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ENGINEERING DATA TRANSMITTAL

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Approval Designator (F)		Reason for Transmittal (G)			Disposition (H) & (I)				
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RELEASE AUTHORIZATION

Document Number: WHC-SD-FF-SSP-053, Rev. 0

Document Title: Early Secondary Sodium Drain Assessment

Release Date: ~~9/2/94~~ 8/31/94

* * * * *

This document was reviewed following the
procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

* * * * *

WHC Information Release Administration Specialist:

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SUPPORTING DOCUMENT		1. Total Pages 17
2. Title EARLY SECONDARY SODIUM DRAIN ASSESSMENT	3. Number WHC-SD-FF-SSP-053	4. Rev No. 0
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7. Abstract <p>The FFTF secondary HTS loops can be drained about two years before the planned Sodium Storage Facility (SSF) is available if part of the sodium is stored in the primary sodium drain tank and the reactor overflow tank and the balance is stored in the normal secondary sodium drain tank. This report documents the results of a study to determine the technical and programmatic viability of such an early secondary sodium drain. The drain sequence that would be used is to drain secondary loops 1 and 2, sequentially to T-44 with intermediate transfers to T-42 and T-43 until sufficient capacity is available in T-44 to accommodate the sodium from loop 3. Draining the secondary sodium loops about two years earlier than now planned by utilizing installed tank storage capacity is clearly technically viable and offers significant programmatic advantages. \$1,642,000 in electrical power and manpower costs can be avoided and applied to other plant shutdown activities. It is recommended that the drain sequence described herein be implemented.</p>		
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MASTER

EARLY SECONDARY SODIUM DRAIN ASSESSMENT

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I. INTRODUCTION AND SUMMARY

The FFTF secondary HTS loops can be drained about two years before the planned Sodium Storage Facility (SSF) is available if part of the sodium is stored in the primary sodium drain tank and the reactor overflow tank and the balance is stored in the normal secondary sodium drain tank. This report documents the results of a study to determine the technical and programmatic viability of such an early secondary sodium drain. The drain sequence that would be used is to drain secondary loops 1 and 2, sequentially to T-44 with intermediate transfers to T-42 and T-43 until sufficient capacity is available in T-44 to accommodate the sodium from loop 3. The sodium would then be transferred to the SSF after it is available for long term storage. The relatively uncontaminated sodium stored in T-44 and the secondary sides of the IHX's would be transferred to a single small tank in SSF to avoid contaminating it. The balance of the sodium would then be transferred to separate tanks in the SSF in the sequence described in the system shutdown plan (reference 1).

II. DISCUSSION

A. LOOP VERSUS TANK CAPACITIES

In order to confirm that sufficient storage capacity exists in T-42, T-43, and T-44 to accommodate the secondary loops sodium inventory, detailed studies of the actual tank capacities, their existing inventories, the existing loop inventories, and the undrainable residuals were performed. The results of those studies are summarized in Table 1. In support of the studies, detailed calculations of IHX secondary side sodium volume were performed to determine the sodium volume that can reasonably be stored in the IHX's as shown in Appendix A. The studies clearly show that sufficient storage capacity exists even when the IHX's are drained to the maximum extent possible without installing dip tubes. The recommended drain sequence is to store about 1500 gallons in each IHX and to store about 29,000 gallons in T-44 (case 7 in Table 1) in order to minimize the volume of secondary sodium that is mixed with the primary sodium because of the higher disposal costs of the mixed waste. That sequence results in 31,750 gallons of secondary sodium being transferred to the primary storage tanks.

B. PRIMARY SODIUM HEATING REQUIREMENTS AND CAPABILITIES

Historical data shows that the primary system insulation heat loss including losses from the reactor vessel is about 320 kw with 400 degree F sodium. Once the secondary sodium is drained there will be three sources to provide that heat. The NBHU can provide 90 kw to the bottom of the reactor vessel. Two immersion heater assemblies planned to be installed in the reactor vessel can provide 168 kw directly to the primary sodium. At full capacity the primary trace heat system can provide 620 kw to the piping, pumps and IHX's. The trace heat system has not been operated or tested for a number of years so it is likely that some of the heaters have failed but since the system was designed with 100% installed but not connected spare heaters, only 26% of the installed capacity would be required to compensate for the

total system heat loss in the absence of the other sources. The required heat input can also be reduced by reducing the system temperature if desired.

C. SCHEDULE IMPROVEMENT

The secondary sodium would not be drained until the reactor is defueled and the immersion heaters are installed. The current shutdown schedule shows that these actions will be completed about two years prior to Sodium Storage Facility availability. Accordingly, the secondary HTS and support systems can be shutdown two years earlier when this drain sequence is followed.

D. COST SAVINGS

\$692,000/year savings in electrical power costs can be realized when the secondary pumps are shut down because heat loss from the secondary loops is eliminated (reference 2).

Table 3 shows that an additional \$214,000/year in HTS equipment maintenance, operations, and engineering manpower costs can be applied to other shutdown activities once the secondary systems are drained.

An additional \$413,000/year in support systems equipment maintenance, operations, and engineering manpower costs can be applied to other shutdown activities once portions of the argon cover gas system, the H&V in the HTS-E&W, the sodium processing system, the HTS I&C system, the trace heat computers, and the ex-containment chilled water system are shut down. The estimates of these savings are also given in Table 3.

E. COST PENALTY FOR CONTAMINATING SECONDARY SODIUM

There is a substantial cost penalty for disposing of the contaminated portion of the secondary sodium which is mixed with the primary as mixed waste rather than hazardous waste as shown in Table 2. Since the disposal will not take place until the late 1990's, a cost penalty of \$1,674/55 gal drum is assumed which results in a \$966,000 cost for the 31,750 additional gallons of mixed waste. It should be noted that if the sodium is instead utilized (e.g. as sodium hydroxide) in processing tank waste, this penalty is eliminated.

F. CONCLUSIONS AND RECOMMENDATIONS

Draining the secondary sodium loops about two years earlier than now planned by utilizing installed tank storage capacity is clearly technically viable and offers significant programmatic advantages. \$1,642,000 in electrical power and manpower costs can be avoided and applied to other plant shutdown activities. It is recommended that the drain sequence described herein be implemented.

G. REFERENCES

1. "System Shutdown Plan for System 51A, 51B, 51C, and portions of 90 and 93", SD-WHC-FF-SSP-032, Rev. 0.
2. "Cost Reduction Proposal - Dump Heat Exchanger Convective Barrier/Heat Loss Reduction", CRP93-1074.

TABLE 1

EARLY SECONDARY DRAIN - LOOP VS TANK CAPACITIES COMPARISON																			
C A S E	T-42 VOLUME	T-43 VOLUME	T-44 VOLUME	HTS LOOP 1 CURRENT INVENTORY	PROC LOOP 1 CURRENT INVENTORY	HTS LOOP 2 CURRENT INVENTORY	PROC LOOP 2 CURRENT INVENTORY	HTS LOOP 3 CURRENT INVENTORY	PROC LOOP 3 CURRENT INVENTORY	VOLUME STORED IN E-1	VOLUME STORED IN E-2	VOLUME STORED IN E-3	T-42 CURRENT INVENTORY	T-43 CURRENT INVENTORY	T-44 CURRENT INVENTORY	VOL AVAIL=TANK CAPACITY - CURRENT INVENTORY	VOL NEED=LOOP VOLUMES-IHX INVENTORY	% OF CAPACITY	REMARKS
1	36200	21000	29400	18020	220	18020	220	18020	220	2210	2210	2210	14118	5460	11760	55,262.00	48,090.00	87.02	DESIGN
2	36200	21000	29400	17750	220	18300	220	16900	220	2210	2210	2210	14118	5460	11760	55,262.00	46,980.00	85.01	ACTUAL LOOP CAP'S, NO IHX DRAIN
3	36200	21000	29400	17750	220	18300	220	16900	220	1500	1500	1500	14118	5460	11760	55,262.00	49,110.00	88.87	ACTUAL LOOP CAP'S, MED IHX DRAIN
4	36200	21000	29400	17750	220	18300	220	16900	220	700	700	700	14118	5460	11760	55,262.00	51,510.00	93.21	ACTUAL LOOP CAP'S, MAX IHX DRAIN

* Secondary sodium fill test report shows actual loop volumes of 17,750, 18,300, and 16,900 for loops 1, 2, and 3 respectively.

TABLE 2

SODIUM BURIAL COSTS

WASTE TYPE	FY 94 \$/DRUM	FY 95 \$/DRUM	FY 96 \$/DRUM	FY 97 \$/DRUM	FY 98 \$/DRUM
HAZARDOUS	557	688	849	1047	1293
MIXED	1280	1576	1954	2405	2967
DELTA \$	723.00	888.00	1,105.00	1,358.00	1,674.00

TABLE 3
SECONDARY SYSTEM SAVINGS

SYSTEM	ENGINEERING HOURS/YEAR	OPERATOR HOURS/YEAR	MAINTENANCE HOURS/ YEAR	RATE \$/HOUR	POWER SAVINGS \$	MANPOWER SAVINGS \$/YEAR	TOTAL SAVINGS \$
H&V IN HTS-E&W AND DHX ENCLOSURES	72	36	144	47.50		11,970.00	23,940.00
SECONDARY SODIUM PROCESSING	200	500	2500	47.50		152,000.00	304,000.00
SECONDARY TRACE HEAT SYSTEM	1000	728	400	47.50		101,080.00	202,160.00
EX CONTAINMENT CHILLED WATER	300	365	350	47.50	100,000	48,212.50	296,425.00
SECONDARY HTS	1800	900	1800	47.50		213,750.00	427,500.00
							1,254,025.00

APPENDIX A

SODIUM VOLUME CALCULATIONS

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ANALYSIS

FOR _____
LOCATION _____
SUBJECT IHX SECONDARY
SODIUM VOLUME

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OBJECTIVES:

1. ESTIMATE (CONFIRM) TOTAL TUBE SIDE VOLUME
2. ESTIMATE VOLUME NOT DRAINABLE WITHOUT DIP TUBE
3. ESTIMATE VOLUME THAT CAN BE STORED ON TUBE SIDE WITH LOOP PIPING DRAINED

CALCULATIONS:

1. TOTAL VOLUME

A. TUBE VOLUME INCLUDING TUBESHEET BORES

PER FWEC REPORT NO. ND/76/3 DATED 2/18/76 "IHX FINAL REPORT", THE IHX'S CONTAIN 1540 0.875" O.D. X 0.047" MINIMUM WALL TUBES. DRAWING H-4-24118-10 SHOWS TOTAL LENGTH BETWEEN TUBESHEETS (OUTSIDE FACES) OF 268.062". FOR CALCS USE 0.049" NOMINAL WALL BY 268" + LENGTH ADDED BY EXPANSION BENDS.

FWEC DWG 27-1130-6-120-9 SHOWS EXPANSION BENDS ARE FOUR 42° ARCS, TWO 4" TANGENT TRANSITIONS, AND ONE 2 1/2" TANGENT TRANSITION WITH AN INSTALLED LENGTH OF 4'10", ARC RADIUS IS 18 1/4".

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ANALYSIS

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$$\text{ARC LENGTH} = \frac{4 \times 42^\circ}{180^\circ} \pi \times 18 \frac{1}{4} \\ = 54.8''$$

EXPANSION BEND DEVELOPED LENGTH

$$L' = 54.8 + 4 + 4 + 2.03 = 64.83'' \text{ SAY } 64.8''$$

SINCE INSTALLED LENGTH IS 58'', LENGTH
ADDED IS $64.8 - 58 = 6.8''$

THE TUBE VOLUME, V_T IS

$$V_T = 1540 \frac{\pi}{4} (.875 - .038)^2 (268 + 6.8) / 1728 \\ = 116.2 \text{ FT}^3 = 869.3 \text{ GAL}$$

B. DOWNCOMER VOLUME TO BOTTOM OF LOWER TUBESHEET

USE $15 \frac{1}{4}''$ ID TO BOTTOM OF INNER THERMAL LINER AND
 $18 \frac{1}{4}''$ ID FOR BALANCE OF LENGTH. IGNORE VOLUME
IN ANNULI. LENGTH OF $15 \frac{1}{4}''$ SECTION PER DWG

27-1130-6-120-9 IS:

$$5 \frac{1}{2}'' + 54 \frac{1}{4}'' + 38 \frac{1}{8}'' + 14 \frac{7}{8}'' + 110 \frac{1}{2}'' = 223.25''$$

54-7400-276 (10-87)

TOTAL LENGTH IS 366''

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ANALYSIS

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THE DOWNCOMER VOLUME, V_{DC} IS

$$V_{DC} = \left[\frac{\pi}{4} (15.25)^2 (223.25) + \frac{\pi}{4} (18.25)^2 (366 - 223.25) \right] / 1728$$

13752.2 37322.2

$$= 45.2 \text{ FT}^3 = 338.4 \text{ GAL}$$

C. LOWER PLENUM

SECTION FROM BOTTOM OF TUBESHEET TO HEAD WELD IS 3.56" HIGH BY 33.9" RADIUS PER H-4-24118-10.

THE TUBESHEET VOLUME, V_{TS} IS

$$V_{TS} = \pi (33.9)^2 (3.56) / 1728$$

$$= 7.4 \text{ FT}^3 = 55.4 \text{ GAL}$$

THE HEMISPHERICAL HEAD VOLUME, V_{HH} IS

$$V_{HH} = \frac{2}{3} \pi (33.9)^3 / 1728$$

$$= 47.2 \text{ FT}^3 = 353.5 \text{ GAL AND}$$

LOWER PLENUM VOLUME, V_{LP} IS

$$V_{LP} = 7.4 + 47.2 = 54.6 \text{ FT}^3 = 408.9 \text{ GAL}$$

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D. UPPER PLENUM VOLUME

GEOMETRY PER H-4-24118-10 EXCEPT VERTICAL
DIMENSIONS SCALED

TOP PART IS HOLLOW CYLINDER 49" HIGH BY 47.75" OD
BY 20.00" ID - IGNORE HEMI HEAD

$$\begin{aligned}
 \text{TAKEN } V_{TP} &= \frac{\pi}{4} (47.75^2 - 20.0^2) (49) / 1728 \\
 &= 41.8 \text{ FT}^3 = 313.1 \text{ GAL}
 \end{aligned}$$

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D. UPPER PLENUM VOLUME

GEOMETRY PER H-4-24118-10 EXCEPT VERTICAL
DIMENSIONS SCALED

TOP PART IS HOLLOW CYLINDER 49" HIGH BY 47.75" OD
BY 20.00" ID - IGNORE HEMI HEAD

$$\begin{aligned}
 \text{THEN } V_{TP} &= \frac{\pi}{4} (47.75^2 - 20.0^2) (49) / 1728 \\
 &= 41.8 \text{ FT}^3 = 313.1 \text{ GAL}
 \end{aligned}$$

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MID PART IS A HOLLOW FRUSTRUM OF A CONE
27" HIGH X 47.75 TOP OD X 66.625 BOTTOM OD X
20" ID

THE MID PART VOLUME, V_{MP} IS

$$V_{MP} = \left[\frac{1}{3} \frac{\pi}{4} (66.6^2 + 47.75^2 + 66.6 \times 47.7) 27 - \frac{\pi}{4} (20^2) 27 \right] / 1728$$

$$35.6 \text{ FT}^3 = 266.4 \text{ GAL}$$

BOTTOM PART IS A HOLLOW CYLINDER

14" HIGH X 66.625 OD X 20" ID

THE BOTTOM PART VOLUME, V_{BP} IS

$$V_{BP} = \frac{\pi}{4} (66.6^2 - 20^2) (14) / 1728$$

$$= 25.7 \text{ FT}^3 = 192.4 \text{ GAL AND}$$

UPPER PLENUM VOLUME, V_{UP} IS

$$V_{UP} = 41.8 + 35.6 + 25.7 = \underline{\underline{103.1 \text{ FT}^3}} = 772.1 \text{ GAL}$$

AND TOTAL TUBE SIDE VOLUME, V_{TS} IS

$$V_{TS} = 116.1 + 45.2 + 54.6 + 103.1 = 319.0 \text{ FT}^3$$

= 2309.3 GAL WHICH CHECKS WITH JDD-51
WITHIN THE ACCURACY OF THE CALCS

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ANALYSIS

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2. UNDRAINABLE VOLUME

CASE A. DRAIN FROM HOT LEG

SIPADON WILL BREAK WHEN LEVEL IN THE DOWNCOMER REACHES THE BOTTOM OF THE LOWER TUBESHEET. SODIUM VOLUME REMAINING WILL BE TUBES, LOWER PLENUM, LOWER AND MID SECTIONS OF UPPER PLENUM, AND ABOUT 1/3 OF THE UPPER SECTION OF THE UPPER PLENUM

UNDRAINABLE VOLUME, V_{UN} IS

$$\begin{aligned} V_{UN} &= V_T + V_{LP} + V_{BP} + V_{MP} + \frac{1}{3} V_{TP} \\ &= 116.1 + 54.6 + 25.7 + 35.6 + \frac{1}{3}(41.8) \\ &= 245.9 \text{ FT}^3 = 1842.0 \text{ GAL} \end{aligned}$$

CASE B. DRAIN FROM COLD LEG

SIPADON WILL BREAK WHEN LEVEL IN THE TUBES REACHES THE BOTTOM OF THE LOWER TUBESHEET. SODIUM VOLUME REMAINING WILL BE LOWER PLENUM, DOWNCOMER, AND ABOUT ONE FOOT OF INLET PIPE.

$$\begin{aligned} V_{UN} &= V_{LP} + V_{DC} + V_{PIPE} \\ &= 54.6 + 45.2 + \frac{\pi}{4}(1.3^2)(1) \\ &= 101.1 \text{ FT}^3 = 757.2 \text{ GAL} \end{aligned}$$

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3. STORABLE VOLUME

THE MAXIMUM VOLUME THAT CAN BE STORED IN THE TUBE SIDE IS THAT OF CASE 2A. ABOVE PLUS THE VOLUME OF THE DOWNCOMER,

$$V_S = V_{2A} + V_{DC}$$

$$= 245.9 + 45.2 = 291.1 \text{ FT}^3 \approx 2180 \text{ GAL}$$

FROM A PRACTICAL STANDPOINT, HOWEVER, SINCE THERE IS NO DIRECT METHOD OF DETERMINING THE LEVEL IN THE DOWNCOMER, THE CASE 2A. VOLUME IS THE MAXIMUM VOLUME THAT SHOULD BE STORED.