Southern Nuclear Operating Company

DOCUMENTATION OF ENGINEERING JUDGMENT

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CST Volume Requirements per Plant Transient Events

Version Record

Version No.	Originator/Date Signature	Reviewer/Date Signature
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Purpose:

The purpose of this analysis is to determine the CST volume required for the plant events that credit the AFW system to cool down the RCS or maintain the plant in a hot standby condition.

Design Inputs (Reference NMP-ES-042): See References Below

References:

1. Auxiliary Feedwater Functional System Description (FSD), A-181010, Ver. 23
2. Calculation BM-95-0961-001, Version 5 – "CST Sizing Verification"
3. Technical Specification, Unit 1 – Amendment 188, Unit 2 –Amendment 183
4. Mechanical Engineering Review Manual, 8th Edition.
5. Cameron Hydraulic Data, 16th Edition
6. Calculation 38.04, Revision 4, Verification of AFW Flow Bases – Unit 2
7. Calculation 40.02, Revsion 4, Verification of AFW Flow Bases – Unit 1
8. U-161693, Version 2.0 - CST General Plan
9. SCS Calculation SM-95-0721-005, Revision 1 – Design Basis Temperature Site/Condensate Storage Tank/Refueling Water Storage Tank.
10. Pump Suction Piping Isometric Drawings D-514547, Rev.1 and D-514548, Rev. 1.
11. MDAFW Pump Suction Piping, D-518847, Sheet 2, Rev.0
12. TDAFW Pump Suction Piping, D-518847, Sheet 1, Rev. 0
13. AFW Suction Line Flow Instrument Drawings, A-175856, Rev. 2 and A-205856, Rev. 3
14. AFW System P&ID, D-175007, Rev. 31; D-205007, Rev. 25
15. WCAP-15097, Revision 1: FNP Units 1 and 2 Replacements Steam Generator Program NSSS Engineering Report Book 1, March 2001.
16. U-161703B, Ver. 0.3; U-161694C, Ver. 0.4; U-213481 Ver.3.0 - CST Internal Dimensions
17. SM-SNC335993-001, Version 2.0 – CST AFW Pump Suction – Submergence Analysis
18. FSAR Section 15.2.8, Rev. 24, June 2012 – Loss of Normal Feedwater
19. WCAP -14722, Nov. 1997: FNP Units 1 and 2 Power Uprate Project NSSS Engineering Report

20. FSAR Section 15.2.9, Rev. 24, June 2012 – Loss of Offsite Power
21. FSAR Section 15.3.1, Rev. 24 June 2012, – Small Break Loss of Coolant Accident
22. FSAR Section 15.4.2.1, Rev. 24, June 2012 - Main Steam Line Break
23. FSAR Section 15.2.13 , Rev. 24, June 2012 – Depressurization of Main Steam
24. FSAR Section 15.4.2.2, Rev. 24, June 2012, – Main Feedwater Line Break
25. FSAR Section 9.2.6, Rev. 24, June 2012, – Condensate Storage Tank
26. Technical Specification Basis, Revision 55, Section B.3.7.6
27. Calculation 01.10, Rev. 0, Condensate Storage, 3/10/72 and Engineering Judgement M1. 10R)/01/CN 96-030 Rev. A

Assumptions:

1. Net RCP heat added to RCS,10MWt, (Reference 15) during power operations is decayed over a 1 hour period in determining CST volume required for RCP heat input.
2. Assume CST inventory loss during Normal cooldown event due to AFW Recirc. Line and Instrumentation line rupture thus requiring a minimum submergence level to prevent vortex formation.
3. Assume CST volume required for core decay heat removal is based on 102% of 2775 MWt (100% power) if not specified in FSAR Chapter 15 – Accident Analysis.
4. To envelop all possible scenarios of decay heat removal, the worst case steam generator back pressure (highest) from Reference 1 will be used to determine the final enthalpy of steam released from the steam generators.
5. During cooldown the steam generator pressure decreases from the hot standby condition,1155 psia to 135 psia (saturation pressure at 350 °F). The enthalpy varies 1204 Btu/lb to an enthalpy of 1187 Btu/lb. The lower enthalpy, 1187 Btu/lb is conservatively used to determine the water volume required (See Attachment "C").
6. The rupture of the pump recirculation line is assumed to occur at the location near the CST connection where the portion of the line is unprotected by the missile barrier (References 8 and 14).
7. The four 3/8" instrumentation lines for the Auxiliary Feedback Pump suction lines are assumed to rupture at the same elevation as of the pump suction nozzle at the CST (el. 156-9") for conservative purpose. This elevation is the lowest point above the ground level for the portion of the instrumentation lines that are unprotected from the missile impact.
8. The time allowed for FNP Operations to manually isolate a faulted SG during a MSLB event is 15 mins. and the time allowed for FNP Operations to manually isolate a faulted SG during a MFWLB event is 30 minutes.
9. It is assumed in the MSLB event that no heat removal from the RCS is achieved by the AFW flow through the faulted SG; thus, the AFW is considered lost and accounted for in the total volume required of the CST. This assumation is considered conservative, in

that, the AFW flow through the faulted SG during this event is removing heat but at an unknown rate since the SG is at atmospheric pressure due to the break.

Evaluation:

Decay Heat

1. Determine CST volume required for Core Decay Heat removal during the following plant events, where decay heat is based on 102% power at 2775 MWt, 9 hours in Mode 3 steaming to atmosphere.
   - Loss of Off-Site Power(LOSP) w/ Tornado (Reference 20)
   - Loss of Off-Site Power(LOSP) w/ Seismic Event (Reference 20)
   - Loss of Off-Site Power(LOSP) (Reference 20)
   - Loss of Normal Feedwater w/o LOSP (Reference 18)
   - Depressurization of Main Steam (Reference 23)
   - Technical Specification Basis (Reference 26)

Adjust decay load from Ref. 2, Attachment "B" which represents 2775 MWt (100% power) plus 10 MWt pump heat to values that represents only decay heat due to fisson products decay heat.

The decay heat from Attachment "B" at 9 hrs after shutdown is 0.1055×10^{10} Btu which includes 10 MWt pump heat.

The portion of decay heat results that is due to pump heat is: 10 MWt / 2785 MWt = 0.00359

Therefore, the decay heat at 9 hrs. after shutdown from fisson products (minus pump heat) is:

$$0.1055 \times 10^{10} - 0.00359(0.1055 \times 10^{10}) = 0.10512 \times 10^{10} \text{ Btu}$$

Since it is conservatively assumed that the reactor trips at 102% of rated reactor thermal power (2775 MWt) for this event, the fission product decay heat at 9 hrs after shutdown becomes:

$$0.10512 \times 10^{10} \text{ Btus} \times 1.02 = \underline{0.10722 \times 10^{10} \text{ Btu}}$$

Therefore, the CST Volume Required for Decay Heat is:

$$W(9hrs.) = \frac{0.10722 \times 10^{10} Btu}{1109\ Btu/lbm}(0.016165 ft^3/lbm)(gal/0.1337\ ft^3)$$

W(9hrs.) = 116,893 gallons

Note: Properties of the AFW are taken from calculation SM-95-0721-005 Ver. 1.0, i.e., AFW temperature of 110 °F (Reference 9).

2. Determine CST volume required for Core Decay Heat removal during the following plant events, where decay heat is based on 102% power at 2775 MWt, 2 hours at hot standby and 4 hours to hot shutdown.

- Small Break LOCA (Reference 21)
- Main Feedwater Line Break w/LOSP (Reference 24)
- Normal Cooldown (References:1, 25 and 26)
- Main Steam Line Break w/ LOSP (Reference 22)

Adjust decay load from Ref. 2, Attachment "B" which represents 2775 MWt (100% power) plus 10 MWt pump heat to values that represents only decay heat due to fisson products decay heat.

The portion of decay heat results that is due to pump heat is: 10 MWt / 2785 MWt = 0.00359

The decay heat from Attachment "B" at 2 hrs after shutdown is 0.35713×10^9 Btu.

Therefore, the decay heat at 2 hrs. after shutdown from fisson products alone is:

$$0.35713 \times 10^9 - 0.00359(0.35713 \times 10^9) = 0.35584 \times 10^9\ Btu$$

Since it is conservatively assumed that the reactor trips at 102% of rated reactor thermal power for this event, the fission product decay heat at 2 hrs after shutdown becomes:

$$0.35584 \times 10^9\ Btu \times 1.02 = \underline{0.3630 \times 10^9\ Btu}$$

The decay heat from Attachment "B" at 6 hrs after shutdown is 0.7878×10^9 Btu.

Therefore, the decay heat at 6 hrs. from fisson product heat alone is:

$0.7878 \times 10^9 - 0.00359(0.7878 \times 10^9) = 0.7849 \times 10^9$ Btu

Since it is conservatively assumed that the reactor trips at 102% of rated reactor thermal power for this event, the fission product decay heat at 6 hrs after shutdown becomes:

0.7849×10^9 Btu x 1.02 = $\underline{0.8006 \times 10^9 \text{ Btu}}$

Volume of water required for heat removal is determined by:

$W = (Q / \Delta h) \times v_f\,(110°F) \times (gal/ft^3)$

Where,

$\Delta h = h_g(1155\text{ psia}) - h_f(110°F)$ (Reference 1 and 9, typical)

$\Delta h = 1187 - 78 = 1109$ Btu/lb (Reference 5, typical)

Calculating the required volume of condensate water for the 2 hour holding period results in:

W(2 hrs) = [0.3630×10^9 Btu / 1109 Btu/lb] (0.016165 ft^3/lb) (1gal /0.1337 ft^3)

<u>W(2 hrs) = 39575 gallons</u>

Calculating the required volume of condensate water for the 4 hour holding period results in:

W(4 hrs) =[(0.8006×10^9 Btu - 0.3630×10^9 Btu) / 1109 Btu/lb] (0.016165 ft^3/lb) (1gal / 0.1337 ft^3)

<u>W(4 hrs) = 47,708 gallons</u>

3. Determine core decay heat for the MSLB w/o LOSP event based on 102% power, 2831 MWT; at 2 hr and 5 hr. Based on FNP operations input, with the all RCPs available the duration of the event should be set at a maximum of 5 hours,i.e., 583°F to 350°F at a conservative cooldown rate of 50 °F/hr.
Duration is determined by: (583°F - 350°F)/ 50 °F/hr = 4.66 hr. ≈ 5 hr.

- <u>Main Steam Line Break w/o LOSP (Reference 22)</u>

Adjust decay load from Ref. 2, Attachment "B" which represents 2775 MWt (100% power) plus 10 MWt pump heat to values that represents only decay heat due to fisson products decay heat.

The portion of decay heat results that is due to pump heat is: 10 MWt / 2785 MWt = 0.00359

The decay heat from Attachment "B" at 2 hrs after shutdown is 0.35713×10^9 Btu.

Therefore, the decay heat at **2 hrs**. after shutdown from fisson products alone is:

$0.35713 \times 10^9 - 0.00359(0.35713 \times 10^9) = \underline{0.35584 \times 10^9 \text{ Btu}}$

Since FSAR Table 15.4-23 (Sheet 1 of 2) conservatively assumes the reactor thermal power is at 102% prior to event, the fission product decay heat at 2 hrs after shutdown becomes:

$0.35584 \times 10^9 \text{ Btu} \times 1.02 = \underline{.3630 \times 10^9 \text{ Btu}}$

The decay heat from Attachment "B" at **5 hrs** after shutdown is $.69009 \times 10^9$ Btu.

Therefore, the decay heat at 5 hrs. from fisson product heat alone is:

$0.69009 \times 10^9 - 0.00359(0.69009 \times 10^9) = \underline{0.68761 \times 10^9 \text{ Btu}}$

Since FSAR Table 15.4-23 (Sheet 1 of 2) conservatively assumes the reactor thermal power is at 102% prior to event, the fission product decay heat at 5 hrs after shutdown becomes:

$0.68761 \times 10^9 \text{ Btu} \times 1.02 = \underline{0.7014 \times 10^9 \text{ Btu}}$

- Volume of water required for deay heat removal is determined by:

$W = (Q / \Delta h) \times v_f\,(110°F) \times (gal/ft^3)$

Where,

$\Delta h = h_g(1155 \text{ psia}) - h_f\,(110°F)$

$\Delta h = 1187 - 78 = 1109$ Btu/lb

Calculating the required volume of condensate water for the 2 hour holding period results in:

$W(2 \text{ hrs}) = [.3630 \times 10^9 \text{ Btu} / 1109 \text{ Btu/lb}]\ (0.016165\ ft^3/lb)\ (1gal / 0.1337\ ft^3)$

W(@2 hrs) = 39575 gallons

Calculating the required volume of condensate water for the 5 hour holding period results in:

W(5hrs) =[(0.7014 x 10^9 Btu - 0.3630 x 10^9 Btu) / 1109 Btu/lb] (0.016165 ft^3/lb) (1gal / 0.1337 ft^3)

W(@5 hrs) = 36893 gallons

Sensible Heat

1. Determine CST volume required for Sensible Heat removal during the following plant events, where sensible heat is based on $T_{no\text{-}load}$ of 547 °F (Ref. 15), 9 hours in Mode 3 steaming to atmosphere.

   - Loss of Off-Site Power (LOSP) w/ Tornado
   - Loss of Off-Site Power (LOSP) w/ Seismic Event
   - Loss of Off-Site Power (LOSP)
   - Loss of Normal Feedwater w/o LOSP
   - Depressurization of Main Steam
   - Technical Specification Basis

   No CST volume is required for the removal of RCS sensible heat, since the unit stays at hot standby conditions through-out the duration of above events.

2. Determine required CST volume for removal of Sensible Heat in the RCS at Tavg (hot) of 577.2°F(Ref. 15) for the following events:

   - Main Feedwater Line Break w/LOSP
   - Normal Cooldown
   - Small Break LOCA
   - Main Steam Line Break w/o LOSP
   - Main Steam Line Break w/ LOSP

An uncertainty of 6°F on the initial reactor average coolant temperature is conservatively assumed. Thus, sensible heat calculation is based on a RCS Tavg (temperature of 577.2 °F + 6°F = 583.2 °F for the thermal capacity of the system metal and the reactor coolant fluid enthalpy change from 583.2 °F to 350°F. The equation used to calculate the sensible heat load is based upon the conservation of mass and energy:

$dU = m \times c_p \times \Delta T + \Delta h \times M$ where;
dU = sensible heat load from RCS temperature of 583.2 °F to 350°F, Btu

m = mass of RCS metal, lbm
$\approx 5.0 \times 10^6$ lbs

ΔT = 583.2°F - 350°F

c_p = specific heat of metal, 0.11 Btu/°F-lbm (from Reference 4)

Δh = enthalpy change of reactor coolant, Btu/lb
@ 583.2 °F; h_{f1} = 593.02 Btu/lb; v_{f1} = 0.022918 ft^3/lb
@ 350°F; h_{f2} = 321.80 Btu/lb; v_{f2} = 0.01799 ft^3/lb

M = total reactor coolant mass, lb
= V / v_f, where

V = total reactor coolant volume, ft^3 (Refererence 27)
= 9,723 ft^3

v_f = specific volume of reactor coolant, where $v_{f1} = v_{f2}$ for conservatism.
= 0.018 ft^3/lb;

M = 9,723 ft^3/0.018 ft^3/lb = 540,167 lbs

Thus,

$dU = m \times c_p \times \Delta T + \Delta h \times M$

= 5.0×10^6 lbs. x 0.11 Btu/°F-lbm x (583.2°F - 350°F) + (593.02 Btu/lb - 321.80 Btu/lb) x 540,167 lbs.

<u>dU = 2.7476×10^8 Btus</u>

<u>Volume of CST required for Sensible Heat Load</u>

$$W\text{ (sensible ht.)} = \frac{2.7476 \times 10^8 \text{ Btu} \times 0.016165 \text{ ft}^3/\text{lbm}}{1109 \text{ Btu/lbm} \times 0.1337 \text{ ft}^3/\text{gal.}}$$

<u>W (sensible ht.) = 29,955 gallons required for sensible heat load</u>

RCP Heat

1. Determine CST volume required for removal of the RCP heat added to the RCS.

    - Loss of Off-Site Power(LOSP) w/ Tornado
    - Loss of Off-Site Power(LOSP) w/ Seismic Event
    - Loss of Off-Site Power(LOSP)
    - Small Break LOCA
    - Main Steam Line Break w/ LOSP
    - Main Feedwater Line Break w/LOSP
    - Tech. Spec. Basis (Mode 3 for 9 hours)

These events are concurrent with a LOSP where no RCPs are in operation; however, the net heat input of 10 MWt due to the RCPs at beginning of the event exists in the RCS and it is assumed this heat decays over a 1 hour period. (Reference 15)

$$10 \text{ MWt} = 3.41297 \times 10^7 \text{ Btu/hr (based on 0.293 watts = 1 Btu/hr)}$$

Therefore, CST volume required due to 10 MWt RCP net heat input at beginning of the event and assumed to decay in 1 hour is:

$$W(\text{10MWt decayed over 1 hr.}) = \frac{3.41297 \times 10^7 \text{Btu/hr}}{1109 \text{ Btu/lbm}} (0.016165 \text{ft}^3/\text{lbm})(\text{gal}/0.1337 \text{ ft}^3) \times 1 \text{ hr.}$$

W (10 MWt decayed over 1 hr.) = 3721 gallons

2. Determine CST volume required for removal of the RCP heat added to the RCS for the following event:

    - Main Steam Line Break w/o LOSP

This RCP heat is based on net heat input of 10 MWt per WCAP-15097 and operation of all RCPs from Tavg(583°F) to 350°F at a cooldown rate of 50°F/hr. The FSAR Section 15.4.2.1 does not assume a conservatively large RCP heat of 15MWt. However, the initial net heat input of 10MWt is assumed to decay over 1 hour and the operation of all three RCPs for the duration of the event is supported by input from Westinghouse and FNP Ops.

- Assume a RCS cooldown rate of 50°F/hr.
- Assume a Tavg of 583 °F(577°F + 6 °F) at the start of the event cooling down to 350 °F in determining the duration of the event at the cooldown rate. Tavg of 583°F is assumed plant is initially at 102% core thermal power per FSAR Table 15.4-23 (Sheet 1 of 2)

Duration of Event is determined by :

(Tavg - 350°F) / 50°F/hr.(cooldown rate)

(583°F - 350°F) / 50°F/hr = 4.66 hrs.

Set duration of the event at 5 hours.

10 MWt pump heat input = 3.41297×10^7 Btu/hr.

Determine No. of gallons per hour required remove **10MWt** pump heat is:

W (gal/hr.) = (3.41297×10^7 Btu/hr / 1109 Btu/lb) x 0.16165 ft^3/lbm x gal/0.1337ft^3

W = 3721 gal/hr to remove 10MWt pump heat

Thus for the 5 hr duration of the event, the CST volume required to remove heat input of all RCPs operating is:

W = 3721 gal/hr x 5.0 hr. = 18605 gallons.

For the initial net RCP heat input of 10MWt that is assumed to decay over 1 hour from the start of the event , the CST volume required is: 3721 gallons.

Therefore, the total CST volume required to remove the initial heat input and operating heat input during the event is:

18605 gallons + 3721 gallons = 22326 gallons

3. Determine CST volume required for removal of the RCP heat added to the RCS for the following event:

- Loss of Normal Feedwater w/o LOSP

This RCP heat is based on net heat input of 15 MWt per WCAP-15097 and operation of all RCPs from Tavg(full power) to 350°F at a cooldown rate of 50°F/hr. The FSAR Section 15.2.8.2.1.A assumes a conservatively large RCP heat input of 15MWt. This initial net heat input of 15 MWt is assumed to decay over 1 hour. Per this FSAR section, all three RCPs operate at the initiation of the event for 10 mins and one(1) RCP operates for the duration of the event; i.e. 9 hrs. in hot standby.

- Per WCAP – 15097(Ref. 15), Tavg of 583°F (577°F + 6°F) at the start of the event cooling down to 350 °F in determining the duration of the event at the cooldown rate.

15 MWt pump heat input = 5.119×10^7 Btu/hr.

Determine number of gallons per hour required to remove **15MWt** pump heat is:

W (gal/hr.) = (5.119×10^7 Btu/hr / 1109 Btu/lb) x 0.016165 ft^3/lbm x gal/ 0.1337ft^3

W = 5580 gal/hr to remove 15MWt pump heat. Thus, assumming 1 hr to decay 15 MWt, the net heat input yields:

5581 gallons

Per FSAR 15.2.8.2.1.A, three RCPs operate for **10 mins** at start of event:

5581 gals/hr. x 1 hr./ 60mins x 10 min. = **930 gallons.**

Thus, for the remaining duration of the event which is; (9 hrs – 10 mins), the CST volume required to remove heat input of one RCPs operating is:

1 RCP heat input = 5 MWt = 1.7065×10^7 Btu/hr.

W (gal/hr) = (1.7065×10^7 Btu/hr / 1109 Btu/lb) x 0.016165 ft^3/lbm x gal./ 0.1337 ft^3

W (gal/hr) = 1860 gal/hr

Now, timing remaining = 9 hrs. – (10min x 1 hr/60 min) = 8.83 hr.

Therefore, volume required for timing remaining during event is:

Volume = 1860 gal/hr x 8.83 hr. = **16,430 gallons**

Total CST volume required for RCP heat added during LNFW event is:

5581+ 930 + 16,430 = <u>22941 gallons</u>

4. Determine the CST volume required for removal of the RCP heat added to the RCS for the following event:

- <u>Depressurization of Main Steam</u>

FSAR 15.2.13 (Ref. 23) nor WCAP 14722 (Ref. 19), section 6.2.13 makes assumptions regarding RCP operation, thus it is assumed that 3 RCPs operating for approx. 10 mins to reach RCS equilibrium than 1 RCP operates for remainder of 9 hours in hot standby condition. Also assumed, RCP heat includes the initial 10 MWt net RCP heat input before reactor trip and this heat is assumed to decay in one (1) hour. Assume Tavg is based on reactor full power operation.

Per WCAP – 15097(Ref. 15), Tavg of 583°F (577°F + 6°F) at the start of the event cooling down to 350 °F in determining the duration of the event at the cooldown rate.

10 MWt pump heat input = 3.41297×10^7 Btu/hr.

Determine number of gallons per hour required to remove **10MWt** pump heat is:

W (gal/hr.) = (3.41297×10^7 Btu/hr / 1109 Btu/lb) x 0.016165 ft^3/lbm x gal / 0.1337ft^3

W = 3721 gal/hr to remove 10MWt pump heat. Thus, assumming 1 hr to decay 10 MWt, the net heat input yields:

<u>3721 gallons</u>

Assuming three RCPs operate for **10 mins** at start of event where the net heat input for 3 RCPs operating is 10 MWt, determine the CST volume required:

3721 gals/hr. x 1 hr./ 60mins x 10 min. = **<u>620 gallons.</u>**

Thus, for the remaining duration of the event which is; 9 hrs – 10 mins, the CST volume required to remove heat input of one RCPs operating is:

1 RCP heat input = 5 MWt = 1.7065×10^7 Btu/hr.

W (gal/hr) = (1.7065 x 10^7 Btu/hr / 1109 Btu/lb) x 0.016165 ft^3/lbm x gal./ 0.1337 ft^3

W (gal/hr) = 1860 gal/hr

Now, timing remaining = 9 hrs. – (10min x 1 hr/60 min) = 8.83 hr.

Therefore, volume required for timing remaining during event is:

Volume = 1860 gal/hr x 8.83 hr. = **16,430 gallons**

Total CST volume required for RCP heat added during the Depressurization of Main Steam event is:

3721 + 620 + 16,430 = 20771 gallons

5. Determine the CST volume required for removal of the RCP heat added to the RCS for the following event:

- Normal Cooldown

For this event, normal cooldown, the heat added to the RCS is based on 1 RCP in operation for the duration of the event, 6 hrs. plus 10MWt net RCP heat added and assumed to decay over 1 hr. after shutdown.

Per Reference 15, the heat added to RCS per pump is assumed at 5 MWt and the net heat input added for all three RCPs is 10 MWt.

For 5 MWt (1 RCP), the CST volume required per hour is:

5 MWt = 5 x 10^6 watts and 1 Btu/hr = 0.293 watts, therefore,

5 MWt = 5 x 10^6 watts x (1 Btu/hr / 0.293 watts) = 1.7065 x 10^7 Btu/hr.

$$W/hr\ (1\ RCP) = \frac{1.7065 \times 10^7\ Btu/hr \times 0.016165\ ft^3/lb\ ;}{1109\ Btu/lb \times 0.1337\ ft^3/gal}$$

where 1109 Btu/lb is the enthalpy heat sink of the AFW, from 110°F to 1155 psia, maximum backpressure of the S/G secondary side,

W/hr (1 RCP) = 1860 gals/hr.

For 10 MWt the CST volume required per hour is:

10 MWt = 3.4129×10^7 Btu/hr

W/hr (10 MWt net heat added) = $\dfrac{3.4129 \times 10^7 \text{ Btu/hr} \times 0.016165 \text{ ft}^3\text{/lb}}{1109 \text{ Btu/lb} \times 0.1337 \text{ ft}^3\text{/gal.}}$;

W/hr (10 MWt net heat added) = 3721 gal/hr.

Therefore, for this normal cooldown event, the CST volume required for removal of RCP heat is;

W (RCP heat) = (6 hr. x 1860 gal/hr) + (1hr x 3721 gal/hr)

W (RCP heat) = 14881 gallons

Pressurizer Heaters Input to RCS

Per FSAR Section 15.2.8, during a Loss of Normal Feedwater (LONF) event, the pressurizer proportional and backup heaters are assumed operable. The total capacity of the pressurizer heaters is 1.4 MWt. The heaters output represents an addition to the RCS energy which must be removed by the AFW system. Therefore, determine CST volume required for removal of this energy during the event duration of 9 hours in Mode 3, steaming to atmosphere.

- Loss of Normal Feedwater

Pressurizer Heater capacity in Btu/hr.

1.4 MWt = 4.7781×10^6 Btu/hr (based on 0.293 watts = 1 Btu/hr)

W/hr (PzrHtrs.) = $\dfrac{4.7781 \times 10^6 \text{ Btu/hr} \times 0.016165 \text{ ft}^3\text{/lb}}{1109 \text{ Btu/lb} \times 0.1337 \text{ ft}^3\text{/gal}}$;

where 1109 Btu/lb is the enthalpy heat sink of the AFW, from 110°F to 1155 psia, maximum backpressure of the SG secondary side,

W/hr (Pzr Htrs.) = 521 gals/hr.

Therefore, for this LONF event, the CST volume required for removal of Pressurizer Heater energy input to the RCS:

W (Pzr Htrs.) = (9 hr. x 521gal/hr)

W (Pzr Htrs.) = 4689 gallons

Steam Generator Refill Volume

Per calculation BM-0961-001,Version 4.0, a steam generator refill volume was added to the CST based on initial low-low steam generator water level for added margin. Per WCAP -15097 Section 4.2.2.4.1, the CST volume conservatively considers refill of the SG to the no-load programmed level.

Since it has been clearly defined that the steam generator refill volume added conservative margin to the CST sizing in calculation BM-0961-001,Version 4.0, this conservatism has been removed per the latest revision of the calculation. Per email from FNP Operations, Thomas Nesbit, dated 3/12/2012, there would be no need to refill the faulted SG Refilling of the SG would be more for equipment preservation rather than RCS cooling once the RHR is aligned.

Based on the above documentation that the SG refill volume is conservative and to add design margin to the CST Volume, this refill volume has been removed from the CST volume sizing verification since other conservatism, such as, instrument and pump recirculation line failures as well as vortex prevention have been added to provide design margin to the CST volume.

An LDCR will be developed to remove this assumption that the SG is refilled to no-load programmed level at the completion of cooldown to 350°F per FNP FSAR-9.2.6.3.

AFW Pumps Recirc. Line and Instrumentation Lines Rupture

1. Determine the CST inventory loss due to the AFW pump's recirculation line and instrumentation line failure during the following events:

   - Loss of Off-Site Power(LOSP) w/ Tornado
   - Loss of Off-Site Power(LOSP) w/ Seismic Event

During a LOSP event assumed for a duration of 9 hours, two MDAFW pumps or the TDAFW pump is started. Heat removal from the RCS is maintaind by natural circulation while the unit is maintained in hot standby. The natural circulation capability of the RCS will remove decay heat from the core aided by the AFW flow in the secondary system. As the steam system pressure rises following a trip, the steam system PORV's are automatically opened to the atmosphere. It is assumed per FSAR 15.2.9.2.1.E for this event that two MDAFW pumps are available to supply a minimum of 350 gpm to three steam generators.

Due to a tornado missile or seismic event, it is assumed that the pump's recirculation line fails. The volume of water lost out from a break in the pump recirculation line will be calculated with an assumption that the ruptured minimum flow recirculation will be isolated within 30 minutes. Three recirculation lines of the pumps form one 6-inch line to the CST. It is assumed that, even though this single 6-inch return line would rupture at a location near the CST, all three pump recirculation lines would be isolated. The MDAFW pumps will be operated with the minimum flow lines isolated during the remaining time of 8.5-hour period and this will not affect the pump performance for this operation mode. Since the valves for the recirculation lines can be closed manually inside the plant, 30-minute span for the action is considered sufficient (Reference 3 Section B.3.7.6).

From References 6 and 7, the maximum recirculation flow for the TDAFW pumps is 100 gpm, and 50 gpm for each MDAFW pump. These recirculation flow values are slightly higher than calculated to conservatively accommodate the slight decrease in frictional loss due to a line break.

Thus, the volume of water that will be lost from two MDAFW pumps during the 30 minute span for isolation of the recirculation lines:

(50 + 50)gpm x 0.5 hour = **3000 gallons.**

Since the nozzle of the AFW pump recirculation line is located at 19 feet above the CST base, which is well above the height (13.25 feet, see below calculation) of the protected 164,832 gallon volume, or even above the protected height of the tank (16') (Reference 11), a possibility of water coming out from the CST through the ruptured recirculation line is not considered.

From References 10,11,12,13,14, four flow instrumentation lines branch out from the two AFW pump suction lines at El. 150 ft. location. Due to a tornado missile or seismic event, it is assumed that these instrument lines fail and are not isolated during the duration of the event. Since the locations of the branch-out are in the pipe trench, for a conservative calculation purpose, the break point of the instrumentation lines is assumed to happen at the lowest location above the ground level (El.156'-9") where the instrumentation lines are exposed to missile impact. This is the same elevation as of the pump suction nozzle at the CST.

The instrument tubing is 3/8" size with 0.065 minimum wall with ID 0.245" (Reference 13). In order to calculate the flow rate at the rupture point, assume all the pressure losses in the 8" pump suction pipe and the instrument tubing are ignored. This will give a conservative result for the flow rate. Since the lower 164,000 gallon volume of the tank shall be reserved for handling decay heat and cooldown, the height of this water volume in the tank is:

Tank bottom area: $\pi r^2 = \pi (23ft)^2 = 1662 ft^2$ (Reference 8)

Height of volume (164,832 gallons) = (164832 gals / 7.48gals/ft^3) / 1662 ft^2 = 13.25 ft. (equivalent to a pressure of 5.73 psi). From Reference 5, page 2-9, the water flow from the break point is calculated by extrapolation. The break size of the tubing (0.245" ID) is approximately equivalent to 1/4". The discharges of 1/4" nozzle at 10 and 15 psi are 5.91 and 7.24 gpm, respectively (Reference 6).

Taking a middle point of the CST water level for the fluid pressure at the instrument line break point, or 2.9 psi, and ignoring all the line losses and the effect of the AFW pump suction pressures for conservatism, then the flow at the break points is calculated as:

5.91 gpm - {[(7.24 – 5.91)/(15-10)] x (10-2.9)} = 5.91 - 1.88 = 4.03 gpm per line

Total outflow for four instrumentation lines : 4.03 x 4 lines = 16.1 gpm

If we consider that these instrumentation lines will not be isolated during the 9-hour cooldown period, than the total volume lost from the ruptured instrument lines for 9 hours is 16.1 x 9 x 60 = **8694 gallons.**

2. Determine the CST inventory loss due to the AFW pump's recirculation line and instrumentation line failure during the following event:

   - Normal Cooldown

During normal plant cooldown, operating one MDAFW pump will permit a maximum initial cooldown rate of 100°F/Hr. Each of the MDAFW pumps is sized to supply the steam generators with 100 percent of the required feedwater flow for a normal safe cooldown of the reactor coolant system (References 1 & 3). Therefore, one MDAFW pump is sufficient for a normal cooling operation with a cooldown rate of 50 °F/Hr assumed for this calculation. For conservative approach for this calculation, all three AFW pumps (the TDAFW and two MDAFW pumps, each at the design flow rate of 700 and 350 gpm, respectively) operate for the first 30 minutes before the TDAFW pump and one MDAFW pump are secured.

For normal plant cooldown, the AFWS is placed under manual control to supply feedwater to the steam generators for removal of decay and sensible heat from the reactor system. The TDAFW pump is designed to be manually or automatically initiated to its rated capacity and head within 1 minute from starting at rest for at least 2 hours independent of any ac power (Reference 1). Operator action to secure the TDAFW and one MDAFW pump within 30 minutes will be adequate for this calculation purpose.

The volume of water lost out from a break in the pump recirculation line will be calculated with an assumption that the ruptured minimum flow recirculation will be isolated within 30 minutes. Three recirculation lines of the pumps form one 6-inch line to the CST. It is assumed that, even though this single 6-inch return line would rupture at a location near the CST, all three pump recirculation lines would be isolated. The MDAFW pumps will be operated with the minimum flow lines isolated during the remaining time of 5.5-hour period and this will not affect the pump performance for this operation mode. Since the valves for the recirculation lines can be closed manually inside the plant, 30-minute span for the action is considered sufficient (Reference 26, Section B.3.7.6).

From References 6 and 7, the maximum recirculation flow for the TDAFW pumps is 100 gpm, and 50 gpm for each MDAFW pump. These recirculation flow values are slightly higher than calculated to conservatively accommodate the slight decrease in frictional loss due to a line break.

Thus, the maximum volume of water that will be lost during the 30–minute span from the recirculation line failure while all three AFW pumps are in operation is:

(100 + 50 + 50)gpm x 0.5 hour = **6,000 gallons.**

Since the nozzle of the AFW pump recirculation line is located at 19 feet above the CST base, which is well above the height (13.25 feet, see below calculation) of the protected 164,832 gallon volume, or even above the protected height of the tank (16') (Reference 8), a possibility of water coming out from the CST through the ruptured recirculation line is not considered.

The basis for the inventory loss from the failure of the instrument tubing for the normal cool down event is the same as that provided for the LSOP events. See sheets 18 and 19 under the LOSP events for this basis.

The total outflow for four instrumentation lines : 4.03 x 4 lines = 16.1 gpm

If we consider that these instrumentation tubing will not be isolated during the 6-hour cooldown period, than the total volume lost from the ruptured instrument lines for 6 hours is 16.1 x 6 x 60 = **5803 gallons.**

The total volume inventory lost from all the ruptured lines is, assuming all the line ruptures occurred at time = 0 sec. of the cooldown mode: 6,000 + 5,803 = 11,803 gallons

Vortex Prevention – CST Minimum Submergence Level

Determine the volume required to prevent the potential of a vortex formation in the CST assuming air enters the tank underneath the tank's diaphragm for the following events:

- Loss of Off-Site Power(LOSP) w/ Tornado
- Loss of Off-Site Power(LOSP) w/ Seismic Event
- Normal Cooldown (2 hours at hot standby and 4 hours to hot shutdown)

- Determine the CST volume required based on the minimum submergence water level required in the CST to prevent vortexing at the AFW pump's suction inlet. Per Reference

17, the minimum submergence level required in the CST based on the operation of two MDAFW pumps or the TDAFW pumps shall be greater than or equal 9.78 inches from the bottom of the tank.

From the internal dimensions of the tank per Reference 16, the volume required is:

Volume Req'd (gallons) = Tank Area (ft^2) x Min. Submergence (ft.) x $\frac{7.48 \text{ gallons}}{ft.^3}$

Tank Area ($ft.^2$) = π radius^2 , where the radius is equal to 23 ft.

Tank Area ($ft.^2$) = $\pi (23)^2$ = 1661.9 $ft.^2$, use 1662 ft^2

Min. Submergence(ft.) = 9.78 inches x (1ft./12inches) = 0.815 ft.

Thus,

Volume Req'd for Vortex Prevention= 1662 ft^2 x 0.815 ft. x $\frac{7.48 \text{ gal}}{ft.^3}$ = 10,132 gallons

Note: This volume includes the unusable volume that is 4 inches from the bottom of the tank below the pump suction nozzles.

Unusable Volume – CST Volume below AFW pump Suction Nozzles

Determine the unusable volume in the CST due to the 4 inches from the AFW pump's suction nozzles to the bottom of the tank for the the following events:

- Loss of Off-Site Power(LOSP)
- Loss of Normal Feedwater w/o LOSP
- Small Break LOCA
- Main Steam Line Break w and w/o LOSP
- Depressurization of Main Steam
- Main Feedwater Line Break w/LOSP
- Technical Specification Basis

Un-usable Volume in CST is equivalent to the 4 inches (0.33 ft) of CST volume below the pumps' suction nozzles since no vortex prevention is required while bringing the unit to hot shutdown, RCS at 350°F. That is, during these events no attached lines to the CST are assumed to fail allowing air to enter the tank below the diaphragm thus creating the potential for vortex formation.

Unusable Volume (gallons) = Tank Area (ft^2) x 0.33 ft. x 7.48 gallons/$ft.^3$

Tank Area ($ft.^2$) = π $radius^2$, where the radius is equal to 23 ft.

Tank Area ($ft.^2$) = π $(23)^2$ = 1661.9 $ft.^2$, use 1662 ft^2

Thus,

Unusable Volume (gallons) = 1662 ft^2 x 0.33 ft. x 7.48 gal/ft^3 = 4102 gallons

Inventory Loss

1. Determine the CST volume inventory loss during the following event:

   - Main Feedwater Line Break

From FLB w/o Isolation, S/G "A", "B" and "C" Faulted, sheets 32 thru sheet 40 of Calculation 40.02, Attachment 8, the inventory loss is summed from pipes 15C, 16C and 17C. The results show the following:

- FLB w/o Isolation, S/G "A" Faulted

Pipes	Faulted S/G	Flow(gpm)
15C	A	496.50

- FLB w/o Isolation, S/G "B" Faulted

Pipes	Faulted S/G	Flow(gpm)
16C	B	495.80

- FLB w/o Isolation, S/G "C" Faulted

Pipes	Faulted S/G	Flow(gpm)
17C	C	496.60

Taking the worst CST inventory loss of the faulted S/Gs w/o isolation for 30 minutes during a feedwater line break yields:

Inventory Loss (gals) = 496.60 gpm x 30 mins = 14898 gallons

However, a 10% margin is added to this value for uncertainity until this value is documented and verified in a new version of the Calculation 40.02. Thus, the new version of calc. 40.02 will be an input to this calculation.

Including the 10% margin: 14898 + 1490 = **16388 gallons**

2. Determine the CST volume inventory loss during the following event:

- Main Steam Line Break

From MSLB w/SG Pressure = 300 psia and S/G "A", "B" and "C" Faulted, sheets 14 thru sheet 26 of calculation 40.02, Attachment 8, the inventory loss is taken from pipes 15C, 16C and 17C. The results show the following:

- SLB w/o Isolation, S/G "A" Faulted

Pipes	Faulted S/G	Flow(gpm)
15C	A	764.2

- SLB w/o Isolation, S/G "B" Faulted

Pipes	Faulted S/G	Flow(gpm)

16C B 763.0

- SLB w/o Isolation, S/G "C" Faulted

Pipes	Faulted S/G	Flow(gpm)
17C	C	763.5

Taking the worst CST inventory loss of the faulted S/Gs w/o isolation for 15 minutes during a main steam line break yields:

Inventory Loss (gals) = 764.2 gpm x 15 mins = **11463 gallons**

However, a 10% margin is added to this value for uncertainity until this value is documented and verified in a new version of the calculation 40.02. Thus, the new version of calc. 40.02 will be an input this this calculation.

Including the 10% margin: 11463 + 1146 = **12609 gallons**

Conclusion:

Summing up the volumes required for each sizing component as applicable; such as, decay heat, sensible heat, etc., the required volumes of the CST for each plant event is summarized below.

CST Volume Required (Gallons) per Plant Event

Plant Events	LOSP/Tornado	LOSP/Seismic	LOSP	SBLOCA	MSLB w/o LOSP	MSLB w/LOSP
CST Volume Required	142,440	142,440	124,716	125,061	145,460	137,670

Plant Events	LNFW w/o LOSP	Depressurizartion of Main Steam	MFWLB w/LOSP	Normal Cooldown	Tech. Spec Basis
CST Volume Required	148,625	141,766	141,449	154,054	124,716

List of Attachments:

A. Excel Spreadsheets; "Condensate Storage Tank Volume Requirements per Plant Events" and "Condensate Storage Tank Volume Sizing Basis"

B. MAP-121, Decay Heat Calculation Code, Version V01; Copyright 1979, 1988 Bechtel Power Corporation

C. Properties of Saturated Steam

D. Email dated 8/10/2012, From: Willie Jennings, To: Thomas H. Nesbit (FNP Operations); Subject: CST Sizing Verification – MSLB and MFWLB Events (Mass Flow Question)

E. Email dated 3/19/2012, From: James D. Andrachek (Westinghouse), To: Willie Jennings; Sublect: Farley CDBI – MSLB Case

F. Email dated 3/18/2012, From: James D. Andrachek (Westinghouse), To: Willie Jennings; Sublect: Farley CDBI – MSLB Case

G. Email dated 3/12/2012, From Thomas H. Nesbit (FNP Operations), To: Willie Jennings; Subject: RCP Heat Addition during Shutdown – CST Sizing for CDBI Response

Condensate Storage Tank Volume Requirements per Plant Events

6/14/2012

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					Plant Events								
	LOSP/Tornado	LOSP/Seismic	LOSP	SBLOCA	MSLB w/o LOSP	MSLB w/LOSP	LNFW w/o LOSP	Depressurization Main Steam	MFWLB w/LOSP Case "A"	MFWLB w/LOSP Case "B"	Normal Cooldown Mode 3/2 hrs	Tech Spec. Basis Mode 3 for 9 hrs.	CST Sizing Components
CST Sizing Components													
Decay Heat (@ 102% Power)	116893	116893	116893				116893	116893				116893	Decay Heat (@102% power)
Trip to Mode 3				39575	39575	39575			39575	39575	39575		Trip to Mode 3
Time to RHR Initiation				47708	36893	47708			47708	47708	47708		Time to RHR Initiation
Sensible Heat @ T avg 583 F, 100% power	0	0	0	29955	29955	29955	0	0	29955	29955	29955	0	Sensible Heat @ T avg 583 F, 100% power
Sensible Heat @ T avg 547 F, No Load													Sensible Heat @ T avg 547 F, No Load
RCP Heat	3721	3721	3721	3721	22326	3721	22941	20771	3721	3721	14881	3721	RCP Heat
PZR Heater Input	0	0	0	0	0	0	4689	0	0	0	0	0	PZR Heater Input
SG Refill No Load	0	0	0	0	0	0	0	0	0	0	0	0	SG Refill No Load
AFW Pumps Recirc Line Rupture	3000	3000	0	0	0	0	0	0	0	0	6000	0	AFW Pumps Recirc Line Rupture
Inst. Line Rupture	8694	8694	0	0	0	0	0	0	0	0	5803	0	Inst. Line Rupture
Condenser Hotwell Makeup	0	0	0	0	0	0	0	0	0	0	0	0	Condenser Hotwell Makeup
Min. Submergence - Vortex	10132	10132	0	0	0	0	0	0	0	0	10132	0	Min. Submergence - Vortex
Unusable Volume 4 inches from BOT	0	0	4102	4102	4102	4102	4102	4102	4102	4102	0	4102	Unusable Volume 4 inches from BOT
Inventory Loss due to MS/FW line break	0	0	0	0	11463	11463	0	0	14898	14898	0	0	Inventory Loss due to MS/FW line break
Inventory Loss due to MS/FW line break 10% margin					1146.3	1146.3			1489.8	1489.8			Inventory Loss due line break 10% margin
Total CST Volume Required:	142440	142440	124716	125061	145460	137670	148625	141766	141449	141449	154054	124716	**Total CST Volume Required:**

W (maximum protected volume of the CST) = 164,832 gallons (Reference 2 of DOEJ)

Condensate Storage Tank Volume Sizing Basis

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CST Sizing Components	Per FSAR 15.2.9 LOSP/Tornado	Per FSAR 15.2.9 LOSP/Seismic	Per FSAR 15.2.9 LOSP	Per FSAR 15.3.1 SBLOCA (Note 6)
Decay Heat (@102% power)	Decay heat based on 102% power at 2775MWt, 9 hours in Mode 3 steaming to the atmosphere. FSAR 15.2.9 and WCAP14722 section 6.2.9 makes no assumption regarding power level; therefore , it is assumed the unit is at 102% of 2775 MWt with 10 MWt of net RCP heat considered under RCP Heat.	Decay heat based on 102% power at 2775MWt, 9 hours in Mode 3 steaming to the atmosphere. FSAR 15.2.9 and WCAP14722 section 6.2.9 makes no assumption regarding power level; therefore , it is assumed the unit is at 102% of 2775 MWt with 10 MWt of net RCP heat considered under RCP Heat.	Decay heat based on 102% power at 2775MWt, 9 hours in Mode 3 steaming to the atmosphere. FSAR 15.2.9 and WCAP14722 section 6.2.9 makes no assumption regarding power level; therefore , it is assumed the unit is at 102% of 2775 MWt with 10 MWt of net RCP heat considered under RCP Heat.	Decay Heat at 102% power, 2775 MWT(100 %); at 2 hr and 6 hr of event.
Sensible Heat @ T avg 583 F, 100% power	No sensible heat since unit will be held at hot standby conditions through this duration.	No sensible heat since unit will be held at hot standby conditions through this duration.	No sensible heat since unit will be held at hot standby conditions through this duration.	Sensible heat based on Tavg of 583°F (577°F + 6°F)
Sensible Heat @ T avg 547 F, No Load	"same as above"	"same as above"		N/A
RCP Heat	No RCP w/LOSP; however, initial 10 MWt net pump heat input is assumed to decay in one hour.	No RCP w/LOSP; however, initial 10 MWt net pump heat input is assumed to decay in one hour.	No RCP w/LOSP; however, initial 10 MWt net pump heat input is assumed to decay in one hour.	FSAR analysis and WCAP 14722 assume LOSP therefore no RCPs w/LOSP; however, initial 10 MWt net pump heat input is assumed to decay in one hour.
SG Refill No Load	Per email from Thomas Nesbit, FNP Ops; from an accident perspective, there is no reason to refill the faulted SG. The faulted SG should be refilled at some point for equipment perservation rather than RCS cooling once RHR is aligned. Per WCAP -15097 Section 4.2.2.4.1, CST volume determination should conservatively consider SG re fill to no-load programmed,	"same as adjacent"	"same as adjacent"	"same as adjacent"
Pressurizer Heat Input	N/A	N/A	N/A	N/A
AFW Pumps Recirc Line Rupture	Only applies to seismic event or tornado missile. Volume per calc. BM-95-0961-001 Ver. 5	Only applies to seismic event or tornado missile. Volume per calc. BM-95-0961-001 Ver. 5	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.
Inst. Line Rupture	Only applies to seismic event or tornado missile. Volume per calc. BM-95-0961-001 Ver. 5	Only applies to seismic event or tornado missile. Volume per calc. BM-95-0961-001 Ver. 5	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.
Condenser Hotwell Makeup	Only applies to seismic event or tornado missile. Failure of line establishes the maximum protected CST volume of 166250 gals. Credible to postulate this failure concurrent with tornado or seismic event.	"same as adjacent"	"same as adjacent"	"same as adjacent"
Min. Submergence - Vortex	Due to any breach of the tank or connecting line that allows air beneath bladder. Applicable to Tornado Event	Due to any breach of the tank or connecting line that allows air beneath bladder. Applicable to Seismic Event.	Not credible to postulate this event concurrent with tornado or seismic event. Vortex N/A	Not credible to postulate this event concurrent with tornado or seismic event.
Unusable Volume 4 inches from BOT	N/A	N/A	Applicable w/ no min. submergence - vortex	Applicable w/ no min. submergence - vortex
Inventory Loss due to MS/FW line break	N/A	N/A	N/A	N/A

Notes:

5. FSAR 15.4.1, Sensitivity study assumes LOSP, no reference to AFW
6. FSAR 15.3.1,LOSP assumed, 1-MDAFW pump

				Per FSAR 15.2.13,					Attachment "A" DOEJ -FRSNC419117-M001 Ver 2
	Per FSAR 15.4.2.1	Per FSAR 15.4.2.1	Per FSAR 15.2.8	Depressurization	MFWLB w/LOSP (Note 2)	MFWLB w/LOSP (Note 3)	Mode 3/2 hrs	Tech Spec. Basis	Shee 3 of 3
CST Sizing Components	MSLB w/o LOSP	MSLB w/LOSP	LNEW w/o LOSP	Main Steam (Note 1)	Case "A"	Case "B"	and 4 hr cooldown to 350 F (Note 4)	Mode 3 for 9 hrs. (Note 4)	CST Sizing Components
Decay Heat (@ 102% power)	Based on Decay Heat at 102% power, 2831 at 2 hr and 5 hr of event. FSAR Table 15.4-23 (sht. 1 of 2) conseratively assumes 102% core thermal power.	Based on Decay Heat at 102% power, 2831 at 2 hr and 6 hr of event. FSAR Table 15.4-23 (sht. 1 of 2) conseratively assumes 102% core thermal power.	Per FSAR 15.2.8.2.1.A decay heat based on 102% NSSS power(2775 MWt plus 10 MWt net pump heat). However for this event, it is assumed RCP heat addition is 15MWt. Unit operates in hot standby conditions for 9 hours steaming to the atmosphere.	Decay heat based on 102% power at 2775MWt, 9 hours in Mode 3 steaming to the atmosphere. FSAR 15.2.9 and WCAP14722 section 6.2.9 makes no assumption regarding power level; therefore , it is assumed the unit is at 102% of 2775 MWt with 10 MWt of net RCP heat considered under RCP Heat.	Based on 102% power at 2775 MWt, 2hrs at hot standby conditions and 4 hours to hot shutdown (RHR cut-in at 350F) for 4 hours.	Based on 102% power at 2775 MWt, 2hrs at hot standby conditions and 4 hours to hot shutdown (RHR cut-in at 350F) for 4 hours.	Based on 102% power at 2775 MWt for 2 hr at hot standby conditions and 4 hours to hot shutdown (RHR cut-in at 350F) at 6 hr. of event.	Decay heat based on 102% power at 2775 MWt, 9 hours in Mode 3 steaming to the atmosphere per FSAR 9.2.6.3 and T.S. 3 7.6	Decay Heat (102%)
Sensible Heat @ T avg 583 F, 100% power	Sensible heat conservatively based on Tavg of 583°F (577°F + 6°F); FSAR 15.4.2.1.2.1.F	Sensible heat conservatively based on Tavg of 583°F (577°F + 6°F); FSAR 15.4.2.1.2.1.F	No sensible heat since unit will be held at hot standby conditions through this duration. Ref. Calc. BM-95-0961-001 Ver. 5	No sensible heat since unit will be held at hot standby conditions through this duration. Ref. Calc. BM-95-0961-001 Ver. 5	Sensible heat based on Tavg of 583°F (577°F + 6°F)	Sensible heat based on Tavg of 583°F (577°F + 6°F)	Sensible heat based on Tavg of 583°F (577°F + 6°F)	No sensible heat since unit will be held at hot standby conditions through this duration. Ref. Calc. BM-95-0961-001 Ver. 5	Sensible Heat @ T avg 583 F, 100% power
Sensible Heat @ T avg 547 F, No Load			"Same as Above"	"Same as Above"	N/A	N/A		N/A	Sensible Heat @ T avg 547 F, No Load
RCP Heat	Based on Net Heat Input of 10 MWt per WCAP-15097 and WCAP-14722. FSAR Section 15.4.2.1 does not assume a conservatively large RCP heat of 15MWt. Assume a cooldown rate of 50F/hr. for all RCPs operating from Tavg no-load to 350F. Also, include initial net heat input of 10MWt decaying over 1 hour. Operation of all three RCPs for the duration of the event is supported by emails from Westinghouse and FNP Ops.	No RCPs w/ LOSP; Added 10MWt net heat input decayed over one (1) hr.	Per FSAR 15.2.8.2.1.A, 3 RCPs operating for approx. 10 mins to reach RCS equalibiram than 1 RCP operates for remainder of 9 hours in hot standby condition. RCP heat also includes the initial 15 MWt conservatively assumed per the FSAR before reactor trip and this heat is assumed to decay in one (1) hour.	FSAR 15.2.13 nor WCAP 14722, section 6.2.13 makes assumptions regarding RCP operation, thus it is assumed that 3 RCPs operating for approx. 10 mins to reach RCS equalibiram than 1 RCP operates for remainder of 9 hours in hot standby condition. Also assumed, RCP heat includes the initial 10 MWt net RCP heat input before reactor trip and this heat is assumed to decay in one (1) hour.	No RCPs w/ LOSP; FSAR indicates analysis assumes LOSP.However, 10 MWt net RCP heat input is added and decayed over 1 hr.	No RCPs w/ LOSP; FSAR indicates analysis assumes LOSP.However, 10 MWt net RCP heat input is added and decayed over 1 hr.	Based on 1 RCP in operation for the duration of the event, 6 hrs. plus 10MWt net RCP heat added and decayed over one(1) hr.	Per FSAR 9.2.6.3, event concurent with LOSP; however, assume net heat input of 10 MWt due to RCPs at being of the event decays in 1 hour.	RCP Heat
SG Refill No Load	Per email from Thomas Nesbit, FNP Ops; from an accident perspective, there is no reason to refill the faulted SG. The faulted SG should be refilled at some point for equipment preservation rather than RCS cooling once RHR is aligned. Per WCAP -15097 Section 4.2.2.4.1, CST volume determination should conservatively consider SG re fill to no-load programmed,	"same as adjacent"	"same as adjacent"	"same as adjacent"	Per email from Thomas Nesbit, FNP Ops; from an accident perspective, there is no reason to refill the faulted SG. The faulted SG should be refilled at some point for equipment preservation rather than RCS cooling once RHR is aligned. Per WCAP - 15097 Section 4.2.2.4.1, CST volume determination should conservatively consider SG re fill to no-load programmed. Per meeting with SNC licensing, it was determined to remove the S/G refill volume since it is indicated as a conservatism in the WCAP 15097.	Per email from Thomas Nesbit, FNP Ops; from an accident perspective, there is no reason to refill the faulted SG. The faulted SG should be refilled at some point for equipment preservation rather than RCS cooling once RHR is aligned. Per WCAP - 15097 Section 4.2.2.4.1, CST volume determination should conservatively consider SG re fill to no-load programmed. Per meeting with SNC licensing, it was determined to remove the S/G refill volume since it is indicated as a conservatism in the WCAP 15097.	Per email from Thomas Nesbit, FNP Ops; from an accident perspective, there is no reason to refill the faulted SG. The faulted SG should be refilled at some point for equipment preservation rather than RCS cooling once RHR is aligned. Per WCAP - 15097 Section 4.2.2.4.1, CST volume determination should conservatively consider SG re fill to no-load programmed. Per meeting with SNC licensing, it was determined to remove the S/G refill volume since it is indicated as a conservatism in the WCAP 15097. However, S/G Refill Vol. is included in FSAR 9.2.6.	No S/G Refill volume required since no line break has occurred in main steam or feedwater.	SG Refill No Load
AFW Pumps Recirc Line Rupture	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	No AFW Pump Recirc. line failure. Not credible to postulate this event concurrent with tornado or seismic event. However, line failure is included in FSAR 9.2.6.	Not credible to postulate this event concurrent with tornado or seismic event.	AFW Pumps Recirc Line Rupture
Inst. Line Rupture	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	No AFW Pump Recirc. line failure. Not credible to postulate this event concurrent with tornado or seismic event. However, line failure is included in FSAR 9.2.6.	Not credible to postulate this event concurrent with tornado or seismic event.	Inst. Line Rupture
Condenser Hotwell Makeup	Only applies to seismic event or tornado missile. Failure of line establishes the maximum protected CST volume of 166250 gals. Credible to postulate this event concurrent with tornado or seismic event.	"same as adjacent"	"same as adjacent"	"same as adjacent"	"same as adjacent"	"same as adjacent"	"same as adjacent"	"same as adjacent"	Condenser Hotwell Makeup
Min. Submergence - Vortex	Due to any breach of the tank or connecting line that allows air beneath bladder. Not credible to postulate this event concurrent with tornado or seismic event.	Due to any breach of the tank or connecting line that allows air beneath bladder. Not credible to postulate this event concurrent with tornado or seismic event.	Due to any breach of the tank or connecting line that allows air beneath bladder. Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event.	Not credible to postulate this event concurrent with tornado or seismic event; however, minimum submergence added as margin.	Not credible to postulate this event concurrent with tornado or seismic event; therefore vortex n/a.	Min. Submergence - Vortex
Unusable Volume 4 inches from BOT	Applicable w/ no min. submergence - vortex	Applicable w/ no min. submergence - vortex	Applicable w/ no min. submergence - vortex	Applicable w/ no min. submergence - vortex	Applicable w/ no min. submergence - vortex	Applicable w/ no min. submergence - vortex	N/A	Applicable w/ no min. submergence - vortex	Unusable Volume 4 inches from BOT
Inventory Loss due to MS/FW line break	Based on calculation 40.02 ver. 3 Att, 8 sheets 14 - 26 with FNP Operation isolating AFW to faulted SG within 15 mins.	Based on calculation 40.02 ver. 3 Att, 8 sheets 14 - 26 with FNP Operation isolating AFW to faulted SG within 15 mins.	No feedwater line break is considered, only loss of normal feedwater due to pump, valve, Etc. malfunction	No Feedwater or mainsteam line break assumed.	Based on calc. 40.02 ver. 3.0 Att. 8 sheets 32 - 40 w/ FNP Ops. Isolation of AFW to Faulted SG within 30 mins.	Based on calc. 40.02 ver. 3.0 Att. 8 sheets 32 40 w/ FNP Ops. Isolation of AFW to Faulted SG within 30 mins.	No Feedwater or mainsteam line break assumed.	No Feedwater or mainsteam line break assumed.	Inventory Loss due to MS/FW line break
Inventory Loss due to MS/FW line break plus 10% margin	Applicable	Applicable			Applicable	Applicable			Inventory Loss plus 10% margin

Notes:

1. Per FSAR 15.2.13, Main Steam Line Depressurization - No rupture of MS line, No LOSP, AFW credited and unit held at hot standby coniitions. Per WCAP 14722, the core response to this event has been evaluated and shown to be bounded by the core response to a rupture of a main steam line
2. FSAR 15.4.2.2, AFW initiated 10 mins after Rx trip, 102% pwr., Per FSAR 6.5.3 time to isolate faulted SG is 30 mins.
3. FSAR 15.4.2.2, AFW 1 min. after LL level signal. Per FSAR 6.5.3 the time to isolate the fautled SG is 30 mins.
4. T.S. B.3.7.6 LCO, FSAR 9.2.6.3, A-181010 3.21.2.2