20
10
0
FW INLET PRESS. @ STEAM DRUM (i.e. SAME AS NORMAL SCRAM)
STEAM GENERATOR SYSTEM
SINGLE PRIMARY PUMP SEIZURE
WITH SCRAM
FOR A.E.C. DEMO PLANT UNIT
FEEDWATER/STEAM FLOW (i.e. SAME AS NORMAL SCRAM)
SODIUM FLOW (i.e. SAME AS NORMAL SCRAM)
TIME, SECONDS

FIG. 3.6.8



SH Na INLET
TEMPERATURE, °
800
600
400
5 SEC. SCRAM DELAY
0
100
200
300
STEAM GENERATOR SYSTEM
INADVERTANT ACTIVATION OF
Na/H2O PROTECTIVE SYSTEM
FOR A.E.C. DEMO PLANT UNIT
% FULL FLOW & PRESSURE
100
90
80
70
60
50
40
30
20
10
0
SECONDARY SODIUM FLOW
5 SEC.
SCRAM DELAY
TIME, SECONDS

FIG. 3.6.9

TABLE 3.6.1

RANGE OF STEADY STATE OPERATING CONDITIONS

	CONDITION			
	100% Power	80	60	40
Heat Load, MWt	26.7	21.4	16	10.7
SODIUM SIDE				
Sodium Flow Rate (lb./hr.)	1.02×10^6	$.880 \times 10^6$	$.700 \times 10^6$	$.486 \times 10^6$
Sodium Inlet Temp. (°F)	960	945	933	926
Sodium Outlet Temp. (°F)	673	665	658	656
Sodium Inlet Pressure (psig)		Later		
Sodium P (psi)	18	11.5	6.5	2.9
STEAM-WATER SIDE				
Feedwater Flow (lbs. hr.)	$.965 \times 10^5$	$.772 \times 10^5$	$.58 \times 10^5$	$.385 \times 10^5$
Feedwater Temp. (°F)	460	440	412	370
Feedwater Pressure (psia)	2666	2624	2590	2563
Recirculation Ratio	3.5	4.0	6.0	9.0
Steam Outlet Temp. (°F)	900	900	900	900
Steam Outlet Pressure (psig)	2500	2500	2500	2500

SPECIFICATION

FOR

ISOLATION AND DUMP VALVES

FOR THE

SGWCS

FOR THE

1000 MWt DEMONSTRATION PLANT

CONTENTS

APPENDIX

1.0 SCOPE

This specification defines requirements for the design, material selection, fabrication, testing, inspection and installation of isolation and dump valves for the SGWCS and specifies typical isolation and dump design normally chosen by C-E for this type duty in compliance with these requirements.

1.1 INTENTIONS

A. It is not the intention of the specification issuer to design the inner working of isolation and dump valves. The intention is to present general design requirements to the valve manufacturer and allow him the freedom to design, select materials, etc. (within certain limits) and assume the responsibility for the inner workings of the valves.

B. It is the specification issuer's intent to ask a valve manufacturer to meet RDT Standards. However, if RDT Standards cannot be met, it must be so stated, and the pump manufacturer must strive to reach and state the highest level of the spirit of RDT Standards that he can reach.

C. The isolation and dump valves are an integral part of the SGWCS, and the SGWCS specification outlines the entire system in great detail. It is not the intention of this specification to needlessly or legalistically repeat SGWCS specification information that is applicable to the isolation and dump valves, such as general description, operation, maintenance, structural design, transients, etc. The intention is to provide additional isolation and dump valve information, major departures, etc. from the SGWCS specification knowing that applicable sections of the SGWCS specification apply without written record.

2.0 REQUIRED TECHNICAL FUNCTIONS AND DESIGN FEATURES

2.1 TECHNICAL FUNCTIONS

A. An isolation valve shall:

(1) Function primarily as a stop valve that is normallly open; it shall close when required.

2.1 TECHNICAL FUNCTIONS

A. (2) Have an operator that closes the valve in one (1) second (or less).

(3) Have low pressure drop, relative to the design.

B. A dump valve shall:

(1) Function primarily as a stop valve that is normally closed; it shall open when required.

(2) Have an operator that opens the valve in one (1) second (or less).

(3) Be capable of operating at critical pressure drop and flashing conditions (dependent on valve location).

2.2 TECHNICAL FEATURES

2.2.1 PROCESS PARAMETERS

A. An isolation valve at the evaporator inlet shall be designed to meet the MCR Process parameters listed in Table 1.

TABLE 1
EVAPORATOR INLET ISOLATION VALVE MCR PROCESS PARAMETERS

Description:		Quantity
Isolation Valve - Evaporator Inlet		9
Connecting Pipe Data:	Inlet	Outlet
Nominal Size (inches)	16	16

Design Conditions:

2910 PSIG at 688°F

Maximum Differential Pressure against which valve is to be operated - up to Downstream - 2910 PSI, as much as possible down to upstream.

Flow at Operating Conditions:

*	Normal - 1,600,000 lb/hr	Sp. Vol. 0.0254	cu. ft/lb
**	Minimum - 1,033,000 lb/hr	Sp. Vol. 0.0250@	cu. ft/lb
***	Maximum - 3,433,000 lb/hr	Sp. Vol. 0.01604	cu. ft/lb

Special Requirements:

A. One (1) Second or less) closing time

B. Low Pressure Drop Required - @ 2 PSI

NOTES:

* 2 Pumps operating CR 4.0 Design - Hot
** 3 Pumps operating CR 3.5 Design - Hot
*** 1 Pump operating CR 4.0 Design - Cold

2.2.1 PROCESS PARAMETERS (Continued)

B. An isolation at the evaporator outlet shall be designed to meet the MCR process parameters listed in Table 2.

TABLE 2

EVAPORATOR OUTLET ISOLATION VALVE MCR PROCESS PARAMETERS

Description:		Quantity
Isolation Valve - Evaporator Outlet		9
Connecting Pipe Data:	**Inlet**	**Outlet**
Nominal Size (inches)	16	16

Design Conditions:

2910 PSIG at 688°F

Maximum Differential Pressure against which valve is to be operated - down to upstream - 2910 PSI as much as possible - up to down

Flow at Operating Conditions:

*	Normal - 1,600,000 lb/hr	Sp. Vol. 0.051 cu. ft/lb.
**	Minimum - 1,033,000 lb/hr	Sp. Vol. 0.054@ cu. ft/lb
***	Maximum - 3,433,000 lb/hr	Sp. Vol. 0.01604cu. ft/lb

Special Requirements:

A. One (1) second (or less) closing time

B. Low Pressure Drop Required - @ 2 PSI

NOTE:

* 2 Pumps operating CR 4.0 Design - Hot
** 3 Pumps operating CR 3.5 Design - Hot
***1 Pump operating CR 4.0 Design - Cold

C. An isolation valve at the superheater inlet shall be designed to meet MCR process parameters listed in Table 3.

TABLE 3

SUPERHEATER INLET ISOLATION VALVE MCR PROCESS PARAMETERS

Description:		Quantity
Isolation Valve Superheater Inlet		9
Connecting Pipe Data:	**Inlet**	**Outlet**
Nominal Size (inches)	14	14

2.2.1 PROCESS PARAMETERS (Continued)

Table 3 continued

Design Conditions:

2840 PSIG at 688°F

Maximum Differential Pressure against which valve is to be operated - up to downstream - 2840 PSI As much as possible down to upstream

Flow at Operating Conditions:

Normal -	400,000 lb/hr	Sp. Vol. 0.1106 cu. ft/lb
Minimum -	20,000 lb/hr	Sp. Vol. 0.1106 cu. ft/lb

Special Requirements:

A. One (1) second closing time

B. Low pressure drop relative to valve design

D. An isolation valve at the superheater outlet shall be designed to meet MCR process parameters listed in Table 4.

TABLE 4

SUPERHEATER OUTLET ISOLATION VALVE PROCESS PARAMETERS

Description:	Quantity	
Isolation Valve Superheater Outlet	9	
Connecting Pipe Data:	Inlet	Outlet
Nominal Size (inches)	14	14

Design Conditions:

2840 PSIG at 960 °F

Maximum Differential Pressure against which valve is to be operated - Down to upstream - 2840 PSI As much as possible up to downstream

Flow at Operating Conditions:

Normal -	400,000 lb/hr	Sp. Vol. 0.27 cu. ft/lb
Minimum -	20,000 lb/hr	Sp. Vol. 0.27 cu. ft/lb

Special Requirements:

A. One (1) second closing time
B. Low Pressure Drop Relative to Valve Design
C. Valve considered boiler stop - to hold against initial hydro test @ 4500 PSI

2.2.1 PROCESS PARAMETERS (Continued)

E. A dump valve at the evaporator outlet shall be designed to meet MCR process parameters listed in Table 5.

TABLE 5

EVAPORATOR DUMP VALVE PROCESS PARAMETERS

Description: Quantity

Evaporator Dump Valve 9

Connecting Pipe Data: Inlet Outlet

Nominal Size (inches) 16 16

Design Conditions:

2910 PSIG at 688 °F

Maximum Differential Pressure against which valve is to be operated - up to downstream 2910 PSI

Flow at Operating Conditions:

Normal * lb/hr Sp. Vol. 0.1106cu. ft/lb

Special Requirements:

A. One (1) second opening time

* By Manufacturer

F. A dump valve at the superheater outlet shall be designed to meet MCR Process Parameters listed in Table 6.

TABLE 6

SUPERHEATER DUMP VALVE PROCESS PARAMETERS

Description: Quantity

Superheater Dump Valve 9

Connecting Pipe Data: Inlet Outlet

Nominal Size (inches) 16 16

Design Conditions

2840 PSIG at 960 °F

2.2.1 PROCESS PARAMETERS (Continued)

TABLE 6 continued

Maximum Differential Pressure against which valve is to be operated - up to downstream 2840 PSI

Flow at Operating Conditions:

Normal - * lb/hr Sp. Vol. 0.27 cu. ft/lb

Special Requirements:

A. One (1) second opening time

*. By Manufacturer

(Partial Listing - Remainder to follow)

2.2.2 SYSTEM CONFIGURATION

There are three (3) steam generator water/steam circulation systems for the 1000 MWt Demonstration Plant:

A. Equipment per SGWCS:

(1) Three (3) evaporator, isolation inlet valves

(2) Three (3) evaporator isolation outlet valves

(3) Three (3) superheater isolation inlet valves

(4) Three (3) superheater isolation outlet valves

(5) Three (3) evaporator dump valves

(6) Three (3) superheater dump valves

B. Equipment per Demonstration Plant

(1) Nine (9) evaporator isolation inlet valves

(2) Nine (9) evaporator isolation outlet valves

(3) Nine (9) superheater isolation inlet valves

(4) Nine (9) superheater isolation outlet valves

(5) Nine (9) evaporator dump valves

(6) Nine (9) superheater dump valves

2.2.3 GENERAL FEATURES

A. The valves shall be used to isolate and dump the water/steam side of the evaporator and superheater vessels that have developed water-to-sodium tube leak.

B. The valves shall be operated by hydraulic driven actuators.

C. Because the use of these valves shall be of an emergency nature, they shall perform, with actuators, as follows:

(1) An isolation valve shall:

(a) Be able to close whether there is or is not pressure in the evaporator or superheater vessel.

(b) Be able to close whether there is or is not hydraulic pressure available to drive actuators.

(c) Be capable of manual trip.

(2) A dump valve shall:

(a) The above shall apply to a dump valve except that the action is to open the valve.

D. Because the evaporator isolation valves are in the recirculation pump system, they shall have a low pressure drop design.

(1) Superheater isolation valves shall have low pressure drop, relative to the design.

3.0 DETAIL SPECIFICATIONS

The following information specifies typical isolation and dump valve design normally chosen by C-E for this type of duty in accordance with requirements outlined in Sections 1.0 and 2.0 of this specification and applicable requirements of the SGWCS Specification.

A. Omission of certain verification statements regarding the adherence to the requirements in Sections 1.0 and 2.0 was intentional for simplicity and avoidance of needless repetition.

B. There are many available valve manufacturers; however, Sulzer Brothers Valves are used in this specification as typical equipment.

3.1 SYSTEM CONFIGURATION

Arrangement drawings ND 723114, ND 723115, and ND 723116 show isolation and dump valve locations in the SGWCS design.

3.2 PROCESS PARAMETERS

The valves are designed for the process parameters are outlined in 2.2.1.

3.3 GENERAL FEATURES

A. Sulzer Isolation Valve and Actuator Description

(1) Isolation valves of Sulzer Type DA 250P is shown in Drawing 1-103.045.807 found in Appendix "C".

It is a single seat valve of the straight-through design with casting valve body. It will be operated by a hydraulic driven actuator of Sulzer Type ASM320f, which is connected to a low thrust hydraulic actuating system, similar to the enclosed "Description of the Light Hydraulic Control System of ASM 400f Actuators". All components are of proven design from many installed units.

The valve will close by system steam pressure and an additional spring force in one (1) second. In the event of a water to sodium tube leak, the quick closing will be effected by opening of a hydraulic bypass pipe between the upper and the lower piston chamber of the hydraulic actuator. The correct and safe action of the valve is independent on the oil supply from the hydraulic actuator.

(2) Sulzer type DA 250-P

Single seat valve of the straight-through design

Material of valve housing: SA 216WCB (SA 217WCG-SH Outlet only)

Seat Surface: Stellite No. 25

Stem guide: Stellite No. 6

Stem: 17 Cr Steel

3.3 GENERAL FEATURES (Continued)

(3) Description of the Light Hydraulic Control System of ASM 400f Actuators (Drwg. SK 31/18510 found in Appendix "C").

The whole control system consists of two different systems; an open-closed system via a four-way electromagnetic valve (6) and a safety system SBE. The safety device SBE is in principle a triplicate piston by-pass. Under normal operation this by-pass is closed by two hydraulic actuated non-return valves (4), to prevent any connection between the upper and lower cylinder chambers.

For this purpose the solenoid pilot valve (3) has to be energized, so that the control connections of the hydraulic de-blockable non-return valves (4) will be connected to the discharge line(L).

In case of an emergency, the rapid closing pilot valve (3) will be de-energized in that way, that the non-return valves will be hydraulically de-blocked by oil (P) supplied from the oil supply unit.

The piston of the hydraulic actuator (1) moves now upwards caused by the force acting from the steam pressure together with the spring power of the actuator - because the oil of the upper cylinder chamber can flow through the two check valves (4), to the lower chamber. The speed of the piston can be selected by adjusting the bore of the throttling device (5).

Simultaneously with the de-energizing of the rapid closing pilot valve (3) the valve for manual operation has to be electrically disconnected, to avoid undesired oil circulation.

On loss of the system pressure P the controllability of the safety device is maintained:

3.3 GENERAL FEATURES (continued)

(3) continued

The oil pressure of the cylinder chamber produced by the spring force and steam pressure is led through check valve (7), to the solenoid valve (3).

B. Sulzer Dump Valves and Actuator Description

(1) The dump valve design is similar to that described for the isolation valve (3.3A) except that the valve and operator action is being designed to open.

APPENDIX "A"

REFERENCES

(To be provided later)

APPENDIX "B"

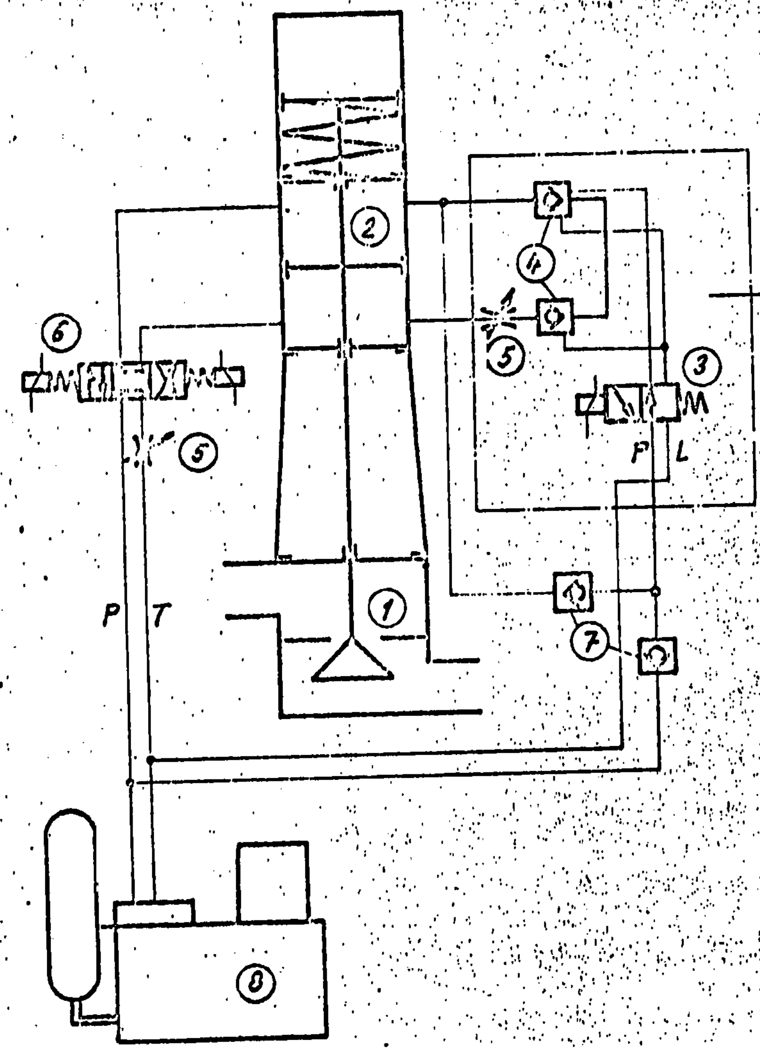
PARAMETERS

(To be provided later)

APPENDIX "C"

DRAWINGS

1. 1-103.045.807 - Sulzer Valve Type DA 250P
2. SK 31/18510 - Hydraulic Actuating System ASM 400f for Rapid Closing



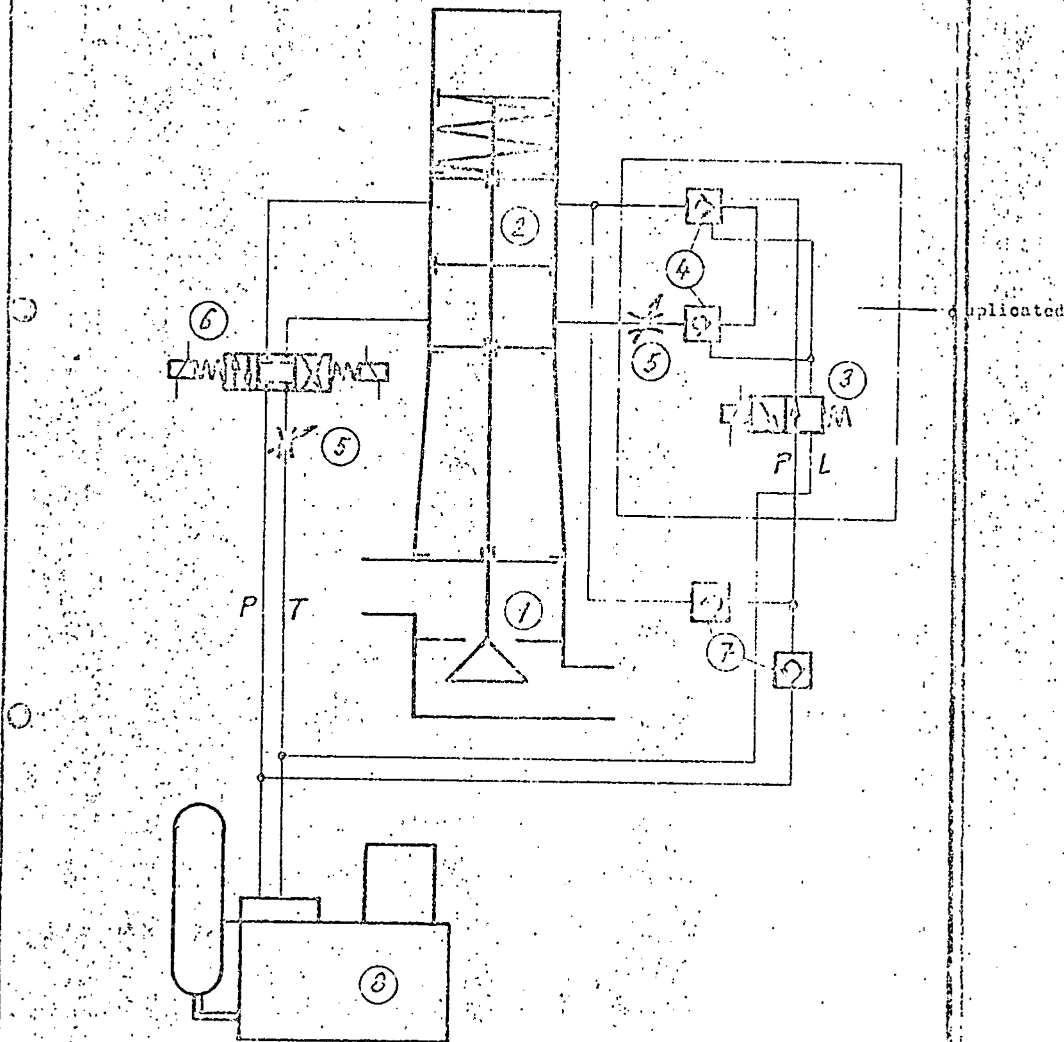
(1) Steam Isolating valve
(2) Hydraulic actuator ASM 400 F
(3) Rapid closing command valve
(4) Hydraulically debloable check valve
(5) Resetable orifice
(6) Valve for manual operation
(7) Non return valve
(8) Oil supply unit

P Reduced pressure from supply unit
T Return line to tank
L Leckage return line

F/ND/SBE
Hydraulic Actuating System ASM 400 F for rapid ...

SULZER

Zeichnung



Anz. Kennzahl / Stückzahl	Positions-Kennzahl / Positions-Art	Artikelnummer / Zeichnungsnummer	Stück-bez.-Buchst.	Benennung / Werkstoff und Bemerkungen	Bezugsvermerk / Gewicht ca. kg/Stück	Änder. Buchst
	001					

1. Steam Isolating valve
2. Hydraulic actuator ASM 400 f
3. Rapid closing command valve
4. Hydraulically deblocable check valve
5. ✓ Resetable orifice
6. ✓ Valve for manual operation
7. ✓ Non return valve
8. ✓ Oil supply unit

(3)–(4): SBE Rapid closing device

(5)–(6): solenoid valves

P Reduced pressure from supply unit

T Return line to tank

L Leckage return line

S. p. Stückverzeichnis ja/nein	Konstruktionsgruppe	Werkstückschlüssel	
Änderungen: Name / Datum	Name / Datum	Ersetzt durch	Orig. Maßstab
		Ersatz für	Name / Datum
F/ND/SBE	Hydraulic Actuating System ASM 400 for rapid closing		