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SODIUM REACTOR EXPERIMENT
POWER EXPANSION PROGRAM-
HEAT TRANSFER SYSTEMS MODIFICATIONS

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EQUIPMENT
52 PAGES

SODIUM REACTOR EXPERIMENT
POWER EXPANSION PROGRAM-
HEAT TRANSFER SYSTEMS MODIFICATIONS

By
SRE-PEP STAFF

Editors
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ABSTRACT

Under the Power Expansion Program (PEP), modifications have been made to the Sodium Reactor Experiment (SRE) facility to improve plant reliability and permit an increase in power to 30 Mwt, with a reactor coolant outlet temperature up to 1200° F.

Pertinent changes in the heat transfer systems include:

- 1) Installation of a new main intermediate heat exchanger,
- 2) Replacement of sodium coolant pumps,
- 3) Increase in diameter of certain main primary sodium coolant lines from 6 to 8 in. ,
- 4) Reduction in number of valve and freeze traps,
- 5) Utilization of flowing vent lines, and
- 6) Installation of a circulating nitrogen atmosphere cooling system for removing excess incidental heat from galleries.

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Figure 1. SRE Steam Plant Facilities

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I. INTRODUCTION

For the Power Expansion Program (PEP) concerning the Sodium Reactor Experiment (SRE), it is necessary to increase total power and operating temperatures so that irradiation experience under advanced operating conditions may be obtained on large scale, high performance fuel elements of the type being developed for the Advanced Sodium Cooled Reactors (ASCR) program.

Primary objectives of the program are: to operate the SRE at a mixed mean outlet temperature of approximately 1200°F with uranium monocarbide (UC) fuel running at a maximum centerline temperature of 2000°F; and to attain under these conditions an average burnup of 25,000 Mwd/MTU in certain central fuel elements within two years.

The purposes for modifying the SRE heat transfer systems are: to increase total plant heat removal capability to 30 Mwt at a primary sodium coolant temperature of 1200°F; and to improve operating reliability so that required irradiation data may be obtained under desired temperature conditions within the 2-yr period.

It is anticipated that significant operating and component utilization experiences will also result from the SRE-PEP. These will provide valuable information leading to the development of the ASCR system as an economic method for the production of nuclear power.

TABLE 1

GENERAL TECHNICAL DATA

PRIMARY COOLANT SYSTEM

Coolant	Liquid sodium
No. of primary loops	Two (one main and one auxiliary)
Operating pressure	0.5 psig at free sodium surface in reactor core tank
Operating temp.	1200°F hot-leg, 650°F cold-leg
Specific activity	0.45 curies/gm at 30 Mw
Flow rate at 1200°F design	1550 gpm main and 102 gpm auxiliary
System pressure drop, design	25.5 psi at 1550 gpm main 12.7 psi at 102 gpm auxiliary

TABLE 1 (Continued)
GENERAL TECHNICAL DATA

PRIMARY COOLANT SYSTEM (Continued)

No. of pumps	One main primary, one auxiliary primary
Pump type	Centrifugal, free surface (MP is single stage, AP is double stage)
Pipe material and size	Type 304 SS, 8-in. OD, Schedule 20 main; 2-in. OD, Schedule 40, auxiliary
Type of intermediate heat exchangers	Shell and tube type, U-tube with "U" bend shell, mounted in vertical plane

SECONDARY COOLANT SYSTEM

Coolant	Sodium
No. of secondary loops	Two (one main and one auxiliary)
Operating pressure	3 psig at free sodium surface in secondary pump and expansion tank
Operating temp.	Hot-leg 1166°F, cold-leg 616°F
Flow rate at 616°F design	77.0 psi at 1410 gpm main 15.3 psi at 93 gpm auxiliary
No. of pumps	One main, one auxiliary
Pump type	Centrifugal, free surface
Pipe material and size	Type 304 SS, 6-in. Schedule 40 and 8-in. Schedule 20, main; 2-in. Schedule 40, auxiliary
Type of steam generator	Once-through type, double wall U-tube with mercury monitoring fluid

POWER CONVERSION LOOP

Coolant	Water and steam
Design pressure	750 psig
Outlet tem. (steam generator)	Approximately 1100°F maximum
Flow rate (maximum)	88,700 lb/hr
Source of superheat	Superheater integral with evaporator
Degrees superheat, design	About 565°F
System pressure drop	50 psi through steam generator
Turbine inlet design temp.	825°F (attenuated from generating conditions of 1100°F nominal)

TABLE 1 (Continued)
GENERAL TECHNICAL DATA

<u>POWER CONVERSION LOOP (Continued)</u>	
Turbine inlet pressure	600 psig
Turbine-generator	3600 rpm, 7500 kva, 4160 volts
Type of turbine	Impulse straight condensing, non-reheat
Condenser type	2 pass, nondivided water box
Condenser coolant flow rate, design	7000 gpm
Type of heat sink	Cooling tower, counter flow, induced draft type

II. DESCRIPTION OF SRE-PEP SYSTEMS

A. HEAT TRANSFER SYSTEMS

The main heat transfer system for the SRE-PEP program consists of two complete heat transfer loops, the main primary and main secondary, with heat transfer through an intermediate heat exchanger. Under the PEP program, maximum heat energy production is 30 Mwt. In addition to the main heat transfer system, an auxiliary system is provided for decay heat removal under certain emergency conditions. (See Figures 2 and 3.)

1. Main Primary System

The main primary heat transfer circuit is designed to remove heat from the reactor core by using the primary sodium coolant which enters the core at 650°F and emerges at approximately 1200°F at a flow rate of 1550. (See Table 2 and Figure 4.) The original 6-in. diameter main primary outlet nozzle and inlet core tank piping have not been modified. Outside the containment barrier adjoining the reactor cavity, the principal piping has been increased from 6 to 8 in. in diameter.

TABLE 2

MAIN PRIMARY HEAT TRANSFER SYSTEM DESIGN DATA

Reactor outlet sodium temperature (°F)	1200
Reactor inlet sodium temperature (°F)	650
Sodium flow for 30-Mwt operation at 1200°F (gpm)	1550
Sodium velocity in 6-in. pipe for 30-Mwt operation (ft/sec)	17.2
Sodium velocity in 8-in. pipe for 30-Mwt operation (ft/sec)	9.6
System pressure drop for 30-Mwt operation (psi)	25.5

Sodium from the core tank outlet nozzle is directed to the main primary pump, which circulates the sodium to the main intermediate heat exchanger. A pump balancing leg is provided for the pump to permit bearing overflow coolant to be readmitted to the pump suction lines. In the heat exchanger, the coolant passes through the exchanger tube bundle and is cooled from 1200 to 650°F. From the main intermediate heat exchanger, the sodium flows through a control valve and a new eddy current brake before returning to the reactor core tank.

Figure 2. Equipment Location Plan

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Figure 3. Sodium System P & I Diagram
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Figure 4. SRE Reactor Vessel R-1

The eddy current brake is provided to brake sodium flow after a reactor scram, and to control the flow rate during start up periods. The flow control valve serves as a backup for the EM brake, and may be used to control main primary sodium flow without placing a load on the electrical system during emergency or shut down periods.

Downstream from the eddy current brake, a 3-in. -diameter moderator plenum coolant supply line branches from the 8-in. -diameter cold-leg return piping. This line goes through the reactor containment barrier, enters the core tank, and terminates at a sparger located on top the core tank grid plate. Moderator plenum coolant flow is controlled by means of a throttle valve which is operated manually from the reactor floor. Another means for applying coolant to the moderator plenum is through an orifice device located in the region of the core tank grid plate. This device is inserted into the support pedestal on a moderator element.

Three 1.5-in. -diameter lines are provided for transporting main primary sodium to and from the primary sodium purification system located in a separate vault. The supply pipe to the hot traps (for carbon and oxygen removal) is connected to the main primary hot-leg, near the main primary pump discharge. Piping to the cold trap and filter units (for particle and oxide removal) is connected near the outlet (cold-leg) of the main intermediate heat exchanger. The common return header from the purification system is connected near the inlet hot-leg to the main primary pump. A mixing tee is installed at the return junction to prevent thermal shock and stresses resulting from sodium temperature differentials.

The 2-in. drain line for the main primary circuit ties into the cold-leg piping immediately downstream from the eddy current brake. In the drain pump vault, this line is interconnected with the drain line from the reactor core tank. The arrangement allows utilization of both E-M drain pumps for draining either system to the primary storage tank; and permits each pump to serve as a spare for the other. Draining operations conducted through the main primary loop drain line cannot expose moderator elements in the core tank or drain the auxiliary primary circuit. Block valves for both primary drain lines are located in the drain pump vault.

At the high point of the main primary system is a tee-fitting connected to a ventline through which a small percent of the main primary sodium flow, plus

any trapped gas, is routed back to the primary pump overflow line. This flowing vent serves to collect incidental gas from the loop, and provides automatic venting of gas when filling or draining the main primary system.

2. Main Secondary System

By means of secondary sodium coolant, the main secondary system transfers heat energy from the SRE to the Southern California Edison steam generator, which is located adjacent to the SRE site. (See Table 3 and Figure 5.) Flowing at 1166°F from the shell side of the main intermediate heat exchanger, the sodium is routed through the steam generator, thence to the free surface main secondary pump, and back to the heat exchanger at 616°F. Flow rate from the pump is 1410 gpm. A spherical shell, approximately 6 ft in diameter encloses the pump, which is located at the high point of the system, and serves as the expansion tank for the main secondary circuit. Inert gas is maintained above the coolant level in the sphere. The original SRE main secondary E-M brake is retained, and is located in the suction line to the pump. Also in the suction line is a temporary startup strainer to remove possible foreign material which could damage the main secondary pump.

TABLE 3
STEAM GENERATOR OPERATING CONDITIONS*

	Initial SRE Condition (20 Mwt)	PEP Condition (30 Mwt)
Heat load (Btu/hr)	-	1.02×10^8
Sodium inlet temp. (°F)	900	1166
Sodium outlet temp. (°F)	440	616
Feedwater temp. (°F)	297	297
Steam temp. at turbine (°F)	825	825
Steam pressure at turbine (psig)	600	600

*The steam generator is designed for 30-Mw heat duty under either condition.

Discharge piping from the pump to the main intermediate heat exchanger and the first portion of outlet line from the exchanger are 8 in. in diameter. The remaining principal piping for the main secondary system is reused 6-in.-diameter material.

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Figure 5. Steam Generator X-2 and Simplified Cutaway View

A 1.5-in.-diameter branch off the pump discharge line passes through the secondary sodium purification system and returns to the pump suction leg. The secondary purification system consists of a cold-trap and a plugging meter.

A 2-in.-diameter drain line connects to the low point of the system near the main intermediate heat exchanger inlet.

3. Auxiliary Primary System

An auxiliary primary heat transfer system is provided to remove decay heat from the reactor core in case of failure of any portion of the main (primary or secondary) heat transfer systems. It has capacity to remove 1.5 to 2 Mw of heat at rated flow and temperature conditions.

The auxiliary primary system consists of new 2-in. sodium piping outside the reactor barrier, a new free-surface type sodium pump which receives 1200°F primary sodium from the core, and the original SRE auxiliary intermediate heat exchanger. This system can pump approximately 102 gpm of sodium at 12 psi differential head. However, during normal operation, flow is approximately 10 gpm. The pump has a balancing leg to permit pump bearing overflow to be returned to the pump suction line. From the tube side of the heat exchanger, primary sodium at 650°F returns to the reactor core tank.

A flowing vent line is installed on the hot-leg between the pump and heat exchanger, and is similar in function to that described for the main primary system. Block valves have been deleted from the auxiliary primary system.

4. Auxiliary Secondary System

The auxiliary secondary system transfers heat from the auxiliary intermediate heat exchanger to the auxiliary air-cooled heat exchanger. Both exchangers are original SRE equipment.

A blocking valve is the only component installed on the hot-leg 2-in.-diameter piping between the two exchangers. A free surface auxiliary secondary pump (new equipment) receives the returning coolant from the auxiliary air-cooled heat exchanger and pumps it back through 2-in. piping to the shell side of the auxiliary intermediate heat exchanger. The new pump is located at the system high point, and the pump enclosure shell serves as an expansion

tank for the circuit. The atmosphere above the coolant in the pump shell is low-pressure inert gas. A temporary startup strainer is installed on the suction line to the auxiliary secondary pump.

Branching off the pump discharge is a 1.5-in.-diameter supply line to the secondary purification system (cold-trap plus plugging meter); this coolant is returned through a 1.5-in.-diameter line connecting near the pump inlet. A 2-in.-diameter drain line ties into the low point of the system, which is near the auxiliary intermediate heat exchanger inlet.

B. GALLERY COOLING SYSTEM

A gallery cooling and dehumidification system of the circulating gas (atmosphere) type is provided in the SRE-PEP program to remove incidental heat and possible water vapor from the main and auxiliary galleries. (See Figure 6.) This system consists of ducting, fans, cooling coils, coolant water pumps, cooling tower, and refrigeration (dehumidification) equipment.

The nitrogen atmosphere in the two galleries is pulled through leak-tight ducting into the cooling unit, T-60, which is a leak-tight vessel. This vessel contains two nitrogen circulating fans, W-60A and W-60B (one is a spare). The nitrogen atmosphere cooling coils, X-60, and the dehumidification refrigerant coil, X-61, also are contained in the vessel. Cooled nitrogen is returned from the cooling unit to the galleries and distributed to the areas of greatest heat load. Treated water for cooling the nitrogen is pumped through the cooling coil, X-60, and the cooling tower, X-62, by means of two pumps, P-60A and P-60B (one is a spare). Heat removed from the circulating nitrogen is transferred to the water and then is dissipated to the outside atmosphere through the cooling tower. This water is circulated in a closed circuit. In the refrigeration system, the refrigerant is circulated through the dehumidification coil and condenser by compressor, K-60. A small sidestream of nitrogen atmosphere gas passes through the dehumidification coil and is cooled by the refrigerant. Water vapor from the nitrogen condenses on the coil and drains off into a collection tank, T-61. The collected water is removed manually by draining the tank.

1. Performance Characteristics

The gallery cooling system is operated essentially on a manually controlled, on-off basis. The system is balanced initially to obtain maximum flow

Figure 6. Gallery Cooling System
P & I Diagram

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to the galleries, and to maintain slightly positive gallery pressures between 0 to 1/4-in. w.g. After balancing, the system operates continuously at the set conditions.

2. Safety Provisions

The gallery cooling system, which contains only nitrogen, water, and refrigerant, is inherently safe. No fire protection system or fire detecting devices are present, because in operation only inert gas is circulated. No pressure-relief devices are provided, since the system is designed to a higher pressure rating than the galleries. All nitrogen atmosphere containing portions of the system utilize all welded construction, providing leak-tight containment. Such portions of the system are designed for a pressure of 10 psig. In event of a pressure excursion in the galleries, a rupture disc fails at 5 psig and relieves the gas into the three other vaults (drain pump, primary sodium storage, and sodium service vaults). Within the cooling unit, cooling water piping is all welded and refrigerant tubing is all silver-brazed to protect against leakage into the circulating nitrogen. A moisture detector, located in the common fan discharge line, is provided to indicate a leak in the cooling coils. A radiation indicator is located in the cooling unit nitrogen inlet line to detect any leakage of radioactive sodium within the galleries.

C. HEAT TRANSFER SYSTEM INSTRUMENTATION

The SRE-PEP process instrumentation senses, monitors, annunciates and records various process temperatures, pressures, flow rates, and leak locations. Process instrumentation also controls coolant flow rates, regulates certain gas services, and governs electrical equipment, as required.

1. Temperature Instrumentation

a. Preheat Thermocouples

Preheat thermocouples monitor and provide temperature signals for monitoring and for controlling electric heaters. On all piping, a pair of thermocouples, one active and the other spare, are present for each unit length of electric heater. On vessels and equipment, a sufficient number of thermocouples are provided to furnish temperature profiles.

Thermocouples are welded directly to pipes and equipment by means of an inert gas shielded arc process. The thermocouples are fabricated from AWG No. 14 asbestos insulated iron-constantan thermocouple wire.

b. Process Thermocouples

Eight process thermocouples welded to the sodium piping measure sodium temperature. These thermocouples are located on the main primary reactor vessel inlet and outlet, main secondary IHX inlet and outlet, auxiliary primary reactor vessel inlet and outlet, auxiliary intermediate heat exchanger secondary outlet, and auxiliary air cooled heat exchanger outlet lines.

All process thermocouples are iron-constantan except for the two thermocouples located on the main primary reactor vessel inlet and outlet, which are chromel-alumel.

c. Other Thermocouples

Six iron constantan thermocouples measure E-M brake coil temperatures — four on the primary E-M brake and two on the secondary E-M brake.

2. Pressure Instrumentation

The eight sodium pressure sensors are of the pneumatic type. All transmitters are NaK-filled, and are connected to the suction and discharge lines of the pumps in the main primary, main secondary, auxiliary primary, and auxiliary secondary systems. Four miniature, 2-pen recorders are used to record the pressure measurements received from the transmitters. The range of the pressure recorders for the main primary loop and main secondary loop is 30 in. Hg vacuum to 33 psig on one scale, and 0 to 125 psig on the other scale. The range of the two pressure recorders for the auxiliary primary loop and the auxiliary secondary loop is 30 in. Hg vacuum to 35 psig on one scale, and 0 to 50 psig on the other. These recorders are mounted in the reactor control room.

3. Flow Instrumentation

Two types of sodium flowmeters are incorporated in the main primary and main secondary systems. One type is a magnetic flowmeter which transmits millivolt signals to recorders. The other type is a venturi-type flow tube on which a NaK-filled flow transmitter is mounted which sends pneumatic signals to recorders.

Flow of sodium in the auxiliary primary and auxiliary secondary systems is sensed by magnetic type flowmeters and recorded on two 0 to 150 gpm recorders.

Magnetic type flowmeters are used to measure sodium flow in the reactor fill and drain line; primary and secondary sodium fill and drain lines; primary and secondary plugging meter; primary and secondary cold-traps and primary hot-traps.

4. Flow Control Instrumentation

Sodium coolant flow regulation is achieved through control of pumping rates and use of flow control devices such as E-M brakes and valves. Speed control for the main primary and main secondary pumps is obtained by use of adjustable-speed magnetic drive units. The primary and secondary speed control units are in a floor-mounted NEMA I enclosure, located in the electrical equipment room. Three hand switches, located on the operators' console, are used to control small drive motors which vary the input voltage to the speed control units.

The auxiliary primary and auxiliary secondary pumps receive power from the 120-v d-c bus. Speed control for these pumps is obtained by varying current to the shunt fields.

Control of low flow in the main systems during startup and convection flow following a scram are obtained by use of the primary and secondary E-M brakes. A motor-operated flow-control valve in the main primary system is a backup for the primary E-M brake.

Identical controls for the reactor fill and drain pumps which serve the reactor and the primary and secondary systems are located in the reactor control room.

5. Sodium Leak Detector Instrumentation

Sodium leak detectors are mounted on main primary and auxiliary primary valves and equipment. These detectors are modified metal-sheathed, magnesium oxide insulated thermocouples in which the MgO insulation has been removed from the end, leaving two exposed wires insulated from each other. Where possible, each detector is mounted at the apex of a formed funnel which permits collection of the sodium in the event of leakage. Sodium which leaks into a detector shorts the wires and actuates an alarm. A resistor is connected across the two lead wires of each leak detector for testing purposes.

The radiation detector described in the gallery cooling system section also serves as a method for sensing primary sodium leaks.

6. Sodium Level Instrumentation

The levels of sodium in the main primary pump case and the primary and secondary storage tanks are measured by means of induction coils. Sodium level in the auxiliary primary pump is measured by a NaK-filled level transducer; the signal is pneumatically transmitted to an indicator. Main secondary pump and the auxiliary secondary pump sodium levels are measured by NaK-filled level transducers and inductance coils. All sodium level indicators are located in the reactor control room.

7. Annunciator Alarm System

The annunciator alarm system consists of visual and audible alarms which are energized when abnormal conditions exist in various portions of the plant. Four annunciator alarm cabinets are mounted on the control panel within view of the plant console operator.

Each cabinet contains 21 windows with printed legends indicating the source of the abnormality when the window lamp is energized. A manual reset of the audible alarms is provided. However, automatic reset is provided for the visual alarms to avoid loss of indication of any abnormal condition until the condition is corrected.

8. Thermal Power Instrumentation

One recorder, located in the control room, registers main primary thermal power.

9. Power Generating System Instrumentation

Steam plant operation information such as electric power output, feed-water flow, and exit sodium temperature from the steam generator are displayed in the SRE control room.

10. Gallery Cooling System Instrumentation

Pressure transducers measure the nitrogen atmosphere pressure in the (a) primary sodium service vault, (b) primary sodium storage tank vault, (c) main primary gallery, and (d) auxiliary primary gallery; and transmit pneumatic

signals to recorders. Local pressure indicators are mounted on the (1) gallery cooler vessel, (2) gallery cooler fan outlet pipe, and (3) each cooling water pump outlet pipe.

An orifice flange is installed on the main primary gallery nitrogen inlet pipe to permit pressure transducers to measure flow and pressure of nitrogen entering the main primary gallery. A pressure switch actuates the main primary gallery nitrogen inlet low-flow alarm. An orifice flange is installed on the auxiliary primary gallery nitrogen inlet pipe, and another orifice flange is located on the nitrogen dehumidification bypass pipe. Flow transducers are mounted on the orifice flanges to measure flow and transmit pneumatic signals to a recorder. Local mounted flow indicators are installed on the cooling water pump outlet line and on the two water inlet pipes to the nitrogen cooling coils. A contact in the flow indicator actuates the cooling water low-flow alarm.

A level glass is mounted on the water collection tank. A radiation detector is installed in the duct through which gallery cooling fans draw nitrogen from the primary galleries.

Water leakage into areas served by the nitrogen cooling system is detected by means of a moisture detector on the nitrogen inlet duct which actuates an alarm.

A moisture detector and an oxygen detector are installed on a line through which a vacuum pump draws samples of nitrogen from the two galleries and the two vaults. Signals from the detectors are transmitted to recorders. Operation of toggle switches opens and closes solenoid valves in order that samples of nitrogen may be drawn from one source.

Hand indicator-controllers remotely operate valves which control flow of nitrogen into the main primary and auxiliary primary galleries.

Temperature switches on the gallery nitrogen-inlet connection and the cooling tower-cooling water discharge actuate high temperature alarms. Temperature test wells are located throughout the gallery cooling system.

D. ELECTRICAL SYSTEM

Electrical system modifications are shown diagrammatically on the 480-v single-line diagram (Figure 7) and on the 240-v heater distribution single-line diagram (Figure 8). The 480-v single-line diagram shows the complete SRE

electrical system, with PEP modifications encircled and identified by drawing revisions F and G. Following is a description of the electrical modifications.

1. Switchgear

Switchgear components are rearranged and modified in order to accommodate the added, and in many cases, larger PEP electrical devices. New cranes are added in the main and auxiliary secondary areas and are fed from breakers in the existing 480-v switchgear. A local disconnect switch and crane control station is provided at a convenient operating position for each crane. The new instrument air compressors, K-1 and 2, and air dryer, D-1 are fed from existing breakers in the auxiliary emergency control power panel located in a section of the 240-v heater switchgear. Formerly, these breakers served the NaK-cooling equipment which has been removed from the SRE system. The 240-v heater switchgear is modified slightly by rearrangement of a few of the existing components to fit requirements of the preheat system. All of the 240-v heating switchgear, distribution panels, and circuits are reidentified to prevent duplicate circuit identification.

A new motor control center with combination breaker and starter units is provided for the new main primary pump motor, gallery cooling system compressor motor, and the fan and cooling tower motors. Included in the new motor control center is the starter for the main secondary pump motor. A breaker in the existing 480-v switchgear is modified for the feeder to the main secondary pump motor.

2. Pump Drives and Speed Controls

The main primary pump, P-1, and main secondary pump, P-2 are furnished with new, open, vertical, squirrel-cage-type drive motors and eddy current speed control couplings. The main secondary drive motor is rated at 200 hp, 480-v, 3-phase, 1800 rpm; and the main primary drive motor is rated at 150 hp, 480-v, 3-phase, 1200 rpm.

Eddy current couplings between the drive motors and the pumps are air-cooled, and are designed for a speed control range of 10 to 96% of drive motor speed. Speed control is provided by means of a solid-state amplified and control system. Provision is made for either manual or automatic speed control. The automatic control system uses motor-operated rheostats, and employs much of the existing SRE sensing and signaling circuitry.

DC drive motors and controls used on the former SRE auxiliary pumps are reused on the new auxiliary system pumps. The only modification made to the control system is to incorporate bearing cooling oil fan interlocks in the pump-motor start circuits.

3. E-M Brakes

Electrical facilities are relocated or modified to meet requirements of E-M Brakes BR-1 and BR-2.

4. Sodium Piping Preheat

New tubular, electrical heaters are provided for all new and relocated sodium piping and equipment except for heaters on the main sodium lines, to and from the Southern California Edison facility. Pipe and equipment heaters are nominal 5/16-in. diameter, and valves heaters are nominal 5/32-in. diameter. Heater sheaths are of seamless alloy steel rated for 1500°F operation. Terminals are standard, threaded, mica washer insulated, and are unsealed. The heaters are rated for 240-v operations, but normally are connected to operate at 120-v. The wattage rating of the heaters is sufficient to preheat the pipes to a maximum temperature of approximately 600°F.

Control of the pipe heaters is by manual operation of the individual circuit breakers. However, all of the pipe heaters in each major sodium system (for example, the main primary system) are fed through a single contactor existing in the switchgear, with push-button control. The heaters on major equipment items are circuited through existing contactors actuated by existing temperature-indicating controllers for automatic control of preheat.

Heaters are installed directly on the pipes and equipment. These heaters on the pipes are covered by a narrow strip of 0.010-in.-thick stainless steel to prevent contact of the heater with the thermal insulation and to increase heater efficiency. Valves and equipment are enclosed in stainless steel jackets. To provide uniform heat distribution on vessels and equipment, heaters are arranged so that approximately two-thirds of the total heat is applied to the lower half of the equipment. The remaining one-third is applied to the upper half. In primary areas, duplicate heaters are provided. One heater is active, the other spare. In secondary areas, single, active heaters are provided.

5. Wiring

In the primary galleries, power, thermocouple, and instrument wiring are provided which is suitable for gallery temperatures and radiation. Initial SRE wiring is cut back and terminated on terminal blocks in new terminal cabinets which are located at the conduit entrances in the galleries. Existing wiring is retained in conduits which lead back to the switchgear and control panels.

In secondary areas, new wiring is provided to the area pullboxes. The existing wiring which runs from the pullboxes to the switchgear and control panels is retained.

Because of the increased size and change in type of the main pump drive motors, new motor feeder circuits are provided.

E. PRINCIPAL EQUIPMENT (new)

1. Primary and Auxiliary Sodium Pumps

a. Main Primary Pump

The main primary sodium pump, P-1, is a free surface type centrifugal pump in which power from the electric motor is transmitted through an E-M coupling to the impeller assembly. (See Figure 9.) Design features include a conventional ball thrust bearing, a gas seal, and a hydraulic radial bearing. The pump barrel contains steel shot for shielding, thermal insulation, and a finned cooling section with a cooling coil backup. Internal machinery is removable from the pump barrel without disconnecting piping or removing the pump case from the floor.

The main primary pump assembly is designed for pumping 1200°F sodium at a maximum rate of approximately 2500 gpm at 53 psi. At PEP design conditions, flow is approximately 1550 gpm at 22 psi. (See Table 4.) The entire pump is fabricated from Type 304 stainless steel with the exception of hard-faced bearing surfaces. The bearing seal device also includes the gas sealing mechanism for the pump. Below the main thrust bearing is a mechanical oil seal, under which are two labyrinth seals; and between the labyrinth seals is a leakoff chamber. In event of failure of the mechanical seal, oil cannot enter the sodium-containing portion of the pump. The hydraulic radial bearing of the pump is cooled and lubricated from the discharge side. Excess sodium which passes through this bearing flows through an overflow line and into a

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Figure 9. Main Primary Pump P-1

TABLE 4

MAIN PRIMARY AND SECONDARY PUMP DESIGN DATA

Characteristics	Primary		Secondary	
	Max	PEP	Max	PEP
Capacity (gpm)	2500	1550	2500	1410
Operating temp. (°F)		1200		616
Total dynamic head at rated flow (psig)	53	22.1	92.3	77.0
NPSH required (ft Na)	15	15	20	20
NPSH available (ft Na)	19.7	19.7	36.5	36.5
Case design pressure (psig)	100	100	100	100
Case design temp. (°F)	1200	1200	750	750
Tank capacity (gal.)	-	-	1120	1120

balancing leg, where it is conveyed back into the pump suction piping. The balancing leg is designed to prevent the drawing of cover-gas back into the pump suction line. The pump is driven by a 150-hp, 1200-rpm squirrel cage type a-c motor through a magnetic, variable speed coupling.

b. Main Secondary Pump

The main secondary pump, P-2, is a free surface type centrifugal pump contained in a spherical shell. (See Figure 10.) The shell serves as the pump casing and the expansion tank for the main secondary system. This pump is designed to pump 616°F sodium at a rate of approximately 2500 gpm at 92.3 psi. At PEP design conditions, the flow is approximately 1410 gpm at 77.0 psi. (See Table 4.) The drive motor is a squirrel-cage-type motor, 200 hp at 1800 rpm nominal speed. Power to the pump is transmitted through an E-M variable speed coupling. The bearing assembly for this pump is identical with that described for the main primary pump, P-1.

c. Auxiliary Primary Pump

The auxiliary primary sodium pump, P-3, is a centrifugal type, 2-stage, free-surface pump, designed for a 1200°F sodium flow rate of approximately 102 gpm, with a total dynamic head of 12.7 psi. (See Figure 11.) This pump is driven by a d-c motor, thus providing speed control. Under normal conditions the pump will not operate at full flow, but at approximately 10% flow.

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Figure 10. Main Secondary Pump P-2

DATA REVIEW	
Reviewed, as noted, subject to the provisions of the related Purchase Order or Contract, by Atomic International, a Division of North American Aviation, Inc., Engineering Dept.	
AC 115-1175	☒ FOR REACTOR MANUFACTURING ☒
AC 115-1175	☐ FOR REACTOR DESIGN ☐
REVIEWING OFFICE REQUESTED	YES ☐ NO ☒
DATE	12-8-64
NO. 7599	6621
Review does not release Seller from any obligation of the related Purchase Order or Contract.	
ATOMIC INTERNATIONAL	
A DIVISION OF NORTH AMERICAN AVIATION, INC.	

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This flow rate is sufficient to maintain proper temperature gradients in the auxiliary sodium system. Pump features include a bearing housing and pump casing similar to that described for the main primary pump, P-1.

d. Auxiliary Secondary Pump

The auxiliary secondary sodium pump, P-4, is a 2-stage, free-surface type, centrifugal pump designed to pump approximately 93 gpm of 616°F sodium against a total dynamic head of 15.3 psi. (See Figure 12.) The pump is driven by the existing d-c motor, which allows speed control. The pump barrel also serves as the expansion tank for the auxiliary secondary sodium system. A bearing assembly similar to that described for the main primary pump, P-1, supports the shaft and impeller.

2. Primary E-M Brake BR-1

The primary E-M brake, BR-1, is provided to control main primary system sodium flow in case of scram. When power is applied to the brake, a braking effect equivalent to 85-psi backpressure is provided within 1 to 3 sec, which permits a shutdown flow of 235 gpm. The coil assembly is designed for operation on d-c current at 105 v and 13 amp; it is cooled by means of gallery atmosphere nitrogen gas which flows through cooling passages. (See Figure 13.) When not energized, the brake causes a maximum pressure-drop of 2 psi in the system under PEP conditions.

3. Flow Control Valve V-103

The flow control valve, V-103, is installed as backup for the E-M brake; it may be used to control main primary flow after a scram without placing a load on the emergency electrical system. This valve is located on the main primary circuit cold-leg and is somewhat similar to a cone-type valve, with an approximate 30° rotation from full-open to full-closed. (See Figure 14.) The valve stem is an all-welded torque tube device which eliminates the possibility of seal leakage. Although the unit may be manually operated, it is normally actuated by a drive assembly which is driven by a motor, mounted above the reactor building floor.

4. Main Intermediate Heat Exchanger X-1

The main intermediate heat exchanger, X-1, was purchased in 1959 in preparation for increasing power of the SRE. It is a U-tube type of heat exchanger, single-pass on the shell and tube side for counter flow. (See Figure 15.)

Figure 13. Primary E-M Brake BR-
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This unit of 304 stainless steel construction is designed for a working pressure up to 110 psig and is capable of transmitting approximately 45 Mwt with a primary temperature gradient of 1200 to 650°F, and a secondary sodium temperature gradient of 616 to 1166°F. For the PEP program, however, the maximum heat transfer requirement is 30 Mwt. (See Table 5.)

The exchanger is mounted in a vertical plane to minimize the possibility of coolant stratification and excessive thermal stresses at low flow conditions.

TABLE 5
MAIN INTERMEDIATE HEAT EXCHANGER, PEP DESIGN CONDITIONS
(30 Mwt*)

Design Characteristics	Shell Side	Tube Side
Sodium flow (gpm)	1410	1550
Temperature in (°F)	616	1200
Temperature out (°F)	1166	650
Pressure drop (psi)	3	1.8
Design pressure (psig)	110	110
Heat exchanged (Btu/hr)	1.02×10^8	1.02×10^8
Heat exchanged (Mwt)	30	30
Mean temp. difference (°F)	34	34
Heating surface (ft ²)	2945	2945

*The exchanger is designed for 45-Mw heat duty. PEP conditions use the exchanger for 30-Mw heat duty.

5. Piping

Piping for the SRE-PEP modification is designed in accordance with the ASA Code for Pressure Piping, B31.1 Section I, and the applicable nuclear (N) code cases. Stainless steel piping in sizes 6 in. and smaller is seamless and fabricated in accordance with ASTM A376, TP 304. Stainless steel piping 8 in. and larger is fabricated from plate in accordance with ASTM A358, TP 304. All stainless piping fabricated from plate is 100% radiographed along the longitudinal seam weld; dye penetrant is used for inspecting the initial and final weld passes. All stainless steel pipe fittings are seamless, and fabricated in accordance with ASTM A403, Grade WP 304.

During erection of the piping systems, special inspection requirements and precautions are specified to assure proper installation of all piping and equipment. These procedures and inspections are designed to eliminate or minimize additional stresses and forces which could be imposed on the piping system because of improper equipment positioning or piping alignment.

All piping systems installed or modified during the SRE-PEP program have been reviewed for flexibility. Where necessary, a detailed stress analysis of a piping system was performed. Expansion loops are utilized to provide for thermal expansion and flexibility in the piping systems.

To increase system reliability and ease of maintenance, valves, wherever possible have been eliminated or are located outside the main galleries. The original SRE block valves on the reactor inlet and outlet connections have been deleted, and block valves for the sodium drain lines are outside the galleries.

Piping for the process systems is supported by using rods, spring hangers, constant support hangers, etc. In general, all major equipment is anchored, and the piping between equipment is unrestrained and free to move with all temperature variations. Where main sodium lines enter or leave galleries, the sodium piping is anchored at the gallery wall, and adequate expansion loops are provided for flexibility. One piece of equipment, the primary E-M brake, BR-1, is not anchored. This component, which is supported from hanger rods and snubbed by a hydraulic unit, is free to move with the piping system.