Attachment 5

To

GNRO-2007/00061

GGNS Calculation M6.7.013, Rev. 1

CALCULATION COVER PAGE ☒ CALCULATION ☐ DRN	(1) **DRN No.** **Page(s) 12** (2) **Initiating Doc.:** **ER-GG-1999-0217** ☐ **DRN Superseded:** ☐ **DRNs Voided:** ☐ **Calculation Superseded/Voided:** ☒ **As-Built/No ICN Required** ☐ **Pending/ICN Required** (Verify current status in IDEAS.) (3) **Reason For Pending Status:** (ER, T.S., Change, etc.)

(4) **Calculation No: M6.7.013**	(5) **Revision: 1**

(6) **Title:** CONDENSATE STORAGE TANK RESERVE CAPACITY

(7) **System(s): P11**		(8) **Component/Equipment Identifier:** **1P11A002**
(9) **Safety Code:** ☒ **Yes** ☐ **Quality** ☐ **No**	(10) **Calc Code:** (ANO/GGNS Only) **MechSys** (20) **Study Calc** ☐ **YES** ☒ **NO**	

(11) **10CFR50.59 Review:**	(12) **Structure:** (Optional)	
☒ Addressed in : **ER-GG-1999-0217** ☐ Attached ☐ No LBD Impact	Bldg. Room Coordinates:	Elev. Wall
(13) **R-Type: J05.02, CALCULATION**	(14) **Org. Code:** (ANO/GGNS/RBS Only) **NPE-Mechanical**	
(15) **Keywords: CST**	(19) **Topical Codes:** (ANO Only)	

REVIEWS

(16) Name/Signature/Date [signature] 3/27/06 Alex Howard **Responsible Engineer**	Robert W Fuller / 3-27-06 (17) Name/Signature/Date Robert Fuller ☒ **Design Verifier** ☐ **Reviewer** ☐ **Checker (Only As-Built DRNs Included in Revision)** ☐ Comments Attached	(18) Name/Signature/Date J. D. Wilson 3/27/06 **Supervisor/Approval** ☐ Comments Attached

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CALCULATION SHEET

CALCULATION NO. M6.7.013 REV. 1

CALCULATION REFERENCE SHEET	CALCULATION NO: M6.7.013 REVISION: 1

I. **DRNs INCORPORATED:**

1.
2.
3.
4.
5.

II Relationships:	Sht	Rev	Input Doc	Output Doc	Impact Y/N	DRN/ Tracking No.
1. ER-GG-1999-0217	0	0	☑	☐	N	
2. C-143.0-N1P11A002-1.3-2-3			☑	☐	N	
3. C-143.0-N1P11A002-1.3-17-2			☑	☐	N	
4. C-143.0-N1P11A002-1.3-16-2			☑	☐	N	
5. C-143.0-N1P11A002-1.3-18-2			☑	☐	N	
6. J-1660B	0	4	☑	☐	N	05-1560
7. SDC-E22	0	2	☑	☐	N	
8. SDC-E51	0	2	☑	☐	N	
9. MC-Q1E22-00010	0	1	☑	☐	N	

III. **CROSS REFERENCES:**

1.
2.
3.

IV. **SOFTWARE USED:**

Title:________ Version/Release:________ Disk/CD No.______

DISK/CDS INCLUDED:

Title:________ Version/Release________ Disk/CD No.______

V. **OTHER CHANGES:**

Revision	Record of Revision
0	Initial issue.
1	Determines available CST volume at a level of 18 feet (TS level) above bottom of tank as well as 18.9 feet (HPCS/RCIC reserve volume), 22 feet (low alarm), 25 feet (normal level), and 29.1 feet (high alarm) above bottom of tank.

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CALCULATION SHEET

CALCULATION NO. M6.7.013 REV. 1

TABLE OF CONTENTS

Entergy

CALCULATION SHEET

CALCULATION NO. M6.7.013 REV. 1

LIST OF EFFECTIVE PAGES

PAGE No.	REVISION
i	1
ii	1
iii	1
iv	1
v	1
vi	1
1	1
2	1
3	1
4	1
5	1
6	1

LIST OF TABLES

Entergy

CALCULATION SHEET

CALCULATION NO. M6.7.013 REV. 1

1.0 PURPOSE

The purpose of this calculation is to determine the available usable Condensate Storage Tank volume at a level of 18 feet, 18.9 feet, 22 feet, 25 feet, and 29.1 feet from the bottom of the tank and the time to the suction swap or vortexing for various HPCS/RCIC pump flow rates.

2.0 CONCLUSION

This calculation provides the available Condensate Storage Tank volume at a level of 18 feet, 18.9 feet, 22 feet, 25 feet, and 29.1 feet from the bottom of the tank and the time to suction swap or vortexing (setpoint for suction swap "Disabled") for various HPCS/RCIC pump flow rates. The results are listed in Table I.

Table I: Usable CST Volume for HPCS/RCIC (time before suction swap or vortexing, assuming continuous flow)

FLOW (gpm)	**Setpoint*** (ft)	**18 ft*** TS Level	**18.9 ft*** stand pipe level (HPCS/RCIC reserve volume)	**22 ft*** low alarm	**25 ft*** min normal level	**29.1 ft*** high alarm
800 (RCIC)	Disabled (See Note)	169,000 gal (3.5 hr)	177,000 gal (3.7 hr)	206,000 gal (4.3 hr)	235,000 gal (4.9 hr)	273,000 gal (5.7 hr)
7115 (HPCS)	Disabled (See Note)	145,000 gal (20 min)	154,000 gal (22 min)	183,000 gal (26 min)	211,000 gal (30 min)	250,000 gal (35 min)
8175 (HPCS)	Disabled (See Note)	137,000 gal (17 min)	145,000 gal (18 min)	174,000 gal (21 min)	203,000 gal (25 min)	241,000 gal (29 min)
8975 (HPCS/ RCIC)	Disabled (See Note)	130,000 gal (14 min)	138,000 gal (15 min)	168,000 gal (19 min)	196,000 gal (22 min)	234,000 gal (26 min)
800	4.0	135,000 gal (2.8 hr)	143,000 gal (3.0 hr)	172,000 gal (3.6 hr)	200,000 gal (4.2 hr)	239,000 gal (5.0 hr)
800	5.0	125,000 gal (2.6 hr)	134,000 gal (2.8 hr)	163,000 gal (3.4 hr)	191,000 gal (4.0 hr)	230,000 gal (4.8 hr)
7115	5.0	107,000 gal (15 min)	115,000 gal (16 min)	145,000 gal (20 min)	173,000 gal (24 min)	211,000 gal (30 min)
8175	5.0	100,000 gal (12 min)	109,000 gal (13 min)	138,000 gal (17 min)	166,000 gal (20 min)	204,000 gal (25 min)
8975	5.0	94,000 gal (10 min)	103,000 gal (11 min)	132,000 gal (15 min)	160,000 gal (18 min)	199,000 gal (22 min)

*Indicated level; actual level is 1'-1" higher. Usable volume does not specifically include an allowance for instrumentation/setpoint uncertainty. The effect is expected to be small and bounded by the conservatism in the assumed instrumentation response times and valve stroke times.

Note: Evaluation of usable CST volume before vortexing begins (transfer switch disabled or fails).

3.0 INPUT AND DESIGN CRITERIA

1. Condensate Storage Tank (CST) set point levels are in accordance with Drawing J-1660B, DRN 05-1560.
2. The minimum reserve volume level given by Technical Specification 3.5.2.2 is ≥18 feet.
3. The design criteria for the High Pressure Core Spray (HPCS) pump flow rate given by SDC-E22, is 7115 gpm with the reactor vessel pressure 200 psi above the pressure at source of suction, with a maximum runout flow into the reactor with a pressure vessel of 14.7 psia of 8175 gpm.
4. The design normal flow rate for the Reactor Core Isolation Cooling (RCIC) pump is 800 gpm.
5. The values for friction loss, minimum CST level instrumentation response time and valve stroke time, and potential vortex level above vortex breaker are derived in Engineering Calculation MC-Q1E22-00010, Rev 1.
6. All CST measurements are derived from Specification C-143.0, N1P11A002.

4.0 ASSUMPTIONS

1. All calculations for flow rate and time assume continuous flow.
2. Normal CST level is 25-29 feet.
3. The CST standpipes are right circular cylinders.

5.0 METHOD OF ANALYSIS

The available usable volume in the CST is a function of CST initial and set point level, instrumentation and valve response time, and piping friction losses. For any given initial CST level, the available usable volume in the CST is the amount of water above the actual vortex breaker after the HPCS/RCIC suction valve opens minus the volume of water displaced by the CST standpipes.

6.0 CALCULATIONS

Given a diameter of 40 ft (Ref 1), the volume of the CST per foot is:

$$\frac{\pi \cdot D^2}{4} = \frac{\pi \cdot (40ft)^2}{4} = 9400.3\frac{gal}{ft}$$

Now calculate the height at which a reserve volume of 170,000 gallons is provided.

$$Reserve_{Vol} = \frac{170000gal}{9400.3\frac{gal}{ft}} = 18.085ft$$

Factor in the level of the vortex breaker (0.75 feet), and the level required for a reserve volume of 170,000 gallons is:

$$ReserveVol_{Height} = 18.085ft + 0.75ft = 18.835ft$$

~18.9 feet

The actual level of the vortex breaker is the difference between the instrument level zero and the level of the vortex breaker, or:

Level of vortex breaker = 9"
Instrument zero level = 1'-1"

$$Vortex_{Level} = 13in - 9in = 0.333ft$$

The height of each of the standpipes is the difference between the centerline height of the standpipe and the cross-sectional radius of the standpipe, minus instrument error. The height of the 12 inch diameter standpipe is:

$$Height_{12stdpipe} = (5.229ft - 0.531ft - 1.083ft) = 3.615ft$$

The height of the 10 inch diameter standpipe is:

$$Height_{10stdpipe} = (5.229ft - 0.448ft - 1.083ft) = 3.698ft$$

Engineering Calculation MC-Q1E22-00010, Rev 1, calculates the friction loss (FL), minimum CST level instrumentation response time and valve stroke time (RT_{min}), and potential vortex level above vortex breaker (VTX) for the HPCS/RCIC pump at rated flow, shown in Table II.

FLOW (gpm)	FL (ft)	RT_{min} (ft)	VTX (ft)
800	0.041	0.0675	N/A
7115	2.738	0.811	2.504
8175	3.592	0.932	3.746
8975	4.313	1.000	4.177

Table II. Flow Data from Engineering Calculation MC-Q1E22-00010, Rev 1

The CST contains four standpipes (3-12" diameter standpipes and 1-10" diameter standpipe) which displace a known volume of usable water. This displaced volume is accounted for by calculating the expected volume per standpipe for a given indicated level, accounting for instrument zero. The volume of each standpipe is calculated as a right circular cylinder using the nominal cross-sectional area (Reference 4). With the low level set points disabled, the displaced volume for each the 3-12 inch diameter standpipes and the 1-10 inch standpipe is:

$$Volume12_{displaced} = 3\cdot\left(\pi\cdot R12_{stdpipe}^{\ 2}\right)\cdot H12_{stdpipe} + 3\cdot\left(\pi\cdot R12_{stdpipe}^{\ 2}\right)\cdot W_{stdpipe}$$

$$Volume10_{displaced} = \left(\pi\cdot R10_{stdpipe}^{\ 2}\right)\cdot H10_{stdpipe} + \left(\pi\cdot R10_{stdpipe}^{\ 2}\right)\cdot W_{stdpipe}$$

$$TotalVolume_{displace} = Volume12_{displaced} + Volume10_{displaced}$$

where: $H12_{stdpipe}$ is the height of the 12 inch diameter standpipe's vertical section accounting for instrument zero and indicated level (see Row 1, Table I) minus the potential vortex level (Table II)

$$H12_{stdpipe} = \left(I_{Level} - 3.615 - VTX\right)$$

$H10_{stdpipe}$ is the height of the 10 inch diameter standpipe's vertical section accounting for instrument zero and indicated level (see Row 1, Table I) minus the potential vortex level (Table II)

$$H10_{stdpipe} = \left(I_{Level} - 3.698 - VTX\right)$$

$W_{stdpipe}$ is the height of the standpipe's horizontal section (1.469 ft)
$R12_{stdpipe}$ is the cross-sectional radius of the 12 inch standpipe (0.531 ft)
$R10_{stdpipe}$ is the cross-sectional radius of the 10 inch standpipe (0.448 ft)

Therefore, the total usable volume in the CST with the low level set points *disabled* is:

$$Vol_{CST} = (I_{Level} - VTX) \cdot 9400.3 \frac{gal}{ft} - TotalVolume_{displace}$$

where: I_{Level} is the indicated level (Row 1, Table I)
VTX is the potential vortex level above vortex breaker (Table II)

Similarly, with the low level set points *enabled*, the displaced volume for each the 3-12 inch diameter standpipes and the 1-10 inch standpipe is:

$$Volume12_{displaced} = 3 \cdot \left(\pi \cdot R12_{stdpipe}^{\ 2}\right) \cdot H12_{stdpipe} + 3 \cdot \left(\pi \cdot R12_{stdpipe}^{\ 2}\right) \cdot W_{stdpipe}$$

$$Volume10_{displaced} = \left(\pi \cdot R10_{stdpipe}^{\ 2}\right) \cdot H10_{stdpipe} + \left(\pi \cdot R10_{stdpipe}^{\ 2}\right) \cdot W_{stdpipe}$$

$$TotalVolume_{displace} = Volume12_{displaced} + Volume10_{displaced}$$

where: $H12_{stdpipe}$ is the height of the 12 inch diameter standpipe's vertical section accounting for instrument zero and indicated level (see Row 1, Table I)

$$H12_{stdpipe} = (I_{Level} - 3.615 - SP - FL + RT_{min})$$

$H10_{stdpipe}$ is the height of the 10 inch diameter standpipe's vertical section accounting for instrument zero and indicated level (see Row 1, Table I)

$$H10_{stdpipe} = (I_{Level} - 3.698 - SP - FL + RT_{min})$$

$W_{stdpipe}$ is the height of the standpipe's horizontal section (1.469 ft)
$R12_{stdpipe}$ is the cross-sectional radius of the 12 inch standpipe (0.531 ft)
$R10_{stdpipe}$ is the cross-sectional radius of the 10 inch standpipe (0.448 ft)

Therefore, the total usable volume in the CST with the low level set points *enabled* is:

$$Vol_{CST} = \left[I_{Level} + Vortex_{Level} - (SP + FL - RT_{min})\right] \cdot 9400.3 \frac{gal}{ft} - TotalVolume_{displace}$$

where: I_{Level} is the indicated level (Row 1, Table I)
$Vortex_{Level}$ is the actual vortex level (0.333 ft)

SP is the CST low level set point for HPCS/RCIC suction transfer (Column 2, Table I)
FL/RT_{min} are taken from Table II for various flow rates
$TotalVolume_{displace}$ is the total volume displaced by all four standpipes

The time allowed before swapping to HPCS/RCIC or vortexing is calculated by dividing the usable CST volume by the flow rate for a given mode (HPCS pump, RCIC pump, combination of both).

$$Time = \frac{Vol_{CST}}{Flowrate}$$

Results of various pump flow rates and CST initial and set point levels is provided in Table I in the CONCLUSION section.