Serial No. 06-096
Docket No. 50-423

ATTACHMENT 4

SUPPLEMENT TO PROPOSED TECHNICAL SPECIFICATIONS CHANGE RECIRCULATION SPRAY SYSTEM

CALCULATION, US (B)-341, REV. 4, CCN 1, "CONTAINMENT ATMOSPHERE IODINE REMOVAL COEFFICIENTS"

(REDACTED VERSION – NON-PROPRIETARY)

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3

bc: (*paper copies as noted; remainder electronic distribution)
Ms. M. B. Bennett – IN2SE
Mr. S. E. Scace – MPS 475/5
Ms. L. M. Cuoco – MPS 475/5
Mr. T. L. Breene - KPS
Mr. P. A. Kemp – NAPS
Mr. B. A. Garber - SPS
Mr. D.W. Dodson – MPS 475/5
Mr. P. R. Willoughby – IN2SE
Mr. D. J. Leon – MPS 475/3
Mr. B. A. Krauth – MPS 475/5
Licensing File - GOV 02-54B*
MSRC/NOB Coordinator - IN2SE
Records Management - (bc original) - IN-GW*

Concurrence:

E. S. Grecheck	____________________
K. L. Basehore	____________________
D. M. Bucheit	____________________
C. L. Funderburk	____________________
D. A. Sommers	____________________
J. A. Price/MPS	____________________

Verification of Accuracy:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Action Plan:

1. Implementation Plan – see AR 05004067

Required Changes to the UFSAR or QA Topical Report:

1. None

Millstone Concurrence:

S. E. Scace	____________________
D. W. Dodson	____________________
P. E. Grossman	____________________
W. J. Eakin	____________________
M. S. Kai	____________________
P. F. L'Heureux	____________________
M. D. Legg	____________________
R. E. Deconto	____________________
J. L. Wheeler	____________________

Deliverable	Identification Number	Revision Number	Confidentiality Status	Transmittal Status
Calculation Temp / Press Profiles	US(B)-273	7	Nonconfidential	Previously Transmitted
Calculation	US(B)-341	4 plus CCN 1	Nonconfidential	Enclosed
Calculation	US(B)-372	0	**Confidential**	Enclosed(1)
Technical Evaluation	M3-EV-04-0014	0	Nonconfidential	Enclosed
Technical Evaluation	M3-EV-04-0015	0	Nonconfidential	Enclosed
Technical Evaluation	M3-EV-04-0032	0	Nonconfidential	Enclosed
Engineering Record Correspondence	25212-ER-05-0023	0	N/A DNC Product	Enclosed
US(B)-273 LOCTIC Data Deck Run	R2004P07		Nonconfidential	On CD at MPS
US(B)-273 LOCTIC Data Deck Run	R2004P01A		Nonconfidential	On CD at MPS
US(B)-273 LOCTIC Data Deck Run	R2004P08		Nonconfidential	On CD at MPS
US(B)-273 LOCTIC Data Deck Run	R2004T01		Nonconfidential	On CD at MPS
US(B)-273 LOCTIC Data Deck Run	R2004T08		Nonconfidential	On CD at MPS

Note 1: Shaw Group / Stone & Webster has not yet provided a redacted copy of this calculation for transmittal

Approved 1/24/02 Effective 1/28/02

TOTAL PAGES: 14

CALCULATION CHANGE NOTICE (CCN)

AFFECTED CALCULATION/PLANT ☐ MP1 ☐ MP2 ☒ MP3 ☐ GENERAL			
CALCULATION NO. N/A		REVISION NO. 4	CHANGE NO. 001
VENDOR CALCULATION NO.: 17273.09-US(B)-341		VENDOR NAME: Stone & Webster, Inc.	
CALCULATION TITLE: Containment Atmosphere Iodine Removal Coefficients			
REFERENCE N/A	50.59 Evaluation or Screen Attached ☐YES ☒NO	CCN Supports DCR/MMOD/EE? ☒YES ☐NO Ref. No.: DCR M3-04004	CCN Supports Other Process? ☐YES ☒NO Reference:

REASON FOR CHANGE

1. To incorporate the proposed RSS pump start signal which is at or near the RWST Low-Low Level in response to NRC Generic Safety Issue GSI-191 (Refs. 5 and 6). The various iodine removal coefficients calculated in Rev. 4 are re-analyzed using the updated containment conditions (Ref. 1) due to the proposed RSS pump start time.
2. To include additional iodine removal coefficients. The elemental iodine removal coefficients for the simultaneous quench and recirculation spray operating condition and for the recirculation spray only operating condition are calculated. Additionally, the particulate iodine removal coefficient for the recirculation spray only operating condition is calculated.

DESCRIPTION OF CHANGE & TECHNICAL JUSTIFICATION

The iodine removal coefficients for the various cases are recalculated or newly added as shown in Tables 4, 5, and 6.

NUCLEAR INDICATOR ☒ CAT I ☐ RWQA ☐ SBOQA ☐ FPQA ☐ ATWSQA ☐ NON-QA	AFFECTED CALC PAGES N/A

Approvals	(Print & Sign Name)		
Preparer: Joon Cho			Date: 3/15/05
Interdiscipline Reviewer: N/A		Discipline: N/A	Date: N/A
Interdiscipline Reviewer: N/A		Discipline: N/A	Date: N/A
Independent Reviewer: Chris Metcalfe		"No Comments"	Date: 3/15/05
Engineering Approver: Joe Green			Date: 3/15/05

Installation Verification

☐ Calculation represents the installed configuration and approved licensing condition (Calculation of Record)

☐ N/A does not affect plant configuration (e.g., study, hypothetical analysis, etc.)

Preparer/Design Engineer: (Print and Sign) Date:

If applicable:

Superseded by Rev. _____ CCN___

Preparer/Design Engineer: (Print and Sign) Date:

Approved 11/17/03 Effective 11/21/03

PassPort DATABASE INPUTS CHANGE

Calculation Number: N/A Revision: N/A

Vendor Calculation Number/Other 17273.09-US(B)-341 Revision: 4

CCN NO.: 001 Calc Voided: ☐ Yes ☒ No

Superseded By: N/A Supersedes: N/A

CHANGES (Change Codes [CC]: "A" = Add; "D" = Delete)

Discipline (Up to 10) CC [A]: N, L, Q, S, Z

CC	Unit M1, M2, M3	Project Reference (EWA)	Component Id	Computer Code	Rev. No./ Level No.
	M3			N/A	N/A

CC	PMMS CODES*			Reference Calculation	Rev No.	CCN
	Structure	System	Component			
	CS	RSS	N/A	12179-US(B)-273	7	N/A
				108788-US(B)-371	0	N/A
				03705-US(B)-360	0	02
				03703.1971-US(B)-350	2	N/A

*The codes required must be alpha codes designed for structure, system and component.

NOTE: Avoid multiple item references on a line, e.g., LT 1210 A-D requires four separate lines.

CC	Reference Drawing	Sheet	Rev. No.
	N/A	N/A	N/A

Comments:

Referenced By Calculation	Impact Y	Impact N	AR Reference/Calc Change Ref.
M3ASTLOCA-04052R3	Y		05000969-01
M3ASTREA-04054R3		N	
M3ODLOCA-04084R3		N	
M3TSCLOCA-04105R3	Y		05000969-01
M3-LOCA94-01048R3		N	
88-019-00096RA		N	
03703.1971-US(B)-349R1		N	

STONE & WEBSTER, INC.

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O NO. 17273.09	DIVISION AND GROUP US(B)	CALCULATION NO. 341	REVISION NUMBER 4	CCN # 001 PAGE 3

REVIEW STATEMENT FOR SAFETY RELATED CALCULATIONS

Review of this calculation was based on the methods below:

			Initial Upon Completion
1)	Review of:		
a)	Inputs to ensure that they have been properly selected and correctly used in the calculation. (Check One)		
	i) Limited review (provide justification)	☐	
	ii) Line by line review	☒	lgm
b)	Assumptions to assure their validity and need for later confirmation.	☒	lgm
c)	Methodology to assure the appropriateness of the overall approach, its implementation, and the correctness of the specific equations utilized.		
	i) Limited review (provide justification)	☐	
	ii) Line by line review	☒	lgm
d)	Results to ensure reasonableness and accuracy	☒	lgm
e)	If alternate calculation is performed to verify c) and d) check here and attach calculation as an appendix	☐	
2)	Check of Calculation (Check One)		
a)	Complete numerical check	☒	lgm
b)	Numerical check of critical items (state items and justification below)	☐	
3)	Administrative check of format and content	☒	lgm
4)	Comments/Justification		

Review Methods Selected as Indicated Above

Chris Metcalfe *[signature]* Reviewer	3/15/05 Date
Chris Metcalfe *[signature]* Independent Reviewer	3/15/05 Date
Joe Green *[signature]* Lead concurrence	3/15/05 Date

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O NO. 17273.09	DIVISION AND GROUP US(B)	CALCULATION NO. 341	REVISION NUMBER 4	CCN # 001 PAGE 4

PURPOSE OF CCN 001 TO REV. 4

The purpose of CCN 001 to Rev. 4 is:

1. To incorporate the proposed RSS pump start signal which is at or near the RWST Low-Low Level in response to NRC Generic Safety Issue GSI-191 (Refs. 5 and 6). The various iodine removal coefficients calculated in Rev. 4 are re-analyzed using the updated containment conditions (Ref. 1) due to the proposed RSS pump start time.

2. To include additional iodine removal coefficients. The elemental iodine removal coefficients for the simultaneous quench and recirculation spray operating condition and for the recirculation spray only operating condition are calculated. Additionally, the particulate iodine removal coefficient for the recirculation spray only operating condition is calculated.

CONFIRMATION REQUIREMENT

This CCN 001 does not require confirmation.

COMPUTER PROGRAM

No computer program was used in this CCN 001.

REFERENCE/DESIGN INPUTS

1. S & W Calculation 12179-US(B)-273, Rev. 7, "Containment Pressure and Temperature Analysis Following a LOCA", 09/29/04.
2. S & W Calculation 108788-US(B)-371, Rev. 0, "Recirculation Spray Coverage", 12/06/04.
3. S & W Calculation 03705-US(B)-360, Rev. 0, CCN 02, "Quench Spray and Containment Recirculation System Thermal Efficiency", 3/31/98.
4. Plot R5943, "Spatial Droplet Size Distribution of 47-0714-17 (1713A) Nozzle Applying Surface Area Correction and Spraying Water at 10 psig under Laboratory Conditions" A. M. Shah, Spraco, Inc., Nashua, NH (8-14-81) (Attachment A).
5. Engineering Record Correspondence Number, 25212-ER-04-0034, Transmittal of Design Input to Support Containment Reanalysis - RSS Pump Start on RWST Low-Low Level Signal.
6. Design Change Record Number, M3-04004, Change RSS Pump Start Signal from Timer to Start on RWST Low-Low Level Signal.
7. S & W Calculation 03703.1971-US(B)-350, Rev. 2, "Trisodium Phosphate System for Sump pH Control", 5/8/98.
8. NUREG/CR-5950, "Iodine Evolution and pH control", December 1992.

ASSUMPTIONS

1. The wetted surface area in the sprayed region is conservatively estimated as 50% of heat sink surface area in the sprayed region, considering remaining 50% of heat sink surface areas are not directly wetted by sprayed waters. Additionally, the heat sink surface area in the sprayed region is estimated as the total containment heat sink surface area multiplied by the quench spray coverage fraction.
2. For bounding LOCA dose calculation, the minimum constant quench and recirculation spray flow rates (i.e., 3,870 gpm and 2,581 gpm) are selected respectively among the various LOCA cases analyzed in Ref. 1, while the quench and recirculation spray operating time intervals are determined based on the maximum ESF assumption. Note that the minimum iodine removal coefficients and minimum spray coverage in conjunction with the minimum quench spray operating time interval result in the most conservative LOCA dose calculation.
3. The average mass-mean diameter of the sprayed droplets from two different spray headers with different drop size distribution is approximated as flow rate weighted average of each mass-mean diameter. Since the calculated elemental iodine removal coefficient with average mass-mean diameter is much higher than the limited value of 20 hr^{-1} (refer to page 9), this approximation is considered to be insignificant.

METHODOLOGY

Refer to the methodology section 5.0 presented in Rev. 4.

CALCULATION

COEFFICIENT FOR ELEMENTAL IODINE REMOVAL THROUGH WALL DEPOSITION

Unsprayed Region:

For conservatism, the elemental iodine removal coefficient through wall deposition in the unsprayed region is only calculated for quench spray only operating condition. The major wetted areas in the unsprayed region are the total surface areas of the containment liner and dome (refer to pages 15 through 17 of Rev. 4). The LOCTIC run outputs in Ref. 1 show that the containment liner and dome surfaces (i.e., heat sink cases 7, 8, and 10) become dry (i.e., no steam condensing on the surface) near 2,000 seconds after the accident. Thus, the containment liner and dome are conservatively considered to be wetted surface area in the unsprayed region of the containment atmosphere for the first 1,800 seconds only. The elemental iodine removal due to wall deposition in the unsprayed region of the containment atmosphere will be valid from time 0 second to 1,800 seconds only.

From Ref. 1, the total surface area of the containment liner and dome ($A_{unsprayed}$)
= 34,827 + 22,325 + 30,852
= 88,004 ft^2.
From Rev. 4, page 18, the unsprayed containment volume ($V_{unsprayed}$) = **1,183,800 ft^3**

Therefore, $\lambda_{wall\ deposition\ (unsprayed)}$ = 16.08 (ft/hr) x 88,004 (ft^2) /1,183,800 (ft^3)
= **1.2 hr^{-1} (valid between $0 \le t \le$ 1,800 sec)**

Sprayed Region:

Since the wetted surface area in the sprayed region ($A_{sprayed}$) is not available, it is conservatively approximated based on spray coverage fraction (f_{spray}) as follows (refer to Assumption 1):

$A_{sprayed}$ = [Total heat sink surface areas] x f_{spray} x 0.5**

Total heat sink surface area = 933,775 ft^2 (Ref. 1)
$f_{spray} = V_{sprayed} / V_{total}$
V_{total} = 2,350,000 ft^3 (Rev. 4, page 17)

** 50% of heat sink surfaces in the sprayed region is assumed to be wetted by spray.

Therefore, $\lambda_{wall\ deposition\ (sprayed)}$ = 16.08 (ft/hr) x [933,775 (ft^2) /2,350,000 (ft^3)] x 0.5
= **3.2 hr^{-1} (valid throughout entire transient of spray operation)**

The elemental iodine removal due to wall deposition in the sprayed region of the containment atmosphere is applicable over the entire spray operating (i.e., quench only, quench and recirculation, and recirculation only) duration.

DETERMINATION OF ELEMENTAL IODINE REMOVAL RATE CONSTANT DUE TO SURFACE DEPOSITION FOR THE SBLOCA CASES WITHOUT SPRAY ACTUATION FOR 30 MINUTES

The calculated **1.2 hr^{-1}** of $\lambda_{wall\ deposition\ (no\ spray)}$ in Rev. 4, page 30 remains valid for all SBLOCA cases with 2" or greater break sizes without spray actuation for 30 minutes.

ELEMENTAL IODINE SPRAY REMOVAL COEFFICIENTS

Quench Spray Only Operating:

The required parameters for the elemental iodine removal coefficient through quench spray are conservatively calculated as follows:

F (volumetric quench spray flow rate) = 3,870 gpm (Ref. 1, LOCTIC run R2004T01: minimum flow rate during quench spray operation)
=► 3,870 (gpm) x 60 (min/hr) x 0.13368 (ft^3/gal) = 31,040 ft^3/hr

V (sprayed containment free volume) = **1,166,200 ft^3** (Rev. 4, page 15)

D (mass-mean diameter of the spray droplets) = 1,100 μ (Rev. 4, pages 21 and 22)
= 3.61 x 10^{-3} ft

t (time of fall of droplets) = 2 x 10^{-3} hr (conservatively assumed from Rev.4, page 25)

K_g (gas phase mass transfer coefficient) = 900 ft/hr (conservatively assumed from Rev. 4, page 26).

Thus, the coefficient for elemental iodine removal through quench spray (λ_{spray})
= {6 x 900 (ft/hr) x (2 x 10^{-3}) (hr) x 31,040 (ft^3/hr)} / {1,166,200 (ft^3) x (3.61 x 10^{-3}) (ft)}
= 80.0 hr^{-1}

Since λ_{spray} is limited to 20 hr^{-1}(Rev. 4, page 13), λ_{spray} is set to **20 hr^{-1}**.

Recirculation Spray Only Operating:

Since the sump solution pH is above 7.0 during the entire period of recirculation spray operation (Ref. 7), the iodine removal by the recirculation spray is considered to be valid. Note that the iodine re-evolution won't occur when the sump pH is equal or higher than 7.0 (Ref. 8).

The required parameters for the elemental iodine removal coefficient through recirculation spray are conservatively calculated as follows:

F (volumetric recirculation spray flow rate) = 2,581 gpm (Ref. 1, LOCTIC run R2004T08: minimum flow rate during recirculation spray operation)
=► 2,581 (gpm) x 60 (min/hr) x 0.13368 (ft^3/gal) = 20,702 ft^3/hr

V (sprayed containment free volume) = **1,102,000 ft^3** (Ref. 2, page 35)

D (mass-mean diameter of the spray droplets) = 0.00526 ft (see below)

In order to determine the mass-mean diameter, the spray droplet size distribution data which is based on pressure drop across the nozzle is required. The LOCTIC run R2004T08 (PSDER with Sequencer failure case) shows that the spray flow rates are 1,927 gpm for one recirculation header and 654 gpm for other recirculation header which are corresponding to the nozzle pressure drop of 10 psid and 2.75 psid, respectively (Ref. 3). The spray droplet size distribution data for 10 psid and 2.75 psid cases (see Tables 1 and 2) are obtained from Attachment A (Ref. 4) and Ref. 3, Table 1, respectively.

The mass-mean diameters for 10 psid and 2.6 psid cases are calculated from Tables 1 and 2 as follows:

STONE & WEBSTER, INC.

CALCULATION SHEET

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O NO. 17273.09	DIVISION AND GROUP US(B)	CALCULATION NO. 341	REVISION NUMBER 4	CCN # 001 PAGE 8

Table 1: Drop Size Distribution for 10 psid

f_i	D_i, cm	$f_i \times D_i^4$, cm^4	$f_i \times D_i^3$, cm^3
0.001	0.0125	2.4414E-11	1.9531E-09
0.002	0.0175	1.8758E-10	1.0719E-08
0.013	0.0225	3.3318E-09	1.4808E-07
0.049	0.0275	2.8024E-08	1.0190E-06
0.105	0.0325	1.1714E-07	3.6045E-06
0.101	0.0375	1.9973E-07	5.3262E-06
0.120	0.0425	3.9150E-07	9.2119E-06
0.100	0.0475	5.0907E-07	1.0717E-05
0.076	0.0525	5.7737E-07	1.0997E-05
0.064	0.0575	6.9960E-07	1.2167E-05
0.034	0.0625	5.1880E-07	8.3008E-06
0.050	0.0675	1.0380E-06	1.5377E-05
0.053	0.0725	1.4643E-06	2.0197E-05
0.052	0.0775	1.8759E-06	2.4205E-05
0.041	0.0825	1.8993E-06	2.3022E-05
0.027	0.0875	1.5827E-06	1.8088E-05
0.019	0.0925	1.3910E-06	1.5038E-05
0.020	0.0975	1.8074E-06	1.8537E-05
0.012	0.1025	1.3246E-06	1.2923E-05
0.010	0.1075	1.3355E-06	1.2423E-05
0.006	0.1125	9.6108E-07	8.5430E-06
0.004	0.1175	7.6245E-07	6.4889E-06
0.003	0.1225	6.7556E-07	5.5148E-06
0.006	0.1275	1.5856E-06	1.2436E-05
0.005	0.1325	1.5411E-06	1.1631E-05
0.006	0.1375	2.1447E-06	1.5598E-05
0.004	0.1425	1.6494E-06	1.1575E-05
0.003	0.1475	1.4200E-06	9.6271E-06
0.002	0.1525	1.0817E-06	7.0932E-06
0.000	0.1575	0.0000E+00	0.0000E+00
0.001	0.1625	6.9729E-07	4.2910E-06
0.000	0.1675	0.0000E+00	0.0000E+00
0.003	0.1725	2.6563E-06	1.5399E-05
0.002	0.1775	1.9853E-06	1.1185E-05
0.000	0.1825	0.0000E+00	0.0000E+00
0.002	0.1875	2.4719E-06	1.3184E-05
0.000	0.1925	0.0000E+00	0.0000E+00
0.002	0.1975	3.0430E-06	1.5407E-05
0.001	0.2025	1.6815E-06	8.3038E-06
0.001	0.2225	2.4509E-06	1.1015E-05
0.001	0.2275	2.6787E-06	1.1775E-05
0.002	0.3025	1.6747E-05	5.5361E-05
	Σ	6.2997E-05	4.5574E-04

Table 2: Drop Size Distribution for 2.75 psid

f_i	D_i, cm	$f_i \times D_i^4$, cm^4	$f_i \times D_i^3$, cm^3
0.103815	0.022429	2.6272E-08	1.1713E-06
0.106023	0.026824	5.4889E-08	2.0463E-06
0.099318	0.030487	8.5794E-08	2.8142E-06
0.094933	0.034882	1.4054E-07	4.0291E-06
0.099787	0.042939	3.3922E-07	7.9001E-06
0.098849	0.051729	7.0780E-07	1.3683E-05
0.097941	0.065647	1.8189E-06	2.7708E-05
0.098437	0.086889	5.6108E-06	6.4574E-05
0.102074	0.122782	2.3198E-05	1.8894E-04
0.098823	0.250238	3.8750E-04	1.5485E-03
	Σ	4.1948E-04	1.8614E-03

D_{10} (mass-mean diameter for 10 psid) = 6.2997 x 10^{-5} /4.5574 x 10^{-4}
= 0.1383 cm

$D_{2.75}$ (mass-mean diameter for 2.75 psid) = 4.1948 x 10^{-4} /1.8614 x 10^{-3}
= 0.2254 cm

Therefore, the average mass-mean diameter of the spray droplets for both headers
= 0.1383 x (1,927/2,581) + 0.2254 x (654/2,581)
= 0.1604 cm (or 1,604 μ)
= 0.00526 ft

t (time of fall of droplets) = 1.2 x 10^{-3} hr (see below)

The terminal velocity for the 1,604 μ diameter droplet (u_{1604}) is conservatively approximated as Rev. 4, page 25,
U_{1604} = 40,000 (ft/hr) x $(1{,}604)^{1.515/1.485}$ / $(880)^{1.515/1.485}$
= 73,799 ft/hr

h (fall height of the spray droplets) = 90.42 ft (Rev. 4, page 15)

Therefore, the droplet fall time = 90.42 (ft) / 73,799 (ft/hr) = 0.0012 hr

K_g (gas phase mass transfer coefficient) = 900 ft/hr (conservatively assumed from Rev. 4, page 26)

Thus, the coefficient for elemental iodine removal through recirculation spray (λ_{spray})
= {6 x 900 (ft/hr) x (1.2 x 10^{-3}) (hr) x 20,702 (ft^3/hr)} / {1,102,000 (ft^3) x (3.61 x 10^{-3}) (ft)}
= 33.7 hr^{-1}
Since λ_{spray} is limited to 20 hr^{-1}(Rev. 4, page 13), λ_{spray} is set to **20 hr^{-1}**.

Simultaneous Quench and Recirculation Spray Operating:

The required parameters for the elemental iodine removal coefficient through quench and recirculation spray are conservatively calculated as follows:

F (volumetric combined quench and recirculation spray flow rate)
= 3,870 gpm (Ref. 1, LOCTIC run R2004T01: minimum flow rate during quench spray operation) +
2,581 gpm (Ref. 1, LOCTIC run R2004T08: minimum flow rate during recirculation operation)
= 6,451 gpm
=► 6,451 (gpm) x 60 (min/hr) x 0.13368 (ft^3/gal) = 51,742 ft^3/hr

V (sprayed containment free volume) = **1,515,858 ft^3** (Rev. 4, page 27)

D (mass-mean diameter of the spray droplets) = 0.00427 ft (see below)

The flow rate weighted average mass-mean diameter of the spray droplets
= 0.11 x {3,870/ (3,870 + 2,581)} + 0.1604 x {2,581/ (3,870 + 2,581)}
= 0.1302 cm (or 1,302 μ)
= 0.00427 ft

t (time of fall of droplets) = 1.2 x 10^{-3} hr (conservatively assumed as recirculation spray droplets)

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O NO. 17273.09	DIVISION AND GROUP US(B)	CALCULATION NO. 341	REVISION NUMBER 4	CCN # 001 PAGE 10

K_g (gas phase mass transfer coefficient) = 900 ft/hr (conservatively assumed from Rev. 4, page 26)

Thus, the coefficient for elemental iodine removal through quench and recirculation sprays (λ_{spray})
= {6 x 900 (ft/hr) x (1.2 x 10^{-3}) (hr) x 51,742 (ft^3/hr)} / {1,515,858 (ft^3) x (4.27 x 10^{-3}) (ft)}
= 51.8 hr^{-1}

Since λ_{spray} is limited to 20 hr^{-1}(Rev. 4, page 13), λ_{spray} is set to **20 hr^{-1}**.

PARTICULATE IODINE SPRAY REMOVAL COEFFICIENTS

Quench Spray Only Operating:

The required parameters for the particulate iodine removal coefficient through quench spray are conservatively calculated as follows:

F (volumetric quench spray flow rate) = 3,870 gpm (Ref. 1, LOCTIC run R2004T01: minimum flow rate during quench spray operation)
=► 3,870 (gpm) x 60 (min/hr) x 0.13368 (ft^3/gal) = 31,040 ft^3/hr

h (fall height of the spray droplets) = 101.67 ft (Rev. 4, page 15)

V (sprayed containment free volume) = **1,166,200 ft^3** (Rev. 4, page 15)

Thus, the coefficient for particulate iodine removal through quench spray ($\lambda_{particulate}$)
= {3 x 101.67 (ft) x 31,040 (ft^3/hr)} / {2 x 1,166,200 (ft^3)} x (E/D) (ft^{-1})
= 4.059 x (E/D) hr^{-1}
=► 4.059 x 3.048 = **12.37 hr^{-1} (for decontamination factor (DF) < 50)**
=► 4.059 x 0.3048 = **1.24 hr^{-1} (for DF ≥ 50)**

Note that DF is defined as C_p (0) / C_p (t), where C_p (0) is the initial concentration of particulate iodine in the containment atmosphere and C_p (t) is the concentration at time t.

Recirculation Spray Only Operating:

The required parameters for the particulate iodine removal coefficient through recirculation spray are conservatively calculated as follows:

F (volumetric quench spray flow rate) = 2,581 gpm (Ref. 1, LOCTIC run R2004T08: minimum flow rate during recirculation spray operation)
=► 2,581 (gpm) x 60 (min/hr) x 0.13368 (ft^3/gal) = 20,702 ft^3/hr

h (fall height of the spray droplets) = 90.42 ft (Rev. 4, page 15)

V (sprayed containment free volume) = **1,102,000 ft^3** (Ref. 2, page 35)

Thus, the coefficient for particulate iodine removal through recirculation spray ($\lambda_{particulate}$)
= {3 x 90.42 (ft) x 20,702 (ft^3/hr)} / {2 x 1,102,000 (ft^3)} x (E/D) (ft^{-1})
= 2.548 x (E/D) hr^{-1}
=► 2.548 x 3.048 = **7.77 hr^{-1} (for decontamination factor (DF) < 50)**
=► 2.548 x 0.3048 = **0.78 hr^{-1} (for DF ≥ 50)**

Simultaneous Quench and Recirculation Spray Operating:

The required parameters for the particulate iodine removal coefficient through quench and recirculation spray are conservatively calculated as follows:

F (volumetric combined quench and recirculation spray flow rate)
= 3,870 gpm (Ref. 1, LOCTIC run R2004T01: minimum flow rate during quench spray operation) +
2,581 gpm (Ref. 1, LOCTIC run R2004T08: minimum flow rate during recirculation operation)
= 6,451 gpm
=▶ 6,451 (gpm) x 60 (min/hr) x 0.13368 (ft^3/gal) = 51,742 ft^3/hr

h (fall height of the spray droplets) = 90.42 ft (Rev. 4, page 15: minimum height is assumed)

V (sprayed containment free volume) = **1,515,858 ft^3** (Rev. 4, page 27)

Thus, the coefficient for particulate iodine removal through quench and recirculation spray ($\lambda_{particulate}$)
= {3 x 90.42 (ft) x 51,742 (ft^3/hr)} / {2 x 1,515,858 (ft^3)} x (E/D) (ft^{-1})
= 4.630 x (E/D) hr^{-1}
=▶ 4.630 x 3.048 = **14.11 hr^{-1} (for decontamination factor (DF) < 50)**
=▶ 4.630 x 0.3048 = **1.41 hr^{-1}** (for DF ≥ 50)

DETERMINATION OF TIME INTERVAL FOR SPRAY ACTUATION

In the previous section, the iodine removal coefficients are calculated for the 3 time periods (i.e., quench spray only operating, simultaneous quench and recirculation spray operating, and recirculation spray only operating). Two time intervals based on the minimum and maximum ESF assumptions which envelope all LOCA cases including Sequencer and MCC failures are shown on Table 3.

As stated in Assumption 2 (see page 5), the time interval based on the maximum ESF assumption is chosen in this CCN for conservative dose calculation.

Table 3: Spraying Time Interval

	Quench Spray Only Operating	Simultaneous Quench and Recirculation Spray Operating	Recirculation Spray Only Operating
Minimum ESF Case (Ref: Rev. 1, LOCTIC run 2004P01A)	71 ≤ t < 4,610	4,610 ≤ t ≤ 9,790	t > 9,790 sec
Maximum ESF Case (Ref: Rev. 1, LOCTIC run 2004P02)	71 ≤ t < 2,710	2,710 ≤ t ≤ 6,620	t > 6,620 sec

RESULTS/CONCLUSION

The calculated elemental and particulate iodine removal coefficients are summarized below.

Table 4: Elemental Iodine Removal Coefficients in the Unsprayed Region

	Large Break LOCA Cases	Small Break LOCA Cases (2" dia or larger) w/o Spray Actuation for 30 minutes
$\lambda_{wall\ deposition\ (unsprayed)}$ (Wall Deposition)	1.2 hr^{-1}	1.2 hr^{-1}
$V_{unsprayed}$ (Unsprayed Volume)	1,183,800 ft^3	2,350,000 ft^3
Valid Time Interval	$0 \le t \le 1{,}800$ s	$0 \le t \le 1{,}800$ s

Table 5: Elemental Iodine Removal Coefficients in the Sprayed Region

	Quench Spray Only Operating	Simultaneous Quench and Recirculation Spray Operating	Recirculation Spray Only Operating
$\lambda_{wall\ deposition\ (sprayed)}$ (Wall Deposition)	3.2 hr^{-1}	3.2 hr^{-1}	3.2 hr^{-1}
λ_{spray} (Spray Removal)	20 hr^{-1}	20 hr^{-1}	20 hr^{-1}
$\lambda_{total\ elemental}$ (Wall Deposition and Spray Removal)	23.2 hr^{-1}	23.2 hr^{-1}	23.2 hr^{-1}
$V_{sprayed}$ (Sprayed Volume)	1,166,200 ft^3	1,515,858 ft^3	1,102,000 ft^3
Valid Time Interval	$71 \le t < 2{,}710$	$2{,}710 \le t \le 6{,}620$	$t > 6{,}620$ sec

Table 6: Particulate Iodine Removal Coefficients in the Sprayed Region

	Quench Spray Only Operating	Simultaneous Quench and Recirculation Spray Operating	Recirculation Spray Only Operating
$\lambda_{particulate}$ For DF < 50	12.37 hr^{-1}	14.11 hr^{-1}	7.77 hr^{-1}
For DF ≥ 50	1.24 hr^{-1}	1.41 hr^{-1}	0.78 hr^{-1}
$V_{sprayed}$ (Sprayed Volume)	1,166,200 ft^3	1,515,858 ft^3	1,102,000 ft^3
Valid Time Interval	$71 \le t < 2{,}710$	$2{,}710 \le t \le 6{,}620$	$t > 6{,}620$ sec

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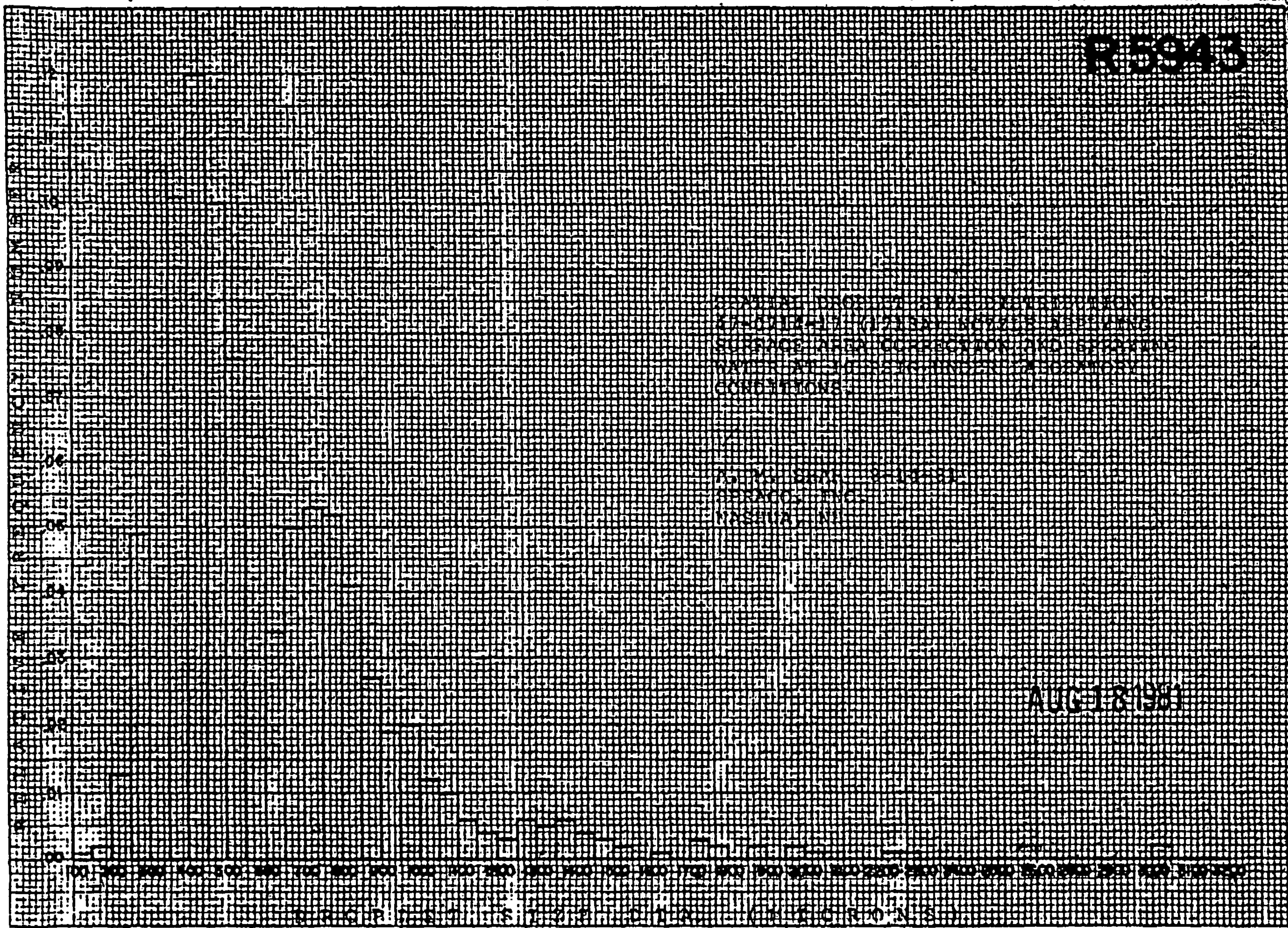

Attachment A, Page 1 of 1

Administrative Review Checklist for a Calculation or Calc Change Notice

17273.09-US(B)-341	4	001
CALCULATION No.	Revision No.	CCN No.

Eng Approver (Print/Sign): Joe Green Date: 3/15/05

OVERALL REVIEW

- ☒ Page count is correct, all pages are included, the total number of pages documented on the Calc/CCN title page, matches the table of contents.
- ☒ Table of Contents for calculations and CCNs (if applicable) defines the page breakdown on the entire document including body of calc/CCN, attachments, appendices, microfiche, CDs, etc. Refer to DCM 05.
- ☒ The entire calculation/CCN is legible, no correction tape, white out, labels were used.
- ☐ If CCN, CCN number was reserved through DA, prior to submitting document to DA.
- ☒ If calculation revision is being submitted, previous revision was signed-out through DA and all associated CCNs have been accounted for on incorporation block of new revision.

TITLE PAGE

- ☒ The Calc/CCN is the original, not a copy.
- ☒ Preparer used correct revision of all DCM forms, per prepared date.
- ☒ Title is correct.
- ☒ Calculation number format is correct, and placed on proper line.
- ☒ Revision is on correct line for calc; or correct box for CCN and numerical not alpha.
- ☐ If CCN, CCN number has been documented in the CHANGE NO. Block, and format is correct.
- ☒ A Nuclear Indicator (QA status) has been checked on the title page.
- ☒ All other fields on the cover sheet have information filled in, blocks checked, or an N/A.
- ☒ Executive summary/reason for change area has proper posting of superseding, VOID, or PassPort Data Sheet info.
- ☐ If calculation is being superseded or calc(s)/CCN(s) is performing the superseding, the additional required calc(s)/CCN(s) is in the package.
- ☐ If the lead calc(s)/CCN(s) performing the superseding are pending Installation Verification, each calculation being superseded is also not signed off IV. Calcs being superseded must be placed "ON HOLD" with new lead calc(s)/CCN(s) until Installation Verification is complete.
- ☒ All names in approval blocks have been printed followed by signatures and dates.
- ☒ Person approving calculation/CCN is valid (authorized to sign calculations and CCN's).
- ☒ Installation Verified block is either totally blank (no blocks checked) or either block checked and name is printed followed by signature and date.

DATABASE INPUT SHEET: (PASSPORT INFORMATION)

- ☒ Each calculation being submitted has a completed 5-1B included (5-5B change form cannot be used for a calc, CCN only).
- ☒ Each CCN being submitted has either a 5-1B , or a 5-5B included
- ☒ The calculation/CCN number(s) are placed on the correct line on the Database Input form.
- ☒ Revision is placed on the correct line of the Database Input form, and numerical, not alpha.
- ☒ Supersede documents are properly referenced if applicable.
- ☒ Form 5-1B has all information filled in, blocks checked or an N/A.
- ☐ If form 5-5B was used, all fields above the discipline line must have information filled in, blocks checked or an N/A.
- ☐ If form 5-5B was used all information being referenced, included the change code (cc) "A"= add or, "D"= delete in the CC blocks.
- ☒ All reference calculations/CCN's documented on database form are the correct format and are valid calculations/CCN's existing in PassPort.
- ☒ All reference drawings documented on database form are the correct format (no vendor dwg. # formats) and duplicate numbers are not listed.
- ☒ Referenced by Calculation block on database form was filled out or indicates None.

QA ☒ Non-QA ☐

DB or LB document change required? yes ☐ no ☒

TECHNICAL EVALUATION

for

Sump pH Impact Review for RSS Start on Low-Low Level

Millstone Unit 3

M3-EV-04-0032

Rev 0

January 4, 2005

Total number of pages: 5

Graham Rossano per telecon	1/4/05
Preparer	Date
Joon Cho	1/4/05
Independent Reviewer	Date
Joe Green	1/4/05
Engineering Approver	Date

1. PURPOSE

The purpose of this technical evaluation is to determine the impact of the delayed Recirculation Spray System (RSS) pump start signal on the containment sump pH control (Ref. 4). This evaluation incorporates the proposed RSS pump start signal at or near the RWST low-low level in response to NRC Generic Safety Issue (GSI) 191 (Refs. 2 and 3).

The following key items regarding the containment sump pH control are investigated in this technical evaluation. They are:

- Trisodium Phosphate (TSP) Requirement
- Sump pH Requirement at the RSS Initiation
- Maximum RSS pH for Material Compatibility
- Ultimate Sump Iodine Partition Coefficients (H) and Decontamination Factor (DF)
- Maximum Sump pH for a Small Break LOCA (SBLOCA) without Containment Depressurization Actuation (CDA)

2. BACKGROUND

The proposed RSS pump start signal time at or near the RWST tank low-low level (i.e., approximately 520,000 gallons remaining in the RWST) (Refs. 2 and 3) will maximize water level on the containment floor to ensure that the containment emergency sump is covered when the RSS pumps start.

Since several input parameters employed in Ref. 4 are revised due to the delayed start of the RSS pumps, the impact assessment of the revised input parameters to Ref. 4 is performed.

3. REFERENCES

1. S & W Calculation 12179-US(B)-273, Rev. 7, "Containment Pressure and Temperature Analysis Following a LOCA".
2. Engineering Record Correspondence Number, 25212-ER-04-0034, Transmittal of Design Input to Support Containment Reanalysis - RSS Pump Start on RWST Low-Low Level Signal.
3. Design Change Record Number, M3-04004, Change RSS Pump Start Signal from Timer to Start on RWST Low-Low Level Signal.
4. S & W Calculation 12179-US(B)-350, Rev. 2 (including CCN 01 & 02), "Trisodium Phosphate System for Sump pH Control".

5. CR M3-99-3916, NRC Identified URI 50-423/99-10-01 Discrepancies in Calculation for MP3 Containment Sump Trisodium Phosphate Concentration.

6. NUREG-0800, SRP Section 6.5.2, "Containment Spray as a Fission Product Cleanup System", Rev. 2, December 1988.

7. S & W Calculation 108788-US(B)-372, Rev. 0, "Simplified Containment Recirculation Spray System (RSS) NPSH and Suction Hydraulic Analysis Without Debris Transport".

8. S & W Calculation 03705-US(B)-352, Rev. 1, "Containment Pressure and Temperature Response for Piping Thermal Analysis".

4. DISCUSSION

As described in Section 1, the key items regarding the containment sump pH control are evaluated as follows:

Trisodium Phosphate (TSP) Requirement

Ref. 4 calculated the TSP volume required to ensure minimum ultimate sump pH of 7.1. All input parameters employed to calculate the required TSP volume are not affected by the proposed RSS pump start signal delay. Therefore, the TSP requirement remains unchanged.

Sump pH Requirement at the RSS Initiation

The sump pH should be above 7 by the onset of the RSS initiation (Ref. 6). Ref. 4 calculated the sump pH at the RSS initiation as 7.29. The RSS initiation time is delayed due to the proposed RSS pump start signal. The revised minimum water level on the containment floor at the RSS initiation is calculated as 52" above EL-24'-6" (Ref. 7) which is higher than the top elevation of TSP basket (i.e., 39" above EL-24'-6":Ref. 4). Therefore, the sump pH at the RSS initiation is at least equal or greater than the minimum ultimate sump pH of 7.1.

Maximum RSS pH for Material Compatibility

The short term localized sump high pH conditions at the RSS initiation may affect the material compatibility. Since all TSP baskets are fully submerged at the RSS initiation, as discussed above, and since the mixing of the TSP with the sump water is enhanced by the extended Quench Spray System (QSS) operation prior to the RSS initiation, the localized sump high pH conditions will be improved by the proposed RSS pump start signal delay.

Ultimate Sump Iodine Partition Coefficients (H) and Decontamination Factor (DF)

Ref. 4 calculated the ultimate (at 30 days) sump iodine partition coefficients and decontamination factor conservatively assuming that the maximum sump pH is 7 and the sump water temperature of 250°F. Since the revised sump water temperature calculated in Ref. 8 is still bounded by conservative 250°F, the ultimate sump H and DF remain unchanged.

Maximum Sump pH for a Small Break LOCA (SBLOCA) without Containment Depressurization Actuation (CDA)

Ref. 4 calculated the ultimate maximum sump pH in the event of a SBLOCA without CDA as less than 8.2 based on the current mass of TSP stored in the containment. Since no CDA is assumed for a SBLOCA scenario, the ultimate sump pH is not affected by the proposed RSS pump start signal delay.

5. SAFETY SIGNIFICANCE

The 10CFR50.59 screen for this Technical Evaluation is being performed by the parent process (Ref. 3).

6. CONCLUSION

The impact of the delayed Recirculation Spray System (RSS) pump start signal on the containment sump pH control is minimal and Ref. 4 results remain valid.

7. ATTACHMENTS

Attachment 1 – Independent Reviewer's Comments, Dated 1/4/05

ATTACHMENT 1

Independent Reviewer Comment and Resolution Sheet(s)

(ER/EV) No. M3-EV-04-0032

Page 1 of 1

Independent Reviewer: Joon Cho Date 1/4/05

Comment No.	ER/EV Section	Comment
1	4, 6	Overall impact of the delayed RSS pump start signal on the sump pH control is considered to be beneficial mainly due to full submergence of the TSP baskets on the containment floor in conjunction with the extended QSS actuation time prior to the RSS initiation which minimize the localized sump pH.