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FOR THE
SODIUM RECEIVING AND PROCESSING SYSTEM
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SODIUM RECEIVING AND PROCESSING SYSTEM

INTRODUCTION

The Sodium Receiving and Processing System provides the equipment and facilities required to receive, store, sample, makeup, purify and dispose of sodium for the following FFTF Reactor Systems:

- Reactor Refueling System
- Reactor Heat Transport System
- Closed Loops System

The topical sections of this CSDD are arranged for classification of the descriptive information to delineate BASELINE and REFERENCE material.

SECTION 1.0, FUNCTIONS AND DESIGN REQUIREMENTS present the baseline information for which firm decisions have been resolved, and as such are subject to change only with formal concurrence of both the AEC and PNL as outlined for Baseline Change Procedure.

The remaining sections of this CSDD describe the current reference concept. The reference features are subject to modifications based upon further engineering studies and evaluations for developing a final system design.

The contents of this document support and expand the requirements established in Overall Conceptual Systems Design Description¹ for the FFTF.

1. Refer to References, Appendix A, Item 31.

SECTION 1.0 FUNCTIONS AND DESIGN REQUIREMENTS

1.1 FUNCTIONS

The FFTF Sodium Receiving and Processing Systems receive, store, and process sodium coolant for the reactor and closed loop heat removal systems and fuel storage facilities. The following functions are required:

- A. Receive, sample, purify, and store fresh sodium for makeup to the reactor and closed loop primary and secondary heat removal systems and fuel storage facilities.
- B. Provide storage capacity to permit draining all systems, portions of systems, or components, for servicing the equipment.
- C. Sample and control purity of sodium in the reactor and closed loop primary and secondary heat removal systems, sodium storage tanks, fuel storage containers and in the contaminated sodium processing facility.
- D. Provide capability of sodium makeup to the reactor and closed loop primary systems to prevent loss of cooling to in-core materials or components in the event of a primary system rupture.¹
- E. Provide for retention and subsequent purification and/or disposal of sodium which becomes excessively contaminated by chemical or radioactive materials.

1.2 DESIGN REQUIREMENTS

The following are the Design Requirements for performing the Functions outlined in Section 1.1.

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- 1. Refer to Support Information Requirements, Appendix B, Items 5 and 21.

1.2.1 Basic Design Requirement

- A. Storage capacity shall be provided to maintain a reserve supply of sodium for makeup requirements, and to permit draining all systems or components for service.¹
- B. Purification equipment shall be capable of controlling oxygen and carbon concentrations in sodium systems to below 1 and 20 ppm respectively in systems operating above 1000 °F, and oxygen at less than 10 ppm in systems operating below 1000 °F.² Provisions shall also be included for controlling other impurities including (but not limited to) nitrogen, hydrogen and fission products. Means shall be provided for controlled addition of impurities to closed loop primary systems.³
- C. Piping and equipment shall generally be type 304 SST except (1) carbon steel may be employed where coolant chemistry control is not affected,⁴ and (2) special materials may be required at temperatures above 1000 °F depending upon the application.⁵
- D. All design, fabrication and construction shall conform to the Hanford Standard Design Criteria HWS-10006.⁶ The most recent issue of codes, standards and specifications listed in Chapter SDC 1.2 including applicable code cases, shall govern. FFTF standards shall be prepared as required for equipment or installations which are not within the scope of HWS-10006.

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- 1. Refer to Support Information Requirements, Appendix B, Item 2.
 - 2. Refer to Purification Provisions for FFTF Sodium Systems, Appendix D.
 - 3. Refer to Support Information Requirements, Appendix B, Item 16.
 - 4. Refer to Support Information Requirements, Appendix B, Item 6.
 - 5. Refer to Support Information Requirements, Appendix B, Item 18.
 - 6. Refer to References, Appendix A, Item 27.

- E. Inert gas blankets shall be provided over sodium surfaces and in void spaces in sodium containing systems. Equipment blanketed with inert gas will be designed to prevent entrainment of gas in a sodium stream which could reach the reactor core.
- F. Heaters¹ shall be provided on all piping and equipment to raise system temperatures above sodium freezing temperature at a rate which will not exceed thermal stress limitations. Heaters shall be zoned to permit melting out frozen systems progressively beginning at open ends and free surfaces. Storage tank heaters shall have sufficient capacity to maintain a constant sodium temperature during cold trapping.
- G. Systems shall be designed to prevent siphoning or self draining in the event of leak or valving error.² Tank connections shall be at or near the vessel top.
- H. Valve stations and controls shall be located in normally accessible areas.³
- I. Instruments and controls shall be integrated into the overall Plant Instrumentation System.^{4,5}
- J. An inert gas atmosphere shall be maintained by the Inert Gas System inside the radioactive sodium equipment rooms to prevent fire and contamination spread in case of a sodium spill.^{6,7}

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- 1. Refer to Interfaces, Appendix C, Item 1.
 - 2. Refer to Support Information Requirements, Appendix B, Item 19.
 - 3. Refer to Support Information Requirements, Appendix B, Item 7.
 - 4. Refer to Support Information Requirements, Appendix B, Items 14 and 15.
 - 5. Refer to Interfaces, Appendix C, Items 21 and 22.
 - 6. Refer to Support Information Requirements, Appendix B, Item 10.
 - 7. Refer to Interfaces, Appendix C, Item 20.

- K. Sodium tank rooms¹ shall have steel liners on floors and walls to provide a secondary boundary in case of tank rupture.
- L. Leak detectors shall be provided on piping and equipment to indicate sodium leakage.²
- M. Smoke detectors or other suitable warning devices shall be provided in all sodium handling areas to warn of fire. Fire control³ equipment shall be provided.
- N. Provisions shall be included for remote servicing of equipment not accessible for contact maintenance.^{4,5}
- O. Sodium equipment shall be insulated to maintain surface temperatures at 140 °F or less to conserve heat in sodium equipment and to avoid excessive heat loads on the building cooling system.⁶
- P. Provisions shall be included for chemical decontamination of the reactor and closed loop primary systems.⁷
- Q. Provisions shall be included for disposing of highly contaminated sodium.⁸
- R. Samplers and in-line monitors and plugging meters shall be provided to permit surveillance of sodium purity in

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- 1. Refer to Interfaces, Appendix C, Items 3 and 4.
 - 2. Refer to Support Information Requirements, Appendix B, Item 22.
 - 3. Refer to Interfaces, Appendix C, Item 9.
 - 4. Refer to Support Information Requirements, Appendix B, Items 4 and 12.
 - 5. Refer to Interfaces, Appendix C, Item 15.
 - 6. Refer to Interfaces, Appendix C, Item 8.
 - 7. Refer to Support Information Requirements, Appendix B, Item 8.
 - 8. Refer to Support Information Requirements, Appendix B, Item 1.

heat removal and purification systems. Capability shall be provided for monitoring sodium purity upstream and downstream from sodium purification apparatus.¹

- S. Provisions shall be included for emergency sodium makeup to the reactor and closed loop primary systems to prevent loss of cooling in case of a primary system rupture.²
- T. Materials surveillance sample holders shall be provided to monitor corrosion mass transfer and material deposition effects.³
- U. The Sodium Receiving and Processing Systems shall be designed to provide a reliability and maintainability consistent with achieving the FFTF overall plant availability goal of 75%. Consideration shall be given to the effects of this system on the availability of interfacing systems, components, and facilities.
- V. Detailed criteria, procedures and responsibilities for determining and verifying the reliability⁴ and quality⁵ of the component shall be defined for the following areas:
 - Design adequacy
 - Fabrication and construction quality
 - Operational capability.

1. Refer to Support Information Requirements, Appendix B, Item 13.
2. Refer to Support Information Requirements, Appendix B, Items 5 and 21.
3. Refer to Support Information Requirements, Appendix B, Item 16.
4. Refer to References, Appendix A, Item 28.
5. Refer to References, Appendix A, Item 29.

SECTION 2.0 PHYSICAL DESCRIPTION OF THE SYSTEM

2.1 SUMMARY DESCRIPTION

2.1.1 General

The conceptual design of the Sodium Receiving and Processing System is based upon a 400 MW loop type reactor concept with a minimum of two independent cooling circuits and six closed test loops. The Sodium Receiving and Processing System are generally similar to those described for the earlier reference concept,¹ prior to the modification to a minimum of two independent cooling circuits. The Sodium Receiving and Processing System Conceptual Design Description is subject to review and revision as may be necessary as a result of alterations of the plant configuration. The Sodium Receiving and Processing System are described in Paragraphs 2.1.2 through 2.1.7. Alternate arrangements are discussed in Paragraph 1.2.8.

2.1.2 Fresh Sodium Receiving and Processing System

The Fresh Sodium Receiving and Processing System receives, purifies, stores and distributes fresh sodium to the reactor² and closed loop³ heat removal systems. Fresh sodium is received in tank cars and melted by circulating heated oil through channels on the tank cars.⁴ The tank car is pressurized with inert gas to transfer the molten sodium through a heated unloading line and filter to the fresh sodium storage tank. The fresh sodium recirculation and transfer pump circulates the sodium through an oxygen

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1. Refer to References, Appendix A, Items 1, 21, and 26.
 2. Refer to Interfaces, Appendix C, Items 11 and 16.
 3. Refer to Interfaces, Appendix C, Item 18.
 4. Refer to Interfaces, Appendix C, Item 5.

removal cold trap, a plugging meter and sodium sampler, and delivers fresh sodium to the reactor, closed loop primary and secondary heat removal systems and fuel storage facilities.

2.1.3 Reactor Secondary Sodium Processing System

The Reactor Secondary Sodium Processing System stores and processes sodium for the reactor secondary heat removal system. The reactor secondary sodium processing system includes a storage tank, recirculation and transfer pump, an oxygen removal cold trap, plugging meter and a sodium sampler. The storage tank maintains a reserve sodium supply for normal makeup to the reactor secondary heat removal loops in addition to maintaining extra capacity to receive the entire contents of the four reactor secondary heat removal systems when they must be drained for maintenance. By proper valving, sodium from storage or from the individual reactor secondary heat removal loops may be circulated by the loop pump or recirculation and transfer pump through the cold trap, sampler and plugging meter, during purification operations. The recirculation and transfer pump may also be valved to transfer sodium from storage to the secondary heat removal systems and vice versa. Provisions are included in the building and in the system piping for future addition of oxygen and carbon removal hot traps.

2.1.4 Closed Loop Secondary Sodium Processing System

A single sodium processing system stores and processes sodium for the secondary heat removal systems of all closed loops. The system includes a storage tank, recirculation and transfer pump, oxygen removal cold trap, oxygen and carbon removal hot traps, plugging meter and a sodium sampler. The storage tank maintains a reserve sodium supply for normal makeup to the closed loop secondary systems in

addition to sufficient extra capacity to receive the entire contents of all the closed loop secondary systems when they must be drained for maintenance. By proper valving, sodium from storage or from the individual loop secondary systems may be circulated through the purification system by the loop pump or the recirculation and transfer pump. The recirculation and transfer pump may also be valved to transfer sodium between the storage tank and the closed loop secondary systems.

2.1.5 Reactor Primary and Fuel Storage Sodium Processing System

The reactor primary and fuel storage¹ sodium processing facilities serve both the reactor primary heat removal system and the fuel storage facilities. The equipment includes a surge tank, two storage tanks, two recirculation and transfer pumps, two oxygen removal cold traps, a plugging meter and a radioactive sodium sampler. Provisions are included in the system piping and in the building for future installation of oxygen and carbon removal hot traps. Process piping and equipment is contained in shielded rooms. Provisions are included for remote replacement of radioactive equipment which is inaccessible because of radiation. The surge tank absorbs sodium volume changes resulting from temperature fluctuations and maintains a reserve of hot sodium on standby for makeup to the reactor in case of a primary system leak.² Sodium is pumped continuously from the surge tank to the reactor and overflows from the reactor to the surge tank to maintain a constant reactor sodium level. The storage tanks are sized to receive the combined contents of the reactor primary system and fuel decay storage to facilitate servicing the reactor or the equipment. The recirculation and transfer pumps

1. Refer to Interfaces, Appendix C, Items 11, 12 and 14.
2. Refer to Interfaces, Appendix C, Item 17.

also recirculate sodium from the surge tank, storage tanks, or from fuel storage through the purification system, or transfer sodium between storage and the reactor primary system or fuel storage. Sodium overflow from the reactor and decay storage vessels removes impurities from the sodium surfaces.

2.1.6 Closed Loop Primary Sodium Processing Systems

Independent sodium processing facilities are provided for each closed loop primary system. The process piping and equipment are located in shielded rooms. Process equipment for each loop includes a storage tank, recirculation and transfer pump, oxygen removal cold trap, plugging meter, radioactive sodium sampler, and oxygen and carbon removal hot traps. The storage tanks maintain a reserve of hot sodium on standby for makeup to the closed loop primary system. Sodium is pumped continuously from the storage tank to the closed loop and overflows back to the storage tank. A bypass stream may be directed through the purification and sampling system. The continuous circulation to the closed loop provides makeup in case of a primary system rupture. In addition, the storage tanks provide capacity to receive the contents of the closed loop primary systems to facilitate loop maintenance. By proper valving, the recirculation and transfer pumps may transfer sodium between storage and the primary systems. Provisions are included for remote replacement of radioactive equipment which is inaccessible because of radiation.

2.1.7 Contaminated Sodium Processing System

The contaminated sodium processing facility receives contaminated sodium from the reactor or closed loop primary sodium processing systems, and from the maintenance cell, and processes it for reuse or disposes of it. Sodium

processed in this system may contain either radioactive or chemical contaminants, or both, which render it unfit for use. The contaminated sodium processing system is located in a shielded room. Process equipment includes a storage tank, recirculation and transfer pump, oxygen removal cold trap, plugging meter and a radioactive sodium sampler. The sodium disposal facility concept¹ includes a tank in which the sodium is reacted with dilute sodium hydroxide solution, and a pump to transfer the waste sodium hydroxide solution to the Radioactive Waste System.² An inert gas purge is provided to sweep out gases to the radioactive vent system to avoid accumulation of hydrogen or radioactive gases or vapors.

2.1.8 Alternate Arrangements

Combining the Sodium Receiving and Processing Systems has been considered as a means of reducing cost of the FFTF. Most combinations are eliminated by consideration of coolant chemistry and radioactive contamination control. Separate facilities are proposed for the required sodium service functions except for the reactor primary sodium processing system which also serves the fuel-decay storage facilities. Alternate arrangements which merit further considerations are as follows:

- A. Combined Fresh Sodium and Reactor Secondary Sodium Storage -- This arrangement is possible but requires isolation of the storage tank during receipt of fresh sodium and until the required purity has been verified by analysis. The acceptability of the isolation is dependent upon the secondary heat removal system design. If purification of fresh sodium is necessary, the isolation period must be extended until

1. Refer to Support Information Requirements, Appendix B, Item 1.
2. Refer to Interfaces, Appendix C, Item 7.

the required purity can be established. Combining to the extent that a common cold trap and sampling station would serve both fresh sodium and reactor secondary sodium should receive further consideration during Preliminary Design.

- B. Combined Fresh Sodium and Closed Loop Secondary Sodium Storage -- As in 2.1.8 A the arrangement is possible but the flexibility restrictions may be even more severe since the sodium purity requirements for the closed loop secondary systems are more stringent than for the reactor secondary. As in 2.1.8 A, the acceptability of this restriction is dependent upon the closed loop secondary design.
- C. Combined Reactor Secondary and Closed Loop Secondary Sodium Storage -- As in 1.2.7 A and B the acceptability of this arrangement depends upon the reactor and closed loop secondary system designs. Separate storage facilities provide maximum flexibility.
- D. Separate Reactor Primary and Fuel Decay Storage Sodium Processing -- A substantial degree of cross contamination between the two systems is expected during refueling, because of the sodium transferred by the wet fuel handling machine.¹ Separate irradiated driver fuel² and experimental specimen³ decay storage pools are to be provided. In addition, the coolant in each of the decay storage pools will be processed by separate purification systems. These facilities will minimize cross contamination between pure, and contaminated sodium and provide the flexibility of controlling the coolant chemistry of the driver fuel or experimental specimens while they are in decay storage pool.

1. Refer to Support Information Requirements, Appendix B, Item 3.
2. Refer to Interfaces, Appendix C, Item 13.
3. Refer to Interfaces, Appendix C, Item 19.

- E. Fresh Sodium Transfer -- Transfer of fresh sodium from tank cars to storage by pumping or by evacuating the storage tank may be considered as alternatives to pressurizing the tank cars with inert gas.
- F. Hot Trap Installation -- Install oxygen and carbon hot traps, for purifying reactor primary sodium to less than 1 ppm oxygen and 20 ppm carbon when operating at sodium temperatures above 1000 °F, at the same time the other reactor primary sodium purifying equipment is installed.

2.2 DETAILED DESCRIPTION

2.2.1 Components

All components, piping and valves in the Sodium Receiving and Processing Systems are shown schematically on the System Flow Diagrams in Appendix G:

SK-3-12715 Fresh Sodium Receiving and Processing
SK-3-12716 Reactor Primary Sodium Processing
SK-3-12717 Reactor Secondary Sodium Processing
SK-3-12718 Closed Loop Primary Sodium Processing
SK-3-12719 Closed Loop Secondary Sodium Processing
SK-3-12720 Contaminated Sodium Processing

System volumes and operating temperatures must be considered in the design of the Sodium Receiving and Processing Systems. These characteristics have not been established but are estimated as shown in Table I based upon current design information. Piping and equipment shall be designed to accommodate ultimate operating conditions.

TABLE I

	Volume (gal)	Initial Temperature (°F)	Ultimate Temperature (°F)
Reactor secondary	80,000 ea	775	1,075
Reactor primary	55,000 ea	900	1,200
Fuel decay storage	25,000 ea		350
Closed loop secondary	6 loops - 1,000 ea		1,300
Closed loop primary	6 loops - 900 ea		1,400

2.2.2 Tank Car Heater

A heating unit is provided for liquifying contents of sodium tank cars by circulating a heat transfer oil through heating channels built into the cars.¹ The unit is selected to melt 80,000 pounds of sodium out of a tank car in a reasonable time, say one or two shifts. The heater includes an oil reservoir for filling and draining the tank car oil channels.

2.2.3 Sodium Filter

A filter is provided to remove particulate matter from fresh sodium during tank car unloading.² Filter pore size is selected for sodium service (HNPF used a 40 μ sintered stainless steel micropore filter).³ The filter is accessible for cleaning or replacement.

2.2.4 Storage Tanks

Storage tanks are sized to hold a reserve supply of sodium for normal and emergency makeup requirements, and to provide sufficient capacity to permit draining of all sodium systems and equipment. Storage tanks are rated for the required positive pressure plus full vacuum. Materials are selected for the expected operating temperatures. All connections are at or near the vessel top except that drains with welded caps are provided at the bottom of storage tanks for cleaning.

2.2.5 Pumps

Electromagnetic pumps are shown on the flow diagrams for sodium processing applications.⁴ An analysis of the

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1. Refer to References, Appendix A, Items 2 and 4.
 2. Refer to References, Appendix A, Items 3, 4, and 5.
 3. Refer to References, Appendix A, Item 5.
 4. Refer to References, Appendix A, Items 4, 6, 7, 8, and 32.

advantages and disadvantages of the various types of EM pumps and mechanical pumps is required before a final pump selection is made.¹ Pump characteristics are matched to the system characteristics, considering system fill time, purification flow rate, emergency makeup requirements, operating temperatures, pressure drops, etc. Each mode of operation indicated under Section 4.2 shall be considered in pump selection.

2.2.6 Cold Traps

Cold traps are provided to remove oxygen and other impurities from the liquid sodium systems by chilling and crystallizing the impurities.² A reference cold trap which may be considered is an Atomics International design based on SRE and HNPF installations.³ Cold trapping can remove oxygen to about 5 to 10 ppm. The cold trap is a gas cooled disposable cartridge having a mesh packed filtering section and external cooling fins. Cold trap auxiliaries include an internal and/or external economizer and a combination preheater and cooler having heaters and cooling coils, a blower and a gas flow regulating damper. Heat transfer capabilities are designed to permit cold trap operation wherein sodium enters at the system operating temperature and is then chilled to a selected trapping temperature. Gas cooling⁴ eliminates the need for a liquid cooling jacket on the cold trap vessel with connections which must be broken and re-established during cold trap changeout.

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1. Refer to Support Information Requirements, Appendix B, Item 9.
 2. Refer to Support Information Requirements, Appendix B, Item 16.
 3. Refer to References, Appendix A, Items 9, 13, 15, 22, and 25.
 4. Refer to Support Information Requirements, Appendix B, Item 11.

Cold trap sizing includes consideration of:

- Sodium residence time in packing
- Oxygen pickup rate in system being serviced
- Time to accomplish the required oxygen removal
- Sodium oxide capacity of cold trap

The contaminated sodium cold trap is intended to remove fission products and other contaminants as well as oxygen. Some sodium may possibly be reclaimed in this manner while other highly contaminated sodium may require cleanup to reduce fission product activity prior to disposal.¹

2.2.7 Hot Traps

Hot traps are provided in the closed loop primary and secondary systems to remove oxygen to $<1 \text{ ppm}^2$ and carbon to $<20 \text{ ppm}$ for operation to about 1000°F and above.³

Provisions are included for future installation of hot traps in the reactor primary and secondary systems to permit future high temperature operation. Hot traps are not provided initially in the reactor primary and secondary systems because initial operating conditions do not require hot trapping.

Reference hot trap designs are based upon Atomics International designs for SRE and HNPF. Basically, a hot trap consists of a large surface of trapping material (stainless steel for carbon and zirconium for oxygen) in a vessel through which a bypass stream of sodium passes. The hot traps operate isothermally at $50\text{-}200^\circ\text{F}$ above the temperature of the system served. External heaters and regenerative heat exchangers maintain the required hot trap temperatures.

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1. Refer to Support Information Requirements, Appendix B, Item 17.
 2. Refer to References, Appendix A, Item 10.
 3. Refer to References, Appendix A, Items 11, 12, 19, 20, 23, and 25.

Hot trap design involves consideration of the following factors:

- System operating temperatures
- Selection of a ratio of bypass flow to the total system volume which has been used successfully at other installations
- Residence time
- Surface area of trapping materials
- Cleanup time
- Service life

2.2.8 Piping and Valves

Piping materials are selected for the system temperatures and pressures. Material selection includes consideration of chemical compatibility and mass transfer in addition to strength. Valve materials match piping. Removable spool pieces and blank flanges in makeup lines from the fresh sodium system to the reactor and closed loop primary systems prevent inadvertent contamination of the fresh sodium system. Valves are designed for sodium service at the required temperatures and pressures. Selection of valve operators and remote controls will be required during Preliminary and Final Design. Also the need for check valves to prevent backflow will require study of the system hydraulics during Preliminary and Final Design.

2.2.9 Vapor Traps

Vapor traps are provided, where required, in the inert gas system to protect sensitive equipment.

2.2.10 Freeze Traps

Freeze traps are provided to function as high point vent valves where required. A reference freeze trap designed by Atomics International (which may be considered) consists of a finned tube 1 inch OD by about 24 inches long having

3 inch diameter fins outside and a heater thimble inside the tube forming an annulus approximately 50 mils wide. A 1/4 inch inert gas supply and vent connection is provided at the top of the annulus. A 1200 W heater is inside the heater thimble. During system filling, the inert gas escapes through the annulus. When venting is complete, sodium enters the annulus and freezes. The unit is designed to pass inert gas at a rate of 10 ft³/min at 450 °F and to freeze sodium from 450 °F in 100 °F ambient forming a seal which will remain leak tight against 100 psi sodium at 1000 °F. Material is type 304 SST. This design has given satisfactory service at HNPF.¹

2.2.11 Sodium Samplers

Sampling devices for both radioactive and nonradioactive sodium require development.¹ Atomics International reports satisfactory results in nonradioactive sodium using a removable section of tubing in which a sodium sample is frozen and removed along with the tubing which is cut up in the laboratory for analysis.² Los Alamos Scientific Laboratory (LASL) uses a more sophisticated sampler which permits withdrawing sodium samples or in-place vacuum distillation of samples for oxygen and carbon analysis. The LASL apparatus may be adaptable to hot cell service for sampling radioactive sodium.

2.2.12 Contaminated Sodium Disposal

The proposed method for disposing of highly contaminated sodium involves injection of the molten sodium into a dilute sodium hydroxide solution,³ and transferring the waste sodium hydroxide solution to the Radioactive Waste System for disposal. Equipment for this operation is shown schematically on drawing SK-3-12720 in Appendix G.

1. Refer to Support Information Requirements, Appendix B, Item 13.

2. Refer to References, Appendix A, Item 5.

3. Refer to References, Appendix A, Item 24.

2.3 INSTRUMENTS, CONTROLS, ALARMS AND PROTECTIVE DEVICES¹

Instrumentation for surveillance and control of process conditions is indicated schematically in the system flow diagrams in Appendix G. Instrumentation for the Sodium Receiving and Processing System is to be integrated into the overall plant data acquisition and control system.² The instrumentation requirements are as follows.

2.3.1 General Characteristics

The instruments used in the Sodium Receiving and Processing System should have the following characteristics:

- Respond with accuracy and speed to signals as required to meet the process control requirements
- Resistance to temperature changes over the full range of reactor operation for both normal and transient conditions
- Resistance to system and atmospheric pressure changes, radiation and chemical properties of sodium
- Compatibility with system materials and leakage requirements
- Maintenance-free operability and subject to ease of calibration consistence
- Consistence with the overall FFTF plant instrumentation system for ease of operation.

2.3.2 Level

Sodium level in tanks and vessels is monitored to provide indication of system volume changes. Alarms are provided to warn of abnormally low or high levels and to activate protective circuits and controls in critical situations.

Several types of instruments are available to measure sodium level in tanks and vessels. Among these are bubbler

1. Refer to Interfaces, Appendix C, Item 2.
2. Refer to Support Information Requirements, Appendix B, Items 13, 14, and 15.

type devices, differential pressure systems, induction probes, resistance probes, buoyant devices and spark-plug type devices. The accuracy requirements for level measurement in this system will vary with the application and will be established for each vessel during Preliminary and Final Design.

2.3.3 Flow

Flow meters are needed to provide measurement and control of the sodium processing flow systems. For the size pipes considered for this system, magnetic flow meters appear to be the most suitable device for flow measurement. Flow is measured as shown on the system flow diagrams to determine system fill and drain rates, system cleanup rates. In addition, they can actuate alarms and interlocks to protect other equipment that could be damaged by loss of flow, such as EM pumps.

2.3.4 Temperature

Temperature indicators are provided for monitoring process equipment operation. In the case of EM pumps, winding temperatures are monitored; hot and cold traps and storage tanks require monitoring and control of internal temperature; heat exchangers require monitoring of upstream and downstream sodium temperatures. Piping requires monitoring and control of temperatures (not shown on flow diagrams).

Thermocouples are the most commonly used sensor for measuring sodium temperatures and will probably be used in this system. Resistance type detectors can also be used but their advantage of greater accuracy is probably not warranted in this system. It is anticipated that temperatures in different parts of the processing system will have differing accuracy requirements. These accuracy requirements will be determined during later design stages based on the control requirements and system operating requirements.

2.3.5 Pressure

Pressure sensors are needed to measure pump and purification system pressure differentials. The pressure measurement system may be in the form of a diaphragm-sealed capillary device. However, sodium pressure measurement problems require further study during Preliminary and Final Design.

2.3.6 Analytical Instruments

- A. Plugging meters are needed to measure the oxygen content of the sodium by measuring the temperature at which an orifice becomes plugged. Most present-day plugging meters work on an intermittent basis but a continuous automatic plugging meter may be available for use in the FFTF.
- B. Other impurity devices will be needed to ensure the quality of the sodium coolant. A carbon meter is needed but commercially available units may not be suitable. A planned design and development analytical study and proof testing program is expected to provide a suitable instrument.

2.3.7 Leak Detectors

Leak detectors are needed to detect any leakage of sodium from the system. The type of leak detector selected will vary with the type of monitoring being done. Smoke detectors can be used to detect airborne sodium. Thermocouples can be used to detect leaks by indicating a temperature increase, and spark-plug type detectors can be used in places where a pool of sodium could collect.

Leak detector requirements to protect the plant and personnel will be established in Preliminary and Final Design.

2.3.8 Alarms and Protective Devices

High and low level alarms are provided for the sodium storage tanks and reactor primary surge tank. Storage tank low

level alarms are interlocked to stop the related pumps to prevent inadvertent loss of pump suction. High temperature alarms are provided on EM pump windings with interlocks to stop the pumps to prevent burnout. Low flow alarms are provided on flow meters with interlocks to stop pumps on loss of flow. High and low temperature alarms are provided on the reactor primary storage tanks to provide a warning of temperatures which may be unsuitable for makeup or recirculation to the reactor or decay storage.

3.0 SAFETY CONSIDERATIONS

3.1 HAZARDS

- A. Rupture of the reactor vessel or primary sodium piping may result in a loss of reactor primary coolant into the reactor cavity. (Not a hazard inherent in the Sodium Receiving and Processing System but requires response by the latter system.)
- B. Rupture of closed loop primary sodium piping or equipment outside the reactor cavity would result in a loss of closed loop coolant. (This is not a hazard inherent in the Sodium Receiving and Processing System but it requires response by the latter system.)
- C. Reactor or closed loop sodium is radioactive.
- D. Rupture of sodium processing equipment or piping would spill sodium in the equipment room.
- E. Sodium reacts readily with air and water with attendant fire and explosion hazards. Radioactive sodium constitutes both a radiological as well as a fire hazard.
- F. A radioactive sodium fire could disperse radioactive sodium oxide to the atmosphere if not properly contained.
- G. Cold traps, filters, dead legs and other low flow areas may concentrate fuel fragments along with fission products and sodium oxide following a fuel failure in primary systems with the attendant risk of creating a critical mass.
- H. Sodium may cause severe burns on contact with exposed parts of the body.
- I. Loss of trap cooling could permit dissolution of cold trap contents and redistribution in the related sodium system.
- J. Lowering of system temperatures below the impurity solubility temperature may crystalize impurities which could cause system plugging.

3.2 PRECAUTIONS (Match items in Section 3.1 above)

- A. A reserve of heated sodium is maintained on standby for makeup to the reactor primary system upon loss of reactor sodium level. The emergency makeup requirements must be established during Preliminary and Final Design. Removable spool pieces in the reactor and decay storage pump down lines prevent inadvertent draining through these lines.
- B. A reserve of heated sodium is maintained on standby for makeup to the closed-loop primary system. The emergency makeup requirements must be established during Preliminary and Final Design.
- C. Radioactive reactor and closed loop sodium processing piping and equipment is located in shielded cells.
- D. Sodium tank rooms have secondary boundaries in the form of steel liners.
- E. Water or steam lines¹ are not permitted in or adjacent to sodium handling areas except in the contaminated sodium disposal facility. Inert atmospheres are provided in radioactive sodium rooms to prevent fire in case of a sodium leak. Leak detectors and fire protection supplies and equipment are provided. Nonradioactive sodium equipment is located outside the containment boundary in areas which are designed to accommodate the heat and pressure resulting from sodium fires. The use of mechanical seals and joints is minimized and valves are especially designed for sodium service to minimize sodium leaks from these sources.
- F. The Reactor Containment System² is designed to prevent uncontrolled dispersion of airborne radioactive contaminants outside the containment boundaries.

1. Refer to Interfaces, Appendix C, Item 6.
2. Refer to Interfaces, Appendix C, Item 10.

- G. The potential for criticality will depend on the size and shape of the cold traps and the maximum amount of fuel that could credibly reach the traps. It is expected that the high critical mass (>100 kg) and the nonoptimum geometry will preclude a criticality hazard; but further evaluation is required in Preliminary and Final Design.
- H. A rigorous operator training program is essential to ensure adherence to safe sodium handling procedures. Prompt first aid treatment to sodium burns will reduce severity of injuries.
- I. Cold trap sodium flow must be discontinued if cold trap cooling is interrupted.
- J. Continuous surveillance of sodium impurity levels must be maintained and system temperatures maintained above the point at which precipitation can occur.

4.0 PRINCIPLES OF OPERATION

The Sodium Receiving and Processing Systems are service systems which may be operated intermittently and independently of the reactor in processing the reactor and closed loop coolants.

4.1 STARTUP

Initial startup involves performing the necessary testing, cleaning and drying operations; then purging of sodium containing equipment with inert gas and then preheating and filling with sodium. Sodium picks up impurities from the piping and equipment during the initial fill. This necessitates repurification in the individual storage tanks and heat removal systems prior to reactor operation. After the heat removal systems have been filled and cleaned to the required purity level, the sodium processing systems may be operated intermittently or continuously as required by plant operating conditions. When any portion of the system is shut down it may be kept hot for standby or allowed to cool, except that the reactor and closed loop emergency makeup equipment must be on standby at all times when emergency coolant injection could be required.

4.2 NORMAL OPERATION

The Sodium Receiving and Processing Systems provide storage and purification facilities for the reactor and closed-loop coolant including purification and/or disposal of highly contaminated sodium. The operations performed by each system are described below. Heavy lines on the reference figures in Appendix F show the principal flow paths for typical operations.

4.2.1 Fresh Sodium Receiving and Processing System

- A. Fresh sodium receiving (Reference Appendix F Figure 1a)-- Fresh sodium is received in tank cars and is liquified by recirculating hot oil from the tank car heater through

heating coils on the tank cars. The melted sodium is transferred from the tank car through the filter to the storage tank. (Alternative methods which will be considered for transferring sodium from the tank car to the fresh sodium storage tank will include pumping or evacuation of the storage tank).

Sampler SS-1-2 permits sampling of the fresh sodium as it is delivered from the tank car.

- B. Fresh Sodium Purification (Reference Appendix F Figure 1b)-- Sodium is drawn from the fresh sodium storage tank by the recirculation and transfer pump and is passed through the cold trap and returned to the fresh sodium storage tank. A sodium sampler may be valved to draw sodium samples from upstream or downstream from the cold trap to monitor sodium purity. Similarly, the plugging meter monitors sodium plugging temperature upstream or downstream from the cold trap. It is expected that sodium would normally be cold trapped to less than 10 parts per million of oxygen in storage before being transferred into the reactor or closed loop systems.
- C. Fresh Sodium Makeup (Reference Appendix F Figure 1c)-- Fresh sodium is transferred from the storage tank by the recirculating and transfer pump to the following systems:
- Reactor primary sodium processing system (as illustrated by Figure 1c)
 - Reactor secondary sodium processing system
 - Closed loop primary sodium processing system
 - Closed loop secondary sodium processing system

Sodium transfer to each of the above systems may be accomplished by the necessary valving and pumping operations except that the contaminated system supply lines, (i.e., the reactor primary, the closed loop primary) have removable spool pieces which are installed prior to fresh sodium

transfer operations to these systems. The purpose of the removable spool pieces is to prevent the backflow of contaminated sodium into the fresh sodium storage tank.

4.2.2 Reactor Secondary Sodium Processing

- A. Fresh Sodium Makeup--Fresh sodium is transferred from the fresh sodium storage tank to the reactor secondary sodium storage tank where it is stored, purified as necessary, and transferred as required to any of the four secondary heat removal loops.
- B. Purification of Secondary Sodium in Storage (Reference Appendix F Figure 2a)--Sodium is pumped from the storage tank through the cold trap and returned to the storage tank. The sodium sampler and plugging meter permit monitoring of sodium purity upstream and downstream of the cold trap during purification.
- C. Reactor Secondary Loop Fill (Reference Appendix F Figure 2b)--Sodium is pumped from the secondary storage tank to the secondary heat removal loops by appropriate valving. Sodium transfer to reactor secondary loop No.1 is illustrated by Figure 2b. (Appendix F).
- D. Reactor Secondary Loop Purification (Reference Appendix F Figure 2c)--The reactor secondary sodium processing system is arranged to permit sodium to flow from the loop secondary pump discharge through the cold trap and back to the secondary pump inlet. Thus, flow through the cold trap is induced by the reactor secondary loop pump. An alternative flow path is available using the recirculation and transfer pump to induce flow through the cold trap if the reactor secondary pump head is insufficient. As in purification of sodium in storage, the sodium sampler and plugging meter can monitor sodium purity upstream and downstream of the cold trap during purification operations.

- E. Reactor Secondary Loop Sodium Storage--The storage tank provides sufficient capacity to permit draining of the four reactor secondary coolant loops for service. The sodium would be pumped from the secondary loop by pump P-2-1 into the storage tank.

4.2.3 Closed Loop Secondary Sodium Processing

- A. Fresh Sodium Makeup (Reference Appendix F Figure 3a)--Fresh sodium is transferred from the fresh sodium storage tank into the closed loop secondary storage tank where it is stored, purified, and transferred as needed into any of the six closed loop secondary heat removal systems.
- B. Storage Tank Purification (Reference Appendix F Figure 3b)--Closed loop secondary sodium is pumped from the storage tank through the cold or hot traps and back to the storage tank. The sodium sampler and plugging meter can monitor sodium purity upstream and downstream of the cold and hot traps. The plugging meter is not used during hot trapping because it is not effective in monitoring oxygen concentrations below about 7-10 parts per million.
- C. Closed Loop Secondary Fill (Reference Appendix F Figure 3c)--Sodium is pumped from the storage tank to any of the six closed loop secondary systems. Transfer to loop No. 1 is illustrated by Figure 3c.
- D. Closed Loop Secondary System Purification (Reference Appendix F Figures 3d and 3e)--Sodium from the secondary loop pump discharge flows through the cold or hot traps and back to the secondary loop pump suction. By this method, the closed loop secondary pump induces the flow through the purification system. An alternative flow path is available which permits use of the recirculation and transfer pump if the loop pump head is insufficient to maintain the necessary flow. Cold trapping and hot trapping using the recirculation and transfer pump is illustrated by Figures 3d and 3e.

- E. Closed Loop Secondary Sodium Storage--The closed loop secondary sodium storage tank T-3-1 provides sufficient capacity to permit draining all of the six closed loop secondary systems simultaneously. The sodium is pumped from the loops by the recirculation and transfer pump P-3-1 and transferred into the closed loop secondary sodium storage tank.

4.2.4 Reactor Primary Sodium Processing

The reactor primary sodium processing system provides dual storage tanks, recirculation and transfer pumps and cold traps for maximum flexibility and reliability. The system serves the purification needs for both the reactor and the fuel decay storage facility. The piping is arranged to provide flexibility of choice of storage tanks, pumps, and cold traps for each operation.

In the following sections, only one flow path for each operation is described. The reader should note the methods by which alternative flow paths are possible.

- A. Storage Tank Fill (Reference Appendix F Figure 4a)--Sodium may be transferred into the reactor primary sodium storage tanks T-4-1A or T-4-1B from either the fresh sodium processing system or from the contaminated sodium processing system. Filling from both sources is illustrated by Figure 4a.
- B. Storage Tank Cleanup (Reference Appendix F Figure 4b)--Sodium is pumped from the storage tanks through the cold traps and back to the storage tanks.
- C. Reactor Fill (Reference Appendix F Figure 4c)--Sodium is pumped from storage tanks through the reactor fill line into the reactor vessel. When the reactor is full the sodium overflows into the surge tank T-4-2 until the sodium level in the surge tank reaches the required level.

Simultaneous with the reactor fill, the reactor primary heat removal system loops are filled from the reactor vessel.

- D. Decay Storage Fill (Reference Appendix F Figure 4d)--Sodium is pumped from storage tanks to decay storage.
- E. Reactor Pumpdown (Reference Appendix F Figure 4e)--Reactor primary sodium storage tanks T-4-1A and T-4-1B provide sufficient capacity so that the reactor primary system and decay storage vessels may be drained simultaneously. The sodium is pumped from the reactor vessel through the pumpdown line to the primary storage tanks.
- F. Decay Storage Pumpdown (Reference Appendix F Figure 4f)--Sodium is pumped from the decay storage vessels through the pumpdown line and into the reactor primary sodium storage tanks in a manner similar to that for the reactor.
- G. Reactor Overflow and Recirculation (Reference Appendix F Figure 4g)--The surge tank T-4-2 maintains a constant reactor sodium level by absorbing the thermal volume changes of the reactor sodium. Sodium overflows from the reactor to the surge tank and is continuously pumped back to the reactor by either or both of the recirculation and transfer pumps. A reserve supply of sodium in the surge tank would be automatically pumped to the reactor in the event of a primary system rupture. Surface impurities are removed from the reactor sodium via the overflow line to the surge tank and subsequently to the cold traps. Loss of recirculation because of pump failure or other cause does not in itself create a hazard to the reactor but does remove a sodium supply source which would require a decision regarding continued reactor operation.
- H. Reactor Primary Sodium Cleanup (Reference Appendix F Figure 4h)--Cold trap cleanup of the reactor sodium during normal recirculation through the surge tank is possible using either or both of the installed cold traps.

- I. Decay Storage Cleanup (Reference Appendix F Figure 4i)--Cold trapping of the decay storage sodium is accomplished by allowing decay storage to overflow into a storage tank and then pumping the sodium from the storage tank and passing it through a cold trap and back to decay storage. This method of cleanup skims impurities from the surface of the decay storage vessels. An alternative method of decay storage cleanup (not illustrated) is to pump the sodium via the decay storage pumpdown line through the cold traps and back to the decay storage. This method (which draws the sodium from the bottom of the decay storage vessels and bypasses the storage tanks) would probably be preferred when failed fuels are being stored to avoid unnecessarily contaminating the sodium storage tanks.
- J. Reactor Primary Sodium Discharge to Contaminated Sodium Processing System (Reference Appendix F Figure 4j)-- Highly contaminated sodium from the reactor sodium primary system or from the decay storage may be pumped to the contaminated sodium processing system.
- K. Sampler and Plugging Meter Operation (Reference Appendix F Figure 4k)--The reference figure indicates the flow paths available to the plugging meter and sodium sampler to permit monitoring sodium purity upstream and downstream of the cold traps during all modes of operation.
- 4.2.5 Closed Loop Primary Sodium Processing
- NOTE: The process flow diagram for the closed loop primary sodium receiving and processing systems is typical for the six loops.
- A. Storage Tank Fill (Reference Appendix F Figure 5a)--The primary sodium storage tanks are filled from fresh sodium storage.

- B. Loop Fill (Reference Appendix F Figure 5b)--Sodium is transferred from the closed loop primary sodium storage tank to the closed loop primary system by the fill and recirculation pump.
- C. Closed Loop Primary Recirculation (Reference Appendix F Figure 5c)--As in the reactor primary system, the closed loop primary systems operate with a continuous sodium overflow from the loops to the closed loop primary sodium storage tank with the sodium being returned to the loop via the fill and recirculation pump. Thus, the primary sodium storage tank serves as a storage tank for the closed loop primary system and provides a supply of sodium for makeup to the loop. The fill and recirculation pump must be operated continuously to maintain the emergency makeup capability for the loop.
- D. Primary Loop Purification (Reference Appendix F Figure 5d)--The closed loop primary pump circulates sodium through the cold trap and hot traps. The sodium flows from the loop through the cold trap or hot trap as required and is returned to the closed loop expansion tank.
- E. Contaminated Sodium Discharge (Reference Appendix F Figure 5e)--The closed loop primary sodium is pumped from the loop to the contaminated sodium dump tank. Because of the overflow operation described in the previous paragraphs the storage tank sodium would also be contaminated to the same degree as that in the primary loop itself, therefore, it would be necessary to follow a loop drainage by pump-down of the storage tank to the contaminated sodium system. Depending upon the nature of the tests planned for the closed loop, it may be necessary to follow the closed loop and storage pumpdown with a flush of clean sodium prior to refilling for operation.

4.2.6 Contaminated Sodium Processing

- A. Contaminated Sodium Dump Tank Fill--Highly contaminated sodium is transferred to the contaminated sodium dump tank from the closed loop primary systems or from the reactor primary system via the contaminated sodium transfer lines.
- B. Contaminated Sodium Purification (Reference Appendix F Figure 6a)--Contaminated sodium is pumped from the contaminated sodium dump tank through the cold trap and back to the dump tank. The normal function of the cold trap is to remove precipitated sodium monoxide from the circulating sodium stream. It has been found, however, that cold traps do remove certain other contaminants including varying amounts of fission products. The mechanisms of this cleanup are not well understood. It is expected however, that a certain degree of cleanup of contaminated sodium by means of the cold trap operation will be possible. This may permit reuse of some contaminated sodium by the reactor primary system. Other sodium which cannot be cleaned up for reuse may require some cleanup prior to its being discharged to the contaminated sodium disposal system.
- C. Contaminated Sodium Return to the Reactor Primary System (Reference Appendix F Figure 6b)--Sodium which has been sufficiently cleaned up for reuse may be pumped to the reactor primary sodium storage tank via the contaminated sodium transfer line as illustrated.
- D. Contaminated Sodium Disposal (Reference Appendix F Figure 6c)--Contaminated sodium is pumped from the contaminated sodium dump tank into the sodium reaction tank through a submerged reaction nozzle. The sodium reacts with water and the resulting radioactive caustic solution is pumped to the radioactive waste system for disposal.

Note: The above method of disposing of radioactive waste sodium at this point is considered to be conceptual only and requires development before it is selected for a final design.

4.3 SHUTDOWN

- A. Sodium transfer operations are performed as necessitated by the reactor requirements prior to shutting down any portion of the sodium receiving and processing system.
- B. Shutdown equipment may be maintained in a hot standby condition or allowed to cool depending upon plant requirements.
- C. Inert gas atmospheres are maintained during shutdown.
- D. Sodium temperature and purity must be re-established when the system is returned to operation.

4.4 ABNORMAL OPERATION

Emergency makeup of sodium to the reactor or closed loop primary systems may be required in the event of a primary system rupture. The systems as illustrated by the system flow diagrams have a normal flow from the reactor primary surge tank and closed loop primary storage into the respective primary systems. In the event of a primary system rupture these flows will continue until the reserve supply of sodium is exhausted. (The emergency makeup requirements including the reserve storage capacity and injection rate must be established during Preliminary and Final Design.¹⁾)

1. Refer to Support Information Requirements, Appendix B, Items 5 and 13.

5.0 MAINTENANCE PRINCIPLES

5.1 PREVENTIVE MAINTENANCE

- A. A maintenance program defining maintenance schedules and procedures for servicing equipment is required.
- B. Contact maintenance methods are employed for servicing nonradioactive equipment and for radioactive equipment as permitted by radiation levels.
- C. Remote maintenance methods are employed for radioactive equipment which is too radioactive for contact maintenance. Removal of radioactive hot and cold traps may require remote handling.
- D. Isolation of equipment for service requires freezing connecting lines where upstream and downstream block valves are not provided.
- E. Periodic routine checks are required to verify proper operation of equipment and controls and to perform such services as are necessary to ensure continued reliable operation.
- F. Vapor traps should be checked periodically for plugging, and melted out as required.
- G. Pressure differentials across filters, cold traps and pumps should be checked periodically. Abnormally high or low pressure drops should be investigated and corrective action taken.

5.2 TROUBLE SHOOTING

Table II lists possible malfunctions and the probable causes and corrections. A more detailed trouble shooting guide will be prepared during Final Design.

TABLE II
Trouble Shooting

Component	Symptom	Possible Cause	Correction
Sodium Filter	Loss of flow	Loss of tank car pressure Flow meter failure Line frozen Valve closed Car empty Filter plugged	Restore pressure Repair instrument Check and repair heaters Open valves Close valves, disconnect car Cool down, change filter element
Plugging meter	Temperature decay deviates from normal Failure to reheat after run Failure to plug at plugging temperature, high flow Two or more breaks in curve	Temperature control failure Plugging valve failed closed Plugging valve failed open Foreign material in sodium	Repair controls Repair plugging valve Repair plugging valve Analyze sample
Cold trap	Excessive ΔT Loss of trap cooling	Premature plugging Control failure Cooling fan failure Excessive sodium flow	Soak at $\sim 600^\circ\text{F}$ several hours. Cool to $\sim 50^\circ\text{F}$ < plugging temperature and re-establish flow Repair controls Repair fan Adjust flow
Valves	Leak past seat Difficult to turn	Foreign material under seat Stem binding Operator rod binding	Open and flush valve Melt out and refreeze freeze-seal stem Repair operator
Hot traps	Incomplete oxygen removal	Trap exhausted Oxygen entering system Low operating temperature	Replace Check for leaks Check heaters and controls
Heaters	Freezeup	Heater failure Control failure	Check heater continuity, resistance and ground. Repair controls
E/M pumps	Loss of flow	Failure to wet throat Coil burnout Control malfunction Gas entrainment	Heat pump to 500 to 600 $^\circ\text{F}$ and reprime Check continuity, repair Check electrically, repair Raise temperature. Check for leak

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APPENDIX A

REFERENCES

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APPENDIX B

SUPPORT INFORMATION REQUIREMENTS

Item	Description	Type of Effort	Results Expected	Information Source	When Required
6	Evaluate carbon steel and select materials of construction for sodium service.	Engineering study	1) Evaluate carbon steel for sodium piping and equipment. 2) Evaluate costs of carbon steels versus stainless or stainless clad equipment. 3) Evaluate cost of cleaning and maintaining cleanliness at acceptable levels. 4) Evaluate risk of inadvertent contamination or mass transfer problems. 5) Select materials of construction for sodium service.	PNL	Prelim. Design
7	Evaluate radioactive sodium processing equipment radiation levels.	Engineering study	1) Determine equipment room shielding requirements. 2) Determine remote maintenance requirements.	PNL & A-E	Prelim. Design
8	Determine chemical decontamination requirements.	Chemical development and engineering study	Recommend provisions to facilitate chemical decontamination of radioactive sodium equipment.	PNL Task-MS-8	Prelim. Design
9	Survey pumps for sodium service	Engineering study	Select pumps for sodium receiving and processing applications.	PNL & A-E	Prelim. Design
10	Determine radioactive sodium equipment room atmosphere requirements. (In support of inert gas system)	Engineering study	Select atmosphere for radioactive sodium equipment rooms.	PNL	Conceptual Design
11	Determine service cooling requirements.	Engineering study	Select cooling system to serve sodium and inert gas systems and other plant service cooling requirements.	PNL & A-E	Prelim. Design

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Item	Description	Type of Effort	Results Expected	Information Source	When Required
12	Evaluate remotely operable pipe connectors for radioactive equipment.	Engineering study	Select pipe connectors to facilitate remote maintenance of radioactive sodium equipment.	PNL & A-E	Prelim. Design
13	Evaluate sodium sampling and analysis techniques.	Analytical chemistry study & proof testing	1) Select sampling and analysis methods for radioactive and non-radioactive sodium. 2) Establish materials surveillance requirements.	Task's SG-3 SG-4 SG-5	Prelim. Design
14	Determine instrumentation requirements. (In support of instrumentation system)	Engineering study & proof testing	Select integrated data acquisition and handling system for the sodium receiving and processing systems.	PNL Task IC-11	Prelim. Design
15	Evaluate sodium level sensors. (In support of inst. system)	Engineering study & proof testing.	Select sodium level transducers for measuring sodium level in closed vessels.	PNL Task-IC-11	Prelim. Design
16	Evaluate impurity removal and control methods.	Engineering study & development	1) Evaluate and select impurity trap designs including fission product removal traps. 2) Evaluate methods for adding and maintaining controlled levels of impurities in sodium.	PNL Task's SG-7, SG-9, MS-9, IC-9	Prelim. Design
17	Evaluate critical mass hazard in cold traps.	Physics study	Evaluate possibility of creating a critical mass by cold trapping sodium contaminated by fertile fuels.	PNL	Completed

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Item	Description	Type of Effort	Results Expected	Information* Source	When Required
18	Evaluate materials for processing sodium to 1450 °F.	Engineering study & development	Recommend materials for hot traps and related closed loop primary sodium processing equipment.	PNL	Prelim. Design
19	Develop means for minimizing risk and consequence from sodium valving errors.	Engineering study	Recommend valve types, arrangements, safety devices and procedures for minimizing hazards from operator errors.	PNL & A-E	Prelim. Design
20	Define containment criteria and boundaries for radioactive sodium processing systems. (In support of containment systems.)	Engineering study		PNL	Prelim. Design
21	Define sodium storage and remote control requirements for emergency makeup to closed loop primary systems.	Engineering study	1) Evaluate closed loop sodium loss potential. 2) Determine emergency storage capacity requirements. 3) Determine emergency makeup control requirements.	PNL	Prelim. Design
22	Define sodium leak detection requirements	Engineering study & proof testing	1) Select leak detector devices	PNL Task IC-21 (N.F.)	Prelim. Design

* Design and development items are to be completed concurrently with conceptual and Preliminary Design as indicated.

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APPENDIX C

INTERFACES

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INTERFACES

<u>ITEM NO.</u>	<u>INTERFACING SYSTEM</u>		<u>INTERFACE AREA</u>
	<u>System No.</u>	<u>System Title</u>	
1	12	Building Electrical Power System	Normal and emergency electrical power - pipe, equipment, and storage tank trace heating.
2	15	Communications System	Television annunciation, alarms, communication stations, noise monitoring.
3	16	Lighting System	Space Lighting
4	21	Structures	Secondary sodium heat removal building
5	22	Site Facilities	Rail siding and tank car unloading station.
6	23	Service Piping System	Instrument air, breathing air, utility air and process water.
7	24	Radioactive Waste System	Disposal of solid and liquid radioactive wastes.
8	25	Heating and Ventilation System	Provides space heating and ventilating in process and operating areas.
9	26	Plant Fire Protection System	Provides system fire detection and prevention.
10	27	Reactor Containment System	Space, support, shielding, and penetrations - Containment areas
11	31	Reactor Core	Sodium purity requirements
12	32	Reactor Vessel & Shielding Components	Reactor nozzles and sodium purity requirements
13	35	First Core Fuel Assembly Component	Impurity deposition rates and corrosion

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ITEM NO.	INTERFACING SYSTEM		INTERFACE AREA
	System No.	System Title	
14	41	Reactor Refueling System	Fuel decay storage sodium supply, purification and storage.
15	44	Radioactive Maintenance System	Repairs, removes and replaces defective equipment and instruments of the sodium purification system.
16	51	Reactor Heat Transport System	Reactor primary and secondary sodium supply, storage and purification.
17	52	Emergency Cooling System	Storage and purification of sodium for emergency cooling.
18	61	Closed Loop System	Supply storage, purification and/or disposal of sodium.
19	67	Open Test Position Facility	Sodium coolant purity and quality control limits.
20	82	Inert Gas Receiving and Processing System	Inert atmosphere over sodium and in radioactive sodium cells.
21	91	Control and Data Handling System	Control of system operation, data acquisition and display.
22	93	Plant Instrumentation System	System measurements, controls, and radiation monitoring.

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APPENDIX D

PURIFICATION PROVISIONS FOR FFTF SODIUM SYSTEMS

APPENDIX D

PURIFICATION PROVISIONS FOR FFTF SODIUM SYSTEMS

INTRODUCTION

Coolant purification of sodium-cooled reactor systems is required to limit corrosion and adverse metallurgical effects of the coolant on circulating systems and reactor structural components, and to prevent plugging of coolant passages by impurity precipitation. Besides the basic coolant purity required for normal reactor operation, the primary FFTF driver fuel heat removal system will require purification to satisfy special testing requirements. This appendix will outline anticipated overall purity requirements and recommended equipment provisions. These requirements may require revision as a result of planned R&D efforts and additional experience gained at existing sodium reactor plants.

Conceptual design considerations will be included for all sodium systems, including accessory systems such as fuel storage and examination.

SUMMARY

The FFTF Program Directive¹ requires control of oxygen, carbon, nitrogen and hydrogen in the sodium coolant. Cold traps are proposed for initial installation in all FFTF sodium systems for control of oxygen during operation below about 1000 °F. Initial installation of oxygen and carbon removal hot traps is recommended for the closed loop primary and secondary systems. Methods for controlling nitrogen and hydrogen in sodium require development. Sodium hydride can be removed from sodium by cold trapping, but it is expected that planned R&D on cover gas interactions will provide greater insight into the most effective means of controlling nitrogen and hydrogen. It is possible that planned research and development tasks may also reveal a need and a means for removal of fission product and corrosion products.

1 Refer to Reference, Appendix A, Item 36.

DISCUSSION

Reactor Primary Sodium Purification

The approach taken in establishing purity requirements and equipment for the reactor primary system is to initially treat the primary system as a conventional nuclear reactor power plant system. Additional provisions necessary to accommodate higher reactor outlet temperatures and open loop testing may be superimposed later.

Under existing directive¹ reactor coolant outlet temperatures to 1200 °F are being evaluated. Control of oxygen, carbon, nitrogen and hydrogen impurities is required. Cold and hot trap methods are available for removal of oxygen and carbon. Proven methods for removal of hydrogen and nitrogen from sodium are not available at present.

It is unlikely that the 1200 °F maximum temperature would be required during initial operation, but would be considered an operating limit for future operation. Initial operation will probably be at temperatures below 1000 °F until open loop testing requires higher temperatures. During this time, purity levels attainable by cold trapping² should be adequate. A factor which must be taken into account is the possibility of introduction of extraneous materials into the sodium systems as in the SRE tetralin incident.³ For instance, with the extensive opening and closing of reactor access ports, such as nozzles, it is possible that some foreign material, such as oil, cleaning solutions, or other extraneous material will find its way into the primary sodium. Most of such materials are carbonaceous, and can be expected to contribute to the carbon content of the primary system sodium. Small increases in carbon level in the primary loop components at reactor bulk coolant

1 Refer to Reference, Appendix A, Item 36.

2 Refer to Reference, Appendix A, Item 25.

3 Refer to Reference, Appendix A, Item 37.

temperatures less than 1000 °F are not expected to be deleterious.¹ Therefore, initial provisions for carbon control do not appear essential. However, it is considered probable that future open loop testing will demand the highest local primary sodium temperatures attainable. This will in turn require a capability of providing high purity in the reactor primary heat removal system. Considering the above factors, it may be desirable and feasible to initially provide sufficient purification equipment for normal reactor operation (without high temperature open loop tests) with sufficient additional space and other building provisions for the purification equipment required to support later high temperature open loop testing. Before attempting operation at the maximum bulk outlet established, it may be necessary to add carbon hot traps to the purification system. Depending upon the purity requirements for high temperature open loop testing, it may also become necessary to add oxygen hot traps to control oxygen at levels lower than that which can be provided by cold trapping.

An approach to design and construction of the primary purification system which would minimize initial capital cost would thus be as follows:

Building and utilities planning and space allocations would be made on the basis of eventually installing hot and cold traps in the primary and secondary purification systems. Cold traps would be provided in the initial installation. Installation of hot traps would be contingent upon justification developed in support of reactor operating conditions including open loop tests.

Reactor Secondary Sodium System

Up to a maximum reactor bulk outlet temperature of 1100 °F, it is reasonable to assume a maximum secondary temperature of 900-1000 °F. This is in the range of well established sodium technology and system operating experience. Such operating

¹ Refer to Reference, Appendix A, Item 25.

experience¹ has shown that sodium systems at these temperatures may be operated satisfactorily with cold trapping only. Since cold trapping can reasonably produce a purity level of ~10 ppm O₂, this would be an acceptable design figure to be used in secondary system purification equipment design. In the event that reactor bulk outlet should exceed 1100 °F, carbon and oxygen hot traps would probably also be required.

Closed Loop Primary System

Coolant chemistry requirements for closed loop primary sodium will probably vary with each closed loop and with each test. However, it appears necessary to establish a baseline for coolant chemistry control, the baseline being high purity sodium. This requires purification equipment capable of the maximum practical purity control.

On the above basis, it is necessary to tentatively provide maximum coolant purity in each closed loop. Closed loop functional requirements are being extensively reviewed by other major nuclear companies in Conceptual Design Studies, in cooperation with BNW. Completion of this review may help to define coolant chemistry needs, but until such time as this and other contributing studies are complete, the following will be acceptable target purity requirements for the closed loop primaries:

Oxygen	<1 ppm
Carbon	<20 ppm
Fission Products	To be established
Nitrogen	To be established
Hydrogen	To be established

This would be accomplished by the use of cold traps and oxygen and carbon hot traps. The effectiveness of these facilities

1 Refer to Reference Appendix A, Item 38.

on the control of fission products, nitrogen and hydrogen, is not established and additional R&D¹ will be required to define requirements for control of these contaminants.

Closed Loop Secondary System

The purification needs for the secondary systems for the closed loops will vary primarily according to secondary system operating temperature. In those closed loops where secondary sodium temperatures in excess of 1000 °F are required, it may be necessary to control carbon and oxygen by the use of hot traps. In loops where the secondary system is operated below 1000 °F, conventional impurity control ($O_2 < 10$ ppm) should be adequate, requiring the use of cold traps only. Requirements for control of fission products, nitrogen and hydrogen require definition.

Fuel Decay Storage

This facility will accommodate fuel elements which have been irradiated in a high purity sodium atmosphere as well as normal driver fuel which may not have been irradiated in high purity sodium. However, the comparatively low operating temperature maintained in these facilities (~350 °F planned) will probably not require that the sodium be highly purified. Cross contamination between the fuel storage containers and the reactor and closed loops during fuel transfer is recognized. Intermittent purification by the reactor primary purification system is considered adequate.

Fresh Sodium Storage

Fresh sodium must be purified to a level where it may be introduced to any other sodium system. Thus hot trapping may be required for fresh sodium makeup to the closed loops. An alternate, which is recommended, is to purify the sodium to cold trapping levels and leave the final purification and conditional adjustment to the supplied facility. On this basis, cold traps only will be required for fresh sodium storage to maintain oxygen at <10 ppm.

¹ Refer to Reference, Appendix A, Item 39.

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APPENDIX E

SODIUM RECEIVING AND PROCESSING SYSTEM EQUIPMENT CHARACTERISTICS

APPENDIX E

Sodium Receiving and Processing Systems Equipment Characteristics

1 of 3

Equip. Piece No.	Description	Capacity	Flow, gpm	Head ft of Na	Max. Oper. Temp., °F	Design Temp., °F	Max. Oper. Press., psig	Design Press., psig	Heat Trans. Med.	Heating/ Cooling Load Btu/hr	Material	Heat Exchanger				Design Study (Items)
												Tube Side		Shell Side		
												In °F	Out °F	In °F	Out °F	
Fresh Sodium Receiving and Processing System																
TCH-1-1	Tank car heater	-	500	-	450	500	50	150	oil	2.5 x 10 ⁶					2, 6, 9	
F-1-1	Filter (Dual)	-	75	-	450	500	20	150 and F.V.	-	-						
T-1-1	Storage tank	12,000 gal	-	-	450	500	<1	50 and F.V.	-	-						
P-1-1	Recirculation and transfer pump	-	100	206	450	500	75	150 and F.V.	-	-						
CT-1-1	Cold trap	450 lb Na ₂ O	100	-	450	500	75	150 and F.V.	-	-						
HC-1-1	Heater cooler	-	-	-	-	-	-	-	air	1.5 x 10 ⁶						
	Piping	-	-	-	450	500	75	150 and F.V.	-	-						
Reactor Secondary Sodium Processing System																
T-2-1A	Storage tank	40,000 gal	-	-	775	825	<1	50 and F.V.	-	-	Type 304 SS				2, 9	
T-2-1B	Storage tank	40,000 gal	-	-	775	825	<1	50 and F.V.	-	-						
P-2-1	Recirculation and transfer pump	-	100	135	775	825	50	150 and F.V.	-	-						
CT-2-1	Cold trap	Identical to CT-1-1 above, Standardized equipment selected to facilitate interchangeability and to minimize spare parts requirements														
HC-2-1	Heater cooler	Identical to HC-1-1 above		-	775	825	100	150 and F.V.	air	1.5 x 10 ⁶						
	Piping	-	-	-	775	825	100	150 and F.V.	-	-						
RHX-2-1	Regenerative Heat Exchanger	-	100	-	775	825	100	150 and F.V.	-	3.9 x 10 ⁶		400	675	775	500	
Closed Loop Secondary Sodium Processing System																
T-3-1	Storage tank	7,000 gal	-	-	1100	1150	5	50 and F.V.	-	-	Type 304 SS				2, 9	
P-3-1	Recirculation and transfer pump	-	100	135	1100	1150	50	150 and F.V.	-	-					18	
CT-3-1	Cold trap	225 lb Na ₂ O	50	-	450	500	50	150 and F.V.	-	-						
HC-3-1	Heater cooler	-	-	-	-	-	-	-	-	6.9 x 10 ⁵						
	Piping	-	-	-	1100	1150	50	150 and F.V.	-	-						
RHX-3-1	Cold Trap Regenerative HX	-	50	-	1100	1150	50	150 and F.V.	-	3.2 x 10 ⁶		1100	600	500	1000	
RHX-3-2	Hot Trap Regenerative HX	-	5 and 10	-	1500	1500	50	150 and F.V.	-	2.0 x 10 ⁵ & 3.9 x 10 ⁵		1500	1200	1100	1400	
CHT-3-1	Carbon Hot Trap	-	5	-	1600	1600	50	150 and F.V.	-	-						
OHT-3-1	Oxygen Hot Trap	-	10	-	1600	1600	50	150 and F.V.	-	-						

¹ Refer to Support Information Appendix B

Equip. Piece No.	Description	Capacity	Flow, gpm	Head ft of Na	Max. Oper. Temp, °F	Design Temp, °F	Max. Oper. Press., psig	Design Press., psig	Heat Trans. Med.	Heating/ Cooling Load Btu/hr	Material	Heat Exchanger				Design Study 1 (Items)	
												Tube Side		Shell Side			
												In °F	Out °F	In °F	Out °F		
Reactor Primary Sodium Processing System																	
T-4-1a	Storage Tank	40,000 gal	-	-	600	650	5	50 and F.V.	-	-	Type 304 SS					2, 5, 1	
T-4-1b	Storage Tank	40,000 gal	-	-	-	-	-	-	-	-						3, 7, 8, 9	
T-4-2	Surge Tank	12,000 gal	-	-	1200	1200	5	50 and F.V.	-	-							
P-4-1a	Recirculation and transfer pump		400	100	600	650	50	150 and F.V.	-	-							
P-4-1b	Recirculation and transfer pump		400	100	600	650	50	150 and F.V.	-	-							
CT-4-1a CT-4-1b	Cold traps	Identical to CT-1-1 above, Standardized to facilitate interchangeability and to minimize spare parts requirements															
HC-4-1a	Heater coolers	-	-	-	-	-	-	-	Inert Gas	1.4 x 10 ⁶							
HC-4-1b	Heater coolers	-	-	-	-	-	-	-	Inert Gas	1.4 x 10 ⁶							
RHX-4-1A	Regenerative Heat Exchanger	-	100	-	600	650	50	150 and F.V.	Na/Na	2.8 x 10 ⁶		300	500	600	400		
RHX-4-1B	Regenerative Heat Exchanger	-	100	-	600	650	50	150 and F.V.	Na/Na	2.8 x 10 ⁶		300	500	600	400		
RHX-4-1C	Effluent RHX	-	400	-	1200	1200	25	150 and F.V.	Na/Na	3.1 x 10 ⁷		500	1100	1200	600		
-	Piping	-	-	-	600/1200	650/1200	100	150 and F.V.									
Closed Loop Primary Sodium Processing (Typical for 6 loops except piece numbers for Loops 2 to 6 would be suffixed by corresponding digits, i.e., T-5-2, T-5-3, etc.)												Type 304 SS					2, 3, 4
T-5-1	Storage Tanks	1,500 gal	-	-	1200	1200	5	50 and F.V.	-	-						7, 8, 9	
P-5-1	Recirculation and transfer pump	-	50	600	1200	1200	215	250 and F.V.	-	-						21, 18, 16	
CT-5-1	Cold trap	45 lb Na ₂ O	10	-	600	650	50	150 and F.V.	-	-							
HC-5-1	Heater cooler	-	-	-	-	-	-	-	-	1.4 x 10 ⁵							
RHX-5-1	Hot trap Regenerative Heat Exchanger	-	1	-	1500	1500	50	150 and F.V.	-	4.1 x 10 ⁴		1500	1200	1100	1400		
RHX-5-2	Cold trap Regenerative Heat Exchanger	-	10	-	1100	1200	50	150 and F.V.	Na/Na	6.7 x 10 ⁵	Type 304 SS	1100	600	500	1000		
OHX-5-1	Oxygen removal hot trap	-	1	-	1600	1600	50	150 and F.V.	-	-							

¹ Refer to Support Information Appendix B

APPENDIX E (contd)

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Equip. Piece No.	Description	Capacity	Flow, gpm	Head ft of Na	Max. Oper. Temp, °F	Design Temp, °F	Max. Oper. Press., psig	Design Press., psig	Heat Trans. Med.	Heating/ Cooling Load Btu/hr	Material	Heat Exchanger				Design Study (Items)	1
												Tube In °F	Side Out °F	Shell In °F	Side Out °F		
CHT-5-1	Carbon removal hot trap	-	1	-	1600	1600	50	150 and F.V.	-	-							
	Piping	-	-	-	600/1600	650/1600	215	250 and F.V.	-	-							
Contaminated Sodium Processing System ²																	
T-6-1	Storage tank	35,000 gal	-	-	450	500	<1	50 psig and F.V.	-	-							1, 2, 7, 4 8, 9, 16
P-6-1	Recirculation and transfer pump	-	25	-	450	500	50	150 and F.V.	-	-							
CT-6-1	Cold trap	Identical to CT-1-1 above															
HC-6-1	Heater cooler	Identical to HC-4-1a above															
T-7-1	Maintenance cell sump tank	500	-	-	350	500	<1	50 psig and F.V.	-	-							
T-8-1	Sodium reaction tank	-	-	-	-	-	-	-	-	-							
RN-8-1	Sodium reaction nozzle	-	-	-	-	-	-	-	-	-							
P-8-1	Waste pump	-	-	-	-	-	-	-	-	-							
	Sodium piping	-	-	-	450	500	75	150 and F.V.	-	-							

1 Refer to Support Information Appendix B

2 To be evaluated more fully in design study

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APPENDIX F

OPERATIONAL DIAGRAM FIGURES

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FRESH SODIUM

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FIGURE 1a. Fresh Sodium Receiving and Processing
(Storage tank fill operation)

FIGURE 1b. Fresh Sodium Receiving and Processing
(Storage tank purification operation)

FIGURE 1c. Fresh Sodium Receiving and Processing
(Fresh sodium transfer operation)

REACTOR SECONDARY

FIGURE 2a. Reactor Secondary Sodium Processing
(Storage tank purification operation)

FIGURE 2b. Reactor Secondary Sodium Processing
(Transfer to secondary sodium loops)

FIGURE 2c. Reactor Secondary Sodium Processing
(Secondary Sodium recirculation purification operation)

FIGURE 2d. Reactor Secondary Sodium Processing
(Storage tank fill operation)

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CLOSED LOOP SECONDARY

FIGURE 3a. Closed Loop Secondary Sodium Processing
(Storage tank fill)

FIGURE 3b. Closed Loop Secondary Sodium Processing
(Storage tank cold trap purification)

FIGURE 3c. Closed Loop Secondary Sodium Processing
(Closed Loop secondary fill)

FIGURE 3d. Closed Loop Secondary Sodium Processing
(Cold trap purification)

FIGURE 3e. Closed Loop Secondary Sodium Processing
(Hot trap purification)

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REACTOR PRIMARY

FIGURE 4a. Reactor Primary Sodium Processing
(Storage tank filling operation)

FIGURE 4b. Reactor Primary Sodium Processing
(Storage tank clean-up)

FIGURE 4c. Reactor Primary Sodium Processing
(Reactor filling operation)

FIGURE 4d. Reactor Primary Sodium Processing
(Decay storage filling operation)

FIGURE 4e. Reactor Primary Sodium Processing
(Reactor pump-down operation)

FIGURE 4f. Reactor Primary Sodium Processing
(Decay storage pump-down operation)

FIGURE 4g. Reactor Primary Sodium Processing
(Recirculation through surge tank to
maintain constant reactor level)

FIGURE 4h. Reactor Primary Sodium Processing
(Reactor sodium clean-up via two cold traps)
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FIGURE 4i. Reactor Primary Sodium Processing
(Decay storage clean-up operation)

FIGURE 4j. Reactor Primary Sodium Processing
(Reactor sodium discharge to con-
taminated sodium processing system)

FIGURE 4k. Reactor Primary Sodium Processing
(Sampler and plugging meter operation)

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CLOSED LOOP PRIMARY

FIGURE 5a. Closed Loop Primary Sodium Processing
(Typical for 6 Loops (Storage tank fill))

FIGURE 5b. Closed Loop Primary Sodium Processing
Typical for 6 Loops (Loop fill)

FIGURE 5c. Closed Loop Primary Sodium Processing
Typical for 6 Loops (Normal recirculation
without purification)

FIGURE 5d. Closed Loop Primary Sodium Processing
Typical for 6 Loops (Loop purification
using loop pump head)

FIGURE 5e. Closed Loop Primary Sodium Processing
Typical for 6 Loops (Loop and storage
pump down to contaminated processing)

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CONTAMINATED SODIUM

FIGURE 6a. Contaminated Sodium Processing
(Cold trap operation)

FIGURE 6b. Contaminated Sodium Processing (Sodium return to reactor primary system)

FIGURE 6c. Contaminated Sodium Processing (Contaminated Sodium disposal)

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APPENDIX G

DRAWINGS

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REACTOR PRIMARY SODIUM PROCESSING

EQUIPMENT LIST CONTINUED						EQUIPMENT LIST					
EQUIPMENT PIECE NUMBER	SYSTEM ITEM NUMBER	DESCRIPTION	SIZE IN INCHES	PRESS. PSI	END CONN.	REMARKS	EQUIPMENT PIECE NUMBER	SYSTEM ITEM NUMBER	DESCRIPTION	SIZE IN INCHES	PRESS. PSI
TRC-4-1A	TRC-4-1A	TEMP. RECORDER-CONTROLLER					T-4-1A	T-4-1A	TANK, REACTOR PRIMARY		
TRC-4-1B	TRC-4-1B						T-4-1B	T-4-1B	TANK, REACTOR PRIMARY		
TRC-4-2A	TRC-4-2A						T-4-2	T-4-2	TANK, REACTOR PRIMARY		
TRC-4-2B	TRC-4-2B						P-4-1A	P-4-1A	PUMP, RECIRCULATION		
TI-4-1A	TI-4-1A	TEMP. INDICATOR					P-4-1B	P-4-1B	PUMP, RECIRCULATION		
TI-4-1B	TI-4-1B						CT-4-1A	CT-4-1A	COLD TRAP		
TI-4-2A	TI-4-2A						CT-4-1B	CT-4-1B	COLD TRAP		
TI-4-2B	TI-4-2B						HC-4-1A	HC-4-1A	HEATER-COOLER		
TI-4-3A	TI-4-3A						HC-4-1B	HC-4-1B	HEATER-COOLER		
TI-4-3B	TI-4-3B						SS-4-1	SS-4-1	SODIUM SAMPLER		
TI-4-4A	TI-4-4A						PM-4-1	PM-4-1	PLUGGING METER		
TI-4-4B	TI-4-4B						EMFM-4-1A	EMFM-4-1A	MAGNETIC FLOW METER		
TI-4-5A	TI-4-5A						EMFM-4-1B	EMFM-4-1B	MAGNETIC FLOW METER		
TI-4-5B	TI-4-5B						VT-4-1A	VT-4-1A	VAPOR TRAP		
TAN-4-1A	TAN-4-1A	TEMP. ALARM HI					VT-4-1B	VT-4-1B	VAPOR TRAP		
TAN-4-1B	TAN-4-1B						FT-4-1A	FT-4-1A	FREEZE TRAP		
TAL-4-1A	TAL-4-1A	LO					FT-4-1B	FT-4-1B	FREEZE TRAP		
TAL-4-1B	TAL-4-1B						FT-4-2A	FT-4-2A			
TAN-4-2	TAN-4-2	HI					FT-4-2B	FT-4-2B			
LI-4-1A	LI-4-1A	LEVEL INDICATOR					RHX-4-1A	RHX-4-1A	REGENERATIVE HEAT EXCH.		
LI-4-1B	LI-4-1B						RHX-4-1B	RHX-4-1B	REGENERATIVE HEAT EXCH.		
LI-4-2	LI-4-2						VT-4-2	VT-4-2	VAPOR TRAP		
LAN-4-1A	LAN-4-1A	LEVEL ALARM HI					V-4-1A	V-4-1A	VALVE		
LAN-4-1B	LAN-4-1B						V-4-1B	V-4-1B	VALVE		
LAN-4-2	LAN-4-2						V-4-2A	V-4-2A	VALVE		
LAL-4-1A	LAL-4-1A	LO					V-4-2B	V-4-2B	VALVE		
LAL-4-1B	LAL-4-1B						V-4-3A	V-4-3A	VALVE		
LAL-4-2	LAL-4-2						V-4-3B	V-4-3B	VALVE		
FI-4-1A	FI-4-1A	FLOW INDICATOR					V-4-4A	V-4-4A	VALVE		
FI-4-1B	FI-4-1B						V-4-4B	V-4-4B	VALVE		
FAL-4-1A	FAL-4-1A	FLOW ALARM LO					V-4-5A	V-4-5A	VALVE		
FAL-4-1B	FAL-4-1B						V-4-5B	V-4-5B	VALVE		
PI-4-1A	PI-4-1A	PRESS. INDICATOR					V-4-6A	V-4-6A	VALVE		
PI-4-1B	PI-4-1B						V-4-6B	V-4-6B	VALVE		
PI-4-2A	PI-4-2A						V-4-7A	V-4-7A	VALVE		
PI-4-2B	PI-4-2B						V-4-7B	V-4-7B	VALVE		
PI-4-3A	PI-4-3A						V-4-8A	V-4-8A	VALVE		
PI-4-3B	PI-4-3B						V-4-8B	V-4-8B	VALVE		

LEGEND			
—	PRINCIPAL FLOW	INERT GAS SUPPLY	TO TI & TAN TO RADIOACTIVE GAS DECAY AND VENT SYS.
- - -	INST. AIR LINE	INERT GAS SUPPLY	FREEZE TRAP
- . - . -	INST. ELECTRICAL LINE	INERT GAS SUPPLY	TO PIC, TI AND TAN TO RADIOACTIVE GAS DECAY AND VENT SYSTEM
~ ~ ~	ELECTRIC HEATER		VAPOR TRAP
□	REMOVABLE SEPARATION	EMFM	ELECTROMAGNETIC FLOWMETER
⊗	DIAPHRAGM OPERATED DAMPER		
⊕	VALVE		
INSTRUMENT SYMBOLS			
LETTER	FIRST	SECOND	THIRD
A		ALARM	
C			CONTROLLER
F			FLOW
H			HI
I		INDICATOR	
L			LO
P			PRESSURE
R			RECORDER
T			TEMPERATURE

NOTE: ALL SYSTEM ITEM NUMBERS SHALL BE PRECEDED BY SYS. NO. 81.

U. S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATION OFFICE

THE PACIFIC NORTHWEST LABORATORIES
A DIVISION OF BATTELLE MEMORIAL INSTITUTE
PACIFIC NORTHWEST LABORATORY
RICHLAND, WASH.

SCALE: NONE

DATE: 5-18-68

BY: J. D. A. / J. D. A.

REVIEWED: J. D. A. / J. D. A.

APPROVED: J. D. A. / J. D. A.

SYSTEM FLOW DIAGRAM
REACTOR PRIMARY
SODIUM PROCESSING

FAST FLUX TEST FACILITY

SK-3-12716

CONCEPTUAL

INSTRUMENT SYMBOLS

LETTER	FIRST	SECOND	THIRD
A		ALARM	
C			CONTROLLER
F	FLOW		
H			HI
I		INDICATOR	
L	LEVEL		LO
P	PRESSURE		
Q		RECORDER	
T	TEMPERATURE		

NOTE: ALL SYSTEM ITEM NUMBERS SHALL BE PRECEDED BY SYSTEM NO. 81, THUS: T-81-2-1A

EQUIPMENT LIST CONT.

EQUIPMENT PIECE NUMBER	SYSTEM ITEM NUMBER	DESCRIPTION	REMARKS
	LAH-2-1A	LEVEL ALARM, HI	
	LAH-2-1B		
	LAL-2-1A		
	LAL-2-1B		
	LI-2-1A	INDICATOR	
	LI-2-1B		
	LS-2-1A	SWITCH	
	LS-2-1B		
	TIC-2-1A	TEMP. IND. CONTROLLER	
	TIC-2-1B		
	TIC-2-2		
	TI-2-1	INDICATOR	
	TI-2-2		
	TI-2-3		
	TI-2-4		
	TI-2-5		
	TAH-2-1	ALARM, HI	
	TRC-2-1	REC. CONTROLLER	
	FAL-2-1	FLOW ALARM, LO	
	FI-2-1	INDICATOR	
	PI-2-1	PRESSURE INDICATOR	
	PI-2-2		

EQUIPMENT LIST

EQUIPMENT PIECE NUMBER	SYSTEM ITEM NUMBER	DESCRIPTION	SIZE (IN INCHES)	PRESS. (PSI)	END CONN.	MATERIAL	REMARKS
	T-2-1A	REACTOR SEC. NO. ST-G					
	T-2-1B						
	P-2-1	PUMP, RECIRC. & TRANSFER					
	CT-2-1	COLD TRAP					
	HC-2-1	HEATER-COOLER					
	RHX-2-1	REGENERATIVE HT. EXCH.					
	SS-2-1	SODIUM SAMPLER					
	EMFM-2-1	MAGNETIC FLOW METER					
	PM-2-1	PLUGGING METER					
	PM-2-2						
	PM-2-3						
	PM-2-4						
	PM-2-5						
	VT-2-1A	VAPOR TRAP					
	VT-2-1B						
	FT-2-1	FREEZE TRAP					
	FT-2-2						
	V-2-1A	VALVE					
	V-2-1B						
	V-2-2A						
	V-2-2B						
	V-2-3A						
	V-2-3B						
	V-2-4						
	V-2-5						
	V-2-6						
	V-2-7						
	V-2-8						
	V-2-9						
	V-2-10						
	V-2-11						
	V-2-12						
	V-2-13						
	V-2-14						
	V-2-15						
	V-2-16						
	V-2-17						
	V-2-18						
	V-2-19						
	V-2-20						
	V-2-21						
	V-2-22						
	V-2-23						
	V-2-24						
	V-2-25						
	V-2-26						
	V-2-27						
	V-2-28						
	V-2-29						
	V-2-30						
	V-2-31						
	V-2-32						
	V-2-33						
	V-2-34						
	LCV-2-1A	LEVEL CONTROL VALVE					
	LCV-2-1B						

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RICHLAND, WASH.

SYSTEM FLOW DIAGRAM
REACTOR SECONDARY
SODIUM PROCESSING

FAST FLUX TEST FACILITY

SK-3-12717

CONCEPTUAL

CLOSED LOOP SECONDARY SODIUM PROCESSING

LEGEND

INSTRUMENT SYMBOLS

○	LOCALLY MOUNTED	BOARD MOUNTED	○
POSITION IDENTIFICATION			
LETTER	FIRST	SECOND	THIRD
A		ALARM	
C			CONTROLLER
F	FLOW		
H			HI
I		INDICATOR	
L	LEVEL		LO
P	PRESSURE		
R		RECORDER	
T	TEMPERATURE		

NOTE: ALL SYSTEM ITEM NUMBERS SHALL BE PRECEDED BY SODIUM SYSTEM NUMBER 81, THUS: T-81-3-1.

EQUIPMENT LIST (CONTINUED)

EQUIPMENT PIECE NUMBER	SYSTEM ITEM NUMBER	DESCRIPTION	SIZE (INCHES)	PRESS. (PSI)	END CONN.	MATERIAL	REMARKS
	V-3-10	VALVE					
	V-3-11						
	V-3-12						
	V-3-13						
	V-3-14						
	V-3-15						
	V-3-16						
	V-3-17						
	V-3-18						
	V-3-19						
	V-3-20						
	V-3-21						
	V-3-22						
	V-3-23						
	V-3-24						
	V-3-25						
	V-3-26						
	V-3-27						
	V-3-28						
	V-3-29						
	V-3-30						
	V-3-31						
	V-3-32						
	V-3-33						
	V-3-34						
	V-3-35						
	V-3-36						
	V-3-37						
	V-3-38						

EQUIPMENT LIST

EQUIPMENT PIECE NUMBER	SYSTEM PIECE NUMBER	DESCRIPTION	SIZE (INCHES)	PRESS. (PSI)	END CONN.	MATERIAL	REMARKS
	T-3-1	TANK					
	P-3-1	PUMP					
	CT-3-1	COLD TRAP					
	HC-3-1	HEATER-COOLER					
	CHT-3-1	CARBON HOT TRAP					
	OHT-3-1	OXYGEN HOT TRAP					
	RHX-3-1	REGEN. HEAT EXCH.					
	RHX-3-2						
	SS-3-1	SODIUM SAMPLER					
	PM-3-1	PLUGGING METER					
	PM-3-2						
	PM-3-3						
	PM-3-4						
	PM-3-5						
	PM-3-6						
	PM-3-7						
	EMFM-3-1	MAGNETIC FLOWMETER					
	VT-3-1	VAPOR TRAP					
	FT-3-1	FREEZE TRAP					
	FT-3-2						
	FT-3-3						
	FT-3-4						
	FT-3-5						
	LAM-3-1	LEVEL ALARM HI					
	LAL-3-1	LO					
	LI-3-1	INDICATOR					
	FAL-3-1	FLOW ALARM LO					
	FI-3-1	INDICATOR					
	TIC-3-1	TEMP. IND. CONTROLLER					
	TRC-3-1	REC.					
	TRC-3-2						
	TRC-3-3						
	TAH-3-1	ALARM HIGH					
	TAH-3-2						
	TAH-3-3						
	TI-3-1	INDICATOR					
	TI-3-2						
	TI-3-3						
	TI-3-4						
	TI-3-5						
	TI-3-6						
	TI-3-7						
	TI-3-8						
	TI-3-9						
	V-3-1	VALVE					
	V-3-2						
	V-3-3						
	V-3-4						
	V-3-5						
	V-3-6						
	V-3-7						
	V-3-8						
	V-3-9						

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SYSTEM FLOW DIAGRAM
CLOSED LOOP SECONDARY
SODIUM PROCESSING

SK-3-12719

CONTAMINATED SODIUM PROCESSING

EQUIPMENT LIST (CONT)					
EQUIPMENT PIECE NUMBER	SYSTEM PIECE NUMBER	DESCRIPTION	SIZE (IN INCHES)	PRESS. (PSI)	REMARKS
T-8-1		TANK, WASTE Na WATER REACTION			
P-8-1		PUMP, TRANSFER			
V-8-1		VALVE			
V-8-2					
V-8-3					
LI-8-1		LEVEL INDICATOR			
TI-8-1		TEMP. INDICATOR			
RN-8-1		REACTION NOZZLE			
pHM-8-1		pH METER			

EQUIPMENT LIST					
EQUIPMENT PIECE NUMBER	SYSTEM PIECE NUMBER	DESCRIPTION	SIZE (IN INCHES)	PRESS. (PSI)	REMARKS
		CONTAMINATED SODIUM PROCESSING			
P-6-1		PUMP RECIRC & TRANSFER			
CT-6-1		COLD TRAP			
HC-6-1		HEATER-COOLER			
SS-6-1		SODIUM SAMPLER			
PM-6-1		PLUGGING METER			
EMFM-6-1		MAGNETIC FLOW METER			
VT-6-1		VAPOR TRAP			
FT-6-1		FREEZE TRAP			
FT-6-2					
T-6-1		TANK, CONTAMINATED Na DUMP			

V-6-1	VALVE	
V-6-2		
V-6-3		
V-6-4		
V-6-5		
V-6-6		
V-6-7		
V-6-8		
V-6-9		
V-6-10		
V-6-11		
V-6-12		
V-6-13		
V-6-14		
V-6-15		
V-6-16		
V-6-17		
V-6-18		
V-6-19		

TRC-6-1	TEMP RECORDER CONT	
LAH-6-1	LEVEL ALARM HIGH	
LI-6-1	INDICATOR	
LAL-6-1	ALARM LOW	
PI-6-1	PRESSURE INDICATOR	
PI-6-2		
TI-6-1	TEMP INDICATOR	
TI-6-2		
TI-6-3		
TIC-6-1		
TAH-6-1	ALARM HIGH	
FI-6-1	FLOW INDICATOR	
FAL-6-1	ALARM LOW	

LEGEND	
	PRINCIPAL FLOW
	INSTRUMENT AIR LINE
	INSTRUMENT ELECTRICAL LINE
	ELECTRIC HEATER
	REMOVABLE SEPARATION
	DIAPHRAGM OPERATED DAMPER
	VALVE
	RESTRICTION ORIFICE
	DIAPHRAGM OPERATED VALVE
	FREEZE TRAP
	VAPOR TRAP
	ELECTROMAGNETIC FLOWMETER

INSTRUMENT SYMBOLS			
POSITION IDENTIFICATION			
LETTER	FIRST	SECOND	THIRD
A		ALARM	
C			CONTROLLER
F	FLOW		
H			HIGH
I		INDICATOR	
L	LEVEL		LOW
P	PRESSURE		
R		RECORDER	
T	TEMPERATURE		

ALL SYSTEM ITEM NUMBERS SHALL BE PRECEDED BY SYSTEM NO 61

SCALE	NONE
DATE	12/1/67
BY	W. J. B. / J. W. B.
CHECKED	W. J. B. / J. W. B.
APPROVED	W. J. B. / J. W. B.
REVISIONS	
NO.	
DATE	
BY	
CHECKED	
APPROVED	
REVISIONS	
NO.	
DATE	
BY	
CHECKED	
APPROVED	

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SYSTEM FLOW DIAGRAM
CONTAMINATED SODIUM
PROCESSING

FAST FLUX TEST FACILITY

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