Department of Energy
Washington, D.C. 20545

Docket No. 50-537
HQ:S:83:171

JAN 07 1983

Mr. Paul S. Check, Director
CRBR Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Check:

NUCLEAR REGULATORY STAFF COMMENTS REGARDING PRELIMINARY SAFETY ANALYSIS REPORT (PSAR) SECTIONS 9.3 AND 9.13 FOR THE CLINCH RIVER BREEDER REACTOR PLANT

In accordance with agreements between our respective staffs, enclosed are responses to questions concerning PSAR Section 9.3, "Auxiliary Liquid Metal Systems," Section 9.13, "Plant Fire Protection System," and other related sections. Enclosure 1 responds to questions from the Chapter 9 working meeting held on December 14 and 15, 1982; Enclosure 2 responds to additional Chapter 9 questions discussed in the Florek, King, et al, telecon of December 20, 1982; Enclosure 3 is the proposed PSAR amended pages that will be submitted in the January amendment reflecting the above responses; and Enclosure 4 is an additional response requested in another Florek, King, et al, December 20, 1982, telecon.

Questions regarding this submittal may be addressed to either Mr. D. Robinson (FTS 626-6098) or Mr. D. Hornstra (FTS 626-6110) of the Project Office Oak Ridge staff.

Sincerely,

John R. Longenecker

John R. Longenecker
Acting Director, Office of
Breeder Demonstration Projects
Office of Nuclear Energy

4 Enclosures

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Standard Distribution
Licensing Distribution

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PSAR SECTION 9.3 ITEMS

1. Question: The design conditions (temperature and pressure) should be specified for each subsystem.

   Response: Design temperatures and pressures are provided for each subsystem on amended PSAR pages 9.1-26, 9.3-la, 7a, 11, 14, 20d.

2. Question: The PSAR should identify the materials of construction of the sodium and NaK receiving stations.

   Response: See amended PSAR page 9.3-la.

3. Question: Appropriate emergency plans should be implemented during receiving and loading of sodium.

   Response: PSAR page 9.3-2 has been amended to say that appropriate and necessary emergency planning with local officials will be taken to consider the possibility of an outside sodium fire during the initial loading of sodium.

   PSAR page 9.3-2 also states that precautions will be taken during liquid metal loading conditions to limit aerosols efects to plant components prior to plant operation.

4. Question: What procedure is planned for replacement of cold traps?

   Response: Amended PSAR pages 9.3-5, 13, and 9.1-21 discusses cold trap removal and storage.

5. Question: What procedure is used for maintaining NaK purity and what has been experience with other plants using NaK?

   Response: As discussed in amended PSAR pages 9.1-21, NaK has been successfully used without impurity problems and no monitoring of NaK impurities are scheduled based upon anticipated maintenance activities of the NaK loops and the capacities of the diffusion traps.

6. Question: Can a leak in the EVS cooling circuits disable cooling of the EVST?

Response: As discussed on PSAR pages 9.1-27, no leak in the EVS system can disable more than one loop. Discussion of the EVST anti-syphon features are provided.

PSAR SECTION 9.13 QUESTIONS

9.13- 1) During cooldown of the cell atmosphere after a liquid metal fire, a negative pressure could result due to the depletion of the oxygen. The PSAR does not state that the pressure differential resulting across the liner is less than the 5 psig design value in this instance. Therefore, the resulting negative pressure in an inerted cell due to cooldown after a sodium spill should be calculated and documented in the PSAR. If need be, a change to the cell design condition for negative pressure should be made.

Response: The Project has done a very conservative analysis of the PHTS cell cooldown pressure effects following a sodium spill. The analysis assumed that the postulated spill pressurizes the cell to 30 psig (approximately twice more than calculated) with a corresponding gas temperature of 1500^{o} F (also twice more than calculated). The analysis assumed that the cell leaks outward at the design leak rate increased for pressure effects. With no inward leakage assumed, the maximum negative pressure with sodium cooling until freezing is 4.5 psi which is still within the cell liner design limits.

9.13- 2) The functional design and evaluation of the catch pan system is based on the sodium/NaK leak rates and spill volumes listed in Table 9.13-9. In all cases, except the case in Cell No. 211A for the storage vessel valve gallery, the total postulated spill volume is identical to the potential spill volume. Since it is stated that no operator action is taken to terminate the leak, it is not obvious why the larger potential spill volume of 69,000 gallons would not also be the total postulated spill volume. If

the spill volume of 69,000 gallons was used it would constitute a much more severe fire potential than the 3400 gallons considered. Provide justification as to why the larger spill volume was not used or change the PSAR and perform the analysis to be consistent with the larger volume.

Response: The maximum potential Na spill volume in either Cell No. 211A or 211 is presently 50,000 gallons, assuming no credit for operator action to mitigate the spill. The analysis and conclusions on PSAR Section 15.6.1.3 for a 45,000 gallon spill are still applicable, since an additional 5000 gallons of sodium do not present any significant additional heat load to the building structures. Appropriate change pages to the PSAR (9.13-45B, 15.6-8) are attached to this response.

9.13-3) Not all cells with catch pans have fire suppression decks. Some have drains that allow the spilled sodium/NaK to go to catch pans with fire suppression decks and others allow open pool burning as long as no safety-related equipment or building structures are affected (generally limited to cells with only small spill potential). However, there are two cells (nos. 211 and 22B) which have the potential for large sodium spills for which no fire suppression decks are provided. Lack of fire suppression decks in these cells have not been justified. It should be noted that the plant design has similar cells to Cell No. 228 (IHTS loop 2 pipe cell) for loops 1 and 3 which have fire suppression decks. Fire suppression decks should be added to Cell Nos. 211

and 228 or justification should be provided as to why the decks are not needed.

Response: Cell No. 211 will be inerted whenever sodium is present in the storage tanks (in excess of the heel) in this cell. Hence, no fire suppression deck is required since the inerted gas precludes any significant burning from a postulated sodium spill accident.

Drains are provided between Cell Nos. 228 and 225 and to cell No. 208 which is provided with a fire suppression deck. Drainage of sodium from Cell No. 228 is required since the free volume of the cell is not sufficient to contain the potential volume of leaked sodium.

9.13-5) The free volume of the catch pans was provided only for the catch pans in Ce-l Nos. 207, 208, and 209 - the reaction product tank cells for IHTS loops 1, 2, and 3. The volumes given were 5251 ft3, 4279 ft3, and 5835 ft3, respectively, and represent approximately 11 percent excess capacity over the maximum postulated spill volume. The catch pans are; however, in cells which are approximately 73 ft x 73 ft which means the catch pan walls are only approximately one foot high. Since according to the applicant's criteria, the catch pans must provide room for the fire suppression decks to sit above the liquid metal pool (minimum 4" above pool is design value) and since the sides of the catch pans are to extend at least one foot above the top of the pool, the volumes of these catch pans do not seem large enough to meet the criteria. To verify that the above criteria are met in all cases the volumes of each catch pan without

a drain should be provided along with its approximate surface area.

Response: The net catch pan floor area for Cell Nos. 207, 208, and 209 is approximately 2334 ft3. Postulated spill volumes in these cells are 4700, 3800, and 5300 ft3, respectively, resulting in corresponding maximum sodium pool depths of 2.0, 1.6, and 2.3 test. The bottom of the fire suppression deck is constrained to 4 inches above each of these sodium pool depths. The sides of the catch pans are a minimum of 22 inches above the bottom of the fire suppression deck in each of these cells.

Similar type design considerations also apply to other cells containing fire suppression decks, namely Cell Nos. 227, 230, 231, 232, 350, 354, and 355.

9.13-6) Cell Nos. 332, 352A, and 353A contain the EVST natural draft heat exchanger and air blast heat exchangers, respectively. These cells do not have fire suppression decks in their catch pans and do not have automatic exhaust damper controls. The postulated spill volumes and release paths in these cells have the potential for generating and releasing more than the 630 lbs. of aerosol allowed from spills in the SGB. The rational needs to be provided as to why aerosol releases in excess of 630 lbs from spills in these locations are acceptable or protective measures provided to close off the exhaust paths or extinguish the fire.

Response: See attached change to PSAR page 15.6-2

9.13-8) The accident analysis of the failure of an ex-containment primary sodium storage tank, reported in Section 15.6.1.3 of the PSAR, uses a postulated spill of 45,000 gallons of sodium in the accident conditions. Table 9-13.9 indicated that the total spillable volume of the tank is 50,000 gallons. There appears to be a discrepancy in the amount of sodium which is considered in the analysis, which needs to be corrected.

Response: The PSAR has been corrected as discussed in response to item 2 above.

9.13-9) There is no indication that the SFPS detectors and instrumentation provide local audible alarms in the fire area served by the detectors. For normally accessible areas this should be provided for the safety of personnel that may be in the area.

Response: The Project will include local audible alarms in sodium fire areas as required to ensure the safety of personnel.

that may be in these areas.

9.13-10) Paragraph 5.0 of Attachment B to Section 3.8-C indicates that the Project is presently developing non-destructive examination (NDE) requirements for the catch pans and fire suppression decks. It is expected that the NDE requirements will be analogous to those specified for cell liners. The NDE program and requirements should be defined in the PSAR.

Response: The NDE requirements for catch pans are provided by PSAR Section 3.8C, Amendment 74 (attached). The NDE requirement for the fire suppression deck is visual inspection.* The confirmation that these NDE requirements are acceptable will be obtained as a result of the Large Scale Sodium Spray Fire Test described in PSAR Section 1.5.

9.13-11) No design methods are listed in the PSAR for the catch pan and fire suppression deck design. As discussed in Section 6.5 of the PSAR these methods will be incorporated in a new section of the PSAR to be added in the future (Section 3A.9). This section will require our review.

Response: Proposed PSAR Section 3A.9 is attached.

9.13-12) Features should be provided in the design of those cells which contain both sodium and water piping to minimize the potential for water leaks impinging on sodium piping and for sodium leaks impinging on water piping. The affects of any impingement should be evaluated in the fire hazards analysis report.

*Visual inspection for the first suppression deck is considered to be adequate since the fire suppression deck has no normal structural support function to perform other than its own weight. In addition, the fire suppression deck is a non-pressure retaining device.

Response: The Project has provided jet impingement shields to minimize the potential for steam/water leaks impinging on sodium piping/components. Conversely, plant features will be provided as required to protect steam/water components from potential sodium jet impingements.

9.13-13) The slope of the catch pan floors with drains was stated to be 1/4" to 1/8" per foot. This corresponds to an angle of 0.60 to 1.20. It is not clear that this is adequate to ensure complete drainage of the spilled liquid metal. (See report PWAC-347 "Liquid Metal Fire Control," dated 6/15/61). Therefore, the slope of the catch pans should be increased to 70 or the liquid metal spill analysis should account for retention and burning of some sodium in the drainable catch pans.

Response: During IHTS design basis sodium spill scenarios, both spray and pool fire evaluations are performed. For the spill durations, an instantaneous pool is assumed to exist in the drainable catch pans. These assumptions are considered to be conservative in assessing the design adequacy of the SGB structures to accommodate postulated sodium spill events.

9.13-14) A description of the insulation to be used on the Na and NaK piping and its compatibility with Na and NaK needs to be provided.

Response: The insulation design for all CRBRP NSSS Na/NaK wetted components and piping includes both metallic and non-metallic materials. All of the metallic parts are either 304 or 316 stainless steel, i.e., the same material as the component or piping being insulated. The thermal insulating material is a refractory fiber blanket, elumine silica, insulation. Both literature searches and physical testing have been accomplished to demonstrate that the material selected does not react with Na/NaK or support combustion. In addition, the material meets the requirements of Regulatory Guide 1.36, Nonmetallic Thermal Insulation for Austinetic Stainless Steel.

The description of the insulation design is as follows:

Immediately adjacent to the component surface, a continuous annulus is formed utilizing stainless steel strapping, stand-offs, and sheathling. The purpose of the annulus is to house the trace heaters and control/monitor thermocouples as required. The thermal insulation blanket material is then added and retained by stainless steel tie-wires. A stainless steel outer sheath is then added, completely encapsulating the thermal insulation. On irregular configurations, fiberglass cloth is used as the outer sheath. The only locations that the thermal insulating material actually comes in contact with the surface being insulated is where convection barriers are required. In most cases, the convection barriers are encapsulated

in fiberglass cloth. It should be noted that this material also does not react with Na/NaK or support combustion.

9.13-15) The seismic category of the fire detection instrumentation should be specified and should be at least Seismic II.

Response:

The seismic class of the non-safety-related sodium/NaK fire detection instrumentation is Category III as is the non-sodium fire detection instrumentation.

In the event of an earthquake, a fire watch will be posted until the instrumentation is verified as operable.

ADDITIONAL ITEMS IDENTIFIED IN THE FLOREK, KING, ET AL, TELECON OF DECEMBER 20, 1982

1) The in-service inspection plan for cell liner welds should call for inspection of those welds which have the highest stress during normal operation and those that have the highest stress during postulated spill conditions. Access to the welds should be provided in the design. In addition, the in-service inspection plans for the catch pans should be developed in a similar fashion with the design allowing sufficient access for performance of this inspection.

   Response: In-service inspection plans for cell liners were provided in the response to Q760.170. Similar in-service inspection plans will be developed for catch pans.

2) The final design analysis for the inerted cells should include a duty cycle of loss of cell cooling. This will lead to cell heatup and eventual reactor shutdown. Realistic assumptions on the duration of the cooling loss and on the number of times the event occurs should be made. The liners should be confirmed to be able to withstand this event.

   Response: Section 3.8-B of the PSAR addresses the requirements for cell liners integrity under the anticipated plant duty cycle. The plant duty cycle shown in Section 3.8-B is being updated per recent design feature changes. The cell liner criteria will be revised to reflect the changes in the plant duty cycle, ensuring cell liner integrity for both normal and off-normal plant events.

3) The catch pans are free floating and are supported above the concrete floor of the cells by a continuous layer of insulating material (MgO aggregate) and by steel beams. The aggregate being loose and not a solid mass would be subject to settling and have the possibility of producing bending stress in the steel catch pan if the aggregate had settled between the steel beams when a full load of sodium were to occur during an accident condition. Measures should be taken to insure that the aggregate will not settle below the level of the steel support beams or a structural analysis should indicate that the catch pan strength is adequate.

Response: The Project will specify compaction criteria for the 3/8" MgO aggregate to ensure that the height of the MgO bed is adequately maintained in conjunction with a postulated liquid metal spill event.

4) For those liquid metal spills in the RSB or SGB which are adjacent to the containment shell, the impact of the spill on containment integrity should be analyzed.

Response: The Project analyzes the impact of postulated liquid metal spills on plant structures, including any effects on containment/confinement.

5) Location of the fire detection instrumentation within an area is not specified. In choosing the locations the flow patterns of the cell atmosphere should be considered so as not to locate the detector in a stagnant area.

Response: The Project will locate fire detection instrumentation in locations considering the flow patterns of individual cell atmospheres.

6) How is the operability of the SGB aerosol mitigating damper assured for the sodium environment it will see?

Response: The subject damper will be tested as discussed in amended PSAR pages 1.5-46 and 46a.

7) Although summary information has been provided on the Integrity of the cell liner and catch pan/fire suppression deck systems under postulated spill conditions, little was provided on the effect of those spills on other plant safety-related equipment. A comprehensive fire hazard analysis needs to be performed and reviewed by the staff to determine the effect of the postulated spills on the ability to shutdown and maintain the plant in a safe condition. The applicant has committed to perform such an analysis, in a letter, J. R. Longenecker to P. Check, "CRBRP/NRC Sodium Fire Protection Meeting," dated June 29, 1982. This evaluation should as a minimum address: (a) the effect of the fire and combustion product release on the plant safety equipment and the operators ability to safely shutdown and remove plant decay heat, (b) the effect of vent steam from behind the cell liners (to non-inerted areas of the plant) on other plant safety-related equipment, (c) the justification for why the release of 630 pounds of combustion products from those acceptable, and (d) the possibility of water collecting in the catch pans due to condensation or small leaks in other piping systems within the cell.

RESPONSE

A comprehensive analysis was performed to determine that postulated sodium spills will not affect the ability to shutdown and maintain the plant in a safe condition. The current fire hazard analyses included only part of this evaluation which traditionally were included in the fire hazard analysis report. Other parts of this evaluation are included in various parts of the PSAR and will be consolidated into the final fire hazard analysis report. Specifically:

a) The effect of the sodium fire on the safety related equipment and structures located in the cell where the fire occurs is described in Chapter 15.6.1 of the PSAR.

   The effect of the sodium combustion release on the plant safety equipment and the operator's ability to safely shutdown and remove decay heat is described in Chapter 6.2.7 of the PSAR.

b) An evaluation has been performed on the effect of steam vented behind the liner. This analysis indicated that the steam vented from behind the cell liners into non-inerted areas will not affect the plant safety related equipment qualification levels. Thus, safe shutdown is assured.

c) The justification for the acceptance for the release of 630 lbs. sodium combustion products is included in Chapter 6.2.7 of the PSAR. The project will provide features to assure that unacceptable quantities of water do not accumulate in catch pans as a result of condensation or small leaks in other piping systems within the cell. The specific features will be discussed in the PSAR

1.5.2.8 Sodium Fires Test Program

1.5.2.8.1 Purpose

The purpose of the sodium fires test program is to verify that plant design features for accommodation of sodium/NaK spills in air-filled cells will result in acceptable cell pressures and structural concrete temperatures. In addition, this test program will be used to demonstrate that the codes used in sodium fire analyses conservatively predict cell accident conditions.

1.5.2.8.2 Programs

The sodium fire experiments have been or will be performed at the Atomics International test facilities in Santa Susana, California. The following small scale tests have been completed:

1) A fast spill (approximately 15 gal/min) of 1000°F sodium onto the fire suppression deck surface

2) A slow spill (approximately 1.5 gal/min) of 1000°F sodium onto the fire suppression deck surface

3) A spray (approximately 15 gal/min) of 1000°F sodium onto the surface of the fire suppression deck

4) A fast spill (approximately 15 gal/min) of 1000°F sodium directly into the catch pan beneath the fire suppression deck

5) A spray (approximately 15 gal/min) of 1000°F sodium, onto the surface of the fire suppression deck, through a walk grating above the deck

6) A spray (approximately 15 gal/min) of 600°F sodium onto the surface of the fire suppression deck, through a walk grating above the deck

The results of the above small scale tests will be documented as the test reports become available. In addition to small tests, a large scale test will be performed using a large-scale model of the CRBRP catch-pan fire suppression deck system to collect spilled sodium under simulated spill conditions. The test facility is designed to accommodate a volume gas as large as 6600 gallons of 1000°F sodium with a sodium discharge flowrate of approximately 70 GPM. This test will verify the operability of SGB aerosol mitigating dampers by testing under prototypic aerosol conditions.

1.5.2.8.3 Schedule

The small scale tests have been completed. The large scale test is planned to be performed in the last quarter of 1982.

1.5.2.8.4 <u>Success Criteria</u>

The small scale tests successfully demonstrated fire suppression deck design features to ensure drainage capability and fire-suppression effectiveness:

- No blockage of drain pipes during spill.

- Post-spill suppression of sodium burning by control of oxygen ingress to sodium pool via oxide plugging of drain pipes and closure of vent lids on vent pipes.

- No leakage of sodium from catch pan.

The success criteria for the large scale test are that the catch pan shall contain the spilled sodium precluding sodium concrete interactions and that resulting test consequences are enveloped by those calculated with the Project's methodology, and that the aerosol mitigation dampers can reclose ~~state~~ as required during the aerosol release.

1.5.2.8.5 <u>Fallback Position</u>

If the effectiveness of the fire-suppression deck/catch pan system and damper are ~~is~~ not demonstrated, alternative techniques to accommodate design basis liquid metal spill events will be considered and/or prediction of plant design basis accident consequences will be made with alternative methods.

All welding repairs shall be made in accordance with a written welding procedure.

4.3 STORAGE, CONDITIONING AND HANDLING OF WELDING MATERIALS

4.3.1 Filler materials shall be stored, conditioned and handled in accordance with the appendices of ASME Code - Section II, Part C which are mandatory parts of this specification.

5.0 NON-DESTRUCTIVE EXAMINATION REQUIREMENTS ~~The Project is presently developing non-destructive examination (NDE) requirements for the catch pans and fire suppression decks. It is expected that the NDE requirements will be analogous to those specified for cell liners.~~

5.0.1 Plate The catch pan plate seam welds shall be full Penetration and will be examined in accordance with Article CC5500 of the ASME B&PVC, Section III, Division 2 requirements. Acceptance standards for welds shall be in accordance with subarticle CC-5540.

The entire length of catch pan plate seam welds shall be examined visually prior to performing any other examination.

Where plate weld joints are made without the use of back up bars, and the weld is accessible, radiography shall be used. Where plate joints are made with the aid of back up bars or if it is not feasible to radiograph the welds, due to the method of construction, the following methods of examination shall be used:

a. The entire length of catch pan plate seam welds shall be examined by the vacuum box method using either a bubble solution or gas detector technique, and
b. The entire length of catch pan plate seam welds shall be examined by the magnetic particle method.

c. The entire length of all attachment welds shall be examined by the magnetic particle method.

Where radiographic examination is required, the builder shall use double film (two separate films in the same cassette) radiographic examination procedures with the film properly exposed and developed for single film viewing.

5.0.2 Ultrasonic Examination

Pre-selected areas in the catch pan floor and wall plates below the postulated pool depth in two SGB and one RSB cell shall be examined ultrasonically in accordance with Article 5, "Ultrasonic Examination" of the ASME Code, Section V, to determine the reference plate thickness to be used in the monitoring of the catch pan plate corrosion. Areas to be selected in the test cells include:

a. Four (4) locations on the floor near the corners of the cell.

b. One (1) location on the wall below the postulated sodium pool level.

5.0.3 Metal Deck

The side lap welding of the adjacent metal deck units shall be visually inspected as per Article IX-2370 "Visual Examination" in Appendix IX "Nondestructive Examination Method" of the ASME code, Section III, Division 2 requirements.

The catch pan system is part of the Sodium Fire Protection System (SFPS) which provides a passive fire suppression system for sodium fires in air filled cells. The overall Sodium Fire Protection System is described in Section 9.13.2.2.

The catch pan - fire suppression system is an Engineered Safety Feature located in non-radioactive Na and NaK cells. It's purpose is to prevent sodium-concrete reactions between the liquid metal pool and concrete following an accidental spill, to reduce pool burning, to limit the temperature imposed on the structural concrete, and to limit the amount of sodium aerosols generated during a sodium-NaK spill accident.

3A.9.1 Design Description

3A.9.1.1 Catch Pan Types

There are two basic types of catch pans located in the air filled cells:

1) Catch Pans with Fire Suppression Deck - This catch pan type is located in ~~potential~~ sodium-NaK ~~spill~~ cells where the consequences of unmitigated sodium-NaK burning would have a significant impact on the structures or safety related systems. In these areas the liquid ~~sodium~~ metal forms a pool in the catch pan below a fire suppression deck. The fire suppresion deck is designed to limit the oxygen supply available to the ~~sodium~~ liquid metal pool for the continued burning of the ~~sodium.~~ ~~The sodium-NaK pool fire is extinguished when the oxygen in the space between catch pan and fire suppresion deck is depleted.~~ liquid metal. In this manner the consequences of ~~the sodium~~ a postulated liquid metal spill are mitigated.

2) Open Catch Pans - This catch pan type is located in ~~potential~~ sodium-NaK ~~spill~~ cells where the volume of ~~sodium~~ spill is small and full burning of the ~~sodium~~ liquid metal will not have significant effects on the structures or safety related equipment. The sodium is collected in open catch pans to prevent sodium-concrete reactions with the liquid metal pool.

   Open catch pans are also used in cells with substantial sodium leak volumes. In these cells, a pool is not allowed to form. The sodium collects in an open catch pan and drains, by gravity, through drain pipes or large openings in the catch pan into a catch pan cell equipped with a fire suppression deck. The flow can be lateral or vertical.

   One exception is Cell 211A which drains into Cell 211 which does not have a fire suppression deck. Both cells have a common atmosphere and contain the Ex-Containment Primary Sodium Storage Tanks and associated ~~System 01~~ piping. These cells are inerted prior to the introduction of sodium.

Further descriptions and catch pan arrangements are presented in PSAR Section 9.13.2.2. Figures 9.13-3 and 9.13-4 present typical arrangements of the two catch pan types described above.

Catch pans are located in the non-radioactive Na/NaK cells of the Steam Ganerator and Reactor Service Buildings. Table 9.13-10 of Section 9.13 lists the RSB and SGB cells having each type of catch pan. The configuration of these cells is shown in PSAR Section 1.2.

3A.9.1.2 Structural Features

3A.9.1.2.1 Catch Pan with Fire Suppression Deck

The components of a Catch Pan with Fire Suppression Deck are shown on Figure 3A.9-1 and consist of the following:

1) Catch Pan

2) Fire Suppression Deck and Structural Support Beams and Columns

3) Fire Suppresion Deck Drains

4) Fire Suppression Deck Vents

5) Insulation

6) Catch Pan Lip Plate

3A.9.1.2.1.1 Catch Pan - The Catch Pan consists of 3/8 inch thick carbon steel plate constructed using full penetration welds and forming a leak tight boundary to catch and contain a potential sodium-NaK spill.

In general, the catch pan is "floating", i.e., it is allowed free thermal expansion to minimize thermal stresses. Gaps are provided between the concrete structures and the catch pan side walls to permit the thermal expansion of the catch pan. Around embedments, penetrations, fire suppression deck support columns or other elements attached directly to the concrete structure, a vertical sidewall catch pan plate is provided to permit the free floating catch pan to expand or translate relative to the fixed embedment location without imposing additional load on the catch pan (Figure 3A.9-1).

3A.9.1.2.1.2 Fire Suppression Deck and Structural Supports - The Fire Suppression System consists of standard metal deck panels, 4-1/2 inches deep, supported on steel framing composed of wide flange beams. The steel framing is supported above the catch pan plate by stub columns with base plates anchored directly to the concrete floor slab. At the perimeter of the catch pan cell, the support beams are attached to steel brackets anchored to the concrete walls. The deck and beam structural connections are designed to allow for thermal expansion thereby minimizing thermal stresses.

ided as a walkway for maintenance access. The steel grating is not a part of the catch pan system and does not have a fire suppression function. It is supported by the fire suppression deck support framing.

A steel grating is located above the fire suppression deck and

3A.9.1.2.1.3 Fire Suppression Deck Drains - As liquid sodium spills onto the fire suppression deck it flows through small diameter drain pipes in the fire suppression deck and into the catch pan. These carbon steel drain pipes are welded to the deck and extended downward to a point 1/2 inch nominal above the catch pan. The drain pipes are spaced to form a uniform array over the catch pan. As the liquid sodium drains into the catch pans, the level of Na in the drain pipe rises, thus limiting the effective surface burning area of the resulting liquid metal pool to the cross sectional area of the drain pipes. Burning is terminated when following the Na spill the drain pipes become plugged with combustion products and air is prevented from reaching the liquid metal surface within the pipes.

3A.9.1.2.1.4 Fire Suppression Deck Vent Pipes - Vent pipes are also welded to the fire suppression deck, ~~and extend above the top surface of the deck.~~ They are provided to vent hot gases from the region below the deck to the cell atmosphere to prevent the buildup of pressure below the fire suppression deck.

3A.9.1.2.1.5 Insulation - Insulation is provided under the catch pan floor and alongside the catch pan walls to protect the reinforced concrete structure from excessive temperature.

Below the catch pan a granular insulation material (MgO) is used in varying thickness to limit the floor slab concrete temperature and to provide a vent path for the water vapor released by the heating of the structural concrete. A blanket ~~of~~ type insulation (~~calcium~~ Aluminum silicate or the equivalent) is attached to the reinforced concrete walls behind the side wall of the catch pan. A gap between the insulation and the catch pan side wall permits the free thermal expansion of the catch pan.

3A.9.1.2.1.6 Catch Pan Lip Plate - To prevent liquid sodium from falling into the gap between the building concrete walls and the catch pan side walls, a continuous steel lip plate is provided along the perimeter of the catch pan. The steel lip plate is welded to a plate embedded in the concrete wall and covers the gap between concrete and steel walls. Lip plates are also provided to cover gaps between catch pan and embedments or penetrations anchored in the concrete floor slab.

3A.9.1.2.2 Open Catch Pans

The open catch pans are similar to the catch pans decribed in Section 3A.9.1.2.1 except that they do not utilize a fire suppression deck. Open catch pans utilize insulation under the catch pan floor but not along the side walls. There is no substantial buildup of ~~sodium burning~~ in open catch pans since they are used where either the volume of liquid metal the spill is small or

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the liquid sodium can be conducted through drains into catch pans with a fire suppression deck. In open catch pans with drains, the catch pan floor is sloped toward the drains to facilitate draining. A minimum slope of 1/8 to 1/4 inch per foot is used except for cells 244, 245 and 246 where the slope is 1/10"/foot. The open catch pan drains in most cells are vertical. However horizontal drains (scuppers) are used in regions where vertical draining is not possible due to the arrangement of the catch pan cells. In a limited number of cells located above cells equipped with fire suppression decks, the sodium flows to the catch pan below through large lined openings passing through the floor slab. Some open catch pans are equipped with a grating to facilitate access for equipment maintenance.

3A.9.2 Design Evaluation

3A.9.2.1 Sodium Spill Evaluation

An evaluation of the consequences of a sodium/NaK spill is provided in PSAR Section 15.6.1.5. The methods and criteria used for the evaluation of the catch pan system are discussed in PSAR Appendix 3.8-C.

3A.9.2.2 Catch Pan System Analysis and Design

The catch pan system is described in Sections 3A.9.1 and 9.13.2.2. The Design Requirements, Load Categories, Load Combinations, Stress and Strain Allowables, and Design Analysis procedures are given in PSAR Appendix 3.8-C. Attachment D to Appendix 3.8-C gives the basis for the strain criteria and strain limits adopted for the cell liner system and utilized for the catch pan system under sodium spill accident conditions.

The catch pan plate has been designed for the loads and temperatures specified in Section 3.8-C, Attachment A. The catch pan is designed as a free floating basin to collect DBA sodium/NaK spills. The catch pan is free to expand under the thermal loading of a DBA sodium spill thus minimizing the induced thermal stresses. The major stresses in the catch pan are generated by the hydrostatic pressure of the sodium/NaK pool including the dynamic effects during an earthquake. The hydrostatic seismic effects were calculated using Housner's theory (TID-7024; Nuclear Reactors and Earthquakes by T. H. Thomas et al. USAEC, August 1963). The reduced strength of the catch pan plate due to sodium spill temperature conditions has been included based on Reference (6) of Section 3A.8.

The fire suppression deck and fire suppression deck framing support structure have been designed based upon typical panels and using beam theory. Seismic effects were considered based upon the applicable floor response spectra by using the appropriate seismic accelerations. The reduction in steel strength with temperature was considered in determining the allowable stresses.

The catch pan is supported on granular insulation.

The primary function of the insulation is to provide a thermal barrier to prevent the degradation of the structural concrete slab supporting the catch pan under DBA sodium spill conditions. The insulation also provides a uniform support for the catch pan plate while providing a vent path, through the voids in the granular matrix, for the release of water vapor generated during the heatup of the structural concrete.

Insulation is also provided, in some cases, along the perimeter of the catch pan to provide a thermal barrier to protect the structural concrete near the sodium pool. The insulation is attached to the structural concrete and separated from the catch pan plate by an air gap to permit the unrestrained growth of the floating catch pan.

3A.9.3 Testing

For testing program see PSAR Section 1.5.2.8.

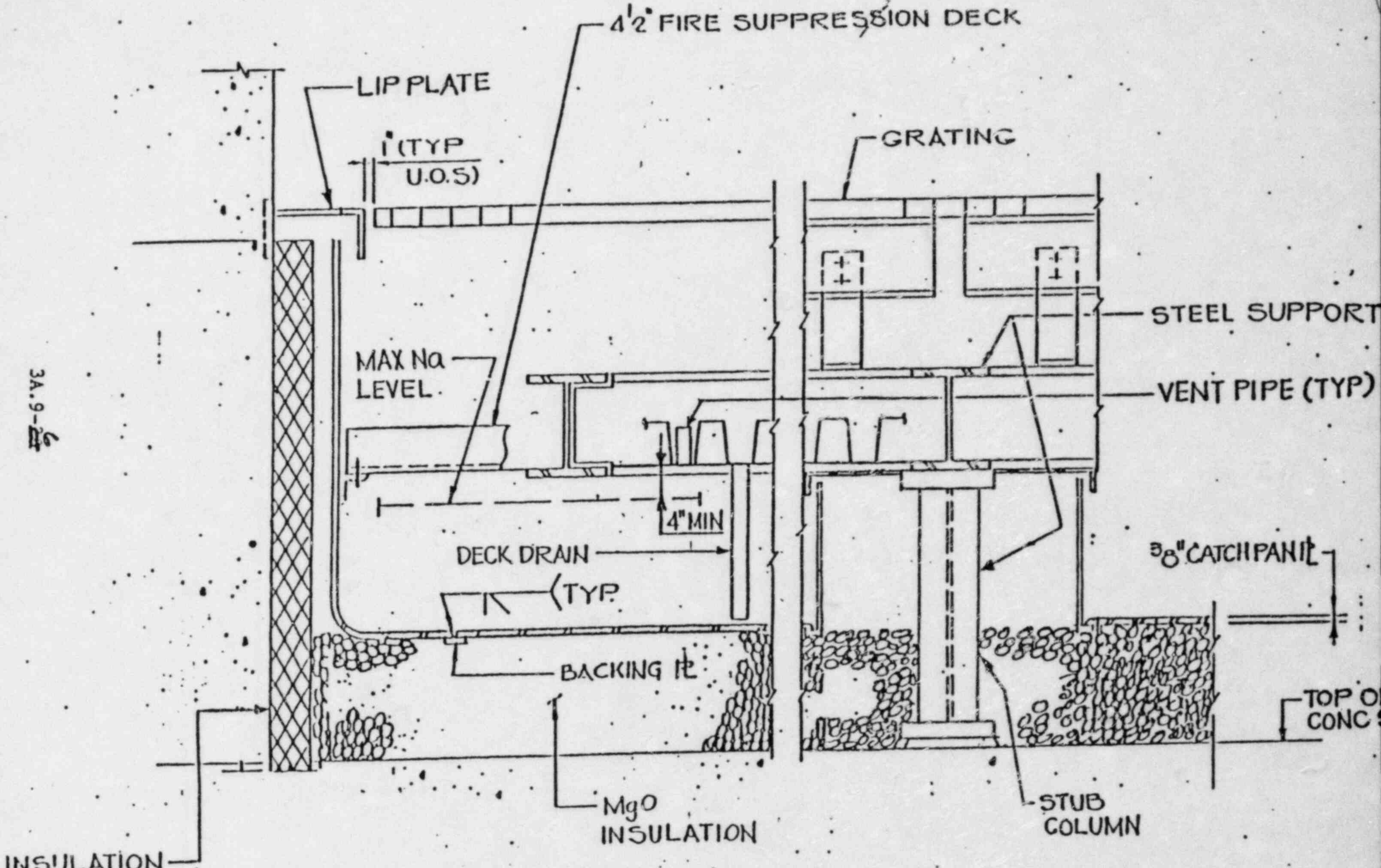
4½" FIRE SUPPRESSION DECK
LIP PLATE
1" (TYP U.O.S)
GRATING
STEEL SUPPORT
MAX Na LEVEL
VENT PIPE (TYP)
4" MIN
DECK DRAIN
(TYP.
3/8" CATCH PAN PL
BACKING PL
TOP OF CONC
MgO INSULATION
STUB COLUMN
INSULATION

FIGURE 3A.9-1

The system provides the capability to maintain the oxygen content
44 of the sodium in the EVST at, or below, 5 ppm. The cold trap used for this
44 service is separate from those used for reactor and primary loop sodium
purification. ←

INSERT A →

The system, working in conjunction with the Primary Sodium Storage
44 and Processing System described in Section 9.3-2, provides a means of remov-
44 ing reactor decay heat in the event of loss of normal heat removal paths.
These two systems, operating together, provide the Direct Heat Removal
Service (DHRS). The DHRS is sized to limit the average bulk primary
sodium temperature to approximately 1140°F when the DHRS is initiated one-
half hour after reactor shutdown. Under this condition, all primary pump
pony motors are assumed operational. When the DHRS is initiated twenty-four
hours after shutdown, the average bulk primary sodium temperature is main-
tained below 900°F, assuming operation of a single primary pump pony motor.
59 Total heat rejection capability of the EVS Sodium Processing System is based
on removal of the required reactor decay heat in addition to the heat generated
by spent fuel within the EVST. The maximum simultaneous EVST and reactor decay
heat load is approximately 11-1/2 MW, with DHRS initiated one-half hour after
26 reactor shutdown.

9.1.3.1.2 Design Description

The EVST design and operating decay heat loads and sodium
coolant outlet temperatures are given in Table 9.1-1.

The major assemblies of the EVST important to decay heat removal,
other than the cooling system itself, are the storage vessel, the guard
44 tank and the internals. The internals, specifically the turntable, separate
and support the spent fuel assemblies (contained in sodium-filled CCP's)
permitting them to be satisfactorily cooled. The structural design of the
44 turntable has already been discussed in 9.1.2.1.

59 The storage vessel has been classified as Safety Class 2 and is
be designed, fabricated and inspected in conformance with the appropriate
codes and standards (see Section 3.2) to provide a leak-proof containment
for the sodium coolant. The sodium level is maintained at a high enough
elevation so that normal fluctuations due to changes in temperature or
number of stored components do not uncover the top of the CCP's in which
the spent fuel is stored. During off-normal conditions, such as a leak or
rupture in either the vessel or the cooling system, the vessel sodium out-
side the CCP's cannot fall below the minimum safe level. This level is
defined as that below which fuel cladding temperatures would exceed the
44 limits specified in Table 9.1-2 for the fuel assembly stored at the highest
possible location within the storage vessel. The sodium nozzles in the ves-
sel are located in the upper elevations of the vessel wall (see Figure 9.1-6).
The EVST sodium inlet lines contain antisyphon devices which prevent a
44 cooling system leak from lowering the vessel sodium below the minimum
safe level.

Their removal and storage procedures would be the same (see Section 9.3.2.2.1); however, the EVS cold trap is expected to last for the life of the plant and would not be removed unless there were a serious malfunction.

PSAR, SECTION 9.1.3.1.1, page 9.1-21

INSERT A

Liquid metal NaK is used as the secondary coolant in each of the 3 EVS cooling loops. It has been used extensively in other plants (SER, EBR-I, EBR-II, SRE, Fermi, Hallam, and FFTF) and there are no reports of any inherent problems with it. Oxygen in the EVS NaK cooling loops initially or entering the system later is removed by diffusion type cold traps (one on each loop). These are simple appendages on the NaK piping that are maintained at a lower temperature by forced air circulation. The temperature gradient and precipitation of impurity (primarily sodium oxide) establishes a concentration gradient which is the driving force for the transport of the impurity into the cold trap. EACH OF THE DIFFUSION COLD TRAPS ARE SIZED TO STORE MORE THAN FOUR TIMES THE MAXIMUM VOLUME OF ANTICIPATED IMPURITIES TO BE COLLECTED.

to each of the normal EVST cooling loops. The DHRS NaK expansion tank is isolated and the EVST NaK pump is increased to 400 gpm each. The cover gas space in the two EVST NaK expansion tanks is cross-connected to equalize tank NaK levels.

9.1.3.1.3 Safety Evaluation

The EVST cooling capability can be provided by either of two identical, forced convection cooling circuits, each of which can remove 1800 kW while maintaining a maximum EVST sodium outlet temperature of ~510°F.

In the extremely unlikely event that the normal circuits are unavailable, heat will be removed through a third independent (backup) natural convection cooling circuit. At 1800 kW this backup cooling circuit will maintain sodium temperatures within the EVST below 775°F.

The critical temperature in a fuel assembly, from the standpoint of safety, is the peak fuel cladding temperature. The normal and emergency limits are given in Table 9.1-2.

The peak fuel cladding temperature is approximately 100°F greater than the sodium outlet temperature shown in Table 9.1-1. Hence, no damage to the stored fuel assemblies will occur.

The codes and standards to which the EVST vessel and the surrounding guard-tank are designed and fabricated assure that leakage of sodium will be a very low probability event. At the minimum level, adequate cooling is maintained with no temperature inceases from those shown in Table 9.1-1.

INSERT B, p. 9.1-26.1

Each of the three sodium cooling loops is designed against the possibility of common-mode failure. Two pump suction lines are provided within the EVST for normal sodium circuit No. 2. The open end elevation of each is different, one high, one low. Each of the two lines is separately valved externally to the EVST. After the initial fill of the loop, the isolation valve in the low suction line is locked closed and remains closed (except for periodic testing) throughout the plant life. This low suction line is used only in the event of a major loop or vessel rupture. One pump suction line is provided within the EVST for normal cooling circuit No. 1. The open end elevation of this line is between those for circuit No. 2. This line is valved externally to the EVST, and is called a "high" pump suction line. During normal system operation, one of the normal cooling loops is operated using the "high" pump suction line. The suction line(s) in the standby normal loops are closed. In the event of a major failure (rupture) of the operating normal sodium cooling loop, the isolation valve in the pump suction line is closed by operator action from the control room, signalled by concurrent alarms, indicating low level

INSERT B

The EVS Processing System components are designed to accepted industrial and nuclear standards to insure stuctural integrity and operational reliability. The components, applicable design code and class, plus their seismic category are listed in Table 9.3-1. Design temperatures and pressures are given in Table 9.3-7.

EACH NORMAL COOLING LOOP RETURN LINE ANTISIPHON VENT IS LOCATED JUST BELOW THE NORMAL EVST SODIUM LEVEL. IN THE EVENT OF A PIPING LEAK A SMALL DROP IN EVST SODIUM LEVEL WILL EXPOSE THIS VENT WHICH WILL INGEST EVST ARGON COVER GAS AND BREAK THE SIPHON. THIS WILL PREVENT UNCOVERING AN EVST SUCTION LINE AND PERMIT EVST COOLING TO C...

in the EVST and a sodium leak within the cooling loop cell. If the isolation valve should not be closed the EVST sodium level could only be siphoned
44 to the (high) pump suction outlet within the tank. Siphoning from the return line is prevented by an antisiphon vent in this line within the EVST.
44 If a failure of normal cooling loop occurs, as described previously, the standby normal cooling circuit can be immediately activated, by valving in
44 its lower pump suction and increasing pump flow to the design rate of 400 gpm. A LEAK ANYWHERE IN THE EVS COOLING SYSTEM OR THE EVST CANNOT DISABLE MORE THAN ONE OF THREE COOLING LOOPS. SEE FIGURE 9.1-12A

In the extremely unlikely event that the second normal loop cannot be activated after the first loop has experienced a failure, the third (backup) circuit will be brought into operation. One suction line is provided within the EVST for the backup cooling circuit. The open end elevation of this suction line is below the lower suction line of normal cooling circuit No. 2. Flow back to the EVST is through the fill/drain line.
44 Siphoning from this return line is prevented because the entire backup loop is elevated above the sodium level in the EVST.

Failure of any component, in any of the sodium or NaK loops,
44 can cause loss of only the circuit in which it is located. The normal standby or backup cooling circuit can then be put into operation within minutes to provide essentially continuous cooling of the EVST sodium. The potential radiological consequences of an extremely unlikely release of
44 59 EVST sodium to an inerted cell is described in Section 15.

All components of the normal sodium and NaK loops which require electrical power are on the Class IE power system, to ensure continuous EVST cooling and reactor decay heat removal. In the event of complete loss of external power to the plant, power to both of the normal cooling circuits
44 is provided by the plant diesels. Immediate activation of the diesel-powered supply is not necessary for the EVST sodium pumps since the sodium volume within the EVST provides a heat sink to minimize sodium temperature rise during loss of circulation. Sodium circulation can be lost for approxi-
44 mately 2 hours before the maximum sodium temperature in the upper portion of
59 the EVST reaches 600°F. Activation of the emergency power supply to the NaK pumps and airblast fans is required within ½ hour, however, to ensure the availability of DHRS for reactor decay heat removal.

44

The only "active" component in the backup loop is the damper on the
26 natural draft heat exchanger. It is operated manually and, therefore, does not require connection to the emergency power system

44

Isolation of all of the cooling circuits (sodium plus the associated NaK loop) in separately shielded, inerted cells precludes both radioactive sodium fire and the possibility of any failure in one loop impairing the operability of the other.

Amend. 59
Dec. 1980

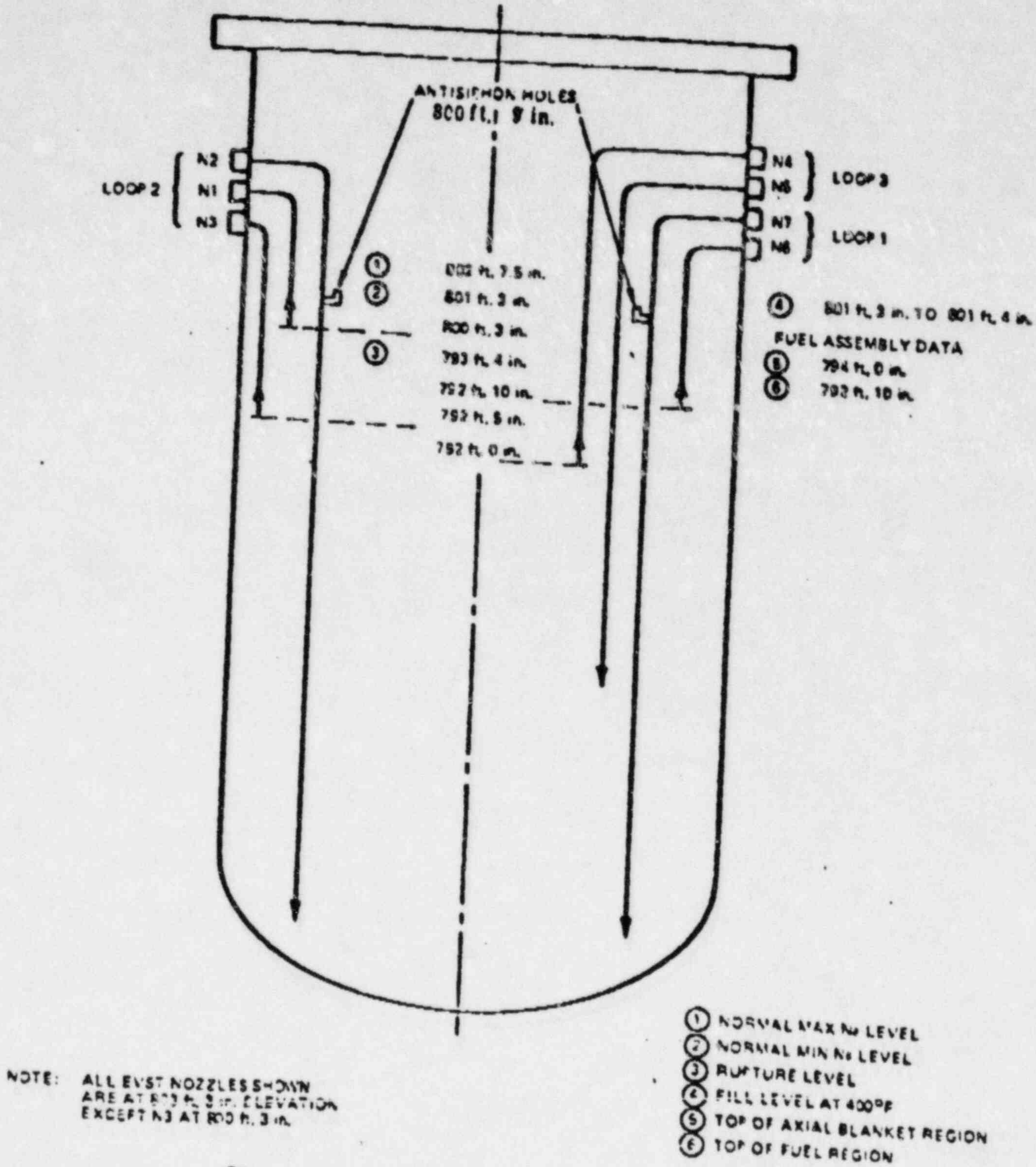

Figure 9.1-12A EVST Sodium and Nozzle Elevations

⑥

9.3.1 Sodium and NaK Receiving System

9.3.1.1 Design Basis

This system provides the capability to receive and melt fresh, solidified sodium, delivered to the site in tank cars or drums, and transfer the sodium to primary and intermediate storage vessels. System capacity is based on meltout and drain of an 80,000-lb capacity tank car in 16 hours.

The system receives and transfers to storage all NaK used in the plant.

All fresh sodium and NaK will be filtered prior to storage. Components used for sodium transfer will not be used for NaK transfer. The system also provides the capability to remove sodium and NaK from plant systems for off-site disposal.

9.3.1.2 Design Description

This system consists of a tank car oil heating station for meltout of sodium tank cars, a clam shell heater for melting drums of sodium, transfer piping and valves, and filters for cleanup of fresh sodium or NaK. The piping and filters for the NaK are on a portable rig, and independent of the sodium system. Both systems are shown on Figure 9.3-1. Transfer of sodium and NaK to system storage vessels is by gravity flow.

9.3.1.3 Design Evaluation

The Sodium and NaK Receiving System components are designed to accepted industrial and nuclear standards to insure structural integrity and operational reliability. The components, applicable design code and class, plus their seismic category are listed in Table 9.3-1.

All liquid metal piping, valves, and filters of the sodium and NaK Receiving System are construction from Type 304 stainless steel.

The design temperatures for the sodium and NaK components are 450°F and 150°F, respectively. The design pressure for both sodium and NaK components of the receiving station is full vacuum to 20 psig.

Prior to receiving sodium on site, appropriate or necessary emergency planning with local officials will be taken to consider an outside fire during loading.

61 The system is monitored for external leaks of liquid metal by leak detection devices. will be

This system for handling the incoming fresh sodium and NaK does not present any radiological hazards, nor is it involved in any way with reactor safety. Portable sodium carbonate fire extinguishers and personnel protective equipment is provided by the Sodium Fire Protection System for protection against potential sodium or NaK fires that can occur during loading and unloading operations. The cells containing system storage vessels are equipped with permanently installed fire protection equipment as described in Section 9.13.2. 2

9.3.1.4 Tests and Inspection

Prior to use, leak checks will be made and instrumentation and preheat capability will be checked according to specific procedures. The system filters will be tested to assure that no blockage exists.

9.3.1.5 Instrumentation Requirements

Instrumentation and controls (I&C) are provided for operation, performance evaluation and diagnosis of the Sodium and NaK Receiving System. These functions are required for off-normal, as well as for the full range of normal operation. Details of the I&C for the Na and NaK receiving system are shown in Figure 9.3-1.

58 | 46 | Temperatures and the tank car sodium level are measured to monitor system status during operation. Leak detection sensors are strategically located to alert the operator of a break in the system in order that correction action may be taken. Table 9.3-4 indicates planned location of leak detection sensors.

No automatic control instrumentation is required for this subsystem as all operations are manual. This subsystem is non-nuclear and operated at peak temperatures of $\sim 400^{\circ}F$. Therefore, commercial grade instrumentation is adequate to monitor subsystem performance. After initial transfer of sodium and NaK into the plant, the system will be inactive at ambient temperature except during actual transfer operations. 1

9.3.2 Primary Na Storage and Processing

9.3.2.1 Design Basis

This system provides primary sodium purification (cold trapping), provides storage for the sodium used in the reactor vessel, the PHTS loops, and the EVST, mitigates the change in reactor vessel sodium level and accommodates thermal expansion and contraction of primary sodium. This system, working in conjunction with the EVS Sodium Processing System, also provides a means of removing reactor decay heat in the event of loss of all the steam generators.

Amend. ~~60~~ 59
DEC. 1982

Precautions will be taken during liquid metal loading conditions to limit effects to plant components prior to plant operation.

8

Specific system design basis are as follows:

a. Primary sodium purification - limit the oxygen content to 2.0 gpm and the hydrogen content to 0.2 gpm, and maintain the tritium content within limits which will satisfy plant radiological release criteria.

b. Primary sodium storage - provide on-site storage capacity sufficient to permit anticipated maintenance on plant systems. Total storage capacity is provided to permit complete drainage of the reactor vessel and loop piping to the first high point. This capacity will accommodate the above, the 3 PHTS Loops or the EVST, but not simultaneously.

c. Reactor level control - provide the capability during all plant operating conditions to maintain the reactor vessel sodium level below the reactor head reflector plate.

d. Primary sodium expansion - accommodate thermal expansion of primary sodium from 400°F to PHTS structural design temperatures of 1015°F hot leg and 765°F cold leg.

e. Reactor decay heat removal - system sizing is based on limiting the average bulk primary sodium temperature to approximately 1140°F when the DHRS is initiated one-half hour after reactor shutdown. ~~with all primary pump pony motors operational~~. With DHRS initiated twenty-four hours after reactor shutdown, system size will maintain the average bulk primary sodium temperature below 900°F. ~~with one primary pump pony motor operating~~.

9.3.2.2 Design Description

The Primary Sodium Storage and Processing System consists of the following components:

a. Primary Sodium Overflow Vessel

b. Primary Sodium Makeup Pumps (2)

c. In-Containment Primary Sodium Storage Vessel

d. Ex-Containment Primary Sodium Storage Vessels (2)

e. Primary Sodium Cold Traps (2)

f. Makeup Pump Drain Vessel

g. Interconnecting Piping and Valves

h. Primary Sodium Overflow Heat Exchanger

pump maintenance can be accomplished after shutdown and isolation of the failed pump from the system. The pump is drained, the cell atmosphere changed to air, and the necessary precautions taken with respect to radioactivity, to allow pump repair.

Two liquid-cooled sodium cold traps, arranged in parallel, are included in a bypass on the reactor makeup return line to provide sodium purification. Each trap is rated at 60 gpm at normal system operating temperature, and at 80 gpm and 600°F (reactor hot standby temperature). During normal plant operation, one trap is in use and the second is in standby. Although both traps can be operated, a single trap is sufficient to remove anticipated oxygen inleakage and maintain the oxygen content below 2 ppm.

46 The concentration of tritium in the primary sodium is also maintained at a low level by cold trap operation. Operation of one primary cold trap, combined with the tritium diffusion through the IHX to the intermediate system maintains
46 the tritium content of the primary sodium at less than 3 μCi T/gm Na.

During a shutdown for fuel handling, both cold traps may be operated, if necessary, to provide a maximum cleanup flow of 160 gpm. The total capacity is designed to provide for removal of potential oxygen inleakage during fuel handling rapidly enough so that no additional plant downtime (over and above
46 that required for fuel handling and normal startup) is required. Flow to the trap(s) is controlled by throttle valves in the outlet from each trap. Electromagnetic flow meters are provided to monitor flow through each pump and each cold trap.

System arrangement also permits independent cold trapping of sodium in the overflow vessel or in the in-containment primary sodium storage vessel during shutdown situations, when makeup to the reactor is not required. The makeup pumps, which can also take suction from these vessels, are used for these operations.

b. Circuit Operation During Reactor Decay Heat Removal - The overflow and makeup circuit is designed to provide reactor decay heat removal in the event of loss of all the steam generators in the intermediate heat transfer system. Operation during this mode is referred to as the Direct Heat Removal Service (DHRS). Switchover to this mode of operation is accomplished remotely from the control room.

DHRS components are subjected, during plant service, to numerous reactor scrams. During a scram, primary sodium temperature decreases. The resultant contraction of coolant lowers the sodium level within the reactor, and the sodium overflow is interrupted. The makeup pumps continue to operate, transferring sodium in the overflow vessel back to the reactor vessel until the sodium overflow resumes at a lower temperature - approximately 600°F.

The primary cold trap lifetime is estimated to be 13 years. This trap will be too radioactive to permit hands-on maintenance. However, steel shielding has been provided around this trap to expedite the replacement operations. The procedure for primary cold trap replacement is as follows. Partially drain the sodium and NaK while maintaining a temperature of 300-400°F, remove all heater power and allow the remaining sodium to freeze, cut and cap weld the sodium and NaK lines, cut the electrical leads, unbolt the supports, pull the trap by crane from the cell, and place it in storage provided in the plant.

Table 9.3-7

DESIGN TEMPERATURES AND PRESSURES*

Na and NaK Receiving System

Sodium Piping and Fresh Sodium Filters	450°F, 20 psig
NaK Piping and Fresh NaK Filters	150°F, 20 psig

Primary Na Storage and Processing System

Overflow Vessel	900°F, 15 psig
Makeup Pumps, Cold-Trap	900°F, 100 psig
Overflow Heat Exchanger	650°F, 100 psig
IC Vessel, Makeup Pump Drain Vessel	650°F, 50 psig
EC Vessel	450°F, 50 psig
Piping PHTS Drain from 51A/81 Interface to "Spec. Change"	1015°F, 200 psig
PHTS Drain From "Spec. Change" to Second Isolation Valve	650°F, 200 psig
Overflow Line and Makeup Pump Suction Line - from OV to isolation Valves on Pump Suction Line	900°F, 15 psig
Balance of Makeup Circuit	900°F, 100 psig
All Other Piping	650°F, 100 psig

EVS Processing System

Cold Trap (including piping thereof)	700°F, 100 psig
EVST Backup Sodium Cooler Piping	800°F, 100 psig
EVST NaK Storage Vessel	150°F, 50 psig
NaK Drain Piping from Loop Isolation Valve to Storage Vessel	150°F, 100 psig
All Other Components and Piping	650°F, 100 psig

Primary Cold Trap NaK Cooling System

All Components	650°F, 100 psig

Intermediate Sodium Processing System

Cold Trap Economizer and Pumps	775°F, 225 psig
Cold Trap Crystallizer and Connecting Piping	750°F, 225 psig
Piping, Normally Operating Cold Trap Circuit (incl. stand by trap and drain lines to first isolation valve)	775°F, 225 psig
Between IHTS Loops and First Isolation Valve	775°F, 325 psig
All Other Drain Piping	700°F, 100 psig

*All System 81 components designed for full vacuum at 450°F

Inadvertent sodium transfer between the EVST sodium cooling loops and the sodium storage vessels is prevented by two normally closed isolation valves in series between the storage vessel and each fill and drain connection to the cooling loops, as shown in Figure 9.3-3.

Inadvertent transfer of sodium to and from the EVST itself, via its drain line (from the bottom of the backup sodium cooler), is prevented by a flanged spool piece in the drain line. Once the EVST is filled, the spool piece is removed and the remaining pipe ends sealed by flanges, to prevent accidental drainage. The removed section is physically located high enough so that any sodium leak at the flanged joint cannot drain the EVST below a level which would interfere with the cooling system.

9.3.2.3 Design Evaluation

The system components are designed to accepted industrial and nuclear standards to insure structural integrity and operational reliability. The components, applicable design code and class, plus their seismic category are listed in Table 9.3-1. Design temperatures and pressures are given in Table 9.3-7.

All parts of the system are monitored by leak detection devices, with alarms for detection of external leakage from piping and components. The

instrumentation also will determine the occurrance of internal leakage from one part of the system to another, and alert the operator so the systems can be shut down for maintenance or repair.

Those cells which house the Primary Sodium Processing System will be inerted during system operation and during all periods while a potential Na spill could otherwise result in potential off-site radiological release excess of 10CFR20 limits.

The Primary Sodium Storage and Processing System is connected to the reactor by the overflow and the makeup return lines. The nozzles for these lines are located near the top of the reactor; so that, in the extremely unlikely event of a line failure, there would be very little sodium lost from the reactor, and reactor cooling would not be affected.

35 All of the system except for the ex-containment storage vessels are located in the RCB, in cells which provide shielding, an inerted atmosphere, and tornado protection.

When it is necessary to store sodium from the Primary Heat Transport System in the ex-containment vessels, it is radioactively decayed for approximately 10 days before it is transferred to the ex-containment vessels.

All components of the overflow and makeup circuit (which may be required for removal of reactor decay heat) are designed as Seismic Class I components. The makeup pumps are connected to the emergency power supply in order to insure operation during decay heat removal.

The worst in-containment accident (or the in-containment primary sodium storage tank) that can be postulated for this system is rupture of the overflow vessel, which could dump ~~~32,000~~ 35,000 gal. of primary sodium into the cell. This accident is discussed in Section ~~15.6.1.1~~ 6.2.1.3.

The possible plugging of the overflow line is not considered a credible event, because it is an 8in. and 6 in. line, normally flowing at
46 150 gpm, with the line sloped to the overflow vessel at 1/2 to 3/4 in./ft. The sodium is maintained at a low oxygen content (2ppm or less) which, combined with the high temperature, keeps oxides from building up in the line. If somehow the line were plugged, the reactor sodium level would slowly rise, until highlevel alarms initiated operator action to shut down the plant. Shutdown lowers the reactor sodium level, and no safety aspects are involved.

9.3.2.3.1 Analysis of Loss of Cold Trap Cooling

In the event cooling is interrupted on the PHTS cold trap and sodium flow continues, the sodium temperature in the crystallizer will rise rapidly and approach the inlet temperature, which will be up to 880°F. The consequence would be dissolution of the solid sodium-oxide (Na_2O) and solid sodium hydride (NaH). 36

Amend. 46
Aug. 1978

Dissolution of Na_2O and NaH

If the PHTS were clean (~2 ppm oxygen and ~0.2 ppm hydrogen) and the first cold trap were filled with Na_2O and NaH, the interruption of cooling on the cold trap without simultaneously cutting off sodium flow could cause a maximum release of oxygen and hydrogen to the system by dissolution. The hot sodium continuing to flow into the uncooled crystallizer would raise its temperature rapidly and cause the Na_2O and NaH to go back into solution.

The time available to take corrective action (e.g., to shut off sodium valves and flow into the cold trap) depends on the rate of dissolution.

Calculations were made of the time required to dissolve the entire contents of the first PHTS cold trap as a function of the sodium temperature in the crystallizer. Table 9.3-5 shows how this time changes significantly with temperature. It shows that there is some minimum temperature required for all of the Na_2O or NaH to be completely dissolved. Below this temperature, the system would reach saturation with Na_2O or NaH after a long time of recirculation through the trap, and the traps would contain a residue of solid Na_2O or NaH.

13

The first cold trap has been estimated to contain 13 v/o (volume percent Na_2O and 87 v/o N-H at end-of-life, which is after about ~~4.3~~ years of full-power operation. Table 9.3-5 shows that it would take 2.7 hours with 800°F sodium flowing at 60 gpm to redissolve all the Na_2O while it would take 7.4 hours to redissolve all the hydrogen. If the sodium were 450°F, it would take 138 hours to dissolve all the Na_2O, but only 25.4% of the NaH would be dissolved after a long time (theoretically approaching infinity).

Conclusion

There is on the order of at least an hour available to the operators to take corrective action following loss of cold trap cooling before enough oxide or hydride can be dissolved from the cold trap to raise their concentrations in the PHTS to saturation levels. Assuming that the sodium flow valves were closed within hours after loss of cooling, no potential for plugging any part of the PHTS would exist. Above 440°F (PHTS sodium temperature), the oxygen could not reach saturation even if all Na_2O were redissolved or flushed from the cold trap. Above 555°F, the hydrogen could not reach saturation even if all NaH were redissolved.

46 Safety related instrumentation will indicate and alarm a cold trap high temperature condition to the operators to assure remote manual
46 closure of the cold trap isolation valves. This will prevent dissolution of enough hydride or oxide to preclude safe cooldown to refueling conditions. Even assuming instrumentation failure and no operator action at all, the dissolved oxide and hydride will remain in solution in the coolant both during reactor operation and following shutdown to hot standby condition. Consequently, operation of the cold trap cooling system is not a safety function and the system should be considered a non-safety class. However, the primary cold traps are connected to the reactor coolant boundary through double automatic isolation valves.

36

of 160 pgm). The total maximum heat transferred from two traps is approx-
46 imately 270 kW. The NaK flow through each trap is regulated by a control valve and a temperature sensing element in each cold trap.

NaK volumetric changes in the system due to temperature variations are accommodated within the ~~EVS NaK expansion tank connected to the high point of the system.~~ primary cold trap NaK storage vessel.

A diffusion cold trap~~, located on the cold leg of the NaK loop between the NaK cooler and the NaK pump,~~ is provided for system cleanup (oxide removal). (See Figure 9.3-4)

The NaK loop is taken up to a near isothermal condition at 600°F and circulated for processing by the NaK diffusion cold trap during initial cleanup, following maintenance operations, or at any other time when maximum cleanup capability is required to reduce the impurities which may have accumulated in the loop. Heat is provided by the pump.

9.3.4.3 Design Evaluation

The Primary Cold Trap NaK Cooling System components are designed to accepted industrial and nuclear standards to insure structural integrity and operational reliability. The components, applicable design code and class, plus their seismic category are listed in Table 9.3-1. Design temperatures and pressures are given in Table 9.3-7.

The NaK Cold Trap Cooling System is a nonradioactive system. The failure of the system causes shutdown of the associated cold trap which would, after some period of time, require an orderly plant shutdown, but would create no safety problems. 1

The system is monitored by leak detection devices for both internal and external leaks with alarms to alert the operator to take corrective action.

The pressure of the NaK in the cold trap cooling system is maintained higher than that of the sodium in the primary cold traps in order to insure in-leakage of NaK rather than out-leakage of radioactive sodium. The NaK is compatible with the primary coolant and NaK inleakage will have no deleterious effect on reactor operation and safety. The immediate result of a NaK-to-sodium leak will be an abnormal decrease in both NaK level and cover gas pressure in the Na storage vessel. Both level and pressure are monitored and provided with high and low alarms for leak detection (high level indicates a Dowtherm-to-NaK leak). Due to a low reserve head in the tank, a large leak will stop due to loss of suction head, and this will also be detected by low flow alarms on system flow meters and high temperature alarms on the pump. Upon indication of a leak, the operating cold trap will be immediately isolated to minimize the NaK in-leakage. The cold trap will be solidified, removed, and replaced. The NaK storage vessel is a vertical vessel in order to maximize the change in NaK level for a given change in inventory, thus enhancing the capability of the level indicator and alarm to sense and detect relatively small leaks. A realistic estimate of NaK inleakage, prior to cold trap isolation, would be 25 gallons or less. A more accurate estimate will be made when system arrangement and component designs are finalized. 1

The system also provides the capability to (1) fill the IHTS loops from the sodium dump tanks (these tanks are part of the Steam Generator System), (2) purify sodium in the dump tanks, independently of the IHTS loops, and (3) permit transfer of sodium from one dump tank to another.

9.3.5.2 Design Description

The Intermediate Sodium Processing System provides purification of the sodium in each of the three IHTS loops. The System does not provide for storage of the IHTS sodium. This capability is provided by the sodium dump tanks, which are part of the Steam Generator System. The Intermediate Sodium Processing System does provide the capability of transferring sodium into the loops from the dump tanks. The same piping network allows the filling of each dump tank with fresh sodium from tank cars or drums at the sodium receiving station. Sodium removal from the tanks into tank cars can be accomplished through the same fill lines.

The system includes the following components:

a. Intermediate Sodium Cold Trap Pumps

b. Intermediate Sodium Cold Traps

c. Interconnecting Piping and Valves

Refer to Figure 9.3-5 for the P&ID and Figures 1.2-8 and 1.2-22 for layout and arrangement.

Each of the three IHTS loops is provided with a separate purification system consisting of a pump, two cold traps, and the necessary valves and piping. A single trap per IHTS loop is sufficient to remove antici-
pated oxygen and hydrogen inleakage and to limit these impurities to a
maximum of 2 and 0.2 ppm, respectively. In addition, the intermediate
50 cold traps maintain the tritium level in the intermediate sodium at 0.012
μCiT/gm Na by effectively trapping about 98% of the tritium which enters
the system by diffusion through the IHX. Most of the remaining tritium,
46 50 0.016 Ci/day, diffuses through the steam generators and enters the water
system. Cold trap flow is ~60 gpm at normal system operating temperatures.
The Intermediate Sodium Processing System is also connected to the sodium dump tanks such that the sodium in the dump tank may be processed by the system.

The intermediate sodium cold trap pumps are used to pump the
46 sodium from the dump tanks into the loops with a small, ~22 psig, cover gas pressure being maintained on the dump tanks. Sodium can also be transferred from one dump tank to another by gas pressure.

The IHTS cold trap lifetime is ~ 3.25 yr unless a regeneration process is adopted. The procedure for replacement of the crystallizer is to partially drain the sodium while maintaining a temperature of 300-400 °F, remove all heater power and allow the remaining sodium to freeze, cut and cap the sodium lines, cut the electrical leads, unbolt the supports, pull the crystallizer, and remove it by crane to storage.

9.3.5.3 Safety Evaluation

The Intermediate Sodium Processing System components are designed to accept industrial and nuclear standards to insure structural integrity and operational reliability. The components, applicable design code and class, plus their seismic category are listed in Table 9.3-1. Design temperatures and pressures are given in Table 9.3-7.

The system is monitored by leak detection devices, with alarm for detection of external leakage from piping and components.

The Intermediate Sodium Processing System is a nonradioactive system. A leakage failure in a purification circuit is considered the most significant event, because it ultimately causes loss of the IHTS loop to which it is connected. The loss of fluid would be signaled by the level indicators on the IHTS loop expansion tank, and operators could immediately isolate the purification circuit (remote controlled isolation valves). This event would cause loss of one IHTS loop because of the inability to maintain required purity levels, but the plant could continue to operate on the other two loops at a reduced power level. Power outage to all pumps, or loss of cooling to all cold traps, may cause plant shutdown, but would not constitute a safety problem.

9.3.5.4 Tests and Inspections

Leak checks will be made on the system prior to filling with sodium. Instrumentation and preheat capability will be checked prior to sodium fill, according to specific procedures. Following sodium fill, the system will be operationally tested.

9.3.5.5 Instrumentation Requirements

Instrumentation and controls (I&C) are provided for operation, performance evaluation, and diagnosis of the Intermediate Sodium Processing System. These functions are required for off-normal, as well as for the full range of normal operation. Details of the I&C for the subsystem are shown in the piping and instrumentation diagram, Figure 9.3-5. The following I&C is required to ensure safe operation of, and to prevent extensive damage to, the Intermediate Sodium Processing System.

Tempertures and loop flow measurements are provided for all systems to monitor their status. Critical temperatures and flows are alarmed to alert the operator to off-normal operations. All EM pumps are provided with winding temperature measurements and winding coolant low flow indication. These measurements are alarmed for the off-normal conditions, and interlocked to automatically shutdown the pump to prevent damaging it.

Differential pressure sensors and flow meters are provided to alert the operator to possible plugging of the cold traps or insufficient cold trap flow. All the bellows seal valves are provided with leak detectors, as indicated on Table 9.3-4. All valves are provided 47

TABLE 9.13-9

SPILL PARAMETERS

Cell	Cell No. ***	Max. Flow* Rate (gpm)	Total Postulated Spill Vol* (gal)	Potential Spill Vol.** (gal)
Reactor Service Building+				
3rd Loop NDHX	332	44	730	730
EVST NaK Storage Vessel	350	1	1500	1500
EVST Exp. Tank	352A	44	430	430
EVST Exp. Tank	353A	44	480	480
Pipeway	354	44	440	440
Pipeway	355	44	440	440
Steam Generator Building++				
Reaction Prod. Tank No. 1	207	1100	35200	35200
Reaction Prod. Tank No. 2	208	1100	28400	28400
Reaction Prod. Tank No. 3	209	1100	39600	39600
Ex. Cont. Na Storage Vessel	211	Tank Rupture		50000
Valve Gallery	211A	47	~~3480~~	~~60000~~ 50000
Steam Gen. Loop No. 1	224/244	1100	35200	35200
Steam Gen. Loop No. 2	225/245	1100	28400	28400
Steam Gen. Loop No. 3	226/246	1100	39600	39600
IB Pipe Cell Loop No. 1	227	1100	35200	35200
IB Pipe Cell Loop No. 2	228	1100	28400	28400
IB Pipe Cell Loop No. 3	230	1100	39600	39600
IHTS Shield Cell Loop No. 1	231	1100	26600	26600
IHTS Shield Cell Loop No. 3	232	1100	28800	28800
IHTS Pipe Chase Loop No. 2	248	1100	22100	22100
IHTS Pipe Chase Loop No. 1	251	1100	20200	20200
IHTS Pipe Chase Loop No. 3	252	1100	19800	19800

*Design basis leak
**Entire spillable volume from full flow piping leak
+NaK spill
++Sodium spill
***See General Arr[redacted]

accident analyses. Included in the basis and discussed in PSAR Section 11.1.5 is a design limit of 100 ppb (parts per billion) for plutonium content of the primary coolant.

2. Retention, fallout, platcout, and agglomeration of sodium aerosol in cells or buildings, whose design does not include specific safety features to accomplish that function are not accounted for in the analysis. Neglecting these factors (an assumption that all of the aerosol is available for release to the atmosphere) leads to over-prediction of potential off-site exposure.

3. No credit for non-safety related fire protection systems is taken.

4. Dispersion of aerosol released to the atmosphere was calculated utilizing the conservative atmosphere dilution factors (X/Q) applicable to discrete time intervals provided in Table 2.3-38 (the 95th Percentile Values). Guidance provided in NRC Regulatory Guide 1.145 was followed in calculating the X/Q values. Detailed descriptions of the atmospheric dilution factors estimates are provided in Section 2.3.4.

5. Fallout of the aerosol during transit downwind was neglected.

6. The cells will be structurally designed to maintain their integrity under the accident temperatures and pressures and the weight of the spilled sodium. For radiological calculations, no credit is taken for cell atmosphere leak tightness.

7. The cell liners, catch pans, and catch pan fire suppression decks are designated as Engineered Safety Features and will have design temperatures equal to or greater than the sodium spill temperature, thus confining the sodium spill.

8. ~~The design basis liquid metal spill for either~~ Both Inerted ~~&~~ and air filled cells ~~is defined as that spill~~ will be ~~are~~ design to accomod. liquid met. spills resulting from a leak in a sodium or NaK pipe/component in the cell producing the worst case spill/temperature condition. The leak is based on a Moderate Energy Fluid System break (1/4 x pipe diameter x pipe thickness) as defined in branch technical position MEB3-1 with the sodium or NaK system operating at its maximum normal operating temperature and pressure.

9. The only credit for operator action in mitigation of postulated sodium spills is shutdown of the Na overflow system makeup pumps 30 minutes after plant scram for a postulated leak in the Primary Heat Transport System (See Section 15.6.1.4).

10. The analysis of postulated liquid metal fires in air-filled cells does not include reaction of the liquid metal with postulated water released from concrete. The validity of this approach is presently being verified in conjunction with the large scale sodium fires test program discussed in Section 1.5.2.8 of the PSAR. If the test program does not support the present analysis approach, the appropriate effects of water release from concrete will be included in subsequent analyses.

Table 15.6-1 provides a summary of the initial conditions for each fire considered and the maximum off-site dose as a percentage of the 10CFR100 guideline limits. As the table indicates, a large margin exists between the potential off-site doses and 10CFR100. A discussion of the pressure/temperature transient for each event is provided in the following sections; in no case do the fires result in conditions beyond the design capability of the cell/building.

The Project is assessing the impacts of a design basis NaK spill in the Reactor Service Building and will provide the results ~~in the PSAR~~ when the assessments are completed. The aerosols released from the RSB as a result of a NaK spill will be controlled so as not to affect safety-related equipment.

15.6.1.3 Failure of an Ex-Containment Primary Sodium Storage Tank

15.6.1.3.1 Identification of Causes and Accident Description

The two ex-containment primary sodium storage tanks are located in a cell (cell 211) on the lowest level of the Intermediate Bay of the Steam Generator Building. These tanks will be used to store primary sodium only in the event maintenance requires the complete drainage of more than 1 PHTS loop or the EVST or maintenance is required in cell 102A. The postulated accident is the complete failure of one of the tanks, when full, which results in the complete spill of the contained sodium to the cell floor. This postulated accident is extremely unlikely.

When the ex-containment sodium tanks are full of liquid sodium, access to the tank cell is prohibited due to the sodium activity and the cell is closed and inerted (~2% O_2). The cell floor area is approximately 2400 ft^2 and the free volume of the cell is 55,700 ft^3. The floor of the cell is protected with a Engineered Safety Feature steel catch pan, 3/8 inch thick. The sides of the catch pan extend vertically upward to a height such that the maximum potential spill volume can be safely contained within the catch pan.

For conservatism, the postulated accident is assumed to occur near the end of plant life (30 years) when the radioactive content of the primary sodium has potentially reached its peak. A minimum of 10 days decay time, in-containment, is required prior to charging an ex-containment storage tank, to insure substantial decay of Na-24.

The postulated accident results in the spill of ~~45,000~~ 50,000 gallons (~~300,000~~ 333,000 lbs.) of 450°F sodium to the cell floor. This spill represents 100% of the contained volume of one of the two tanks and is an extremely conservative upper bound. The total postulated spill is contained by the catch pan.

15.6.1.3.2 Analysis of Effects and Consequences

The consequences of this postulated event were determined as follows:

a. The spilled sodium reacts with the available oxygen (2%) in the cell, burns and releases 27% of the Na_2O formed as airborne particles (Reference 3).

b. The radioisotope concentrations in the aerosol are the same as the initial concentrations in the sodium.

c. Radioactive decay during the accident is neglected.

d. No credit for retention, plate-out, or settling of the aerosol in either the ex-containment storage tank or the Steam Generator Building was taken. It was conservatively assumed for radiological evaluations that all the aerosol generated during combustion was released directly to the environment.

e. Fallout of the aerosol during transit downwind was neglected.

SOFIRE-II analysis of the fire in the inerted cell indicates that combustion

Enclosure 4

9.1 - 12 Comment

Provide additional justification why the Fuel Handling Cell cooling system and boundary are not safety related.

Response

Off-site doses from a combined argon cooling system failure and cooling grapple blower failure with a bare core assembly in the FHC are enveloped by the accident in PSAR Section 15.5.2.3 and the RSB fuel handling accident margin source term. Therefore safety related FHC equipment is not required to support the safety analysis of PSAR Chapter 15.

The RSB HVAC system described in PSAR 9.6.3 is designed to mitigate the consequences of an RSB fuel handling accident margin source term. This margin source term is a 20kw fuel assembly with a release of 100% of fission product inert gases, 100% of halogons, 1% of other fission products and 1% of Pu. The off-site doses from this fuel handling accident margin source term are:

Site Boundary Dose	0-2 hr
Whole Body	1.27 Rem
Thyroid	64 Rem
Lung	2.4 Rem
Bone	1.3 Rem
Low Population Zone Dose	0-30 day
Whole Body	.57 Rem
Thyroid	25 Rem
Lung	1.1 Rem
Bone	.81 Rem

On site doses from the above FHC accident have been evaluated to confirm that operator action can be taken in the RSB to further mitigate this accident and to operate other equipment.

For a 15kW bare assembly in the FHC, the RSB would have to be evacuated or breathing apparatus donned approximately 10 min after a loss of argon cooling system plus failure of the FHC cooling grapple blower. Dose to an operator with breathing

apparatus in the FHC gallery would be .43 Rem in the first hour, 1.2 Rem in the second hour and the dose rate will not exced 1.65 Rem/hr.

For a 6kW bare assembly in the FHC, the RSB would have to be evacuated or breathing apparatus donned approximately 30 min after a loss of the argon cooling system plus failure of the FHC cooling grapple blower. Dose rate to an operator with breathing apparatus in the FHC operating gallery will not exceed 1 mrem/hr.

Even upon the loss of offsite power, actions could be taken to return the fuel assembly to the core component pot by remote-manual operation of the FHC crane. The above dose rates will allow this effort to continue until the fuel assembly is in a core component pot where it can be left unattended.