Attachment B

Calculation N-6030-001

"Containment Aerosol and Iodine Removal Rates"

CALCULATION TITLE PAGE

ICCN NO / PRELIM. CCN NO.	PAGE ___ OF

CCN CONVERSION: CCN NO. CCN-

Calc. No. N-6030-001 DCP/FIDCN/FCN/ECP No. & Rev. N/A

Subject Containment Aerosol and Iodine Removal Rates Sheet 1 of 281

System Number/Primary Station System Designator 1206 / BKA SONGS Unit 2 and 3 Q-Class II *

Tech. Spec./LCS Affecting? ☒ NO ☐ YES, Section No. ______ Equipment Tag No. N/A

Site Programs/Procedure Impact? ☒ NO ☐ YES, AR No. ______

10CFR50.59 REVIEW	CONTROLLED COMPUTER PROGRAM/DATABASE		
IS THIS CALCULATION REVISION BEING ISSUED SOLELY TO INCORPORATE CCNs? ☒ NO ☐ YES AR No. N/A (see below)____	☐ PROGRAM ☐ DATABASE ACCORDING TO SO123-XXIV-5.1	PROGRAM/DATABASE NAME(S) ☐ ALSO, LISTED BELOW ICONC, NE316 REMOVE, NE305	VERSION/RELEASE NO.(S) 3.0 4.0

RECORDS OF ISSUES

REV. DISC.	DESCRIPTION	TOTAL SHTS. LAST SHT.	PREPARED (Print name/sign/date)	APPROVED (Signature/date)	
0	ISSUED FOR USE	281	ORIG. Jorge Schulz PQS 3T2RE46 8/15/2003	FLS 9/5/03	Other
BPC		281	IRE D. T. Dexheimer PQS 3T2RE46 8/15/03	Other Mark Drucker PQS 3T2RE42 8/25/03	Other
			ORIG.	FLS	Other
			IRE	Other	Other
			ORIG.	FLS	Other
			IRE	Other	Other
			ORIG.	FLS	Other
			IRE	Other	Other

Space for RPE Stamp, identify use of an alternate calc., and notes as applicable.

* Consistent with the Q-List (Document 90034, Revision 7), this Calculation addressing UFSAR Section 6.2.2 Containment Spray System performance has been classified as Quality Class II

This calculation uses Regulatory Guide 1.183 Alternative Source Term (AST) methodology to determine removal rates for iodine and particulate species by natural processes and by the containment spray. The application of AST methodology requires NRC review and approval. Per Procedure SO123-XV-44 [Revision 5, Section 6.5.2, Note (1)], one may proceed directly to the license amendment process without the need to prepare a 50.59 screen or evaluation if there is a predetermination that NRC review and approval are required.

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This calc. was prepared for the identified DCP/FCN/ISCO ECP. DCP/FCN/ECP completion and turnover acceptance to be verified by receipt of a memorandum directing DCN/ECN Conversion. Upon receipt, this calc. represents the as-built condition. Memo date ______ by ______.

SCE 26-121-1 REV. 5 7/01 [REFERENCE: SO123-XXIV-7.15]

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N-6030-001

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CALCULATION CROSS-INDEX

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Calc rev. number and responsible FLS initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/document require revision?	Identify output interface calc/document CCN, ECN TCN/Rev., FIDCN, or tracking number
	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.	YES/NO	
0	Units 2&3 Calculation A-92-NF-0002	0				
	Units 2&3 Calculation M-0014-009	0 & CCNs 1 to 4				
	Units 2&3 Calculation N-0220-013	0 & CCNs 1 & 2				
	Units 2&3 Calculation-4080-026	1 & CCNs 4 & 5				
VFN	Units 2&3 Calculation-4080-027	1 & CCNs 4 & 5				
9/5/03	Units 2&3 Calculation-6097-001	0				
	Units 2&3 Drawing 10003	9				
	Units 2&3 Drawing 23000	5				
	Units 2&3 Drawing 23116	12				
	Units 2&3 Drawing 23117	18				
	Unit 2 Drawing 40114B	17				
	Unit 3 Drawing 40114BSO23	14				
	Unit 2 Drawing 40494	6				
	Unit 3 Drawing 41994	6				
	Unit 2 Technical Specifications	to Amend. 189				
	Unit 3 Technical Specifications	to Amend. 180				

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1 PURPOSE

1.1 *TASK DESCRIPTION*

When calculating consequences from design basis events (DBE) using the alternative source term, removal of iodine and particulate aerosol species by natural processes and by the containment spray may be credited using the guidance of Regulatory Guide 1.183 (Reference 6.4e). Previous NRC guidance allowed removal of iodine species only.

This calculation determines appropriate time-dependent removal rates inside the containment that can be used as inputs to the *LocaDose* (Reference 6.6a) computer program.

Two types of removal rates are calculated: removal by natural processes, and removal by containment sprays. Removal of iodines and aerosols by natural processes are calculated using the models presented in SRP Section 6.5.2 (Reference 6.4f) and NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments" (Reference 6.4j). Removal of iodines and aerosols by containment sprays are calculated using the models presented in SRP Section 6.5.2 and NUREG/CR-5966 "A Simplified Model of Aerosol Removal by Containment Sprays" (Reference 6.4i).

This calculation provides closure for AR Assignment 020400823-28.

1.2 *CRITERIA, CODES AND STANDARDS*

Paragraph 3.2 of Appendix A of Regulatory Guide 1.183 (Reference 6.4e) states in part:

> *Reduction in airborne radioactivity in the containment by natural deposition within the containment may be credited. Acceptable models for removal of iodine and aerosols are described in Chapter 6.5.2 "Containment Spray as a Fission Product Cleanup System," of the Standard Review Plan (SRP), NUREG-0800 (Ref. A-1) and in NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments," (Ref. A-2).*

Paragraph 3.3 of Appendix A of Regulatory Guide 1.183 (Reference 6.4e) states in part:

> *Reduction in airborne radioactivity in the containment by containment spray systems that have been designed and are maintained in accordance with Chapter 6.5.2 of the SRP (Ref. A-1) may be credited. Acceptable models for the removal of iodine and aerosols are described in Chapter 6.5.2 of the SRP and NUREG/CR-5966, "A Simplified Model of Aerosol Removal by Containment Sprays" (Ref. A-4).*

2 RESULTS/CONCLUSIONS AND RECOMMENDATIONS

2.1 *RESULTS/CONCLUSION*

As shown in Section 8.4, removal rates are determined for three different percentile levels: 90th percentile for the reasonable upper bound value, 50th percentile for the median value, and 10th percentile for the conservative lower bound value. To calculate doses using the guidance of Regulatory Guide 1.183 the removal rates associated with the 10th percentile level should be used. The appropriate removal rates from Table 8-31 for the sprayed containment region and from Table 8-32 for the unsprayed containment region are summarized below on Table 2-1 and Table 2-2, respectively.

Table 2-1 — Containment Sprayed Region Removal Rates (hr^{-1}) for Compliance with Regulatory Guide 1.183 (per Table 8-31)

LocaDose Time-Steps				Elemental Iodine Rate	Elemental Iodine DF	Particulate Iodine	Alkali Metals	Other Particulates
0.0000E+00	--	8.3333E-03	hr	0	N/A	0	0	0
8.3333E-03	--	1.6667E-02	hr	4.26	110	2.94E-02	2.94E-02	0
1.6667E-02	--	8.3333E-02	hr	5.28	110	5.18	5.18	5.15
8.3333E-02	--	3.3333E-01	hr	5.28	110	5.18	5.18	5.15
3.3333E-01	--	5.0000E-01	hr	5.28	110	5.18	5.18	5.15
5.0000E-01	--	5.0833E-01	hr	5.28	110	5.19	5.19	5.18
5.0833E-01	--	6.9372E-01	hr	5.28	110	5.19	5.19	5.18
0.694	--	1	hr	24.26	170	5.19	5.19	5.18
1	--	1.8	hr	24.26	170	5.19	5.19	5.18
1.8	--	2	hr	24.26	170	3.88	3.88	3.88
2.000	--	3.8	hr	24.26	160	1.41	1.41	1.41
3.8	--	4	hr	24.26	160	0.91	0.91	0.91
4	--	8	hr	23.12	140	0.73	0.73	0.73
8	--	13.8	hr	20.27	110	0.63	0.63	0.63
13.8	--	22.2	hr	17.26	84	0.59	0.59	0.59
22.2	--	24	hr	17.26	84	0.50	0.50	0.50
24	--	48	hr	14.35	64	0.50	0.50	0.50
48	--	96	hr	12.10	48	0.50	0.50	0.50
96	--	720	hr	8.04	25	0.50	0.50	0.50

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Table 2-2 — Containment Unsprayed Region Removal Rates (hr^{-1}) for Compliance with Regulatory Guide 1.183 (per Table 8-32)

LocaDose Time-Steps				Elemental Iodine Rate	Elemental Iodine DF	Particulate Iodine	Alkali Metals	Other Particulates
0.0000E+00	—	8.3333E-03	hr	0	N/A	0	0	0
8.3333E-03	—	1.6667E-02	hr	4.26	110	2.94E-02	2.94E-02	0
1.6667E-02	—	8.3333E-02	hr	4.26	110	2.94E-02	2.94E-02	0
8.3333E-02	—	3.3333E-01	hr	4.26	110	2.94E-02	2.94E-02	0
3.3333E-01	—	5.0000E-01	hr	4.26	110	2.94E-02	2.94E-02	0
5.0000E-01	—	5.0833E-01	hr	4.26	110	3.95E-02	4.17E-02	3.12E-02
5.0833E-01	—	6.9372E-01	hr	4.26	110	3.95E-02	4.17E-02	3.12E-02
0.694	—	1	hr	4.26	170	3.95E-02	4.17E-02	3.12E-02
1	—	1.8	hr	4.26	170	3.95E-02	4.17E-02	3.12E-02
1.8	—	2	hr	4.26	170	8.93E-02	8.93E-02	8.93E-02
2.000	—	3.8	hr	4.26	160	8.93E-02	8.93E-02	8.93E-02
3.8	—	4	hr	4.26	160	1.16E-01	1.16E-01	1.16E-01
4	—	8	hr	4.26	140	1.16E-01	1.16E-01	1.16E-01
8	—	13.8	hr	4.26	110	1.16E-01	1.16E-01	1.16E-01
13.8	—	22.2	hr	4.26	84	8.60E-02	8.60E-02	8.60E-02
22.2	—	24	hr	4.26	84	0	0	0
24	—	48	Hr	4.26	64	0	0	0
48	—	96	Hr	4.26	48	0	0	0
96	—	720	Hr	4.26	25	0	0	0

2.2 *RECOMMENDATIONS*

The removal rates presented on Table 2-1 and Table 2-2 are suitable for use to calculate consequences from DBEs using the alternative source term when containment spray operation is considered. For DBEs where no containment spray operation is considered, the values presented on Table 2-2 can be used for all containment regions.

For calculation of realistic dose consequences, the 50^{th} percentile removal rates presented on Table 8-29 and Table 8-30 may be used.

2.3 *COMPARISON TO PREVIOUS RESULTS*

The resultant removal rates presented in Table 2-1 and Table 2-2 are compared to the results in the Analysis of Record (AOR), WCAP-10974 (Reference 6.1g) on Table 2-3. WCAP-10974 determined removal rates for elemental iodine and particulate iodine only. Removal rates for other particulates were not considered. As can be seen, the AOR removal rates are constant, while the removal rates determined in this calculation are time-dependent. This comparison illustrates the difference between the methodology used to generate the removal rates in this calculation and the current AOR.

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Table 2-3 — Comparison of Removal Rates

Removal Rate (hr^{-1})	This Calculation	WCAP-10974
Elemental Iodine – Sprayed Region	4.26 – 24.26	6.65
Elemental Iodine – Unsprayed Region	4.26	11.3
Particulate Iodine – Sprayed Region	0.0294 – 5.19	2.505
Particulate Iodine – Unsprayed Region	0.0294 – 0.116	0.0
Alkali Metals – Sprayed Region	0.0294 – 5.19	N/A
Alkali Metals – Unsprayed Region	0.0294 – 0.116	N/A
Other Particulates – Sprayed Region	0.50 – 5.18	N/A
Other Particulates – Unsprayed Region	0.0312 – 0.116	N/A

3 MODELING ASSUMPTIONS

3.1 *CONFIGURATION SYMMETRY BETWEEN UNITS 2 AND 3*

This analysis and its conclusions are applicable to both Units 2 and 3. References are provided to show that assumptions and design input data that have unit applicability are representative of both units.

3.2 *CONTAINMENT SURFACE AREA USED FOR DEPOSITION*

For the purposes of this calculation, the surface area used for natural deposition is assumed to be the same as the surface area used to determine the passive heat sinks in containment. As discussed in NUREG/CR-0009 (Reference 6.4h), the natural deposition model for elemental iodine assumes that the bulk gas in the containment atmosphere is well-mixed by natural convection, by steam flows, and by spray operations, therefore, all surfaces within the containment are available for elemental iodine and particulate aerosol deposition.

3.3 *NUMBER OF CONTAINMENT SPRAY SYSTEM (CSS) HEADERS IN OPERATION*

For the purposes of this calculation it is assumed that only one CSS header is in operation. One spray header in operation instead of both headers lowers the containment spray flow rate and the spray flux, thereby minimizing activity removal by the sprays and maximizing the airborne radionuclide concentrations.

3.4 *CONTAINMENT SPRAY SYSTEM FLOW RATE*

The CSS has two phases of operation, an injection phase and a recirculation phase. During the injection phase the CSS draws water from the RWST until this source is exhausted. Following this phase the CSS enters the recirculation phase, where water is drawn from the containment sump and recirculated through the CSS. Per Design Input 4.10, the recirculation phase flow rate is greater than the injection phase flow rate. For the purposes of this calculation the lower injection phase flow rate is modeled throughout the CSS operation. The lower flow rate and resultant spray flux minimizes the activity removal by the sprays and maximizes the airborne radionuclide concentrations.

3.5 *DENSITY OF SPRAY SOLUTION*

For the purposes of this calculation, the density of the spray solution is assumed to be equivalent to water at standard conditions. A value of 1 g/cm^3 is used.

3.6 *APPLICABILITY OF DOCUMENT SO23-954-M4*

Document SO23-954-M4 Revision 0 (Reference 6.6d) is considered "for information only." This document contains information on spray nozzle 1713A used in SONGS Units 2 & 3. This document contains data and information regarding this spray nozzle not found on other documents; therefore, it is assumed to be valid for use in this calculation.

3.7 *SPRAY COVERAGE FOR "TYPE D" NOZZLES*

Reference 6.2f shows four different orientations for the SPRACO 1713A nozzles used in the spray system. These are designated as follows:

Type A	Flow oriented vertically down
Type B	Flow oriented at an angle of 45° downward
Type C	Flow oriented horizontally
Type D	Flow oriented at an angle of 10° downward

The Spray Engineering Company in Reference 6.6d provides coverage information for orientations of types A through C, but not for D. Since type D is 10° from vertical, the coverage information for type A orientation is used in this calculation. This results in over estimating the coverage area for the spray rings using this orientation, which results in a lower spray flux rate and consequently in a lower aerosol spray removal coefficient.

3.8 *CONTAINMENT SUMP VOLUME*

This calculation assumes that the containment sump liquid volume is 348,946 gallons (about 46,647 ft^3). This volume is determined in Calculation A-92-NF-002 (Reference 6.1a, sheet 20), and represents the minimum containment emergency sump volume available at the start of the post-LOCA CSS and SIS recirculation mode of operation. This volume is equal to:

+ useable Refueling Water Storage Tank volume
+ four Safety Injection Tank discharge volumes
+ Reactor Coolant System depressurized volume
- volume of water trapped in the reactor cavity and ducts
- volume of water needed to refill the reactor pressure vessel to the hot leg nozzle

3.9 *SPRAY DROPLET TEMPERATURE*

The calculation of elemental iodine spray removal rate performed requires as an input the spray droplet temperature. Given the post LOCA containment conditions and the small size of each individual droplet, it is assumed that the spray droplets reach an equilibrium temperature with the bulk containment atmosphere temperature.

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4 DESIGN INPUTS

4.1 THERMAL POWER LEVEL

The maximum allowed core power level by the SONGS Unit 2 and Unit 3 license is 3,438 MWt (Reference 6.4a, Section 2.C.(1), and Reference 6.4b, Section 2.C.(1)).

4.2 PWR CORE INVENTORY FRACTION RELEASED INTO CONTAINMENT

The core inventory release fractions, by radionuclide groups, for the gap release and early in-vessel damage phases for DBA LOCAs are listed on Table 4-1. These release fractions are obtained from Regulatory Guide 1.183 (Reference 6.4e, Table 2).

Table 4-1 — PWR Core Release Fractions

Group	Gap Release Phase	Early In-vessel Phase	Total
Noble Gases	0.05	0.95	1.0
Halogens	0.05	0.35	0.4
Alkali Metals	0.05	0.25	0.3
Tellurium Metals	0.00	0.05	0.05
Ba, Sr	0.00	0.02	0.02
Noble Metals	0.00	0.0025	0.0025
Cerium Group	0.00	0.0005	0.0005
Lanthanides	0.00	0.0002	0.0002

4.3 TIMING OF RELEASE PHASES

The timing of the release phases is obtained from Regulatory Guide 1.183 (Reference 6.4e, Table 4). Table 4-2 presents the onset and duration of each sequential release phase for DBA LOCAs for PWRs. The specified onset is the time following initiation of the accident (i.e., time = 0). The early in-vessel phase immediately follows the gap release phase.

Table 4-2 — PWR LOCA Release Phases

Phase	Onset	Duration
Gap Release	30 sec	0.5 hr
Early In-Vessel	0.5 hr	1.3 hr

4.4 *CHEMICAL FORM*

Per Regulatory Guide 1.183 (Reference 6.4e, Section 3.5), of the radioiodine released from the reactor coolant system (RCS) to the containment in a postulated accident, 95 percent of the iodine released should be assumed to be cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. This includes releases from the gap and the fuel pellets. With the exception of elemental and organic iodine and noble gases, fission products should be assumed to be in particulate form.

4.5 *MASS TRANSFER COEFFICIENT FOR ELEMENTAL IODINE WALL DEPOSITION*

Standard Review Plan (SRP) 6.5.2 (Reference 6.4f, Section III.4.c.(1)) suggests that the mass transfer coefficient used for wall deposition should conservatively envelop all available experimental data. SRP 6.5.2 cites NUREG/CR-0009 (Reference 6.4h) as the source of the bounding mass transfer coefficient. NUREG/CR-0009 states on page 17:

> *"As is described in section 6.1.9, the value of kg should not exceed 0.137 cm/sec. This maximum value is based on CSE [Containment Systems Experiment] tests, and its use assures that the predicted deposition rates remain within the range where the Knudsen-Hilliard model applies."*

The value of 0.137 cm/sec is consistent with the value of 4.9 m/hr recommended by SRP 6.5.2 (Section III.4.c.(1)) and will be used in this calculation.

4.6 *PRIMARY CONTAINMENT NET FREE AIR VOLUME*

The containment is modeled with a sprayed volume of 1,907,000 cubic feet and an unsprayed volume of 459,000 cubic feet, of which 82,000 cubic feet are assumed to be eventually flooded. The sprayed, unsprayed, and flooded volumes are consistent with WCAP-10974 (Reference 6.1g, page 4-4).

The total primary containment net free air volume is then 1,907,000 + 459,000 – 82,000 = 2,284,000 cubic feet.

4.7 *CONTAINMENT OPERATING FLOOR ELEVATION*

The containment operating floor is at plant elevation 63' – 6" (see References 6.2a, 6.2c, and 6.2d).

4.8 *CONTAINMENT INNER DIAMETER*

From drawing 23000 (Reference 6.2b), the containment inner diameter is 150' – 0".

4.9 *PRIMARY CONTAINMENT SURFACE AREA*

Per Modeling Assumption 3.2, the wetted surface area used for natural deposition is assumed to be the same surface area used for the passive heat sinks in the containment pressure/temperature (P/T) analysis for LOCA. The containment P/T analysis for LOCA, calculation N-4080-026 (Reference 6.1d, Design Input 4.8) states that the passive heat sinks are identical to those developed and used in the containment P/T response calculation for the design basis main steam line break (MSLB) event documented in calculation N-4080-027 (Reference 6.1e). From Section 8.2 of calculation N-4080-027, there are 21 heat sinks. These heat sinks and their exposed surface areas are shown on Table 4-3.

Table 4-3 — Containment Surface Area

Heat Sink Number	Passive Heat Sink	Exposed Surface Area (ft^2)
1	Containment building dome	33,017
2	Containment building cylinder (above grade)	34,067
3	Containment building cylinder (below grade)	5,535
4	Reactor building basemat (exluding reactor cavity basemat)	12,773
5	Reactor cavity basemat and steam generator pedestals	1,644
6	Reactor cavity walls below containment floor	1,546
7	Reactor cavity walls above containment floor	1,311
8	Lined refueling canal walls and floor	9,192
9	Unlined exterior faces of refueling canal walls	11,050
10	Steam generator compartment walls and missile shields	43,085
11	Steam generator compartment walls with embeds	6,914
12	Elevated floor slabs (top half-thickness)	17,474
13	Elevated floor slabs (lower half-thickness with CS decking)	23,240
14	Lifting devices (carbon steel)	59,265
15	Miscellaneous carbon steel (thickness > 2.5 inch)	2,248
16	Miscellaneous carbon steel (1 inch <thickness <= 2.5 inch)	9,230
17	Miscellaneous carbon steel (0.5 inch <thickness <= 1.0 inch)	8,718
18	Miscellaneous carbon steel (thickness <= 0.5 inch)	158,855
19	Electrical equipment and other galvanized steel	131,698
20	Miscellaneous stainless steel	26,893
21	Reactor building stiffened sections	3,764
	Total exposed Surface Area	601,519

4.10 *SPRAY SYSTEM FLOW RATE*

Per Modeling Assumption 3.3 only one spray header of the containment spray system is assumed to be in operation. The minimum flow rate per spray header during the injection phase is 1,606 gpm from

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Calculation M-0014-009 (Reference 6.1b, page A6). The minimum flow rate per spray header during the recirculation phase is 1,991 gpm from Calculation M-0014-009 (Reference 6.1b, page A6).

Per Modeling Assumption 3.4 the injection phase flow rate is used. For the purposes of this calculation this value is rounded down to 1,600 gpm.

4.11 *Containment Spray System Piping*

The containment spray system consists of two independent spray headers (Reference 6.2e). Each spray header consists of three concentric rings of spray nozzles (Reference 6.2f). Each concentric ring is furnished with SPRACO 1713A nozzles (Reference 6.2f). Each containment spray header is capable of covering the containment with spray water. Parameters used in this calculation are shown in below:

Table 4-4 — Spray System Parameters

Parameter	Value	Reference
Spray Header 1		
Ring 052-2½"-C-KEO		
Number of nozzles	20	6.2e
Type A (vertical)	10	6.2f
Type B (45°)	10	6.2f
Spray ring radius	25' – 6"	6.2f
Spray ring plant elevation	180' – 11 3/16"	6.2f
Ring 051-4"-C-KEO		
Number of nozzles	40	6.2e
Type A (vertical)	20	6.2f
Type C (horizontal)	20	6.2f
Spray ring radius	43' – 0"	6.2f
Spray ring plant elevation	171' – 7 5/16"	6.2f
Ring 049-4"-C-KEO		
Number of nozzles	56	6.2e
Type B (45°)	28	6.2f
Type D (10°)	28	6.2f
Spray ring radius	66' – 6"	6.2f
Spray ring plant elevation	143' – 3 11/16"	6.2f

Table 4-4 — Spray System Parameters

Parameter	Value	Reference
Spray Header 2		
Ring 046-2½"-C-KEO		
Number of nozzles	20	6.2e
Type A (vertical)	10	6.2f
Type B (45°)	10	6.2f
Spray ring radius	22' – 6"	6.2f
Spray ring plant elevation	181' – 11 11/16"	6.2f
Ring 045-4"-C-KEO		
Number of nozzles	40	6.2e
Type A (vertical)	20	6.2f
Type C (horizontal)	20	6.2f
Spray ring radius	46' – 0"	6.2f
Spray ring plant elevation	169' – 3 15/16"	6.2f
Ring 043-4"-C-KEO		
Number of nozzles	56	6.2e
Type B (45°)	28	6.2f
Type D (10°)	28	6.2f
Spray ring radius	63' – 6"	6.2f
Spray ring plant elevation	149' – 0 3/16"	6.2f

4.12 SPRACO 1713A NOZZLE SPRAY ORIFICE DIAMETER AND INITIAL DISPERSION

The SPRACO 1713A nozzle orifice diameter is 3/8" (Reference 6.2g).

Page 17 of the Spray Engineering Company 1713A information booklet (Reference 6.6d) states that *"in a nozzle of this type, the liquid is given rotational motion in a swirl chamber and then leaves the nozzle through an orifice. The center of the orifice is occupied by an air core, which normally fills 60 to 80% of the orifice diameter. The liquid flows through the annulus outside the air core and forms a conical sheet that breaks into drops a short distance from the nozzle."*

Given that a smaller annular region for a given spray flow rate produces a higher exit velocity, and that with a higher exit velocity the spray drops spend less time airborne, the upper end of the air core fraction (80%) will be used in this calculation.

Per Modeling Assumption 3.6, this data is assumed to be applicable to the SONGS design.

4.13 SPRACO 1713A NOZZLE SPRAY COVERAGE

The spray coverage from a single SPRACO 1713A nozzle is dependent on the orientation of the nozzle. The Spray Engineering Company (Reference 6.6d) provides information for the coverage areas for three different configurations, horizontal, vertical, and 45° downward. These coverage areas are shown on Figure 4–1 through Figure 4–3 (Reference 6.6d, page 8). For the purposes of this calculation the coverage areas and offsets from the nozzle at a drop height of 100 feet are used. Offsets are assumed from the pipe centerline. These parameters are summarized below:

Table 4-5 — SPRACO 1713A Nozzle Spray Coverage

Orientation	Coverage Diameter	Offset from Centerline
Vertical (Types A & D)	19 feet	N/A
Horizontal (Type C)	24 feet	7 feet
45° Downward (Type B)	21 feet	4 feet

Per Modeling Assumption 3.6, this data is assumed to be applicable to the SONGS design.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

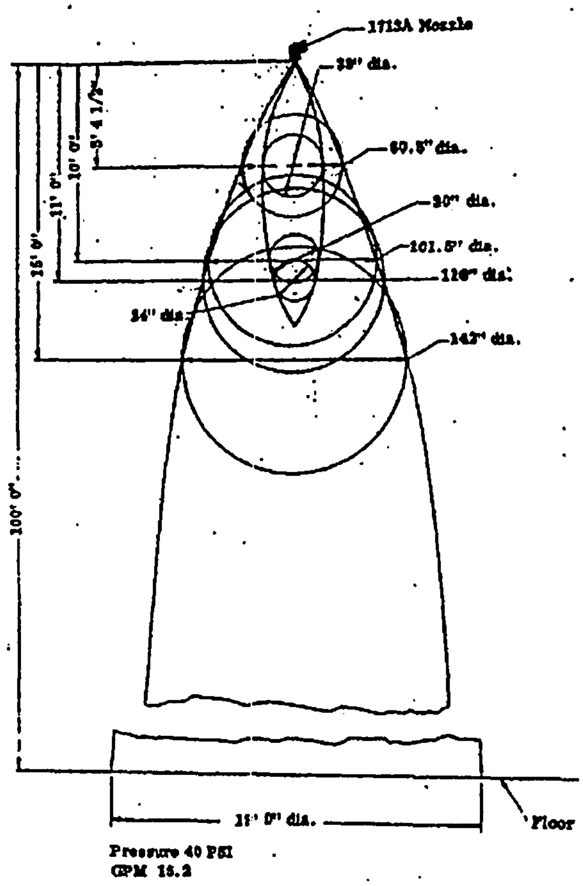

Figure 4–1 — Nozzle 1713A Spraying Vertically Downward

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

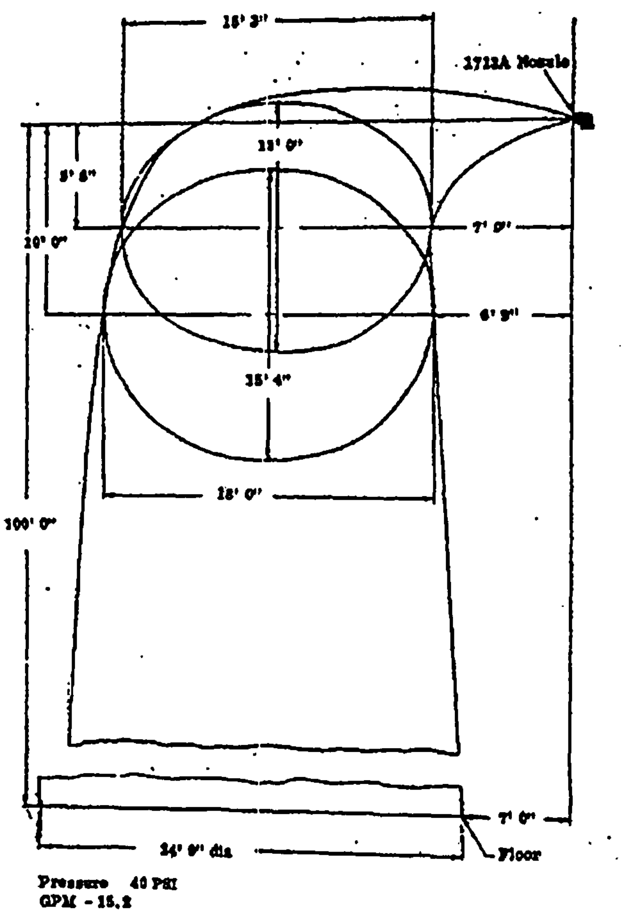

Figure 4-2 — 1713A Nozzle Spraying Horizontally

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

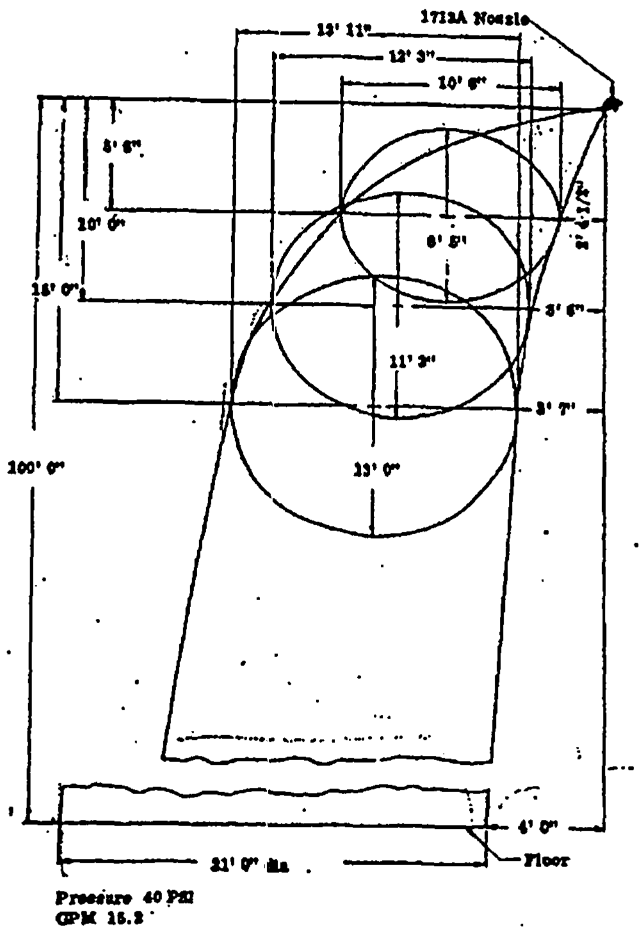

Figure 4–3 — 1713A Nozzle Spraying Downward on 45°

4.14 *Sump pH Level*

Calculation N-0220-013 (Reference 6.1c, page A-9) determines the maximum pH of the containment sump ECCS fluid during the post LOCA recirculation phase. This calculation states that "results of this calculation support the existing pH range of 7.0 to 8.0 as stated in the UFSAR and environmental documentation. The existing Technical Specification Limiting Condition for Operation 3.6.2.2 and Surveillance Requirements 4.6.2.2 remain acceptable."

For the purposes of this calculation the minimum pH level of 7.0 is used for the recirculation phase of spray operation and for the calculation of partition coefficients.

4.15 *ELEMENTAL IODINE EQUILIBRIUM CONSTANTS K_1 AND K_3*

The elemental iodine equilibrium constants K1 and K3 used to calculate the iodine partition coefficients are obtained from Tables 1 and 2 of ORNL-TM-2412 Part IV (Reference 6.6e). These values are shown below on Table 4-6.

Table 4-6 — Equilibrium Constants K_1 and K_3

Temperature (°C)	K_1	Temperature (°C)	K_3
0	315	0	4.1E-14
10	173	10	1.2E-13
20	102	20	3.4E-13
25	74.6	25	5.4E-13
30	61	30	8.4E-13
40	39	40	2.1E-12
50	26.2	50	4.8E-12
60	19	60	1.0E-11
70	15.4	70	2.2E-11
80	13	80	4.3E-11
90	10.5	90	8.4E-11
100	9	100	1.5E-10
106	8.4	105	2.1E-10
110	8.36	110	2.7E-10
112.3	8.32	120	4.8E-10
120	7.14	130	7.8E-10
130	6.37	140	1.2E-09
140	5.95	150	2.0E-09
150	5.52		

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

4.16 *Iodine Core Inventory*

The reactor core inventory of iodine isotopes is as shown in Table 4-7. The full core iodine mass is obtained from calculation N-6097-001 (Reference 6.1f, Table 8-4). This iodine mass inventory is valid for any San Onofre Units 2 and 3 cycle which meets the following requirements:

1. 3.8 w/o $\leq$ Core Average Enrichment $\leq$ 4.8 w/o
2. Core Average Burnup $\leq$ 40.0 GWD/T
3. Core Uranium Loading $\leq$ 95.5 MTU
4. Core Thermal Power $\leq$ 3,507 MW-t (Including Uncertainty)
5. Number of Fuel Rods $\geq$ 51,132 Rods

Table 4-7 — Iodine Core Inventory

Isotope	Full Core Inventory (g)
I—127	4.64E+03
I—128	1.87E-02
I—129	2.05E+04
I—130	1.28E+00
I-130M	8.27E-03
I—131	7.55E+02
I—132	1.31E+01
I—133	1.75E+02
I-133M	1.58E-03
I—134	8.42E+00
I-134M	5.14E-02
I—135	5.27E+01
I—136	9.24E-02
I-136M	2.43E-02
I—137	2.82E-02
I—138	3.75E-03
I—139	7.62E-04
I—140	6.68E-05

4.17 *RWST Temperature Range*

Per surveillance requirement (SR) 3.5.4.1 of LCO 3.5.4 (References 6.4c and 6.4d), the Refueling Water Storage Tank (RWST) borated water temperature is verified every 24 hours to be $\geq$ 40 °F and $\leq$ 100 °F.

4.18 *Post LOCA Containment and Sump Temperature Profile*

Calculation N-4080-026 (Reference 6.1d) determines the containment and sump water temperature profile for 9 different LOCA cases. As discussed in Section 2.2.1 of calculation N-4080-026 Rev. 1, cases 1, 4, and 7 with diesel generator failure are the bounding LOCA cases. The temperature profiles for the containment atmosphere and sump water for these cases are used in this calculation and are obtained from Tables 9-1A, 9-4A, and 9-7A of calculation N-4080-026 Rev. 1 for cases 1, 4, and 7, respectively. The temperature profiles are shown below on Table 4-8:

Table 4-8 — Containment Atmosphere and Water Sump Temperature Profile

Time (sec)	Time (hr)	Vapor Temperature (°F) Case 1	Vapor Temperature (°F) Case 4	Vapor Temperature (°F) Case 7	Sump Temperature (°F) Case 1	Sump Temperature (°F) Case 4	Sump Temperature (°F) Case 7
0.00	2.778E-14	120	120	120	120	120	120
0.1	2.778E-05	90.5	89.9	111.8	197.8	206.4	216.1
0.2	5.556E-05	112.5	105	133.1	206.9	210.9	219.3
0.3	8.333E-05	127.4	116.7	146.1	211	213.9	217.7
0.4	1.111E-04	139.3	126.3	156	213.8	216.4	218.1
0.5	1.389E-04	148.8	135.3	163.9	215	218.3	218.2
0.6	1.667E-04	156.1	142.6	170.5	216.4	219.9	218.8
0.7	1.944E-04	162.6	148.1	176.2	217.6	220	218.6
0.8	2.222E-04	167.6	153.7	181.1	217.4	220.3	218.1
0.9	2.500E-04	172.8	158.1	185.4	217.4	220.9	218.9
1	2.778E-04	178	162.1	189.1	218.4	220.6	218.9
2	5.556E-04	206.9	193	214.7	219.2	222.4	223.7
3	8.333E-04	221.9	210.2	230.5	222.5	225.3	230.9
4	1.111E-03	231.9	220.5	241.3	225.2	228	236.7
5	1.389E-03	239.8	228	249.3	227.3	231.1	241.4
6	1.667E-03	245.5	234.1	255.2	229.2	234.1	245.3
7	1.944E-03	250.4	239.2	260.1	230.5	236.6	246.9
8	2.222E-03	254.3	243.5	263.3	230.9	238.9	247.6
9	2.500E-03	257.3	247.2	265.1	230.5	241	248
10	2.778E-03	258.9	250.5	265.9	229.7	242.5	248.3
11	3.056E-03	260.3	253.3	266.7	229.4	243.5	248.6
12	3.333E-03	260.8	255.4	267.4	229.8	244.4	248.7
13	3.611E-03	260.7	257	266.8	230.4	245.1	248.9
14	3.889E-03	260.3	258	266.2	230.7	245.9	249
15	4.167E-03	259.8	258.6	265.7	230	246.6	249.1
16	4.444E-03	259.3	258.7	265.4	229.1	247.1	249.2
17	4.722E-03	258.8	258.9	265.1	228.2	247.5	249.3
18	5.000E-03	258.6	258.6	264.8	227.3	247.8	249.4
19	5.278E-03	258.6	258.2	264.7	226.5	247.9	249.5
20	5.556E-03	258.9	257.8	264.6	225.7	248	249.5
22	6.111E-03	259	257.8	264.6	221.4	248	249.7
24	6.667E-03	258.8	258.6	264.5	217.1	242.7	249.8
26	7.222E-03	258.9	258.8	264.4	213.4	236.7	249.9
28	7.778E-03	259.1	259.1	264.3	210.2	231.7	250
30	8.333E-03	259.3	259.5	264.2	207.3	227.5	250.1
32	8.889E-03	259.7	260	264	205.8	223.9	250.1
34	9.444E-03	260.1	260.5	263.9	204.5	220.8	250.2

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REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 4-8 — Containment Atmosphere and Water Sump Temperature Profile

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
36	1.000E-02	260.3	261	263.7	203.3	218.1	250.3
38	1.056E-02	260.5	261.3	263.6	202.2	215.7	250.3
40	1.111E-02	260.5	261.4	263.4	201.2	213.6	250.4
42	1.167E-02	260.3	261.4	263.3	200.3	211.7	250.4
44	1.222E-02	259.7	261	263.5	199.4	210	250.5
46	1.278E-02	258.9	260.3	263.3	198.6	208.4	250.5
48	1.333E-02	258	259.5	263.1	197.9	207.1	250.6
50	1.389E-02	256.9	258.6	262.9	197.2	205.8	250.6
52	1.444E-02	255.8	257.7	262.8	196.6	204.7	250.7
54	1.500E-02	255.8	256.6	262.6	196	203.6	250.7
56	1.556E-02	255.7	256.1	262.5	195.5	202.6	250.8
58	1.611E-02	255.7	256.1	262.3	195	201.8	250.8
60	1.667E-02	255.7	256.1	262.1	194.5	201	250.9
62	1.722E-02	255.6	256.1	261.9	194.1	200.3	250.9
64	1.778E-02	255.5	256	261.7	193.7	199.7	251
66	1.833E-02	255.5	256.1	261.6	193.4	199.1	251.2
68	1.889E-02	255.5	256	261.4	193	198.5	251.4
70	1.944E-02	255.5	256.1	261.2	192.7	198	251.6
72	2.000E-02	255.4	256.1	261	192.5	197.6	251.8
74	2.056E-02	255.4	256.1	260.9	192.4	197.2	252
76	2.111E-02	255.3	256.2	260.7	192.4	196.8	252.1
78	2.167E-02	255.4	256.1	260.6	192.5	196.5	252.3
80	2.222E-02	255.7	256.2	260.4	192.6	196.1	252.5
82	2.278E-02	255.9	256.2	260.3	192.7	195.9	252.6
84	2.333E-02	256.1	256.2	260.1	192.8	195.6	252.8
86	2.389E-02	256.3	256	260	192.9	195.4	253
88	2.444E-02	256.4	256	259.8	193	195.3	253.1
90	2.500E-02	256.8	256	259.7	193.1	195.2	253.3
92	2.556E-02	256.9	256.4	259.6	193.1	195.2	253.4
94	2.611E-02	257.1	256.6	259.4	193.2	195.4	253.6
96	2.667E-02	257.3	257	259.3	193.3	195.6	253.7
98	2.722E-02	257.5	257.1	259.2	193.4	195.7	253.9
100	2.778E-02	257.7	257.3	259.1	193.5	195.9	254
105	2.917E-02	258.2	257.8	258.8	193.7	196.2	254.3
110	3.056E-02	258.6	258.2	258.5	193.9	196.6	254.7
115	3.194E-02	259	258.5	258.3	194.1	197	255
120	3.333E-02	259.5	258.8	258	194.3	197.4	255.3
125	3.472E-02	259.8	258.9	257.8	194.5	197.7	255.5
130	3.611E-02	260.2	259	257.6	194.7	198.1	255.8
135	3.750E-02	260.6	259.1	257.4	194.9	198.5	256.1
140	3.889E-02	260.9	259.2	257.2	195.1	198.9	256.3
145	4.028E-02	261.3	259.2	257	195.3	199.3	256.6
150	4.167E-02	261.6	259.2	256.8	195.5	199.7	256.8
155	4.306E-02	262	259.2	256.5	195.7	200.1	257
160	4.444E-02	262.3	259.2	256.2	195.9	200.4	257.3
165	4.583E-02	262.6	259.2	255.9	196.1	200.8	257.5
170	4.722E-02	263	259.1	255.6	196.3	201.2	257.7

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

Table 4-8 — Containment Atmosphere and Water Sump Temperature Profile

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
175	4.861E-02	263.4	259.1	255.3	196.4	201.6	257.9
180	5.000E-02	263.6	259	255	196.6	202	258.1
185	5.139E-02	264	258.9	254.8	196.8	202.5	258.3
190	5.278E-02	264.2	258.8	254.6	197	202.9	258.5
195	5.417E-02	264.4	258.7	254.2	197.2	203.4	258.7
200	5.556E-02	264.7	258.6	253.8	197.4	204	258.9
205	5.694E-02	264.9	258.5	253.5	197.7	204.5	259.1
210	5.833E-02	265	258.4	253.2	198	205	259.2
215	5.972E-02	265.2	258.3	252.8	198.3	205.5	259.4
220	6.111E-02	265.3	258.2	252.5	198.6	206	259.5
225	6.250E-02	265.4	258.1	252.1	198.9	206.5	259.6
230	6.389E-02	265.5	258	251.8	199.3	207	259.7
235	6.528E-02	265.6	257.9	251.4	199.7	207.5	259.8
240	6.667E-02	265.6	257.8	251.1	200.1	208	259.9
245	6.806E-02	265.7	257.7	250.8	200.6	208.5	260
250	6.944E-02	265.8	257.6	250.5	201	209	260
255	7.083E-02	265.8	257.5	250.2	201.4	210.3	260.1
260	7.222E-02	265.9	257.3	249.9	201.9	211	260.1
265	7.361E-02	265.9	257	249.6	202.4	211.4	260.2
270	7.500E-02	265.9	256.8	249.3	202.8	211.9	260.2
275	7.639E-02	265.9	256.6	249	203.3	212.3	260.2
280	7.778E-02	265.8	256.4	248.7	203.8	212.8	260.3
285	7.917E-02	265.8	256.3	248.4	204.2	213.2	260.3
290	8.056E-02	265.7	256.1	248.1	204.7	213.6	260.3
295	8.194E-02	265.6	255.9	247.8	205.2	214	260.3
300	8.333E-02	265.5	255.7	247.6	205.6	214.5	260.3
310	8.611E-02	265.3	255.4	247.1	206.6	215.3	260.3
320	8.889E-02	264.9	255	246.5	206.4	216	260.2
330	9.167E-02	264.5	255.1	246	207.4	216.8	260.1
340	9.444E-02	264.1	254.5	245.5	208.3	217.5	260
350	9.722E-02	263.8	254.2	245.2	209.2	218.2	259.9
360	1.000E-01	263.4	253.9	244.7	210	218.9	259.8
370	1.028E-01	263.2	253.6	244.2	210.8	219.5	259.7
380	1.056E-01	262.9	253.2	243.7	211.6	220.2	259.5
390	1.083E-01	262.5	252.9	243.3	212.4	220.8	259.4
400	1.111E-01	262.2	252.7	242.8	213.1	221.4	259.2
420	1.167E-01	261.6	252.1	241.9	214.6	222.6	258.8
440	1.222E-01	260.9	251.5	241	215.9	223.7	258.3
460	1.278E-01	260.3	251	240.2	217.2	224.7	257.9
480	1.333E-01	259.8	250.5	239.3	218.4	225.7	257.4
500	1.389E-01	259.2	249.8	238.5	219.5	226.6	256.8
520	1.444E-01	258.6	249	237.7	220.6	227.4	256.3
540	1.500E-01	258	248.1	236.9	221.7	228.1	255.7
560	1.556E-01	257.2	247.4	236.2	222.7	228.7	255.1
580	1.611E-01	256.4	246.6	235.4	223.6	229.3	254.6
600	1.667E-01	255.7	245.8	234.6	224.5	229.7	254
650	1.806E-01	253.9	244.1	233	226.2	230.5	252.4

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REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 4-8 — Containment Atmosphere and Water Sump Temperature Profile

Time (sec)	Time (hr)	Vapor Temperature (°F) Case 1	Vapor Temperature (°F) Case 4	Vapor Temperature (°F) Case 7	Sump Temperature (°F) Case 1	Sump Temperature (°F) Case 4	Sump Temperature (°F) Case 7
700	1.944E-01	252	242.3	231.2	227.4	230.9	250.9
750	2.083E-01	250.2	240.6	229.4	228.2	231.1	249.4
800	2.222E-01	248.4	239	227.7	228.7	231.1	247.8
850	2.361E-01	246.7	237.3	226.1	229	230.9	246.3
900	2.500E-01	245.5	235.8	224.5	229	230.5	244.8
950	2.639E-01	243.7	234.2	223	228.9	230.1	243.3
1000	2.778E-01	242.1	232.9	221.4	228.6	229.6	241.8
1050	2.917E-01	240.6	231.4	220.1	228.2	229	240.3
1100	3.056E-01	239.1	230	218.7	227.8	228.3	238.9
1150	3.194E-01	237.6	228.5	217.3	227.3	227.6	237.5
1200	3.333E-01	236.2	227.2	215.9	226.7	226.9	236.1
1220	3.389E-01	235.6	226.6	215.3	226.5	226.6	235.6
1240	3.444E-01	235	226.1	214.7	226.2	226.3	235.1
1260	3.500E-01	234.5	225.5	214.2	226	226	234.6
1280	3.556E-01	234.2	225	213.7	225.7	225.7	234
1300	3.611E-01	233.5	224.5	213.1	225.5	225.5	233.5
1320	3.667E-01	233	224	212.6	225.3	225.2	233
1340	3.722E-01	232.4	223.4	212	225	224.9	232.5
1360	3.778E-01	231.9	222.9	211.5	224.7	224.6	232
1380	3.833E-01	231.4	222.4	211	224.5	224.3	231.6
1400	3.889E-01	230.8	221.9	210.5	224.2	224	231.1
1450	4.028E-01	229.5	220.7	209.2	223.6	223.2	229.9
1500	4.167E-01	228.2	219.6	207.9	222.9	222.5	228.8
1550	4.306E-01	226.9	218.4	206.8	222.3	221.8	227.7
1600	4.444E-01	225.6	217.2	205.6	221.6	221.1	226.6
1650	4.583E-01	224.4	216	204.4	221	220.4	225.6
1700	4.722E-01	223.1	214.8	203.2	220.4	219.7	224.6
1750	4.861E-01	221.9	213.6	202	219.7	219	223.6
1800	5.000E-01	220.7	212.5	200.8	219.1	218.3	222.6
1850	5.139E-01	219.7	211.4	199.7	218.5	217.6	221.7
1900	5.278E-01	218.5	210.3	198.6	217.9	217	220.8
1950	5.417E-01	217.4	209.2	197.5	217.2	216.3	219.9
2000	5.556E-01	216.2	208.1	196.5	216.6	215.7	219
2050	5.694E-01	215.1	207.2	195.4	216	215.1	218.2
2100	5.833E-01	214	206.1	194.3	215.4	214.4	217.4
2150	5.972E-01	212.8	205.1	193.3	214.9	213.8	216.6
2200	6.111E-01	211.8	204.1	192.3	214.3	213.2	215.8
2250	6.250E-01	210.7	203	191.3	213.7	212.6	215
2300	6.389E-01	209.6	202	190.3	213.2	212	214.3
2350	6.528E-01	208.6	201.1	189.3	212.6	211.5	213.6
2400	6.667E-01	207.5	200.1	188.3	212	210.9	212.9
2420	6.722E-01	207.2	199.7	188	211.8	210.7	212.8
2440	6.778E-01	206.8	199.3	188.3	211.7	210.5	212.7
2460	6.833E-01	206.5	199	187.6	211.6	210.4	212.6
2480	6.889E-01	206.1	198.7	187.2	211.6	210.3	212.5
2500	6.944E-01	205.8	198.4	186.9	211.5	210.3	212.4
2600	7.222E-01	204	196.9	185.5	211.3	210.1	212.1

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 4-8 — Containment Atmosphere and Water Sump Temperature Profile

Time (sec)	Time (hr)	Vapor Temperature (°F) Case 1	Vapor Temperature (°F) Case 4	Vapor Temperature (°F) Case 7	Sump Temperature (°F) Case 1	Sump Temperature (°F) Case 4	Sump Temperature (°F) Case 7
2700	7.500E-01	203.4	196.5	187.9	211.3	210	211.9
2800	7.778E-01	205.7	199	191	211.1	209.9	211.6
2900	8.056E-01	207.8	201.3	193.5	211	209.7	211.4
3000	8.333E-01	209.1	203.2	195.7	210.9	209.7	211.2
3100	8.611E-01	210.5	204.8	197.6	210.8	209.6	211.1
3200	8.889E-01	211.6	206.2	199.1	210.8	209.5	210.9
3300	9.167E-01	212.7	207.4	200.4	210.7	209.5	210.8
3400	9.444E-01	213.6	208.4	201.6	210.7	209.5	210.6
3500	9.722E-01	214.4	209.3	202.6	210.6	209.4	210.5
3600	1.000E+00	215.1	210.1	203.6	210.6	209.4	210.4
3700	1.028E+00	215.7	210.8	204.4	210.6	209.4	210.3
3800	1.056E+00	216.3	211.5	205.2	210.5	209.4	210.3
3900	1.083E+00	216.8	212.1	205.9	210.5	209.4	210.2
4000	1.111E+00	217.3	212.7	206.5	210.5	209.4	210.1
4500	1.250E+00	219.3	215	209	210.6	209.6	209.9
5000	1.389E+00	220.4	216.6	210.8	210.7	209.8	209.9
5500	1.528E+00	221.1	217.6	211.8	210.9	210.2	209.9
6000	1.667E+00	221.6	218.1	212.4	211.1	210.5	210
6500	1.806E+00	221.7	218.4	212.8	211.3	210.9	210.1
7000	1.944E+00	221.5	218.4	212.9	211.5	211.2	210.3
7500	2.083E+00	221.1	218.2	213.3	211.8	211.6	210.1
8000	2.222E+00	220.7	218.1	213.9	212.1	211.9	209.7
8500	2.361E+00	220.5	217.9	214.4	212.4	212.2	209.3
9000	2.500E+00	220.1	217.8	214.7	212.6	212.4	209.1
9500	2.639E+00	219.8	217.6	215	212.9	212.7	208.8
10000	2.778E+00	219.4	217.4	215.2	213.1	212.9	208.6
12500	3.472E+00	217.7	216.2	215.3	213.7	213.8	207.7
15000	4.167E+00	215.7	214.5	214.3	213.8	214.1	207
17500	4.861E+00	213.2	212.2	212.5	213.5	214	206.2
20000	5.556E+00	210.8	210	210.6	212.8	213.6	205.3
22500	6.250E+00	208.9	208.2	209	211.9	212.8	204.3
25000	6.944E+00	207.1	206.5	207.5	210.8	211.9	203.2
27500	7.639E+00	205.2	204.6	205.9	209.7	210.9	202.1
30000	8.333E+00	203.2	202.7	204.1	208.5	209.8	200.9
35000	9.722E+00	199.1	198.6	200.4	205.9	207.4	198.5
40000	1.111E+01	195.4	194.9	197	203.2	204.8	195.9
45000	1.250E+01	192.2	191.7	194.2	200.6	202.3	193.5
50000	1.389E+01	189.4	188.7	191.6	198.3	200	191.2
55000	1.528E+01	186.4	185.6	189.1	196.1	197.7	189.1
60000	1.667E+01	183.9	183	187	194	195.7	187.1
65000	1.806E+01	181.7	180.8	185	192.1	193.8	185.4
70000	1.944E+01	179.7	178.7	183.1	190.5	192.1	183.8
75000	2.083E+01	177.8	176.7	181.4	189	190.6	182.3
80000	2.222E+01	176.2	175	180	187.6	189.3	181
85000	2.361E+01	174.6	173.3	178.7	186.4	188	179.8
90000	2.500E+01	173.2	171.8	177.6	185.3	186.9	178.8
95000	2.639E+01	171.9	170.5	176.6	184.2	185.9	177.8

Table 4-8 — Containment Atmosphere and Water Sump Temperature Profile

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
100000	2.778E+01	170.8	169.3	175.7	183.3	184.9	177
125000	3.472E+01	166.2	164.7	171.7	179.8	181.5	173.9
150000	4.167E+01	162	160.4	168.1	177.1	178.7	171.3
175000	4.861E+01	158	156.1	164.5	174.6	176.1	168.8
200000	5.556E+01	154.7	152.7	161.6	172.3	173.9	166.7
225000	6.250E+01	151.7	149.8	159.1	170.5	172.1	164.9
250000	6.944E+01	149	146.8	156.5	168.8	170.4	163.2
275000	7.639E+01	146.5	144.1	154.2	167.3	168.8	161.6
300000	8.333E+01	144.4	141.9	152.4	166	167.5	160.3
400000	1.111E+02	136.5	133.7	145.6	161.4	162.9	155.9
500000	1.389E+02	130.5	127.6	140.4	157.8	159.4	152.4
600000	1.667E+02	126	122.8	136.6	155.3	156.7	150
700000	1.944E+02	121.6	120	132.6	152.8	154.6	147.6
800000	2.222E+02	119.9	118.3	130.5	151.6	152.5	146.1
900000	2.500E+02	118.2	114.8	128.4	150.2	150.2	144.8
1000000	2.778E+02	117	114	126.2	148.3	148.1	143.5
1250000	3.472E+02	113	115.7	123	145.2	145.1	141.5
1500000	4.167E+02	112.3	112.2	120.7	142.9	142.9	140
1750000	4.861E+02	114.4	114.4	118.3	140.7	140.7	138.6
2000000	5.556E+02	113.8	113.8	115.9	138.7	138.7	137.1
2500000	6.944E+02	111.5	113	113.2	134.6	134.6	134.7
3000000	8.333E+02	110.8	112.5	112.6	132.5	132.5	132.6
3500000	9.722E+02	112.2	112.2	109.3	131.1	131.1	131.1
4000000	1.111E+03	111.8	111.8	108.9	129.6	129.6	129.6
5000000	1.389E+03	111	111	108.1	126.7	126.7	126.7
6000000	1.667E+03	110.3	110.2	110.3	123.7	123.7	123.7
7000000	1.944E+03	109.9	109.9	109.9	122.5	122.5	122.5
8000000	2.222E+03	109.6	109.6	109.6	121.4	121.4	121.4
9000050	2.500E+03	109.3	109.3	109.3	120.3	120.3	120.3
10000050	2.778E+03	109	109	109	119.2	119.2	119.2

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

5 METHODOLOGY

5.1 NATURAL DEPOSITION

5.1.1 Aerosols

Natural deposition includes many phenomena (e.g., gravitational settling, thermophoresis, diffusiophoresis). This removal mechanism is considered valid only for aerosols; organic iodine and noble gases are non-reactive and therefore are not likely to be affected by these mechanisms.

A simplified natural deposition model for aerosols was developed by Powers et. al. (Reference 6.4j). This model accounts for effects due to turbulence and to the multiple aerosol releases specified in NUREG-1465 (Reference 6.4g). To account for the uncertainties, a large number of calculations were performed with the modified mechanistic model, with specific values for the type of reactor containment, reactor power, and the source term release phase, while varying the values of the uncertain parameters. Typical uncertain parameters were the containment pressure during the various release phases, the floor and wall surface areas, the zirconium inventory, the ratio for containment volume to thermal power, and the properties of the concrete. These calculations resulted in a highly simplified model for aerosol decontamination using a first order removal rate coefficient (λ_{dep}).

The first order removal rate coefficient was solved over the various release time intervals and for the different types of reactors and various operating power levels (P in MWt) using a Monte Carlo uncertainty analysis. The results of these analyses for PWR design basis accidents are summarized in Table 5-1.

Table 5-1 — Correlation of PWR Effective Natural Deposition Decontamination Coefficients with Reactor Thermal Power (Table 36 of Reference 6.4j)

Released Material	Time Interval (s)	Correlation (hr^{-1})
Gap	0 – 1,800	$\lambda_{dep}(90) = 0.0365 + 3.580 \times 10^{-6}$ P
	(0 – 0.5 hr)	$\lambda_{dep}(50) = 0.0268 + 3.475 \times 10^{-6}$ P
		$\lambda_{dep}(10) = 0.0182 + 3.260 \times 10^{-6}$ P
gap	1,800 – 6,480	$\lambda_{dep}(90) = 0.1036 [1 - e^{-2.239 P/1000}]$
	(0.5 – 1.8 hr)	$\lambda_{dep}(50) = 0.0820 [1 - e^{-1.159 P/1000}]$
		$\lambda_{dep}(10) = 0.0645 [1 - e^{-0.938 P/1000}]$
early in-vessel	1,800 – 6,480	$\lambda_{dep}(90) = 0.0522 [1 - e^{-2.458 P/1000}]$
	(0.5 – 1.8 hr)	$\lambda_{dep}(50) = 0.0417 [1 - e^{-1.258 P/1000}]$
		$\lambda_{dep}(10) = 0.0326 [1 - e^{-0.910 P/1000}]$

Table 5-1 — Correlation of PWR Effective Natural Deposition Decontamination Coefficients with Reactor Thermal Power (Table 36 of Reference 6.4j)

Released Material	Time Interval (s)	Correlation (hr^{-1})
gap + early in-vessel	6,480 – 13,680 (1.8 – 3.8 hr)	$\lambda_{dep}(90) = 0.421\ [1 - e^{-2.530\ P/1000}]$ $\lambda_{dep}(50) = 0.196\ [1 - e^{-1.040\ P/1000}]$ $\lambda_{dep}(10) = 0.094\ [1 - e^{-0.869\ P/1000}]$
gap + early in-vessel	13,680 – 49,680 (3.8 – 13.8 hr)	$\lambda_{dep}(90) = 0.1920 - 1.35 \times 10^{-6}\ P$ $\lambda_{dep}(50) = 0.1382 + 6.85 \times 10^{-6}\ P$ $\lambda_{dep}(10) = 0.0811 + 10.15 \times 10^{-6}\ P$
gap + early in-vessel	49,680 – 80,000 (13.8 – 22.22 hr)	$\lambda_{dep}(90) = 0.1010$ $\lambda_{dep}(50) = 0.0912$ $\lambda_{dep}(10) = 0.0860\ [1 - e^{-2.384\ P/1000}]$

Per Regulatory Guide 1.183 (Reference 6.4e, Table 2) only the halogens and alkali metals have a gap release phase. All isotope groups have an early in-vessel release phase. During the 1,800 – 6,480 second time period, both the gap and early in-vessel release phase aerosols for the halogens and alkali metals are present; therefore the removal rate coefficient is a combination of the individual release rates weighted by the release rate for each phase per NUREG/CR-6604 (Reference 6.4k, page 200) as follows:

$$\lambda_{eff} = \frac{\lambda_{gap} \times r_{gap} + \lambda_{iv} \times r_{iv}}{r_{gap} + r_{iv}} \qquad \textbf{Equation 5-1}$$

Where:

- λ_{eff} is the effective natural deposition rate (hr^{-1})
- λ_{gap} is the gap phase natural deposition rate for the 1,800 – 6,480 s time period
- λ_{iv} is the early in-vessel phase natural deposition rate for the 1,800 – 6,480 s time period
- r_{gap} is the release rate (fraction of core per hour) during the gap phase
- r_{iv} is the release rate (fraction of core per hour) during the early in-vessel phase

5.1.2 Elemental Iodine

Removal of elemental iodine by wall deposition may be estimated using the methodology of SRP 6.5.2 (Reference 6.4f). From SRP 6.5.2 Section III.4.c.(1), the removal rate is given by:

$$\lambda_w = \frac{K_w \cdot A}{V} \qquad \textbf{Equation 5-2}$$

Where:

λ_w is the first-order removal coefficient by wall deposition
A is the wetted surface area
V is the containment building net free volume
K_w is a mass-transfer coefficient

5.2 *Spray Removal Rates*

5.2.1 Aerosol

Aerosol removal by sprays is determined using the Powers model from NUREG/CR-5966 (Reference 6.4i). The extent to which sprays will decontaminate an aerosol-laden atmosphere depends on the number of spray droplets falling through the atmosphere and the distance they fall. The water flux into the containment atmosphere is time dependent and the fall distance is dependent upon the containment design. The Powers model is a mechanistic model of aerosol removal by sprays based upon how a single falling droplet would scavenge particles. Powers suggested that many of the properties and phenomena affecting the process are not accurately predictable. To account for these uncertainties, a large number of calculations were performed with the mechanistic model (with specific values for the height and water flux) and varying the uncertain parameters. Typical uncertain parameters were the containment pressure, aerosol particle size, the water droplet distribution, the dynamic shape factors, and the properties of the water. In all, 20 parameters that were related to the phenomena were varied. An uncertainty analysis was performed using a Monte Carlo method to sample all of the calculations.

The results of the uncertainty analysis were used to construct simplified expressions for spray removal coefficients. The model input parameters are the spray water flux Q (cm^3 H_20/ cm^2-s) and the fall height of the spray droplets H (cm). Since the model was developed from an uncertainty study, three percentile levels are suggested by Powers. The best estimate value is associated with the 50th percentile, or median values; the lower bound is associated with the 10th percentile; and the reasonable upper bound, or largest decontamination factor, with the 90th percentile.

The model was developed using values for the spray water flux ranging from 0.001 to 0.25 cm^3 H_20/ cm^2-s and fall heights ranging from 500 to 5,000 cm. The model should not be used for spray water fluxes and fall heights outside of these ranges.

The aerosol removal coefficient is dependent on the fraction of the aerosol suspended in the atmosphere, m_f, which is defined as the aerosol mass in the atmosphere at a given time, t, divided by the total aerosol mass released into the compartment atmosphere until this time. This aerosol removal coefficient can be used in a simple differential equation to calculate decontamination (NUREG/CR-5966 [Reference 6.4i] page 149):

$$\frac{dm_f}{dt} = -\lambda(Q, H, m_f) \cdot m_f$$ **Equation 5-3**

Where $\lambda(Q, H, m_f)$ is the aerosol removal coefficient for a given water flux Q ($cm^3\ H_20/\ cm^2$-s), fall height H (cm), and aerosol mass fraction m_f. Powers developed correlations for $\lambda(Q, H, m_f = 0.9)$ and the ratio $\lambda(m_f)/\lambda(m_f=0.9)$. The aerosol removal coefficient is then:

$$\lambda(Q,H,m_f)=\lambda(Q,H,m_f=0.9)\frac{\lambda(m_f)}{\lambda(m_f=0.9)} \qquad \textbf{Equation 5-4}$$

The correlation for $\lambda(Q, H, m_f = 0.9)$ is given by (NUREG/CR-5966 [Reference 6.4i] page 153 and NUREG/CR-6604 [Reference 6.4k] equation 6, page 197):

$$\lambda(Q,H,m_f=0.9)=\exp\left[A+B\ln Q+CH+DQ^2H+EQH^2+FQ+GQ^2H^2\right] \qquad \textbf{Equation 5-5}$$

The correlation for $\lambda(m_f)/\lambda(m_f=0.9)$ is given by (NUREG/CR-5966 [Reference 6.4i] page 154):

$$\frac{\lambda(m_f)}{\lambda(m_f=0.9)}=\left[a+b\log_{10}Q\right]\left[1-\left(\frac{m_f}{0.9}\right)^c\right]+\left(\frac{m_f}{0.9}\right)^c \qquad \textbf{Equation 5-6}$$

The constants A, B, C, D, E, F, G, a, b, and c are defined below in Table 5-2.

The above model was originally developed for a puff release of aerosol into a system. In those cases where there is a continuous release, the size distribution will continually be renewed by the injected aerosols. The model has been extended for this case by setting the mass fraction $m_f = 1$ until the release stops.

Table 5-2 — Values for Constants Used in Equation 5-5 and Equation 5-6

Constant	10th Percentile	50th Percentile	90th Percentile
A	5.5750	6.83707	7.10927
B	0.94362	1.0074	0.92549
C	0.0	-2.4045×10^{-5}	0.0
D	-6.9821×10^{-3}	-4.1731×10^{-3}	-8.0868×10^{-4}
E	-7.327×10^{-7}	9.006×10^{-8}	0.0
F	0.0	-1.2478	0.0
G	3.555×10^{-6}	0.0	0.0
a	0.1108	0.1815	0.3751
b	-0.00201	-0.01153	0.00648
c	0.8945	0.5843	0.2786

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

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As discussed above, $\lambda(Q, H, m_f = 0.9)$ is dependent on the spray flux and the drop height. Individual $\lambda(Q, H, m_f = 0.9)$ are calculated for each spray header and spray header ring. The overall $\lambda(Q, H, m_f = 0.9)$ is then the sum of the individual spray header ring aerosol removal rates.

5.2.1.1 Time Dependent Aerosol Removal Rates

The expression for the aerosol removal rate constant as shown in Equation 5-4 is dependent on the mass fraction, m_f. Therefore, Equation 5-4 in conjunction with Equation 5-6 will be calculated as a function of m_f. The time to reach the mass fraction is then calculated assuming that the removal rate is constant over a small time period Δt and for an initial mass release at t=0. The basic equation is:

$$m_f(t_2) = m_f(t_1)e^{-\lambda \Delta t} \qquad \textbf{Equation 5-7}$$

Equation 5-7 is then solved for t_2, noting that $\Delta t = t_2 - t_1$,

$$t_2 = t_1 - \frac{\ln\left(\frac{m_f(t_2)}{m_f(t_1)}\right)}{\lambda(m_f)} \qquad \textbf{Equation 5-8}$$

5.2.1.2 Average Aerosol Removal Rate

The program *LocaDose*, NE319 (Reference 6.6a) treats the removal rates as constants for any given time period; therefore, to model the time dependency, average removal rates are calculated for specified *LocaDose* time periods. The determination of an average removal for a specific time period begins by assuming that over that time period the removal rate λ behaves as an exponential of the form:

$$\lambda(t) = \lambda_1 e^{-\alpha(t-t_1)} \qquad \textbf{Equation 5-9}$$

Therefore, at time t_2, the removal rate is given by:

$$\lambda_2 = \lambda_1 e^{-\alpha(t_2-t_1)} \qquad \textbf{Equation 5-10}$$

The constant α for the t_1 to t_2 time interval can be calculated from the above equation to be:

$$\alpha = -\frac{\ln\left(\lambda_2/\lambda_1\right)}{(t_2 - t_1)}$$ **Equation 5-11**

Integrating Equation 5-9 between times t_1 to t_2 yields:

$$\int \lambda(t)dt = \int_{t_1}^{t_2} \lambda_1 e^{-\alpha(t-t_1)}dt$$ **Equation 5-12**

$$\int \lambda(t)dt = -\frac{\lambda_1}{\alpha}\left|e^{-\alpha(t-t_1)}\right|_{t_1}^{t_2}$$ **Equation 5-13**

$$\int \lambda(t)dt = -\frac{\lambda_1}{\alpha}\left[e^{-\alpha(t_2-t_1)} - 1\right]$$ **Equation 5-14**

Inserting Equation 5-10 and Equation 5-11 into Equation 5-14 yields the following time integrated removal rate for the t_1 to t_2 time interval:

$$\lambda I(\Delta t) = \int \lambda(t)dt = \frac{\lambda_2 - \lambda_1}{\ln\left(\lambda_2/\lambda_1\right)}(t_2 - t_1)$$ **Equation 5-15**

Equation 5-15 is calculated for small time increments between times T_1 and T_2, the *LocaDose* time interval. The results are then summed together and divided by this time interval to develop the average removal rate:

$$\bar{\lambda}(T_1 \rightarrow T_2) = \frac{\sum_j \lambda I_j(\Delta t_j)}{T_2 - T_1}$$ **Equation 5-16**

5.2.2 Elemental Iodine

5.2.2.1 Spray Removal Rates

Elemental iodine removal rates by sprays are calculated using the Bechtel Standard Computer Program *REMOVE*, NE305 (Reference 6.6b). *REMOVE* is a computer program used to calculate spray removal rate constants for elemental, particulate, and organic iodines. A spectrum of drop sizes produced by the SPRACO 1713A nozzle is used in the model to determine a spray removal rate constant.

Characteristics of each drop size such as diameter, terminal velocity, fall time, Reynolds number, Sherwood number, saturation fraction and removal rate constant are calculated and printed. The total spray removal rate constant for removal of iodine is the sum of the individual removal rates for each drop size.

REMOVE incorporates the models of SRP 6.5.2 (Reference 6.4f) and NUREG/CR-0009 (Reference 6.4h) to determine the iodine spray removal coefficients.

For this calculation, the *REMOVE* code was executed on a Dell Latitude D400 personal computer (Bechtel ID No. BSII 29279). Use of the *REMOVE* code on this computer has been verified and validated as required by SONGS Procedures SO123-XXIV-7.15 (Reference 6.5a) and SO123-XXIV-5.1 (Reference 6.5b). The validation cases provided with the code package were run and compared to the results provided and shown to be identical.

For the purposes of this calculation the elemental iodine removal rates calculated by REMOVE are used. Although *REMOVE* calculates particulate and organic iodine removal rates, these values are not used or reported in this calculation. Particulate iodine removal rates are calculated using the methodology presented in Section 5.2.1, and the organic iodine removal rates are conservatively neglected in this analysis.

Spray removal rates are calculated for each spray header and each ring individually, and then added together to determine an overall elemental iodine spray removal rate.

5.2.2.2 Partition Coefficients and DF Values

The partition coefficients are calculated using the Bechtel Standard Computer Program *ICONC*, NE316 (Reference 6.6c). *ICONC* calculates the partition coefficient of iodine between water and air using the methodology developed by L. P. Parsly in ORNL-TM-2412 Part IV (Reference 6.6e). The input parameters needed to execute *ICONC* are as follows:

- Water temperature in °F
- Water pH value
- Volume of gaseous phase in cubic feet
- Volume of liquid phase in cubic feet
- Initial iodine inventory in water in moles
- Equilibrium constants K_1 and K_3

For this calculation, the *ICONC* code was executed on a Dell Latitude D400 personal computer (Bechtel ID No. BSII 29279). Use of the *ICONC* code on this computer has been verified and validated as required by SONGS Procedures SO123-XXIV-7.15 (Reference 6.5a) and SO123-XXIV-5.1 (Reference 6.5b). The validation cases provided with the code package were run and compared to the results provided and shown to be identical.

5.2.2.2.1 Initial Elemental Iodine Inventory

Using the iodine mass presented in Design Input 4.16, the number of moles, *n*, is determined as follows:

$$n_i = \frac{M_i}{2 \times MW_i}$$ **Equation 5-17**

Where:

- n_i is the number of moles for iodine isotope *i*
- M_i is the mass of iodine isotope *i* (g)
- MW_i is the molecular weight of iodine isotope *i* (g/mole)

The factor of 2 in the denominator accounts for the fact that elemental iodine is a diatomic molecule (i.e., I_2).

5.2.2.2.2 Equilibrium Constants K_1 and K_3

The equilibrium constants K_1 and K_3 are given as a function of temperature in Design Input 4.15. These values obey an approximate exponential relationship with respect to temperature; therefore, to calculate equilibrium constants at intermediate temperatures, an exponential interpolation is used as follows:

$$K(T) = K(T_1)\left(\frac{K(T_2)}{K(T_1)}\right)^{\left[\frac{T_1 - T}{T_1 - T_2}\right]}$$ **Equation 5-18**

6 REFERENCES

6.1 *CALCULATIONS*

6.1a Unit 2 & 3 Calculation A-92-NF-002, Revision 0, *Realistic Dose Assessment to Disposition LER 2-92-006.*

6.1b Unit 2 & 3 Calculation M-0014-009, Revision 0 (including CCNs 1 to 4), *Containment Spray in Service Testing Minimum Requirements.*

6.1c Unit 2 & 3 Calculation N-0220-013, Revision 0 (including CCNs 1 & 2), TSP Requirements for 24 Month Equilibrium Cycle Operation – Supplement A

6.1d Unit 2 & 3 Calculation N-4080-026, Revision 1 (including CCNs 4 & 5), *Containment P-T Analysis for Design Basis LOCA.*

6.1e Unit 2 & 3 Calculation N-4080-027, Revision 1 (including CCNs 4 & 5), *Containment P-T Analysis for Design Basis MSLB.*

6.1f Unit 2 & 3 Calculation N-6097-001, Revision 0, *SO23 Alternative Source Term – ORIGEN-S Results.*

6.1g WCAP-10974, *Spray Additive Tank Deletion Analysis for the San Onofre Nuclear Generating Station Units 2 and 3*, submitted by Westinghouse Electric Corporation, dated 12/5/85 (CDM Retrieval Number C860314G-33).

6.2 *DRAWINGS*

6.2a Unit 2 & 3 Drawing 10003, Revision 9, *Containment Structure Penetration Bld. Floor Plan El. 63'– 6" and details*

6.2b Unit 2 & 3 Drawing 23000, Revision 5 (including DCN 3), *Containment Structure General Arrangement*

6.2c Unit 2 & 3 Drawing 23116, Revision 12 (including DCNs 14 to 16), *Containment Interior Struct. Reinforced Concrete North Partial Plan, El. 63' – 6"*

6.2d Unit 2 & 3 Drawing 23117, Revision 18, *Containment Interior Struct. Reinforced Concrete South Partial Plan, El. 63' – 6"*

6.2e P & I Diagram, Containment Spray System, System No. 1206
- a) Unit 2 Drawing 40114B, Revision 17
- b) Unit 3 Drawing 40114BSO3, Revision 14

6.2f Containment Spray Water Piping Plan & Details
a) Unit 2 Drawing 40494 Revision 6
b) Unit 3 Drawing 41994 Revision 6

6.2g Drawing SO23-954-2-0, Outline of Mod. 1713A Ramp Nozzle, (Spray Engineering Co, Burlington, Mass., drawing EXKN16532, December 1969).

6.3 CORRESPONDENCE

None

6.4 REGULATORY DOCUMENTS

6.4a San Onofre Unit 2 Facility Operating License NPF-10, Amendment 189

6.4b San Onofre Unit 3 Facility Operating License NPF-15, Amendment 180

6.4c San Onofre Unit 2 Technical Specifications,
i) LCO 3.5.4 page 3.5-9 [Amendment 127]

6.4d San Onofre Unit 3 Technical Specifications,
i) LCO 3.5.4 page 3.5-9 [Amendment 116]

6.4e Regulatory Guide 1.183, Revision 0, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors*, USNRC, July 2000.

6.4f NUREG-0800, Standard Review Plan 6.5.2, Revision 2, *Containment Spray as a Fission Product Cleanup System*, USNRC, December 1988.

6.4g NUREG-1465, *Accident Source Terms for Light-Water Nuclear Power Plants*, USNRC, February 1995.

6.4h NUREG/CR-0009, *Technological Bases for Models of Spray Washout of Airborne Contaminants in Containment Vessels.*

6.4i NUREG/CR-5966, *A Simplified Model of Aerosol Removal by Containment Sprays*, USNRC, June 1993.

6.4j NUREG/CR-6189, *A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments*, USNRC, July 1996.

6.4k NUREG/CR-6604, *RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation*

6.5 PROCEDURES

6.5a SO123-XXIV-7.15 Revision 3 (including TCN3-2), Preparation and Verification of Design Calculations.

6.5b SO123-XXIV-5.1 Revision 4, Engineering and Technical Services Software Qualitiy Assurance.

6.6 OTHER DOCUMENTS

6.6a *LocaDose* Computer Program, Bechtel Standard Computer Program NE319, Version 6.01, September 2002.

6.6b *Remove* Computer Program, Bechtel Standard Computer Program NE305, Version 4.0, December 1991.

6.6c *Iconc* Computer Program, Bechtel Standard Computer Program NE316, Version 3.0, April 1990.

6.6d Document SO23-954-M4 Revision 0, SPRACO's 1713A Nozzle for Nuclear Containment Vessels, Spray Engineering Company, Burlington, Massachusetts, 01803.

6.6e L. F. Parsly, *Design Considerations of Reactor Containment Spray Systems – Part IV. Calculation of Iodine-Water Partition Coefficients*, ORNL-TM-2412 Part IV, Oak Ridge National Laboratory, January 1970.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

7 NOMENCLATURE

7.1 *ACRONYMS*

AR	Action Request
AOR	Analysis of Record
CCN	Calculation Change Notice
CE	Combustion Engineering
CFR	Code of Federal Regulations
CSS	Containment Spray System
DBA	Design Basis Accident
DBE	Design Basis Event
DCN	Document Change Notice
DCP	Design Change Package
ECN	Engineering Change Notice
ICCN	Interim Calculation Change Notice
LCO	Technical Specification Limiting Condition for Operation
LCS	Licensee Controlled Specification
LOCA	Loss of Coolant Accident
NRC	Nuclear Regulatory Commission
RCS	Reactor Coolant System
RG	Regulatory Guide
RWST	Refueling Water Storage Tank
SRP	Standard Review Plan (NUREG-75/087 or NUREG-0800)
UxCyy	Unit x Cycle yy
UFSAR	Updated Final Safety Analysis Report

7.2 *UNITS*

cm^3	cubic centimeters
cfm	cubic feet per minute
ft	feet
GWD/T	Gigawatt-days per metric tonne of uranium
hr	hours
in	inches
m	meters
min	minutes
MTU	Metric tons of uranium
MWt	Megawatt-thermal
psig	pounds of force per square inch, gauge
s or sec	seconds
°C	degrees Centigrade
°F	degrees Fahrenheit

8 COMPUTATIONS

8.1 *TIME PERIODS*

The natural deposition and spray removal rates are time dependent. These removal rates will be used to determine releases and subsequent doses from the facility using the Bechtel Standard Computer Program *LocaDose*, NE319 (Reference 6.6a). *LocaDose*, NE319 treats the removal rates as constants for any given time period; therefore, to model the time dependency, average removal rates are calculated for specified *LocaDose* time periods. The specified time periods are presented in below:

Table 8-1 — Time Periods Used in the Removal Rate Calculation

Time	Description	*LocaDose* Time-Steps
30sec	Gap release onset	0.0000E+00—8.3333E-03 hr
1min	Containment spray system (CSS) actuation	8.3333E-03—1.6667E-02 hr
5min	Alternate containment spray system actuation time	1.6667E-02—8.3333E-02 hr
20min	Recirculation phase begins for two CSS trains operating	8.3333E-02—3.3333E-01 hr
30min	Potential ESF recirculation phase start time	3.3333E-01—5.0000E-01 hr
30.5min	Gap release termination, early in-vessel release begins	5.0000E-01—5.0833E-01 hr
2,497.4sec	Spray injection phase ends, recirculation phase begins	5.0833E-01—6.9372E-01 hr
1hr	Intermediate time-step	0.694—1 hr
6,480.0sec	End of early in-vessel release	1—1.8 hr
2hr	χ/Q change - CSS system secured manually (optional)	1.8—2 hr
13,680sec	Aerosol deposition rate change	2.000—3.8 hr
4hr	CSS system secured manually (optional)	3.8 4 hr
8hr	χ/Q change - CSS system secured manually (optional)	4—8 hr
49,680sec	Aerosol deposition rate change	8—13.8 hr
80,000sec	Aerosol deposition rate change	13.8—22.2 hr
24hr	χ/Q change - CSS system secured manually (optional)	22.2—24 hr
48hr	CSS system secured manually (optional)	24—48 hr
96hr	χ/Q change - CSS system secured manually (optional)	48—96 hr
720hr	End of analysis	96—720 hr

8.2 *Natural Deposition Rates*

8.2.1 Aerosols

Using the methodology described in Section 5.1.1, the natural deposition correlations shown on Table 5-1, and the core thermal power level of Design Input 4.1, the natural deposition aerosol removal rates for the gap release and the early in-vessel release phases for the different time periods are calculated and presented on Table 8-2.

Table 8-2 — Natural Deposition Rates (hr^{-1})

Time Period (s)	Gap Release 90%ile	Gap Release Mean	Gap Release 10%ile	Early in-vessel 90%ile	Early in-vessel Mean	Early in-vessel 10%ile
0 – 1,800	4.88E-02	3.87E-02	2.94E-02			
1,800 – 6,480	1.04E-01	8.05E-02	6.19E-02	5.22E-02	4.11E-02	3.12E-02
6,480 – 13,680	4.21E-01	1.91E-01	8.93E-02			
13,680 – 49,680	1.87E-01	1.62E-01	1.16E-01			
49,680 – 80,000	1.01E-01	9.12E-02	8.60E-02			

The following examples show how Table 8-2 was constructed.

1. The 10%ile natural deposition rate for the gap release phase for 0 – 1,800 s is calculated explicitly using the correlation of Table 5-1 and a core power level of 3,438 MWt:

$$\lambda_{dep}(10) = 0.0182 + 3.260 \times 10^{-6}\, P = 0.0182 + 3.260 \times 10^{-6} \times 3{,}438 = 0.0294$$

2. The 10%ile natural deposition rate for the gap release phase for 1,800 – 8,640 s is calculated explicitly using the correlation of Table 5-1 and a core power level of 3,438 MWt:

$$\lambda_{dep}(10) = 0.0645\,[\,1 - e^{-0.938\,P/1000}] = 0.0645\,[\,1 - e^{-0.938 \times 3438/1000}] = 0.0619$$

3. The 10%ile natural deposition rate for the early in-vessel release phase for 1,800 – 8,640 s is calculated explicitly using the correlation of Table 5-1 and a core power level of 3,438 MWt:

$$\lambda_{dep}(10) = 0.0326\,[\,1 - e^{-0.910\,P/1000}] = = 0.0326\,[\,1 - e^{-0.910 \times 3438/1000}] = 0.0312$$

The natural deposition rate for time periods less than 1,800 seconds and for time periods greater than 6,480 seconds for all aerosol groups is taken from the gap release columns of Table 8-2. For the 1,800 to 6,480 second time period, the effective natural deposition rate is calculated using Equation 5-1. The deposition rates for halogens, alkali metals, and other particulates are shown on Table 8-3 through Table 8-5.

For example, for halogens the 10%ile natural deposition rate is determined as follows:

From Design Input 4.2, the release fraction of halogens is 0.05 for the gap phase and 0.35 for the early in-vessel phase.

From Design Input 4.3, the gap release phase duration is 0.5 hours, and the early in-vessel release phase is 1.3 hours.

The release rate during the gap phase is then 0.05/0.5 hr = 0.1 fraction/hour

The release rate during the early in-vessel phase is then 0.35/1.3 = 0.269 fraction/hour

Using Equation 5-1, the halogen removal rate is then:

$$\lambda_{eff} = \frac{\lambda_{gap} \times r_{gap} + \lambda_{iv} \times r_{iv}}{r_{gap} + r_{iv}} = \frac{0.0619 \times 0.1 + 0.0312 \times 0.269}{0.1 + 0.269} = 0.0395 hr^{-1}$$

A second example, for alkali metals, the 10%ile natural deposition rate is determined as follows:

From Design Input 4.2, the release fraction of alkali metals is 0.05 for the gap phase and 0.25 for the early in-vessel phase.

From Design Input 4.3, the gap release phase duration is 0.5 hours, and the early in-vessel release phase is 1.3 hours.

The release rate during the gap phase is then 0.05/0.5 hr = 0.1 fraction/hour

The release rate during the early in-vessel phase is then 0.25/1.3 = 0.192 fraction/hour

Using Equation 5-1, the alkali metal removal rate is then:

$$\lambda_{eff} = \frac{\lambda_{gap} \times r_{gap} + \lambda_{iv} \times r_{iv}}{r_{gap} + r_{iv}} = \frac{0.0619 \times 0.1 + 0.0312 \times 0.192}{0.1 + 0.192} = 0.0417 hr^{-1}$$

Table 8-3 — Halogen Natural Deposition Rates (hr^{-1})

Time Period (s)	90%ile	Mean	10%ile
0–1,800	4.88E-02	3.87E-02	2.94E-02
1,800–6,480	6.61E-02	5.18E-02	3.95E-02
6,480–13,680	4.21E-01	1.91E-01	8.93E-02
13,680–49,680	1.87E-01	1.62E-01	1.16E-01
49,680–80,000	1.01E-01	9.12E-02	8.60E-02

Table 8-4 — Alkali Metals Natural Deposition Rates (hr^{-1})

Time Period (s)	90%ile	Mean	10%ile
0 – 1,800	4.88E-02	3.87E-02	2.94E-02
1,800 – 6,480	6.98E-02	5.46E-02	4.17E-02
6,480 – 13,680	4.21E-01	1.91E-01	8.93E-02
13,680 – 49,680	1.87E-01	1.62E-01	1.16E-01
49,680 – 80,000	1.01E-01	9.12E-02	8.60E-02

Table 8-5 — Other Particulates Natural Deposition Rates (hr^{-1})

Time Period (s)	90%ile	Mean	10%ile
0 – 1,800	N/A	N/A	N/A
1,800 – 6,480	5.22E-02	4.11E-02	3.12E-02
6,480 – 13,680	4.21E-01	1.91E-01	8.93E-02
13,680 – 49,680	1.87E-01	1.62E-01	1.16E-01
49,680 – 80,000	1.01E-01	9.12E-02	8.60E-02

8.2.2 Elemental Iodine

Natural deposition of elemental iodine is calculated using Equation 5-2. From Design Input 4.5, the mass transfer coefficient, K_w, is 0.137 cm/sec. From Design Input 4.6, the primary containment free air volume, V, is 2,284,000 ft^3. From Design Input 4.9, the wetted surface area, A, is 601,519 ft^2. The natural deposition rate for elemental iodine is then:

$$\lambda_w = \frac{K_w \cdot A}{V} = 0.137\,cm/\sec \times 3{,}600\,\sec/hr \frac{601{,}519\,ft^2}{2{,}284{,}000\,ft^3 \times 30.48\,cm/ft} = 4.26\,hr^{-1}$$

8.3 SPRAY REMOVAL RATES

8.3.1 Aerosol Removal Rates

8.3.1.1 Applicability of the Powers Aerosol Removal Rate Model

As discussed in Section 5.2.1, the Powers model of aerosol removal is valid for total water flux between 0.001 to 0.25 cm^3 H_2O/ cm^2-s and a fall height between 500 to 5,000 cm. In the following subsections, the total spray flux and the range of fall heights for the SONGS spray system are calculated to determine if they fall within the range of applicability of the Powers model.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

8.3.1.1.1 Total Spray Flux

As discussed in Section 5.2.1, the Powers model of aerosol removal is valid for total water flux between 0.001 to 0.25 cm^3 H_2O/ cm^2-s. The total flux is defined as the spray system volumetric flow rate divided by the floor coverage area.

From Design Input 4.10, the minimum spray system flow rate for one header is 1,600 gpm. This translates to:

$$F = 1{,}600\,gpm \times 3.78624\,l/gal \times 1{,}000\,cm^3/l/60\,s/\min = 1.010\times10^5\,cm^3/s$$

The floor coverage area is taken to be the area of a circle given by the inner diameter of the containment. The inner diameter of the containment, from Design Input 4.8 is 150 ft. Therefore, the floor area is:

$$A = \pi \times \left(\frac{150\,ft \times 30.48\,cm/ft}{2}\right)^2 = 1.642\times10^7\,cm^2$$

The total flux is then:

$$Q = \frac{F}{A} = \frac{1.010\times10^5\,cm^3/s}{1.642\times10^7\,cm^2} = 0.00615\,cm^3\,H_2O/cm^2 - s$$

This flux is within the range of applicability for the Powers model.

8.3.1.1.2 Maximum and Minimum Fall Heights

From Design Input 4.11, the minimum spray ring plant elevation is 143' – 3 11/16", and the maximum spray ring elevation is 181' – 11 11/16". From Design Input 4.7, the operating floor plant elevation is 63' – 6".

The minimum fall height is then:

$$H_{min} = \left(143 + \left(\frac{3+11/16}{12}\right)ft - 63.5\,ft\right) \times 30.48\,cm/ft = 2{,}433\,cm$$

The maximum fall height is then:

$$H_{max} = \left(181 + \left(\frac{11+11/16}{12}\right)ft - 63.5\,ft\right) \times 30.48\,cm/ft = 3{,}611\,cm$$

These fall heights are within the range of applicability of the Powers model.

8.3.1.2 Individual Spray Ring Aerosol Removal Rate Calculation

Since each spray ring is located at a different height, and will have different coverage areas, individual aerosol removal rates will be determined. For each spray ring, the fall height, H, and spray flux, Q, is determined, then the $\lambda(Q, H, m_f = 0.9)$ is calculated using Equation 5-5. The aerosol removal rates for each ring in a spray header are summed together, and the lowest header value is used to determine the time dependent aerosol removal rate.

Per Design Input 4.11 there are 116 nozzles per spray header (20+40+56). Per Design Input 4.10 the minimum flow rate per header is 1,600 gpm, therefore the minimum average flow per nozzle is 13.79 gpm.

8.3.1.2.1 Spray Header 1 Removal Rate Calculation

Spray header 1 consists of three concentric rings designed to provide full spray coverage. The calculation of the spray fall height, spray flux, and resultant aerosol removal rates is shown on Table 8-6 through Table 8-8. Representative sample calculations are provided.

<u>Fall height for ring 052-2 ½"-C-KEO:</u>

From Design Input 4.11, the centerline plant elevation of this ring is 180' – 11 3/16" (180.93 ft). From Design Input 4.7, the operating floor plant elevation is 63' – 6", therefore the fall height is:

$$H = (180.93\,ft - 63.5\,ft)(30.48\,cm/ft) = 117.43\,ft \times 30.48\,cm/ft = 3{,}579\,cm$$

This value is in excellent agreement with the value shown on Table 8-6.

<u>Spray flow for ring 052-2 ½"-C-KEO:</u>

From Design Input 4.11, the number of nozzles for this ring is 20. As calculated above, the flow per nozzle is 13.79 gpm. The total spray flow for this ring is then 275.86 gpm.

$$F = 275.86\,gpm \times 3.78624\,l/gal \times 1{,}000\,cm^3/l / 60\,s/\min = 1.741 \times 10^4\,cm^3/s$$

This value is in excellent agreement with the value shown on Table 8-6.

<u>Coverage area for ring 052-2 ½"-C-KEO:</u>

This ring has nozzles oriented vertically downward and nozzles oriented at a 45° angle downward. The coverage area forms an annular region. The inner and outer radii of this annulus are determined as follows:

From Reference 6.2f, the spray nozzles are oriented towards the center of the containment building; therefore, the outer radius is defined by the vertically oriented nozzles, and the inner radius is defined by the 45° downward oriented nozzles.

From Design Input 4.13, the vertical nozzles have a coverage area of 19 feet centered on the nozzle centerline. Therefore, the outer radius of the coverage annulus is offset from the ring radius by 9.5 feet. From Design Input 4.11, the radius of this ring is 25.5 feet. The outer radius is then 25.5 + 9.5 = 35 feet, or 1,066.8 cm.

From Design Input 4.13, the 45° downward oriented nozzles have a coverage area of 21 feet offset by 4 feet from the nozzle centerline. The inner radius is then 25.5 – 21 – 4 = 0.5 feet, or 15.2 cm.

The coverage area is then:

$$A = \pi\left(r_{outer}^2 - r_{inner}^2\right) = \pi\left(1{,}066.8^2 - 15.2^2\right) = 3.575\times10^6\ cm^2$$

This value is in excellent agreement with the value shown on Table 8-6.

Spray flux for ring 052-2 ½"-C-KEO:

The spray flux is the total flow rate divided by the coverage area:

$$Q = \frac{F}{A} = \frac{1.741\times10^4\ cm^3/\sec}{3.575\times10^6\ cm^2} = 4.870\times10^{-3}\ cm^3\ H_2O/cm^2-\sec$$

This value is in excellent agreement with the value shown on Table 8-6.

Aerosol Removal Rate Coefficient, $\lambda(Q, H, m_f = 0.9)$ for ring 052-2 ½"-C-KEO:

The aerosol removal rate coefficient is calculated using Equation 5-5, the parameters determined above, and the constants provided in Table 5-2. As an example, the removal rate coefficient for the 10th percentile level is calculated:

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

$$\lambda(Q,H,m_f=0.9)=\exp\left[A+B\ln Q+CH+DQ^2H+EQH^2+FQ+GQ^2H^2\right]$$

$$=\exp\begin{bmatrix}5.5750+0.943621\ln(4.870\times10^{-3})-6.9821\times10^{-3}\times(4.870\times10^{-3})^2\times3{,}579\\-7.327\times10^{-7}\times4.870\times10^{-3}\times(3{,}579)^2\\+3.555\times10^{-6}\times(4.870\times10^{-3})^2\times(3{,}579)^2\end{bmatrix}$$

$$=\exp[0.5053]=1.66\,hr^{-1}$$

This value is in excellent agreement with the value shown on Table 8-6.

Table 8-6 — Containment Spray Header 1 Ring 052-2 ½"-C-KEO

Number of nozzles	20		Design Input 4.11
Type A (Vertical)	10		Design Input 4.11
Type B (45°)	10		Design Input 4.11
Flow rate per nozzle	13.79	gpm	*Calculated*
Spray ring radius	25.5	feet	Design Input 4.11
Spray Header Elevation	180.9	feet	Design Input 4.11
Fall height Calculation			
Operating Deck Elevation	63.5	feet	Design Input 4.7
Fall height	117.43	feet	*Calculated*
	3,579	cm	*Calculated*
Spray Ring Flow Calculation			
Total Flow	275.9	gpm	*Calculated*
	17.41	l sec^{-1}	*Calculated*
	1.741E+04	cm^3 sec^{-1}	*Calculated*
Coverage Area Calculation			
Nozzle Type A			
Coverage Diameter	19	feet	Design Input 4.13
Offset from centerline	0	feet	Design Input 4.13
Nozzle Type B			
Coverage Diameter	21	feet	Design Input 4.13
Offset from centerline	4	feet	Design Input 4.13
Outer Coverage Radius	35.0	feet	*Calculated*
	1066.8	cm	*Calculated*
Inner Coverage Radius	0.5	feet	*Calculated*
	15.2	cm	*Calculated*
Coverage Area	3.575E+06	cm^2	*Calculated*
Resultant Spray Flux	4.870E-03	cm^3/cm^2-s	*Calculated*
Resultant $\lambda(m_f=0.9)$			
Median	4.00	hr^{-1}	*Calculated*
90%ile	8.86	hr^{-1}	*Calculated*
10%ile	1.66	hr^{-1}	*Calculated*

Table 8-7 — Containment Spray Header 1 Ring 051-4"-C-KEO			
Number of nozzles	40		Design Input 4.11
Type A (Vertical)	20		Design Input 4.11
Type C (Horizontal)	20		Design Input 4.11
Flow rate per nozzle	13.79	gpm	*Calculated*
Spray ring radius	43	feet	Design Input 4.11
Spray Header Elevation	171.6	feet	Design Input 4.11
Fall height Calculation			
Operating Deck Elevation	63.5	feet	Design Input 4.7
Fall height	108.11	feet	*Calculated*
	3,295	cm	*Calculated*
Spray Ring Flow Calculation			
Total Flow	551.7	gpm	*Calculated*
	34.82	$l\ sec^{-1}$	*Calculated*
	3.482E+04	$cm^3\ sec^{-1}$	*Calculated*
Coverage Area Calculation			
Nozzle Type A			
Coverage Diameter	19	feet	Design Input 4.13
Offset from centerline	0	feet	Design Input 4.13
Nozzle Type C			
Coverage Diameter	24	feet	Design Input 4.13
Offset from centerline	7	feet	Design Input 4.13
Outer Coverage Radius	52.5	feet	*Calculated*
	1600.2	cm	*Calculated*
Inner Coverage Radius	12	feet	*Calculated*
	365.8	cm	*Calculated*
Coverage Area	7.624E+06	cm^2	*Calculated*
Resultant Spray Flux	4.567E-03	cm^3/cm^2-s	*Calculated*
Resultant $\lambda(m_f=0.9)$			
Median	3.77	hr^{-1}	*Calculated*
90%ile	8.35	hr^{-1}	*Calculated*
10%ile	1.57	hr^{-1}	*Calculated*

Table 8-8 — Containment Spray Header 1 Ring 049-4"-C-KEO

Number of nozzles	56		Design Input 4.11
Type D (10°)	28		Design Input 4.11
Type B (45°)	28		Design Input 4.11
Flow rate per nozzle	13.79	gpm	*Calculated*
Spray ring radius	66.5	feet	Design Input 4.11
Spray Header Elevation	143.3	feet	Design Input 4.11
Fall height Calculation			
Operating Deck Elevation	63.5	feet	Design Input 4.7
Fall height	79.81	feet	*Calculated*
	2,433	cm	*Calculated*
Spray Ring Flow Calculation			
Total Flow	772.4	gpm	*Calculated*
	48.74	$l\ sec^{-1}$	*Calculated*
	4.874E+04	$cm^3\ sec^{-1}$	*Calculated*
Coverage Area Calculation			
Nozzle Type D			
Coverage Diameter	19	feet	Design Input 4.13
Offset from centerline	0	feet	Design Input 4.13
Nozzle Type B			
Coverage Diameter	21	feet	Design Input 4.13
Offset from centerline	4	feet	Design Input 4.13
Outer Coverage Radius	75.0	feet	*Calculated*
	2286.8	cm	*Calculated*
Inner Coverage Radius	41.5	feet	*Calculated*
	1264.9	cm	*Calculated*
Coverage Area	1.139E+07	cm^2	*Calculated*
Resultant Spray Flux	4.279E-03	cm^3/cm^2-s	*Calculated*
Resultant $\lambda(m_f$=0.9)			
Median	3.60	hr^{-1}	*Calculated*
90%ile	7.86	hr^{-1}	*Calculated*
10%ile	1.51	hr^{-1}	*Calculated*

8.3.1.2.2 Spray Header 2 Removal Rate Calculation

Spray header 2 consists of three concentric rings designed to provide full spray coverage. The calculation of the spray fall height, spray flux, and resultant aerosol removal rates is shown on Table 8-9 through Table 8-11. Representative sample calculations are provided.

Fall height for ring 043-4"-C-KEO:

From Design Input 4.11, the centerline plant elevation of this ring is 149' – 0 3/16" (149.0 ft). From Design Input 4.7, the operating floor plant elevation is 63' – 6", therefore the fall height is:

$$H = (149.0ft - 63.5ft)(30.48cm/ft) = 85.52ft \times 30.48cm/ft = 2,607cm$$

This value is in excellent agreement with the value shown on Table 8-11.

Spray flow for ring 043-4"-C-KEO:

From Design Input 4.11, the number of nozzles for this ring is 56. As calculated above, the flow per nozzle is 13.79 gpm. The total spray flow for this ring is then 772.41 gpm.

$$F = 772.41gpm \times 3.78624l/gal \times 1,000cm^3/l/60s/\min = 4.874 \times 10^4 cm^3/s$$

This value is in excellent agreement with the value shown on Table 8-11.

Coverage area for ring 043-4"-C-KEO:

This ring has nozzles oriented 10° downward and nozzles oriented at a 45° angle downward. The coverage area forms an annular region. The inner and outer radii of this annulus are determined as follows:

> From Reference 6.2f, the spray nozzles are oriented towards the center of the containment building; therefore, the outer radius is defined by the 10° downward oriented nozzles, and the inner radius is defined by the 45° downward oriented nozzles.
>
> From Modeling Assumption 3.7, the nozzles oriented 10° downward are assumed to have the same coverage parameters as the vertical nozzles. From Design Input 4.13, the vertical nozzles have a coverage area of 19 feet centered on the nozzle centerline. Therefore, the outer radius of the coverage annulus is offset from the ring radius by 9.5 feet. From Design Input 4.11, the radius of this ring is 63.5 feet. The outer radius is then 63.5 + 9.5 = 73 feet, or 2,225.0 cm.
>
> From Design Input 4.13, the 45° downward oriented nozzles have a coverage area of 21 feet offset by 4 feet from the nozzle centerline. The inner radius is then 63.5 – 21 – 4 = 38.5 feet, or 1,173.5 cm.

The coverage area is then:

$$A=\pi\left(r_{outer}^2-r_{inner}^2\right)=\pi\left(2{,}225.0^2-1{,}173.5^2\right)=1.123\times10^7\ cm^2$$

This value is in excellent agreement with the value shown on Table 8-11.

<u>Spray flux for ring 043-4"-C-KEO:</u>

The spray flux is the total flow rate divided by the coverage area:

$$Q=\frac{F}{A}=\frac{4.874\times10^4\ cm^3/\sec}{1.123\times10^7\ cm^2}=4.340\times10^{-3}\ cm^3\ H_2O/cm^2-\sec$$

This value is in excellent agreement with the value shown on Table 8-11.

<u>Aerosol Removal Rate Coefficient, $\lambda(Q, H, m_f = 0.9)$ for ring 043-4"-C-KEO:</u>

The aerosol removal rate coefficient is calculated using Equation 5-5 and the parameters determined above and the constants provided in Table 5-2. As an example, the removal rate coefficient for the 10th percentile level is calculated:

$$\lambda(Q,H,m_f=0.9)=\exp\left[A+B\ln Q+CH+DQ^2H+EQH^2+FQ+GQ^2H^2\right]$$

$$=\exp\begin{bmatrix}5.5750+0.943621\ln\left(4.340\times10^{-3}\right)-6.9821\times10^{-3}\times\left(4.340\times10^{-3}\right)^2\times2{,}607\\-7.327\times10^{-7}\times4.340\times10^{-3}\times(2{,}607)^2\\+3.555\times10^{-6}\times\left(4.340\times10^{-3}\right)^2\times(2{,}607)^2\end{bmatrix}$$

$$=\exp[0.4206]=1.52\,hr^{-1}$$

This value is in excellent agreement with the value shown on Table 8-11.

Table 8-9 — Containment Spray Header 2 Ring 046-2 ½"-C-KEO

Number of nozzles	20		Design Input 4.11
Type A (Vertical)	10		Design Input 4.11
Type B (45°)	10		Design Input 4.11
Flow rate per nozzle	13.79	gpm	*Calculated*
Spray ring radius	22.5	feet	Design Input 4.11
Spray Header Elevation	182.0	feet	Design Input 4.11
Fall height Calculation			
Operating Deck Elevation	63.5	feet	Design Input 4.7
Fall height	118.47	feet	*Calculated*
	3,611	cm	*Calculated*
Spray Ring Flow Calculation			
Total Flow	275.9	gpm	*Calculated*
	17.41	$l\ sec^{-1}$	*Calculated*
	1.741E+04	$cm^3\ sec^{-1}$	*Calculated*
Coverage Area Calculation			
Nozzle Type A			
Coverage Diameter	19	feet	Design Input 4.13
Offset from centerline	0	feet	Design Input 4.13
Nozzle Type B			
Coverage Diameter	21	feet	Design Input 4.13
Offset from centerline	4	feet	Design Input 4.13
Outer Coverage Radius	32.0	feet	*Calculated*
	975.4	cm	*Calculated*
Inner Coverage Radius	0.0	feet	*Calculated*
	0.0	cm	*Calculated*
Coverage Area	2.989E+06	cm^2	*Calculated*
Resultant Spray Flux	5.825E-03	$cm^3/cm^2\text{-}s$	*Calculated*
Resultant $\lambda(m_f=0.9)$			
Median	4.79	hr^{-1}	*Calculated*
90%ile	10.45	hr^{-1}	*Calculated*
10%ile	1.94	hr^{-1}	*Calculated*

Table 8-10 — Containment Spray Header 2 Ring 045-4"-C-KEO			
Number of nozzles	40		Design Input 4.11
Type A (Vertical)	20		Design Input 4.11
Type C (Horizontal)	20		Design Input 4.11
Flow rate per nozzle	13.79	gpm	*Calculated*
Spray ring radius	46	feet	Design Input 4.11
Spray Header Elevation	169.3	feet	Design Input 4.11
Fall height Calculation			
Operating Deck Elevation	63.5	feet	Design Input 4.7
Fall height	105.83	feet	*Calculated*
	3,226	cm	*Calculated*
Spray Ring Flow Calculation			
Total Flow	551.7	gpm	*Calculated*
	34.82	$l\ sec^{-1}$	*Calculated*
	3.482E+04	$cm^3\ sec^{-1}$	*Calculated*
Coverage Area Calculation			
Nozzle Type A			
Coverage Diameter	19	feet	Design Input 4.13
Offset from centerline	0	feet	Design Input 4.13
Nozzle Type C			
Coverage Diameter	24	feet	Design Input 4.13
Offset from centerline	7	feet	Design Input 4.13
Outer Coverage Radius	55.5	feet	*Calculated*
	1691.6	cm	*Calculated*
Inner Coverage Radius	15	feet	*Calculated*
	457.2	cm	*Calculated*
Coverage Area	8.333E+06	cm^2	*Calculated*
Resultant Spray Flux	4.178E-03	cm^3/cm^2-s	*Calculated*
Resultant $\lambda(m_f=0.9)$			
Median	3.45	hr^{-1}	*Calculated*
90%ile	7.69	hr^{-1}	*Calculated*
10%ile	1.45	hr^{-1}	*Calculated*

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Table 8-11 — Containment Spray Header 2 Ring 043-4"-C-KEO

Number of nozzles	56		Design Input 4.11
Type D (10°)	28		Design Input 4.11
Type B (45°)	28		Design Input 4.11
Flow rate per nozzle	13.79	gpm	*Calculated*
Spray ring radius	63.5	feet	Design Input 4.11
Spray Header Elevation	149.0	feet	Design Input 4.11
Fall height Calculation			
Operating Deck Elevation	63.5	feet	Design Input 4.7
Fall height	85.60	feet	*Calculated*
	2,607	cm	*Calculated*
Spray Ring Flow Calculation			
Total Flow	772.4	gpm	*Calculated*
	48.74	$l\ sec^{-1}$	*Calculated*
	4.874E+04	$cm^3\ sec^{-1}$	*Calculated*
Coverage Area Calculation			
Nozzle Type D			
Coverage Diameter	19	feet	Design Input 4.13
Offset from centerline	0	feet	Design Input 4.13
Nozzle Type B			
Coverage Diameter	21	feet	Design Input 4.13
Offset from centerline	4	feet	Design Input 4.13
Outer Coverage Radius	73.0	feet	*Calculated*
	2225.0	cm	*Calculated*
Inner Coverage Radius	38.5	feet	*Calculated*
	1173.5	cm	*Calculated*
Coverage Area	1.123E+07	cm^2	*Calculated*
Resultant Spray Flux	4.341E-03	cm^3/cm^2-s	*Calculated*
Resultant $\lambda(m_f=0.9)$			
Median	3.64	hr^{-1}	*Calculated*
90%ile	7.96	hr^{-1}	*Calculated*
10%ile	1.52	hr^{-1}	*Calculated*

8.3.1.2.3 Total Aerosol Removal Rate

In the previous subsections (8.3.1.2.1 and 8.3.1.2.2), the individual spray ring aerosol removal rate constants were determined. In this subsection these removal rates for each spray ring are added together for each of the spray headers to calculate a total aerosol spray removal rate. The lowest value

is then used for determining the time dependent aerosol removal rate. This calculation showing that CSS Header 1 results in the lowest total aerosol removal rate is shown on Table 8-12.

Table 8-12 — Overall Aerosol Spray Removal Rate	
Resultant Aerosol Spray $\lambda(m_f=0.9)$ for Header 1	
Median	11.37 hr^{-1}
90%ile	25.06 hr^{-1}
10%ile	4.73 hr^{-1}
Resultant Aerosol Spray $\lambda(m_f=0.9)$ for Header 2	
Median	11.88 hr^{-1}
90%ile	26.10 hr^{-1}
10%ile	4.92 hr^{-1}
Minimum Resultant Aerosol Spray $\lambda(m_f=0.9)$	
Median	11.37 hr^{-1}
90%ile	25.06 hr^{-1}
10%ile	4.73 hr^{-1}

As an example, the median aerosol spray removal rate for spray header 1 is calculated:

Spray Ring	**Source**	**Removal Rate (hr^{-1})**
052-2 ½"-C-KEO	Table 8-6	4.00
051-4"-C-KEO	Table 8-7	3.77
049-4"-C-KEO	Table 8-8	3.60
	Total:	11.37

The aerosol spray removal rate of 11.37 hr^{-1} for spray header 1 calculated above is in excellent agreement with the value presented in Table 8-12.

8.3.1.3 Time-Dependent Aerosol Removal Rate

The time-dependent aerosol removal rates for an initial mass release rate at t = 0 are determined by first calculating the removal rates as a function of m_f using Equation 5-4 and Equation 5-6. The calculation term $\lambda(Q, H, m_f = 0.9)$ for the three percentile levels is presented in Section 8.3.1.2. Using the removal rates as a function of m_f thus calculated, the removal rates as a function of time are calculated using Equation 5-8. The results of these calculations are shown on Table 8-13.

The spray flux Q in Equation 5-6 is the total flux as calculated in Section 8.3.1.1.1 instead of the summation of the individual spray ring spray fluxes calculated in Section 8.3.1.2.1 for spray header 1 and in Section 8.3.1.2 2 for spray header 2. This is conservative since the total spray flux calculated in Section 8.3.1.1.1, 6.15×10^{-3} cm^3 H_2O/cm^2-s, is less than the sum of the individual spray fluxes:

Spray header 1: $4.870 \times 10^{-3} + 4.567 \times 10^{-3} + 4.279 \times 10^{-3} = 1.37 \times 10^{-2}$ cm^3 H_2O/cm^2-s
Spray header 2: $5.825 \times 10^{-3} + 4.178 \times 10^{-3} + 4.341 \times 10^{-3} = 1.43 \times 10^{-2}$ cm^3 H_2O/cm^2-s

Sample calculations are presented below:

Aerosol removal rate for the 10th percentile and mass fraction of 0.98

Using Equation 5-6 and $m_f = 0.98$ and the parameters for the 10th percentile of Table 5-2:

$$\frac{\lambda(m_f)}{\lambda(m_f = 0.9)} = [a + b\cdot\log_{10} Q]\left[1-\left(\frac{m_f}{0.9}\right)^c\right]+\left(\frac{m_f}{0.9}\right)^c$$

$$= \left[0.1108 - 0.00201 \times \log_{10}(6.15\times10^{-3})\right]\left[1-\left(\frac{0.98}{0.9}\right)^{0.8945}\right]+\left(\frac{0.98}{0.9}\right)^{0.8945}$$

$$= 1.07$$

Therefore, the removal rate for $m_f = 0.98$ is 4.73 x 1.07 = 5.06,which is in good agreement with the results shown on Table 8-13.

Time to reach $m_f = 0.98$ for the 10th percentile level

Using Equation 5-8, $\lambda = 5.07$, $m_f(t_1) = 0.99$, and $t_1 = 1.97 \times 10^{-3}$ hr from Table 8-13:

$$t_2 = t_1 - \frac{\ln\left(\frac{m_f(t_2)}{m_f(t_1)}\right)}{\lambda(m_f)} = 1.97\times10^{-3} - \frac{\ln\left(\frac{0.98}{0.99}\right)}{5.07} = 3.97\times10^{-3}$$

This value is in good agreement with the results shown on Table 8-13.

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Table 8-13 — Time dependent Aerosol Removal Rate Calculation

Mass Fraction	Aerosol Removal Rate (hr^{-1}) 90%ile	Median	10%ile	Time to Reach Mass Fraction (hrs) 90%ile	Median	10%ile
0.9999	25.54	11.98	5.15	3.92E-06	8.35E-06	1.94E-05
9.99E-01	25.53	11.97	5.15	3.92E-05	8.36E-05	1.94E-04
9.90E-01	25.49	11.92	5.11	3.94E-04	8.43E-04	1.97E-03
9.80E-01	25.45	11.86	5.07	7.93E-04	1.70E-03	3.97E-03
9.70E-01	25.40	11.80	5.03	1.20E-03	2.57E-03	6.01E-03
9.60E-01	25.35	11.74	4.99	1.61E-03	3.45E-03	8.09E-03
9.50E-01	25.30	11.68	4.94	2.02E-03	4.35E-03	1.02E-02
9.40E-01	25.26	11.62	4.90	2.44E-03	5.26E-03	1.24E-02
9.30E-01	25.21	11.56	4.86	2.86E-03	6.18E-03	1.46E-02
9.20E-01	25.16	11.49	4.82	3.29E-03	7.12E-03	1.68E-02
9.10E-01	25.11	11.43	4.78	3.73E-03	8.08E-03	1.91E-02
9.00E-01	25.06	11.37	4.73	4.17E-03	9.05E-03	2.14E-02
8.80E-01	24.96	11.25	4.65	5.07E-03	1.11E-02	2.63E-02
8.60E-01	24.86	11.12	4.57	5.99E-03	1.31E-02	3.13E-02
8.40E-01	24.76	10.99	4.48	6.94E-03	1.53E-02	3.65E-02
8.20E-01	24.65	10.86	4.40	7.92E-03	1.75E-02	4.20E-02
8.00E-01	24.54	10.73	4.31	8.93E-03	1.98E-02	4.78E-02
7.80E-01	24.44	10.60	4.23	9.96E-03	2.22E-02	5.37E-02
7.60E-01	24.32	10.47	4.14	1.10E-02	2.46E-02	6.00E-02
7.40E-01	24.21	10.33	4.05	1.21E-02	2.72E-02	6.66E-02
7.20E-01	24.10	10.20	3.97	1.33E-02	2.99E-02	7.35E-02
7.00E-01	23.98	10.06	3.88	1.44E-02	3.27E-02	8.08E-02
6.80E-01	23.86	9.92	3.80	1.57E-02	3.56E-02	8.84E-02
6.60E-01	23.74	9.78	3.71	1.69E-02	3.87E-02	9.64E-02
6.40E-01	23.61	9.64	3.62	1.82E-02	4.19E-02	1.05E-01
6.20E-01	23.48	9.49	3.53	1.96E-02	4.52E-02	1.14E-01
6.00E-01	23.35	9.35	3.45	2.10E-02	4.87E-02	1.23E-01
5.80E-01	23.22	9.20	3.36	2.24E-02	5.24E-02	1.34E-01
5.60E-01	23.08	9.05	3.27	2.40E-02	5.63E-02	1.44E-01
5.40E-01	22.94	8.89	3.18	2.55E-02	6.04E-02	1.56E-01
5.20E-01	22.79	8.74	3.09	2.72E-02	6.47E-02	1.68E-01
5.00E-01	22.64	8.58	3.00	2.89E-02	6.93E-02	1.81E-01
4.80E-01	22.49	8.42	2.91	3.07E-02	7.41E-02	1.95E-01
4.60E-01	22.33	8.26	2.82	3.27E-02	7.93E-02	2.10E-01
4.40E-01	22.17	8.09	2.73	3.47E-02	8.48E-02	2.26E-01
4.20E-01	22.00	7.92	2.64	3.68E-02	9.06E-02	2.44E-01
4.00E-01	21.82	7.75	2.55	3.90E-02	9.69E-02	2.63E-01
3.80E-01	21.64	7.57	2.46	4.14E-02	1.04E-01	2.84E-01

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

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Table 8-13 — Time dependent Aerosol Removal Rate Calculation

Mass Fraction	Aerosol Removal Rate (hr^{-1}) 90%ile	Median	10%ile	Time to Reach Mass Fraction (hrs) 90%ile	Median	10%ile
3.60E-01	21.45	7.39	2.37	4.39E-02	1.11E-01	3.07E-01
3.40E-01	21.26	7.21	2.27	4.66E-02	1.19E-01	3.32E-01
3.20E-01	21.05	7.02	2.18	4.95E-02	1.28E-01	3.60E-01
3.00E-01	20.84	6.82	2.09	5.26E-02	1.37E-01	3.91E-01
2.80E-01	20.61	6.62	1.99	5.59E-02	1.47E-01	4.25E-01
2.60E-01	20.38	6.42	1.90	5.95E-02	1.59E-01	4.64E-01
2.40E-01	20.13	6.21	1.80	6.35E-02	1.72E-01	5.09E-01
2.20E-01	19.86	5.99	1.70	6.79E-02	1.86E-01	5.60E-01
2.00E-01	19.58	5.76	1.60	7.28E-02	2.03E-01	6.19E-01
1.80E-01	19.27	5.52	1.51	7.82E-02	2.22E-01	6.89E-01
1.60E-01	18.94	5.27	1.40	8.45E-02	2.44E-01	7.73E-01
1.40E-01	18.58	5.01	1.30	9.16E-02	2.71E-01	8.76E-01
1.20E-01	18.18	4.73	1.20	1.00E-01	3.04E-01	1.00E+00
1.00E-01	17.73	4.43	1.10	1.10E-01	3.45E-01	1.17E+00
8.00E-02	17.20	4.11	0.99	1.23E-01	3.99E-01	1.40E+00
6.00E-02	16.58	3.75	0.88	1.41E-01	4.76E-01	1.72E+00
4.00E-02	15.77	3.33	0.76	1.66E-01	5.98E-01	2.25E+00
2.00E-02	14.59	2.81	0.64	2.14E-01	8.44E-01	3.33E+00
1.00E-02	13.61	2.47	0.58	2.65E-01	1.13E+00	4.53E+00
9.90E-03	13.60	2.46	0.58	2.66E-01	1.13E+00	4.55E+00
9.80E-03	13.59	2.46	0.58	2.66E-01	1.13E+00	4.56E+00
9.70E-03	13.58	2.45	0.58	2.67E-01	1.14E+00	4.58E+00
9.60E-03	13.56	2.45	0.58	2.68E-01	1.14E+00	4.60E+00
9.50E-03	13.55	2.45	0.58	2.69E-01	1.15E+00	4.62E+00
9.40E-03	13.54	2.44	0.57	2.69E-01	1.15E+00	4.64E+00
9.30E-03	13.52	2.44	0.57	2.70E-01	1.15E+00	4.66E+00
9.20E-03	13.51	2.43	0.57	2.71E-01	1.16E+00	4.67E+00
9.10E-03	13.50	2.43	0.57	2.72E-01	1.16E+00	4.69E+00
9.00E-03	13.48	2.42	0.57	2.73E-01	1.17E+00	4.71E+00
8.80E-03	13.45	2.42	0.57	2.74E-01	1.18E+00	4.75E+00
8.60E-03	13.43	2.41	0.57	2.76E-01	1.19E+00	4.79E+00
8.40E-03	13.40	2.40	0.57	2.78E-01	1.20E+00	4.83E+00
8.20E-03	13.37	2.39	0.57	2.80E-01	1.21E+00	4.88E+00
8.00E-03	13.34	2.38	0.57	2.81E-01	1.22E+00	4.92E+00
7.80E-03	13.31	2.37	0.56	2.83E-01	1.23E+00	4.96E+00
7.60E-03	13.28	2.36	0.56	2.85E-01	1.24E+00	5.01E+00
7.40E-03	13.25	2.35	0.56	2.87E-01	1.25E+00	5.06E+00
7.20E-03	13.21	2.35	0.56	2.89E-01	1.26E+00	5.11E+00

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

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Table 8-13 — Time dependent Aerosol Removal Rate Calculation

Mass Fraction	Aerosol Removal Rate (hr^{-1}) 90%ile	Median	10%ile	Time to Reach Mass Fraction (hrs) 90%ile	Median	10%ile
7.00E-03	13.18	2.34	0.56	2.92E-01	1.27E+00	5.16E+00
6.80E-03	13.15	2.33	0.56	2.94E-01	1.29E+00	5.21E+00
6.60E-03	13.11	2.32	0.56	2.96E-01	1.30E+00	5.26E+00
6.40E-03	13.08	2.31	0.55	2.98E-01	1.31E+00	5.32E+00
6.20E-03	13.04	2.30	0.55	3.01E-01	1.33E+00	5.38E+00
6.00E-03	13.01	2.29	0.55	3.03E-01	1.34E+00	5.44E+00
5.80E-03	12.97	2.28	0.55	3.06E-01	1.36E+00	5.50E+00
5.60E-03	12.93	2.27	0.55	3.09E-01	1.37E+00	5.56E+00
5.40E-03	12.89	2.26	0.55	3.11E-01	1.39E+00	5.63E+00
5.20E-03	12.85	2.25	0.55	3.14E-01	1.40E+00	5.70E+00
5.00E-03	12.81	2.24	0.54	3.17E-01	1.42E+00	5.77E+00
4.80E-03	12.77	2.22	0.54	3.21E-01	1.44E+00	5.84E+00
4.60E-03	12.73	2.21	0.54	3.24E-01	1.46E+00	5.92E+00
4.40E-03	12.68	2.20	0.54	3.28E-01	1.48E+00	6.01E+00
4.20E-03	12.63	2.19	0.54	3.31E-01	1.50E+00	6.09E+00
4.00E-03	12.58	2.18	0.54	3.35E-01	1.52E+00	6.18E+00
3.80E-03	12.53	2.17	0.54	3.39E-01	1.55E+00	6.28E+00
3.60E-03	12.48	2.15	0.53	3.43E-01	1.57E+00	6.38E+00
3.40E-03	12.43	2.14	0.53	3.48E-01	1.60E+00	6.49E+00
3.20E-03	12.37	2.13	0.53	3.53E-01	1.63E+00	6.60E+00
3.00E-03	12.31	2.12	0.53	3.58E-01	1.66E+00	6.72E+00
2.80E-03	12.25	2.10	0.53	3.64E-01	1.69E+00	6.85E+00
2.60E-03	12.18	2.09	0.53	3.70E-01	1.73E+00	7.00E+00
2.40E-03	12.11	2.07	0.52	3.77E-01	1.76E+00	7.15E+00
2.20E-03	12.04	2.06	0.52	3.84E-01	1.81E+00	7.31E+00
2.00E-03	11.96	2.04	0.52	3.92E-01	1.85E+00	7.50E+00
1.80E-03	11.88	2.03	0.52	4.01E-01	1.91E+00	7.70E+00
1.60E-03	11.79	2.01	0.52	4.11E-01	1.96E+00	7.93E+00
1.40E-03	11.69	1.99	0.52	4.22E-01	2.03E+00	8.19E+00
1.20E-03	11.57	1.97	0.51	4.35E-01	2.11E+00	8.48E+00
1.00E-03	11.45	1.95	0.51	4.51E-01	2.20E+00	8.84E+00
8.00E-04	11.30	1.93	0.51	4.71E-01	2.32E+00	9.28E+00
6.00E-04	11.13	1.91	0.51	4.97E-01	2.47E+00	9.84E+00
4.00E-04	10.91	1.88	0.51	5.34E-01	2.68E+00	1.06E+01
2.00E-04	10.58	1.84	0.51	6.00E-01	3.06E+00	1.20E+01
1.00E-04	10.31	1.82	0.50	6.67E-01	3.44E+00	1.34E+01
9.00E-05	10.27	1.82	0.50	6.77E-01	3.50E+00	1.36E+01
8.00E-05	10.23	1.82	0.50	6.89E-01	3.56E+00	1.38E+01

Table 8-13 — Time dependent Aerosol Removal Rate Calculation

Mass Fraction	Aerosol Removal Rate (hr^{-1}) 90%ile	Median	10%ile	Time to Reach Mass Fraction (hrs) 90%ile	Median	10%ile
7.00E-05	10.19	1.81	0.50	7.02E-01	3.64E+00	1.41E+01
6.00E-05	10.14	1.81	0.50	7.17E-01	3.72E+00	1.44E+01
5.00E-05	10.09	1.81	0.50	7.35E-01	3.82E+00	1.48E+01
4.00E-05	10.02	1.80	0.50	7.57E-01	3.95E+00	1.52E+01
3.00E-05	9.95	1.80	0.50	7.86E-01	4.11E+00	1.58E+01
2.00E-05	9.85	1.79	0.50	8.27E-01	4.33E+00	1.66E+01
1.00E-05	9.71	1.79	0.50	8.99E-01	4.72E+00	1.80E+01
1.00E-06	9.39	1.78	0.50	1.14E+00	6.02E+00	2.25E+01
1.00E-07	9.23	1.77	0.50	1.39E+00	7.31E+00	2.71E+01
1.00E-08	9.14	1.77	0.50	1.65E+00	8.61E+00	3.17E+01
1.00E-09	9.09	1.77	0.50	1.90E+00	9.91E+00	3.62E+01
1.00E-10	9.07	1.77	0.50	2.15E+00	1.12E+01	4.08E+01
1.00E-11	9.06	1.77	0.50	2.41E+00	1.25E+01	4.54E+01
1.00E-12	9.05	1.77	0.50	2.66E+00	1.38E+01	5.00E+01
1.00E-13	9.05	1.77	0.50	2.92E+00	1.51E+01	5.45E+01
1.00E-14	9.04	1.77	0.50	3.17E+00	1.64E+01	5.91E+01
1.00E-15	9.04	1.77	0.50	3.42E+00	1.77E+01	6.37E+01
1.00E-16	9.04	1.77	0.50	3.68E+00	1.90E+01	6.82E+01
1.00E-17	9.04	1.77	0.50	3.93E+00	2.03E+01	7.28E+01
1.00E-18	9.04	1.77	0.50	4.19E+00	2.16E+01	7.74E+01
1.00E-19	9.04	1.77	0.50	4.44E+00	2.29E+01	8.20E+01
1.00E-20	9.04	1.77	0.50	4.70E+00	2.42E+01	8.65E+01
1.00E-21	9.04	1.77	0.50	4.95E+00	2.55E+01	9.11E+01
1.00E-22	9.04	1.77	0.50	5.21E+00	2.68E+01	9.57E+01
1.00E-23	9.04	1.77	0.50	5.46E+00	2.81E+01	1.00E+02
1.00E-24	9.04	1.77	0.50	5.72E+00	2.94E+01	1.05E+02
1.00E-25	9.04	1.77	0.50	5.97E+00	3.07E+01	1.09E+02
1.00E-26	9.04	1.77	0.50	6.23E+00	3.20E+01	1.14E+02
1.00E-27	9.04	1.77	0.50	6.48E+00	3.33E+01	1.19E+02
1.00E-28	9.04	1.77	0.50	6.74E+00	3.46E+01	1.23E+02
1.00E-29	9.04	1.77	0.50	6.99E+00	3.59E+01	1.28E+02
1.00E-30	9.04	1.77	0.50	7.24E+00	3.72E+01	1.32E+02
1.00E-31	9.04	1.77	0.50	7.50E+00	3.85E+01	1.37E+02
1.00E-32	9.04	1.77	0.50	7.75E+00	3.98E+01	1.41E+02
1.00E-33	9.04	1.77	0.50	8.01E+00	4.11E+01	1.46E+02
1.00E-34	9.04	1.77	0.50	8.26E+00	4.24E+01	1.51E+02
1.00E-35	9.04	1.77	0.50	8.52E+00	4.37E+01	1.55E+02
1.00E-36	9.04	1.77	0.50	8.77E+00	4.50E+01	1.60E+02

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

Table 8-13 — Time dependent Aerosol Removal Rate Calculation

Mass Fraction	Aerosol Removal Rate (hr^{-1}) 90%ile	Median	10%ile	Time to Reach Mass Fraction (hrs) 90%ile	Median	10%ile
1.00E-37	9.04	1.77	0.50	9.03E+00	4.63E+01	1.64E+02
1.00E-38	9.04	1.77	0.50	9.28E+00	4.76E+01	1.69E+02
1.00E-39	9.04	1.77	0.50	9.54E+00	4.89E+01	1.73E+02
1.00E-40	9.04	1.77	0.50	9.79E+00	5.01E+01	1.78E+02

The aerosol removal rates as a function of time for an initial mass release at t = 0 are plotted on Figure 8–1. As can be seen on this figure and on Table 8-13, the removal rates reach an asymptotic value for each percentile curve. For example, the 90th percentile aerosol removal rate reaches a value of 9.04 approximately 3 hours after the release, and the 10th percentile aerosol removal rate reaches a value of 0.50 approximately 13 hours after the release.

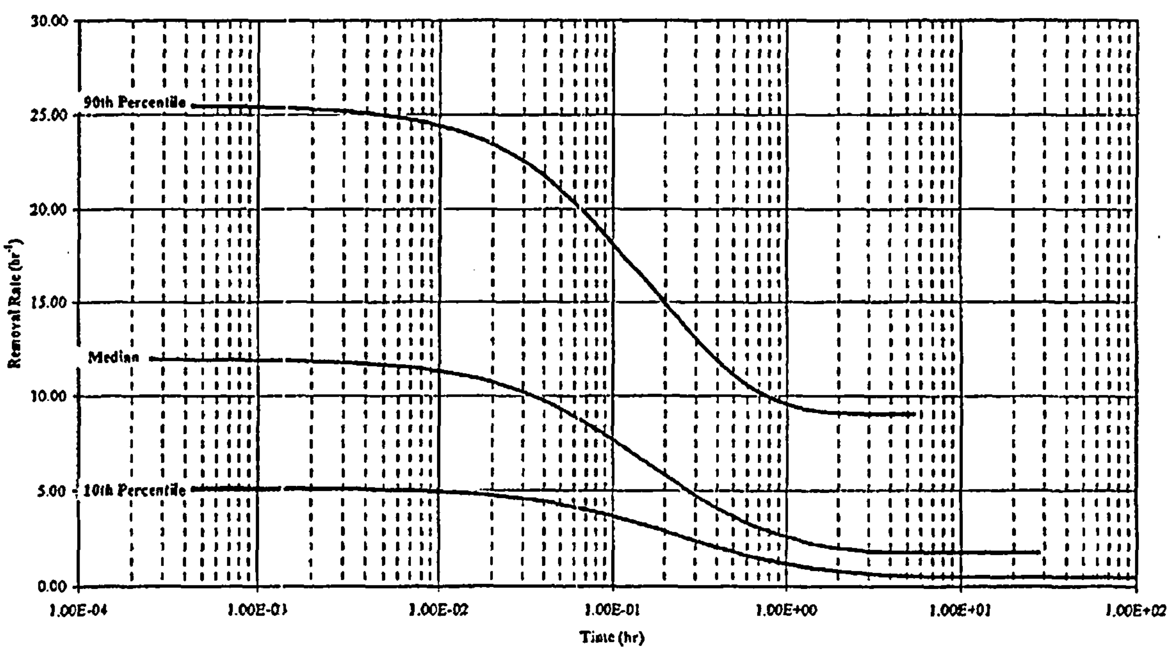

Figure 8–1 — Aerosol Removal Rates

It is more convenient for further processing to provide the aerosol removal rates for each of the three percentile levels for common times. Therefore, the values presented on Table 8-13 are interpolated

using a semi-log interpolation to construct the following table. The semi-log interpolation is of the form:

$$\lambda(t)=\lambda(t_1)+[\lambda(t_2)-\lambda(t_1)]\frac{\ln\left(t/t_1\right)}{\ln\left(t_2/t_1\right)}$$ **Equation 8-1**

For example, from Table 8-13, the 10th percentile aerosol removal rate at 0.464 hours is 1.90 hr^{-1}, and the removal rate at 0.509 hours is 1.80 hr^{-1}. The aerosol removal rate at 0.5 hours is then:

$$\lambda(0.5)=1.90+[1.80-1.90]\frac{\ln\left(0.5/0.464\right)}{\ln\left(0.509/0.464\right)}=1.82\ hr^{-1}$$

This value is in excellent agreement with the value shown on Table 8-14.

Table 8-14 — Aerosol Removal Rate (hr^{-1})

Time (hrs)	90%ile	Median	10%ile
0	25.54	11.98	5.15
1.00E-04	25.52	11.97	5.15
1.00E-03	25.42	11.91	5.12
2.00E-03	25.31	11.84	5.11
3.00E-03	25.19	11.77	5.09
4.00E-03	25.08	11.70	5.07
5.00E-03	24.97	11.63	5.05
6.00E-03	24.86	11.57	5.03
7.00E-03	24.75	11.50	5.01
8.00E-03	24.64	11.44	4.99
9.00E-03	24.54	11.37	4.97
1.00E-02	24.43	11.31	4.95
2.00E-02	23.44	10.72	4.76
3.00E-02	22.55	10.19	4.59
4.00E-02	21.74	9.72	4.43
5.00E-02	21.01	9.29	4.28
6.00E-02	20.35	8.91	4.14
7.00E-02	19.74	8.56	4.01
8.00E-02	19.18	8.24	3.89
9.00E-02	18.66	7.94	3.78
1.00E-01	18.19	7.67	3.67

Table 8-14 — Aerosol Removal Rate (hr^{-1})

Time (hrs)	90%ile	Median	10%ile
2.00E-01	14.91	5.80	2.88
3.00E-01	13.06	4.76	2.39
4.00E-01	11.88	4.10	2.06
5.00E-01	11.11	3.66	1.82
6.00E-01	10.58	3.32	1.64
7.00E-01	10.19	3.09	1.49
8.00E-01	9.91	2.89	1.38
9.00E-01	9.71	2.73	1.28
1.00E+00	9.57	2.61	1.20
1.50E+00	9.19	2.19	0.95
2.00E+00	9.08	2.00	0.81
2.20E+00	9.07	1.95	0.77
3.00E+00	9.04	1.85	0.68
4.00E+00	9.04	1.80	0.61
5.00E+00	9.04	1.78	0.56
6.00E+00	9.04	1.78	0.54
6.20E+00	9.04	1.78	0.54
7.00E+00	9.04	1.78	0.53
8.00E+00	9.04	1.77	0.52
9.00E+00	9.04	1.77	0.51
1.20E+01	9.04	1.77	0.51
2.00E+01	9.04	1.77	0.50
2.22E+01	9.04	1.77	0.50
3.00E+01	9.04	1.77	0.50
4.00E+01	9.04	1.77	0.50
4.62E+01	9.04	1.77	0.50
5.00E+01	9.04	1.77	0.50
6.00E+01	9.04	1.77	0.50
7.00E+01	9.04	1.77	0.50
8.00E+01	9.04	1.77	0.50
9.00E+01	9.04	1.77	0.50
9.42E+01	9.04	1.77	0.50
1.00E+02	9.04	1.77	0.50
2.00E+02	9.04	1.77	0.50
3.00E+02	9.04	1.77	0.50
4.00E+02	9.04	1.77	0.50
5.00E+02	9.04	1.77	0.50
6.00E+02	9.04	1.77	0.50
7.00E+02	9.04	1.77	0.50

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

Table 8-14 — Aerosol Removal Rate (hr^{-1})

Time (hrs)	90%ile	Median	10%ile
7.18E+02	9.04	1.77	0.50
8.00E+02	9.04	1.77	0.50
9.00E+02	9.04	1.77	0.50
1.00E+03	9.04	1.77	0.50

8.3.1.4 Average Aerosol Removal Rates for Specific Time Periods

The methodology presented in Section 5.2.1.2 is used to determine the average aerosol removal rates for the *LocaDose* time periods presented in Table 8-1. First, the integrated removal rate using Equation 5-15 is calculated for the times used in Table 8-14. These are shown on Table 8-15.

As an example, a calculation for the 0.2 to 0.3 10th percentile level is performed. From Table 8-14, the removal rate at 0.2 hours is 2.88 hr^{-1}, and at 0.3 hours is 2.39 hr^{-1}. Therefore, the integrated removal rate for this time period is:

$$\lambda I(\Delta t)=\frac{\lambda_2-\lambda_1}{\ln\left(\lambda_2/\lambda_1\right)}(t_2-t_1)=\frac{2.39-2.88}{\ln\left(2.39/2.88\right)}(0.3-0.2)=0.263$$

This value is in excellent agreement with the result provided on Table 8-15.

Table 8-15 — Interval Integrated Aerosol Removal Rates ($hr^{-1}\cdot hr$)

Time Interval (hrs)		90%ile	Median	10%ile
0 –	1.00E-04	2.55E-03	1.20E-03	5.15E-04
1.00E-04 –	1.00E-03	2.29E-02	1.07E-02	4.62E-03
1.00E-03 –	2.00E-03	2.54E-02	1.19E-02	5.12E-03
2.00E-03 –	3.00E-03	2.52E-02	1.18E-02	5.10E-03
3.00E-03 –	4.00E-03	2.51E-02	1.17E-02	5.08E-03
4.00E-03 –	5.00E-03	2.50E-02	1.17E-02	5.06E-03
5.00E-03 –	6.00E-03	2.49E-02	1.16E-02	5.04E-03
6.00E-03 –	7.00E-03	2.48E-02	1.15E-02	5.02E-03
7.00E-03 –	8.00E-03	2.47E-02	1.15E-02	5.00E-03
8.00E-03 –	9.00E-03	2.46E-02	1.14E-02	4.98E-03
9.00E-03 –	1.00E-02	2.45E-02	1.13E-02	4.96E-03
1.00E-02 –	2.00E-02	2.39E-01	1.10E-01	4.85E-02
2.00E-02 –	3.00E-02	2.30E-01	1.05E-01	4.67E-02
3.00E-02 –	4.00E-02	2.21E-01	9.95E-02	4.51E-02

Table 8-15 — Interval Integrated Aerosol Removal Rates ($hr^{-1} \cdot hr$)

Time Interval (hrs)		90%ile	Median	10%ile
4.00E-02 –	5.00E-02	2.14E-01	9.51E-02	4.35E-02
5.00E-02 –	6.00E-02	2.07E-01	9.10E-02	4.21E-02
6.00E-02 –	7.00E-02	2.00E-01	8.73E-02	4.08E-02
7.00E-02 –	8.00E-02	1.95E-01	8.39E-02	3.95E-02
8.00E-02 –	9.00E-02	1.89E-01	8.09E-02	3.83E-02
9.00E-02 –	1.00E-01	1.84E-01	7.80E-02	3.72E-02
1.00E-01 –	2.00E-01	1.65E+00	6.69E-01	3.26E-01
2.00E-01 –	3.00E-01	1.40E+00	5.26E-01	2.63E-01
3.00E-01 –	4.00E-01	1.25E+00	4.42E-01	2.22E-01
4.00E-01 –	5.00E-01	1.15E+00	3.87E-01	1.94E-01
5.00E-01 –	6.00E-01	1.08E+00	3.49E-01	1.72E-01
6.00E-01 –	7.00E-01	1.04E+00	3.21E-01	1.56E-01
7.00E-01 –	8.00E-01	1.01E+00	2.99E-01	1.43E-01
8.00E-01 –	9.00E-01	9.81E-01	2.81E-01	1.33E-01
9.00E-01 –	1.00E+00	9.64E-01	2.67E-01	1.24E-01
1.00E+00 –	1.50E+00	4.69E+00	1.20E+00	5.36E-01
1.50E+00 –	2.00E+00	4.57E+00	1.05E+00	4.41E-01
2.00E+00 –	2.20E+00	1.81E+00	3.96E-01	1.59E-01
2.20E+00 –	3.00E+00	7.24E+00	1.52E+00	5.79E-01
3.00E+00 –	4.00E+00	9.04E+00	1.82E+00	6.40E-01
4.00E+00 –	5.00E+00	9.04E+00	1.79E+00	5.84E-01
5.00E+00 –	6.00E+00	9.04E+00	1.78E+00	5.51E-01
6.00E+00 –	6.20E+00	1.81E+00	3.55E-01	1.08E-01
6.20E+00 –	7.00E+00	7.23E+00	1.42E+00	4.25E-01
7.00E+00 –	8.00E+00	9.04E+00	1.77E+00	5.22E-01
8.00E+00 –	9.00E+00	9.04E+00	1.77E+00	5.15E-01
9.00E+00 –	1.20E+01	2.71E+01	5.32E+00	1.53E+00
1.20E+01 –	2.00E+01	7.23E+01	1.42E+01	4.04E+00
2.00E+01 –	2.22E+01	1.99E+01	3.90E+00	1.11E+00
2.22E+01 –	3.00E+01	7.05E+01	1.38E+01	3.93E+00
3.00E+01 –	4.00E+01	9.04E+01	1.77E+01	5.04E+00
4.00E+01 –	4.62E+01	5.61E+01	1.10E+01	3.12E+00
4.62E+01 –	5.00E+01	3.44E+01	6.74E+00	1.91E+00
5.00E+01 –	6.00E+01	9.04E+01	1.77E+01	5.04E+00
6.00E+01 –	7.00E+01	9.04E+01	1.77E+01	5.04E+00
7.00E+01 –	8.00E+01	9.04E+01	1.77E+01	5.04E+00
8.00E+01 –	9.00E+01	9.04E+01	1.77E+01	5.00E+00
9.00E+01 –	9.42E+01	3.80E+01	7.45E+00	2.12E+00
9.42E+01 –	1.00E+02	5.24E+01	1.03E+01	2.92E+00
1.00E+02 –	2.00E+02	9.04E+02	1.77E+02	5.04E+01

Table 8-15 — Interval Integrated Aerosol Removal Rates ($hr^{-1} \cdot hr$)

Time Interval (hrs)		90%ile	Median	10%ile
2.00E+02 –	3.00E+02	9.04E+02	1.77E+02	5.04E+01
3.00E+02 –	4.00E+02	9.04E+02	1.77E+02	5.04E+01
4.00E+02 –	5.00E+02	9.04E+02	1.77E+02	5.04E+01
5.00E+02 –	6.00E+02	9.04E+02	1.77E+02	5.04E+01
6.00E+02 –	7.00E+02	9.04E+02	1.77E+02	5.04E+01
7.00E+02 –	7.18E+02	1.65E+02	3.23E+01	9.17E+00
7.18E+02 –	8.00E+02	7.40E+02	1.45E+02	4.12E+01
8.00E+02 –	9.00E+02	9.04E+02	1.77E+02	5.04E+01
9.00E+02 –	1.00E+03	9.04E+02	1.77E+02	5.04E+01

Using the values presented above, the average removal rates for the *LocaDose* time periods are determined using Equation 5-16.

As discussed in Section 5.2.1, the model was originally developed for a puff release of aerosol into a system. In those cases where there is a continuous release, the size distribution will continually be renewed by the injected aerosols. The model has been extended for this case by setting the mass fraction $m_f = 1$ until the release stops. The release continues until 1.8 hours after the onset of the LOCA per Design Input 4.3, therefore the aerosol removal rates for this period are held constant to the value at t = 0 from Table 8-14.

Since the aerosol removal rates are held constant for the first 1.8 hours, the time dependency shown on Table 8-14 and Table 8-15 is offset by 1.8 hours. For example, the *LocaDose* time period of 1.8 to 2 hrs is equivalent to the 0 to 0.2 time period of Table 8-15. Table 8-16 is constructed using Equation 5-16 and the information presented on Table 8-15.

Table 8-16 — Average Aerosol Removal Rates (hr^{-1})

Time Period (hrs)	90%ile	Median	10%ile
0 — 1.8	25.54	11.98	5.15
1.8 — 2	18.89	8.08	3.79
2 — 3.8	10.07	2.84	1.32
3.8 — 4	9.07	1.98	0.79
4 — 8	9.04	1.82	0.62
8 — 13.8	9.04	1.77	0.52
13.8 — 24	9.04	1.77	0.50
24 — 48	9.04	1.77	0.50
48 — 96	9.04	1.77	0.50
96 — 720	9.04	1.77	0.50

As an example, calculate the average aerosol removal rate for the *LocaDose* time period of 2 to 3.8 hours for the 10[th] percentile level. This time period corresponds to the 0.2 to 2.0 hour time period of Table 8-15. The interval integrated aerosol removal rates for this period are:

Time Period (hrs)	10[th] Percentile Interval Integrated Removal Rate ($hr^{-1} \cdot hr$)
2.00E-01 – 3.00E-01	2.63E-01
3.00E-01 – 4.00E-01	2.22E-01
4.00E-01 – 5.00E-01	1.94E-01
5.00E-01 – 6.00E-01	1.72E-01
6.00E-01 – 7.00E-01	1.56E-01
7.00E-01 – 8.00E-01	1.43E-01
8.00E-01 – 9.00E-01	1.33E-01
9.00E-01 – 1.00E+00	1.24E-01
1.00E+00 – 1.50E+00	5.36E-01
1.50E+00 – 2.00E+00	4.41E-01
Total 0.2 – 2.0	2.38

The average removal rate is then ($2.38\ hr^{-1} \cdot hr$)/(3.8-2.0 hr) = $1.32\ hr^{-1}$, in excellent agreement with the result shown on Table 8-16.

8.3.2 Elemental Iodine Removal Rates

8.3.2.1 Calculation of Elemental Iodine Mass Released to Containment

The number of moles of iodine in the containment is calculated using the methodology described in Section 5.2.2.2.1. Using the iodine core inventory presented in Design Input 4.16, the total iodine released during the gap and the early in-vessel phases from Design Input 4.2 (5% and 35%, respectively), and the elemental iodine fraction from Design Input 4.4 (4.85%), the number of moles released is calculated using Equation 5-17. The results are presented in Table 8-17.

As an example, the number of moles of I-131 that are released to the containment are calculated.

$$n = \frac{M}{2 \times MW} = \frac{755}{2 \times 131} = 2.88$$

The number of moles released to the containment is then 2.88 x 0.40 x 0.0485 = 0.0559.

The values above are in good agreement with the values in Table 8-17.

Table 8-17 — Elemental Iodine Mass Release

Isotope	Molecular Weight	Core Mass (g)	Number of Moles	Released Moles
I--127	127	4.64E+03	1.83E+01	3.54E-01
I--128	128	1.87E-02	7.30E-05	1.42E-06
I--129	129	2.05E+04	7.95E+01	1.54E+00
I--130	130	1.28E+00	4.92E-03	9.55E-05
I-130M	130	8.27E-03	3.18E-05	6.17E-07
I--131	131	7.55E+02	2.88E+00	5.59E-02
I--132	132	1.31E+01	4.96E-02	9.63E-04
I--133	133	1.75E+02	6.58E-01	1.28E-02
I-133M	133	1.58E-03	5.94E-06	1.15E-07
I--134	134	8.42E+00	3.14E-02	6.10E-04
I-134M	134	5.14E-02	1.92E-04	3.72E-06
I--135	135	5.27E+01	1.95E-01	3.79E-03
I--136	136	9.24E-02	3.40E-04	6.59E-06
I-136M	136	2.43E-02	8.93E-05	1.73E-06
I--137	137	2.82E-02	1.03E-04	2.00E-06
I--138	138	3.75E-03	1.36E-05	2.64E-07
I--139	139	7.62E-04	2.74E-06	5.32E-08
I--140	140	6.68E-05	2.39E-07	4.63E-09
Total		2.61E+04	1.02E+02	1.97E+00

The total number of moles used in the *ICONC* runs (see Section 9.1) is 2.03 (based on a preliminary prediction of the core iodine inventory). This is greater than the 1.97 value shown in Table 8-17 by 3%. Since the partition coefficients decrease with increasing iodine available in the containment, the value of 2.03 is conservative and will be used in this calculation.

8.3.2.2 Calculation of Partition Coefficients

As discussed in Section 5.2.2.2, the partition coefficients are calculated using the program *ICONC*. *ICONC* requires the following parameters:

- Water temperature in °F

  During the injection phase, when RWST borated water is used, the minimum sump temperature is 40 °F (Design Input 4.17). The maximum temperature is determined from the post-LOCA sump temperature profiles (Design Input 4.18). The maximum temperature is 260.3 °F for case 7. To encompass all temperatures, a range from 40 °F to 280 °F is used in *ICONC*.

- Water pH value

  Per Design Input 4.14, the sump is maintained at a minimum pH level of 7. The partition coefficients increase with increased pH; therefore, it is conservative to use the minimum pH level in this calculation

- Volume of gaseous phase in cubic feet

  The volume of the gaseous phase is taken to be the free air volume of the containment. From Design Input 4.6, the net free air volume is 2,284,000 ft^3.

- Volume of liquid phase in cubic feet

  The volume of the liquid phase is taken to be the minimum sump volume. Per Modeling Assumption 3.8, the minimum sump volume is 46,647 ft^3. The minimum sump volume is appropriate for this calculation since larger volumes will retain more iodine thus increasing the partition coefficient.

- Initial iodine inventory in water in moles

  The initial iodine inventory is assumed to be the elemental iodine available for release, calculated to be 2.03 moles in Section 8.3.2.1.

- Equilibrium constants K_1 and K_3

  The equilibrium constants K_1 and K_3 are provided on Table 4-6 (Design Input 4.15). The temperature values presented on Table 4-6 are in °C and do not match the values used as shown on Table 8-18. Therefore, Equation 5-18 is used to interpolate the constants K_1 and K_3 at the Table 8-18 temperature values.

  For example equilibrium constants K_1 and K_3 are calculated at 100 °F (37.78 °C). From Table 4-6:

Temperature (°C)	K_1	Temperature (°C)	K_3
30	61	30	8.4E-13
40	39	40	2.1E-12

K_1 is then:

$$K_1(T) = K_1(T_1)\left(\frac{K_1(T_2)}{K(T_1)}\right)^{\left[\frac{T_1-T}{T_1-T_2}\right]} = 61\cdot\left(\frac{39}{61}\right)^{\left[\frac{30-37.78}{30-40}\right]} = 43.08$$

K_2 is then:

$$K_2(T)=K_2(T_1)\left(\frac{K_2(T_2)}{K_2(T_1)}\right)^{\left[\frac{T_1-T}{T_1-T_2}\right]}=8.4\times10^{-13}\cdot\left(\frac{2.1\times10^{-12}}{8.4\times10^{-13}}\right)^{\left[\frac{30-37.78}{30-40}\right]}=1.71\times10^{-12}$$

These values are in excellent agreement with the values shown on Table 8-18.

These values were then used to develop the *ICONC* input file shown on Section 9.1.1. The *ICONC* output is shown on Section 9.1.2. The partition coefficients and the decontamination factors from *ICONC* are presented on Table 8-18. The partition coefficients as a function of temperature are also shown on Figure 8–2. As shown on this figure, the partition coefficient increases with increasing temperature beginning from 60 °F.

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-18 — Elemental Iodine Partition Coefficients

Sump Temperature (°F)	K_1	K_3	Partition Coefficient	DF
40	241.34	6.61E-14	475.3	10.71
50	173.00	1.20E-13	427.2	9.73
60	129.00	2.14E-13	419.8	9.57
70	95.15	3.77E-13	430.2	9.79
80	69.76	6.26E-13	445.1	10.09
90	55.23	1.03E-12	511.4	11.45
100	43.08	1.71E-12	603.0	13.32
110	34.16	2.77E-12	726.0	15.83
120	27.38	4.38E-12	880.2	18.98
130	22.71	6.65E-12	1,076	22.97
140	19.00	1.00E-11	1,324	28.03
150	16.91	1.55E-11	1,791	37.58
160	15.11	2.37E-11	2,415	50.32
170	13.76	3.44E-11	3,165	65.63
180	12.40	4.99E-11	4,111	84.97
190	11.01	7.24E-11	5,273	108.7
200	9.97	1.02E-10	6,705	137.9
210	9.16	1.41E-10	8,496	174.5
220	8.55	2.02E-10	11,338	232.6
230	8.36	2.70E-10	14,797	303.2
240	7.80	3.72E-10	19,002	389.1
250	7.05	5.07E-10	23,391	478.7
260	6.62	6.63E-10	28,707	587.3
270	6.27	8.58E-10	35,172	719.3
280	6.04	1.09E-09	43,029	879.8

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

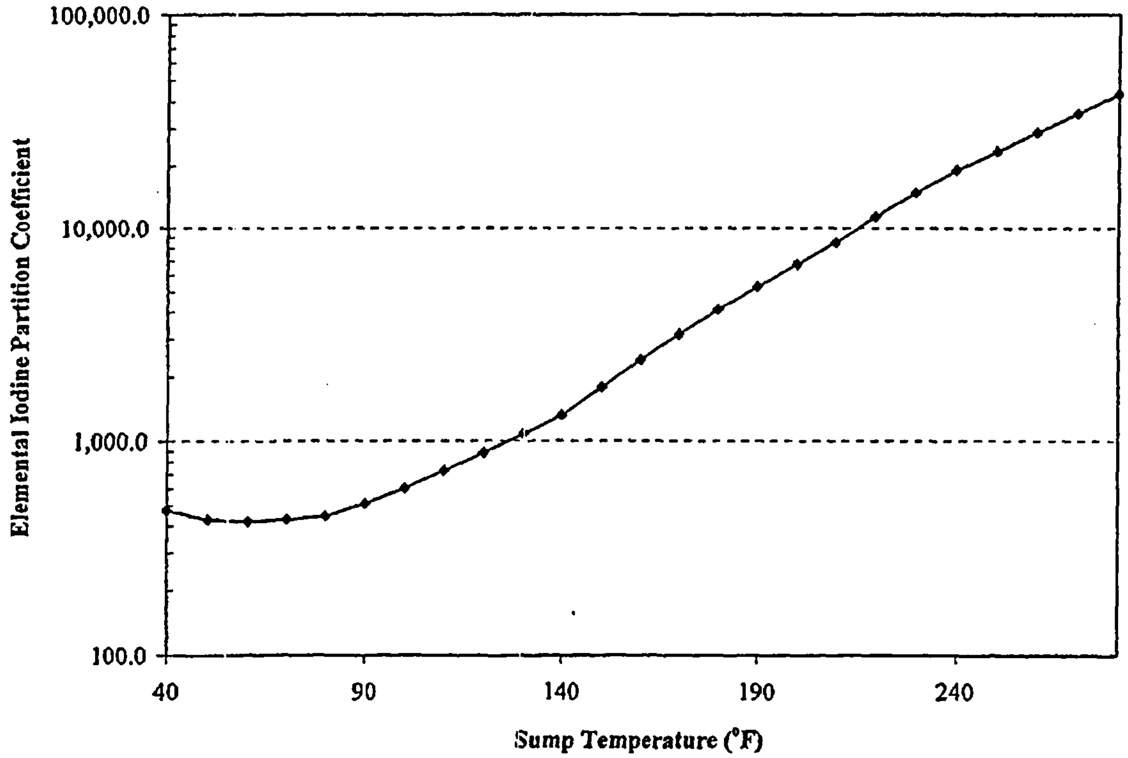

Figure 8–2 — Elemental Iodine Partition Coefficient as a Function of Sump Temperature

8.3.2.3 Elemental Iodine Spray Removal Rates

As discussed in Section 5.2.2.1, the elemental iodine spray removal rates are calculated using the program *REMOVE*. The input parameters used by *REMOVE* are described in the following sections. Removal rates are calculated as a function of time for two phases, the injection phase and the recirculation phase. Parameters that are common to both are described in Section 8.3.2.3.1, parameters that apply to the injection phase are described in Section 8.3.2.3.2, and parameters that apply to the recirculation phase are described in Section 8.3.2.3.3.

Removal rates are calculated for each spray header and each individual ring within the spray header. The resultant spray removal rates are then summed together for each spray header. The lowest total spray removal rate is then selected to represent the elemental spray removal rate capability of the spray system.

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

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8.3.2.3.1 Common Parameters

Per Design Input 4.11, the SONGS containment spray system is designed with SPRACO 1713A nozzles, therefore the drop size distribution for this nozzle, which is built into the *REMOVE* program, will be used (Table 1 of the *REMOVE* Theoretical Manual [Reference 6.6b]). This distribution contains 69 different size groups, of which the smallest drop size diameter is 0.00375 cm.

The sprayed volume is the containment sprayed region. From Design Input 4.6, the containment sprayed region volume is 1,907,000 ft^3.

The plate out area is used by *REMOVE* to determine the elemental iodine deposition rates. Although the deposition rates calculated by *REMOVE* are not used in this calculation, the wall surface area from Design Input 4.9 of 601,519 ft^2 is entered.

The spray system parameters used by REMOVE are shown on Table 8-19. The number of nozzles and the initial spray angle are obtained from Design Input 4.11. The fall height was calculated in previous sections and presented in the listed tables.

Table 8-19 — Spray System Parameters used by *REMOVE*

Spray Ring	Initial Angle	Number of Nozzles	Fall Height (ft)	Fall Height Source
049-4"-C-KEO	10	28	79.81	Table 8-8
049-4"-C-KEO	45	28	79.81	Table 8-8
043-4"-C-KEO	10	28	85.60	Table 8-11
043-4"-C-KEO	45	28	85.60	Table 8-11
045-4"-C-KEO	0	20	105.83	Table 8-10
045-4"-C-KEO	90	20	105.83	Table 8-10
051-4"-C-KEO	0	20	108.11	Table 8-7
051-4"-C-KEO	90	20	108.11	Table 8-7
052-2 ½"-C-KEO	0	10	117.43	Table 8-6
052-2 ½"-C-KEO	45	10	117.43	Table 8-6
046-2 ½"-C-KEO	0	10	118.47	Table 8-9
046-2 ½"-C-KEO	45	10	118.47	Table 8-9

The flow rate per nozzle, as calculated in Section 8.3.1.2, is 13.79 gpm.

The initial spray velocity is calculated using the information from Design Input 4.12. From Design Input 4.12, the nozzle orifice is 0.375" in diameter and is 80% air filled (0.3" air fill diameter). The annular area is then:

$$A = \pi\left[\left(\frac{0.375\,in \cdot 2.54\,cm/in}{2}\right)^2 - \left(\frac{0.30\,in \cdot 2.54\,cm/in}{2}\right)^2\right] = 0.257\,cm^2$$

The flow per nozzle, from above, is 13.79 gpm = 52.22 lpm = 870.4 cm^3/sec. Therefore, the initial velocity is 870.4 cm^3/sec ÷ 0.257 cm2 = 3,393 cm/sec.

Spray Removal Rates as a Function of Air-Steam Temperature

The removal rates are dependent on the temperature of the air-steam mixture in the containment; therefore, a parametric study is performed to determine the appropriate temperatures that will result in conservative removal rate estimates. This parametric is arbitrarily performed on the 10° nozzles of ring 049-4"-C-KEO. The temperature range encompasses the range in temperature as provided in Design Input 4.18. From Table 4-8, the minimum containment air temperature is 89.9 °F (32.2 °C), and the maximum containment air temperature is 267.4 °F (130.8 °C). The input files for the parametric study are shown in Section 9.2.1.1. The results of this parametric study are presented on Table 8-20 and on Figure 8–3.

Table 8-20 — Elemental Iodine Spray Removal Rate Parametrics

Containment Temperature (°C)	Spray Removal Rate (hr^{-1})
30	4.5685
40	4.7679
50	4.9357
60	5.0724
70	5.1780
75	5.2192
80	5.2527
85	5.2787
90	5.2974
95	5.3091
100	5.3141
105	5.3129
110	5.3058
120	5.2755
130	5.2279

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

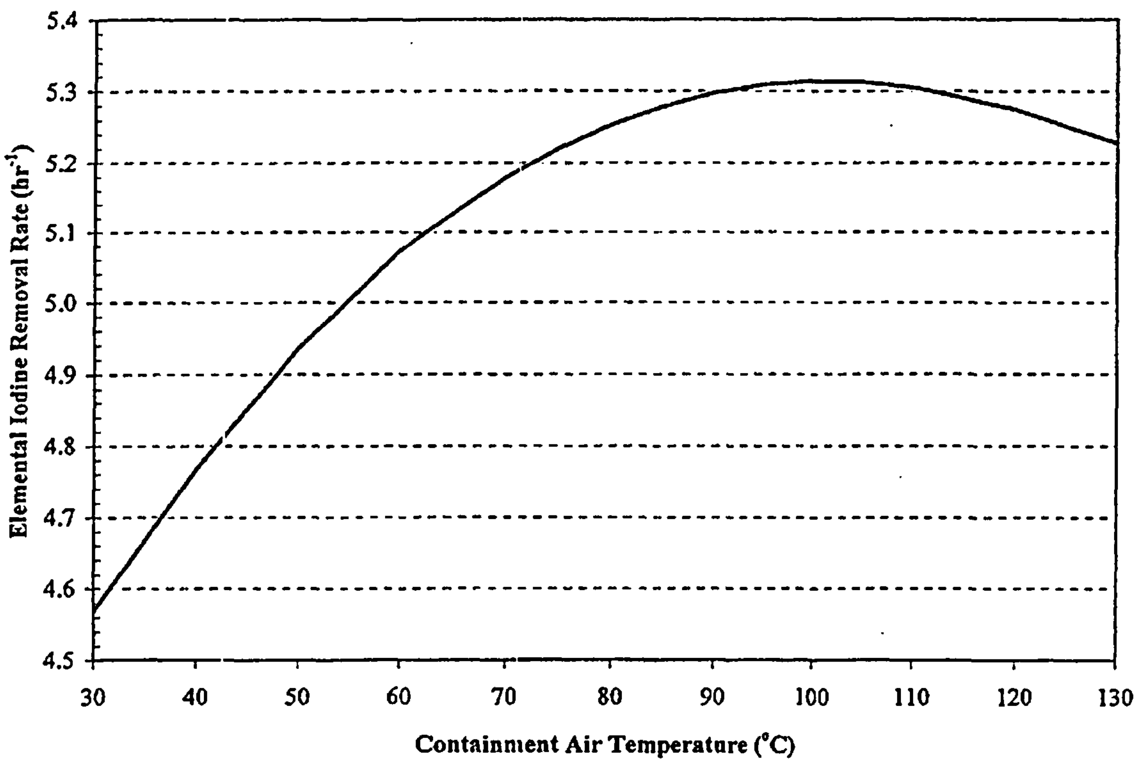

Figure 8–3 — Elemental Iodine Spray Removal Rate as a Function of Containment Air Temperature

As shown above, the removal rate increases with temperature until about 100 °C, and then decreases with increasing temperature. Within the temperature range of interest, the maximum removal rate is 5.314 hr^{-1}, and the minimum removal rate is 4.569 hr^{-1}, for a ratio of 1.2 between these extremes. Since the removal rates determined in this calculation are dependent on a post LOCA environment that may be revised due to changes in the reactor power, reactor system or steam generator characteristics, the resultant removal rates will be conservatively reduced by a factor of 1.2.

8.3.2.3.2 Injection Phase Parameters

The injection phase begins with initiation of spray and lasts from a minimum of approximately 20 minutes (with two trains in operation) to a maximum of approximately 40 minutes (with one train in operation).

Partition Coefficient

During the injection phase, borated water from the RWST is used in the spray system. Per NUREG/CR-0009 (Reference 6.4h page 61) a partition coefficient of 200 for boric acid solutions is used.

Air-Steam Mixture Temperature

From Design Input 4.18, the temperature range in the 30 sec to 40 min time period is 188.3 to 265.9 °F. (86.8 to 129.9 °C). From Table 8-20 it can be seen that the removal rate at 130 °C is lower than the removal rate at 85 °C or even 90 °C, therefore the upper temperature of this time period (129.9 °C) will be used to calculate the spray removal rates for the injection phase.

8.3.2.3.3 Recirculation Phase Parameters

To determine the partition coefficients and the air-steam mixture temperature, the temperature profile of Design Input 4.18 needs to be expanded to include the *LocaDose* time-steps. In particular, containment and sump temperatures at 2, 4, 8, 13.8, 24, 48, 96, and 720 hours are needed. The temperatures for these times are linearly interpolated from adjacent temperatures from Table 4-8. The temperature history results are presented on Table 8-21 with the added time steps highlighted.

For example, the vapor temperature for case 1 at 4 hours (14,400 sec) is calculated:

$$T(14{,}400) = 217.7\ °F + (215.7\ °F - 217.7\ °F)\frac{14{,}400 - 12{,}500}{15{,}000 - 12{,}500} = 216.2\ °F$$

This value is in excellent agreement with the value shown on Table 8-21.

Table 8-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
0.0	0.000E+00	120	120	120	120	120	120
0.1	2.778E-05	90.5	89.9	111.8	197.8	206.4	216.1
0.2	5.556E-05	112.5	105	133.1	206.9	210.9	219.3
0.3	8.333E-05	127.4	116.7	146.1	211	213.9	217.7
0.4	1.111E-04	139.3	126.3	156	213.8	216.4	218.1
0.5	1.389E-04	148.8	135.3	163.9	215	218.3	218.2
0.6	1.667E-04	156.1	142.6	170.5	216.4	219.9	218.8
0.7	1.944E-04	162.6	148.1	176.2	217.6	220	218.6
0.8	2.222E-04	167.6	153.7	181.1	217.4	220.3	218.1
0.9	2.500E-04	172.8	158.1	185.4	217.4	220.9	218.9
1	2.778E-04	178	162.1	189.1	218.4	220.6	218.9
2	5.556E-04	206.9	193	214.7	219.2	222.4	223.7
3	8.333E-04	221.9	210.2	230.5	222.5	225.3	230.9
4	1.111E-03	231.9	220.5	241.3	225.2	228	236.7
5	1.389E-03	239.8	228	249.3	227.3	231.1	241.4
6	1.667E-03	245.5	234.1	255.2	229.2	234.1	245.3
7	1.944E-03	250.4	239.2	260.1	230.5	236.6	246.9
8	2.222E-03	254.3	243.5	263.3	230.9	238.9	247.6
9	2.500E-03	257.3	247.2	265.1	230.5	241	248
10	2.778E-03	258.9	250.5	265.9	229.7	242.5	248.3
11	3.056E-03	260.3	253.3	266.7	229.4	243.5	248.6
12	3.333E-03	260.8	255.4	267.4	229.8	244.4	248.7
13	3.611E-03	260.7	257	266.8	230.4	245.1	248.9
14	3.889E-03	260.3	258	266.2	230.7	245.9	249
15	4.167E-03	259.8	258.6	265.7	230	246.6	249.1
16	4.444E-03	259.3	258.7	265.4	229.1	247.1	249.2
17	4.722E-03	258.8	258.9	265.1	228.2	247.5	249.3
18	5.000E-03	258.6	258.6	264.8	227.3	247.8	249.4
19	5.278E-03	258.6	258.2	264.7	226.5	247.9	249.5
20	5.556E-03	258.9	257.8	264.6	225.7	248	249.5
22	6.111E-03	259	257.8	264.6	221.4	248	249.7
24	6.667E-03	258.8	258.6	264.5	217.1	242.7	249.8
26	7.222E-03	258.9	258.8	264.4	213.4	236.7	249.9
28	7.778E-03	259.1	259.1	264.3	210.2	231.7	250
30	8.333E-03	259.3	259.5	264.2	207.3	227.5	250.1
32	8.889E-03	259.7	260	264	205.8	223.9	250.1
34	9.444E-03	260.1	260.5	263.9	204.5	220.8	250.2

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

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Table 3-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
36	1.000E-02	260.3	261	263.7	203.3	218.1	250.3
38	1.056E-02	260.5	261.3	263.6	202.2	215.7	250.3
40	1.111E-02	260.5	261.4	263.4	201.2	213.6	250.4
42	1.167E-02	260.3	261.4	263.3	200.3	211.7	250.4
44	1.222E-02	259.7	261	263.5	199.4	210	250.5
46	1.278E-02	258.9	260.3	263.3	198.6	208.4	250.5
48	1.333E-02	258	259.5	263.1	197.9	207.1	250.6
50	1.389E-02	256.9	258.6	262.9	197.2	205.8	250.6
52	1.444E-02	255.8	257.7	262.8	196.6	204.7	250.7
54	1.500E-02	255.8	256.6	262.6	196	203.6	250.7
56	1.556E-02	255.7	256.1	262.5	195.5	202.6	250.8
58	1.611E-02	255.7	256.1	262.3	195	201.8	250.8
60	1.667E-02	255.7	256.1	262.1	194.5	201	250.9
62	1.722E-02	255.6	256.1	261.9	194.1	200.3	250.9
64	1.778E-02	255.5	256	261.7	193.7	199.7	251
66	1.833E-02	255.5	256.1	261.6	193.4	199.1	251.2
68	1.889E-02	255.5	256	261.4	193	198.5	251.4
70	1.944E-02	255.5	256.1	261.2	192.7	198	251.6
72	2.000E-02	255.4	256.1	261	192.5	197.6	251.8
74	2.056E-02	255.4	256.1	260.9	192.4	197.2	252
76	2.111E-02	255.3	256.2	260.7	192.4	196.8	252.1
78	2.167E-02	255.4	256.1	260.6	192.5	196.5	252.3
80	2.222E-02	255.7	256.2	260.4	192.6	196.1	252.5
82	2.278E-02	255.9	256.2	260.3	192.7	195.9	252.6
84	2.333E-02	256.1	256.2	260.1	192.8	195.6	252.8
86	2.389E-02	256.3	256	260	192.9	195.4	253
88	2.444E-02	256.4	256	259.8	193	195.3	253.1
90	2.500E-02	256.8	256	259.7	193.1	195.2	253.3
92	2.556E-02	256.9	256.4	259.6	193.1	195.2	253.4
94	2.611E-02	257.1	256.6	259.4	193.2	195.4	253.6
96	2.667E-02	257.3	257	259.3	193.3	195.6	253.7
98	2.722E-02	257.5	257.1	259.2	193.4	195.7	253.9
100	2.778E-02	257.7	257.3	259.1	193.5	195.9	254
105	2.917E-02	258.2	257.8	258.8	193.7	196.2	254.3
110	3.056E-02	258.6	258.2	258.5	193.9	196.6	254.7
115	3.194E-02	259	258.5	258.3	194.1	197	255
120	3.333E-02	259.5	258.8	258	194.3	197.4	255.3
125	3.472E-02	259.8	258.9	257.8	194.5	197.7	255.5

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

Table 8-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
130	3.611E-02	260.2	259	257.6	194.7	198.1	255.8
135	3.750E-02	260.6	259.1	257.4	194.9	198.5	256.1
140	3.889E-02	260.9	259.2	257.2	195.1	198.9	256.3
145	4.028E-02	261.3	259.2	257	195.3	199.3	256.6
150	4.167E-02	261.6	259.2	256.8	195.5	199.7	256.8
155	4.306E-02	262	259.2	256.5	195.7	200.1	257
160	4.444E-02	262.3	259.2	256.2	195.9	200.4	257.3
165	4.583E-02	262.6	259.2	255.9	196.1	200.8	257.5
170	4.722E-02	263	259.1	255.6	196.3	201.2	257.7
175	4.861E-02	263.4	259.1	255.3	196.4	201.6	257.9
180	5.000E-02	263.6	259	255	196.6	202	258.1
185	5.139E-02	264	258.9	254.8	196.8	202.5	258.3
190	5.278E-02	264.2	258.8	254.6	197	202.9	258.5
195	5.417E-02	264.4	258.7	254.2	197.2	203.4	258.7
200	5.556E-02	264.7	258.6	253.8	197.4	204	258.9
205	5.694E-02	264.9	258.5	253.5	197.7	204.5	259.1
210	5.833E-02	265	258.4	253.2	198	205	259.2
215	5.972E-02	265.2	258.3	252.8	198.3	205.5	259.4
220	6.111E-02	265.3	258.2	252.5	198.6	206	259.5
225	6.250E-02	265.4	258.1	252.1	198.9	206.5	259.6
230	6.389E-02	265.5	258	251.8	199.3	207	259.7
235	6.528E-02	265.6	257.9	251.4	199.7	207.5	259.8
240	6.667E-02	265.6	257.8	251.1	200.1	208	259.9
245	6.806E-02	265.7	257.7	250.8	200.6	208.5	260
250	6.944E-02	265.8	257.6	250.5	201	209	260
255	7.083E-02	265.8	257.5	250.2	201.4	210.3	260.1
260	7.222E-02	265.9	257.3	249.9	201.9	211	260.1
265	7.361E-02	265.9	257	249.6	202.4	211.4	260.2
270	7.500E-02	265.9	256.8	249.3	202.8	211.9	260.2
275	7.639E-02	265.9	256.6	249	203.3	212.3	260.2
280	7.778E-02	265.8	256.4	248.7	203.8	212.8	260.3
285	7.917E-02	265.8	256.3	248.4	204.2	213.2	260.3
290	8.056E-02	265.7	256.1	248.1	204.7	213.6	260.3
295	8.194E-02	265.6	255.9	247.8	205.2	214	260.3
300	8.333E-02	265.5	255.7	247.6	205.6	214.5	260.3
310	8.611E-02	265.3	255.4	247.1	206.6	215.3	260.3
320	8.889E-02	264.9	255	246.5	206.4	216	260.2
330	9.167E-02	264.5	255.1	246	207.4	216.8	260.1

Table 8-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time (sec)	Time (hr)	Vapor Temperature (°F) Case 1	Vapor Temperature (°F) Case 4	Vapor Temperature (°F) Case 7	Sump Temperature (°F) Case 1	Sump Temperature (°F) Case 4	Sump Temperature (°F) Case 7
340	9.444E-02	264.1	254.5	245.5	208.3	217.5	260
350	9.722E-02	263.8	254.2	245.2	209.2	218.2	259.9
360	1.000E-01	263.4	253.9	244.7	210	218.9	259.8
370	1.028E-01	263.2	253.6	244.2	210.8	219.5	259.7
380	1.056E-01	262.9	253.2	243.7	211.6	220.2	259.5
390	1.083E-01	262.5	252.9	243.3	212.4	220.8	259.4
400	1.111E-01	262.2	252.7	242.8	213.1	221.4	259.2
420	1.167E-01	261.6	252.1	241.9	214.6	222.6	258.8
440	1.222E-01	260.9	251.5	241	215.9	223.7	258.3
460	1.278E-01	260.3	251	240.2	217.2	224.7	257.9
480	1.333E-01	259.8	250.5	239.3	218.4	225.7	257.4
500	1.389E-01	259.2	249.8	238.5	219.5	226.6	256.8
520	1.444E-01	258.6	249	237.7	220.6	227.4	256.3
540	1.500E-01	258	248.1	236.9	221.7	228.1	255.7
560	1.556E-01	257.2	247.4	236.2	222.7	228.7	255.1
580	1.611E-01	256.4	246.6	235.4	223.6	229.3	254.6
600	1.667E-01	255.7	245.8	234.6	224.5	229.7	254
650	1.806E-01	253.9	244.1	233	226.2	230.5	252.4
700	1.944E-01	252	242.3	231.2	227.4	230.9	250.9
750	2.083E-01	250.2	240.6	229.4	228.2	231.1	249.4
800	2.222E-01	248.4	239	227.7	228.7	231.1	247.8
850	2.361E-01	246.7	237.3	226.1	229	230.9	246.3
900	2.500E-01	245.5	235.8	224.5	229	230.5	244.8
950	2.639E-01	243.7	234.2	223	228.9	230.1	243.3
1,000	2.778E-01	242.1	232.9	221.4	228.6	229.6	241.8
1,050	2.917E-01	240.6	231.4	220.1	228.2	229	240.3
1,100	3.056E-01	239.1	230	218.7	227.8	228.3	238.9
1,150	3.194E-01	237.6	228.5	217.3	227.3	227.6	237.5
1,200	3.333E-01	236.2	227.2	215.9	226.7	226.9	236.1
1,220	3.389E-01	235.6	226.6	215.3	226.5	226.6	235.6
1,240	3.444E-01	235	226.1	214.7	226.2	226.3	235.1
1,260	3.500E-01	234.5	225.5	214.2	226	226	234.6
1,280	3.556E-01	234.2	225	213.7	225.7	225.7	234
1,300	3.611E-01	233.5	224.5	213.1	225.5	225.5	233.5
1,320	3.667E-01	233	224	212.6	225.3	225.2	233
1,340	3.722E-01	232.4	223.4	212	225	224.9	232.5
1,360	3.778E-01	231.9	222.9	211.5	224.7	224.6	232
1,380	3.833E-01	231.4	222.4	211	224.5	224.3	231.6

Table 8-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
1,400	3.889E-01	230.8	221.9	210.5	224.2	224	231.1
1,450	4.028E-01	229.5	220.7	209.2	223.6	223.2	229.9
1,500	4.167E-01	228.2	219.6	207.9	222.9	222.5	228.8
1,550	4.306E-01	226.9	218.4	206.8	222.3	221.8	227.7
1,600	4.444E-01	225.6	217.2	205.6	221.6	221.1	226.6
1,650	4.583E-01	224.4	216	204.4	221	220.4	225.6
1,700	4.722E-01	223.1	214.8	203.2	220.4	219.7	224.6
1,750	4.861E-01	221.9	213.6	202	219.7	219	223.6
1,800	5.000E-01	220.7	212.5	200.8	219.1	218.3	222.6
1,850	5.139E-01	219.7	211.4	199.7	218.5	217.6	221.7
1,900	5.278E-01	218.5	210.3	198.6	217.9	217	220.8
1,950	5.417E-01	217.4	209.2	197.5	217.2	216.3	219.9
2,000	5.556E-01	216.2	208.1	196.5	216.6	215.7	219
2,050	5.694E-01	215.1	207.2	195.4	216	215.1	218.2
2,100	5.833E-01	214	206.1	194.3	215.4	214.4	217.4
2,150	5.972E-01	212.8	205.1	193.3	214.9	213.8	216.6
2,200	6.111E-01	211.8	204.1	192.3	214.3	213.2	215.8
2,250	6.250E-01	210.7	203	191.3	213.7	212.6	215
2,300	6.389E-01	209.6	202	190.3	213.2	212	214.3
2,350	6.528E-01	208.6	201.1	189.3	212.6	211.5	213.6
2,400	6.667E-01	207.5	200.1	188.3	212	210.9	212.9
2,420	6.722E-01	207.2	199.7	188	211.8	210.7	212.8
2,440	6.778E-01	206.8	199.3	188.3	211.7	210.5	212.7
2,460	6.833E-01	206.5	199	187.6	211.6	210.4	212.6
2,480	6.889E-01	206.1	198.7	187.2	211.6	210.3	212.5
2,500	6.944E-01	205.8	198.4	186.9	211.5	210.3	212.4
2,600	7.222E-01	204	196.9	185.5	211.3	210.1	212.1
2,700	7.500E-01	203.4	196.5	187.9	211.3	210	211.9
2,800	7.778E-01	205.7	199	191	211.1	209.9	211.6
2,900	8.056E-01	207.8	201.3	193.5	211	209.7	211.4
3,000	8.333E-01	209.1	203.2	195.7	210.9	209.7	211.2
3,100	8.611E-01	210.5	204.8	197.6	210.8	209.6	211.1
3,200	8.889E-01	211.6	206.2	199.1	210.8	209.5	210.9
3,300	9.167E-01	212.7	207.4	200.4	210.7	209.5	210.8
3,400	9.444E-01	213.6	208.4	201.6	210.7	209.5	210.6
3,500	9.722E-01	214.4	209.3	202.6	210.6	209.4	210.5
3,600	1.000E+00	215.1	210.1	203.6	210.6	209.4	210.4
3,700	1.028E+00	215.7	210.8	204.4	210.6	209.4	210.3

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
3,800	1.056E+00	216.3	211.5	205.2	210.5	209.4	210.3
3,900	1.083E+00	216.8	212.1	205.9	210.5	209.4	210.2
4,000	1.111E+00	217.3	212.7	206.5	210.5	209.4	210.1
4,500	1.250E+00	219.3	215	209	210.6	209.6	209.9
5,000	1.389E+00	220.4	216.6	210.8	210.7	209.8	209.9
5,500	1.528E+00	221.1	217.6	211.8	210.9	210.2	209.9
6,000	1.667E+00	221.6	218.1	212.4	211.1	210.5	210
6,500	1.806E+00	221.7	218.4	212.8	211.3	210.9	210.1
7,000	1.944E+00	221.5	218.4	212.9	211.5	211.2	210.3
[redacted]							
7,500	2.083E+00	221.1	218.2	213.3	211.8	211.6	210.1
8,000	2.222E+00	220.7	218.1	213.9	212.1	211.9	209.7
8,500	2.361E+00	220.5	217.9	214.4	212.4	212.2	209.3
9,000	2.500E+00	220.1	217.8	214.7	212.6	212.4	209.1
9,500	2.639E+00	219.8	217.6	215	212.9	212.7	208.8
10,000	2.778E+00	219.4	217.4	215.2	213.1	212.9	208.6
12,500	3.472E+00	217.7	216.2	215.3	213.7	213.8	207.7
[redacted]							
15,000	4.167E+00	215.7	214.5	214.3	213.8	214.1	207
17,500	4.861E+00	213.2	212.2	212.5	213.5	214	206.2
20,000	5.556E+00	210.8	210	210.6	212.8	213.6	205.3
22,500	6.250E+00	208.9	208.2	209	211.9	212.8	204.3
25,000	6.944E+00	207.1	206.5	207.5	210.8	211.9	203.2
27,500	7.639E+00	205.2	204.6	205.9	209.7	210.9	202.1
[redacted]							
30,000	8.333E+00	203.2	202.7	204.1	208.5	209.8	200.9
35,000	9.722E+00	199.1	198.6	200.4	205.9	207.4	198.5
40,000	1.111E+01	195.4	194.9	197	203.2	204.8	195.9
45,000	1.250E+01	192.2	191.7	194.2	200.6	202.3	193.5
[redacted]							
50,000	1.389E+01	189.4	188.7	191.6	198.3	200	191.2
55,000	1.528E+01	186.4	185.6	189.1	196.1	197.7	189.1
60,000	1.667E+01	183.9	183	187	194	195.7	187.1
65,000	1.806E+01	181.7	180.8	185	192.1	193.8	185.4
70,000	1.944E+01	179.7	178.7	183.1	190.5	192.1	183.8
75,000	2.083E+01	177.8	176.7	181.4	189	190.6	182.3
80,000	2.222E+01	176.2	175	180	187.6	189.3	181
85,000	2.361E+01	174.6	173.3	178.7	186.4	188	179.8

E&TS DEPARTMENT

CALCULATION SHEET

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Project or DCP/FCN/ECP N/A Calc No. N-6030-001

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REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-21 — Containment Atmosphere and Water Sump Temperature Profile with Added Time-steps

Time		Vapor Temperature (°F)			Sump Temperature (°F)		
(sec)	(hr)	Case 1	Case 4	Case 7	Case 1	Case 4	Case 7
[redacted]							
90,000	2.500E+01	173.2	171.8	177.6	185.3	186.9	178.8
95,000	2.639E+01	171.9	170.5	176.6	184.2	185.9	177.8
100,000	2.778E+01	170.8	169.3	175.7	183.3	184.9	177
125,000	3.472E+01	166.2	164.7	171.7	179.8	181.5	173.9
150,000	4.167E+01	162	160.4	168.1	177.1	178.7	171.3
[redacted]							
175,000	4.861E+01	158	156.1	164.5	174.6	176.1	168.8
200,000	5.556E+01	154.7	152.7	161.6	172.3	173.9	166.7
225,000	6.250E+01	151.7	149.8	159.1	170.5	172.1	164.9
250,000	6.944E+01	149	146.8	156.5	168.8	170.4	163.2
275,000	7.639E+01	146.5	144.1	154.2	167.3	168.8	161.6
300,000	8.333E+01	144.4	141.9	152.4	166	167.5	160.3
[redacted]							
400,000	1.111E+02	136.5	133.7	145.6	161.4	162.9	155.9
500,000	1.389E+02	130.5	127.6	140.4	157.8	159.4	152.4
600,000	1.667E+02	126	122.8	136.6	155.3	156.7	150
700,000	1.944E+02	121.6	120	132.6	152.8	154.6	147.6
800,000	2.222E+02	119.9	118.3	130.5	151.6	152.5	146.1
900,000	2.500E+02	118.2	114.8	128.4	150.2	150.2	144.8
1,000,000	2.778E+02	117	114	126.2	148.3	148.1	143.5
1,250,000	3.472E+02	113	115.7	123	145.2	145.1	141.5
1,500,000	4.167E+02	112.3	112.2	120.7	142.9	142.9	140
1,750,000	4.861E+02	114.4	114.4	118.3	140.7	140.7	138.6
2,000,000	5.556E+02	113.8	113.8	115.9	138.7	138.7	137.1
2,500,000	6.944E+02	111.5	113	113.2	134.6	134.6	134.7
[redacted]							
3,000,000	8.333E+02	110.8	112.5	112.6	132.5	132.5	132.6
3,500,000	9.722E+02	112.2	112.2	109.3	131.1	131.1	131.1
4,000,000	1.111E+03	111.8	111.8	108.9	129.6	129.6	129.6
5,000,000	1.389E+03	111	111	108.1	126.7	126.7	126.7
6,000,000	1.667E+03	110.3	110.2	110.3	123.7	123.7	123.7
7,000,000	1.944E+03	109.9	109.9	109.9	122.5	122.5	122.5
8,000,000	2.222E+03	109.6	109.6	109.6	121.4	121.4	121.4
9,000,050	2.500E+03	109.3	109.3	109.3	120.3	120.3	120.3
10,000,050	2.778E+03	109	109	109	119.2	119.2	119.2

Using Table 8-21 and the *LocaDose* time periods defined on Table 8-1, the maximum and minimum temperatures are determined for each of the *LocaDose* time periods. The maximum temperatures are shown on Table 8-22. The minimum temperatures are shown on Table 8-23.

Table 8-22 — Maximum Temperatures

	Vapor Temperature (°F)			Sump Temperature (°F)		
Time Period	**Case 1**	**Case 4**	**Case 7**	**Case 1**	**Case 4**	**Case 7**
30 min - 2 hr	221.7	218.4	213.1	218.5	217.6	221.7
2 hr - 4 hr	221.1	218.2	215.3	213.8	214.0	210.1
4 hr - 8 hr	215.7	214.5	214.3	213.8	214.1	207.0
8 hr - 13.8 hr	203.2	202.7	204.1	208.5	209.8	200.9
13.8 hr - 24 hr	189.4	188.7	191.6	198.3	200.0	191.2
24 hr - 48 hr	173.2	171.8	177.6	185.3	186.9	178.8
48 hr - 96 hr	158.0	156.1	164.5	174.6	176.1	168.8
96 hr - 720 hr	136.5	133.7	145.6	161.4	162.9	155.9
	Vapor Temperature (°C)			**Sump Temperature (°C)**		
Time Period	**Case 1**	**Case 4**	**Case 7**	**Case 1**	**Case 4**	**Case 7**
30 min - 2 hr	105.4	103.6	100.6	103.6	103.1	105.4
2 hr - 4 hr	105.1	103.4	101.8	101.0	101.1	98.9
4 hr - 8 hr	102.1	101.4	101.3	101.0	101.2	97.2
8 hr - 13.8 hr	95.1	94.8	95.6	98.1	98.8	93.8
13.8 hr - 24 hr	87.4	87.1	88.7	92.4	93.3	88.4
24 hr - 48 hr	78.4	77.7	80.9	85.2	86.1	81.6
48 hr - 96 hr	70.0	68.9	73.6	79.2	80.1	76.0
96 hr - 720 hr	58.1	56.5	63.1	71.9	72.7	68.8

Table 8-23 — Minimum Temperatures

Time Period	Vapor Temperature (°F) Case 1	Case 4	Case 7	Sump Temperature (°F) Case 1	Case 4	Case 7
30 min - 2 hr	203.4	196.5	185.5	210.5	209.4	209.9
2 hr - 4 hr	216.2	214.9	213.3	211.8	211.6	207.2
4 hr - 8 hr	204.2	203.6	205.0	209.1	210.3	201.5
8 hr - 13.8 hr	189.6	188.9	191.8	198.4	200.1	191.3
13.8 hr - 24 hr	174.2	172.9	178.4	186.1	187.7	179.5
24 hr - 48 hr	158.4	156.5	164.8	174.8	176.3	169.0
48 hr - 96 hr	140.8	138.2	149.3	163.9	165.4	158.3
96 hr - 720 hr	111.4	112.2	113.1	134.2	134.2	134.3
Time Period	**Vapor Temperature (°C) Case 1**	**Case 4**	**Case 7**	**Sump Temperature (°C) Case 1**	**Case 4**	**Case 7**
30 min - 2 hr	95.2	91.4	85.3	99.2	98.6	98.8
2 hr - 4 hr	102.3	101.6	100.7	99.9	99.8	97.3
4 hr - 8 hr	95.6	95.3	96.1	98.4	99.1	94.2
8 hr - 13.8 hr	87.5	87.2	88.8	92.5	93.4	88.5
13.8 hr - 24 hr	79.0	78.3	81.3	85.6	86.5	82.0
24 hr - 48 hr	70.2	69.2	73.8	79.3	80.2	76.1
48 hr - 96 hr	60.4	59.0	65.2	73.3	74.1	70.2
96 hr - 720 hr	44.1	44.6	45.0	56.8	56.8	56.8

<u>Air-Steam Mixture Temperature</u>

The maximum and minimum temperatures encompassing each of the three cases presented above are summarized on Table 8-24. The air steam mixture temperature for use by *REMOVE* is determined using the information from Table 8-20 is also presented on this table based on the lowest removal rate consideration.

Table 8-24 — Air-Steam Temperature Range

Time Period	All Cases (°C) Minimum	Maximum	Used in *REMOVE*
30 min - 2 hr	85.3	105.4	85.3
2 hr - 4 hr	100.7	105.1	100.7
4 hr - 8 hr	95.3	102.1	95.3
8 hr - 13.8 hr	87.2	95.6	87.2
13.8 hr - 24 hr	78.3	88.7	78.3
24 hr - 48 hr	69.2	80.9	69.2
48 hr - 96 hr	59.0	73.6	59.0
96 hr - 720 hr	44.1	63.1	44.1

As an example of the methodology used to determine the air-steam mixture temperature, the methodology used to determine the appropriate temperature for the 4 – 8 hour time period is described. Reviewing the values presented on Table 8-20 shows that the lower temperature (95.3 °C) has a lower removal rate than the upper temperature (102.1 °C), therefore the lower value is used in the *REMOVE* runs.

Partition Coefficients

As shown on Figure 8-2, partition coefficients increase with increasing sump temperature after about 60 °F. As shown on Table 8-22 and Table 8-23, the sump temperatures are always above 60 °F post LOCA. Therefore, the minimum temperatures are used to determine the appropriate partition coefficients for use by *REMOVE*. The partition coefficients and the DFs are calculated using a linear interpolation between the values presented on Table 8-18. These values are then truncated to two significant digits. The results are presented on Table 8-25.

Table 8-25 — Elemental Iodine Partition Coefficients and Decontamination Factors

Time Period	Minimum Sump Temperature (°F)	Partition Coefficient	DF	Truncated Partition Coefficient	Truncated DF
30 min - 2 hr	209.4	8,389	172.30	8,300	170
2 hr - 4 hr	207.2	7,989	164.13	7,900	160
4 hr - 8 hr	201.5	6,969	143.30	6,900	140
8 hr - 13.8 hr	191.3	5,466	112.63	5,400	110
13.8 hr - 24 hr	179.5	4,066	84.04	4,000	84
24 hr - 48 hr	169.0	3,092	64.13	3,000	64
48 hr - 96 hr	158.3	2,309	48.15	2,300	48
96 hr - 720 hr	134.2	1,180	25.10	1,100	25

As an example, the partition coefficient for the 4 – 8 hour time period is calculated:

From Table 8-18, the partition coefficient at 200 °F is 6,705, and the partition coefficient at 210 °F is 8,495. The partition coefficient at 201.5 °F is then:

$$PF(201.5) = 6{,}705 + (8{,}496 - 6{,}705)\frac{201.5 - 200}{210 - 200} = 6{,}974$$

This value is in good agreement with the result shown on Table 8-25. The difference (less than 0.1%) is due to the accuracy used by Excel to calculate the values and the accuracy of the hand calculation shown above.

As a second example, the DF for the 24 – 48 hour period is calculated:

From Table 8-18, the DF at 160 °F is 50.32, and the DF at 170 °F is 65.63. The DF at 169.0 °F is then:

$$DF(169.0) = 50.32 + (65.63 - 50.32)\frac{169.0 - 160}{170 - 160} = 64.10$$

This value is in good agreement with the result shown on Table 8-25. The difference (less than 0.1%) is due to the accuracy used by Excel to calculate the values and the accuracy of the hand calculation shown above.

8.3.2.3.4 REMOVE Results

The parameters determined in Sections 8.3.2.3.1 through 8.3.2.3.3 were entered into REMOVE input files shown on Section 9.2.1. The resultant elemental spray removal rates are summarized on Table 8-26. The result for each spray header are summed together and the results also shown on Table 8-26. The minimum removal rate of the two headers is selected. This removal rate is reduced by a factor of 1.2 as discussed in Section 8.3.2.3.1 and the adjusted spray removal rate is shown on the last row of Table 8-26.

Table 8-26 — Elemental Iodine Spray Removal Rates (hr^{-1})

				Recirculation Phase							
	Header	Nozzle Angle	Injection	30 min - 2hr	2 - 4 hr	4 - 8 hr	8 - 13.8 hr	13.8 - 24 hr	24 - 48 hr	48 - 96 hr	96 - 720 hr
049-4"-C-KEO	1	10	0.2853	5.2509	5.1578	4.7970	4.1359	3.3524	2.6564	2.0745	1.0122
049-4"-C-KEO	1	45	0.2865	5.3183	5.2355	4.9155	4.2049	3.4494	2.6985	2.1091	1.0270
043-4"-C-KEO	2	10	0.2885	5.3945	5.3378	5.0145	4.2624	3.4322	2.7186	2.1218	1.0310
043-4"-C-KEO	2	45	0.2906	5.5567	5.4826	5.0483	4.3825	3.5138	2.7913	2.1770	1.0553
045-4"-C-KEO	2	0	0.2140	4.4990	4.4490	4.0605	3.4988	2.7736	2.1810	1.6891	0.8099
045-4"-C-KEO	2	90	0.2174	4.8015	4.7077	4.3762	3.7124	2.9840	2.3075	1.7805	0.8513
051-4"-C-KEO	1	0	0.2145	4.4441	4.4033	4.1072	3.4661	2.8056	2.1611	1.6736	0.8019
051-4"-C-KEO	1	90	0.2179	4.8255	4.7341	4.4252	3.7304	3.0140	2.3155	1.7894	0.8530
052-2.5"-C-KEO	1	0	0.1088	2.3503	2.3273	2.1722	1.8212	1.4712	1.1260	0.86955	0.41473
052-2.5"-C-KEO	1	45	0.1092	2.4032	2.3730	2.2163	1.8577	1.5002	1.1473	0.88558	0.42180
046-2.5"-C-KEO	2	0	0.1089	2.3607	2.3377	2.1838	1.8285	1.4783	1.1296	0.87213	0.41577
046-2.5"-C-KEO	2	45	0.1093	2.4147	2.3844	2.2280	1.8656	1.5072	1.1513	0.88838	0.42295
Spray Header 1 Total			1.2221	24.5923	24.2310	22.6334	19.2162	15.5928	12.1048	9.4017	4.5306
Spray Header 2 Total			1.2288	25.0271	24.6992	22.9113	19.5502	15.6891	12.2793	9.5289	4.5862
Minimum Spray Removal Rate (hr^{-1}):			1.22	24.59	24.23	22.63	19.22	15.59	12.10	9.40	4.53
Adjusted Spray Removal Rate (hr^{-1}):			1.02	20.49	20.19	18.86	16.01	12.99	10.09	7.83	3.78

8.4 *Total Removal Rates*

In the previous sections the natural deposition removal rates and the spray removal rates were calculated. In this section the individual removal rates will be combined into total containment removal rates for use in dose assessment calculations using the program *LocaDose*. Individual removal rates as a function of time for four groups are determined: elemental iodines, particulate iodines including other halogens, alkali metals, and all other particulates.

The natural deposition rates and spray removal rates for aerosols are provided for three different percentile levels; 90th percentile, the reasonable upper bound value; 50th percentile, the median value, and 10th percentile, the lower bound value. For elemental iodine removal, only one value was determined. This value is used for all three percentile levels.

The total removal rate is calculated by combining the individual removal rates from the following sources:

1. The aerosol natural deposition rates from Table 8-3 through Table 8-5
2. The elemental iodine natural deposition rate calculated in section 8.2.2
3. The aerosol spray removal rates from Table 8-16
4. The elemental iodine spray removal rates from Table 8-26

Table 8-26 shows that the elemental iodine spray removal rates for the 30 min to 2 hr and the 2 hr to 4 hr time periods are over 20 hr^{-1}. Standard Review Plan 6.5.2 (Reference 6.4f, Section III.4.c.(1)) indicates that the elemental spray removal rate be limited to a maximum of 20 hr^{-1}; therefore, 20 hr^{-1} is used for the 30 min to 2 hr and the 2 hr to 4 hr time periods.

Removal rates are determined for the sprayed and the unsprayed containment regions. In the sprayed containment region the total removal rate consists of a combination of natural deposition and spray removal. In the unsprayed containment region the total removal rate consists only of the natural deposition rated. The resultant total containment removal rates are shown on Table 8-27 and Table 8-28 for the 90th percentile level, on Table 8-29 and Table 8-30 for the 50th percentile level, and on Table 8-31 and Table 8-32 for the 10th percentile level.

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-27 — Sprayed Containment Region 90th Percentile Removal Rates (hr^{-1})

LocaDose Time-Steps				Elemental Iodine				Particulate Iodine			Alkali Metals			Other Particulates		
				Spray	Wall Deposition	Total	DF	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total
0.0000E+00	—	8.3333E-03	hr	0	0	0	N/A	0	0	0	0	0	0	0	0	0
8.3333E-03	—	1.6667E-02	hr	0	4.26	4.26	110	0	4.88E-02	4.88E-02	0	4.88E-02	4.88E-02	0	0	0
1.6667E-02	—	8.3333E-02	hr	1.02	4.26	5.28	110	25.54	4.88E-02	25.59	25.54	4.88E-02	25.59	25.54	0	25.54
8.3333E-02	—	3.3333E-01	hr	1.02	4.26	5.28	110	25.54	4.88E-02	25.59	25.54	4.88E-02	25.59	25.54	0	25.54
3.3333E-01	—	5.0000E-01	hr	1.02	4.26	5.28	110	25.54	4.88E-02	25.59	25.54	4.88E-02	25.59	25.54	0	25.54
5.0000E-01	—	5.0833E-01	hr	1.02	4.26	5.28	110	25.54	6.61E-02	25.60	25.54	6.98E-02	25.61	25.54	5.22E-02	25.59
5.0833E-01	—	6.9372E-01	hr	1.02	4.26	5.28	110	25.54	6.61E-02	25.60	25.54	6.98E-02	25.61	25.54	5.22E-02	25.59
0.694	—	1	hr	20.00	4.26	24.26	170	25.54	6.61E-02	25.60	25.54	6.98E-02	25.61	25.54	5.22E-02	25.59
1	—	1.8	hr	20.00	4.26	24.26	170	25.54	6.61E-02	25.60	25.54	6.98E-02	25.61	25.54	5.22E-02	25.59
1.8	—	2	hr	20.00	4.26	24.26	170	18.89	4.21E-01	19.31	18.89	4.21E-01	19.31	18.89	4.21E-01	19.31
2.000	—	3.8	hr	20.00	4.26	24.26	160	10.07	4.21E-01	10.49	10.07	4.21E-01	10.49	10.07	4.21E-01	10.49
3.8		4	hr	20.00	4.26	24.26	160	9.07	1.87E-01	9.26	9.07	1.87E-01	9.26	9.07	1.87E-01	9.26
4	—	8	hr	18.86	4.26	23.12	140	9.04	1.87E-01	9.23	9.04	1.87E-01	9.23	9.04	1.87E-01	9.23
8	—	13.8	hr	16.01	4.26	20.27	110	9.04	1.87E-01	9.23	9.04	1.87E-01	9.23	9.04	1.87E-01	9.23
13.8	—	22.2	hr	12.99	4.26	17.26	84	9.04	1.01E-01	9.14	9.04	1.01E-01	9.14	9.04	1.01E-01	9.14
22.2	—	24	hr	12.99	4.26	17.26	84	9.04	0	9.04	9.04	0	9.04	9.04	0	9.04
24	—	48	hr	10.09	4.26	14.35	64	9.04	0	9.04	9.04	0	9.04	9.04	0	9.04
48	—	96	hr	7.83	4.26	12.10	48	9.04	0	9.04	9.04	0	9.04	9.04	0	9.04
96	—	720	hr	3.78	4.26	8.04	25	9.04	0	9.04	9.04	0	9.04	9.04	0	9.04

Table 8-28 — Unsprayed Containment Region 90th Percentile Removal Rates (hr^{-1})

LocaDose Time-Steps				Elemental Iodine				Particulate Iodine			Alkali Metals			Other Particulates		
				Spray	Wall Deposition	Total	DF	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total
0.0000E+00	—	8.3333E-03	hr	0	0	0	N/A	0	0	0	0	0	0	0	0	0
8.3333E-03	—	1.6667E-02	hr	0	4.26	4.26	110	0	4.88E-02	4.88E-02	0	4.88E-02	4.88E-02	0	0	0
1.6667E-02	—	8.3333E-02	hr	0	4.26	4.26	110	0	4.88E-02	4.88E-02	0	4.88E-02	4.88E-02	0	0	0
8.3333E-02	—	3.3333E-01	hr	0	4.26	4.26	110	0	4.88E-02	4.88E-02	0	4.88E-02	4.88E-02	0	0	0
3.3333E-01	—	5.0000E-01	hr	0	4.26	4.26	110	0	4.88E-02	4.88E-02	0	4.88E-02	4.88E-02	0	0	0
5.0000E-01	—	5.0833E-01	hr	0	4.26	4.26	110	0	6.61E-02	6.61E-02	0	6.98E-02	6.98E-02	0	5.22E-02	5.22E-02
5.0833E-01	—	6.9372E-01	hr	0	4.26	4.26	110	0	6.61E-02	6.61E-02	0	6.98E-02	6.98E-02	0	5.22E-02	5.22E-02
0.694	—	1	hr	0	4.26	4.26	170	0	6.61E-02	6.61E-02	0	6.98E-02	6.98E-02	0	5.22E-02	5.22E-02
1	—	1.8	hr	0	4.26	4.26	170	0	6.61E-02	6.61E-02	0	6.98E-02	6.98E-02	0	5.22E-02	5.22E-02
1.8	—	2	hr	0	4.26	4.26	170	0	4.21E-01	4.21E-01	0	4.21E-01	4.21E-01	0	4.21E-01	4.21E-01
2.000	—	3.8	hr	0	4.26	4.26	160	0	4.21E-01	4.21E-01	0	4.21E-01	4.21E-01	0	4.21E-01	4.21E-01
3.8		4	hr	0	4.26	4.26	160	0	1.87E-01	1.87E-01	0	1.87E-01	1.87E-01	0	1.87E-01	1.87E-01
4	—	8	hr	0	4.26	4.26	140	0	1.87E-01	1.87E-01	0	1.87E-01	1.87E-01	0	1.87E-01	1.87E-01
8	—	13.8	hr	0	4.26	4.26	110	0	1.87E-01	1.87E-01	0	1.87E-01	1.87E-01	0	1.87E-01	1.87E-01
13.8	—	22.2	hr	0	4.26	4.26	84	0	1.01E-01	1.01E-01	0	1.01E-01	1.01E-01	0	1.01E-01	1.01E-01
22.2	—	24	hr	0	4.26	4.26	84	0	0	0	0	0	0	0	0	0
24	—	48	hr	0	4.26	4.26	64	0	0	0	0	0	0	0	0	0
48	—	96	hr	0	4.26	4.26	48	0	0	0	0	0	0	0	0	0
96	—	720	hr	0	4.26	4.26	25	0	0	0	0	0	0	0	0	0

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Table 8-29 — Sprayed Containment Region 50th Percentile Removal Rates (hr^{-1})

LocaDose Time-Steps	Elemental Iodine				Particulate Iodine			Alkali Metals			Other Particulates		
	Spray	Wall Deposition	Total	DF	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total
0.0000E+00 — 8.3333E-03 hr	0	0	0	N/A	0	0	0	0	0	0	0	0	0
8.3333E-03 — 1.6667E-02 hr	0	4.26	4.26	110	0	3.87E-02	3.87E-02	0	3.87E-02	3.87E-02	0	0	0
1.6667E-02 — 8.3333E-02 hr	1.02	4.26	5.28	110	11.98	3.87E-02	12.02	11.98	3.87E-02	12.02	11.98	0	11.98
8.3333E-02 — 3.3333E-01 hr	1.02	4.26	5.28	110	11.98	3.87E-02	12.02	11.98	3.87E-02	12.02	11.98	0	11.98
3.3333E-01 — 5.0000E-01 hr	1.02	4.26	5.28	110	11.98	3.87E-02	12.02	11.98	3.87E-02	12.02	11.98	0	11.98
5.0000E-01 — 5.0833E-01 hr	1.02	4.26	5.28	110	11.98	5.18E-02	12.03	11.98	5.46E-02	12.03	11.98	4.11E-02	12.02
5.0833E-01 — 6.9372E-01 hr	1.02	4.26	5.28	110	11.98	5.18E-02	12.03	11.98	5.46E-02	12.03	11.98	4.11E-02	12.02
0.694 — 1 hr	20.00	4.26	24.26	170	11.98	5.18E-02	12.03	11.98	5.46E-02	12.03	11.98	4.11E-02	12.02
1 — 1.8 hr	20.00	4.26	24.26	170	11.98	5.18E-02	12.03	11.98	5.46E-02	12.03	11.98	4.11E-02	12.02
1.8 — 2 hr	20.00	4.26	24.26	170	8.08	1.91E-01	8.27	8.08	1.91E-01	8.27	8.08	1.91E-01	8.27
2.000 — 3.8 hr	20.00	4.26	24.26	160	2.84	1.91E-01	3.03	2.84	1.91E-01	3.03	2.84	1.91E-01	3.03
3.8 4 hr	20.00	4.26	24.26	160	1.98	1.62E-01	2.14	1.98	1.62E-01	2.14	1.98	1.62E-01	2.14
4 — 8 hr	18.86	4.26	23.12	140	1.82	1.62E-01	1.98	1.82	1.62E-01	1.98	1.82	1.62E-01	1.98
8 — 13.8 hr	16.01	4.26	20.27	110	1.77	1.62E-01	1.94	1.77	1.62E-01	1.94	1.77	1.62E-01	1.94
13.8 — 22.2 hr	12.99	4.26	17.26	84	1.77	9.12E-02	1.87	1.77	9.12E-02	1.87	1.77	9.12E-02	1.87
22.2 — 24 hr	12.99	4.26	17.26	84	1.77	0	1.77	1.77	0	1.77	1.77	0	1.77
24 — 48 hr	10.09	4.26	14.35	64	1.77	0	1.77	1.77	0	1.77	1.77	0	1.77
48 — 96 hr	7.83	4.26	12.10	48	1.77	0	1.77	1.77	0	1.77	1.77	0	1.77
96 — 720 hr	3.78	4.26	8.04	25	1.77	0	1.77	1.77	0	1.77	1.77	0	1.77

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-30 — Unsprayed Containment Region 50th Percentile Removal Rates (hr^{-1})

LocaDose Time-Steps	Elemental Iodine				Particulate Iodine			Alkali Metals			Other Particulates		
	Spray	Wall Deposition	Total	DF	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total
0.0000E+00 — 8.3333E-03 hr	0	0	0	N/A	0	0	0	0	0	0	0	0	0
8.3333E-03 — 1.6667E-02 hr	0	4.26	4.26	110	0	3.87E-02	3.87E-02	0	3.87E-02	3.87E-02	0	0	0
1.6667E-02 — 8.3333E-02 hr	0	4.26	4.26	110	0	3.87E-02	3.87E-02	0	3.87E-02	3.87E-02	0	0	0
8.3333E-02 — 3.3333E-01 hr	0	4.26	4.26	110	0	3.87E-02	3.87E-02	0	3.87E-02	3.87E-02	0	0	0
3.3333E-01 — 5.0000E-01 hr	0	4.26	4.26	110	0	3.87E-02	3.87E-02	0	3.87E-02	3.87E-02	0	0	0
5.0000E-01 — 5.0833E-01 hr	0	4.26	4.26	110	0	5.18E-02	5.18E-02	0	5.46E-02	5.46E-02	0	4.11E-02	4.11E-02
5.0833E-01 — 6.9372E-01 hr	0	4.26	4.26	110	0	5.18E-02	5.18E-02	0	5.46E-02	5.46E-02	0	4.11E-02	4.11E-02
0.694 — 1 hr	0	4.26	4.26	170	0	5.18E-02	5.18E-02	0	5.46E-02	5.46E-02	0	4.11E-02	4.11E-02
1 — 1.8 hr	0	4.26	4.26	170	0	5.18E-02	5.18E-02	0	5.46E-02	5.46E-02	0	4.11E-02	4.11E-02
1.8 — 2 hr	0	4.26	4.26	170	0	1.91E-01	1.91E-01	0	1.91E-01	1.91E-01	0	1.91E-01	1.91E-01
2.000 — 3.8 hr	0	4.26	4.26	160	0	1.91E-01	1.91E-01	0	1.91E-01	1.91E-01	0	1.91E-01	1.91E-01
3.8 4 hr	0	4.26	4.26	160	0	1.62E-01	1.62E-01	0	1.62E-01	1.62E-01	0	1.62E-01	1.62E-01
4 — 8 hr	0	4.26	4.26	140	0	1.62E-01	1.62E-01	0	1.62E-01	1.62E-01	0	1.62E-01	1.62E-01
8 — 13.8 hr	0	4.26	4.26	110	0	1.62E-01	1.62E-01	0	1.62E-01	1.62E-01	0	1.62E-01	1.62E-01
13.8 — 22.2 hr	0	4.26	4.26	84	0	9.12E-02	9.12E-02	0	9.12E-02	9.12E-02	0	9.12E-02	9.12E-02
22.2 — 24 hr	0	4.26	4.26	84	0	0	0	0	0	0	0	0	0
24 — 48 hr	0	4.26	4.26	64	0	0	0	0	0	0	0	0	0
48 — 96 hr	0	4.26	4.26	48	0	0	0	0	0	0	0	0	0
96 — 720 hr	0	4.26	4.26	25	0	0	0	0	0	0	0	0	0

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-31 — Sprayed Containment Region 10th Percentile Removal Rates (hr^{-1})

LocaDose Time-Steps	Elemental Iodine				Particulate Iodine			Alkali Metals			Other Particulates		
	Spray	Wall Deposition	Total	DF	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total
0.0000E+00 – 8.3333E-03 hr	0	0	0	N/A	0	0	0	0	0	0	0	0	0
8.3333E-03 – 1.6667E-02 hr	0	4.26	4.26	110	0	2.94E-02	2.94E-02	0	2.94E-02	2.94E-02	0	0	0
1.6667E-02 – 8.3333E-02 hr	1.02	4.26	5.28	110	5.15	2.94E-02	5.18	5.15	2.94E-02	5.18	5.15	0	5.15
8.3333E-02 – 3.3333E-01 hr	1.02	4.26	5.28	110	5.15	2.94E-02	5.18	5.15	2.94E-02	5.18	5.15	0	5.15
3.3333E-01 – 5.0000E-01 hr	1.02	4.26	5.28	110	5.15	2.94E-02	5.18	5.15	2.94E-02	5.18	5.15	0	5.15
5.0000E-01 – 5.0833E-01 hr	1.02	4.26	5.28	110	5.15	3.95E-02	5.19	5.15	4.17E-02	5.19	5.15	3.12E-02	5.18
5.0833E-01 – 6.9372E-01 hr	1.02	4.26	5.28	110	5.15	3.95E-02	5.19	5.15	4.17E-02	5.19	5.15	3.12E-02	5.18
0.694 – 1 hr	20.00	4.26	24.26	170	5.15	3.95E-02	5.19	5.15	4.17E-02	5.19	5.15	3.12E-02	5.18
1 – 1.8 hr	20.00	4.26	24.26	170	5.15	3.95E-02	5.19	5.15	4.17E-02	5.19	5.15	3.12E-02	5.18
1.8 – 2 hr	20.00	4.26	24.26	170	3.79	8.93E-02	3.88	3.79	8.93E-02	3.88	3.79	8.93E-02	3.88
2.000 – 3.8 hr	20.00	4.26	24.26	160	1.32	8.93E-02	1.41	1.32	8.93E-02	1.41	1.32	8.93E-02	1.41
3.8. 4 hr	20.00	4.26	24.26	160	0.79	1.16E-01	0.91	0.79	1.16E-01	0.91	0.79	1.16E-01	0.91
4 – 8 hr	18.86	4.26	23.12	140	0.62	1.16E-01	0.73	0.62	1.16E-01	0.73	0.62	1.16E-01	0.73
8 – 13.8 hr	16.01	4.26	20.27	110	0.52	1.16E-01	0.63	0.52	1.16E-01	0.63	0.52	1.16E-01	0.63
13.8 – 22.2 hr	12.99	4.26	17.26	84	0.50	8.60E-02	0.59	0.50	8.60E-02	0.59	0.50	8.60E-02	0.59
22.2 – 24 hr	12.99	4.26	17.26	84	0.50	0	0.50	0.50	0	0.50	0.50	0	0.50
24 – 48 hr	10.09	4.26	14.35	64	0.50	0	0.50	0.50	0	0.50	0.50	0	0.50
48 – 96 hr	7.83	4.26	12.10	48	0.50	0	0.50	0.50	0	0.50	0.50	0	0.50
96 – 720 hr	3.78	4.26	8.04	25	0.50	0	0.50	0.50	0	0.50	0.50	0	0.50

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Table 8-32 — Unsprayed Containment Region 10th Percentile Removal Rates (hr^{-1})

LocaDose Time-Steps				Elemental Iodine				Particulate Iodine			Alkali Metals			Other Particulates		
				Spray	Wall Deposition	Total	DF	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total	Spray	Wall Deposition	Total
0.0000E+00	—	8.3333E-03	hr	0	0	0	N/A	0	0	0	0	0	0	0	0	0
8.3333E-03	—	1.6667E-02	hr	0	4.26	4.26	110	0	2.94E-02	2.94E-02	0	2.94E-02	2.94E-02	0	0	0
1.6667E-02	—	8.3333E-02	hr	0	4.26	4.26	110	0	2.94E-02	2.94E-02	0	2.94E-02	2.94E-02	0	0	0
8.3333E-02	—	3.3333E-01	hr	0	4.26	4.26	110	0	2.94E-02	2.94E-02	0	2.94E-02	2.94E-02	0	0	0
3.3333E-01	—	5.0000E-01	hr	0	4.26	4.26	110	0	2.94E-02	2.94E-02	0	2.94E-02	2.94E-02	0	0	0
5.0000E-01	—	5.0833E-01	hr	0	4.26	4.26	110	0	3.95E-02	3.95E-02	0	4.17E-02	4.17E-02	0	3.12E-02	3.12E-02
5.0833E-01	—	6.9372E-01	hr	0	4.26	4.26	110	0	3.95E-02	3.95E-02	0	4.17E-02	4.17E-02	0	3.12E-02	3.12E-02
0.694	—	1	hr	0	4.26	4.26	170	0	3.95E-02	3.95E-02	0	4.17E-02	4.17E-02	0	3.12E-02	3.12E-02
1	—	1.8	hr	0	4.26	4.26	170	0	3.95E-02	3.95E-02	0	4.17E-02	4.17E-02	0	3.12E-02	3.12E-02
1.8	—	2	hr	0	4.26	4.26	170	0	8.93E-02	8.93E-02	0	8.93E-02	8.93E-02	0	8.93E-02	8.93E-02
2.000	—	3.8	hr	0	4.26	4.26	160	0	8.93E-02	8.93E-02	0	8.93E-02	8.93E-02	0	8.93E-02	8.93E-02
3.8		4	hr	0	4.26	4.26	160	0	1.16E-01	1.16E-01	0	1.16E-01	1.16E-01	0	1.16E-01	1.16E-01
4	—	8	hr	0	4.26	4.26	140	0	1.16E-01	1.16E-01	0	1.16E-01	1.16E-01	0	1.16E-01	1.16E-01
8	—	13.8	hr	0	4.26	4.26	110	0	1.16E-01	1.16E-01	0	1.16E-01	1.16E-01	0	1.16E-01	1.16E-01
13.8	—	22.2	hr	0	4.26	4.26	84	0	8.60E-02	8.60E-02	0	8.60E-02	8.60E-02	0	8.60E-02	8.60E-02
22.2	—	24	hr	0	4.26	4.26	84	0	0	0	0	0	0	0	0	0
24	—	48	hr	0	4.26	4.26	64	0	0	0	0	0	0	0	0	0
48	—	96	hr	0	4.26	4.26	48	0	0	0	0	0	0	0	0	0
96	—	720	hr	0	4.26	4.26	25	0	0	0	0	0	0	0	0	0

9 COMPUTER FILES

9.1 *ICONC INPUT AND OUTPUT FILES*

9.1.1 ICONC Input File

```
8
iconc.out
SONGS Iodine Partition Factors
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
40
7
241.34
6.61e-14
2.03
2284000
46647
1
50
7
173.0
1.20e-13
2.03
2284000
46647
1
60
7
129.00
2.14e-13
2.03
2284000
46647
1
70
7
95.15
3.77e-13
2.03
2284000
46647
1
80
7
69.76
6.26e-13
2.03
2284000
46647
1
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
90
7
55.23
1.03e-12
2.03
2284000
46647
1
100
7
43.08
1.71e-12
2.03
2284000
46647
1
110
7
34.16
2.77e-12
2.03
2284000
46647
1
120
7
27.38
4.38e-12
2.03
2284000
46647
1
130
7
22.71
6.65e-12
2.03
2284000
46647
1
140
7
19.00
1.00e-11
2.03
2284000
46647
1
150
7
16.91
1.55e-11
2.03
2284000
46647
1
160
7
15.11
2.37e-11
2.03
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2284000
46647
1
170
7
13.76
3.44e-11
2.03
2284000
46647
1
180
7
12.40
4.99e-11
2.03
2284000
46647
1
190
7
11.01
7.24e-11
2.03
2284000
46647
1
200
7
9.97
1.02e-10
2.03
2284000
46647
1
210
7
9.16
1.41e-10
2.03
2284000
46647
1
220
7
8.55
2.02e-10
2.03
2284000
46647
1
230
7
8.36
2.70e-10
2.03
2284000
46647
1
240
7
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
7.80
3.72e-10
2.03
2284000
46647
1
250
7
7.05
5.07e-10
2.03
2284000
46647
1
260
7
6.62
6.63e-10
2.03
2284000
46647
1
270
7
6.27
8.58e-10
2.03
2284000
46647
1
280
7
6.04
1.09e-9
2.03
2284000
46647
2
```

9.1.2 ICONC Output File

```
Bechtel Standard Compute: Program       ICONC    , NE316 Version 3.0
(c) 1990                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  SONGS Iodine Partition Factors            Sheet No.       1
==========================================================================



         ----------------------------------------------
         |                                            |
         |         Standard Computer Program          |
         |         NE316 ICONC   Version 3.0          |
         |          for the IBM PC/XT/AT              |
         |                                            |
         ----------------------------------------------


         Abstract:

         The ICONC program calculates the partition
         coefficient of iodine between water and air
         in any containment given the following:  water
         temperature, water pH, volume of water, volume
         of air, and the initial iodine concentration in
         water.


    Output in file iconc.out    was created on 14 Jun 2003  at 10:54: 7

Bechtel Standard Computer Program       ICONC   , NE316 Version 3.0
(c) 1990                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003
Project  SONGS                                     Job No. 16575-167
Subject  SONGS Iodine Partition Factors            Sheet No.       2
==========================================================================


 Results of iodine - Water partition coefficient calculations

 Temperature=  40.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 241.3
 Equilibrium constant K2= 1290.
 Equilibrium constant K3=6.6100E-14
 Equilibrium constant K4=4.6000E-12
 Initial iodine inventory in water= 2.030      moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=    4
```

```
Concentration of I2 liquid=7.0740E-07 moles/liter
Concentration of HIO=6.8511E-07 moles/liter
Concentration of H2OI=4.7540E-12 moles/liter
Concentration of I-=6.8449E-07 moles/liter

Concentration of I3-=6.2442E-10 moles/liter
Concentration of total aqueous iodine=1.3931E-06 moles/liter
Partition coefficient= 475.3
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 10.71
Iodine concentration in gas phase=2.9311E-09 moles/liter


Bechtel Standard Computer Program       ICONC  , NE316 Version 3.0
(c) 1990                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003
Project  SONGS                                   Job No. 16575-167
Subject  SONGS Iodine Partition Factors          Sheet No.       3
================================================================================

Results of iodine - Water partition coefficient calculations

Temperature=  50.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 173.0
Equilibrium constant K2= 1099.
Equilibrium constant K3=1.2000E-13
Equilibrium constant K4=6.6000E-12
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   4
Concentration of I2 liquid=5.5825E-07 moles/liter
Concentration of HIO=8.1991E-07 moles/liter
Concentration of H2OI=4.4964E-12 moles/liter
Concentration of I-=8.1941E-07 moles/liter

Concentration of I3-=5.0269E-10 moles/liter
Concentration of total aqueous iodine=1.3787E-06 moles/liter
Partition coefficient= 427.2
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 9.726
Iodine concentration in gas phase=3.2269E-09 moles/liter


Bechtel Standard Computer Program       ICONC  , NE316 Version 3.0
(c) 1990                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003
Project  SONGS                                   Job No. 16575-167
Subject  SONGS Iodine Partition Factors          Sheet No.       4
================================================================================

Results of iodine - Water partition coefficient calculations

Temperature=  60.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 129.0
Equilibrium constant K2= 948.2
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Equilibrium constant K3=2.1400E-13
Equilibrium constant K4=8.6000E-12
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   4
Concentration of I2 liquid=4.2289E-07 moles/liter
Concentration of HIO=9.5288E-07 moles/liter
Concentration of H2OI=3.8182E-12 moles/liter
Concentration of I-=9.5250E-07 moles/liter

Concentration of I3-=3.8196E-10 moles/liter
Concentration of total aqueous iodine=1.3762E-06 moles/liter
Partition coefficient= 419.8
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 9.573
Iodine concentration in gas phase=3.2782E-09 moles/liter


Bechtel Standard Computer Program       ICONC  , NE316 Version 3.0
(c) 1990                                 Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003
Project   SONGS                          Job No. 16575-167
Subject   SONGS Iodine Partition Factors          Sheet No.      5
================================================================================


Results of iodine - Water partition coefficient calculations

Temperature=  70.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 95.15
Equilibrium constant K2= 827.8
Equilibrium constant K3=3.7700E-13
Equilibrium constant K4=1.0600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   4
Concentration of I2 liquid=3.0513E-07 moles/liter
Concentration of HIO=1.0742E-06 moles/liter
Concentration of H2OI=3.0116E-12 moles/liter
Concentration of I-=1.0740E-06 moles/liter

Concentration of I3-=2.7127E-10 moles/liter
Concentration of total aqueous iodine=1.3796E-06 moles/liter
Partition coefficient= 430.2
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 9.786
Iodine concentration in gas phase=3.2069E-09 moles/liter


Bechtel Standard Computer Program       ICONC  , NE316 Version 3.0
(c) 1990                                 Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003
Project   SONGS                          Job No. 16575-167
Subject   SONGS Iodine Partition Factors          Sheet No.      6
================================================================================
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Results of iodine - Water partition coefficient calculations

Temperature=  80.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 69.76
Equilibrium constant K2= 730.6
Equilibrium constant K3=6.2600E-13
Equilibrium constant K4=1.2600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   4
Concentration of I2 liquid=2.1697E-07 moles/liter
Concentration of HIO=1.1672E-06 moles/liter
Concentration of H2OI=2.3425E-12 moles/liter
Concentration of I-=1.1670E-06 moles/liter

Concentration of I3-=1.8499E-10 moles/liter
Concentration of total aqueous iodine=1.3844E-06 moles/liter
Partition coefficient= 445.1
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 10.09
Iodine concentration in gas phase=3.1102E-09 moles/liter


Bechtel Standard Computer Program       ICONC  , NE316 Version 3.0
(c) 1990                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003
Project  SONGS                                   Job No. 16575-167
Subject  SONGS Iodine Partition Factors          Sheet No.       7
==================================================================================


Results of iodine - Water partition coefficient calculations

Temperature=  90.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 55.23
Equilibrium constant K2= 651.4
Equilibrium constant K3=1.0300E-12
Equilibrium constant K4=1.4600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   4
Concentration of I2 liquid=1.5145E-07 moles/liter
Concentration of HIO=1.2508E-06 moles/liter
Concentration of H2OI=1.7679E-12 moles/liter
Concentration of I-=1.2507E-06 moles/liter

Concentration of I3-=1.2338E-10 moles/liter
Concentration of total aqueous iodine=1.4024E-06 moles/liter
Partition coefficient= 511.4
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 11.45
Iodine concentration in gas phase=2.7421E-09 moles/liter
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ____________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates Sheet 107 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Bechtel Standard Computer Program       ICONC  , NE316 Version 3.0
(c) 1990                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz            Date 14 Jun 2003
Project  SONGS                                    Job No. 16575-167
Subject  SONGS Iodine Partition Factors           Sheet No.       8
===========================================================================


 Results of iodine - Water partition coefficient calculations

 Temperature= 100.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 43.08
 Equilibrium constant K2= 586.3
 Equilibrium constant K3=1.7100E-12
 Equilibrium constant K4=1.6600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   4
 Concentration of I2 liquid=1.0154E-07 moles/liter
 Concentration of HIO=1.3196E-06 moles/liter
 Concentration of H2OI=1.2773E-12 moles/liter
 Concentration of I-=1.3196E-06 moles/liter

 Concentration of I3-=7.8555E-11 moles/liter
 Concentration of total aqueous iodine=1.4213E-06 moles/liter
 Partition coefficient= 603.0
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 13.32
 Iodine concentration in gas phase=2.3570E-09 moles/liter


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 Results of iodine - Water partition coefficient calculations

 Temperature= 110.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 34.16
 Equilibrium constant K2= 532.5
 Equilibrium constant K3=2.7700E-12
 Equilibrium constant K4=1.8600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   4
 Concentration of I2 liquid=6.7736E-08 moles/liter
 Concentration of HIO=1.3718E-06 moles/liter
 Concentration of H2OI=9.1846E-13 moles/liter
 Concentration of I-=1.3717E-06 moles/liter

 Concentration of I3-=4.9475E-11 moles/liter
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Concentration of total aqueous iodine=1.4396E-06 moles/liter
Partition coefficient= 726.0
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 15.83
Iodine concentration in gas phase=1.9829E-09 moles/liter


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 Results of iodine - Water partition coefficient calculations

 Temperature= 120.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 27.38
 Equilibrium constant K2= 487.7
 Equilibrium constant K3=4.3800E-12
 Equilibrium constant K4=2.0600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   3
 Concentration of I2 liquid=4.5281E-08 moles/liter
 Concentration of HIO=1.4104E-06 moles/liter
 Concentration of H2OI=6.6140E-13 moles/liter
 Concentration of I-=1.4103E-06 moles/liter

 Concentration of I3-=3.1143E-11 moles/liter
 Concentration of total aqueous iodine=1.4557E-06 moles/liter
 Partition coefficient= 380.2
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 18.98
 Iodine concentration in gas phase=1.6538E-09 moles/liter


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 Results of iodine - Water partition coefficient calculations

 Temperature= 130.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 22.71
 Equilibrium constant K2= 450.2
 Equilibrium constant K3=6.6500E-12
 Equilibrium constant K4=2.2600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3
```

```
Number of iterations=   3
Concentration of I2 liquid=3.1035E-08 moles/liter
Concentration of HIO=1.4387E-06 moles/liter
Concentration of H2OI=4.8752E-13 moles/liter
Concentration of I-=1.4387E-06 moles/liter

Concentration of I3-=2.0099E-11 moles/liter
Concentration of total aqueous iodine=1.4697E-06 moles/liter
Partition coefficient= 1076.
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 22.97
Iodine concentration in gas phase=1.3666E-09 moles/liter


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==============================================================================


Results of iodine - Water partition coefficient calculations

Temperature= 140.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 19.00
Equilibrium constant K2= 418.6
Equilibrium constant K3=1.0000E-11
Equilibrium constant K4=2.4600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   3
Concentration of I2 liquid=2.1270E-08 moles/liter
Concentration of HIO=1.4606E-06 moles/liter
Concentration of H2OI=3.5826E-13 moles/liter
Concentration of I-=1.4606E-06 moles/liter

Concentration of I3-=1.3005E-11 moles/liter
Concentration of total aqueous iodine=1.4818E-06 moles/liter
Partition coefficient= 1324.
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 28.03
Iodine concentration in gas phase=1.1195E-09 moles/liter


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Results of iodine - Water partition coefficient calculations

Temperature= 150.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 16.91
```

```
Equilibrium constant K2= 392.0
Equilibrium constant K3=1.5500E-11
Equilibrium constant K4=2.6600E-11
Initial iodine inventory in water= 2.030    moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=  3
Concentration of I2 liquid=1.4122E-08 moles/liter
Concentration of HIO=1.4816E-06 moles/liter
Concentration of H2OI=2.5353E-13 moles/liter
Concentration of I-=1.4316E-06 moles/liter

Concentration of I3-=8.2023E-12 moles/liter
Concentration of total aqueous iodine=1.4958E-06 moles/liter
Partition coefficient= 1791.
Total iodine inventory in containment= 2.030    moles
The iodine decontamination factor DF= 37.58
Iodine concentration in gas phase=8.3512E-10 moles/liter


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Results of iodine - Water partition coefficient calculations

Temperature= 160.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 15.11
Equilibrium constant K2= 369.5
Equilibrium constant K3=2.3700E-11
Equilibrium constant K4=2.8600E-11
Initial iodine inventory in water= 2.030    moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=  3
Concentration of I2 liquid=9.4244E-09 moles/liter
Concentration of HIO=1.4967E-06 moles/liter
Concentration of H2OI=1.8009E-13 moles/liter
Concentration of I-=1.4967E-06 moles/liter

Concentration of I3-=5.2120E-12 moles/liter
Concentration of total aqueous iodine=1.5061E-06 moles/liter
Partition coefficient= 2415.
Total iodine inventory in containment= 2.030    moles
The iodine decontamination factor DF= 50.32
Iodine concentration in gas phase=6.2372E-10 moles/liter


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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

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Results of iodine - Water partition coefficient calculations

Temperature= 170.00 Deg F
Water pH value= 7.00
Equilibrium constant K1= 13.76
Equilibrium constant K2= 350.4
Equilibrium constant K3=3.4400E-11
Equilibrium constant K4=3.0600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   3
Concentration of I2 liquid=6.5798E-09 moles/liter
Concentration of HIO=1.5067E-06 moles/liter
Concentration of H2OI=1.3363E-13 moles/liter
Concentration of I-=1.5067E-06 moles/liter

Concentration of I3-=3.4742E-12 moles/liter
Concentration of total aqueous iodine=1.5133E-06 moles/liter
Partition coefficient= 3165.
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 65.63
Iodine concentration in gas phase=4.7818E-10 moles/liter


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================================================================================

Results of iodine - Water partition coefficient calculations

Temperature= 180.00 Deg F
Water pH value= 7.00
Equilibrium constant K1= 12.40
Equilibrium constant K2= 334.3
Equilibrium constant K3=4.9900E-11
Equilibrium constant K4=3.2600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   3
Concentration of I2 liquid=4.5802E-09 moles/liter
Concentration of HIO=1.5140E-06 moles/liter
Concentration of H2OI=9.8624E-14 moles/liter
Concentration of I-=1.5140E-06 moles/liter

Concentration of I3-=2.3182E-12 moles/liter
Concentration of total aqueous iodine=1.5186E-06 moles/liter
Partition coefficient= 4111.
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 84.97
Iodine concentration in gas phase=3.6937E-10 moles/liter
```

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0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

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 Results of iodine - Water partition coefficient calculations

 Temperature= 190.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 11.01
 Equilibrium constant K2= 320.7
 Equilibrium constant K3=7.2400E-11
 Equilibrium constant K4=3.4600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   3
 Concentration of I2 liquid=3.1792E-09 moles/liter
 Concentration of HIO=1.5193E-06 moles/liter
 Concentration of H2OI=7.2399E-14 moles/liter
 Concentration of I-=1.5193E-06 moles/liter

 Concentration of I3-=1.5488E-12 moles/liter
 Concentration of total aqueous iodine=1.5225E-06 moles/liter
 Partition coefficient= 5273.
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 108.7
 Iodine concentration in gas phase=2.8875E-10 moles/liter

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 Results of iodine - Water partition coefficient calculations

 Temperature= 200.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 9.970
 Equilibrium constant K2= 309.2
 Equilibrium constant K3=1.0200E-10
 Equilibrium constant K4=3.6600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   3
 Concentration of I2 liquid=2.2682E-09 moles/liter
 Concentration of HIO=1.5233E-06 moles/liter
 Concentration of H2OI=5.4500E-14 moles/liter
 Concentration of I-=1.5233E-06 moles/liter
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
 Concentration of I3-=1.3682E-12 moles/liter
 Concentration of total aqueous iodine=1.5255E-06 moles/liter
 Partition coefficient= 6705.
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 137.9
 Iodine concentration in gas phase=2.2750E-10 moles/liter


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 Results of iodine - Water partition coefficient calculations

 Temperature= 210.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 9.160
 Equilibrium constant K2= 299.5
 Equilibrium constant K3=1.4100E-10
 Equilibrium constant K4=3.8600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=    3
 Concentration of I2 liquid=1.6472E-09 moles/liter
 Concentration of HIO=1.5262E-06 moles/liter
 Concentration of H2OI=4.1660E-14 moles/liter
 Concentration of I-=1.5262E-06 moles/liter

 Concentration of I3-=7.5302E-13 moles/liter
 Concentration of total aqueous iodine=1.5279E-06 moles/liter
 Partition coefficient= 8496.
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 174.5
 Iodine concentration in gas phase=1.7983E-10 moles/liter


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=================================================================================

 Results of iodine - Water partition coefficient calculations

 Temperature= 220.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 8.550
 Equilibrium constant K2= 291.5
 Equilibrium constant K3=2.0200E-10
 Equilibrium constant K4=4.0600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Number of iterations=   3
Concentration of I2 liquid=1.1538E-09 moles/liter
Concentration of HIO=1.5289E-06 moles/liter
Concentration of H2OI=3.0640E-14 moles/liter
Concentration of I-=1.5289E-06 moles/liter

Concentration of I3-=5.1431E-13 moles/liter
Concentration of total aqueous iodine=1.5301E-06 moles/liter
Partition coefficient=1.1338E+04
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 232.6
Iodine concentration in gas phase=1.3495E-10 moles/liter


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 Results of iodine - Water partition coefficient calculations

 Temperature= 230.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 8.360
 Equilibrium constant K2= 285.0
 Equilibrium constant K3=2.7000E-10
 Equilibrium constant K4=4.2600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   2
 Concentration of I2 liquid=8.6530E-10 moles/liter
 Concentration of HIO=1.5307E-06 moles/liter
 Concentration of H2OI=2.4081E-14 moles/liter
 Concentration of I-=1.5307E-06 moles/liter

 Concentration of I3-=3.7750E-13 moles/liter
 Concentration of total aqueous iodine=1.5316E-06 moles/liter
 Partition coefficient=1.4797E+04
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 303.2
 Iodine concentration in gas phase=1.0350E-10 moles/liter


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================================================================================

 Results of iodine - Water partition coefficient calculations

 Temperature= 240.00 Deg F
 Water pH value=  7.00
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Equilibrium constant K1= 7.800
Equilibrium constant K2= 279.8
Equilibrium constant K3=3.7200E-10
Equilibrium constant K4=4.4600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   2
Concentration of I2 liquid=6.2916E-10 moles/liter
Concentration of HIO=1.5321E-06 moles/liter
Concentration of H2OI=1.8315E-14 moles/liter
Concentration of I-=1.5321E-06 moles/liter

Concentration of I3-=2.6967E-13 moles/liter
Concentration of total aqueous iodine=1.5327E-06 moles/liter
Partition coefficient=1.9002E+04
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 389.1
Iodine concentration in gas phase=8.0661E-11 moles/liter


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Results of iodine - Water partition coefficient calculations

Temperature= 250.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 7.050
Equilibrium constant K2= 275.7
Equilibrium constant K3=5.0700E-10
Equilibrium constant K4=4.6600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   2
Concentration of I2 liquid=4.6218E-10 moles/liter
Concentration of HIO=1.5330E-06 moles/liter
Concentration of H2OI=1.4049E-14 moles/liter
Concentration of I-=1.5330E-06 moles/liter

Concentration of I3-=1.9533E-13 moles/liter
Concentration of total aqueous iodine=1.5335E-06 moles/liter
Partition coefficient=2.3391E+04
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 478.7
Iodine concentration in gas phase=6.5557E-11 moles/liter


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REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

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Results of iodine - Water partition coefficient calculations

Temperature= 260.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 6.620
Equilibrium constant K2= 272.7
Equilibrium constant K3=6.6300E-10
Equilibrium constant K4=4.8600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   2
Concentration of I2 liquid=3.5375E-10 moles/liter
Concentration of HIO=1.5337E-06 moles/liter
Concentration of H2OI=1.1210E-14 moles/liter
Concentration of I-=1.5337E-06 moles/liter

Concentration of I3-=1.4794E-13 moles/liter
Concentration of total aqueous iodine=1.5340E-06 moles/liter
Partition coefficient=2.8707E+04
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 587.3
Iodine concentration in gas phase=5.3437E-11 moles/liter


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Results of iodine - Water partition coefficient calculations

Temperature= 270.00 Deg F
Water pH value=  7.00
Equilibrium constant K1= 6.270
Equilibrium constant K2= 270.6
Equilibrium constant K3=8.5800E-10
Equilibrium constant K4=5.0600E-11
Initial iodine inventory in water= 2.030     moles
Volume of gaseous phase=2.2840E+06 ft**3
Volume of liquid phase=4.6647E+04 ft**3

Number of iterations=   2
Concentration of I2 liquid=2.7356E-10 moles/liter
Concentration of HIO=1.5343E-06 moles/liter
Concentration of H2OI=9.0219E-15 moles/liter
Concentration of I-=1.5343E-06 moles/liter

Concentration of I3-=1.1359E-13 moles/liter
Concentration of total aqueous iodine=1.5345E-06 moles/liter
Partition coefficient=3.5172E+04
Total iodine inventory in containment= 2.030     moles
The iodine decontamination factor DF= 719.3
Iodine concentration in gas phase=4.3629E-11 moles/liter
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

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 Results of iodine - Water partition coefficient calculations

 Temperature= 280.00 Deg F
 Water pH value=  7.00
 Equilibrium constant K1= 6.040
 Equilibrium constant K2= 269.5
 Equilibrium constant K3=1.0900E-09
 Equilibrium constant K4=5.2600E-11
 Initial iodine inventory in water= 2.030     moles
 Volume of gaseous phase=2.2840E+06 ft**3
 Volume of liquid phase=4.6647E+04 ft**3

 Number of iterations=   2
 Concentration of I2 liquid=2.1546E-10 moles/liter
 Concentration of HIO=1.5347E-06 moles/liter
 Concentration of H2OI=7.3845E-15 moles/liter
 Concentration of I-=1.5347E-06 moles/liter

 Concentration of I3-=8.9113E-14 moles/liter
 Concentration of total aqueous iodine=1.5349E-06 moles/liter
 Partition coefficient=4.3029E+04
 Total iodine inventory in containment= 2.030     moles
 The iodine decontamination factor DF= 879.8
 Iodine concentration in gas phase=3.5672E-11 moles/liter
```

9.2 *REMOVE INPUT AND OUTPUT FILES*

9.2.1 Input Files

9.2.1.1 Parametric Study Input Files

9.2.1.1.1 I2-30.in

```
8
I2-30.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
30.0                  - Air-steam temperature (degC)
30.0                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.2 I2-40.in

```
8
I2-40.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
40.0                  - Air-steam temperature (degC)
40.0                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
8389                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
2                        - Another case? (1=yes, 2=no)
```

9.2.1.1.3 I2-50.in

```
8
I2-50.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
50.0                     - Air-steam temperature (degC)
50.0                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
8389                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
2                        - Another case? (1=yes, 2=no)
```

9.2.1.1.4 I2-60.in

```
8
I2-60.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
```

```
60.0                    - Air-steam temperature (degC)
60.0                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8389                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
2                       - Another case? (1=yes, 2=no)
```

9.2.1.1.5 I2-70.in

```
8
I2-70.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
70.0                    - Air-steam temperature (degC)
70.0                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8389                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
2                       - Another case? (1=yes, 2=no)
```

9.2.1.1.6 I2-75.in

```
8
I2-75.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
```

```
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
75.0                    - Air-steam temperature (degC)
75.0                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8389                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
2                       - Another case? (1=yes, 2=no)
```

9.2.1.1.7 I2-80.in

```
8
I2-80.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
80.0                    - Air-steam temperature (degC)
80.0                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8389                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
2                       - Another case? (1=yes, 2=no)
```

9.2.1.1.8 I2-85.in

```
8
I2-85.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
```

```
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
85.0                  - Air-steam temperature (degC)
85.0                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.9 I2-90.in

```
8
I2-90.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
90.0                  - Air-steam temperature (degC)
90.0                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.10 I2-95.in

```
8
I2-95.out
I2 Spray Temperature Parametrics
Jorge Schulz
```

```
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
95.0                  - Air-steam temperature (degC)
95.0                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.11 I2-100.in

```
8
I2-100.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
100.0                 - Air-steam temperature (degC)
100.0                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.12 I2-105.in

```
8
```

```
I2-105.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
105.0                 - Air-steam temperature (degC)
105.0                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.13 I2-110.in

```
8
I2-110.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
110.0                 - Air-steam temperature (degC)
110.0                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
8389                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.1.14 I2-120.in

```
8
I2-120.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
120.0                   - Air-steam temperature (degC)
120.0                   - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8389                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
2                       - Another case? (1=yes, 2=no)
```

9.2.1.1.15 I2-130.in

```
8
I2-130.out
I2 Spray Temperature Parametrics
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
130.0                   - Air-steam temperature (degC)
130.0                   - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8389                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
```

```
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
```

9.2.1.2 Injection Phase Input File (*i2-boric.in*)

```
8
I2-boric.out
I2 Spray Removal - Injection
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
129.9                 - Air-steam temperature (degC)
129.9                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
200                   - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
129.9                 - Air-steam temperature (degC)
129.9                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
45                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
200                   - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
129.9                 - Air-steam temperature (degC)
129.9                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
85.60                 - Spray fall height (ft) - 043-4"-C-KEO
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
200                     - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
129.9                   - Air-steam temperature (degC)
129.9                   - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
45                      - Initial angle
85.60                   - Spray fall height (ft) - 043-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
200                     - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
129.9                   - Air-steam temperature (degC)
129.9                   - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
0                       - Initial angle
105.83                  - Spray fall height (ft) - 045-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
200                     - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
20                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
129.9                   - Air-steam temperature (degC)
129.9                   - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
89                      - Initial angle
105.83                  - Spray fall height (ft) - 045-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
200                     - Elemental Iodine partition coefficient
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
129.9                - Air-steam temperature (degC)
129.9                - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
200                  - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
129.9                - Air-steam temperature (degC)
129.9                - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
89                   - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
200                  - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
129.9                - Air-steam temperature (degC)
129.9                - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
117.43               - Spray fall height (ft) - 052-2.5"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
200                  - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
10                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
```

```
601519          - Effective plateout area
1907000         - Sprayed volume
1               - Another case? (1=yes, 2=no)
2
69              - Number of size groups
0.00375         - Mean drop diameter (cm)
129.9           - Air-steam temperature (degC)
129.9           - Droplet temperature (degC)
3393            - Initial velocity (cm/sec)
45              - Initial angle
117.43          - Spray fall height (ft) - 052-2.5"-C-KEO
2               - 1=Trajectory, 2=lambda
2               - Print individual drop parameters
1               - 1=NRC E model, 2= Entered E value
200             - Elemental Iodine partition coefficient
2               - Calculate organic iodine removal (1=yes, 2=no)
13.79           - Flow per nozzle (gpm)
10              - Number of nozzles
1               - Temperature difference between air and wall (degC)
601519          - Effective plateout area
1907000         - Sprayed volume
1               - Another case? (1=yes, 2=no)
2
69              - Number of size groups
0.00375         - Mean drop diameter (cm)
129.9           - Air-steam temperature (degC)
129.9           - Droplet temperature (degC)
3393            - Initial velocity (cm/sec)
0               - Initial angle
118.47          - Spray fall height (ft) - 046-2.5"-C-KEO
2               - 1=Trajectory, 2=lambda
2               - Print individual drop parameters
1               - 1=NRC E model, 2= Entered E value
200             - Elemental Iodine partition coefficient
2               - Calculate organic iodine removal (1=yes, 2=no)
13.79           - Flow per nozzle (gpm)
10              - Number of nozzles
1               - Temperature difference between air and wall (degC)
601519          - Effective plateout area
1907000         - Sprayed volume
1               - Another case? (1=yes, 2=no)
2
69              - Number of size groups
0.00375         - Mean drop diameter (cm)
129.9           - Air-steam temperature (degC)
129.9           - Droplet temperature (degC)
3393            - Initial velocity (cm/sec)
45              - Initial angle
118.47          - Spray fall height (ft) - 046-2.5"-C-KEO
2               - 1=Trajectory, 2=lambda
2               - Print individual drop parameters
1               - 1=NRC E model, 2= Entered E value
200             - Elemental Iodine partition coefficient
2               - Calculate organic iodine removal (1=yes, 2=no)
13.79           - Flow per nozzle (gpm)
10              - Number of nozzles
1               - Temperature difference between air and wall (degC)
601519          - Effective plateout area
1907000         - Sprayed volume
2               - Another case? (1=yes, 2=no)
2
```

9.2.1.3 30 min to 2 hr Input File (*i2-max01.in*)

```
8
I2-max01.out
I2 Spray Max Temp 30 min - 2 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
85.3                    - Air-steam temperature (degC)
85.3                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8300                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
85.3                    - Air-steam temperature (degC)
85.3                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
45                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
8300                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
85.3                    - Air-steam temperature (degC)
85.3                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
85.60                   - Spray fall height (ft) - 043-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
8300                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
28                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
85.3                 - Air-steam temperature (degC)
85.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
45                   - Initial angle
85.60                - Spray fall height (ft) - 043-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
8300                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
28                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
85.3                 - Air-steam temperature (degC)
85.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
105.83               - Spray fall height (ft) - 045-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
8300                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
85.3                 - Air-steam temperature (degC)
85.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
89                   - Initial angle
105.83               - Spray fall height (ft) - 045-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
8300                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
```

```
13.79          - Flow per nozzle (gpm)
20             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
85.3           - Air-steam temperature (degC)
85.3           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
0              - Initial angle
108.11         - Spray fall height (ft) - 051-4"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
8300           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
20             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
85.3           - Air-steam temperature (degC)
85.3           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
89             - Initial angle
108.11         - Spray fall height (ft) - 051-4"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
8300           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
20             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
85.3           - Air-steam temperature (degC)
85.3           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
0              - Initial angle
117.43         - Spray fall height (ft) - 052-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
8300           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
1907000          - Sprayed volume
1                - Another case? (1=yes, 2=no)
2
69               - Number of size groups
0.00375          - Mean drop diameter (cm)
85.3             - Air-steam temperature (degC)
85.3             - Droplet temperature (degC)
3393             - Initial velocity (cm/sec)
45               - Initial angle
117.43           - Spray fall height (ft) - 052-2.5"-C-KEO
2                - 1=Trajectory, 2=lambda
2                - Print individual drop parameters
1                - 1=NRC E model, 2= Entered E value
8300             - Elemental Iodine partition coefficient
2                - Calculate organic iodine removal (1=yes, 2=no)
13.79            - Flow per nozzle (gpm)
10               - Number of nozzles
1                - Temperature difference between air and wall (degC)
601519           - Effective plateout area
1907000          - Sprayed volume
1                - Another case? (1=yes, 2=no)
2
69               - Number of size groups
0.00375          - Mean drop diameter (cm)
85.3             - Air-steam temperature (degC)
85.3             - Droplet temperature (degC)
3393             - Initial velocity (cm/sec)
0                - Initial angle
118.47           - Spray fall height (ft) - 046-2.5"-C-KEO
2                - 1=Trajectory, 2=lambda
2                - Print individual drop parameters
1                - 1=NRC E model, 2= Entered E value
8300             - Elemental Iodine partition coefficient
2                - Calculate organic iodine removal (1=yes, 2=no)
13.79            - Flow per nozzle (gpm)
10               - Number of nozzles
1                - Temperature difference between air and wall (degC)
601519           - Effective plateout area
1907000          - Sprayed volume
1                - Another case? (1=yes, 2=no)
2
69               - Number of size groups
0.00375          - Mean drop diameter (cm)
85.3             - Air-steam temperature (degC)
85.3             - Droplet temperature (degC)
3393             - Initial velocity (cm/sec)
45               - Initial angle
118.47           - Spray fall height (ft) - 046-2.5"-C-KEO
2                - 1=Trajectory, 2=lambda
2                - Print individual drop parameters
1                - 1=NRC E model, 2= Entered E value
8300             - Elemental Iodine partition coefficient
2                - Calculate organic iodine removal (1=yes, 2=no)
13.79            - Flow per nozzle (gpm)
10               - Number of nozzles
1                - Temperature difference between air and wall (degC)
601519           - Effective plateout area
1907000          - Sprayed volume
2                - Another case? (1=yes, 2=no)
2
```

9.2.1.4 2 to 4 hr Input File (*i2-max02.in*)

```
8
I2-max02.out
I2 Spray Max Temp 2 - 4 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
100.7                    - Air-steam temperature (degC)
100.7                    - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
7900                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
100.7                    - Air-steam temperature (degC)
100.7                    - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
45                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
7900                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
100.7                    - Air-steam temperature (degC)
100.7                    - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
85.60                    - Spray fall height (ft) - 043-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
7900                      - Elemental Iodine partition coefficient
2                         - Calculate organic iodine removal (1=yes, 2=no)
13.79                     - Flow per nozzle (gpm)
28                        - Number of nozzles
1                         - Temperature difference between air and wall (degC)
601519                    - Effective plateout area
1907000                   - Sprayed volume
1                         - Another case? (1=yes, 2=no)
2
69                        - Number of size groups
0.00375                   - Mean drop diameter (cm)
100.7                     - Air-steam temperature (degC)
100.7                     - Droplet temperature (degC)
3393                      - Initial velocity (cm/sec)
45                        - Initial angle
85.60                     - Spray fall height (ft) - 043-4"-C-KEO
2                         - 1=Trajectory, 2=lambda
2                         - Print individual drop parameters
1                         - 1=NRC E model, 2= Entered E value
7900                      - Elemental Iodine partition coefficient
2                         - Calculate organic iodine removal (1=yes, 2=no)
13.79                     - Flow per nozzle (gpm)
28                        - Number of nozzles
1                         - Temperature difference between air and wall (degC)
601519                    - Effective plateout area
1907000                   - Sprayed volume
1                         - Another case? (1=yes, 2=no)
2
69                        - Number of size groups
0.00375                   - Mean drop diameter (cm)
100.7                     - Air-steam temperature (degC)
100.7                     - Droplet temperature (degC)
3393                      - Initial velocity (cm/sec)
0                         - Initial angle
105.83                    - Spray fall height (ft) - 045-4"-C-KEO
2                         - 1=Trajectory, 2=lambda
2                         - Print individual drop parameters
1                         - 1=NRC E model, 2= Entered E value
7900                      - Elemental Iodine partition coefficient
2                         - Calculate organic iodine removal (1=yes, 2=no)
13.79                     - Flow per nozzle (gpm)
20                        - Number of nozzles
1                         - Temperature difference between air and wall (degC)
601519                    - Effective plateout area
1907000                   - Sprayed volume
1                         - Another case? (1=yes, 2=no)
2
69                        - Number of size groups
0.00375                   - Mean drop diameter (cm)
100.7                     - Air-steam temperature (degC)
100.7                     - Droplet temperature (degC)
3393                      - Initial velocity (cm/sec)
89                        - Initial angle
105.83                    - Spray fall height (ft) - 045-4"-C-KEO
2                         - 1=Trajectory, 2=lambda
2                         - Print individual drop parameters
1                         - 1=NRC E model, 2= Entered E value
7900                      - Elemental Iodine partition coefficient
2                         - Calculate organic iodine removal (1=yes, 2=no)
13.79                     - Flow per nozzle (gpm)
20                        - Number of nozzles
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
1          - Temperature difference between air and wall (degC)
601519     - Effective plateout area
1907000    - Sprayed volume
1          - Another case? (1=yes, 2=no)
2
69         - Number of size groups
0.00375    - Mean drop diameter (cm)
100.7      - Air-steam temperature (degC)
100.7      - Droplet temperature (degC)
3393       - Initial velocity (cm/sec)
0          - Initial angle
108.11     - Spray fall height (ft) - 051-4"-C-KEO
2          - 1=Trajectory, 2=lambda
2          - Print individual drop parameters
1          - 1=NRC E model, 2= Entered E value
7900       - Elemental Iodine partition coefficient
2          - Calculate organic iodine removal (1=yes, 2=no)
13.79      - Flow per nozzle (gpm)
20         - Number of nozzles
1          - Temperature difference between air and wall (degC)
601519     - Effective plateout area
1907000    - Sprayed volume
1          - Another case? (1=yes, 2=no)
2
69         - Number of size groups
0.00375    - Mean drop diameter (cm)
100.7      - Air-steam temperature (degC)
100.7      - Droplet temperature (degC)
3393       - Initial velocity (cm/sec)
89         - Initial angle
108.11     - Spray fall height (ft) - 051-4"-C-KEO
2          - 1=Trajectory, 2=lambda
2          - Print individual drop parameters
1          - 1=NRC E model, 2= Entered E value
7900       - Elemental Iodine partition coefficient
2          - Calculate organic iodine removal (1=yes, 2=no)
13.79      - Flow per nozzle (gpm)
20         - Number of nozzles
1          - Temperature difference between air and wall (degC)
601519     - Effective plateout area
1907000    - Sprayed volume
1          - Another case? (1=yes, 2=no)
2
69         - Number of size groups
0.00375    - Mean drop diameter (cm)
100.7      - Air-steam temperature (degC)
100.7      - Droplet temperature (degC)
3393       - Initial velocity (cm/sec)
0          - Initial angle
117.43     - Spray fall height (ft) - 052-2.5"-C-KEO
2          - 1=Trajectory, 2=lambda
2          - Print individual drop parameters
1          - 1=NRC E model, 2= Entered E value
7900       - Elemental Iodine partition coefficient
2          - Calculate organic iodine removal (1=yes, 2=no)
13.79      - Flow per nozzle (gpm)
10         - Number of nozzles
1          - Temperature difference between air and wall (degC)
601519     - Effective plateout area
1907000    - Sprayed volume
1          - Another case? (1=yes, 2=no)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
100.7                 - Air-steam temperature (degC)
100.7                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
45                    - Initial angle
117.43                - Spray fall height (ft) - 052-2.5"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
7900                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
10                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
100.7                 - Air-steam temperature (degC)
100.7                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
118.47                - Spray fall height (ft) - 046-2.5"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
7900                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
10                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
100.7                 - Air-steam temperature (degC)
100.7                 - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
45                    - Initial angle
118.47                - Spray fall height (ft) - 046-2.5"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
7900                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
10                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
2                     - Another case? (1=yes, 2=no)
2
```

9.2.1.5 4 to 8 hr Input File (*i2-max03.in*)

```
8
I2-max03.out
I2 Spray Max Temp 4 - 8 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
95.3                    - Air-steam temperature (degC)
95.3                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - C49-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
6900                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
95.3                    - Air-steam temperature (degC)
95.3                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
45                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
6900                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
95.3                    - Air-steam temperature (degC)
95.3                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
85.60                   - Spray fall height (ft) - 043-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
6900              - Elemental Iodine partition coefficient
2                 - Calculate organic iodine removal (1=yes, 2=no)
13.79             - Flow per nozzle (gpm)
28                - Number of nozzles
1                 - Temperature difference between air and wall (degC)
601519            - Effective plateout area
1907000           - Sprayed volume
1                 - Another case? (1=yes, 2=no)
2
69                - Number of size groups
0.00375           - Mean drop diameter (cm)
95.3              - Air-steam temperature (degC)
95.3              - Droplet temperature (degC)
3393              - Initial velocity (cm/sec)
45                - Initial angle
85.60             - Spray fall height (ft) - 043-4"-C-KEO
2                 - 1=Trajectory, 2=lambda
2                 - Print individual drop parameters
1                 - 1=NRC E model, 2= Entered E value
6900              - Elemental Iodine partition coefficient
2                 - Calculate organic iodine removal (1=yes, 2=no)
13.79             - Flow per nozzle (gpm)
28                - Number of nozzles
1                 - Temperature difference between air and wall (degC)
601519            - Effective plateout area
1907000           - Sprayed volume
1                 - Another case? (1=yes, 2=no)
2
69                - Number of size groups
0.00375           - Mean drop diameter (cm)
95.3              - Air-steam temperature (degC)
95.3              - Droplet temperature (degC)
3393              - Initial velocity (cm/sec)
0                 - Initial angle
105.83            - Spray fall height (ft) - 045-4"-C-KEO
2                 - 1=Trajectory, 2=lambda
2                 - Print individual drop parameters
1                 - 1=NRC E model, 2= Entered E value
6900              - Elemental Iodine partition coefficient
2                 - Calculate organic iodine removal (1=yes, 2=no)
13.79             - Flow per nozzle (gpm)
20                - Number of nozzles
1                 - Temperature difference between air and wall (degC)
601519            - Effective plateout area
1907000           - Sprayed volume
1                 - Another case? (1=yes, 2=no)
2
69                - Number of size groups
0.00375           - Mean drop diameter (cm)
95.3              - Air-steam temperature (degC)
95.3              - Droplet temperature (degC)
3393              - Initial velocity (cm/sec)
89                - Initial angle
105.83            - Spray fall height (ft) - 045-4"-C-KEO
2                 - 1=Trajectory, 2=lambda
2                 - Print individual drop parameters
1                 - 1=NRC E model, 2= Entered E value
6900              - Elemental Iodine partition coefficient
2                 - Calculate organic iodine removal (1=yes, 2=no)
13.79             - Flow per nozzle (gpm)
20                - Number of nozzles
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
95.3                 - Air-steam temperature (degC)
95.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
6900                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
95.3                 - Air-steam temperature (degC)
95.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
89                   - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
6900                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
95.3                 - Air-steam temperature (degC)
95.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
117.43               - Spray fall height (ft) - 052-2.5"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
6900                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
10                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
95.3           - Air-steam temperature (degC)
95.3           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
45             - Initial angle
117.43         - Spray fall height (ft) - 052-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
6900           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
95.3           - Air-steam temperature (degC)
95.3           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
0              - Initial angle
118.47         - Spray fall height (ft) - 046-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
6900           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
95.3           - Air-steam temperature (degC)
95.3           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
45             - Initial angle
118.47         - Spray fall height (ft) - 046-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
6900           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
2              - Another case? (1=yes, 2=no)
2
```

9.2.1.6 8 to 13.8 hr Input File (*i2-max04.in*)

```
8
I2-max04.out
I2 Spray Max Temp 8 - 13.8 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
87.2                    - Air-steam temperature (degC)
87.2                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
5400                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
87.2                    - Air-steam temperature (degC)
87.2                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
45                      - Initial angle
79.81                   - Spray fall height (ft) - 049-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
5400                    - Elemental Iodine partition coefficient
2                       - Calculate organic iodine removal (1=yes, 2=no)
13.79                   - Flow per nozzle (gpm)
28                      - Number of nozzles
1                       - Temperature difference between air and wall (degC)
601519                  - Effective plateout area
1907000                 - Sprayed volume
1                       - Another case? (1=yes, 2=no)
2
69                      - Number of size groups
0.00375                 - Mean drop diameter (cm)
87.2                    - Air-steam temperature (degC)
87.2                    - Droplet temperature (degC)
3393                    - Initial velocity (cm/sec)
10                      - Initial angle
85.60                   - Spray fall height (ft) - 043-4"-C-KEO
2                       - 1=Trajectory, 2=lambda
2                       - Print individual drop parameters
1                       - 1=NRC E model, 2= Entered E value
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ____________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
5400          - Elemental Iodine partition coefficient
2             - Calculate organic iodine removal (1=yes, 2=no)
13.79         - Flow per nozzle (gpm)
28            - Number of nozzles
1             - Temperature difference between air and wall (degC)
601519        - Effective plateout area
1907000       - Sprayed volume
1             - Another case? (1=yes, 2=no)
2
69            - Number of size groups
0.00375       - Mean drop diameter (cm)
87.2          - Air-steam temperature (degC)
87.2          - Droplet temperature (degC)
3393          - Initial velocity (cm/sec)
45            - Initial angle
85.60         - Spray fall height (ft) - 043-4"-C-KEO
2             - 1=Trajectory, 2=lambda
2             - Print individual drop parameters
1             - 1=NRC E model, 2= Entered E value
5400          - Elemental Iodine partition coefficient
2             - Calculate organic iodine removal (1=yes, 2=no)
13.79         - Flow per nozzle (gpm)
28            - Number of nozzles
1             - Temperature difference between air and wall (degC)
601519        - Effective plateout area
1907000       - Sprayed volume
1             - Another case? (1=yes, 2=no)
2
69            - Number of size groups
0.00375       - Mean drop diameter (cm)
87.2          - Air-steam temperature (degC)
87.2          - Droplet temperature (degC)
3393          - Initial velocity (cm/sec)
0             - Initial angle
105.83        - Spray fall height (ft) - 045-4"-C-KEO
2             - 1=Trajectory, 2=lambda
2             - Print individual drop parameters
1             - 1=NRC E model, 2= Entered E value
5400          - Elemental Iodine partition coefficient
2             - Calculate organic iodine removal (1=yes, 2=no)
13.79         - Flow per nozzle (gpm)
20            - Number of nozzles
1             - Temperature difference between air and wall (degC)
601519        - Effective plateout area
1907000       - Sprayed volume
1             - Another case? (1=yes, 2=no)
2
69            - Number of size groups
0.00375       - Mean drop diameter (cm)
87.2          - Air-steam temperature (degC)
87.2          - Droplet temperature (degC)
3393          - Initial velocity (cm/sec)
89            - Initial angle
105.83        - Spray fall height (ft) - 045-4"-C-KEO
2             - 1=Trajectory, 2=lambda
2             - Print individual drop parameters
1             - 1=NRC E model, 2= Entered E value
5400          - Elemental Iodine partition coefficient
2             - Calculate organic iodine removal (1=yes, 2=no)
13.79         - Flow per nozzle (gpm)
20            - Number of nozzles
```

E&TS DEPARTMENT
CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ______ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates — Sheet 144 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
87.2                  - Air-steam temperature (degC)
87.2                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
108.11                - Spray fall height (ft) - 051-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
5400                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
87.2                  - Air-steam temperature (degC)
87.2                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
89                    - Initial angle
108.11                - Spray fall height (ft) - 051-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
5400                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
87.2                  - Air-steam temperature (degC)
87.2                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
117.43                - Spray fall height (ft) - 052-2.5"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
5400                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
10                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
```

```
2
69                  - Number of size groups
0.00375             - Mean drop diameter (cm)
87.2                - Air-steam temperature (degC)
87.2                - Droplet temperature (degC)
3393                - Initial velocity (cm/sec)
45                  - Initial angle
117.43              - Spray fall height (ft) - 052-2.5"-C-KEO
2                   - 1=Trajectory, 2=lambda
2                   - Print individual drop parameters
1                   - 1=NRC E model, 2= Entered E value
5400                - Elemental Iodine partition coefficient
2                   - Calculate organic iodine removal (1=yes, 2=no)
13.79               - Flow per nozzle (gpm)
10                  - Number of nozzles
1                   - Temperature difference between air and wall (degC)
601519              - Effective plateout area
1907000             - Sprayed volume
1                   - Another case? (1=yes, 2=no)
2
69                  - Number of size groups
0.00375             - Mean drop diameter (cm)
87.2                - Air-steam temperature (degC)
87.2                - Droplet temperature (degC)
3393                - Initial velocity (cm/sec)
0                   - Initial angle
118.47              - Spray fall height (ft) - 046-2.5"-C-KEO
2                   - 1=Trajectory, 2=lambda
2                   - Print individual drop parameters
1                   - 1=NRC E model, 2= Entered E value
5400                - Elemental Iodine partition coefficient
2                   - Calculate organic iodine removal (1=yes, 2=no)
13.79               - Flow per nozzle (gpm)
10                  - Number of nozzles
1                   - Temperature difference between air and wall (degC)
601519              - Effective plateout area
1907000             - Sprayed volume
1                   - Another case? (1=yes, 2=no)
2
69                  - Number of size groups
0.00375             - Mean drop diameter (cm)
87.2                - Air-steam temperature (degC)
87.2                - Droplet temperature (degC)
3393                - Initial velocity (cm/sec)
45                  - Initial angle
118.47              - Spray fall height (ft) - 046-2.5"-C-KEO
2                   - 1=Trajectory, 2=lambda
2                   - Print individual drop parameters
1                   - 1=NRC E model, 2= Entered E value
5400                - Elemental Iodine partition coefficient
2                   - Calculate organic iodine removal (1=yes, 2=no)
13.79               - Flow per nozzle (gpm)
10                  - Number of nozzles
1                   - Temperature difference between air and wall (degC)
601519              - Effective plateout area
1907000             - Sprayed volume
2                   - Another case? (1=yes, 2=no)
2
```

9.2.1.7 13.8 to 24 hr Input File (*i2-max05.in*)

```
8
I2-max05.out
I2 Spray Max Temp 13.8 - 24 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
78.3                     - Air-steam temperature (degC)
78.3                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
4000                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
78.3                     - Air-steam temperature (degC)
78.3                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
45                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
4000                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
78.3                     - Air-steam temperature (degC)
78.3                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
85.60                    - Spray fall height (ft) - 043-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
4000                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
78.3                  - Air-steam temperature (degC)
78.3                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
45                    - Initial angle
85.60                 - Spray fall height (ft) - 043-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
4000                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
78.3                  - Air-steam temperature (degC)
78.3                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
105.83                - Spray fall height (ft) - 045-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
4000                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
78.3                  - Air-steam temperature (degC)
78.3                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
89                    - Initial angle
105.83                - Spray fall height (ft) - 045-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
4000                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
```

```
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
78.3                 - Air-steam temperature (degC)
78.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
4000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
78.3                 - Air-steam temperature (degC)
78.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
89                   - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
4000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
78.3                 - Air-steam temperature (degC)
78.3                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
117.43               - Spray fall height (ft) - 052-2.5"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
4000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
10                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
```

E&TS DEPARTMENT
CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ________ **Calc No.** N-6030-001

Subject Containment Aerosol and Iodine Removal Rates **Sheet** 149 **of** 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
78.3                     - Air-steam temperature (degC)
78.3                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
45                       - Initial angle
117.43                   - Spray fall height (ft) - 052-2.5"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
4000                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
10                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
78.3                     - Air-steam temperature (degC)
78.3                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
0                        - Initial angle
118.47                   - Spray fall height (ft) - 046-2.5"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
4000                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
10                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
78.3                     - Air-steam temperature (degC)
78.3                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
45                       - Initial angle
118.47                   - Spray fall height (ft) - 046-2.5"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
4000                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
10                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
2                        - Another case? (1=yes, 2=no)
2
```

9.2.1.8 24 to 48 hr Input File (*i2-max06.in*)

```
0
I2-max06.out
I2 Spray Max Temp 24 - 48 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
69.2                  - Air-steam temperature (degC)
69.2                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
3000                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
69.2                  - Air-steam temperature (degC)
69.2                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
45                    - Initial angle
79.81                 - Spray fall height (ft) - 049-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
3000                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
69.2                  - Air-steam temperature (degC)
69.2                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
10                    - Initial angle
85.60                 - Spray fall height (ft) - 043-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates Sheet 151 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
28                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
69.2                 - Air-steam temperature (degC)
69.2                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
45                   - Initial angle
85.60                - Spray fall height (ft) - 043-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
28                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
69.2                 - Air-steam temperature (degC)
69.2                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
105.83               - Spray fall height (ft) - 045-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
69.2                 - Air-steam temperature (degC)
69.2                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
89                   - Initial angle
105.83               - Spray fall height (ft) - 045-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
```

```
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
69.2                 - Air-steam temperature (degC)
69.2                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
69.2                 - Air-steam temperature (degC)
69.2                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
89                   - Initial angle
108.11               - Spray fall height (ft) - 051-4"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
20                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
2
69                   - Number of size groups
0.00375              - Mean drop diameter (cm)
69.2                 - Air-steam temperature (degC)
69.2                 - Droplet temperature (degC)
3393                 - Initial velocity (cm/sec)
0                    - Initial angle
117.43               - Spray fall height (ft) - 052-2.5"-C-KEO
2                    - 1=Trajectory, 2=lambda
2                    - Print individual drop parameters
1                    - 1=NRC E model, 2= Entered E value
3000                 - Elemental Iodine partition coefficient
2                    - Calculate organic iodine removal (1=yes, 2=no)
13.79                - Flow per nozzle (gpm)
10                   - Number of nozzles
1                    - Temperature difference between air and wall (degC)
601519               - Effective plateout area
1907000              - Sprayed volume
1                    - Another case? (1=yes, 2=no)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
69.2           - Air-steam temperature (degC)
69.2           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
45             - Initial angle
117.43         - Spray fall height (ft) - 052-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
3000           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
69.2           - Air-steam temperature (degC)
69.2           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
0              - Initial angle
118.47         - Spray fall height (ft) - 046-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
3000           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
1              - Another case? (1=yes, 2=no)
2
69             - Number of size groups
0.00375        - Mean drop diameter (cm)
69.2           - Air-steam temperature (degC)
69.2           - Droplet temperature (degC)
3393           - Initial velocity (cm/sec)
45             - Initial angle
118.47         - Spray fall height (ft) - 046-2.5"-C-KEO
2              - 1=Trajectory, 2=lambda
2              - Print individual drop parameters
1              - 1=NRC E model, 2= Entered E value
3000           - Elemental Iodine partition coefficient
2              - Calculate organic iodine removal (1=yes, 2=no)
13.79          - Flow per nozzle (gpm)
10             - Number of nozzles
1              - Temperature difference between air and wall (degC)
601519         - Effective plateout area
1907000        - Sprayed volume
2              - Another case? (1=yes, 2=no)
2
```

9.2.1.9 48 to 96 hr Input File (*i2-max07.in*)

```
8
I2-max07.out
I2 Spray Max Temp 48 - 96 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                          - Number of size groups
0.00375                     - Mean drop diameter (cm)
59.0                        - Air-steam temperature (degC)
59.0                        - Droplet temperature (degC)
3393                        - Initial velocity (cm/sec)
10                          - Initial angle
79.81                       - Spray fall height (ft) - 049-4"-C-KEO
2                           - 1=Trajectory, 2=lambda
2                           - Print individual drop parameters
1                           - 1=NRC E model, 2= Entered E value
2300                        - Elemental Iodine partition coefficient
2                           - Calculate organic iodine removal (1=yes, 2=no)
13.79                       - Flow per nozzle (gpm)
28                          - Number of nozzles
1                           - Temperature difference between air and wall (degC)
601519                      - Effective plateout area
1907000                     - Sprayed volume
1                           - Another case? (1=yes, 2=no)
2
69                          - Number of size groups
0.00375                     - Mean drop diameter (cm)
59.0                        - Air-steam temperature (degC)
59.0                        - Droplet temperature (degC)
3393                        - Initial velocity (cm/sec)
45                          - Initial angle
79.81                       - Spray fall height (ft) - 049-4"-C-KEO
2                           - 1=Trajectory, 2=lambda
2                           - Print individual drop parameters
1                           - 1=NRC E model, 2= Entered E value
2300                        - Elemental Iodine partition coefficient
2                           - Calculate organic iodine removal (1=yes, 2=no)
13.79                       - Flow per nozzle (gpm)
28                          - Number of nozzles
1                           - Temperature difference between air and wall (degC)
601519                      - Effective plateout area
1907000                     - Sprayed volume
1                           - Another case? (1=yes, 2=no)
2
69                          - Number of size groups
0.00375                     - Mean drop diameter (cm)
59.0                        - Air-steam temperature (degC)
59.0                        - Droplet temperature (degC)
3393                        - Initial velocity (cm/sec)
10                          - Initial angle
85.60                       - Spray fall height (ft) - 043-4"-C-KEO
2                           - 1=Trajectory, 2=lambda
2                           - Print individual drop parameters
1                           - 1=NRC E model, 2= Entered E value
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
28          - Number of nozzles
1           - Temperature difference between air and wall (degC)
601519      - Effective plateout area
1907000     - Sprayed volume
1           - Another case? (1=yes, 2=no)
2
69          - Number of size groups
0.00375     - Mean drop diameter (cm)
59.0        - Air-steam temperature (degC)
59.0        - Droplet temperature (degC)
3393        - Initial velocity (cm/sec)
45          - Initial angle
85.60       - Spray fall height (ft) - 043-4"-C-KEO
2           - 1=Trajectory, 2=lambda
2           - Print individual drop parameters
1           - 1=NRC E model, 2= Entered E value
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
28          - Number of nozzles
1           - Temperature difference between air and wall (degC)
601519      - Effective plateout area
1907000     - Sprayed volume
1           - Another case? (1=yes, 2=no)
2
69          - Number of size groups
0.00375     - Mean drop diameter (cm)
59.0        - Air-steam temperature (degC)
59.0        - Droplet temperature (degC)
3393        - Initial velocity (cm/sec)
0           - Initial angle
105.83      - Spray fall height (ft) - 045-4"-C-KEO
2           - 1=Trajectory, 2=lambda
2           - Print individual drop parameters
1           - 1=NRC E model, 2= Entered E value
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
20          - Number of nozzles
1           - Temperature difference between air and wall (degC)
601519      - Effective plateout area
1907000     - Sprayed volume
1           - Another case? (1=yes, 2=no)
2
69          - Number of size groups
0.00375     - Mean drop diameter (cm)
59.0        - Air-steam temperature (degC)
59.0        - Droplet temperature (degC)
3393        - Initial velocity (cm/sec)
89          - Initial angle
105.32      - Spray fall height (ft) - 045-4"-C-KEO
2           - 1=Trajectory, 2=lambda
2           - Print individual drop parameters
1           - 1=NRC E model, 2= Entered E value
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
20          - Number of nozzles
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
59.0                     - Air-steam temperature (degC)
59.0                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
0                        - Initial angle
108.11                   - Spray fall height (ft) - 051-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
2300                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
20                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
59.0                     - Air-steam temperature (degC)
59.0                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
89                       - Initial angle
108.11                   - Spray fall height (ft) - 051-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
2300                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
20                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
59.0                     - Air-steam temperature (degC)
59.0                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
0                        - Initial angle
117.43                   - Spray fall height (ft) - 052-2.5"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
2300                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
10                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
```

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CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
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Project or DCP/FCN/ECP ______________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2
69          - Number of size groups
0.00375     - Mean drop diameter (cm)
59.0        - Air-steam temperature (degC)
59.0        - Droplet temperature (degC)
3393        - Initial velocity (cm/sec)
45          - Initial angle
117.43      - Spray fall height (ft) - 052-2.5"-C-KEO
2           - 1=Trajectory, 2=lambda
2           - Print individual drop parameters
1           - 1=NRC E model, 2= Entered E value
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
10          - Number of nozzles
1           - Temperature difference between air and wall (degC)
601519      - Effective plateout area
1907000     - Sprayed volume
1           - Another case? (1=yes, 2=no)
2
69          - Number of size groups
0.00375     - Mean drop diameter (cm)
59.0        - Air-steam temperature (degC)
59.0        - Droplet temperature (degC)
3393        - Initial velocity (cm/sec)
0           - Initial angle
118.47      - Spray fall height (ft) - 046-2.5"-C-KEO
2           - 1=Trajectory, 2=lambda
2           - Print individual drop parameters
1           - 1=NRC E model, 2= Entered E value
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
10          - Number of nozzles
1           - Temperature difference between air and wall (degC)
601519      - Effective plateout area
1907000     - Sprayed volume
1           - Another case? (1=yes, 2=no)
2
69          - Number of size groups
0.00375     - Mean drop diameter (cm)
59.0        - Air-steam temperature (degC)
59.0        - Droplet temperature (degC)
3393        - Initial velocity (cm/sec)
45          - Initial angle
118.47      - Spray fall height (ft) - 046-2.5"-C-KEO
2           - 1=Trajectory, 2=lambda
2           - Print individual drop parameters
1           - 1=NRC E model, 2= Entered E value
2300        - Elemental Iodine partition coefficient
2           - Calculate organic iodine removal (1=yes, 2=no)
13.79       - Flow per nozzle (gpm)
10          - Number of nozzles
1           - Temperature difference between air and wall (degC)
601519      - Effective plateout area
1907000     - Sprayed volume
2           - Another case? (1=yes, 2=no)
2
```

9.2.1.10 96 to 720 hr Input File (*i2-max08.in*)

```
8
I2-max08.out
I2 Spray Max Temp 96 - 720 hr
Jorge Schulz
SONGS
16575-167
N-6030-001
0
1
9
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
44.1                     - Air-steam temperature (degC)
44.1                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
1100                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
44.1                     - Air-steam temperature (degC)
44.1                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
45                       - Initial angle
79.81                    - Spray fall height (ft) - 049-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
1100                     - Elemental Iodine partition coefficient
2                        - Calculate organic iodine removal (1=yes, 2=no)
13.79                    - Flow per nozzle (gpm)
28                       - Number of nozzles
1                        - Temperature difference between air and wall (degC)
601519                   - Effective plateout area
1907000                  - Sprayed volume
1                        - Another case? (1=yes, 2=no)
2
69                       - Number of size groups
0.00375                  - Mean drop diameter (cm)
44.1                     - Air-steam temperature (degC)
44.1                     - Droplet temperature (degC)
3393                     - Initial velocity (cm/sec)
10                       - Initial angle
85.60                    - Spray fall height (ft) - 043-4"-C-KEO
2                        - 1=Trajectory, 2=lambda
2                        - Print individual drop parameters
1                        - 1=NRC E model, 2= Entered E value
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
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Project or DCP/FCN/ECP ____________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

Sheet 159 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
44.1                  - Air-steam temperature (degC)
44.1                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
45                    - Initial angle
85.60                 - Spray fall height (ft) - 043-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
28                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
44.1                  - Air-steam temperature (degC)
44.1                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
105.83                - Spray fall height (ft) - 045-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
44.1                  - Air-steam temperature (degC)
44.1                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
89                    - Initial angle
105.83                - Spray fall height (ft) - 045-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
```

```
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
44.1                  - Air-steam temperature (degC)
44.1                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
108.11                - Spray fall height (ft) - 051-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
44.1                  - Air-steam temperature (degC)
44.1                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
89                    - Initial angle
108.11                - Spray fall height (ft) - 051-4"-C-KEO
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
20                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
2
69                    - Number of size groups
0.00375               - Mean drop diameter (cm)
44.1                  - Air-steam temperature (degC)
44.1                  - Droplet temperature (degC)
3393                  - Initial velocity (cm/sec)
0                     - Initial angle
117.43                - Spray fall height (ft) - 052-2.5"-C-KE
2                     - 1=Trajectory, 2=lambda
2                     - Print individual drop parameters
1                     - 1=NRC E model, 2= Entered E value
1100                  - Elemental Iodine partition coefficient
2                     - Calculate organic iodine removal (1=yes, 2=no)
13.79                 - Flow per nozzle (gpm)
10                    - Number of nozzles
1                     - Temperature difference between air and wall (degC)
601519                - Effective plateout area
1907000               - Sprayed volume
1                     - Another case? (1=yes, 2=no)
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ______ **Calc No.** N-6030-001

Subject Containment Aerosol and Iodine Removal Rates **Sheet** 161 **of** 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
2
69              - Number of size groups
0.00375         - Mean drop diameter (cm)
44.1            - Air-steam temperature (degC)
44.1            - Droplet temperature (degC)
3393            - Initial velocity (cm/sec)
45              - Initial angle
117.43          - Spray fall height (ft) - 052-2.5"-C-KE
2               - 1=Trajectory, 2=lambda
2               - Print individual drop parameters
1               - 1=NRC E model, 2= Entered E value
1100            - Elemental Iodine partition coefficient
2               - Calculate organic iodine removal (1=yes, 2=no)
13.79           - Flow per nozzle (gpm)
10              - Number of nozzles
1               - Temperature difference between air and wall (degC)
601519          - Effective plateout area
1907000         - Sprayed volume
1               - Another case? (1=yes, 2=no)
2
69              - Number of size groups
0.00375         - Mean drop diameter (cm)
44.1            - Air-steam temperature (degC)
44.1            - Droplet temperature (degC)
3393            - Initial velocity (cm/sec)
0               - Initial angle
118.47          - Spray fall height (ft) - 046-2.5"-C-KEO
2               - 1=Trajectory, 2=lambda
2               - Print individual drop parameters
1               - 1=NRC E model, 2= Entered E value
1100            - Elemental Iodine partition coefficient
2               - Calculate organic iodine removal (1=yes, 2=no)
13.79           - Flow per nozzle (gpm)
10              - Number of nozzles
1               - Temperature difference between air and wall (degC)
601519          - Effective plateout area
1907000         - Sprayed volume
1               - Another case? (1=yes, 2=no)
2
69              - Number of size groups
0.00375         - Mean drop diameter (cm)
44.1            - Air-steam temperature (degC)
44.1            - Droplet temperature (degC)
3393            - Initial velocity (cm/sec)
45              - Initial angle
118.47          - Spray fall height (ft) - 046-2.5"-C-KEO
2               - 1=Trajectory, 2=lambda
2               - Print individual drop parameters
1               - 1=NRC E model, 2= Entered E value
1100            - Elemental Iodine partition coefficient
2               - Calculate organic iodine removal (1=yes, 2=no)
13.79           - Flow per nozzle (gpm)
10              - Number of nozzles
1               - Temperature difference between air and wall (degC)
601519          - Effective plateout area
1907000         - Sprayed volume
2               - Another case? (1=yes, 2=no)
2
```

9.2.2 Output Files

9.2.2.1 Parametric Study

9.2.2.1.1 I2-30.out

```
Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics        Sheet No.       1
==============================================================================

                 ________________________________________
                |                                        |
                |        Standard Computer Program       |
                |        NE305 REMOVE  Version 4.0       |
                |          for the IBM PC/XT/AT          |
                |                                        |
                |________________________________________|

                Abstract:

                The REMOVE program calculates the containment
                spray removal rate constants and a mean drop
                diameter or drop trajectories


      Output in file I2-30.out    was created on 14 Jun 2003  at 10:54:59

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics        Sheet No.       2
==============================================================================


Temperature of air-steam mixture=   30.000     Degree C
Pressure of air-steam mixture=   1.0592     Atm.
Temperature of droplet liquid=   30.000     Degree C
Density of air-steam mixture=  1.21538E-03 G/CC
Viscosity of air-steam mixture=  1.81599E-04 Poise
Density of droplet liquid=   .99529     G/CC
Viscosity of droplet liquid=  8.01072E-03 Poise
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Diff. coeff. of elemental I2 in air-steam mixture=  8.57445E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11198     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  1.47833E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  1.59648E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7426
Schmidt number for methyl iodine=   1.3344
Grashof number=  2.59335E+12
Try mean diameter=  8.43032E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM        SEC                   CM/SEC      CM/SEC

34  8.4303E-02   6.124      194.9       12.29       345.4       270.1

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
        CM                                           CM/SEC       /HR

34  8.4303E-02   4.176     5.0952E-02   .3352     1.1538E-03    4.567

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.5685     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.7211     per hour

Organic removal rate due to wall deposition=    .00000      per hour

Mean drop diameter=  8.43032E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.2 I2-40.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003 Checked________Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics        Sheet No.       1
==========================================================================

            ________________________________________
           |                                        |
           |        Standard Computer Program       |
           |        NE305 REMOVE  Version 4.0       |
           |         for the IBM PC/XT/AT           |
           |                                        |
           |________________________________________|

            Abstract:

            The REMOVE program calculates the containment
            spray removal rate constants and a mean drop
            diameter or drop trajectories

     Output in file I2-30.out   was created on 14 Jun 2003  at 10:54:59

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003 Checked________Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics        Sheet No.       2
==========================================================================

Temperature of air-steam mixture=   30.000     Degree C
Pressure of air-steam mixture=   1.0592     Atm.
Temperature of droplet liquid=   30.000     Degree C
Density of air-steam mixture=  1.21538E-03 G/CC
Viscosity of air-steam mixture=  1.81599E-04 Poise
Density of droplet liquid=    .99529      G/CC
Viscosity of droplet liquid=  8.01072E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.57445E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .11198      sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  1.47833E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  1.59648E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7426
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.3344
Grashof number=  2.59335E+12
Try mean diameter=  8.43032E-02

Drop parameters for elemental
        (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
        CM         SEC                   CM/SEC      CM/SEC

 34  8.4303E-02   6.124      194.9       12.29       345.4      270.1

 I    Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                             CM/SEC      /HR

 34  8.4303E-02   4.176     5.0952E-02   .3352      1.1538E-03   4.567

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.5685     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.7211     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.43032E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.3   I2-50.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.       1
==========================================================================

                 Standard Computer Program
                 NE305 REMOVE  Version 4.0
                  for the IBM PC/XT/AT

Abstract:

The REMOVE program calculates the containment
spray removal rate constants and a mean drop
diameter or drop trajectories

     Output in file I2-50.out    was created on 14 Jun 2003  at 10:55:23

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.       2
==========================================================================

Temperature of air-steam mixture=   50.000     Degree C
Pressure of air-steam mixture=   1.2061     Atm.
Temperature of droplet liquid=   50.000     Degree C
Density of air-steam mixture=  1.26801E-03 G/CC
Viscosity of air-steam mixture=  1.85425E-04 Poise
Density of droplet liquid=   .98761     G/CC
Viscosity of droplet liquid=  5.49585E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.57252E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11194     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.29696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.48055E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7058
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ______ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.3064
Grashof number=  3.17627E+12
Try mean diameter=  8.54446E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                   CM/SEC      CM/SEC

34  8.5445E-02   6.233       199.0       12.15        340.6       259.4

 I   Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                              CM/SEC       /HR

34  8.5445E-02   2.695      7.8443E-02   .3621      1.7688E-03   4.934

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.9357     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=  .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9840     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.54446E-02
```

9.2.2.1.4 I2-60.out

```
Bechtel Standard Computer Program        REMOVE  , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.        1
=============================================================================



                Standard Computer Program
                NE305 REMOVE  Version 4.0
                  for the IBM PC/XT/AT


            Abstract:

            The REMOVE program calculates the containment
            spray removal rate constants and a mean drop
            diameter or drop trajectories



     Output in file I2-60.out    was created on 14 Jun 2003  at 10:55:35

Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.        2
=============================================================================


Temperature of air-steam mixture=   60.000     Degree C
Pressure of air-steam mixture=   1.3145     Atm.
Temperature of droplet liquid=   60.000     Degree C
Density of air-steam mixture=  1.31522E-03 G/CC
Viscosity of air-steam mixture=  1.85731E-04 Poise
Density of droplet liquid=    .98289     G/CC
Viscosity of droplet liquid=  4.68809E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.38831E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .10958     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.77606E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.99793E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6835
```

```
Schmidt number for methyl iodine=   1.2887
Grashof number=  3.75337E+12
Try mean diameter=  8.58842E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall.Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

34  8.5884E-02   6.333      204.6       11.93        336.4      255.5

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

34  8.5884E-02   2.199     9.5346E-02   .3722      2.1268E-03    5.071

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.0724     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.58842E-02
```

9.2.2.1.5 I2-70.out

```
Bechtel Standard Computer Program        REMOVE   , NE305 Version 4.0
(c) 1991                                            Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003   Checked_______Date_________
Project  SONGS                                      Job No. 16575-167
Subject  I2 Spray Temperature Parametrics           Sheet No.      1
==========================================================================

          ________________________________________
         |                                        |
         |        Standard Computer Program       |
         |        NE305 REMOVE  Version 4.0       |
         |          for the IBM PC/XT/AT          |
         |                                        |
         |________________________________________|


                 Abstract:
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
The REMOVE program calculates the containment
spray removal rate constants and a mean drop
diameter or drop trajectories



Output in file I2-70.out    was created on 14 Jun 2003  at 10:55:47

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                       Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                 Job No. 16575-167
Subject  I2 Spray Temperature Parametrics      Sheet No.        2
===========================================================================


Temperature of air-steam mixture=   70.000     Degree C
Pressure of air-steam mixture=   1.4590     Atm.
Temperature of droplet liquid=   70.000     Degree C
Density of air-steam mixture=  1.38315E-03 G/CC
Viscosity of air-steam mixture=  1.84945E-04 Poise
Density of droplet liquid=    .97759     G/CC
Viscosity of droplet liquid=   4.06143E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.06100E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .10539     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.30057E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.56436E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6588
Schmidt number for methyl iodine=   1.2687
Grashof number=  4.58987E+12
Try mean diameter=  8.62381E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time  Reynolds    M.T.Coeff G     T.V.      drop no.
       CM          SEC                    CM/SEC       CM/SEC

34  8.6238E-02   6.477       213.2       11.56         330.6       252.3

 I   Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                              CM/SEC       /HR

34  8.6238E-02   1.801       .1150       .3800       2.5182E-03   5.178

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.1780     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour
```

```
Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter=  8.62381E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.6 I2-75.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date_________
Project   SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.       1
================================================================================


                 ------------------------------------------------
                 |                                              |
                 |          Standard Computer Program           |
                 |          NE305 REMOVE  Version 4.0           |
                 |            for the IBM PC/XT/AT              |
                 |                                              |
                 |______________________________________________|


                 Abstract:

                 The REMOVE program calculates the containment
                 spray removal rate constants and a mean drop
                 diameter or drop trajectories


     Output in file I2-75.out    was created on 14 Jun 2003  at 10:55:59

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date_________
Project . SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.       2
================================================================================


Temperature of air-steam mixture=   75.000     Degree C
Pressure of air-steam mixture=   1.5487     Atm.
Temperature of droplet liquid=   75.000     Degree C
Density of air-steam mixture=  1.42687E-03 G/CC
Viscosity of air-steam mixture=  1.84197E-04 Poise
Density of droplet liquid=    .97473     G/CC
Viscosity of droplet liquid=  3.79951E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.84376E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10261     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.57950E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.86559E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6458
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2581
Grashof number=  5.12569E+12
Try mean diameter=  8.63926E-02

Drop parameters for elemental
        (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
         CM         SEC                  CM/SEC      CM/SEC

35   8.6393E-02   6.567      218.8       11.33       327.0       251.0

 I    Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
         CM                                           CM/SEC        /HR

35   8.6393E-02   1.630      .1260       .3830     2.7262E-03    5.219

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2192     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.63926E-02
```

9.2.2.1.7 I2-80.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.        1
================================================================================

                 ________________________________________________
                |                                                |
                |            Standard Computer Program           |
                |            NE305 REMOVE  Version 4.0           |
                |             for the IBM PC/XT/AT               |
                |                                                |
                |________________________________________________|


                Abstract:

                The REMOVE program calculates the containment
                spray removal rate constants and a mean drop
                diameter or drop trajectories


     Output in file I2-80.out   was created on 14 Jun 2003  at 10:56:10

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.        2
================================================================================


Temperature of air-steam mixture=    80.000     Degree C
Pressure of air-steam mixture=   1.6524     Atm.
Temperature of droplet liquid=   80.000     Degree C
Density of air-steam mixture=  1.47831E-03 G/CC
Viscosity of air-steam mixture=  1.83263E-04 Poise
Density of droplet liquid=   .97174     G/CC
Viscosity of droplet liquid=  3.56538E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.59322E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.93942E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.86934E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.17859E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6326
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2472
Grashof number=  5.75187E+12
Try mean diameter=  8.65248E-02

Drop parameters for elemental
           (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
         CM         SEC                  CM/SEC      CM/SEC

35  8.6525E-02   6.673       225.4       11.06       322.9       249.8

 I    Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
         CM                                          CM/SEC       /HR

35  8.6525E-02   1.474       .1380       .3854     2.9424E-03   5.252

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2527     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.65248E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

9.2.2.1.8 I2-85.out

```
Bechtel Standard Computer Program      REMOVE , NE305 Version 4.0
(c) 1991                                Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz    Date 14 Jun 2003  Checked________Date_________
Project  SONGS                          Job No. 16575-167
Subject  I2 Spray Temperature Parametrics   Sheet No.      1
==========================================================================

         ____________________________________
        |                                    |
        |      Standard Computer Program     |
        |     NE305 REMOVE  Version 4.0      |
        |       for the IBM PC/XT/AT         |
        |                                    |
        |____________________________________|


        Abstract:

        The REMOVE program calculates the containment
        spray removal rate constants and a mean drop
        diameter or drop trajectories


    Output in file I2-85.out    was created on 14 Jun 2003  at 10:56:22

Bechtel Standard Computer Program      REMOVE , NE305 Version 4.0
(c) 1991                                Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz    Date 14 Jun 2003  Checked________Date_________
Project  SONGS                          Job No. 16575-167
Subject  I2 Spray Temperature Parametrics   Sheet No.      2
==========================================================================

Temperature of air-steam mixture=   85.000     Degree C
Pressure of air-steam mixture=   1.7723     Atm.
Temperature of droplet liquid=   85.000     Degree C
Density of air-steam mixture=  1.53848E-03 G/CC
Viscosity of air-steam mixture=  1.82194E-04 Poise
Density of droplet liquid=    .96862     G/CC
Viscosity of droplet liquid=  3.35520E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.31266E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.57876E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.16994E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.50322E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6195
```

E&TS DEPARTMENT
CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ____________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates Sheet 177 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2363
Grashof number=  6.47834E+12
Try mean diameter=  8.66359E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.6636E-02   6.796      232.8      10.76        318.2       248.9

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

35  8.6636E-02  1.333       .1510       .3873      3.1669E-03   5.278

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2787     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.66359E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.9 I2-90.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date_________
Project   SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.        1
==============================================================================

                 ___________________________________________
                |                                           |
                |          Standard Computer Program        |
                |          NE305 REMOVE  Version 4.0        |
                |            for the IBM PC/XT/AT           |
                |                                           |
                |___________________________________________|

                Abstract:

                The REMOVE program calculates the containment
                spray removal rate constants and a mean drop
                diameter or drop trajectories


 Output in file I2-90.out    was created on 14 Jun 2003  at 10:56:33

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date_________
Project   SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.        2
==============================================================================

Temperature of air-steam mixture=   90.000     Degree C
Pressure of air-steam mixture=   1.9105     Atm.
Temperature of droplet liquid=   90.000     Degree C
Density of air-steam mixture=  1.60846E-03 G/CC
Viscosity of air-steam mixture=  1.81049E-04 Poise
Density of droplet liquid=   .96536     G/CC
Viscosity of droplet liquid=  3.16578E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.00639E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.18436E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.48114E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.83929E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6065
```

E&TS DEPARTMENT
CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ____________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates Sheet 179 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2256
Grashof number=  7.31507E-12
Try mean diameter=  8.67246E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.6725E-02   6.937      241.2       10.43       313.0       248.1

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC       /HR

35  8.6725E-02   1.203      .1653       .3887     3.3998E-03   5.296

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2974     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.67246E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.10 I2-95.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.       1
================================================================================


                  ______________________________________________
                 |                                              |
                 |          Standard Computer Program           |
                 |          NE305 REMOVE  Version 4.0           |
                 |           for the IBM PC/XT/AT               |
                 |                                              |
                 |______________________________________________|


                 Abstract:

                 The REMOVE program calculates the containment
                 spray removal rate constants and a mean drop
                 diameter or drop trajectories


     Output in file I2-95.out    was created on 14 Jun 2003  at 10:56:44

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Temperature Parametrics          Sheet No.       2
================================================================================


Temperature of air-steam mixture=   95.000      Degree C
Pressure of air-steam mixture=   2.0696     Atm.
Temperature of droplet liquid=   95.000      Degree C
Density of air-steam mixture=  1.68945E-03 G/CC
Viscosity of air-steam mixture=  1.79888E-04 Poise
Density of droplet liquid=   .96198      G/CC
Viscosity of droplet liquid=  2.99442E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.67953E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.76266E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.80280E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.18666E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5941
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2151
Grashof number= 8.27249E+12
Try mean diameter= 8.67925E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds    M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.6793E-02   7.099      250.4       10.07       307.2       247.5

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

35  8.6793E-02   1.085      .1811       .3895      3.6410E-03   5.308

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.3091     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0750     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=   8.67925E-02
```

9.2.2.1.11 I2-100.out

```
Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date_________
Project   SONGS                                    Job No. 16575-167
Subject   I2 Spray Temperature Parametrics         Sheet No.       1
==================================================================================


              ________________________________________________
             |                                                |
             |           Standard Computer Program            |
             |           NE305 REMOVE  Version 4.0            |
             |             for the IBM PC/XT/AT               |
             |                                                |
             |________________________________________________|


               Abstract:

               The REMOVE program calculates the containment
               spray removal rate constants and a mean drop
               diameter or drop trajectories


     Output in file I2-100.out   was created on 14 Jun 2003   at 10:56:56

Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date_________
Project   SONGS                                    Job No. 16575-167
Subject   I2 Spray Temperature Parametrics         Sheet No.       2
==================================================================================


Temperature of air-steam mixture=   100.00     Degree C
Pressure of air-steam mixture=   2.2522     Atm.
Temperature of droplet liquid=   100.00     Degree C
Density of air-steam mixture=  1.78269E-03 G/CC
Viscosity of air-steam mixture=  1.78774E-04 Poise
Density of droplet liquid=    .95848      G/CC
Viscosity of droplet liquid=  2.83886E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.33767E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.32075E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.13479E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.54518E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5823
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2052
Grashof number=  9.36102E+12
Try mean diameter=  8.68402E-02

Drop parameters for elemental
        (For mean drop)

 I    Diameter    Fall Time  Reynolds    M.T.Coeff G    T.V.      drop no.
         CM          SEC                    CM/SEC      CM/SEC

35   8.6840E-02    7.283      260.5        9.695       300.8       247.1

 I    Diameter    Sherwood     Time       Sat. Frac.  M.T.Coeff L   Removal
         CM                                              CM/SEC       /HR

35   8.6840E-02    .9773       .1984       .3899      3.8905E-03    5.313

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.3141     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9871     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.68402E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.12 I2-105.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.       1
==============================================================================
```

```
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|                                             |
|          Standard Computer Program          |
|          NE305 REMOVE  Version 4.0          |
|            for the IBM PC/XT/AT             |
|                                             |
|_____________________________________________|
```

```
Abstract:

The REMOVE program calculates the containment
spray removal rate constants and a mean drop
diameter or drop trajectories
```

```
    Output in file I2-105.out   was created on 14 Jun 2003  at 10:57: 6

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.       2
==============================================================================


Temperature of air-steam mixture=   105.00     Degree C
Pressure of air-steam mixture=   2.4612     Atm.
Temperature of droplet liquid=   105.00     Degree C
Density of air-steam mixture=  1.88954E-03 G/CC
Viscosity of air-steam mixture=  1.77766E-04 Poise
Density of droplet liquid=   .95485     G/CC
Viscosity of droplet liquid=  2.69716E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  5.98655E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  7.86599E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.47695E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.91469E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5715
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.1960
Grashof number=  1.05911E+13
Try mean diameter=  8.68688E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
        CM         SEC                  CM/SEC      CM/SEC

35  8.6869E-02   7.490      271.4       9.298       293.9      246.9

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
        CM                                          CM/SEC        /HR

35  8.6869E-02   .8790      .2174       .3898     4.1484E-03    5.311

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.3129     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.8795     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.68688E-02
```

9.2.2.1.13 I2-110.out

```
Bechtel Standard Computer Program        REMOVE  , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project   SONGS                                    Job No. 16575-167
Subject   I2 Spray Temperature Parametrics         Sheet No.       1
==========================================================================


            ________________________________________
           |                                        |
           |         Standard Computer Program      |
           |         NE305 REMOVE  Version 4.0      |
           |          for the IBM PC/XT/AT          |
           |                                        |
           |________________________________________|


           Abstract:

           The REMOVE program calculates the containment
           spray removal rate constants and a mean drop
           diameter or drop trajectories


     Output in file I2-110.out   was created on 14 Jun 2003  at 10:57:17

Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003  Checked_______Date________
Project   SONGS                                    Job No. 16575-167
Subject   I2 Spray Temperature Parametrics         Sheet No.       2
==========================================================================


Temperature of air-steam mixture=   110.00     Degree C
Pressure of air-steam mixture=   2.6998      Atm.
Temperature of droplet liquid=   110.00     Degree C
Density of air-steam mixture=  2.01144E-03 G/CC
Viscosity of air-steam mixture=  1.76918E-04 Poise
Density of droplet liquid=   .95110      G/CC
Viscosity of droplet liquid=  2.56770E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  5.63178E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  7.40561E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.82918E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  6.29507E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5618
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.1877
Grashof number=  1.19729E+13
Try mean diameter=  8.68793E-02

Drop parameters for elemental
           (For mean drop)

 I    Diameter    Fall Time  Reynolds    M.T.Coeff G    T.V.      drop no.
        CM          SEC                    CM/SEC      CM/SEC

35  8.6879E-02   7.722       283.0        8.888       286.5       246.8

 I    Diameter    Sherwood     Time       Sat. Frac.  M.T.Coeff L   Removal
        CM                                              CM/SEC       /HR

35  8.6879E-02   .7895       .2385        .3893      4.4147E-03    5.304

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.3058     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.7547     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.68793E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

9.2.2.1.14 I2-120.out

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.       1
==========================================================================


              Standard Computer Program
              NE305 REMOVE  Version 4.0
               for the IBM PC/XT/AT


Abstract:

The REMOVE program calculates the containment
spray removal rate constants and a mean drop
diameter or drop trajectories


    Output in file I2-120.out   was created on 14 Jun 2003  at 10:57:27

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Temperature Parametrics         Sheet No.       2
==========================================================================


Temperature of air-steam mixture=   120.00      Degree C
Pressure of air-steam mixture=   3.2789      Atm.
Temperature of droplet liquid=   120.00      Degree C
Density of air-steam mixture=  2.30660E-03 G/CC
Viscosity of air-steam mixture=  1.75892E-04 Poise
Density of droplet liquid=   .94327      G/CC
Viscosity of droplet liquid=  2.33999E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.93146E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  6.49425E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  6.56335E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.08792E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5463
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Schmidt number for methyl iodine=   1.1742
Grashof number=  1.52337E-13
Try mean diameter=  8.68527E-02

Drop parameters for elemental
          (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

35  8.6853E-02   8.263      308.1       8.050        270.5       247.0

 I    Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                            CM/SEC      /HR

35  8.6853E-02   .6349      .2876       .3871      4.9722E-03   5.274

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2755     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.4645     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.68527E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.1.15 I2-130.out

```
Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics        Sheet No.       1
==========================================================================

              ______________________________________
             |                                      |
             |       Standard Computer Program      |
             |       NE305 REMOVE  Version 4.0      |
             |        for the IBM PC/XT/AT          |
             |                                      |
             |______________________________________|


             Abstract:

             The REMOVE program calculates the containment
             spray removal rate constants and a mean drop
             diameter or drop trajectories


    Output in file I2-130.out   was created on 14 Jun 2003  at 10:57:37

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Temperature Parametrics        Sheet No.       2
==========================================================================

Temperature of air-steam mixture=   130.00    Degree C
Pressure of air-steam mixture=   4.0191     Atm.
Temperature of droplet liquid=   130.00     Degree C
Density of air-steam mixture=  2.68157E-03 G/CC
Viscosity of air-steam mixture=  1.75994E-04 Poise
Density of droplet liquid=    .93500      G/CC
Viscosity of droplet liquid=  2.14666E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27023E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63071E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.33645E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.92281E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5369
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Schmidt number for methyl iodine=   1.1656
Grashof number=  1.92271E+13
Try mean diameter=  8.67635E-02

Drop parameters for elemental
          (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM          SEC                  CM/SEC      CM/SEC

35  8.6764E-02   8.916       334.8       7.220       253.2       247.8

 I    Diameter   Sherwood    Time       Sat. Frac.  M.T.Coeff L  Removal
        CM                                             CM/SEC      /HR

35  8.6764E-02   .5089       .3476       .3836      5.5636E-03   5.227

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=    5.2279     per hour

Particulate iodine removal constant=    .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =    4.1405     per hour

Organic removal rate due to wall deposition=    .00000     per hour

Mean drop diameter=  8.67635E-02
```

9.2.2.2 Injection Phase Output File (*i2-boric.out*)

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Removal - Injection             Sheet No.        1
==========================================================================


                 ----------------------------------------------
                 |                                            |
                 |          Standard Computer Program         |
                 |          NE305 REMOVE  Version 4.0         |
                 |            for the IBM PC/XT/AT            |
                 |                                            |
                 |____________________________________________|


                 Abstract:

                 The REMOVE program calculates the containment
                 spray removal rate constants and a mean drop
                 diameter or drop trajectories


     Output in file I2-boric.out was created on 14 Jun 2003  at 10:58:21

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Removal - Injection             Sheet No.        2
==========================================================================


Temperature of air-steam mixture=   129.90     Degree C
Pressure of air-steam mixture=   4.0108      Atm.
Temperature of droplet liquid=   129.90      Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=    .93509      G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.1656
Grashof number=  1.91833E+13
Try mean diameter=   .10758

Drop parameters for elemental
        (For mean drop)

 I   Diameter  Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM        SEC                   CM/SEC      CM/SEC

43   .1076      7.431      490.7       6.893       299.8      130.0

 I   Diameter  Sherwood     Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                          CM/SEC      /HR

43   .1076      25.30      .1882       .8781     4.4823E-03   .2853

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .28526    per hour

Particulate iodine removal constant=   .59268    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.1439    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter=   .10758
Temperature of air-steam mixture=   129.90    Degree C
Pressure of air-steam mixture=   4.0108    Atm.
Temperature of droplet liquid=   129.90    Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509    G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  1.91833E+13
Try mean diameter=   .10334

Drop parameters for elemental
        (For mean drop)

 I   Diameter  Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM        SEC                   CM/SEC      CM/SEC

43   .1083      7.670      496.7       6.881       301.4      255.7

 I   Diameter  Sherwood     Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                          CM/SEC      /HR

43   .1083      25.43      .1916       .8819     4.4508E-03   .2865
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  .28649     per hour

Particulate iodine removal constant=  .59268     per hour

Total organic removal constant=  .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.1439     per hour

Organic removal rate due to wall deposition=  .00000     per hour

Mean drop diameter=   .10834
Temperature of air-steam mixture=   129.90     Degree C
Pressure of air-steam mixture=   4.0108     Atm.
Temperature of droplet liquid=   129.90     Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509     G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  2.36686E+13
Try mean diameter=   .10868

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G   T.V.      drop no.
       CM         SEC                    CM/SEC     CM/SEC

43   .1087      7.954      499.6       6.877       302.1       379.3

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

43   .1087      25.50      .1974       .8882      4.4369E-03   .2885

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  .28852     per hour

Particulate iodine removal constant=  .63567     per hour

Total organic removal constant=  .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.1439     per hour

Organic removal rate due to wall deposition=  .00000     per hour

Mean drop diameter=   .10868
Temperature of air-steam mixture=   129.90     Degree C
Pressure of air-steam mixture=   4.0108     Atm.
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Temperature of droplet liquid=   129.90      Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509      G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  2.36686E+13
Try mean diameter=   .10878

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

44   .1088       8.229      500.3       6.875        302.3       501.7

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

44   .1088       25.51      .2039       .8946      4.4328E-03   .2906

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .29061      per hour

Particulate iodine removal constant=   .63567      per hour

Total organic removal constant=   .00000      per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.1439      per hour

Organic removal rate due to wall deposition=   .00000      per hour

Mean drop diameter=   .10878
Temperature of air-steam mixture=   129.90      Degree C
Pressure of air-steam mixture=   4.0108      Atm.
Temperature of droplet liquid=   129.90      Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509      G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  4.47279E+13
Try mean diameter=   .11038

Drop parameters for elemental
        (For mean drop)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
44	.1104	9.857	513.3	6.853	305.7	990.8

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
44	.1104	25.80	.2372	.9225	4.3686E-03	.2140

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= .21403 per hour

Particulate iodine removal constant= .56136 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 4.1439 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= .11038
Temperature of air-steam mixture= 129.90 Degree C
Pressure of air-steam mixture= 4.0108 Atm.
Temperature of droplet liquid= 129.90 Degree C
Density of air-steam mixture= 2.67738E-03 G/CC
Viscosity of air-steam mixture= 1.75987E-04 Poise
Density of droplet liquid= .93509 G/CC
Viscosity of droplet liquid= 2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5370
Schmidt number for methyl iodine= 1.1656
Grashof number= 4.47279E+13
Try mean diameter= .11076

Drop parameters for elemental
(For mean drop)

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
44	.1108	10.86	516.4	6.848	306.5	1476.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
44	.1108	25.87	.2595	.9368	4.3535E-03	.2174

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= .21736 per hour

Particulate iodine removal constant= .56136 per hour

Total organic removal constant= .00000 per hour

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.1439    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  .11076
Temperature of air-steam mixture=  129.90    Degree C
Pressure of air-steam mixture=  4.0108    Atm.
Temperature of droplet liquid=  129.90    Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=  .93509    G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.5370
Schmidt number for methyl iodine=  1.1656
Grashof number=  4.76815E+13
Try mean diameter=  .11084

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                   CM/SEC      CM/SEC

44   .1108      10.05       517.0       6.847        306.6      1964.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

44   .1108      25.89        .2398      .9244      4.3506E-03    .2145

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  .21449    per hour

Particulate iodine removal constant=  .57345    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.1439    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  .11084
Temperature of air-steam mixture=  129.90    Degree C
Pressure of air-steam mixture=  4.0108    Atm.
Temperature of droplet liquid=  129.90    Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=  .93509    G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
```

```
Diff. coeff. of elemental I2 in droplet liquid= 7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5370
Schmidt number for methyl iodine= 1.1656
Grashof number= 4.76815E+13
Try mean diameter= .11097

Drop parameters for elemental
        (For mean drop)

 I   Diameter  Fall Time  Reynolds  M.T.Coeff G   T.V.      drop no.
       CM        SEC                  CM/SEC     CM/SEC

44   .1110     11.07      518.1      6.845       306.9      2448.

 I   Diameter  Sherwood   Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                        CM/SEC       /HR

44   .1110     25.91      .2635      .9391      4.3452E-03   .2179

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  .21791    per hour

Particulate iodine removal constant=  .57345    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.1439    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  .11097
Temperature of air-steam mixture=  129.90    Degree C
Pressure of air-steam mixture=  4.0108    Atm.
Temperature of droplet liquid=  129.90    Degree C
Density of air-steam mixture= 2.67738E-03 G/CC
Viscosity of air-steam mixture= 1.75987E-04 Poise
Density of droplet liquid=  .93509    G/CC
Viscosity of droplet liquid= 2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5370
Schmidt number for methyl iodine= 1.1656
Grashof number= 6.11068E+13
Try mean diameter= .11103

Drop parameters for elemental
        (For mean drop)

 I   Diameter  Fall Time  Reynolds  M.T.Coeff G   T.V.      drop no.
       CM        SEC                  CM/SEC     CM/SEC

44   .1110     10.96      518.6      6.844       307.0      2932.

 I   Diameter  Sherwood   Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                        CM/SEC       /HR
```

E&TS DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates Sheet 199 of 281

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
44   .1110     25.92      .2607     .9375     4.3431E-03   .1088

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .10877     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.1439     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=   .11103
Temperature of air-steam mixture=   129.90     Degree C
Pressure of air-steam mixture=   4.0108     Atm.
Temperature of droplet liquid=   129.90     Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509     G/CC
Viscosity of droplet liquid=  2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  6.11068E+13
Try mean diameter=   .11107

Drop parameters for elemental
        (For mean drop)

 I   Diameter  Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM        SEC                   CM/SEC      CM/SEC

44   .1111     11.26      518.8       6.843       307.0       3414.

 I   Diameter  Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                          CM/SEC      /HR

44   .1111     25.93      .2675       .9413     4.3414E-03   .1092

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .10921     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.1439     per hour

Organic removal rate due to wall deposition=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter=   .11107
Temperature of air-steam mixture=  129.90     Degree C
Pressure of air-steam mixture=   4.0108     Atm.
Temperature of droplet liquid=   129.90     Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509     G/CC
Viscosity of droplet liquid=   2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=   4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=   7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=   7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  6.27447E+13
Try mean diameter=   .11109

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

44   .1111       11.06      519.1       6.843        307.1      3898.

 I   Diameter   Sherwood    Time      Sat. Frac.   M.T.Coeff L   Removal
       CM                                             CM/SEC       /HR

44   .1111       25.93      .2628      .9387       4.3407E-03    .1089

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .10890     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.1439    per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=   .11109
Temperature of air-steam mixture=   129.90     Degree C
Pressure of air-steam mixture=   4.0108     Atm.
Temperature of droplet liquid=   129.90     Degree C
Density of air-steam mixture=  2.67738E-03 G/CC
Viscosity of air-steam mixture=  1.75987E-04 Poise
Density of droplet liquid=   .93509     G/CC
Viscosity of droplet liquid=   2.14844E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=   4.27657E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   5.63900E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=   7.32853E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=   7.91426E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5370
Schmidt number for methyl iodine=   1.1656
Grashof number=  6.27447E+13
Try mean diameter=   .11111
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G   T.V.      drop no.
       CM         SEC                  CM/SEC      CM/SEC

44   .1111       11.36      519.2       6.842       307.1      4380.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC      /HR

44   .1111       25.94      .2697       .9424     4.3397E-03   .1093

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .10934     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.1439     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=   .11111
```

9.2.2.3 30 min to 2 hr Output File (*I2-max01.out*)

```
Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project   SONGS                                  Job No. 16575-167
Subject  I2 Spray Max Temp 30 min - 2 hr         Sheet No.       1
================================================================================


                    ________________________________________________
                   |                                                |
                   |            Standard Computer Program           |
                   |            NE305 REMOVE  Version 4.0           |
                   |              for the IBM PC/XT/AT              |
                   |                                                |
                   |________________________________________________|


                    Abstract:

                    The REMOVE program calculates the containment
                    spray removal rate constants and a mean drop
                    diameter or drop trajectories


      Output in file I2-max01.out was created on 14 Jun 2003  at 11: 0:58

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project   SONGS                                  Job No. 16575-167
Subject  I2 Spray Max Temp 30 min - 2 hr         Sheet No.       2
================================================================================


Temperature of air-steam mixture=   85.300     Degree C
Pressure of air-steam mixture=   1.7800     Atm.
Temperature of droplet liquid=   85.300     Degree C
Density of air-steam mixture= 1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=    .96843      G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6187
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2357
Grashof number=  6.52532E+12
Try mean diameter=  8.67179E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

35  8.6718E-02   6.798      233.7      10.74       318.2       248.2

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                           CM/SEC       /HR

35  8.6718E-02   1.340      .1514       .3894      3.1779E-03   5.250

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2509     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.67179E-02
Temperature of air-steam mixture=   85.300     Degree C
Pressure of air-steam mixture=   1.7800     Atm.
Temperature of droplet liquid=   85.300     Degree C
Density of air-steam mixture=  1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=   .96843     G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6187
Schmidt number for methyl iodine=   1.2357
Grashof number=  6.52532E+12
Try mean diameter=  8.79148E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

35  8.7915E-02   7.044      239.7      10.71       322.0       486.3

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                           CM/SEC       /HR

35  8.7915E-02   1.354      .1527       .3944      3.1346E-03   5.316
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  5.3183    per hour

Particulate iodine removal constant=  .59268    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter= 8.79148E-02
Temperature of air-steam mixture=  85.300    Degree C
Pressure of air-steam mixture=  1.7800    Atm.
Temperature of droplet liquid=  85.300    Degree C
Density of air-steam mixture= 1.54239E-03 G/CC
Viscosity of air-steam mixture= 1.82127E-04 Poise
Density of droplet liquid=  .96843    G/CC
Viscosity of droplet liquid= 3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.6187
Schmidt number for methyl iodine=  1.2357
Grashof number= 8.05102E+12
Try mean diameter= 8.83115E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.8311E-02   7.226      241.7       10.70       323.2      721.4

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC       /HR

35  8.8311E-02   1.359      .1552       .4001     3.1205E-03    5.393

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  5.3945    per hour

Particulate iodine removal constant=  .63567    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter= 8.83115E-02
Temperature of air-steam mixture=  85.300    Degree C
Pressure of air-steam mixture=  1.7800    Atm.
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Temperature of droplet liquid=  85.300     Degree C
Density of air-steam mixture=  1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=  .96843     G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.6187
Schmidt number for methyl iodine=  1.2357
Grashof number=  8.05102E+12
Try mean diameter=  8.84947E-02

Drop parameters for elemental
      (For mean drop)

 I   Diameter    Fall Time   Reynolds   M.T.Coeff G    T.V.      drop no.
       CM           SEC                   CM/SEC      CM/SEC

35  8.8495E-02    7.547       242.7       10.70       323.8       954.2

 I   Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                              CM/SEC       /HR

35  8.8495E-02    1.361       .1615       .4121     3.1141E-03    5.556

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  5.5567     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.84947E-02
Temperature of air-steam mixture=   85.300     Degree C
Pressure of air-steam mixture=   1.7800     Atm.
Temperature of droplet liquid=  85.300     Degree C
Density of air-steam mixture=  1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=  .96843     G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.6187
Schmidt number for methyl iodine=  1.2357
Grashof number=  1.52144E+13
Try mean diameter=  8.88932E-02

Drop parameters for elemental
      (For mean drop)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
36	8.8893E-02	9.060	244.7	10.68	325.0	1173.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
36	8.8893E-02	1.366	.1921	.4672	3.1001E-03	4.499

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 4.4990 per hour

Particulate iodine removal constant= .56136 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.1040 per hour

Organic removal rate due to wall deposition= .C0000 per hour

Mean drop diameter= 8.88932E-02
Temperature of air-steam mixture= 85.300 Degree C
Pressure of air-steam mixture= 1.7800 Atm.
Temperature of droplet liquid= 85.300 Degree C
Density of air-steam mixture= 1.54239E-03 G/CC
Viscosity of air-steam mixture= 1.82127E-04 Poise
Density of droplet liquid= .96843 G/CC
Viscosity of droplet liquid= 3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6187
Schmidt number for methyl iodine= 1.2357
Grashof number= 1.52144E+13
Try mean diameter= 9.01980E-02

Drop parameters for elemental
(For mean drop)

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
36	9.0198E-02	10.16	251.4	10.65	329.1	2331.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
36	9.0198E-02	1.382	.2093	.4985	3.0553E-03	4.800

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 4.8015 per hour

Particulate iodine removal constant= .56136 per hour

Total organic removal constant= .00000 per hour

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.01980E-02
Temperature of air-steam mixture=   85.300    Degree C
Pressure of air-steam mixture=   1.7800    Atm.
Temperature of droplet liquid=   85.300    Degree C
Density of air-steam mixture=  1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=   .96843    G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6187
Schmidt number for methyl iodine=   1.2357
Grashof number=  1.62191E+13
Try mean diameter=  9.05139E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time   Reynolds    M.T.Coeff G    T.V.      drop no.
       CM          SEC                    CM/SEC       CM/SEC

36  9.0514E-02    9.120       253.0       10.64        330.1      3493.

 I   Diameter    Sherwood     Time       Sat. Frac.  M.T.Coeff L   Removal
       CM                                              CM/SEC       /HR

36  9.0514E-02    1.386       .1865       .4614      3.0446E-03   4.443

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.4441    per hour

Particulate iodine removal constant=   .57345    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.05139E-02
Temperature of air-steam mixture=   85.300    Degree C
Pressure of air-steam mixture=   1.7800    Atm.
Temperature of droplet liquid=   85.300    Degree C
Density of air-steam mixture=  1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=   .96843    G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0.	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Diff. coeff. of elemental I2 in droplet liquid= 4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6187
Schmidt number for methyl iodine= 1.2357
Grashof number= 1.62191E+13
Try mean diameter= 9.07411E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0741E-02   10.33      254.2       10.64       330.8       4649.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

36  9.0741E-02   1.388      .2101       .5010      3.0370E-03    4.825

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.8255    per hour

Particulate iodine removal constant=   .57345    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter= 9.07411E-02
Temperature of air-steam mixture=   85.300    Degree C
Pressure of air-steam mixture=   1.7800    Atm.
Temperature of droplet liquid=   85.300    Degree C
Density of air-steam mixture= 1.54239E-03 G/CC
Viscosity of air-steam mixture= 1.82127E-04 Poise
Density of droplet liquid=   .96843    G/CC
Viscosity of droplet liquid= 3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6187
Schmidt number for methyl iodine= 1.2357
Grashof number= 2.07858E+13
Try mean diameter= 9.08429E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0843E-02   9.947      254.8       10.64       331.1       5805.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR
```

```
36  9.0843E-02   1.390      .2019      .4881     3.0336E-03   2.350

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.3503     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.08429E-02
Temperature of air-steam mixture=   85.300     Degree C
Pressure of air-steam mixture=   1.7800     Atm.
Temperature of droplet liquid=   85.300     Degree C
Density of air-steam mixture=  1.54239E-03 G/CC
Viscosity of air-steam mixture=  1.82127E-04 Poise
Density of droplet liquid=   .96843     G/CC
Viscosity of droplet liquid=  3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6187
Schmidt number for methyl iodine=   1.2357
Grashof number=  2.07858E+13
Try mean diameter=  9.09189E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter    Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                   CM/SEC      CM/SEC

36  9.0919E-02   10.29      255.1       10.63       331.4       6959.

 I   Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC       /HR

36  9.0919E-02   1.391      .2086      .4991     3.0311E-03   2.403

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.4032     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter= 9.09189E-02
Temperature of air-steam mixture= 85.300 Degree C
Pressure of air-steam mixture= 1.7800 Atm.
Temperature of droplet liquid= 85.300 Degree C
Density of air-steam mixture= 1.54239E-03 G/CC
Viscosity of air-steam mixture= 1.82127E-04 Poise
Density of droplet liquid= .96843 G/CC
Viscosity of droplet liquid= 3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6187
Schmidt number for methyl iodine= 1.2357
Grashof number= 2.13430E+13
Try mean diameter= 9.09623E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
        CM          SEC                  CM/SEC      CM/SEC

36  9.0962E-02   10.03      255.4       10.63        331.5      8114.

 I   Diameter    Sherwood    Time     Sat. Frac.  M.T.Coeff L  Removal
        CM                                          CM/SEC       /HR

36  9.0962E-02   1.391      .2031       .4902      3.0296E-03   2.360

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 2.3607 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.1040 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.09623E-02
Temperature of air-steam mixture= 85.300 Degree C
Pressure of air-steam mixture= 1.7800 Atm.
Temperature of droplet liquid= 85.300 Degree C
Density of air-steam mixture= 1.54239E-03 G/CC
Viscosity of air-steam mixture= 1.82127E-04 Poise
Density of droplet liquid= .96843 G/CC
Viscosity of droplet liquid= 3.34328E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.29496E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.55598E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.18831E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.52306E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6187
Schmidt number for methyl iodine= 1.2357
Grashof number= 2.13430E+13
Try mean diameter= 9.10041E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Drop parameters for elemental
      (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

36  9.1004E-02   10.38      255.6       10.63        331.6       9267.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
        CM                                           CM/SEC        /HR

36  9.1004E-02   1.392      .2100       .5015      3.0282E-03   2.414

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.4147     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.10041E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.4 2 to 4 hr Output File (*I2-max02.out*)

```
Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date_________
Project   SONGS                                   Job No. 16575-167
Subject  I2 Spray Max Temp 2 - 4 hr               Sheet No.       1
=======================================================================


                ______________________________________
               |                                      |
               |       Standard Computer Program      |
               |       NE305 REMOVE  Version 4.0      |
               |        for the IBM PC/XT/AT          |
               |                                      |
               |______________________________________|


               Abstract:

               The REMOVE program calculates the containment
               spray removal rate constants and a mean drop
               diameter or drop trajectories


     Output in file I2-max02.out was created on 14 Jun 2003  at 11: 2:57

Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date_________
Project   SONGS                                   Job No. 16575-167
Subject  I2 Spray Max Temp 2 - 4 hr               Sheet No.       2
=======================================================================


Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798      Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=    .95798      G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2039
Grashof number=  9.52447E+12
Try mean diameter=  8.72943E-02

Drop parameters for elemental
          (For mean drop)

  I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
         CM         SEC                   CM/SEC      CM/SEC

 35  8.7294E-02   7.276       264.5       9.630        301.2       243.3

  I    Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
         CM                                             CM/SEC       /HR

 35  8.7294E-02   1.027       .1979       .4018      3.9060E-03    5.156

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.1578     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.72943E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798     Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798      G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  9.52447E+12
Try mean diameter=  8.81753E-02

Drop parameters for elemental
          (For mean drop)

  I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
         CM         SEC                   CM/SEC      CM/SEC

 35  8.8175E-02   7.524       269.4       9.609        303.8       477.0

  I    Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
         CM                                             CM/SEC       /HR

 35  8.8175E-02   1.035       .2006       .4079      3.8669E-03    5.234
```

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.2355     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter= 8.81753E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=  2.2798     Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798    G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  1.17514E+13
Try mean diameter=  8.84958E-02

Drop parameters for elemental
        (For mean drop)

 I    Diameter    Fall Time   Reynolds   M.T.Coeff G    T.V.      drop no.
         CM          SEC                   CM/SEC      CM/SEC

35   8.8496E-02   7.763       271.2       9.602        304.7      707.6

 I    Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
         CM                                              CM/SEC      /HR

35   8.8496E-02   1.038       .2055       .4159      3.8529E-03    5.337

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.3378     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.84958E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=  2.2798     Atm.
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798      G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  1.17514E+13
Try mean diameter=  8.86265E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.8627E-02   8.069      272.0       9.599       305.1       936.0

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC       /HR

35  8.8627E-02   1.039      .2129       .4272     3.8472E-03    5.482

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.4826     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.86265E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798     Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798      G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  2.22073E+13
Try mean diameter=  8.90382E-02

Drop parameters for elemental
       (For mean drop)
```

```
 I   Diameter    Fall Time   Reynolds    M.T.Coeff G    T.V.      drop no.
       CM          SEC                      CM/SEC      CM/SEC

36  8.9018E-02   9.717       274.2        9.590        306.2      1150.

 I   Diameter    Sherwood     Time       Sat. Frac.  M.T.Coeff L   Removal
       CM                                              CM/SEC        /HR

36  8.9018E-02   1.043       .2542        .4854      3.8303E-03   4.449

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.4490     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.90182E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798      Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=    .95798      G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  2.22073E+13
Try mean diameter=  9.02519E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time   Reynolds    M.T.Coeff G    T.V.      drop no.
       CM          SEC                      CM/SEC      CM/SEC

36  9.0252E-02   10.76       281.2        9.561        309.8      2286.

 I   Diameter    Sherwood     Time       Sat. Frac.  M.T.Coeff L   Removal
       CM                                              CM/SEC        /HR

36  9.0252E-02   1.054       .2737        .5135      3.7780E-03   4.707

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.7077     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour
```

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.02519E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798     Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798     G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  2.36737E+13
Try mean diameter=  9.05520E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                   CM/SEC     CM/SEC

36  9.0552E-02   9.792      283.0       9.554       310.6       3426.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC        /HR

36  9.0552E-02   1.057      .2475       .4803      3.7654E-03   4.402

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.4033     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9732     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.05520E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798     Atm.
Temperature of droplet liquid=   100.70     Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798     G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
```

```
Diff. coeff. of elemental I2 in droplet liquid= 5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5808
Schmidt number for methyl iodine= 1.2039
Grashof number= 2.36737E+13
Try mean diameter= 9.07675E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0768E-02   10.93      284.2       9.549       311.3      4559.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC      /HR

36  9.0768E-02   1.059      .2750       .5164      3.7565E-03   4.733

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.7341     per hour

Particulate iodine removal constant=   .57345    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.9732    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter= 9.07675E-02
Temperature of air-steam mixture=   100.70     Degree C
Pressure of air-steam mixture=   2.2798     Atm.
Temperature of droplet liquid=   100.70    Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=   .95798     G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5808
Schmidt number for methyl iodine=   1.2039
Grashof number=  3.03393E+13
Try mean diameter=  9.08660E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0866E-02   10.67      284.8       9.547       311.5      5693.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC      /HR
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
36  9.0866E-02  1.060     .2680     .5078     3.7524E-03  2.327

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  2.3273    per hour

Particulate iodine removal constant=  .31145    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.9732    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.08660E-02
Temperature of air-steam mixture=  100.70    Degree C
Pressure of air-steam mixture=  2.2798    Atm.
Temperature of droplet liquid=  100.70    Degree C
Density of air-steam mixture=  1.79680E-03 G/CC
Viscosity of air-steam mixture=  1.78625E-04 Poise
Density of droplet liquid=  .95798    G/CC
Viscosity of droplet liquid=  2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.5808
Schmidt number for methyl iodine=  1.2039
Grashof number=  3.03393E+13
Try mean diameter=  9.09375E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM         SEC                   CM/SEC      CM/SEC

36  9.0937E-02   11.00      285.2      9.545       311.7      6824.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC      /HR

36  9.0937E-02   1.060      .2758      .5178      3.7495E-03   2.373

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  2.3730    per hour

Particulate iodine removal constant=  .31145    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  4.9732    per hour

Organic removal rate due to wall deposition=  .00000    per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Mean drop diameter= 9.09375E-02
Temperature of air-steam mixture= 100.70 Degree C
Pressure of air-steam mixture= 2.2798 Atm.
Temperature of droplet liquid= 100.70 Degree C
Density of air-steam mixture= 1.79680E-03 G/CC
Viscosity of air-steam mixture= 1.78625E-04 Poise
Density of droplet liquid= .95798 G/CC
Viscosity of droplet liquid= 2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5808
Schmidt number for methyl iodine= 1.2039
Grashof number= 3.11526E+13
Try mean diameter= 9.09787E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

36  9.0979E-02   10.76      285.4       9.545        311.9      7957.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
        CM                                          CM/SEC       /HR

36  9.0979E-02   1.061      .2696       .5101     3.7478E-03    2.338

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 2.3377 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 4.9732 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.09787E-02
Temperature of air-steam mixture= 100.70 Degree C
Pressure of air-steam mixture= 2.2798 Atm.
Temperature of droplet liquid= 100.70 Degree C
Density of air-steam mixture= 1.79680E-03 G/CC
Viscosity of air-steam mixture= 1.78625E-04 Poise
Density of droplet liquid= .95798 G/CC
Viscosity of droplet liquid= 2.81823E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 6.28893E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 8.25769E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 5.18208E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 5.59625E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5808
Schmidt number for methyl iodine= 1.2039
Grashof number= 3.11526E+13
Try mean diameter= 9.10180E-02
```

Drop parameters for elemental
(For mean drop)

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
36	9.1018E-02	11.09	285.6	9.544	312.0	9088.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
36	9.1018E-02	1.061	.2776	.5203	3.7462E-03	2.384

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 2.3844 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 4.9732 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.10180E-02

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.5 4 to 8 hr Output File (*i2-max03.out*)

```
Bechtel Standard Computer Program        REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz            Date 14 Jun 2003  Checked_______Date________
Project   SONGS                                   Job No. 16575-167
Subject   I2 Spray Max Temp 4 - 8 hr              Sheet No.       1
================================================================================




              ________________________________________
             |                                        |
             |         Standard Computer Program      |
             |         NE305 REMOVE  Version 4.0      |
             |          for the IBM PC/XT/AT          |
             |                                        |
             |________________________________________|


             Abstract:

             The REMOVE program calculates the containment
             spray removal rate constants and a mean drop
             diameter or drop trajectories



     Output in file I2-max03.out was created on 14 Jun 2003  at 11: 4:49

Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz            Date 14 Jun 2003  Checked_______Date________
Project   SONGS                                   Job No. 16575-167
Subject   I2 Spray Max Temp 4 - 8 hr              Sheet No.       2
================================================================================


Temperature of air-steam mixture=   95.300      Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178      G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2145
Grashof number=  8.33401E+12
Try mean diameter=  8.82054E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.8205E-02   7.003      258.6       10.02       311.1      235.8

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

35  8.8205E-02   1.328      .1736       .4279     3.5973E-03    4.796

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.7970     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.82054E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178     G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  8.33401E+12
Try mean diameter=  8.86292E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

35  8.8629E-02   7.295      260.9       10.01       312.3      462.2

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

35  8.8629E-02   1.333      .1791       .4386     3.5801E-03    4.915
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.9155     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.86292E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178     G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  1.02826E+13
Try mean diameter=  8.87986E-02

Drop parameters for elemental
      (For mean drop)

 I   Diameter    Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC       CM/SEC

36  8.8799E-02   7.523      261.8       10.00        312.8       685.6

 I   Diameter    Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

36  8.8799E-02   1.335      .1840       .4474      3.5733E-03    5.014

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.0145     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  8.87986E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178      G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  1.02826E+13
Try mean diameter=  9.01178E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0118E-02   7.745      269.0       9.972       316.8       1361.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

36  9.0118E-02   1.350      .1840       .4503      3.5210E-03    5.047

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   5.0483     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.01178E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799      Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178      G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  1.94316E+13
Try mean diameter=  9.07008E-02

Drop parameters for elemental
        (For mean drop)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                   CM/SEC      CM/SEC

36  9.0701E-02   9.295       272.3       9.958       318.5      2024.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

36  9.0701E-02   1.357       .2179       .5071     3.4984E-03   4.060

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.0605     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.07008E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178     G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  1.94316E+13
Try mean diameter=  9.09045E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                   CM/SEC      CM/SEC

36  9.0905E-02   10.46       273.4       9.953       319.1      2680.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

36  9.0905E-02   1.360       .2442       .5466     3.4905E-03   4.376

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.3762     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour
```

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.C9045E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178     G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  2.07146E+13
Try mean diameter=  9.09338E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM         SEC                    CM/SEC      CM/SEC

36  9.0934E-02   9.491       273.5       9.953       319.2      3340.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC      /HR

36  9.0934E-02   1.360       .2214       .5130     3.4894E-03   4.107

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.1072     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.09338E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178     G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
```

```
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  2.07148E+13
Try mean diameter=  9.10300E-02

Drop parameters for elemental
      (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                  CM/SEC       CM/SEC

36  9.1030E-02   10.67      274.1       9.950       319.5       3995.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

36  9.1030E-02   1.361      .2483       .5528      3.4857E-03    4.425

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.4252     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.10300E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178      G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  2.65472E+13
Try mean diameter=  9.10625E-02

Drop parameters for elemental
      (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                  CM/SEC       CM/SEC

36  9.1062E-02   10.37      274.3       9.950       319.6       4649.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR
```

```
36  9.1062E-02   1.361     .2412     .5426     3.4845E-03   2.172

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.1722     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.10625E-02
Temperature of air-steam mixture=   95.300     Degree C
Pressure of air-steam mixture=   2.0799     Atm.
Temperature of droplet liquid=   95.300     Degree C
Density of air-steam mixture=  1.69468E-03 G/CC
Viscosity of air-steam mixture=  1.79819E-04 Poise
Density of droplet liquid=   .96178     G/CC
Viscosity of droplet liquid=  2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.5934
Schmidt number for methyl iodine=   1.2145
Grashof number=  2.65472E+13
Try mean diameter=  9.10951E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

36  9.1095E-02   10.71      274.4       9.949       319.7       5302.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

36  9.1095E-02   1.362     .2489      .5537      3.4832E-03    2.216

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.2163     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter= 9.10951E-02
Temperature of air-steam mixture= 95.300 Degree C
Pressure of air-steam mixture= 2.0799 Atm.
Temperature of droplet liquid= 95.300 Degree C
Density of air-steam mixture= 1.69468E-03 G/CC
Viscosity of air-steam mixture= 1.79819E-04 Poise
Density of droplet liquid= .96178 G/CC
Viscosity of droplet liquid= 2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5934
Schmidt number for methyl iodine= 1.2145
Grashof number= 2.72588E+13
Try mean diameter= 9.11070E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds  M.T.Coeff G   T.V.     drop no.
       CM          SEC                 CM/SEC      CM/SEC

36  9.1107E-02   10.46      274.5      9.949       319.7      5956.

 I   Diameter   Sherwood    Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                          CM/SEC       /HR

36  9.1107E-02   1.362      .2431     .5456      3.4828E-03   2.184

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 2.1838 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.0703 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.11070E-02
Temperature of air-steam mixture= 95.300 Degree C
Pressure of air-steam mixture= 2.0799 Atm.
Temperature of droplet liquid= 95.300 Degree C
Density of air-steam mixture= 1.69468E-03 G/CC
Viscosity of air-steam mixture= 1.79819E-04 Poise
Density of droplet liquid= .96178 G/CC
Viscosity of droplet liquid= 2.98466E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 6.65939E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 8.73664E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.82243E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 5.20786E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.5934
Schmidt number for methyl iodine= 1.2145
Grashof number= 2.72588E+13
Try mean diameter= 9.11287E-02
```

```
Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

36  9.1129E-02   10.80      274.6       9.948        319.8      6608.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC       /HR

36  9.1129E-02   1.362      .2509       .5566      3.4819E-03   2.228

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.2280    per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0703     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.11287E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

9.2.2.6 8 to 13.8 hr Output File (*i2-max04.out*)

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz            Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Max Temp 8 - 13.8 hr           Sheet No.        1
================================================================================



               ____________________________________________
              |                                            |
              |          Standard Computer Program         |
              |          NE305 REMOVE  Version 4.0         |
              |           for the IBM PC/XT/AT             |
              |                                            |
              |____________________________________________|


              Abstract:

              The REMOVE program calculates the containment
              spray removal rate constants and a mean drop
              diameter or drop trajectories



     Output in file I2-max04.out was created on 14 Jun 2003  at 11: 6:43

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz            Date 14 Jun 2003  Checked_______Date_________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Max Temp 8 - 13.8 hr           Sheet No.        2
================================================================================


Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307     Atm.
Temperature of droplet liquid=   87.200     Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=    .96720      G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=    1.6137
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=  1.2316
Grashof number= 6.83231E+12
Try mean diameter= 8.96994E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  8.9699E-02   6.635      251.9       10.54       325.4       224.2

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

36  8.9699E-02   2.034      .1420       .4714     3.1583E-03    4.135

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  4.1359    per hour

Particulate iodine removal constant=   .59268    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter= 8.95994E-02
Temperature of air-steam mixture=  87.200    Degree C
Pressure of air-steam mixture=  1.8307    Atm.
Temperature of droplet liquid=  87.200    Degree C
Density of air-steam mixture= 1.56799E-03 G/CC
Viscosity of air-steam mixture= 1.81696E-04 Poise
Density of droplet liquid=  .96720    G/CC
Viscosity of droplet liquid= 3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.6137
Schmidt number for methyl iodine=  1.2316
Grashof number= 6.83231E+12
Try mean diameter= 9.06480E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0648E-02   6.903      256.9       10.52       328.4       439.9

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

36  9.0648E-02   2.051      .1447       .4793     3.1252E-03    4.204
```

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  4.2049     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.06480E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307     Atm.
Temperature of droplet liquid=   87.200     Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720     G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  8.42980E+12
Try mean diameter=  9.09719E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

36  9.0972E-02   7.083      258.6      10.51       329.4      652.8

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
      .CM                                            CM/SEC      /HR

36  9.0972E-02   2.056      .1474      .4859     3.1141E-03   4.262

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  4.2624     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.09719E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307     Atm.
```

```
Temperature of droplet liquid=   87.200     Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720     G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  8.42980E+12
Try mean diameter=  9.11175E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                   CM/SEC      CM/SEC

36  9.1117E-02   7.406      259.3       10.51       329.8      863.6

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

36  9.1117E-02   2.059      .1536       .4996     3.1091E-03    4.382

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   4.3825     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.11175E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307     Atm.
Temperature of droplet liquid=   87.200     Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720     G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  1.59302E+13
Try mean diameter=  9.15150E-02

Drop parameters for elemental
        (For mean drop)
```

```
 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

37  9.1515E-02   8.888      261.4       10.50       331.0       1061.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                           CM/SEC       /HR

37  9.1515E-02   2.066      .1828       .5584     3.0956E-03   3.498

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.4988     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.15150E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307     Atm.
Temperature of droplet liquid=   87.200     Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720     G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  1.59302E+13
Try mean diameter=  9.27607E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter.  Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

37  9.2761E-02   10.00      268.0       10.47       334.8       2109.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                           CM/SEC       /HR

37  9.2761E-02   2.088      .2002       .5925     3.0540E-03   3.712

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.7124     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.1040 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.27607E-02
Temperature of air-steam mixture= 87.200 Degree C
Pressure of air-steam mixture= 1.8307 Atm.
Temperature of droplet liquid= 87.200 Degree C
Density of air-steam mixture= 1.56799E-03 G/CC
Viscosity of air-steam mixture= 1.81696E-04 Poise
Density of droplet liquid= .96720 G/CC
Viscosity of droplet liquid= 3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6137
Schmidt number for methyl iodine= 1.2316
Grashof number= 1.69822E+13
Try mean diameter= 9.30501E-02

Drop parameters for elemental
(For mean drop)

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
37	9.3050E-02	8.960	269.6	10.46	335.7	3160.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
37	9.3050E-02	2.093	.1782	.5531	3.0445E-03	3.465

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 3.4661 per hour

Particulate iodine removal constant= .57345 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.1040 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.30501E-02
Temperature of air-steam mixture= 87.200 Degree C
Pressure of air-steam mixture= 1.8307 Atm.
Temperature of droplet liquid= 87.200 Degree C
Density of air-steam mixture= 1.56799E-03 G/CC
Viscosity of air-steam mixture= 1.81696E-04 Poise
Density of droplet liquid= .96720 G/CC
Viscosity of droplet liquid= 3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= 9.40902E-02 sq. cm/sec

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Diff. coeff. of elemental I2 in droplet liquid= 4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  1.69822E+13
Try mean diameter=  9.32719E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3272E-02   10.83       252.0      10.14        313.1       4205.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

37  9.3272E-02   2.034       .2143      .6095      3.0373E-03    3.819

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.7304     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.32719E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307     Atm.
Temperature of droplet liquid=   87.200     Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720      G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  2.17637E+13
Try mean diameter=  9.33660E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3366E-02   9.776       271.3      10.45        336.7       5251.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR
```

```
 37  9.3366E-02   2.099      .1931      .5813     3.0342E-03   1.821

 ***********SPRAY REMOVAL RATES***********

 Total elemental removal constant=   1.8212      per hour

 Particulate iodine removal constant=   .31145     per hour

 Total organic removal constant=   .00000     per hour

 *****REMOVAL DUE TO WALL DEPOSITION*****

 Elemental removal rate due to wall deposition =   5.1040     per hour

 Organic removal rate due to wall deposition=   .00000     per hour

 Mean drop diameter=  9.33660E-02
 Temperature of air-steam mixture=   87.200     Degree C
 Pressure of air-steam mixture=   1.8307     Atm.
 Temperature of droplet liquid=   87.200     Degree C
 Density of air-steam mixture=  1.56799E-03 G/CC
 Viscosity of air-steam mixture=  1.81696E-04 Poise
 Density of droplet liquid=   .96720     G/CC
 Viscosity of droplet liquid=  3.26947E-03 Poise
 Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
 Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
 Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
 Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
 Schmidt number for elemental iodine=   1.6137
 Schmidt number for methyl iodine=   1.2316
 Grashof number=  2.17637E+13
 Try mean diameter=  9.34385E-02

 Drop parameters for elemental
           (For mean drop)

  I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
         CM         SEC                   CM/SEC      CM/SEC

 37  9.3439E-02   10.12      271.7       10.45       336.9      6294.

  I    Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
         CM                                           CM/SEC       /HR

 37  9.3439E-02   2.100      .1997      .5930     3.0319E-03   1.858

 ***********SPRAY REMOVAL RATES***********

 Total elemental removal constant=   1.8577      per hour

 Particulate iodine removal constant=   .31145     per hour

 Total organic removal constant=   .00000     per hour

 *****REMOVAL DUE TO WALL DEPOSITION*****

 Elemental removal rate due to wall deposition =   5.1040     per hour

 Organic removal rate due to wall deposition=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter=  9.34385E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307      Atm.
Temperature of droplet liquid=   87.200      Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720     G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  2.23471E+13
Try mean diameter=  9.34788E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                  CM/SEC      CM/SEC

37  9.3479E-02   9.859      271.9       10.45       337.0       7339.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC       /HR

37  9.3479E-02   2.101      .1943       .5837     3.0306E-03   1.828

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.8285     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.34788E-02
Temperature of air-steam mixture=   87.200     Degree C
Pressure of air-steam mixture=   1.8307      Atm.
Temperature of droplet liquid=   87.200      Degree C
Density of air-steam mixture=  1.56799E-03 G/CC
Viscosity of air-steam mixture=  1.81696E-04 Poise
Density of droplet liquid=   .96720     G/CC
Viscosity of droplet liquid=  3.26947E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.18078E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  9.40902E-02 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  4.30557E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.64969E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6137
Schmidt number for methyl iodine=   1.2316
Grashof number=  2.23471E+13
Try mean diameter=  9.35188E-02
```

```
Drop parameters for elemental
      (For mean drop)

 I   Diameter  Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
        CM        SEC                  CM/SEC      CM/SEC

37  9.3519E-02   10.21      272.1       10.45       337.2      8382.

 I   Diameter  Sherwood     Time     Sat. Frac.  M.T.Coeff L  Removal
        CM                                          CM/SEC       /HR

37  9.3519E-02   2.102      .2010       .5955     3.0293E-03   1.865

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.8656     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =    5.1040     per hour

Organic removal rate due to wall deposition=    .00000     per hour

Mean drop diameter=  9.35188E-02
```

9.2.2.7 13.8 to 24 hr Output File (*i2-max05.out*)

```
Bechtel Standard Compute:: Program        REMOVE , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz           Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Max Temp 13.8 - 24 hr            Sheet No.       1
===============================================================================



          ____________________________________________________
         |                                                    |
         |              Standard Computer Program             |
         |              NE305 REMOVE  Version 4.0             |
         |               for the IBM PC/XT/AT                 |
         |                                                    |
         |____________________________________________________|


          Abstract:

          The REMOVE program calculates the containment
          spray removal rate constants and a mean drop
          diameter or drop trajectories



  Output in file I2-max05.out was created on 14 Jun 2003  at 11: 8:42

Bechtel Standard Computer Program        REMOVE , NE305 Version 4.0
(c) 1991                                           Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz           Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                     Job No. 16575-167
Subject  I2 Spray Max Temp 13.8 - 24 hr            Sheet No.       2
===============================================================================


Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=   1.6155    Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278     G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Schmidt number for methyl iodine=   1.2509
Grashof number=  5.52826E+12
Try mean diameter=  9.11396E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

36  9.1140E-02   6.306       246.0       11.03       339.4       213.8

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

36  9.1140E-02   3.335       .1145       .5160      2.7214E-03    3.352

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.3524     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.11396E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=   1.6155     Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278     G/CC
Viscosity of droplet liquid=   3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  5.52826E+12
Try mean diameter=  9.13685E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.1369E-02   6.635       247.1       11.03       340.1       419.1

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

37  9.1369E-02   3.341       .1198       .5309      2.7146E-03    3.449
```

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.4494     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.13685E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=   1.6155     Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278     G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  6.82084E+12
Try mean diameter=  9.26863E-02

Drop parameters for elemental
          (For mean drop)

  I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
         CM         SEC                  CM/SEC      CM/SEC

 37  9.2686E-02   6.718      253.8       10.99       344.3      829.0

  I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
         CM                                           CM/SEC       /HR

 37  9.2686E-02   3.379      .1179       .5281     2.6760E-03   3.431

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.4322     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.26863E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=   1.6155     Atm.
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Temperature of droplet liquid=   78.300      Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278      G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053      sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  6.82084E+12
Try mean diameter=  9.30996E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3100E-02   7.034      255.9       10.98       345.6       1237.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC       /HR

37  9.3100E-02   3.391      .1224       .5407      2.6641E-03   3.513

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   3.5138      per hour

Particulate iodine removal constant=   .63567      per hour

Total organic removal constant=   .00000      per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040      per hour

Organic removal rate due to wall deposition=   .00000      per hour

Mean drop diameter=  9.30996E-02
Temperature of air-steam mixture=   78.300      Degree C
Pressure of air-steam mixture=   1.6155      Atm.
Temperature of droplet liquid=   78.300      Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278      G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053      sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  1.28897E+13
Try mean diameter=  9.34342E-02

Drop parameters for elemental
         (For mean drop)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3484E-02   8.423      257.8       10.97       346.9       1632.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

37  9.3484E-02   3.402      .1453       .5976     2.6532E-03    2.773

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.7736     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.34842E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=   1.6155      Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278      G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  1.28897E+13
Try mean diameter=  9.36256E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3626E-02   9.670      258.6       10.97       347.3       2022.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

37  9.3626E-02   3.406      .1663       .6430     2.6492E-03    2.984

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.9840     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour
```

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .C0000     per hour

Mean drop diameter=  9.36256E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=    1.6155     Atm.
Temperature of droplet liquid=    78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278     G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  1.37409E+13
Try mean diameter=  9.35890E-02

Drop parameters for elemental
         (For mean drop)

  I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

 37  9.3589E-02   8.614      258.4       10.97       347.2       2417.

  I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
        CM                                            CM/SEC        /HR

 37  9.3589E-02   3.405      .1483       .6045      2.6502E-03   2.805

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.8056     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.35890E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=    1.6155     Atm.
Temperature of droplet liquid=    78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278     G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Diff. coeff. of elemental I2 in droplet liquid= 3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6371
Schmidt number for methyl iodine= 1.2509
Grashof number= 1.37409E+13
Try mean diameter= 9.36747E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.3675E-02   9.867      258.8       10.97        347.5      2806.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC       /HR

37  9.3675E-02   3.407      .1695       .6495     2.6478E-03   3.014

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  3.0140    per hour

Particulate iodine removal constant=  .57345    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter= 9.36747E-02
Temperature of air-steam mixture=  78.300    Degree C
Pressure of air-steam mixture=  1.6155    Atm.
Temperature of droplet liquid=  78.300    Degree C
Density of air-steam mixture= 1.45989E-03 G/CC
Viscosity of air-steam mixture= 1.83598E-04 Poise
Density of droplet liquid=  .97278    G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  .10053    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6371
Schmidt number for methyl iodine= 1.2509
Grashof number= 1.76090E+13
Try mean diameter= 9.36812E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.3681E-02   9.424      258.8       10.97        347.5      3195.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC       /HR
```

```
37  9.3681E-02   3.408      .1619      .6340      2.6476E-03   1.471

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.4712     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.36812E-02
Temperature of air-steam mixture=   78.300     Degree C
Pressure of air-steam mixture=   1.6155     Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278     G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  1.76098E+13
Try mean diameter=  9.37034E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.3703E-02   9.785      258.9       10.97       347.5       3582.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC       /HR

37  9.3703E-02   3.408      .1680      .6465      2.6470E-03   1.500

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.5002     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Mean drop diameter= 9.37034E-02
Temperature of air-steam mixture=   78.300      Degree C
Pressure of air-steam mixture=   1.6155     Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278      G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  1.80818E+13
Try mean diameter=  9.36992E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3699E-02   9.513      258.9       10.97       347.5      3971.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

37  9.3699E-02   3.408      .1634       .6371     2.6471E-03    1.478

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.4783     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.36992E-02
Temperature of air-steam mixture=   78.300      Degree C
Pressure of air-steam mixture=   1.6155     Atm.
Temperature of droplet liquid=   78.300     Degree C
Density of air-steam mixture=  1.45989E-03 G/CC
Viscosity of air-steam mixture=  1.83598E-04 Poise
Density of droplet liquid=   .97278      G/CC
Viscosity of droplet liquid=  3.64212E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  7.68196E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10053     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.76958E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  4.07086E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6371
Schmidt number for methyl iodine=   1.2509
Grashof number=  1.80818E+13
Try mean diameter=  9.37158E-02
```

E&TS DEPARTMENT
CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ___ OF ___
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ______ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Drop parameters for elemental
      (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

37  9.3716E-02    9.875      259.0      10.97        347.6      4357.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
        CM                                           CM/SEC        /HR

37  9.3716E-02    3.409      .1695      .6495      2.6466E-03    1.507

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.5072     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.37158E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

9.2.2.8 24 to 48 hr Output File (*i2-max06.out*)

```
Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Max Temp 24 - 48 hr            Sheet No.      1
=========================================================================


            ------------------------------------------------
            |                                              |
            |          Standard Computer Program           |
            |          NE305 REMOVE  Version 4.0           |
            |            for the IBM PC/XT/AT              |
            |                                              |
            |______________________________________________|


            Abstract:

            The REMOVE program calculates the containment
            spray removal rate constants and a mean drop
            diameter or drop trajectories


     Output in file I2-max06.out was created on 14 Jun 2003  at 11:10:43

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                         Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                   Job No. 16575-167
Subject  I2 Spray Max Temp 24 - 48 hr            Sheet No.      2
=========================================================================

Temperature of air-steam mixture=   69.200      Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=    .97804     G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2704
Grashof number=  4.51192E+12
Try mean diameter=  9.20090E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                   CM/SEC      CM/SEC

37  9.2009E-02    6.064       239.9       11.44       350.4       207.8

 I   Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC        /HR

37  9.2009E-02    5.386     9.3317E-02   .5450     2.3291E-03    2.656

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.6564     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.20090E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804      G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  4.51192E+12
Try mean diameter=  9.30589E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter    Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                   CM/SEC      CM/SEC

37  9.3059E-02    6.349       245.0       11.41       353.9       407.1

 I   Diameter    Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC        /HR

37  9.3059E-02    5.434     9.5520E-02   .5537     2.3028E-03    2.698
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  2.6985     per hour

Particulate iodine removal constant=  .59268     per hour

Total organic removal constant=  .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040     per hour

Organic removal rate due to wall deposition=  .00000     per hour

Mean drop diameter=  9.30589E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804     G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  5.56686E+12
Try mean diameter=  9.34011E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.3401E-02   6.473      246.7      11.40       355.0       604.2

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

37  9.3401E-02   5.450     9.6672E-02   .5579     2.2944E-03   2.718

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  2.7186     per hour

Particulate iodine removal constant=  .63567     per hour

Total organic removal constant=  .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040     per hour

Organic removal rate due to wall deposition=  .00000     per hour

Mean drop diameter=  9.34011E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
```

```
Temperature of droplet liquid=   69.200      Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804      G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  5.56686E+12
Try mean diameter=  9.35667E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3567E-02   6.815      247.5       11.40        355.5       799.3

 I   Diameter   Sherwood     Time       Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC       /HR

37  9.3567E-02   5.457      .1014       .5728      2.2903E-03   2.791

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.7913      per hour

Particulate iodine removal constant=   .63567      per hour

Total organic removal constant=   .00000      per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040      per hour

Organic removal rate due to wall deposition=   .00000      per hour

Mean drop diameter=  9.35667E-02
Temperature of air-steam mixture=   69.200      Degree C
Pressure of air-steam mixture=   1.4459      Atm.
Temperature of droplet liquid=   69.200      Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804      G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  1.05200E+13
Try mean diameter=  9.39547E-02

Drop parameters for elemental
          (For mean drop)
```

```
 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC     CM/SEC

38  9.3955E-02   8.146      249.4       11.39       356.8       983.3

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                             CM/SEC       /HR

38  9.3955E-02   5.475      .1202       .6266      2.2809E-03   2.181

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.1810     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.39547E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804      G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  1.05200E+13
Try mean diameter=  9.52322E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC     CM/SEC

38  9.5232E-02   9.334      255.7       11.36       360.9       1955.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                             CM/SEC       /HR

38  9.5232E-02   5.534      .1341       .6629      2.2503E-03   2.307

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.3075     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.52322E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804     G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  1.12147E+13
Try mean diameter=  9.55312E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

38  9.5531E-02   8.212      257.2       11.35       361.9       2931.

 I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

38  9.5531E-02   5.547      .1172       .6208      2.2432E-03   2.161

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.1611     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.55312E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=   .97804     G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580    sq. cm/sec
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  1.12147E+13
Try mean diameter=  9.57577E-02

Drop parameters for elemental
        (For mean drop)

  I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

 38  9.5758E-02   9.486      258.4       11.34       362.6      3901.

  I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                             CM/SEC      /HR

 38  9.5758E-02   5.558      .1348       .6652     2.2379E-03   2.315

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.3155     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.1040     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.57577E-02
Temperature of air-steam mixture=   69.200     Degree C
Pressure of air-steam mixture=   1.4459     Atm.
Temperature of droplet liquid=   69.200     Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=   1.85045E-04 Poise
Density of droplet liquid=   .97804     G/CC
Viscosity of droplet liquid=   4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10580     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6608
Schmidt number for methyl iodine=   1.2704
Grashof number=  1.43723E+13
Try mean diameter=  9.58539E-02

Drop parameters for elemental
        (For mean drop)

  I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

 38  9.5854E-02   8.969      258.8       11.34       362.9      4872.

  I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                             CM/SEC      /HR
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
38  9.5854E-02   5.562     .1272     .6470     2.2357E-03   1.126

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  1.1260    per hour

Particulate iodine removal constant=  .31145    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.58539E-02
Temperature of air-steam mixture=  69.200    Degree C
Pressure of air-steam mixture=  1.4459    Atm.
Temperature of droplet liquid=  69.200    Degree C
Density of air-steam mixture=  1.37681E-03 G/CC
Viscosity of air-steam mixture=  1.85045E-04 Poise
Density of droplet liquid=  .97804    G/CC
Viscosity of droplet liquid=  4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  .10580    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine=  1.6608
Schmidt number for methyl iodine=  1.2704
Grashof number=  1.43723E+13
Try mean diameter=  9.59290E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G   T.V.     drop no.
       CM         SEC                  CM/SEC      CM/SEC

38  9.5929E-02   9.335     259.2      11.34       363.2      5841.

 I   Diameter   Sherwood    Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                          CM/SEC      /HR

38  9.5929E-02   5.566     .1322     .6592     2.2339E-03   1.147

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  1.1473    per hour

Particulate iodine removal constant=  .31145    per hour

Total organic removal constant=  .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.1040    per hour

Organic removal rate due to wall deposition=  .00000    per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter= 9.59290E-02
Temperature of air-steam mixture= 69.200 Degree C
Pressure of air-steam mixture= 1.4459 Atm.
Temperature of droplet liquid= 69.200 Degree C
Density of air-steam mixture= 1.37681E-03 G/CC
Viscosity of air-steam mixture= 1.85045E-04 Poise
Density of droplet liquid= .97804 G/CC
Viscosity of droplet liquid= 4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= .10580 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6608
Schmidt number for methyl iodine= 1.2704
Grashof number= 1.47576E+13
Try mean diameter= 9.59701E-02

Drop parameters for elemental
        (For mean drop)
```

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
38	9.5970E-02	9.046	259.4	11.34	363.3	6810.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
38	9.5970E-02	5.567	.1280	.6491	2.2330E-03	1.130

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 1.1296 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.1040 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.59701E-02
Temperature of air-steam mixture= 69.200 Degree C
Pressure of air-steam mixture= 1.4459 Atm.
Temperature of droplet liquid= 69.200 Degree C
Density of air-steam mixture= 1.37681E-03 G/CC
Viscosity of air-steam mixture= 1.85045E-04 Poise
Density of droplet liquid= .97804 G/CC
Viscosity of droplet liquid= 4.10621E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 8.09251E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= .10580 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 3.25696E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 3.51727E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6608
Schmidt number for methyl iodine= 1.2704
Grashof number= 1.47576E+13
Try mean diameter= 9.60117E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Drop parameters for elemental
(For mean drop)

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
38	9.6012E-02	9.415	259.6	11.34	363.4	7779.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
38	9.6012E-02	5.569	.1331	.6615	2.2320E-03	1.151

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= 1.1513 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.1040 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.60117E-02

9.2.2.9 48 to 96 hr Output File (*i2- max07.out*)

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Max Temp 48 - 96 hr             Sheet No.       1
=========================================================================


              Standard Computer Program
              NE305 REMOVE  Version 4.0
                for the IBM PC/XT/AT


              Abstract:

              The REMOVE program calculates the containment
              spray removal rate constants and a mean drop
              diameter or drop trajectories


     Output in file I2-max07.out was created on 14 Jun 2003  at 11:12:48

Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz         Date 14 Jun 2003  Checked_______Date________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Max Temp 48 - 96 hr             Sheet No.       2
=========================================================================

Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
Temperature of droplet liquid=   59.000     Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339     G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.2906
Grashof number=  3.68496E+12
Try mean diameter=  9.21541E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.2154E-02   5.893      232.9       11.78       358.5       206.8

 I   Diameter   Sherwood      Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC       /HR

37  9.2154E-02   8.654     7.5662E-02   .5552     1.9464E-03    2.074

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.0745     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.21541E-02
Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
Temperature of droplet liquid=   59.000     Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339     G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  3.68496E+12
Try mean diameter=  9.31201E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

37  9.3120E-02   6.191      237.5       11.75       361.8       405.3

 I   Diameter   Sherwood      Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC       /HR

37  9.3120E-02   8.725     7.7853E-02   .5645     1.9262E-03    2.109
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.1091     per hour

Particulate iodine removal constant=    .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.3?201E-02
Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
Temperature of droplet liquid=   59.000     Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=    .98339     G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  4.54656E+12
Try mean diameter=  9.34340E-02

Drop parameters for elemental
        (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G     T.V.      drop no.
         CM         SEC                  CM/SEC       CM/SEC

37  9.3434E-02   6.300       239.0       11.74        362.8       601.8

 I    Diameter   Sherwood      Time      Sat. Frac.  M.T.Coeff L   Removal
         CM                                              CM/SEC       /HR

37  9.3434E-02   8.748      7.8690E-02   .5679      1.9197E-03   2.122

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.1218     per hour

Particulate iodine removal constant=    .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.34340E-02
Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
```

```
Temperature of droplet liquid=   59.000      Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339      G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  4.54656E+12
Try mean diameter=  9.35877E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                 CM/SEC      CM/SEC

37  9.3588E-02   6.649      239.7       11.74       363.3       796.3

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

37  9.3588E-02   8.760     8.2773E-02   .5827      1.9166E-03   2.177

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   2.1770     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.35877E-02
Temperature of air-steam mixture=   59.000      Degree C
Pressure of air-steam mixture=   1.3023      Atm.
Temperature of droplet liquid=   59.000      Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339      G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  8.59187E+12
Try mean diameter=  9.39515E-02

Drop parameters for elemental
       (For mean drop)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

38  9.3952E-02   7.938      241.5       11.73       364.5       980.4

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
      . CM                                           CM/SEC       /HR

38  9.3952E-02   8.787     9.8067E-02   .6330     1.9092E-03   1.689

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.6891     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.39515E-02
Temperature of air-steam mixture=   59.000      Degree C
Pressure of air-steam mixture=   1.3023      Atm.
Temperature of droplet liquid=   59.000      Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339      G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  8.46825E+12
Try mean diameter=  9.52286E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                  CM/SEC      CM/SEC

38  9.5229E-02   9.109      247.6       11.69       368.8       1950.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                           CM/SEC       /HR

38  9.5229E-02   8.881      .1095       .6672     1.8836E-03   1.780

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.7805     per hour

Particulate iodine removal constant=   .55865     per hour

Total organic removal constant=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.0963    per hour

Organic removal rate due to wall deposition=  .00000    per hour

Mean drop diameter=  9.52286E-02
Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
Temperature of droplet liquid=   59.000     Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339     G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  9.15923E+12
Try mean diameter=  9.55296E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM          SEC                 CM/SEC       CM/SEC

38  9.5530E-02   8.002      249.1      11.69        369.8      2923.

 I   Diameter   Sherwood    Time       Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

38  9.5530E-02   8.903    9.5616E-02    .6271      1.8776E-03   1.673

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.6736    per hour

Particulate iodine removal constant=   .57345    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =  5.0963    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter=  9.55296E-02
Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
Temperature of droplet liquid=   59.000     Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339     G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990     sq. cm/sec
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
Diff. coeff. of elemental I2 in droplet liquid= 2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6858
Schmidt number for methyl iodine= 1.2906
Grashof number= 9.15923E+12
Try mean diameter= 9.57576E-02

Drop parameters for elemental
        (For mean drop)

 I  Diameter   Fall Time  Reynolds   M.T.Coeff G   T.V.     drop no.
      CM         SEC                  CM/SEC      CM/SEC

38  9.5758E-02   9.299     250.2      11.68       370.5     3890.

 I  Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
      CM                                           CM/SEC      /HR

38  9.5758E-02   8.919     .1106      .6705      1.8732E-03   1.789

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.7894    per hour

Particulate iodine removal constant=   .57345    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter= 9.57576E-02
Temperature of air-steam mixture=   59.000    Degree C
Pressure of air-steam mixture=   1.3023    Atm.
Temperature of droplet liquid=   59.000    Degree C
Density of air-steam mixture= 1.30967E-03 G/CC
Viscosity of air-steam mixture= 1.85751E-04 Poise
Density of droplet liquid=   .98339    G/CC
Viscosity of droplet liquid= 4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number= 1.17381E+13
Try mean diameter= 9.58512E-02

Drop parameters for elemental
        (For mean drop)

 I  Diameter   Fall Time  Reynolds   M.T.Coeff G   T.V.     drop no.
      CM         SEC                  CM/SEC      CM/SEC

38  9.5851E-02   8.743     250.6      11.68       370.9     4858.

 I  Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L  Removal
      CM                                           CM/SEC      /HR
```

```
38  9.5851E-02   8.926      .1038       .6517      1.8713E-03   .8695

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .86955     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.50512E-02
Temperature of air-steam mixture=   59.000     Degree C
Pressure of air-steam mixture=   1.3023     Atm.
Temperature of droplet liquid=   59.000     Degree C
Density of air-steam mixture=  1.30967E-03 G/CC
Viscosity of air-steam mixture=  1.85751E-04 Poise
Density of droplet liquid=   .98339     G/CC
Viscosity of droplet liquid=  4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .10990     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.6858
Schmidt number for methyl iodine=   1.2906
Grashof number=  1.17381E+13
Try mean diameter=  9.59264E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC       CM/SEC

38  9.5926E-02   9.116      251.0       11.68        371.1       5824.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L   Removal
       CM                                           CM/SEC        /HR

38  9.5926E-02   8.932      .1080       .6637      1.8699E-03   .8855

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .88558     per hour

Particulate iodine removal constant=   .31145     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   5.0963     per hour

Organic removal rate due to wall deposition=   .00000     per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter= 9.59264E-02
Temperature of air-steam mixture= 59.000 Degree C
Pressure of air-steam mixture= 1.3023 Atm.
Temperature of droplet liquid= 59.000 Degree C
Density of air-steam mixture= 1.30967E-03 G/CC
Viscosity of air-steam mixture= 1.85751E-04 Poise
Density of droplet liquid= .98339 G/CC
Viscosity of droplet liquid= 4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= .10990 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6858
Schmidt number for methyl iodine= 1.2906
Grashof number= 1.20528E+13
Try mean diameter= 9.59681E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                   CM/SEC      CM/SEC

38  9.5968E-02   6.818       251.2       11.68       371.2       6792.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

38  9.5968E-02   8.935       .1044      .6536      1.8691E-03    .8721

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= .87213 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 5.0963 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.59681E-02
Temperature of air-steam mixture= 59.000 Degree C
Pressure of air-steam mixture= 1.3023 Atm.
Temperature of droplet liquid= 59.000 Degree C
Density of air-steam mixture= 1.30967E-03 G/CC
Viscosity of air-steam mixture= 1.85751E-04 Poise
Density of droplet liquid= .98339 G/CC
Viscosity of droplet liquid= 4.75969E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 8.41306E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture= .10990 sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 2.72609E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 2.94397E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.6858
Schmidt number for methyl iodine= 1.2906
Grashof number= 1.20528E+13
Try mean diameter= 9.60097E-02
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Drop parameters for elemental
      (For mean drop)

  I    Diameter    Fall Time   Reynolds    M.T.Coeff G    T.V.      drop no.
          CM          SEC                    CM/SEC      CM/SEC

 38   9.6010E-02    9.194       251.4        11.67       371.4       7757.

  I    Diameter    Sherwood      Time       Sat. Frac.  M.T.Coeff L  Removal
          CM                                              CM/SEC       /HR

 38   9.6010E-02    8.938       .1088        .6658     1.8682E-03    .8883

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=    .88838     per hour

Particulate iodine removal constant=    .31420     per hour

Total organic removal constant=    .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =    5.0963     per hour

Organic removal rate due to wall deposition=    .00000     per hour

Mean drop diameter=   9.60097E-02
```

9.2.2.10 96 to 720 hr Output File (*i2- max08.out*)

```
Bechtel Standard Computer Program       REMOVE  , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Max Temp 96 - 720 hr            Sheet No.        1
=============================================================================



        ______________________________________________
        |                                            |
        |          Standard Computer Program         |
        |          NE305 REMOVE  Version 4.0         |
        |           for the IBM PC/XT/AT             |
        |                                            |
        |____________________________________________|


        Abstract:

        The REMOVE program calculates the containment
        spray removal rate constants and a mean drop
        diameter or drop trajectories



    Output in file I2-max08.out was created on 14 Jun 2003  at 11:14:54

Bechtel Standard Computer Program       REMOVE , NE305 Version 4.0
(c) 1991                                          Calc No. N-6030-00 Rev No. 0
Originator Jorge Schulz          Date 14 Jun 2003 Checked_______Date________
Project  SONGS                                    Job No. 16575-167
Subject  I2 Spray Max Temp 96 - 720 hr            Sheet No.        2
=============================================================================


Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549      Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013      G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Schmidt number for methyl iodine=   1.3156
Grashof number=  2.93485E+12
Try mean diameter=  9.20964E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.2096E-02   5.723      228.3       12.03       367.0      207.2

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

37  9.2096E-02   24.74     5.4946E-02   .5664     1.4546E-03   1.012

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.0122     per hour

Particulate iodine removal constant=   .59268     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.20964E-02
Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549     Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013     G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  2.93485E+12
Try mean diameter=  9.30719E-02

Drop parameters for elemental
       (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.3072E-02   6.028      232.8       12.01       370.4      406.3

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
       CM                                            CM/SEC       /HR

37  9.3072E-02   24.95     5.6669E-02   .5747     1.4394E-03   1.027
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003					

REV INDICATOR

```
***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.0270    per hour

Particulate iodine removal constant=   .59268    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter=  9.30719E-02
Temperature of air-steam mixture=   44.100    Degree C
Pressure of air-steam mixture=   1.1549    Atm.
Temperature of droplet liquid=   44.100    Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013    G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  3.62106E+12
Try mean diameter=  9.33906E-02

Drop parameters for elemental
        (For mean drop)

 I    Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.     drop no.
        CM         SEC                   CM/SEC      CM/SEC

37   9.3391E-02   6.119      234.3       12.00       371.5      603.7

 I    Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L  Removal
        CM                                            CM/SEC      /HR

37   9.3391E-02   25.01    5.7138E-02   .5770     1.4344E-03   1.031

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   1.0310    per hour

Particulate iodine removal constant=   .63567    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter=  9.33906E-02
Temperature of air-steam mixture=   44.100    Degree C
Pressure of air-steam mixture=   1.1549    Atm.
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Temperature of droplet liquid=  44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013      G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  3.62106E+12
Try mean diameter=  9.35459E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

37  9.3546E-02   6.474      235.1       11.99       372.0       799.3

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

37  9.3546E-02   25.05     6.0250E-02   .5906     1.4321E-03    1.055

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=  1.0553     per hour

Particulate iodine removal constant=   .63567     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.35459E-02
Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549      Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013      G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  6.84291E+12
Try mean diameter=  9.38782E-02

Drop parameters for elemental
          (For mean drop)
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
  I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

 38  9.3878E-02   7.721      236.6       11.98       373.2       985.6

  I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
       .CM                                          CM/SEC        /HR

 38  9.3878E-02   25.12     7.1347E-02   .6346     1.4270E-03    .8098

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .80987     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.38782E-02
Temperature of air-steam mixture=   44.100    Degree C
Pressure of air-steam mixture=   1.1549     Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013      G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  6.84291E+12
Try mean diameter=  9.51770E-02

Drop parameters for elemental
         (For mean drop)

  I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
        CM         SEC                   CM/SEC      CM/SEC

 38  9.5177E-02   8.957      242.7       11.95       377.6       1961.

  I   Diameter   Sherwood    Time      Sat. Frac.  M.T.Coeff L   Removal
        CM                                          CM/SEC        /HR

 38  9.5177E-02   25.39     8.0523E-02   .6670     1.4075E-03    .8512

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .85128     per hour

Particulate iodine removal constant=   .56136     per hour

Total organic removal constant=   .00000     per hour
```

```
*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038     per hour

Organic removal rate due to wall deposition=   .C0000     per hour

Mean drop diameter=  9.55770E-02
Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549     Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013     G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  7.29478E+12
Try mean diameter=  9.55062E-02

Drop parameters for elemental
         (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM         SEC                   CM/SEC      CM/SEC

38  9.5506E-02   7.779      244.3      11.94       378.7      2939.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                             CM/SEC        /HR

38  9.5506E-02   25.46     6.9453E-02   .6283      1.4027E-03   .8018

************SPRAY REMOVAL RATES************

Total elemental removal constant=   .80192     per hour

Particulate iodine removal constant=   .57345     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038     per hour

Organic removal rate due to wall deposition=   .00000     per hour

Mean drop diameter=  9.55062E-02
Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549     Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013     G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253     sq. cm/sec
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Diff. coeff. of elemental I2 in droplet liquid= 2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.7177
Schmidt number for methyl iodine= 1.3156
Grashof number= 7.29478E+12
Try mean diameter= 9.57295E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM         SEC                    CM/SEC      CM/SEC

38  9.5730E-02   9.099       245.4       11.93       379.5      3913.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR

38  9.5730E-02   25.51     8.0863E-02    .6683     1.3994E-03     .8529

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .85296    per hour

Particulate iodine removal constant=   .57345    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter= 9.57295E-02
Temperature of air-steam mixture=   44.100    Degree C
Pressure of air-steam mixture=   1.1549    Atm.
Temperature of droplet liquid=   44.100    Degree C
Density of air-steam mixture= 1.24766E-03 G/CC
Viscosity of air-steam mixture= 1.84718E-04 Poise
Density of droplet liquid=   .99013    G/CC
Viscosity of droplet liquid= 6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture= 8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=  .11253    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid= 2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid= 2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine= 1.7177
Schmidt number for methyl iodine= 1.3156
Grashof number= 9.34871E+12
Try mean diameter= 9.58341E-02

Drop parameters for elemental
        (For mean drop)

 I   Diameter   Fall Time   Reynolds   M.T.Coeff G    T.V.     drop no.
       CM         SEC                    CM/SEC      CM/SEC

38  9.5834E-02   8.502       245.9       11.93       379.8      4887.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC        /HR
```

```
38  9.5834E-02   25.53     7.5386E-02   .6499     1.3979E-03   .4147

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .41473    per hour

Particulate iodine removal constant=   .31145    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038    per hour

Organic removal rate due to wall deposition=   .00000    per hour

Mean drop diameter=  9.58341E-02
Temperature of air-steam mixture=   44.100    Degree C
Pressure of air-steam mixture=   1.1549    Atm.
Temperature of droplet liquid=   44.100    Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=   .99013     G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=   .11253    sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  9.34871E+12
Try mean diameter=  9.59113E-02

Drop parameters for elemental
            (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G   T.V.     drop no.
       CM          SEC                  CM/SEC     CM/SEC

38  9.5911E-02   8.881      246.2       11.93      380.1      5859.

 I   Diameter   Sherwood     Time     Sat. Frac.  M.T.Coeff L  Removal
       CM                                           CM/SEC      /HR

38  9.5911E-02   25.55     7.8624E-02   .6610     1.3967E-03   .4218

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .42180    per hour

Particulate iodine removal constant=   .31145    per hour

Total organic removal constant=   .00000    per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =   4.9038    per hour

Organic removal rate due to wall deposition=   .00000    per hour
```

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

```
Mean drop diameter= 9.59113E-02
Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549      Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=    .99013      G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  9.59930E+12
Try mean diameter=  9.59557E-02

Drop parameters for elemental
          (For mean drop)

 I   Diameter   Fall Time  Reynolds   M.T.Coeff G    T.V.      drop no.
       CM          SEC                  CM/SEC      CM/SEC

38  9.5956E-02   8.575      246.5       11.93       380.3       6832.

 I   Diameter   Sherwood     Time      Sat. Frac.  M.T.Coeff L   Removal
       CM                                            CM/SEC       /HR

38  9.5956E-02   25.56     7.5842E-02   .6515      1.3961E-03    .4157

***********SPRAY REMOVAL RATES***********

Total elemental removal constant=   .41577     per hour

Particulate iodine removal constant=   .31420     per hour

Total organic removal constant=   .00000     per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition =    4.9038      per hour

Organic removal rate due to wall deposition=   .00000      per hour

Mean drop diameter= 9.59557E-02
Temperature of air-steam mixture=   44.100     Degree C
Pressure of air-steam mixture=   1.1549      Atm.
Temperature of droplet liquid=   44.100     Degree C
Density of air-steam mixture=  1.24766E-03 G/CC
Viscosity of air-steam mixture=  1.84718E-04 Poise
Density of droplet liquid=    .99013      G/CC
Viscosity of droplet liquid=  6.08709E-03 Poise
Diff. coeff. of elemental I2 in air-steam mixture=  8.61899E-02 sq. cm/sec
Diff. coeff. of methyl I2 in air-steam mixture=    .11253     sq. cm/sec
Diff. coeff. of elemental I2 in droplet liquid=  2.03600E-05 sq. cm/sec
Diff. coeff. of methyl I2 in droplet liquid=  2.19872E-05 sq. cm/sec
Schmidt number for elemental iodine=   1.7177
Schmidt number for methyl iodine=   1.3156
Grashof number=  9.59930E+12
Try mean diameter=  9.59982E-02
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E&TS DEPARTMENT
CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN

Project or DCP/FCN/ECP ________ Calc No. N-6030-001

Subject Containment Aerosol and Iodine Removal Rates

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
0	J. Schulz	8/15/2003	D. T. Dexheimer	8/15/2003						

Drop parameters for elemental
(For mean drop)

I	Diameter CM	Fall Time SEC	Reynolds	M.T.Coeff G CM/SEC	T.V. CM/SEC	drop no.
38	9.5998E-02	8.957	246.7	11.93	380.4	7803.

I	Diameter CM	Sherwood	Time	Sat. Frac.	M.T.Coeff L CM/SEC	Removal /HR
38	9.5998E-02	25.56	7.9155E-02	.6628	1.3955E-03	.4229

***********SPRAY REMOVAL RATES***********

Total elemental removal constant= .42295 per hour

Particulate iodine removal constant= .31420 per hour

Total organic removal constant= .00000 per hour

*****REMOVAL DUE TO WALL DEPOSITION*****

Elemental removal rate due to wall deposition = 4.9038 per hour

Organic removal rate due to wall deposition= .00000 per hour

Mean drop diameter= 9.59982E-02

Enclosure 2

Response to Request for

Additional Information

Dated October 7, 2005

RAI 1:
Confirm that the 1993 through 2002 site meteorological data provided in the SCE letter to the staff dated October 6, 2004, are the same data used to generate the ACRON96 control room χ/Q values presented in the application. (RAI Category Code 2.a)

RESPONSE:

The meteorological data contained in the SCE letter to the staff dated October 6, 2004 was the data used to generate the ARCON96 control room χ/Q values presented in the application dated December 27, 2004. However, the ARCON96 control room χ/Q values presented in the original application have been revised to correct an error in the 1999 data file (to be discussed in the response to RAI 2). The corrected ARCON96 control room χ/Q values have been provided to the staff in an October 27, 2005 Supplement to the application. Enclosed with this RAI response is an electronic copy of the 1993 through 2002 site meteorological data used to generate the ARCON96 control room χ/Q values presented in the October 27, 2005 Supplement to the application.

RAI 2:

A review of the 1993 through 2002 onsite meteorological database revealed that the average lower and upper level wind speeds in 1999 were approximately 1.8 times higher than the lower and upper level wind speeds averaged over the remaining 9-year period (1993 through 1998 and 2000 through 2002). Explain this phenomenon (e.g., verify that the 1999 electronic data file has been properly formatted and unit conversions have been performed correctly) and its impact on the resulting ARCON96 dispersion analyses. (RAI Category Code 2.a)

RESPONSE:

It has been determined that the 1999 meteorological data used to generate the ARCON96 control room χ/Q values presented in the application dated December 27, 2004 was erroneous. The corrected ARCON96 control room χ/Q values have been provided to the staff in an October 27, 2005 Supplement to the application. The October 27, 2005 Supplement to the application updated the control room doses to reflect modeling of the corrected ARCON96 control room χ/Q values.

RAI 3:
Provide a site plan showing the locations of all potential accident release pathways and control room intakes and unfiltered inleakage pathways. If possible, the drawing should be approximately to scale and indicate true north. (RAI Category Code 4.b)

RESPONSE:

Section 4.4.2 of the AST application identifies the various accident release pathways and control room ventilation outside air intake locations. The attached Figure 1 is a draft revision to UFSAR Figure 6.4-3 that shows the plant layout, including the location of potential radiological release points with respect to the control room ventilation outside air intakes. The figure is scaled and shows plant north, which is 57 degrees west of "true north".

The release point locations are:

- Main plant vent (Figure 1 location 1)
- Containment shell diffusion
- Containment equipment hatch (Figure 1 location 8)
- Main Steam Safety Valves (Figure 1 location 9)
- Atmospheric Dump Valves (Figure 1 location 10)
- Steam Line Break Outside Containment (Figure 1 location 11)
- Auxiliary Feedwater Turbine steam discharge (Figure 1 location 12)
- Refueling Water Storage Tank Area (Figure 1 location 13)
- Fuel Handling Building (Figure 1 location 14)

The three control room ventilation outside air intake locations are:

- Control room normal air intake (Figure 1 location 6)
- Control room Unit 2 emergency air intake (Figure 1 location 7)
- Control room Unit 3 emergency air intake (Figure 1 location 7)

Based on the plant coordinates the locations of the three control room ventilation intakes are as follows:

Air Intake Location	From Unit 2 Containment Centerline		From Unit 3 Containment Centerline	
Normal	147 ft West	144.50 ft South	147 ft West	286.50 ft North
Unit 2 Emergency	147 ft West	131.83 ft South	147 ft West	299.17 ft North
Unit 3 Emergency	147 ft West	299.17 ft South	147 ft West	131.83 ft North

As discussed in Section 4.3.2.1 of the application, the AST dose analyses conservatively assume that unfiltered inleakage into the control room envelope (CRE) is from the radioactive plumes released from the facility as they pass west of the CRE.

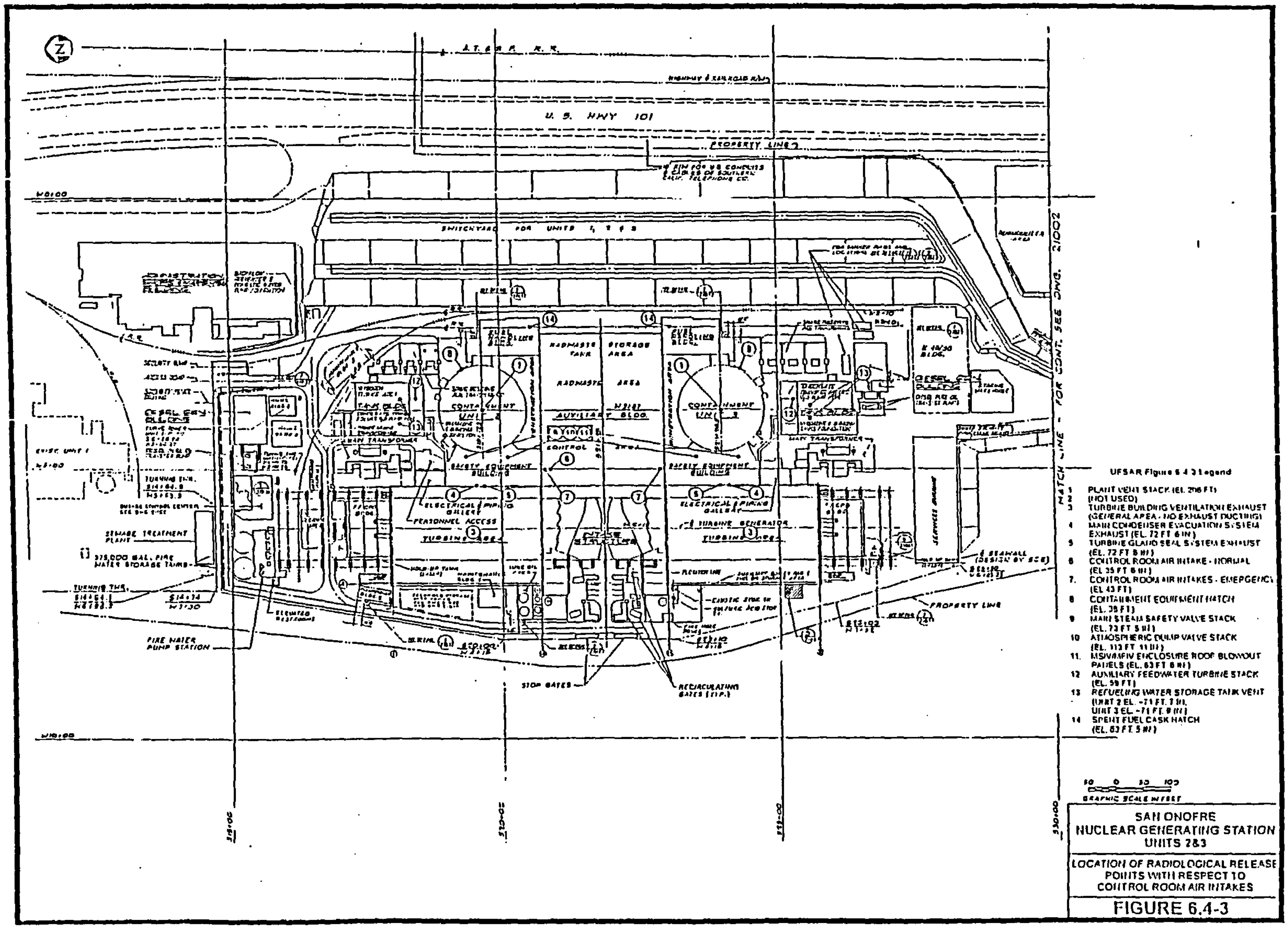


Figure 1 — Radiological Release Point and Control Room Air Intake Locations
(Draft UFSAR Figure 6.4-3)

RAI 4:
Unfiltered leakage into the control room was modeled using control room air intake χ/Q values. Confirm (using the results of tracer gas testing if possible) that there are no potential unfiltered inleakage pathways (during both normal and emergency modes) that could result in χ/Q values that are higher than the control room intake χ/Q values. (RAI Category Code 2.a)

RESPONSE:

As discussed in Section 4.3.2.1 of the AST application, only the west side of the control room envelope (CRE) is exposed to the radioactive plumes released from the facility.

The most likely source of unfiltered inleakage is the ductwork that leaves the Control Room Cabinet Areas to the fan rooms at the 50' level, outside of the Control Room Envelope. The adjacent areas and structures to the north, south, and east of the CRE, and the adjacent areas and structures above and below the CRE, do not contain activity release points. These adjacent areas and locations can only become contaminated with air introduced via intake or infiltration of radioactive material contained in the radioactive plumes released from the facility, which are then recirculated and diluted throughout these regions. Consequently, the resultant activity concentrations in the adjacent areas and structures will be less contaminated than any radioactive plume. For this reason, the AST dose analyses conservatively assume that all intake and infiltration (i.e., inleakage) into the CRE is from the radioactive plumes released from the facility as they pass west of the CRE.

The control room normal air intake is located near the northwest corner of the CRE, and the control room emergency air intakes are located near the northwest and southwest corners of the CRE. As discussed in Sections 4.3.2.1 and 4.4.5 of the AST application, the maximum atmospheric dispersion factor for any activity release location to any of the three outside air intakes is modeled in the evaluation of contaminated air intake and unfiltered inleakage.

RAI 5:
Explain the basis for using the same source-receptor horizontal distances for containment equipment hatch releases assuming flow both around and over (through) the containment building. (RAI Category Code 2.a)

RESPONSE:

As discussed in Section 4.4.4.4 of the AST application, the containment equipment hatch release is assumed to be from its mid-height at elevation 38 feet above grade. Per Section 4.4.4.1 of the AST application, the control room emergency air intakes are no higher than elevation 43 feet. Per Section 4.4.4.4 of the AST application, the containment building is between the containment equipment hatch release point and the control room air intakes. The containment building rises to an elevation 161 feet.

Atmospheric dispersion was evaluated for flow paths both around the containment and over the containment. The flow path lengths are to be calculated using the "taut string length" method allowed by Regulatory Guide 1.194 Section 3.4. The containment equipment hatch to receptor distance around the containment is shorter than the containment equipment hatch to receptor distance over the containment. As discussed in Section 4.4.4.4 and reported in Table 4.4-4 of the AST application, for each release point and control room receptor combination, the ARCON96 analysis modeled the conservatively shorter "taut string length" distance associated with the path around the containment.

RAI 6:
The following questions concern the atmospheric dispersion modeling for the main steamline safety valve (MSSV) and atmospheric dump valve (ADV) release pathways:

a. Provide a diagram showing the relative locations of the main steam isolation valves (MSIVs), MSSV stacks, ADV stacks, and control room air intakes. If possible, the diagram should be approximately to scale. Show on the diagram the locations modeled as the MSSV release points. (RAI Category Code 4.b)

RESPONSE:

The response to RAI # 3 shows a scaled drawing with the relative locations of the MSSV and ADV release locations, and the control room air intakes. Provided as Attachment A to this Enclosure are Drawings 40483 and 41983 which show the Units 2 and 3 MSIV, MSSVs and ADV locations relative to the containment centerlines. As shown in these drawings, the MSIVs are numbered 2HV8204, 2HV8205, 3HV8204 and 3HV8205. Nine MSSVs are arranged around each MSIV. The fifty-inch ADV stack associated with each main steam line is located between the containment outer wall and the steam line's MSIV and MSSVs. These drawings, in conjunction with the control room air intake coordinates provided in the response to RAI 3 and Figure 1 can be used to determine the relative distances from the release points to the intakes.

RAI 6:
The following questions concern the atmospheric dispersion modeling for the main steamline safety valve (MSSV) and atmospheric dump valve (ADV) release pathways:

b. Explain the methodology and assumptions used to calculate the minimum MSSV stack exit velocity. (RAI Category Code 2.b)

RESPONSE:

Section 6.0 of Regulatory Guide 1.194 states that, in lieu of mechanistically addressing the amount of buoyant plume rise:

> "...the ground level χ/Q value calculated with ARCON96 (on the basis of the physical height of the release point) may be reduced by a factor of 5. This reduction may be taken only if (1) the release point is uncapped and vertically oriented and (2) the time-dependent vertical velocity exceeds the 95th-percentile wind speed (at the release point height) by a factor of 5."

The SONGS MSSVs are uncapped and vertically oriented. Thus, to take credit for plume rise, the flow velocities at the stack exit must be determined.
Per Section 4.4.4.5 of the AST application, the minimum flow velocity at the exit of the MSSV stack is determined by calculating the minimum volumetric flowrate at the exit and dividing by the internal cross-sectional area of the MSSV stack. The minimum volumetric flow rate at the exit is equal to the product of the minimum mass flowrate through an MSSV and the specific volume of the steam at the exit.

The minimum mass flowrate through an MSSV is set equal to the flow capacity for the lowest set pressure MSSV.

The specific volume of steam is determined for the saturated steam pressure in the MSSV stack. The saturated steam pressure in the MSSV stack is equal to the maximum backpressure on the MSSVs during blowdown minus the pressure drop through the MSSV stack. The pressure drop through the MSSV stack is calculated from the following equation:

$$\Delta P = 0.00000028 \frac{K W^2 \overline{V}}{Y^2 d^4}$$

where:

K is the total resistance coefficient from the MSSV outlet to the stack exit
W is the mass flowrate in lbm/hr
$\overline{V}$ is the specific volume of steam in ft^3/lb
Y is the net expansion factor for compressible flow
d is the inside diameter of the stack in inches

In evaluating the preceding equation, the following conservative assumptions are made:

1. All MSSVs lift at the lowest set pressure of all the valves.
2. The pressure in the MSSV stack is equal to the maximum backpressure.

3. No credit is taken for head loss due to elevation changes or pipe friction.
4. No credit is taken for expansion of the steam through the stack.

As discussed in Section 4.4.4.5 of the AST application, the minimum MSSV stack exit velocity of 72 meters/second was calculated using the preceding equation and assumptions.

RAI 6:
The following questions concern the atmospheric dispersion modeling for the main steamline safety valve (MSSV) and atmospheric dump valve (ADV) release pathways:

c. Confirm that a stuck-open MSSV concurrent with other design basis accidents is excluded from the licensing basis for the MSSVs. (RAI Category Code 2.a)

RESPONSE:

UFSAR Section 10.3 addresses the design and licensing basis of the main steam supply system, including the main steam safety valves. The SONGS 2 and 3 licensing basis, as reflected in the UFSAR, does not require that a stuck-open MSSV be considered concurrent with other design basis accidents.

The inadvertent opening of a safety valve is a transient that is considered in UFSAR Chapter 15. However, this transient is not modeled concurrent with other design basis accidents.

RAI 6:

The following questions concern the atmospheric dispersion modeling for the main steamline safety valve (MSSV) and atmospheric dump valve (ADV) release pathways:

d. Table 4.4-11 of Enclosure 2 to the application presents χ/Q values for ADV releases with plume rise credit. Please identify the release scenarios where these χ/Q values have been used and describe the methodology and assumptions used to determine that the ADV stack exit vertical flow velocity for these release scenarios exceeds 5 times the 95^{th} percentile upper level wind speed of 6.8 miles per second. (RAI Category Code 2.b)

RESPONSE:

Clarification: Per the October 27, 2005 supplement to the application, the 95^{th} percentile upper level wind speed has been revised from 6.8 miles per second to 6.4 miles per second.

The events addressed in the AST application do not use the χ/Q values for ADV releases with plume rise credit.

Although no event has yet been identified where credit for plume rise is necessary, the application presents χ/Q values for ADV releases with plume rise credit to allow for their future use.

Per Section 4.4.4.6 of the AST application, the accident analyses assume that an ADV is operated manually; therefore, the flow velocity at the ADV stack exit will decrease over time, as the steam generator blows down. Thus, in order to credit plume rise in an ADV release dose analysis, the time period for which the ADV stack exit vertical flow velocity exceeds five times the 95th percentile upper level wind speed of 6.4 m/s (i.e., exceeds 5 x 6.4 m/s = 32 m/s) would need to be determined and the plume rise adjustment factor applied, on an event-specific and time-interval specific basis.

As of this date, a calculation of the ADV stack exit velocity for the purpose of crediting plume rise has not been performed. If it were to be performed, the time-dependent flow velocity at the exit of the ADV stack would be determined using a methodology similar to that described in the response to RAI # 6b, based on the time-dependent ADV mass release rate and steam specific volume.

RAI 6:
The following questions concern the atmospheric dispersion modeling for the main steamline safety valve (MSSV) and atmospheric dump valve (ADV) release pathways:

e. Provide a copy of the output files for the bounding ARCON96 MSSV and ADV runs. (RAI Category Code 2.b)

RESPONSE:

Per Section 4.4.4.5 of the AST application, the results of the ARCON96 analysis show that the Unit 2 MSSVs centered at MSIV 8204 to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). This ARCON96 run is identified by file name ms4-u2u2 (.rsf, .log and .cfd). Electronic copies of these files are enclosed with this response.

Per Section 4.4.4.6 of the AST application, the results of the ARCON96 analysis show that the Unit 2 ADV 607 to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). This ARCON96 run is identified by file name ad7-u2u2 (.rsf, .log and .cfd). Electronic copies of these files are enclosed with this response.

Excerpts from TABLE 4.4-11: 95th Percentile Control Room χ/Qs (sec/m^3)

Time Interval	ADV (no plume rise credit)	MSSV (no plume rise credit)	MSSV (with plume rise credit)
Computer run:	N-4010-003 R2 Section 9.7.4 ad7-u2u2.rsf ad7-u2u2.log ad7-u2u2.cfd	N-4010-003 R2 Section 9.6.1 ms4-u2u2.rsf ms4-u2u2.log ms4-u2u2.cfd	Previous values divided by a factor of five (5)
0 to 2 hrs	3.70E-03	6.08E-03	1.22E-03
2 to 8 hrs	1.99E-03	3.76E-03	7.52E-04
8 to 24 hrs	6.95E-04	1.24E-03	2.48E-04
1 to 4 days	7.04E-04	1.43E-03	2.86E-04
4 to 30 days	6.34E-04	1.30E-03	2.60E-04

RAI 7:
In order to understand the atmospheric dispersion modeling for the steam line break outside containment (SLB-OC) release pathways, provide a diagram showing the relative locations of the main steam line isolation valve, the main steam isolation valve/main feedwater isolation valve (MFIV) enclosure structures, the walkway between the turbine building east wall and the MSIV/MFIV enclosure structures, and control room air intakes. If possible, the diagram should be approximately to scale. Also show on the diagram the location of the blowout panels on the roof and walls of the MSIV/MFIV enclosure, as well as the location modeled as the SLB-OC release location. (RAI Category Code 4.b)

RESPONSE:

The response to RAI # 3 shows a scaled drawing with the relative locations of the steam line break outside containment release location, and the control room air intakes. The response to RAI # 6.a shows a scaled drawing with the relative location of the main steam isolation valve within the MSIV/MFIV enclosure structure.

Provided in Attachment B of this Enclosure is Drawing 10328 Sheet 1 which shows the walkway between the Unit 2 turbine building east wall and the Unit 2 MSIV/MFIV enclosure structures (Unit 3 is similarly designed).

Also provided in Attachment B of this Enclosure are Drawings 23090, 23075 and 23069. Drawing 23090 presents the design of the various MSIV/MFIV enclosure walls and Drawing 23075 presents the design of the MSIV/MFIV enclosure roof. The blow out panels in these walls and the roof are presented in Drawing 23069.

These drawings and figures, in conjunction with the control room air intake coordinates provided in the response to RAI # 3 can be used to determine the relative distance from the SLB-OC release point to the intakes.

RAI 8:
In order to understand the atmospheric dispersion modeling for the fuel handling building (FHB) release pathways, provide a diagram showing the relative locations of all the FHB spent fuel cask hatches and the control room air intakes. (RAI Category Code 4.b)

RESPONSE:

Provided as Attachment C of this Enclosure is drawing 10201, Sheet 1, Revision 7. The portion of this drawing showing the floor plan at elevation 63'-6" shows the fuel cask hatch openings. The larger cask hatch over the south end of the U2 railroad access bay (north end of U3 bay) is assumed to be the point of release from the fuel handling building. This hatch is closer to the control room air intake locations than other potential release locations, such as the smaller cask hatch over the opposite ends of the respective railroad bays.

The response to RAI # 3 shows a scaled drawing with the relative locations of the FHB spent fuel cask hatch release location and the control room air intakes. Drawing 10201, Sheet 1, Revision 7, in conjunction with the control room air intake coordinates provided in the response to RAI 3, can be used to determine the relative distances from the release point to the intakes.

RAI 9:
In Section 4.5.1.3.5 in Enclosure 2 of the application, the total combined fission product removal rates in the containment by combining the individual removal rates from natural deposition and spray were provided. This is incorrect in that the various removal mechanisms would be acting simultaneously in an accident (i.e., the particulates being removed by spray would also include particulates being removed by deposition because the two different processes can not be separated). NUREG/CR-6189, "A Simplified Method for Aerosol Removal by Natural Processes in Reactor Containment," and NUREG/CR-5966, "A Simplified Model for Aerosol Removal by Containment Spray," assume individual removal process independent of each removal mechanism (natural deposition and spray). Discuss why the total combined fission product removal rate in the containment is determined by combining the individual removal rates from natural deposition and spray, or revise your analysis accordingly to properly account for both processes occurring at the same time. (RAI Category Code 2.b)

RESPONSE:

As discussed in Section 4.5.1.3.5 of the AST application, the Bechtel LocaDose code is used to calculate the activity as a function of time in the containment sprayed and unsprayed regions. The governing equation used is similar to the governing equation used by the RADTRAD code (Equation 1 in NUREG/CR-6604 Section 2). The only difference is that the spray removal coefficient and the natural deposition removal coefficient are combined into an effective removal coefficient for each region. This is consistent with SRP 6.5.2 Section III.4.b. In the containment sprayed region, spray and deposition removal rates are combined. In the containment unsprayed region, only deposition removal rates are modeled.

As discussed in Section 4.5.1.3.3 of the AST application, aerosol spray removal is modeled using the Powers tenth percentile spray removal model described in NUREG/CR-5966. In the Powers model, aerosol removal by sprays is derived based on how a single falling droplet would scavenge particles. The extent to which sprays will decontaminate an aerosol-laden atmosphere depends on the number of spray droplets falling through the atmosphere and the distance they fall. As discussed in Section 4.5.1.3.5 of the AST application, spray removal of aerosols is only modeled during the first 4 hours of the LOCA event.

As discussed in Section 4.5.1.3.1 of the AST application, aerosol natural deposition removal is modeled using the Powers tenth percentile deposition model described in NUREG/CR-6189. In the Powers model, by the end of the in-vessel release phase, the natural deposition process is primarily due to the removal of heavier particulates from the containment atmosphere due to the effects of gravitational settling. Therefore, it is appropriate to take the credit of gravitational deposition during and following the post-LOCA spray operation. As shown in Table 4.5-7 of the AST application, deposition removal of aerosols is only modeled during the first 22.2 hours of the LOCA event.

Of note, a comparison of Tables 4.5-6 and 4.5-7 of the AST application shows that the aerosol natural deposition rates are approximately two orders of magnitude smaller than

the aerosol spray removal rates during the majority of the time between 1 minute to 4 hours, when containment spray is modeled. As such combining the spray and deposition aerosol removal rates has little impact on the results.

Spray removal of the elemental iodine is only modeled during the first four hours of the LOCA event. During this time period the elemental iodine activity removed by containment spray and deposition mechanism is limited by the elemental iodine decontamination factor (DF). The elemental iodine DF is reached within 2 hours. Further removal by deposition or spray after the DF is reached is not credited.

RAI 10:
In Tables 4.5-8, 4.4-9, and 4.5.10, in Enclosure 2 of the application, an iodine flashing fraction of 10 percent was assumed. Section 5.5 of Appendix A to Regulatory Guide (RG) 1.183 states that the amount of iodine that becomes airborne should be assumed to be 10 percent of the total iodine activity (i.e., iodine in particulate, elemental, and organic forms) in the leaked fluid. In NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plant," the staff stated that iodine entering the containment is at least 95 percent cesium iodine with the remaining 5 percent as elemental iodine. Once the iodine enters the containment sump in aqueous environment which becomes the emergency core cooling system leakage source, cesium iodine in particulate form will readily dissolve in sump water and it enters ionic iodine form. Clarify whether you have included all forms of iodine in your 10 percent iodine flashing parameter. (RAI Category Code 2.b)

RESPONSE:

All forms of iodine have been included in the 10 percent iodine flashing parameter. The post-LOCA ESF leakage dose analysis models the iodine in the containment sump liquid source term as 97 percent elemental and 3 percent organic. A flashing fraction of 10 percent is applied to both iodine species.

RAI 11:
In Section 4.5.2.2 and Table 4.5-8 in Enclosure 2 of the application, the maximum engineered safety feature (ESF) recirculation loop leakage rate of 7E-3 cubic feet per minute (cfm) for the accident duration of 20 minutes to 30 days was stated. Further it was stated that this leakage value represents two times the sum of the simultaneous maximum expected leakage from ESF systems consistent with guidance provided in RG 1.183. Discuss if this leakage value (one-half of 7E-3 cfm) is specified in the current SONGS Technical Specifications (TSs). If it is not specified in the SONG TSs, provide the bases and references for this leakage value and discuss how this leakage would be tested to meet this leakage limit. (RAI Category Code 2.a)

RESPONSE:

Technical Specification Section 5.5.2.8 requires establishment of a "Primary Coolant Sources Outside Containment Program" to provide controls to minimize leakage from those portions of systems outside containment that could contain highly radioactive fluids during a serious transient or accident to levels as low as practicable. SONGS Units 2&3 Procedure SO23-XVII-8 describes the establishment, implementation and maintenance of the Program. Per the procedure, leakage from the High Pressure Safety Injection, Low Pressure Safety Injection, and Containment Spray Systems is limited to 5,950 cm^3/hour. This value is one-half of the 7E-3 cfm modeled in the post-LOCA ESF Leakage dose analysis described in Section 4.5.2.2 and Table 4.5-8 of the application.

RAI 12:
In Section 4.5.1.3.2 in Enclosure 2 of the application, the resultant elemental iodine natural deposition rate in the containment was provided using the methodology provided in Standard Review Plan (SRP) Section 6.5.2. The methodology provided in SRP Section 6.5.2 is only applicable for use in conjunction with the containment spray operation and is not applicable for natural deposition processes. Discuss why the use of SRP 6.5.2 methodology is applicable to the elemental iodine natural deposition rate in the containment, or revise your analysis accordingly. (RAI Category Code 2.b)

RESPONSE:

As discussed in Section 4.5.1.3 of the AST application, elemental iodine natural deposition is calculated using the elemental iodine natural deposition methodology provided in Section III.4.c.(1) of Standard Review Plan (SRP) Section 6.5.2. Consistent with the SRP, elemental iodine removal by natural deposition is only credited concurrent with containment spray system operation.

Elemental iodine removal by natural deposition is only credited until the elemental iodine decontamination factor value is reached. The elemental iodine DF value is reached approximately 2 hours after the onset of the LOCA.

As discussed in Sections 4.5.1.3.4 and 4.5.1.3.5 of the AST application, credit for spray removal is assumed for four hours after the onset of the LOCA (i.e., continuing for a period of time beyond which elemental iodine removal by natural deposition is no longer credited).

Therefore, the elemental iodine natural deposition modeled in the dose analysis is consistent with the SRP 6.5.2 methodology.

RAI 13:
In Tables 4.5-4, 4.5-5, and 4.5-6 in Enclosure 2 of the application, the elemental and aerosol iodine removal rates by the containment spray were provided. Provide your detailed calculations in determining (1) elemental and aerosol iodine removal rates by the containment spray, and (2) elemental iodine removal cutoff times after reaching decontamination factor (DF) as specified in SRP Section 6.5.2, Revision 2. In your response, show the major parameters used and their references. The DF is defined as the maximum iodine concentration in the containment atmosphere divided by the concentration of iodine in the containment atmosphere at some time after decontamination. (RAI Category Code 2.a)

RESPONSE:

Attachment B of Enclosure 1 of this letter provides a copy of Calculation N-6030-001 which calculates the elemental iodine and aerosol containment spray removal rates and the elemental iodine decontamination factors (DF) used in the dose calculation.

The elemental iodine DF is calculated by the Bechtel LocaDose code that has been used for the AST dose analysis. Activity sprayed or plated out is collected into a specially designated computer code node called the "sump node". At the end of every time-step, a check is made to determine if the elemental iodine DF level has been reached. The DF level is calculated as the ratio of total elemental iodine activity in the containment airborne regions plus sump node, divided by the elemental iodine activity present in the sump node. Once the elemental iodine DF level is reached, re-suspension from the sump to the containment airborne regions is initiated to keep the DF at the equilibrium level.

The LocaDose code modeling is more conservative than merely stopping spray or deposition removal at a DF defined as the maximum iodine concentration in the containment atmosphere divided by the concentration of iodine in the containment atmosphere at some time after decontamination. In the LocaDose code model, following the initial achievement of the DF the airborne activity is depleted by both decay and leakage to the environment, while the sump activity is depleted by only decay. The net effect is a more rapid reduction in the airborne activity relative to the sump activity. To maintain the DF, the LocaDose code resuspends sump activity into the containment air region. This increases the airborne activity available for subsequent leakage to the environment.

RAI 14:
In Tables 4.5-3, and 4.5-7 in Enclosure 2 of the application, the containment natural deposition rates of aerosols using NUREG/CR-6189 were provided. Provide the calculations used to determine the containment natural deposition rates. (RAI Category Code 2.b)

RESPONSE:

Attachment B of Enclosure 1 of this letter provides a copy of Calculation N-6030-001 which calculates the containment natural deposition removal rates used in the dose calculation.

RAI 15:
In Table 4.5-9, "Loss-of-Coolant Accident Refueling Water Storage Tank (RWST) Release Analysis Parameters," of Enclosure 2 of the application, it is assumed that the RWST inflow rates from the ESF pump mini-flow isolation valve and RWST discharge check valve are 1.5 and 5 gallons per minute (gpm), respectively. Provide the bases and references for these leak rate assumptions. (RAI Category Code 2.a)

RESPONSE:

As discussed in Section 4.5.3.2.1 of the AST application, the Safety Injection System (SIS) and Containment Spray System (CSS) pumps minimum flow return paths to the RWST are isolated following a Recirculation Actuation Signal (RAS) by two sets of 4-inch mini-flow isolation valves. Valves 1204-HV-9306 and 1204-HV-9307 are in series in one flow path, and valves 1204-HV-9347 and 1204-HV-9348 are in series in a second flow path. The maximum allowable leakage rate for each of the valves is 0.75 gpm per the leakage acceptance criteria specified in SONGS Units 2&3 Document No. 90055, "Selection of Valves and Determination of Inservice Testing". Consequently, for either path with its two valves in series, the maximum allowable path leakage rate is assumed to be 0.75 gpm. For the scenario of a LOCA without an assumed DG failure, the total leakage rate past the valves in the two parallel flow paths is 1.5 gpm.

As discussed in Section 4.5.3.2.2 of the AST application, following a RAS, each of the two RWSTs is isolated from the ESF recirculation loop by an RWST discharge check valve (1204-MU-001 or 1204-MU-002). The maximum allowable leakage through both check valves combined is 5 gpm per the leakage acceptance criteria specified in SONGS Units 2&3 Document No. 90055, "Selection of Valves and Determination of Inservice Testing".

NOTE: no RAI #16 was provided

RAI 17:
In Section 4.5.3.2.3 in Enclosure 2 of the application, it is stated that an iodine partition coefficient of 200 was used for the RWST water. Discuss if this coefficient applies to all forms of iodine (particulate and elemental) and provide the RWST water pH values as a function of time. (RAI Category Code 2.a)

RESPONSE:

Please refer to RAI 3 response provided in Enclosure 1 of this letter.

RAI 18:
Section 15.7.3.4.2.2, "Structural Evaluation of Fuel Assembly," and Table 15.7.5 of the SONGS updated final safety analysis report (UFSAR) stated that the design basis assumption for the number of failed fuel rods due to the postulated fuel-handling accident (FHA) is 60. In Table 4.6-1 of Enclosure 2 of the application, it is assumed there are 16 failed fuel rods for the FHA inside the containment. Explain the discrepancies. (RAI Category Code 2.a)

RESPONSE:

There is no discrepancy between the SONGS UFSAR and the AST application.

UFSAR Sections 15.7.3.4 and 15.10.7.3.4 address a postulated fuel handling accident inside the fuel handling building (FHA-FHB). Per the UFSAR, the design basis FHA-FHB fails 60 fuel rods. As discussed in Section 4.7 of the AST application, the failure of 60 fuel rods is also modeled in the AST FHA-FHB analysis.

UFSAR Sections 15.7.3.9 and 15.10.7.3.9 address a postulated fuel handling accident inside the containment building (FHA-IC). Per the UFSAR, the design basis FHA-IC fails 16 fuel rods in the dropped fuel bundle and 210 fuel rods in the impacted fuel bundles. As discussed in Section 4.6 of the AST application, the failure of 16 fuel rods in the dropped fuel bundle and 210 fuel rods in the impacted fuel bundles is also modeled in the AST FHA-IC analysis.

RAI 19:
For the postulated FHA, provide noble gases and iodine activity inventory in the fuel rod gaps that are available for release to the water surrounding the failed fuel assemblies (1) during normal operation, and (2) prior to fuel movement after a 75-hour decay period. Also provide the amount of noble gases and iodine activities released (in curies) to the environment following the postulated FHA. (RAI Category Code 2.b)

RESPONSE:

Clarification – As discussed in Section 4.1.1 of the AST application, the fuel handling accident dose analyses model 72 hours of radioactive decay prior to an event, which is the minimum decay time required by SONGS Units 2 and 3 Licensee Controlled Specification (LCS) 3.9.101 prior to movement of irradiated fuel in the reactor vessel.

Table 4.1-3 of the AST application lists the average fuel rod noble gases and iodine isotope activity inventory at shutdown, prior to any post-shutdown decay (i.e., during normal operation). The noble gases and iodine activity inventory in the fuel rod gaps that are available for release to the water surrounding the failed fuel assemblies are calculated by scaling the Table 4.1-3 activity inventory by the radial peaking factor and the core iodine and noble gas fission product fractions in fuel rod gaps specified in Tables 4.6-1 and 4.7-1 of the AST application. Table 19-1 of this document performs this scaling operation.

Table 4.1-4 of the AST application lists the average fuel rod noble gases and iodine isotope activity inventory at 72 hours post-shutdown. The noble gases and iodine activity inventory in the fuel rod gaps that are available for release to the water surrounding the failed fuel assemblies are calculated by scaling the Table 4.1-4 activity inventory by the radial peaking factor and the core iodine and noble gas fission product fractions in fuel rod gaps specified in Tables 4.6-1 and 4.7-1 of the AST application. Table 19-2 of this document performs this scaling operation.

Section 4.6 of the AST application describes the AST fuel handling accident inside containment (FHA-IC) analysis. Use of the parameters presented in Table 4.6-1 of the application yields the containment airborne activity inventory specified in Table 19-3. As discussed in Section 4.6 of the AST application, this activity (less any activity removed by radioactive decay) is released to the environment over a two-hour time interval.

Section 4.7 of the AST application describes the AST fuel handling accident inside the fuel handling building (FHA-FHB) analysis. Use of the parameters presented in Table 4.7-1 of the AST application yields the FHB airborne activity inventory specified in Table 19-3. As discussed in Section 4.7 of the AST application, this activity (less any activity removed by radioactive decay) is released to the environment over a two-hour time interval.

Table 19-1: Average Fuel Rod Gap Inventory at Shutdown

ISOTOPE	AVERAGE FUEL ROD INVENTORY AT SHUTDOWN (CURIES) [A]	RADIAL PEAKING FACTOR [B]	GAP FRACTION [C]	AVERAGE FUEL ROD GAP INVENTORY AT SHUTDOWN (CURIES) [= A x B x C]
XE-131M	2.38E+01	1.75	0.05	2.08E+00
XE-133M	1.18E+02	1.75	0.05	1.03E+01
XE-133	3.78E+03	1.75	0.05	3.31E+02
XE-135M	7.94E+02	1.75	0.05	6.95E+01
XE-135	1.38E+03	1.75	0.05	1.21E+02
XE-137	3.52E+03	1.75	0.05	3.08E+02
XE-138	3.50E+03	1.75	0.05	3.06E+02
KR-83M	2.79E+02	1.75	0.05	2.44E+01
KR-85M	6.11E+02	1.75	0.05	5.35E+01
KR-85	2.13E+01	1.75	0.10	3.73E+00
KR-87	1.25E+03	1.75	0.05	1.09E+02
KR-88	1.76E+03	1.75	0.05	1.54E+02
KR-89	2.25E+03	1.75	0.05	1.97E+02
I-129	7.09E-05	1.75	0.05	6.20E-06
I-130	4.88E+01	1.75	0.05	4.27E+00
I-131	1.83E+03	1.75	0.08	2.56E+02
I-132	2.67E+03	1.75	0.05	2.34E+02
I-133	3.87E+03	1.75	0.05	3.39E+02
I-134	4.41E+03	1.75	0.05	3.86E+02
I-135	3.65E+03	1.75	0.05	3.19E+02
I-136	1.80E+03	1.75	0.05	1.58E+02
I-137	1.85E+03	1.75	0.05	1.62E+02
I-138	9.25E+02	1.75	0.05	8.09E+01

[A] per Table 4.1-3 of the AST application
[B] per Section 4.1.3 of the AST application
[C] per Tables 4.1-6 and 4.1-7 of the AST application

Table 19-2: Average Fuel Rod Gap Inventory at 72 Hours Post-Shutdown

ISOTOPE	AVERAGE FUEL ROD INVENTORY AT 72 HOURS POST-SHUTDOWN (CURIES) [A]	RADIAL PEAKING FACTOR [B]	GAP FRACTION [C]	AVERAGE FUEL ROD GAP INVENTORY AT 72 HOURS POST-SHUTDOWN (CURIES) [= A x B x C]
I-129	7.09E-05	1.75	0.05	6.20E-06
I-130	8.62E-01	1.75	0.05	7.54E-02
I-131	1.41E+03	1.75	0.08	1.97E+02
I-132	8.76E-07	1.75	0.05	7.67E-08
I-133	3.56E+02	1.75	0.05	3.12E+01
I-134	7.57E-22	1.75	0.05	6.62E-23
I-135	1.92E+00	1.75	0.05	1.68E-01
KR-83m	4.01E-10	1.75	0.05	3.51E-11
KR-85m	8.89E-03	1.75	0.05	7.78E-04
KR-85	2.13E+01	1.75	0.10	3.73E+00
KR-87	1.13E-14	1.75	0.05	9.89E-16
KR-88	4.66E-05	1.75	0.05	4.08E-06
XE-131m	2.00E+01	1.75	0.05	1.75E+00
XE-133m	4.57E+01	1.75	0.05	4.00E+00
XE-133	2.54E+03	1.75	0.05	2.22E+02
XE-135	5.74E+00	1.75	0.05	5.02E-01

[A] per Table 4.1-4 of the AST application
[B] per Section 4.1.3 of the AST application
[C] per Tables 4.1-6 and 4.1-7 of the AST application

Table 19-3: Init al FHA Airborne Activity Available for Release to Environment

ISOTOPE	INITIAL CONTAINMENT AIRBORNE ACTIVITY AVAILABLE FOR RELEASE TO ENVIRONMENT (CURIES)	INITIAL FHB AIRBORNE ACTIVITY AVAILABLE FOR RELEASE TO ENVIRONMENT (CURIES)
I-129	7.01E-06	1.86E-06
I-130	8.53E-02	2.26E-02
I-131	2.24E+02	5.93E+01
I-132	8.66E-08	2.30E-08
I-133	3.52E+01	9.33E+00
I-134	7.49E-23	1.99E-23
I-135	1.90E-01	5.05E-02
Kr-83m	7.93E-09	2.11E-09
Kr-85m	1.76E-01	4.67E-02
Kr-85	8.42E+02	2.24E+02
Kr-87	2.24E-13	5.94E-14
Kr-88	9.22E-04	2.45E-04
Xe-131m	3.95E+02	1.05E+02
Xe-133m	9.03E+02	2.40E+02
Xe-133	5.03E+04	1.34E+04
Xe-135	1.14E+02	3.01E+01

RAI 20:
The main steamline break (MSLB) in the SONGS UFSAR Section 15.1.3 assumed that the steam generators would have the maximum 1 gpm primary-to-secondary leakage specified in SONG TSs and this entire leakage is occurring in the faulted steam generator. Instead, it is stated that only 0.5 gpm in Table 4.8-1 in Enclosure 2 of the application for the MSLB. Explain the discrepancy. (RAI Category Code 2.a)

RESPONSE:

SONGS Units 2 and 3 Technical Specification LCO 3.4.13 limits primary to secondary leakage to 720 gallons/day (i.e., 0.5 gallons/minute [gpm]) through any one steam generator, and 1 gpm total leakage through all (i.e., both) steam generators.

The AST MSLB analysis is evaluated using the 0.5 gpm limit for primary to secondary leakage rate into any one steam generator.

SCE submitted PCN-564 for NRC review and approval on November 30, 2005. PCN-564 is a request to revise LCO 3.4.13 to eliminate reference to the 1 gpm total leakage rate through all steam generators criterion, and to reduce the limit for primary to secondary leakage rate into any single steam generator to 150 gallons/day (i.e., approximately 0.1 gallons/minute).

RAI 21:
In Table 4.8-1 in Enclosure 2 of the application, an iodine flashing factor of 20 during the steam generator uncovery is assumed. Provide the basis for this assumption and how this value is used in the MSLB radiological consequence analysis. (RAI Category Code 2.a)

RESPONSE:

As discussed in Section 4.8.2 of the AST application, during periods where the steam generator tubes are uncovered, a portion of the primary-to-secondary leakage flashes to vapor based on the thermodynamic conditions in the reactor coolant and the secondary coolant. The flashing fraction is calculated using the following expression:

$$FF = \frac{h_{f_1} - h_{f_2}}{h_{g_2} - h_{f_2}}$$

Where:

FF	is the flashing fraction
h_{f_1}	is the enthalpy of the liquid at primary coolant conditions (btu/lbm)
h_{f_2}	is the enthalpy of the liquid at secondary system conditions (btu/lbm)
h_{g_2}	is the enthalpy of steam at secondary system conditions (btu/lbm)

The thermodynamic conditions are evaluated at 60 second intervals for each steam generator. In the main steam line break analysis a maximum flashing fraction in either steam generator of 14.41% occurs at the start of the event. Conservatively, the pre-trip SLB-OC AST dose analysis models a bounding flashing fraction of 20% during periods of steam generator tube uncovery.

As discussed in Section 4.8.2 of the AST application, during periods of full tube coverage the primary-to-secondary leakage is directed to the water space of the steam generators. During the period of tube uncovery, the flashed portion of the primary to secondary leakage (20% of the leakage) is directed to the steam space of the steam generator, and the remainder (80% of the leakage) is directed to the water space of the steam generator.

RAI 22:
In Table 4.8-1 in Enclosure 2 of the application, 10 percent of the fuel rods in the core were assumed to fail following the postulated MSLB. The design basis for the failed fuel rods in SONGS UFSAR Section 15.1.3.1.1.4 is that "fuel clad barrier is evaluated on the basis that all fuel rods which experience a [departure from nucleate boiling ratio (DNBR)] less than 1.31 are assumed to experience cladding perforation." The UFSAR further stated that, "the radiological consequence analysis is conservatively based on the assumption that all fuel pins with a DNBR value below the DNBR limit fail." Explain how it was determined that 10 percent of the fuel rods in the core would fail following the postulated MSLB. (RAI Category Code 2.a)

RESPONSE:

Fuel failure estimates for the steam line break event are prepared as part of each core reload safety analysis campaign. The fuel failure estimates are established on the basis that all fuel rods which experience a departure from nucleate boiling ratio (DNBR) less than 1.31 are assumed to experience cladding perforation. The transient evaluations for Unit 2 Cycle 12 and Unit 3 Cycle 12 operation determined that no more than 7 percent fuel failure would occur. As noted in Section 4.8.1 of the AST application, the pre-trip steam line break outside containment AST dose analysis conservatively assumes 10 percent fuel failure to bound future operating cycle fuel failure predictions.

RAI 23:
For the MSLB accident, please provide the following:

a. Concentrations of dose equivalent iodine 131 for each iodine isotope for pre-existing and accident initiated iodine spikes. (RAI Category Code 2.b)

RESPONSE:

Ten percent fuel damage is postulated for the MSLB AST dose analysis. As stated in Section 4.8.1 of the AST application, consistent with RG 1.183 Appendix E Section 2, because more than minimal fuel damage is postulated, the pre-trip SLB-OC AST activity release model does not address primary coolant iodine spiking.

If more than minimal fuel damage had not been postulated for the MSLB event, then the MSLB would have been evaluated using the pre-existing and accident initiated iodine spike characteristics described in Section 4.1.2 of the AST application.

Table 4.1-5 of the AST application provides concentrations for each iodine isotope for the pre-existing iodine spike. The corresponding dose equivalent iodine-131 concentrations for each iodine isotope for the pre-existing iodine spike are provided in the following table:

Isotope	Primary Side Pre-Accident Iodine Spike Concentration (microCi/gm DE I-131)
I-131	4.95E+01
I-132	8.04E-02
I-133	9.68E+00
I-134	5.49E-03
I-135	7.61E-01
Total	60

An accident initiated iodine spike results in time-dependent primary side iodine concentrations. As such, it is not possible to provide concentrations of dose equivalent iodine-131 for each iodine isotope for an accident initiated iodine spike.

RAI 23:
For the MSLB accident, please provide the following:

b. Curie contents of each iodine isotope in the primary coolant and secondary coolant at 1.0 micro curie per gram and 60 micro curie per gram. (RAI Category Code 2.b)

RESPONSE:

As stated in the response to RAI 23.a, because more than minimal fuel damage is postulated, the pre-trip SLB-OC AST activity release model does not address primary coolant iodine spiking. If more than minimal fuel damage had not been postulated for the MSLB event, then the MSLB would have been evaluated using the pre-existing and accident initiated iodine spike characteristics described in Section 4.1.2 of the AST application.

As stated in Section 4.1.2 of the AST application, Table 4.1-5 summarizes the primary side equilibrium (no iodine spike) activity concentration profile determined for the Technical Specification LCO 3.4.16 condition of 1.0 µCi/gram Iodine-131 dose equivalency. Table 4.1-5 of the AST application also summarizes the primary side pre-existing iodine spike activity concentration profile determined for the Technical Specification LCO 3.4.16 condition of 60 µCi/gram Iodine-131 dose equivalency.

Per Table 4.8-1 of the AST application, the RCS dilution mass modeled in the MSLB event is approximately 2.015E+08 grams. The curie content of each iodine isotope in the primary coolant at 1.0 or 60 µCi/gram Iodine-131 dose equivalency is the product of this dilution mass and the Table 4.1-5 primary side iodine isotope activity concentration.

As stated in Section 4.1.2 of the AST application, Table 4.1-5 also summarizes the secondary side water iodine activity concentration profile determined for the Technical Specification LCO 3.7.19 condition of 0.1 µCi/gram Iodine-131 dose equivalency (please note that there is no requirement to evaluate secondary side water iodine activity concentration profiles at 1.0 or 60 µCi/gram Iodine-131 dose equivalency).

Per Table 4.8-1 of the AST application, the secondary dilution water mass modeled in the MSLB event is approximately 1.59E+05 lbm. The curie content of each iodine isotope in the secondary coolant at 0.1 microcurie per gram is the product of this dilution mass and the Table 4.1-5 secondary side water iodine isotope activity concentration.

RAI 23:
For the MSLB accident, please provide the following:

c. Iodine production rates for accident initiated iodine spikes. (RAI Category Code 2.b)

RESPONSE:

As stated in the response to RAI 23.a, because more than minimal fuel damage is postulated, the pre-trip SLB-OC AST activity release model does not address primary coolant iodine spiking. If more than minimal fuel damage had not been postulated for the MSLB event, then the MSLB would have been evaluated using the pre-existing and accident initiated iodine spike characteristics described in Section 4.1.2 of the AST application.

Section 4.1.2 of the AST application addresses accident initiated iodine spiking. Table 4.1-6 of the AST application summarizes the concurrent iodine spike release rate in terms of escape rate coefficients that are to be modeled with the AST reactor core iodine inventory and an assumed 0.62 percent failed fuel.

When an escape rate coefficient of 1.3E-08 sec^{-1} is modeled with the AST reactor core iodine inventory and 0.62 percent fuel failure, the resultant equilibrium primary coolant iodine activity concentration is 1.0 µCi/gram DE I-131.

An accident initiated spiking factor of 335 can be modeled with an escape rate coefficient of 4.4E-06 sec^{-1}, an AST reactor core iodine inventory, and 0.62 percent fuel failure.

An accident initiated spiking factor of 500 can be modeled with an escape rate coefficient of 6.5E-06 sec^{-1}, an AST reactor core iodine inventory, and 0.62 percent fuel failure.

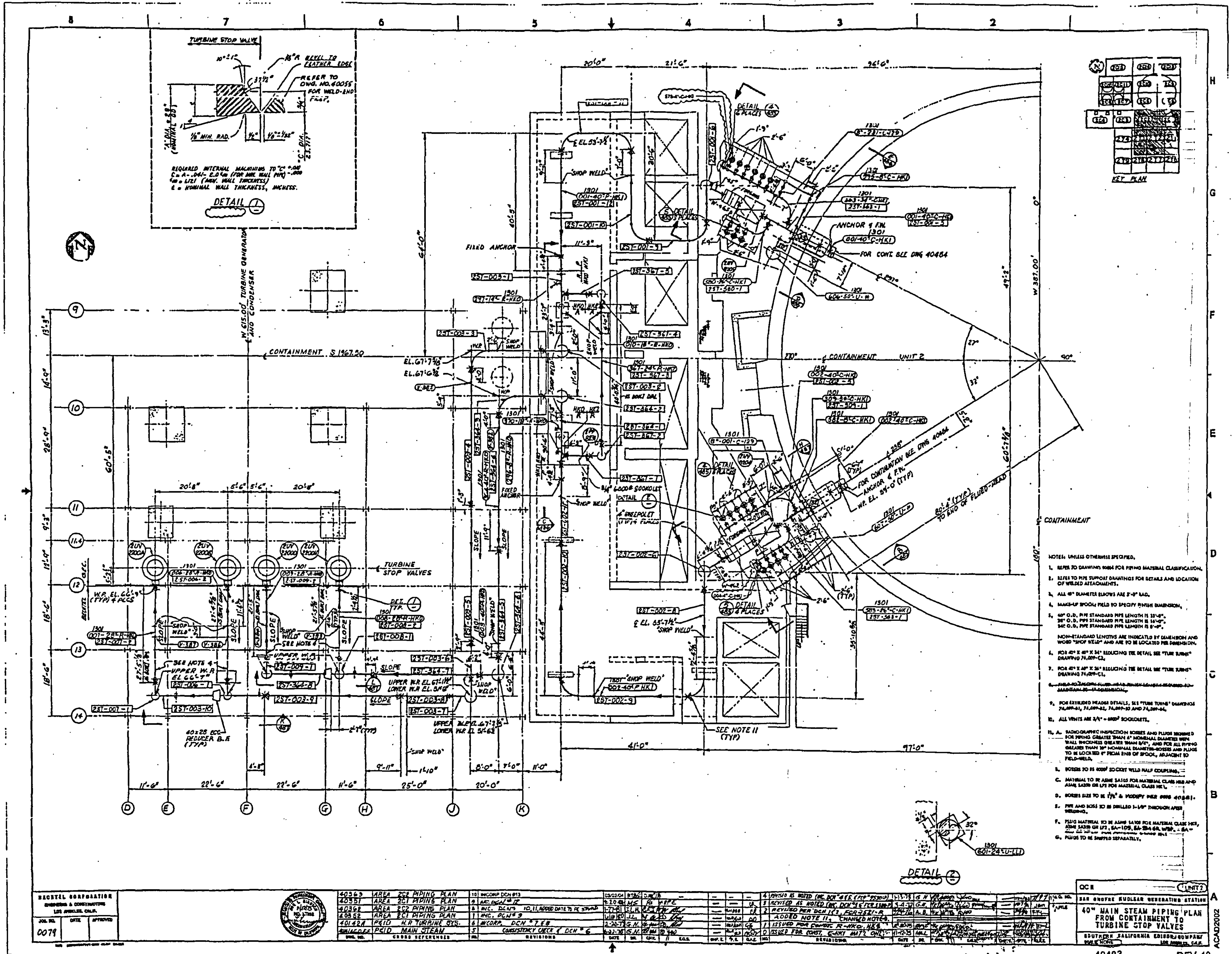
RAI 24:
List any deviations or exceptions taken in your radiological consequence analyses performed for the design-basis loss-of-coolant accident, FHAs inside and outside containment, and the MSLB accident from RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors." (RAI Category Code 2.a)

RESPONSE:

No deviations or exceptions from RG 1.183 were taken in the radiological consequence analyses performed for the design-basis loss-of-coolant accident, FHAs inside and outside containment, and the MSLB accident. Sections 4.5 through 4.8 of the application provide explicit statements as to how the analyses comply with the applicable portions of RG 1.183 guidance.

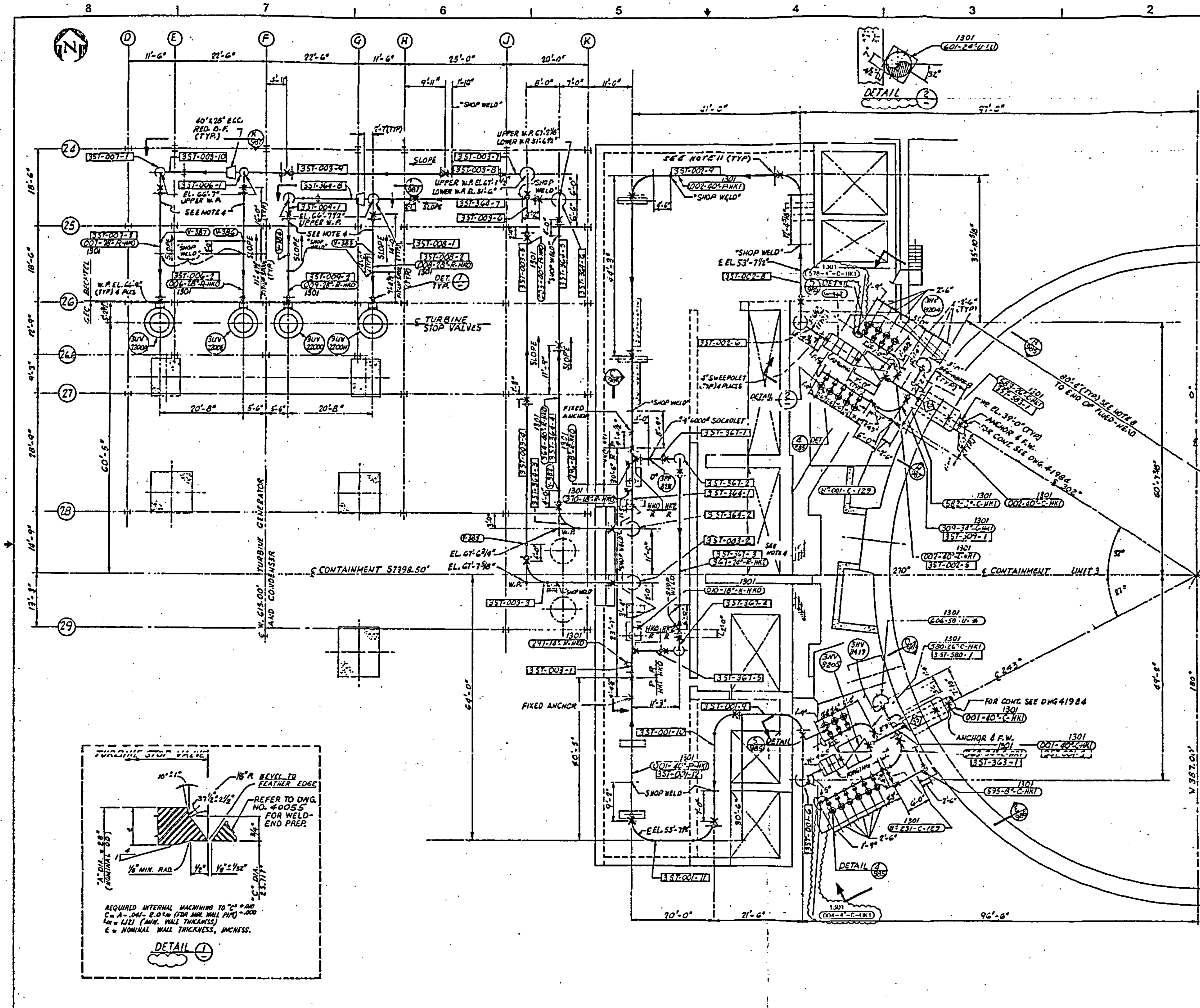
Attachment A

Drawing Nos. 40483 and 41983



TURBINE STOP VALVE
DETAIL 1
KEY PLAN
CONTAINMENT
TURBINE STOP VALVES
FIXED ANCHOR
SHOP WELD
DETAIL 2
NOTES: UNLESS OTHERWISE SPECIFIED.
ALL VENTS ARE 3/4" - 6000# SOCKOLETS.
PLUGS TO BE SHIPPED SEPARATELY.
BECHTEL CORPORATION
QC II
UNIT 2
SAN ONOFRE NUCLEAR GENERATING STATION
40" MAIN STEAM PIPING PLAN FROM CONTAINMENT TO TURBINE STOP VALVES
SOUTHERN CALIFORNIA EDISON COMPANY
LOS ANGELES, CALIF.
SCALE NONE
40483
REV 10
ACAD2002

10483



NOTES UNLESS OTHERWISE NOTED.

1. REFER TO DRAWING 90004 FOR PIPING MATERIAL CLASSIFICATION.
2. REFER TO PIPE SUPPORT DRAWINGS FOR DETAILS AND LOCATION OF WELDED ATTACHMENTS.
3. ALL 40" DIAMETER ELBOWS ARE 5'-3" RAD.
4. MAKE-UP SPOOL FIELD TO SPECIFY FINISH DIMENSION.
5. 40" O.D. PIPE STANDARD PIPE LENGTH IS 13'-0". 28" O.D. PIPE STANDARD PIPE LENGTH IS 16'-0". 26" O.D. PIPE STANDARD PIPE LENGTH IS 8'-0".

   NON-STANDARD LENGTHS ARE INDICATED BY DIMENSION AND WORD "SHOP WELD" AND ARE TO BE LOCATED PER DIMENSION.
6. FOR 40" X 40" X 34" REDUCING TEE DETAIL SEE "TUBE TURNS" DRAWING 74.089-C2.
7. FOR 40" X 40" X 26" REDUCING TEE DETAIL SEE "TUBE TURNS" DRAWING 74.089-C1.
8. ~~FIELD TO SPECIFY FLUED HEAD FINISH LENGTH REQUIRED TO MAINTAIN 80'-4" DIMENSION.~~
9. FOR EXTRUDED HEADER DETAILS, SEE "TUBE TURNS" DRAWINGS 74.089-81, 74.089-82, 74.089-83 AND 74.089-84.
10. ALL VENTS ARE 3/4" - 6000# SOCKOLETS.
11. A. RADIOGRAPHIC INSPECTION BOSSES AND PLUGS REQUIRED FOR PIPING GREATER THAN 4" NOMINAL DIAMETER WITH WALL THICKNESS GREATER THAN 3/4", AND FOR ALL PIPING GREATER THAN 10" NOMINAL DIAMETER-BOSSES AND PLUGS TO BE LOCATED 4" FROM END OF SPOOL, ADJACENT TO FIELD-WELD.
    B. BOSSES TO BE 6000# SOCKET WELD HALF COUPLING.
    C. MATERIAL TO BE ASME SA105 FOR MATERIAL CLASS HK0 AND ASME SA350 GR LF2 FOR MATERIAL CLASS HK1.
    D. BOSSES SIZE TO BE 1 1/2" ¢ MOD. PER DWG. 40381.
    E. PIPE AND BOSS TO BE DRILLED 1-1/8" THROUGH AFTER WELDING.
    F. PLUG MATERIAL TO BE ASME SA-105 FOR MATERIAL CLASS HK0. ASME SA-350 GR. LF2, SA-105, SA-234 GR. WPB, & SA-420 GR. WPL6 FOR MATERIAL CLASS HK1
    G. PLUGS TO BE SHIPPED SEPARATELY

POOR QUALITY DOCUMENT
BEST COPY AVAILABLE
SIGNED: [illegible] 01/21/05
DOCUMENT ORIGINATOR DATE

DWG. NO.	CROSS REFERENCES
41862	AREA 3C2 PIPING PLAN
41852	AREA 3C1 PIPING PLAN
41863	AREA 3C2 PIPING PLAN
41851	AREA 3C1 PIPING PLAN
40142A503	P&ID H.P. TURBINE SYS
P&ID MAIN STM.	40141A, C, D, E, F, 503

BECHTEL CORPORATION
ENGINEERS & CONSTRUCTORS
LOS ANGELES, CALIF.

JOB NO.	DATE	APPROVED
10079		

NO.	REVISIONS	DATE	DR.	CHK.	E.G.S.	CHF.E.	P.E.	O.A.E.
8	INCORP DCN 12	01/21/05						

QC II UNIT 3

SAN ONOFRE NUCLEAR GENERATING STATION

40" MAIN STEAM PIPING PLAN FROM CONTAINMENT TO TURBINE STOP VALVES

SOUTHERN CALIFORNIA EDISON COMPANY
SCALE NONE LOS ANGELES, CALIF.

41983 REV 8

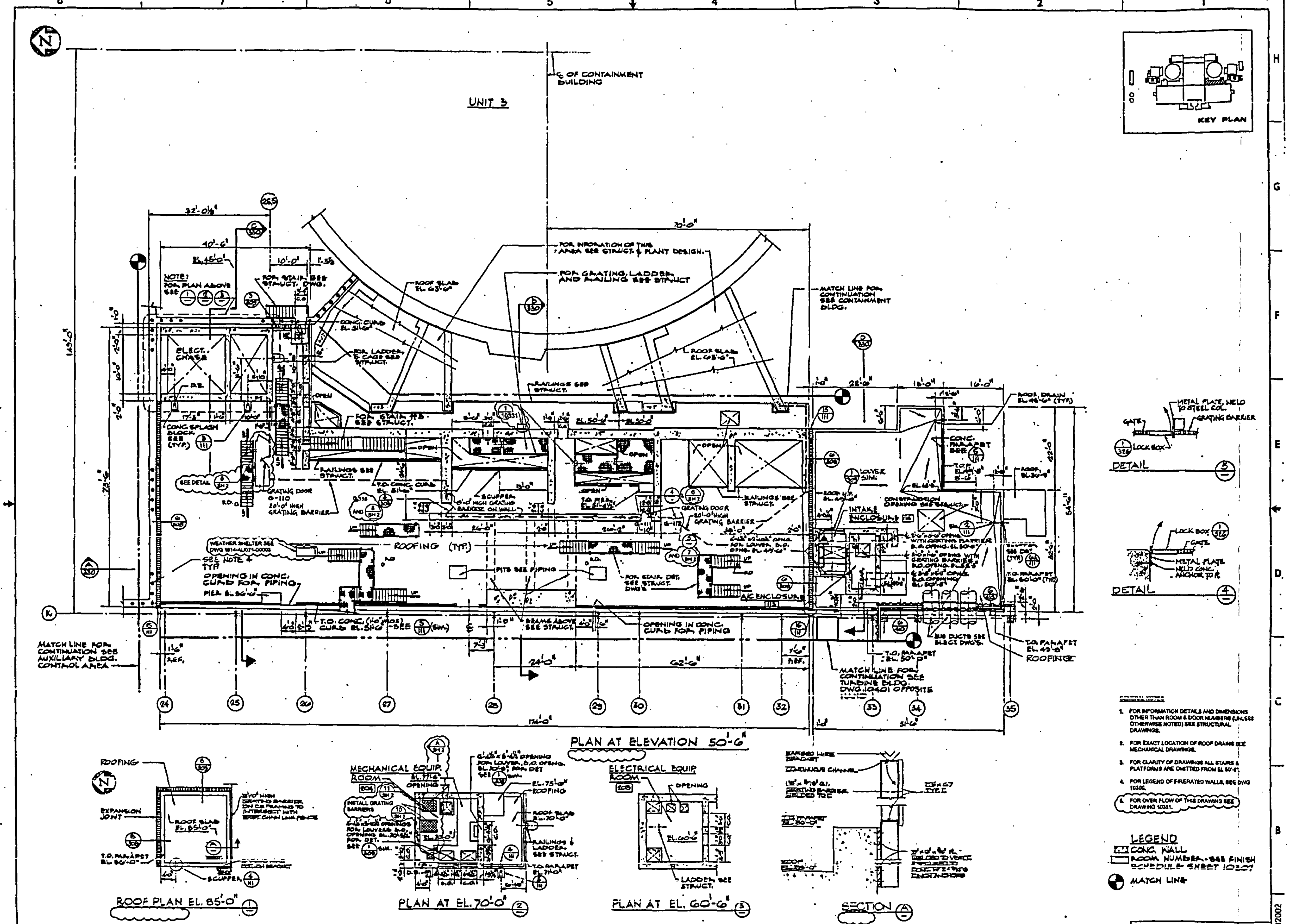
ACAD2002 A

Site File Copy
41983

Attachment B

Drawing Numbers 10328, Sheet 1; and

Drawing Numbers 23090, 23075 and 23069



BECHTEL CORPORATION
ENGINEERS & CONSTRUCTORS
LOS ANGELES, CALIF.

JOB NO.	DATE	APPROVED
10079		

DWG. NO	CROSS REFERENCES
10330	BUILDING SECTIONS
10329	ELEVATION & DETAILS
10309	MISC. DETAILS
10307	SCHEDULES & DETAILS
10111	ROOF DETAILS

NO.	REVISIONS
11	UPDATE FIRERATING PER FHA AMEND 13.
10	INCORPORATE DCN #4. (DCP 3-15-2.)
9	INCORPORATE DCN #3
8	INCORPORATE DCN #2
7	INCORPORATE DCN #1
6	ADD GRATING BARRIER
5	ADD GRATING BARRIER
4	REV. PARAPET EL.
3	REV. ROOFING
12	INCORP DCNs 6 & 8 AND PARTIAL DCNs 6 & 7. ADDED SH 1. SEE SH 2 FOR REMAINDER OF DCNs 6 & 7
0	ISSUED FOR CONSTRUCTION

QCIV — UNIT 3

SAN ONOFRE NUCLEAR GENERATING STATION

SAFETY EQUIPMENT BLDG.
UNIT 3
ROOF PLAN EL. 50'-6"

SOUTHERN CALIFORNIA EDISON COMPANY
SCALE (NONE) — LOS ANGELES, CALIF.

10328 (SH 1) REV 12

ACAD2002

File Copy

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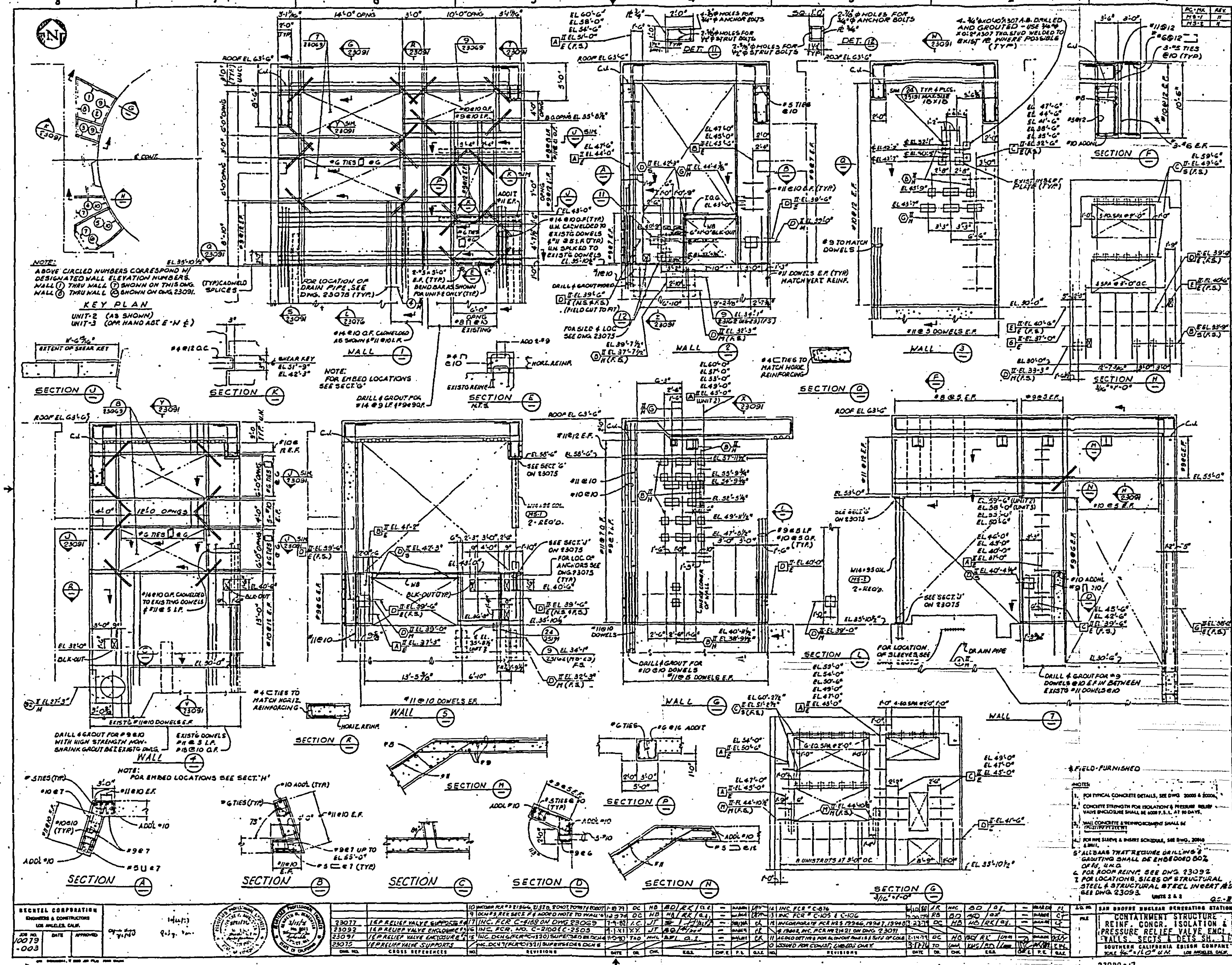
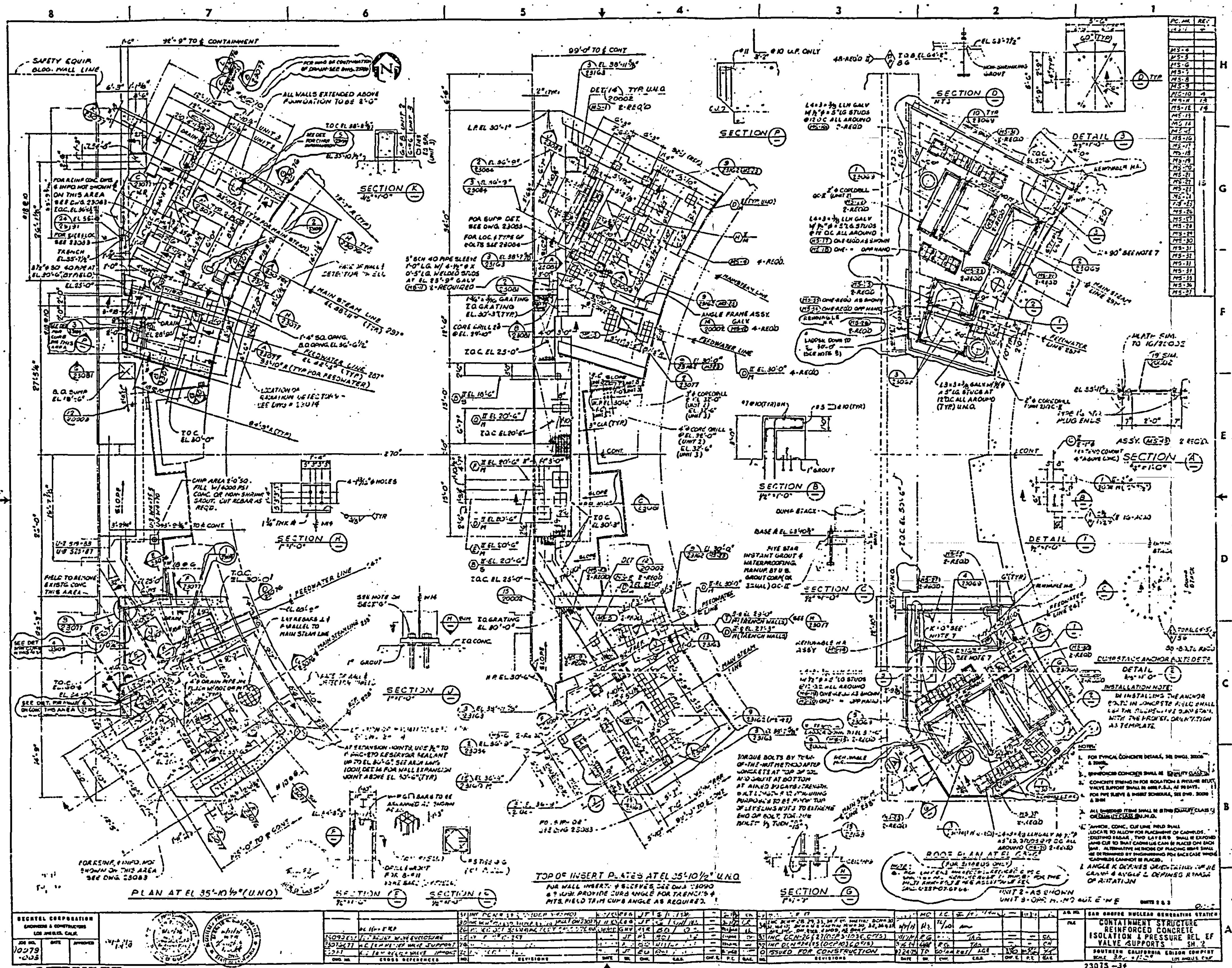

KEY PLAN
UNIT-2 (AS SHOWN)
UNIT-3 (OPP. HAND ABT. E-W ℄)
NOTE:
ABOVE CIRCLED NUMBERS CORRESPOND W/ DESIGNATED WALL ELEVATION NUMBERS.
WALL 1 THRU WALL 7 SHOWN ON THIS DWG.
WALL 8 THRU WALL 16 SHOWN ON DWG. 23091.
WALL 1
WALL 2
WALL 3
WALL 4
WALL 5
WALL 6
WALL 7
SECTION A
SECTION B
SECTION C
SECTION D
SECTION E
SECTION F
SECTION G
SECTION H
SECTION J
SECTION K
SECTION L
SECTION M
SECTION N
SECTION P
SECTION Q
SECTION R
DET. 11
DET. 12
* FIELD-FURNISHED
NOTES:
1. FOR TYPICAL CONCRETE DETAILS, SEE DWG. 20005 & 20006.
2. CONCRETE STRENGTH FOR ISOLATION & PRESSURE RELIEF VALVE ENCLOSURE SHALL BE 6000 P.S.I. AT 90 DAYS.
3. WALL CONCRETE & REINFORCEMENT SHALL BE
4. FOR PIPE SLEEVE & INSERT SCHEDULE, SEE DWG. 20010 & 20011.
5. ALL BARS THAT REQUIRE DRILLING & GROUTING SHALL BE EMBEDDED 80% OF ld, U.N.O.
6. FOR ROOF REINF. SEE DWG. 23092
7. FOR LOCATIONS, SIZES OF STRUCTURAL STEEL & STRUCTURAL STEEL INSERT PLS SEE DWG. 23093.
UNITS 2 & 3
Q.C.-II
BECHTEL CORPORATION
ENGINEERS & CONSTRUCTORS
LOS ANGELES, CALIF.
JOB NO. 10079-003
SAN ONOFRE NUCLEAR GENERATING STATION
CONTAINMENT STRUCTURE
REINF. CONCR. ISOLATION & PRESSURE RELIEF VALVE ENCL. WALLS, SECTS & DETS SH. 1
SOUTHERN CALIFORNIA EDISON COMPANY
LOS ANGELES, CALIF.
SCALE 1/4"=1'-0" U.N.
23090-17

23090



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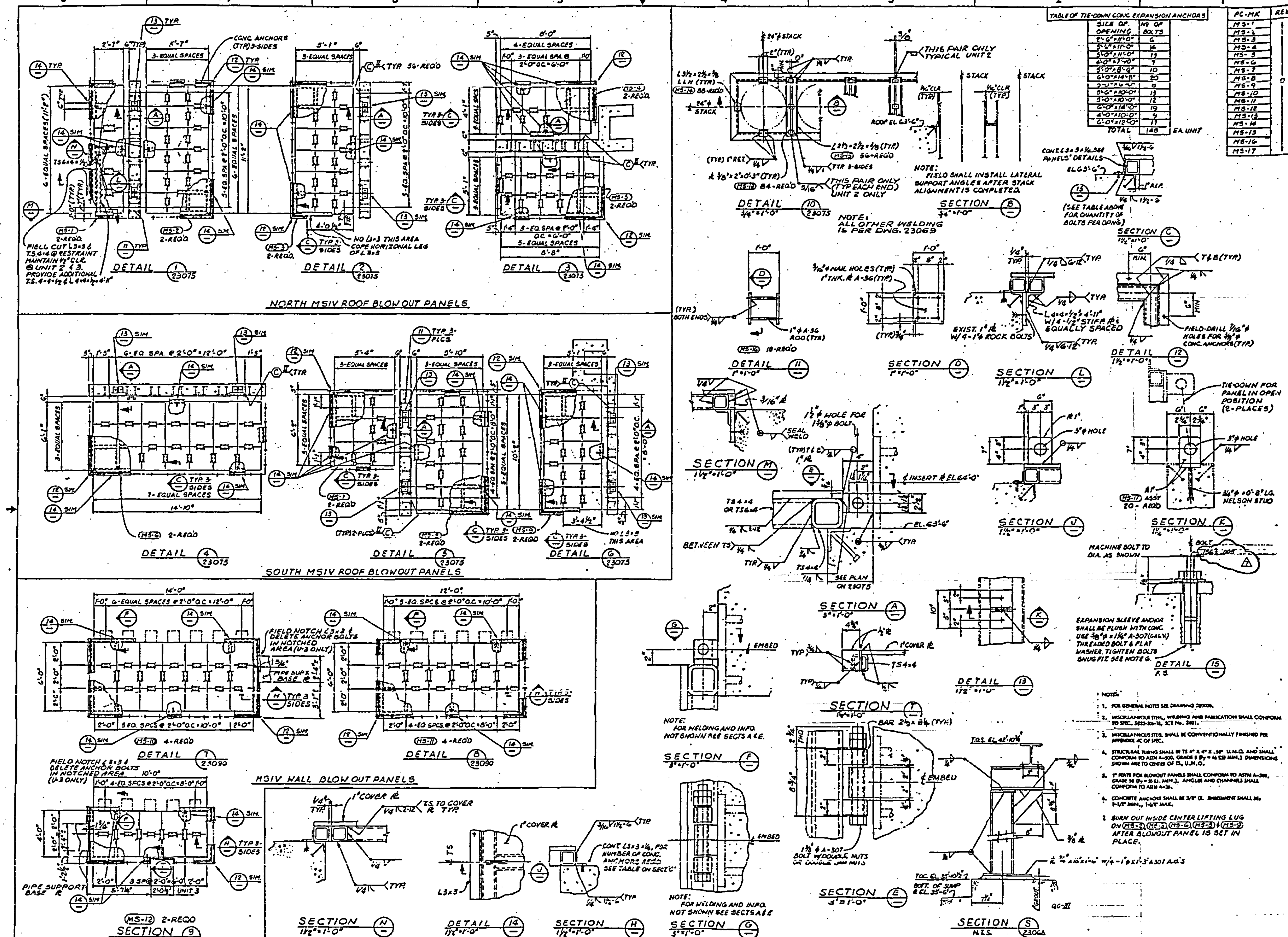


TABLE OF TIE-DOWN CONC EXPANSION ANCHORS

SIZE OF OPENING	Nº OF BOLTS
2'-6" x 11'-0"	6
5'-6" x 11'-0"	14
5'-0" x 11'-0"	13
4'-0" x 7'-10"	7
5'-0" x 8'-6"	10
6'-0" x 14'-8"	20
[illegible]	8
5'-6" x 10'-0"	13
5'-0" x 10'-0"	12
6'-0" x 14'-0"	19
4'-0" x 10'-0"	9
6'-0" x 12'-0"	17
TOTAL	148 EA. UNIT

PC-MK	REV
MS-1	0
MS-2	0
MS-3	0
MS-4	0
MS-5	0
MS-6	0
MS-7	0
MS-8	0
MS-9	0
MS-10	0
MS-11	0
MS-12	0
MS-13	0
MS-14	0
MS-15	0
MS-16	0
MS-17	0

NO.	REVISIONS	DATE	DR.	CHK.
5	INC. FCR C-6118 From Dwg 23090. INC. FCR C-6178	7-9-82	I.C.	JT
4	INC. FCR # C-3447	4-1-81	JEO	BO
3	INC. DCN 1 (FCR C-1553) & ADDED SECT. S; INC. DCN 2 (FCR C-1686)	10-2-80		MMC
2	CHG. 3" CHANNEL TO BAR	3-19-79	BD	HB
1	CLARIFY DETAIL 6	3-1-79	DC	HB
0	ISSUED FOR CONSTRUCTION	2-14-79	DC	HB

CROSS REFERENCES

DWG. NO.	
23093	MSIV ROOF STL DKG & FRMG SUPP
23092	MSIV ROOF SLAB @ EL. 63'-6"
23090-91	MSIV WALL ELEVATIONS
23075-77	MSIV FOUNDATION & INSERTS

BECHTEL CORPORATION
ENGINEERS & CONSTRUCTORS
LOS ANGELES, CALIF.
JOB NO. 10079-005

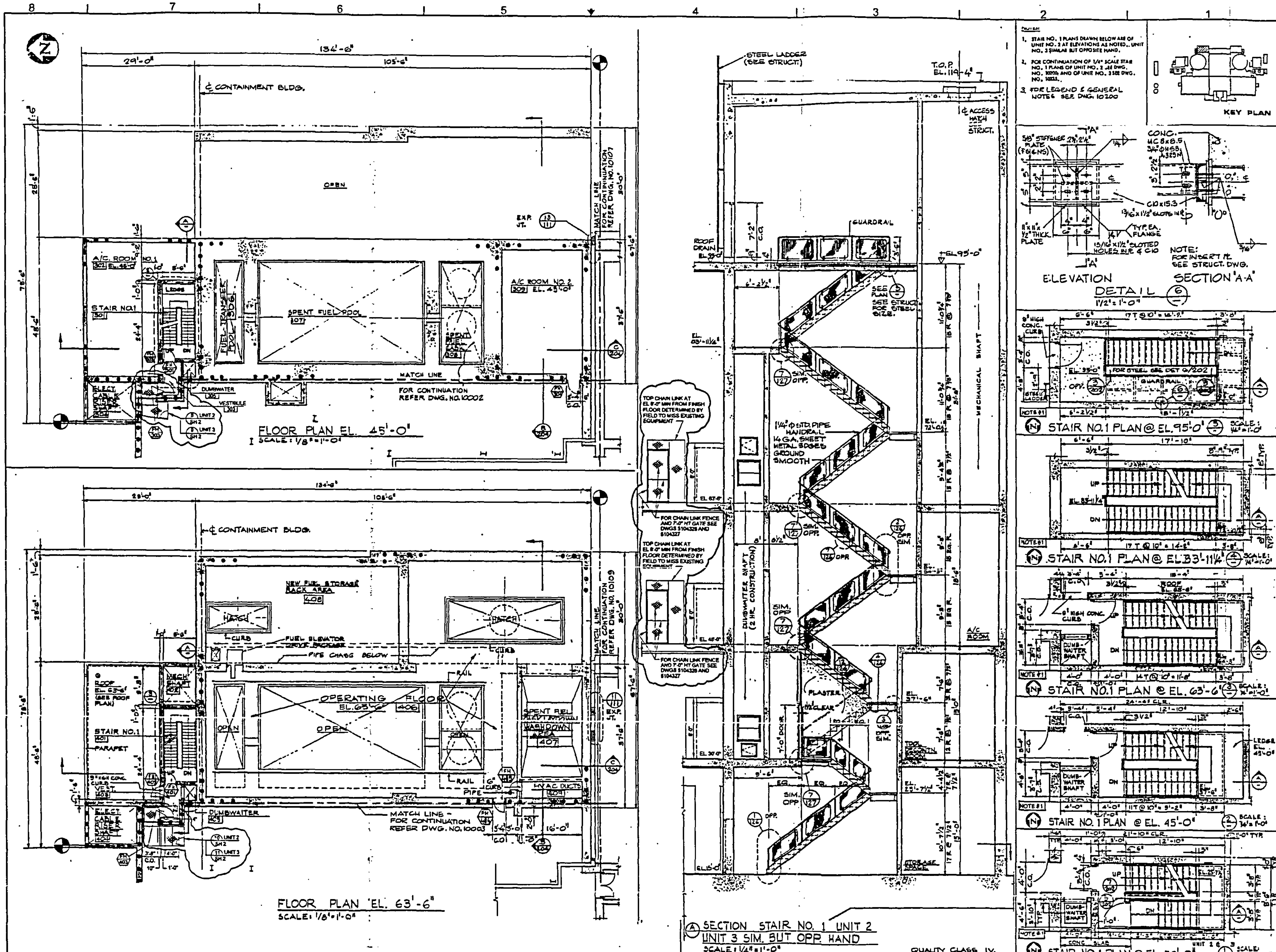
SAN ONOFRE NUCLEAR GENERATING STATION
CONTAINMENT STRUCTURE
MSIV – INSERTS, SECTIONS AND DETAILS
SOUTHERN CALIFORNIA EDISON COMPANY
SCALE 3/8" = 1'-0" U.N.O. LOS ANGELES, CALIF.

23069 - 7

23069

Attachment C

Drawing Number 10201, Sheet 1, Revision 7



QUALITY CLASS IV.

BECHTEL CORPORATION
ENGINEERS & CONSTRUCTORS
LOS ANGELES, CALIF.

JOB NO.	DATE	APPROVED
10079 003		

DWG. NO.	CROSS REFERENCES
10201 SH 2	DETAILS & SECTIONS
5104327 SH 2	FENCING DETAINS
5104326 SH 1	FENCING DETAILS

NO.	REVISIONS	DATE	DR.	CHK.	E.R.S.	CHF. E.	P.E.	Q.C.E.
7	INC. PARTIAL DCN 1 & 2. INC. PARTIAL DCN 1 & 2 ON DWG 10201 SH 2. ADDED SH 1 PER ECP 021001586-1	10-31-02	RRO	S.O.	—	—	—	—
6	UPDATE FIRERATING PER FHA AMEND 13.	11-27-79		GL		—		

NO.	REVISIONS	DATE	DR.	CHK.	E.G.S.	DIV. A	P.E.	Q.E.
5	REV. WALL EL. 63'-6"	10-4-77				—		
4	REV. DET. 6, 5, 1, PLAN EL. 63'-6", REV. ROOF	3-11-77				—		
3	REV. EL. 63'-6", STAIR & EL. 95'-0" ADD. DET. 6	7-2-76						
2	GEN. REV. (NOTES, DIM, WALLS)	3-26-76						
1	REV. REF. DET. & DIM. @ STAIR #1	10-6-75						
C	ISSUED FOR CONSTRUCTION	9-17-75	FAS	GVS				

SAN ONOFRE NUCLEAR GENERATING STATION

FUEL HANDLING BLDG.
UNIT 2 FL. PLANS EL.45'-0" & 63'-6"
STAIR PLANS & SECTIONS

SOUTHERN CALIFORNIA EDISON COMPANY
SCALE AS NOTED — LOS ANGELES CALIF.

10201 SH. 1 REV. 7

Site File Copy
10201

Enclosure 3

Complete Replacement of PCN-555,

"Alternative Source Term"

LICENSEE'S EVALUATION

PCN 555

Alternative Source Term

1.0 INTRODUCTION

This letter is a request to amend Operating Licenses NPF-10 and NPF-15 for San Onofre Nuclear Generating Station (SONGS) Units 2 and 3, respectively.

This license amendment request will revise the accident source term used in the design basis radiological consequences analyses to an Alternative Source Term (AST) in accordance with the requirements of 10 CFR 50.67.

This license amendment request will also expand the allowed use of fuel failure estimates by Departure from Nucleate Boiling (DNB) statistical convolution methodology from only the reactor coolant pump sheared shaft event to the UFSAR Chapter 15 non-LOCA events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel.

2.0 PROPOSED CHANGE

This license amendment is requested in accordance with the requirements of 10 CFR 50.67, which addresses the use of an AST at operating reactors, and relevant guidance of Regulatory Guide 1.183 (Reference 1). This license amendment request represents full-scope implementation of the AST described in Regulatory Guide 1.183.

Full-scope implementation of an AST requires re-analysis of Updated Final Safety Analysis Report (UFSAR) Chapter 15 accident analyses, including the Loss-of-Coolant Accident (LOCA) and Fuel Handling Accident (FHA) at a minimum. Southern California Edison (SCE) has re-analyzed the LOCA, FHA inside containment (FHA-IC), and FHA in the Fuel Handling Building (FHA-FHB). In addition, to ensure that the most limiting accident in terms of dose consequences has been included, SCE has re-analyzed the pre-trip Steam Line Break Outside Containment (SLB-OC) accident as well.

This license amendment request will also expand the allowed use of fuel failure estimates by DNB statistical convolution methodology from only the reactor coolant pump sheared shaft event to the UFSAR Chapter 15 non-LOCA events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel.

Implementation of this license amendment will require changes to the SONGS UFSAR Chapter 15 control room and offsite radiological consequence analyses for these four Design Basis Accidents (DBAs). Following approval of this license amendment request, SCE will provide the revised UFSAR sections to the NRC as part of its normal UFSAR update required by 10 CFR 50.71(e).

In summary, the requested license amendment will revise the accident source term used in the design basis radiological consequences analyses to an

Alternative Source Term in accordance with the requirements of 10 CFR 50.67, and allow fuel failure estimates for UFSAR Chapter 15 non-LOCA events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel, to be based on the DNB statistical convolution methodology.

3.0 BACKGROUND

Generic Letter 2003-01

On June 12, 2003, the NRC issued Generic Letter (GL) 2003-01, "Control Room Habitability" (Reference 2) GL 2003-01 discussed the results of Control Room Envelope (CRE) inleakage testing at several plants. These test results indicate that current testing methods (positive pressure testing) do not give a good indication of CRE inleakage. GL 2003-01 requested that licensees confirm that the most limiting unfiltered inleakage into the CRE is no more than the value assumed in the design basis radiological analyses. SCE performed CRE inleakage testing in May, 2004 and transmitted the results of this testing to the NRC by letter dated September 17, 2004 (Reference 3).

As stated in SCE's August 5, 2003 letter (Reference 4) responding to GL 2003-01, the current value of assumed unfiltered inleakage into the CRE in the design basis radiological analyses is 0 cfm, plus an additional assumed 10 cfm for ingress and egress. As described in SCE's letter dated September 17, 2004, testing has shown that actual CRE inleakage exceeds that assumed in the current design basis radiological analyses. Since testing was completed, SONGS Units 2 and 3 have continued to operate based on operability assessments that rely on AST methodology. Approval of this proposed change will make the AST the SONGS Units 2 and 3 licensing and design basis and will restore the SONGS Units 2 and 3 CRE to full qualification.

As described above, this license amendment request represents full-scope implementation of the AST as described in Regulatory Guide 1.183. The LOCA, FHA-IC, FHA-FHB, and pre-trip SLB-OC analyses have been updated and show results within the acceptance criteria defined in 10CFR50.67 with an assumed CRE unfiltered boundary inleakage of 990 cfm plus 10 cfm assumed unfiltered inleakage due to CRE ingress and egress. Following approval of this license amendment request, future revisions to UFSAR Chapter 15 design basis accident control room and offsite radiological consequence analyses will be performed using AST methodology. In addition, following approval of this license amendment request, fuel failure estimates for UFSAR Chapter 15 non-LOCA events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel may be based on the DNB statistical convolution methodology.

There are no physical changes to plant equipment or operation of the plant as a result of this proposed change. There are no changes to the Technical Specifications (TSs) as a result of this proposed change.

Impact to the Site

The following clarifications are provided to address source term implementation considerations of RG 1.183 that are not explicitly stated elsewhere in this proposed change:

1. Impact on Equipment Environmental Qualification

Regulatory Guide 1.183 Regulatory Position 1.3.5 states that equipment Environmental Qualification (EQ) analyses that have assumptions or inputs affected by a proposed plant modification associated with the AST implementation should be updated to address these impacts. Regulatory Position 1.3.5 of RG 1.183 also states that the NRC staff is assessing the effect of increased cesium releases on EQ doses to determine whether licensee action is warranted, and that until such time as this generic issue (GSI-187) is resolved, licensees may use either the AST or the Technical Information Document (TID) 14844 assumptions for performing the required EQ analyses. The GSI has since been closed with the determination that a generic action was not warranted. Consistent with the RG 1.183 guidance and the GSI closure determination, since no plant modifications are required to address AST implementation, the existing equipment qualification analyses, which are based upon the TID-14844 source term, are considered acceptable. Future EQ analyses may use either the AST or TID-14844 source term.

2. Control Room Habitability

NUREG-0737 (Reference 5), Task III.D.3.4, "Control-Room Habitability Requirements," requires that the control room (CR) operators be adequately protected against the effects of accidental release of radioactive gases, and that the nuclear power plant can be safely operated or shut down under design basis accident conditions (as required by 10 CFR 50, Appendix A, General Design Criterion 19). With approval of the Alternative Source Term methodology, the dose acceptance criterion for CR operators will become the 5 rem Total Effective Dose Equivalent (TEDE) dose criterion of 10 CFR 50.67.

As documented in Section 4, the CR operator post-accident dose for each of the evaluated events is less than 5 rem TEDE. Compliance with this dose acceptance criterion ensures that the CR operators are adequately protected against the effects of accidental release of radioactive gases, and that the nuclear power plant can be safely operated or shut down under design basis accident conditions.

3. Emergency Response Facility Habitability

The Emergency Response Facilities (ERFs) consist of the Technical Support Center (TSC), the Operations Support Center (OSC), and the Emergency Operations Facility (EOF).

NUREG-0737, Task II.B.2, "Design Review of Plant Shielding and Environmental Qualification of Equipment for Spaces/Systems Which May Be Used in Postaccident Operations", provides dose criteria for CR and TSC occupants. This document states that the dose to individuals in the CR or TSC should not be in excess of 5 rem whole body, or its equivalent to any part of the body for the duration of the accident. The document also states the CR and TSC dose criteria should be based on the control room occupancy factors contained in Standard Review Plan 6.4.

The TSC is located within the control room envelope, in rooms that overlook the Units 2 and 3 control room operating areas. TSC occupants receive the same inhalation and immersion doses calculated for CR occupants. SCE has determined that although a given gamma shine dose to a TSC occupant may be higher or lower than the dose to a CR occupant, the net effect from all post-accident gamma shine sources is that the TSC shine dose is no more than the CR shine dose. Since the CR dose criterion of 5 rem TEDE is met using an AST methodology, the TSC dose criterion of 5 rem would also be met.

The OSC is located in the Auxiliary Building. This facility does not have isolation or filtration capabilities. Consistent with current emergency planning requirements, post-accident radiation dose rate surveys of the OSC would be performed by Health Physics personnel, and protective actions would be taken if necessary.

The EOF is located at the SONGS Mesa Facility across Interstate 5 from San Onofre Units 2 and 3. The EOF is protected by charcoal and HEPA filtration systems. Because of the distance from the various possible release points and the available filtration systems, any doses seen in the EOF would be bounded by those seen in the control room or TSC.

4. Impact on Emergency Planning Radiological Assessment Methodology

Implementation of an AST will impact several aspects of Emergency Planning Radiological Dose Assessment Methodology. The behavior of radioactive iodine released under post-accident conditions, which is defined by the accident source term, is an input to emergency planning dose assessment calculations. Following approval of this license amendment request, the manual dose calculation methodology as described in Emergency Planning Implementation Procedures (EPIPs)

and other Emergency Planning guidance documents will be revised to reflect AST methodology.

Raddose V dose assessment software will be evaluated by June 30, 2005, to determine what specific changes may be warranted in order to maintain consistency with the manual dose assessment calculation methodology.

5. Post Accident Sampling Capability

Post Accident Sampling System (PASS) licensing requirements were deleted from the SONGS Units 2 & 3 Technical Specifications per Unit 2 License Amendment 178 and Unit 3 License Amendment 169 (Reference 6). Currently, the diluted depressurized grab sample portion of the PASS is retained for severe accident management only. Application of AST methodology has determined that, if required for severe accident management, an individual can draw a PASS sample approximately 17 hours following the onset of a loss of coolant accident without exceeding the NUREG-0737 dose criteria for whole body and extremity exposures.

Application of AST methodology has also determined that an individual performing reactor coolant sample collection and analysis at the Normal Sampling Station (NSS) for boron, hydrogen, gas activity, and liquid activity at 3 hours following a non-LOCA event, and with up to 5% fuel clad failures, will not exceed the 5 rem whole body dose limit. This determination is consistent with the current licensing basis source term dose evaluation for this same exposure mechanism.

As described in the Safety Evaluation Report for License Amendments 178 and 169 for San Onofre Units 2 and 3, SCE is committed to maintain the capability for classifying fuel damage events at the Alert level threshold of 300 µCi/gram dose equivalent iodine-131. The value of 300 µCi/gram DE I-131 is unaffected by use of an AST. Therefore, the capability for classifying fuel damage events at the Alert level threshold is unchanged.

6. Accident Monitoring Instrumentation

A review of Accident Monitoring setpoint calculations was performed. This review determined that no setpoint changes will be required to implement the AST. Some setpoint calculations were unaffected. The remaining calculations were determined to be conservative relative to calculations that would be based on an AST, because the mix of isotopes predicted by the AST calculations is bounded by the mix of isotopes expected under the current licensing basis. Following approval of this license amendment request, future revisions to Accident Monitoring setpoint calculations will reflect the AST source term.

7. Other Design Bases Not Affected

This proposed change has been determined to have no affect on post-accident access, environmental reports, facility siting, or leakage control.

4.0 TECHNICAL ANALYSIS

To address the issue of measured CRE inleakage rate exceeding the currently assumed CRE inleakage rate, a series of new radiological dose analyses have been originated using the AST methodology of Regulatory Guide (RG) 1.183 to document the acceptability of an assumed increase in SONGS Units 2 and 3 CRE unfiltered inleakage rate to a value of 1,000 cfm (including ingress and egress related inleakage). This Section summarizes the analyses supporting the SONGS Units 2 and 3 license amendment request.

As recommended by RG 1.183, a complete LOCA dose analysis has been performed. Additionally, dose analyses have been performed to assess the radiological consequences of FHAs in both the containment and fuel handling buildings, and the radiological consequences of a pre-trip SLB-OC. The FHAs and SLB-OC have been re-analyzed since the current licensing basis analyses for these events challenge the offsite dose acceptance criteria. In addition, the pre-trip SLB-OC had not been previously evaluated for control room dose consequences.

With the exception of the Increased Main Steam Flow with single failure (IMSF-SF) event, all other design basis accidents that are currently evaluated in the SONGS Units 2 and 3 UFSAR Chapter 15 have control room and offsite dose consequences that are less severe than those of the LOCA, FHA, and pre-trip SLB-OC accidents. The IMSF-SF Exclusion Area Boundary (EAB) whole body gamma dose is slightly greater than for the pre-trip SLB-OC. The IMSF-SF EAB thyroid inhalation dose is significantly less than for the pre-trip SLB-OC. For this reason, the IMSF-SF has not been re-evaluated as part of this license amendment request.

Following approval of this license amendment request, future revisions to UFSAR Chapter 15 design basis accident control room and offsite radiological consequence analyses will be evaluated using AST methodology whenever a need arises for them to be updated.

Section 4.1 summarizes the core and fuel rod fission product inventories that were recalculated using the guidance in AST RG 1.183 as clarified in RG 1.195 (Reference 7). Section 4.1 also presents the recalculated activity profiles associated with operation at the primary and secondary activity concentration limits, with and without iodine spiking, as specified in Technical Specification Limiting Conditions For Operation (LCOs) 3.4.16 and 3.7.19.

Section 4.2 summarizes the model used in evaluating offsite dose consequences at the EAB and at the outer boundary of the low population zone (LPZ). This model is generic to the dose analyses evaluating offsite dose consequences.

Section 4.3 summarizes the model used in evaluating control room dose consequences. This model is generic to the dose analyses evaluating control room dose consequences.

Adoption of the AST methodology guidance has imposed the need to recalculate atmospheric dispersion between various post-accident release points and the control room outside air ventilation intakes. The atmospheric dispersion analysis uses the ARCON96 computer code and guidance provided in RG 1.194 (Reference 8). Section 4.4 summarizes the ARCON96 analyses.

Section 4.5 summarizes the model used in evaluating the radiological consequences of a loss of coolant accident.

Section 4.6 summarizes the model used in evaluating the radiological consequences of a fuel handling accident inside the containment building.

Section 4.7 summarizes the model used in evaluating the radiological consequences of a fuel handling accident inside the fuel handling building.

Section 4.8 summarizes the model used in evaluating the radiological consequences of a pre-trip steam line break outside containment.

Section 4.1 ACTIVITY INVENTORIES AND TECHNICAL SPECIFICATION ACTIVITY PROFILES

The SONGS Units 2 and 3 core and fuel rod fission product inventories have been recalculated using the guidance in AST RG 1.183 as clarified in RG 1.195. Activity profiles have also been recalculated for operation at the primary and secondary activity concentration limits, with and without iodine spiking.

Section 4.1.1 Core and Average Fuel Rod Activity Inventories

Table 4.1-1 summarizes the parameters modeled in the evaluation of the reactor core activity inventory. The core inventory of fission products is based on the maximum full-power operation of the core with, as a minimum, currently licensed values for fuel enrichment, fuel burnup, and an assumed core power equal to the current licensed rated thermal power times the emergency core cooling system (ECCS) evaluation uncertainty. These parameters were examined parametrically to maximize the fission product inventory. The period of irradiation is of sufficient duration to allow the activity of dose significant radionuclides to reach equilibrium or to reach maximum values. The core inventory was developed using the SAS2H and ORIGEN-S modules of the NRC-sponsored SCALE code package, which is an appropriate isotope generation and depletion computer code.

TABLE 4.1-1: ACTIVITY INVENTORY MODEL PARAMETERS

PARAMETER	MODELED VALUE
Maximum Core Average Burnup	40.0 GWD/T
Maximum Core Average Enrichment	4.8 w/o U-235
Maximum Core Uranium Loading	95.5 MTU
Core Rated Thermal Power	3,438 MW-t
Core Thermal Power Uncertainty	0.58% actual, 2.0% modeled
Analyzed Core Thermal Power	3,507 MW-t
Minimum Number of Fuel Rods per Core	51,132 rods/core

The ORIGEN-S code was executed for the various combinations of core average burnups (0, 10, 20, 30 and 40 GWD/T) and enrichments (3.8 and 4.8 w/o U-235). Each ORIGEN-S code run evaluated the activity inventory in a single fuel assembly. In any code run, the maximum curie value of an isotope represents the sum of the ORIGEN-S code output identified as "Light Elements", "Fission Products", and "Actinides". For each isotope, the maximum curie value from the ORIGEN-S code runs was chosen to represent the inventory of that isotope in the composite fuel assembly. Activity inventories were originated for 540 isotopes of the elements listed in RG 1.183 Table 5. The maximum full core accident source term was determined by multiplying the composite maximum fuel assembly activity inventory by 217 fuel assemblies per core.

Table 4.1-2 summarizes the full core accident source term. The original 540 isotopes were reduced to the Table 4.1-2 listing of 166 isotopes that are included in the Bechtel LocaDose code isotope library. Per the guidance of RG 1.183 Regulatory Position 4.1.1, the isotope libraries contain all radionuclides, including progeny from the decay of parent radionuclides, that are significant with regard to dose consequences and the released radioactivity. The 166 isotopes include all but one of the isotopes listed in the RADTRAD code isotope library as identified in NUREG/CR-6604 (Reference 9) Table 1.4.3.3-2. The missing isotope is Niobium-97m, which is a short-lived daughter of Zirconium-97, and which does not have a dose conversion factor in Federal Guidance Report 11 (Reference 10). Niobium-97m decays to Niobium-97. The Bechtel LocaDose code isotope library conservatively assumes that Zirconium-97 decays directly to Niobium-97.

Consistent with the guidance of RG 1.183 Regulatory Position 3.1, for events that do not involve the entire core, Table 4.1-3 summarizes the average fission product inventory of each damaged fuel rod as determined by dividing the Table 4.1-2 total core inventory by the minimum number of fuel rods in the core.

Per RG 1.183 Regulatory Positions 3.2 and 3.4, the only elements to be considered in design basis analyses for non-LOCA events, including fuel handling accidents, are xenon, krypton, iodine, bromine, cesium, and rubidium.

TABLE 4.1-2: REACTOR CORE ISOTOPE INVENTORY AT SHUTDOWN

ISOTOPE	CORE INVENTORY [curies]	ISOTOPE	CORE INVENTORY [curies]	ISOTOPE	CORE INVENTORY [curies]	ISOTOPE	CORE INVENTORY [curies]
XE-131M	1.22E+06	TE-127M	1.44E+06	CO-58	2.21E+05	CM-243	2.26E+03
XE-133M	6.05E+06	TE-127	8.48E+06	CO-60	4.60E+05	CM-244	3.91E+05
XE-133	1.93E+08	TE-129M	5.95E+06	LA-140	1.90E+08	CM-245	3.06E+01
XE-135M	4.06E+07	TE-129	2.91E+07	LA-141	1.67E+08	CM-246	8.05E+00
XE-135	7.05E+07	TE-131M	1.92E+07	LA-142	1.66E+08	CM-247	4.34E-05
XE-137	1.80E+08	TE-131	7.90E+07	LA-143	1.63E+08	CM-248	1.97E-04
XE-138	1.79E+08	TE-132	1.34E+08	ZR-93	1.56E+02	AM-241	1.57E+04
KR-83M	1.43E+07	TE-133M	9.20E+07	ZR-95	1.78E+08	AM-242M	1.06E+03
KR-85M	3.12E+07	TE-133	1.11E+08	ZR-97	1.69E+08	AM-242	9.20E+06
KR-85	1.09E+06	TE-134	1.92E+08	ND-144	0.00E+00	AM-243	2.93E+03
KR-87	6.38E+07	SB-124	8.79E+04	ND-147	6.55E+07	CE-141	1.67E+08
KR-88	8.98E+07	SB-125	1.03E+06	EU-152	9.37E+02	CE-142	3.19E-03
KR-89	1.15E+08	SB-126M	5.13E+04	EU-154	7.68E+05	CE-143	1.64E+08
I-129	3.62E+00	SB-126	4.37E+04	EU-155	3.12E+05	CE-144	1.29E+08
I-130	2.50E+06	SB-127	8.57E+06	EU-156	2.65E+07	PU-236	5.34E+01
I-131	9.37E+07	SB-129	3.06E+07	NB-93M	2.16E+02	PU-237	7.05E+02
I-132	1.36E+08	SE-79	7.86E+00	NB-95M	2.05E+06	PU-238	3.56E+05
I-133	1.98E+08	BA-136M	6.36E+05	NB-95	1.79E+08	PU-239	3.60E+04
I-134	2.26E+08	BA-137M	1.19E+07	NB-97	1.70E+08	PU-240	5.16E+04
I-135	1.87E+08	BA-139	1.82E+08	PM-147	1.87E+07	PU-241	1.53E+07
I-136	9.20E+07	BA-140	1.81E+08	PM-148M	3.30E+06	PU-242	2.50E+02
I-137	9.46E+07	BA-141	1.66E+08	PM-148	1.84E+07	PU-243	4.95E+07
I-138	4.73E+07	SR-89	1.24E+08	PM-149	5.97E+07	PU-244	0.00E+00
BR-82	3.43E+05	SR-90	9.48E+06	PM-151	1.95E+07	NP-236	1.24E-03
BR-83	1.42E+07	SR-91	1.53E+08	PR-143	1.58E+08	NP-237	4.04E+01
BR-84	2.73E+07	SR-92	1.55E+08	PR-144M	1.81E+06	NP-238	4.67E+07
BR-85	3.12E+07	SR-93	1.68E+08	PR-144	1.30E+08	NP-239	2.03E+09
BR-87	5.10E+07	SR-94	1.63E+08	SM-147	1.97E-04	GD-152	0.00E+00
BR-88	5.10E+07	SR-95	1.46E+08	SM-148	0.00E+00	U-232	0.00E+00
CS-134M	4.56E+06	RU-103	1.55E+08	SM-149	0.00E+00	U-234	0.00E+00
CS-134	1.87E+07	RU-105	1.12E+08	SM-151	5.14E+04	U-236	0.00E+00
CS-135	5.97E+01	RU-106	6.08E+07	SM-153	5.01E+07	U-237	0.00E+00
CS-136	5.58E+06	RH-103M	1.55E+08	Y-89M	1.33E+05	U-238	0.00E+00
CS-137	1.25E+07	RH-105	1.02E+08	Y-90M	5.82E+02	PA-233	0.00E+00
CS-138	1.90E+08	RH-106	6.73E+07	Y--90	9.94E+06	TH-228	0.00E+00
CS-139	1.79E+08	PD-107	1.32E+01	Y-91M	8.85E+07	TH-230	0.00E+00
RB-86	1.90E+05	PD-109	4.06E+07	Y--91	1.51E+08	TH-232	0.00E+00
RB-87	2.54E-03	MO-99	1.80E+08	Y--92	1.56E+08	TH-234	0.00E+00
RB-88	9.20E+07	TC-99M	1.59E+08	Y--93	1.13E+08	U-233	0.00E+00
RB-89	1.22E+08	TC-99	1.55E+03	Y--94	1.75E+08	TH-229	0.00E+00
RB-90	1.14E+08	TC-101	1.59E+08	Y--95	1.77E+08	-	-
TE-125M	2.23E+05	CO-57	0.00E+00	CM-242	5.08E+06	-	-

TABLE 4.1-3: AVERAGE FUEL ROD ISOTOPE INVENTORY AT SHUTDOWN

ISOTOPE	AVG. ROD INVENTORY [curies]	ISOTOPE	AVG. ROD INVENTORY [curies]	ISOTOPE	AVG. ROD INVENTORY [curies]	ISOTOPE	AVG. ROD INVENTORY [curies]
XE-131M	2.38E+01	TE-127M	2.81E+01	CO-58	4.33E+00	CM-243	4.41E-02
XE-133M	1.18E+02	TE-127	1.66E+02	CO-60	9.00E+00	CM-244	7.64E+00
XE-133	3.78E+03	TE-129M	1.16E+02	LA-140	3.72E+03	CM-245	5.98E-04
XE-135M	7.94E+02	TE-129	5.69E+02	LA-141	3.26E+03	CM-246	1.57E-04
XE-135	1.38E+03	TE-131M	3.76E+02	LA-142	3.24E+03	CM-247	8.49E-10
XE-137	3.52E+03	TE-131	1.54E+03	LA-143	3.19E+03	CM-248	3.85E-09
XE-138	3.50E+03	TE-132	2.62E+03	ZR-93	3.04E-03	AM-241	3.06E-01
KR-83M	2.79E+02	TE-133M	1.80E+03	ZR-95	3.48E+03	AM-242M	2.07E-02
KR-85M	6.11E+02	TE-133	2.17E+03	ZR-97	3.31E+03	AM-242	1.80E+02
KR-85	2.13E+01	TE-134	3.76E+03	ND-144	0.00E+00	AM-243	5.73E-02
KR-87	1.25E+03	SB-124	1.72E+00	ND-147	1.28E+03	CE-141	3.26E+03
KR-88	1.76E+03	SB-125	2.01E+01	EU-152	1.83E-02	CE-142	6.24E-08
KR-89	2.25E+03	SB-126M	1.00E+00	EU-154	1.50E+01	CE-143	3.21E+03
I-129	7.09E-05	SB-126	8.55E-01	EU-155	6.11E+00	CE-144	2.52E+03
I-130	4.88E+01	SB-127	1.68E+02	EU-156	5.18E+02	PU-236	1.04E-03
I-131	1.83E+03	SB-129	5.98E+02	NB-93M	4.23E-03	PU-237	1.38E-02
I-132	2.67E+03	SE-79	1.54E-04	NB-95M	4.02E+01	PU-238	6.96E+00
I-133	3.87E+03	BA-136M	1.24E+01	NB-95	3.50E+03	PU-239	7.04E-01
I-134	4.41E+03	BA-137M	2.32E+02	NB-97	3.32E+03	PU-240	1.01E+00
I-135	3.65E+03	BA-139	3.56E+03	PM-147	3.65E+02	PU-241	2.98E+02
I-136	1.80E+03	BA-140	3.54E+03	PM-148M	6.45E+01	PU-242	4.88E-03
I-137	1.85E+03	BA-141	3.24E+03	PM-148	3.60E+02	PU-243	9.68E+02
I-138	9.25E+02	SR-89	2.42E+03	PM-149	1.17E+03	PU-244	0.00E+00
BR-82	6.71E+00	SR-90	1.85E+02	PM-151	3.81E+02	NP-236	2.42E-08
BR-83	2.78E+02	SR-91	2.98E+03	PR-143	3.10E+03	NP-237	7.89E-04
BR-84	5.35E+02	SR-92	3.03E+03	PR-144M	3.54E+01	NP-238	9.12E+02
BR-85	6.11E+02	SR-93	3.28E+03	PR-144	2.53E+03	NP-239	3.97E+04
BR-87	9.97E+02	SR-94	3.19E+03	SM-147	3.85E-09	GD-152	0.00E+00
BR-88	9.97E+02	SR-95	2.86E+03	SM-148	0.00E+00	U-232	0.00E+00
CS-134M	8.91E+01	RU-103	3.04E+03	SM-149	0.00E+00	U-234	0.00E+00
CS-134	3.67E+02	RU-105	2.19E+03	SM-151	1.01E+00	U-236	0.00E+00
CS-135	1.17E-03	RU-106	1.19E+03	SM-153	9.80E+02	U-237	0.00E+00
CS-136	1.09E+02	RH-103M	3.03E+03	Y-89M	2.61E+00	U-238	0.00E+00
CS-137	2.44E+02	RH-105	2.00E+03	Y-90M	1.14E-02	PA-233	0.00E+00
CS-138	3.71E+03	RH-106	1.32E+03	Y--90	1.94E+02	TH-228	0.00E+00
CS-139	3.50E+03	PD-107	2.58E-04	Y-91M	1.73E+03	TH-230	0.00E+00
RB-86	3.72E+00	PD-109	7.94E+02	Y--91	2.95E+03	TH-232	0.00E+00
RB-87	4.97E-08	MO-99	3.52E+03	Y--92	3.06E+03	TH-234	0.00E+00
RB-88	1.80E+03	TC-99M	3.10E+03	Y--93	2.22E+03	U-233	0.00E+00
RB-89	2.38E+03	TC-99	3.03E-02	Y--94	3.42E+03	TH-229	0.00E+00
RB-90	2.24E+03	TC-101	3.11E+03	Y--95	3.47E+03	-	-
TE-125M	4.37E+00	CO-57	0.00E+00	CM-242	9.93E+01	-	-

Consistent with RG 1.183 Appendix B Section 3.1, the fuel handling accident dose analyses model 72 hours of radioactive decay prior to an event, which is the minimum decay time required by SONGS Units 2 and 3 Licensee Controlled Specification (LCS) 3.9.101 prior to movement of irradiated fuel in the reactor vessel (Note: some licensees refer to the LCS as their Technical Requirements Manual). Table 4.1-4 summarizes the average fuel rod isotope inventory for use in the fuel handling accident AST dose analyses. Table 4.1-4 determines the fission product inventory of an average fuel rod by decaying the Table 4.1-3 average rod inventory for 72 hours.

Per RG 1.183 Regulatory Positions 3.2 and 3.4, the only elements considered in design basis analyses for fuel handling accidents are xenon, krypton, iodine, bromine, cesium, and rubidium. The limited number of elements listed in Table 4.1-4 is consistent with RG 1.183 Appendix B Section 3, which indicates that particulate radionuclides are retained by the water in the fuel storage pool or refueling water.

TABLE 4.1-4: AVERAGE FUEL ROD ISOTOPE INVENTORY AT 72 HOURS POST-SHUTDOWN

ISOTOPE	AVERAGE FUEL ROD INVENTORY 72 HOURS AFTER SHUTDOWN [curies]
BR-82	1.64E+00
BR-83	2.39E-07
I-129	7.09E-05
I-130	8.62E-01
I-131	1.41E+03
I-132	8.76E-07
I-133	3.56E+02
I-134	7.57E-22
I-135	1.92E+00
KR-83m	4.01E-10
KR-85m	8.89E-03
KR-85	2.13E+01
KR-87	1.13E-14
KR-88	4.66E-05
XE-131m	2.00E+01
XE-133m	4.57E+01
XE-133	2.54E+03
XE-135	5.74E+00

Section 4.1.2 Primary and Secondary Coolant Activity Profiles

Several of the AST dose analyses model primary and secondary activity profiles, with and without iodine spiking, associated with operation at the concentration limits specified in Technical Specification Limiting Conditions For Operation (LCOs) 3.4.16 and 3.7.19. These activity profiles have been recalculated for use in AST dose analyses to address changes in the maximum core activity profile specified in Section 4.1.1.

Table 4.1-5 summarizes the primary side equilibrium (no iodine spike) activity concentration profile determined for the conditions of 1.0 μCi/gram Iodine-131 dose equivalency and 100/Ē μCi/gram average activity concentration for other non-iodine isotopes, including tritium. These activity limits are consistent with LCO 3.4.16, "Reactor Coolant System Specific Activity". The primary side iodine activity concentration profile is based on the Technical Specification Section 1.1 definition for DOSE EQUIVALENT I-131 (DE I-131), using ICRP-30 thyroid inhalation dose conversion factors. The primary side non-iodine activity concentration profile is based on the Technical Specification Section 1.1 definition for Ē – AVERAGE DISINTEGRATION ENERGY, using total gamma and average beta disintegration energies provided in NUREG/CR-1413 (Reference 11).

TABLE 4.1-5: ACTIVITY CONCENTRATIONS AT TECH. SPEC. LIMITS

Isotope	Primary Side Equilibrium (No Spiking) Concentration [microCi/gm]	Primary Side Pre-Accident Iodine Spike Concentration [microCi/gm]	Secondary Side Water Concentration [microCi/gm]	Secondary Side Steam Concentration [microCi/gm]
I-131	8.24E-01	4.95E+01	8.33E-02	8.33E-04
I-132	2.28E-01	1.37E+01	1.55E-02	1.55E-04
I-133	9.54E-01	5.72E+01	9.19E-02	9.19E-04
I-134	9.15E-02	5.49E+00	4.04E-03	4.04E-05
I-135	4.31E-01	2.59E+01	3.73E-02	3.73E-04
H-3	1.80E+00	-	3.62E-02	3.62E-02
Br-84	3.81E-02	-	2.85E-05	2.85E-07
Kr-85m	1.84E+00	-	0.00E+00	6.52E-05
Kr-85	6.41E+00	-	0.00E+00	2.27E-04
Kr-87	1.08E+00	-	0.00E+00	3.82E-05
Kr-88	3.36E+00	-	0.00E+00	1.19E-04
Rb-88	3.40E+00	-	1.81E-03	3.63E-06
Sr-89	9.16E-03	-	3.38E-05	6.76E-08
Sr-90	5.93E-04	-	2.19E-06	4.38E-09
Y-90	1.53E-03	-	5.51E-06	1.10E-08
Sr-91	5.29E-03	-	1.65E-05	3.30E-08
Y-91m	3.25E-03	-	3.85E-06	7.69E-09
Y-91	4.09E-02	-	1.51E-04	3.02E-07
Zr-95	1.10E-02	-	4.05E-05	8.09E-08
Mo-99	2.13E+00	-	7.69E-03	1.54E-05
Ru-103	1.45E-02	-	5.39E-05	1.08E-07
Ru-106	3.79E-03	-	1.41E-05	2.82E-08
Te-129	4.41E-02	-	6.48E-05	1.30E-07
Xe-131m	4.74E+00	-	0.00E+00	1.67E-04
Te-132	6.53E-01	-	2.37E-03	4.73E-06
Xe-133	3.27E+02	-	0.00E+00	1.16E-02
Cs-134	2.78E+00	-	1.04E-02	2.07E-05
Xe-135m	8.11E-01	-	0.00E+00	2.87E-05
Xe-135	1.41E+01	-	0.00E+00	4.99E-04
Cs-136	8.28E-01	-	3.07E-03	6.14E-06
Cs-137	1.87E+00	-	6.96E-03	1.39E-05
Xe-138	5.58E-01	-	0.00E+00	1.97E-05
Ba-140	1.19E-02	-	4.38E-05	8.76E-08
La-140	1.20E-02	-	4.25E-05	8.50E-08
Pr-143	9.87E-03	-	3.63E-05	7.26E-08
Ce-144	8.01E-03	-	2.96E-05	5.92E-08
Cr-51	3.36E-03	-	1.24E-05	2.48E-08
Mn-54	1.60E-03	-	5.92E-06	1.18E-08
Co-60	3.54E-03	-	1.31E-05	2.62E-08
Fe-59	1.76E-03	-	6.50E-06	1.30E-08
Co-58	2.82E-02	-	1.04E-04	2.08E-07

Table 4.1-5 summarizes the primary side iodine activity concentration profile determined for the conditions of 60 μCi/gram DE I-131 at full power operations (i.e., a pre-accident iodine spike). This activity limit is permitted by LCO 3.4.16. The primary side pre-accident iodine spike activity concentration profile is a factor of 60 greater than the Table 4.1-5 profile for the normal operation conditions of 1.0 μCi/gram DE I-131.

Table 4.1-5 summarizes the secondary side water iodine activity concentration profile determined for the condition of 0.1 μCi/gram Iodine-131 dose equivalency. This activity limit is consistent with LCO 3.7.19, "Secondary Specific Activity". The secondary side iodine activity concentration profile is based on the Technical Specification Section 1.1 definition for DOSE EQUIVALENT I-131, using ICRP-30 thyroid inhalation dose conversion factors. Table 4.1-5 also summarizes the secondary side water non-iodine activity concentration profile. No Technical Specification limit exists for the secondary side water non-iodine activity concentration profile. The secondary side water non-iodine activity concentration profile was determined using a steady-state activity balance. Primary side activity at LCO 3.4.16 concentrations was introduced into the steam generator liquid at the Technical Specification LCO 3.4.13, "Reactor Coolant System Operational Leakage", total maximum primary-to-secondary leakage rate of 1.0 gallon/minute. Secondary side water activity was removed via partitioning into the secondary steam, demineralization by the full-flow condensate polisher demineralizer and the blowdown demineralizer, secondary side leakage, and radioactive decay. The concentration of noble gases in the secondary side water is negligible since all noble gas activity is assumed to be released to the steam generator gas space. This is modeled as a steam generator liquid to steam noble gas partition coefficient (i.e., liquid concentration divided by gas concentration) of 0.0.

Table 4.1-5 summarizes the secondary side steam activity concentration profile. No Technical Specification limit exists for the secondary side steam activity concentration profile. The secondary side steam iodine and particulate activity concentrations were determined by considering partitioning and moisture carryover from the secondary side water activity concentration profile. The secondary side steam noble gas activity concentrations were determined using a steady-state activity balance and the assumption of a steam generator liquid to steam noble gas partition coefficient of 0.0. Primary side activity at LCO 3.4.16 concentrations was introduced into the steam generator water at the LCO 3.4.13 total maximum primary-to-secondary leakage rate of 1.0 gallon/minute. Secondary side steam noble gas activity was removed at the total main steam flow rate.

In addition to the condition of a pre-accident iodine spike, AST dose analyses may model an accident induced (i.e., coincident or concurrent) iodine spike. Per RG 1.183 Appendices E and F, the concurrent iodine spike assumes that the iodine release rate from the fuel rods to the primary coolant increases to a value

of 335 or 500 times greater than the release rate corresponding to the iodine concentration at the equilibrium value of 1.0 μCi/gram DE I-131 specified in the Technical Specifications. The calculation of the concurrent iodine spike release rate conservatively assumed maximum letdown flow, maximum allowable identified and unidentified primary coolant leak rates, maximum allowable primary-to-secondary leak rate, maximum reactor coolant pump seal controlled bleed-off flow rate, 100 percent removal of all iodine from the letdown stream by the purification ion exchanger, and minimum reactor coolant system mass. Table 4.1-6 summarizes the concurrent iodine spike release rate in terms of escape rate coefficients that are to be modeled with the AST reactor core iodine inventory and an assumed 0.62 percent failed fuel. As an example, when the iodine spike release rate for the equilibrium case of 1.3E-08 sec^{-1} is modeled with the AST reactor core iodine inventory and 0.62 percent fuel failure, the resultant equilibrium primary coolant iodine activity concentration is 1.0 μCi/gram DE I-131.

TABLE 4.1-6: CONCURRENT IODINE SPIKE ESCAPE RATE COEFFICIENTS

Condition	Iodine Escape Rate Coefficient [1/second]	Iodine Escape Rate Coefficient [1/hour]
Equilibrium (no spike)	1.3E-08	4.7E-05
Spiking Factor of ~~335~~500	6.5E-06	2.4E-02
Spiking Factor of ~~500~~335	4.4E-06	1.6E-02

Section 4.1.3 Radial Peaking Factor

Consistent with the guidance of RG 1.183 Regulatory Position 3.1, to account for differences in power level across the core, Radial Peaking Factors (RPFs) are applied to the Section 4.1.1 Tables 4.1-3 and 4.1-4 average fuel rod isotope inventory in determining the activity inventory of the damaged fuel rods when only a portion of the core is damaged.

Per RG 1.183 Regulatory Position 3.1, the RPFs should be values from the facility's Core Operating Limits Report (COLR) or Technical Specifications. SONGS Units 2 and 3 do not report RPFs in the facility's COLR or in the SONGS Technical Specifications. SONGS Units 2 and 3 calculate RPFs in unit and cycle specific reload physics analyses.

A review of the recent SONGS Units 2 and 3 Cycle 11 and 12 reload physics analyses identified RPFs with values no greater than 1.67 at 100 percent power. For conservatism the non-LOCA AST dose calculations addressed in this AST license amendment request model an RPF of 1.75 for all damaged fuel rods. For the DBA LOCA, all fuel assemblies are damaged and the core average inventory (without peaking factor) is used.

Section 4.1.4 Fuel Damage in Non-LOCA Design Basis Accidents

Per RG 1.183 Regulatory Position 3.6, the amount of fuel damage caused by non-LOCA design basis events should be analyzed to determine the fraction of the fuel that reaches or exceeds the initiation temperature of fuel melt and the fraction of fuel elements for which the fuel clad is breached.

Consistent with the NRC approved SONGS Units 2 & 3 reload analysis methodology documented in Section 3.4.2.1 of SCE-9801-P-A, "Reload Analysis Methodology for the San Onofre Nuclear Generating Station Units 2 and 3," fuel failure for the control element assembly (i.e., rod) ejection event is currently based on enthalpy deposition methodology. Per SCE-9801-P-A, fuel failure for the reactor coolant pump sheared shaft event is currently based on the Departure from Nucleate Boiling (DNB) statistical convolution methodology, and fuel failure for the remaining non-LOCA events that fail fuel are currently based on the DNB deterministic methodology.

Following approval of this license amendment request, in addition to the reactor coolant pump sheared shaft event, fuel failure estimates for UFSAR Chapter 15 non-LOCA events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel (currently steam system piping failures and increased main steam flow with single failure) may be based on the DNB statistical convolution methodology.

The DNB statistical convolution technique is described in NRC approved Combustion Engineering document CENPD-183-A "C-E Methods for Loss of Flow Analysis" (Reference 18). The DNB statistical convolution technique estimates the amount of fuel failure by the probability density function with the DNB distribution. The DNB deterministic technique ignores the DNB distribution and uses a single value, the Departure from Nucleate Boiling Ratio (DNBR) Specified Acceptable Fuel Design Limit (SAFDL), as the fuel failure criterion.

The DNB statistical convolution technique is widely used to determine fuel failure for events at Combustion Engineering designed reactors. The SONGS Units 2 & 3 current licensing basis uses the DNB statistical convolution technique for predicting fuel failure for the reactor coolant pump sheared shaft evaluation. In addition, the Palo Verde Nuclear Generating Station uses the DNB statistical convolution technique for the calculation of fuel failures for transients that result in fuel failure.

Section 4.2 OFFSITE DOSE MODEL

Regulatory Guide 1.183 Regulatory Position 4.1 provides guidance to be used in determining the TEDE for persons located at or beyond the boundary of the exclusion area, including the outer boundary of the LPZ. This Section addresses the applicability of this guidance to the SONGS Units 2 and 3 AST dose analyses as it relates to the offsite dose exposure parameters.

The characteristics of the offsite dose exposure parameters as modeled in the AST dose analyses are summarized in Tables 4.2-1 and 4.2-2 for the EAB and LPZ dose receptors, respectively.

TABLE 4.2-1: EAB DOSE EXPOSURE PARAMETERS

EXCLUSION AREA BOUNDARY PARAMETER	MODELED VALUE
EAB dose acceptance criterion, Rem TEDE	Varies by event
EAB dose exposure duration, hours	2-hour window
Committed effective dose equivalent (CEDE) dose conversion factors	Per Federal Guidance Report (FGR)-11
Effective dose equivalent (EDE) dose conversion factors	Per FGR-12
EAB breathing rate, event duration, m^3/second	3.5E-04
EAB atmospheric dispersion factor, event duration, seconds/m^3	2.72E-04

TABLE 4.2-2: LPZ DOSE EXPOSURE PARAMETERS

LOW POPULATION ZONE PARAMETER	MODELED VALUE
LPZ dose acceptance criterion, Rem TEDE	Varies by event
LPZ dose exposure duration, hours	Event Duration
Committed effective dose equivalent (CEDE) dose conversion factors	Per FGR-11
Effective dose equivalent (EDE) dose conversion factors	Per FGR-12
LPZ breathing rates, m^3/second	
0 to 8 hours	3.5E-04
8 to 24 hours	1.8E-04
1 day to end of event	2.3E-04
LPZ atmospheric dispersion factors, seconds/m^3	
0 to 8 hours	7.72E-06
8 to 24 hours	4.74E-06
1 to 4 days	3.67E-06
4 days to end of event	2.67E-06

Consistent with RG 1.183 Regulatory Position 4.1.1, the offsite dose calculations determine TEDE, which is the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure. Consistent with RG 1.183 Regulatory Position 4.1.4, the EDE from external exposure is used in lieu of DDE in determining the contribution of external dose to the TEDE. The calculation of the CEDE and EDE components of the TEDE consider all radionuclides identified in Section 4.1 of this license

amendment request, including progeny from the decay of parent radionuclides, that are significant with regard to dose consequences and the released radioactivity.

Consistent with RG 1.183 Regulatory Position 4.1.2, the AST analyses model CEDE dose conversion factors taken from the column headed "effective" in Table 2.1 of Federal Guidance Report (FGR) 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion".

Consistent with RG 1.183 Regulatory Position 4.1.3, for the first 8 hours, the breathing rate of persons at the outer boundary of the LPZ is assumed to be 3.5E-4 cubic meters per second. From 8 to 24 hours following the accident, the breathing rate is assumed to be 1.8E-4 cubic meters per second. After that and until the end of the accident, the rate is assumed to be 2.3E-4 cubic meters per second. The breathing rate for persons at the EAB is assumed to be 3.5E-4 cubic meters per second for the event duration.

Consistent with RG 1.183 Regulatory Position 4.1.4, the AST analyses model EDE dose conversion factors taken from the column headed "effective" in Table III.1 of Federal Guidance Report (FGR) 12, "External Exposure to Radionuclides in Air, Water, and Soil" (Reference 12).

Consistent with RG 1.183 Regulatory Positions 4.1.5, 4.1.6 and 4.4, the radiological criteria for the EAB and for the outer boundary of the LPZ are in 10 CFR 50.67. These criteria are stated for evaluating reactor accidents of exceedingly low probability of occurrence and low risk of public exposure to radiation, e.g., a large-break LOCA. For events with a higher probability of occurrence, postulated EAB and LPZ doses should not exceed the criteria tabulated in RG 1.183 Table 6.

Consistent with RG 1.183 Regulatory Position 4.1.5, the maximum EAB TEDE for any two-hour period following the start of the radioactivity release is determined and used in determining compliance with the dose criteria. The Bechtel LocaDose code used in the AST dose analyses determines the maximum two-hour TEDE at the EAB by calculating the postulated dose for a series of small time increments and performing a "sliding" sum over the increments for successive two-hour periods. The time increments appropriately reflect the progression of the accident to capture the peak dose interval between the start of the event and the end of radioactivity release.

The AST dose analyses for exposure to individuals at the EAB and LPZ consider immersion of the individual in the radioactive plume released from the facility. Consistent with RG 1.183 Regulatory Position 5.3, the atmospheric dispersion values for the EAB and the LPZ that were approved by the NRC staff during initial facility licensing are used in performing the AST radiological analyses. These atmospheric dispersion factors for the EAB and LPZ are the five percentile

values listed in SONGS Units 2 and 3 UFSAR Appendix 15B Table 15B-4. Consistent with RG 1.183 Regulatory Position 4.1.7, no correction is made for depletion of the effluent plume by deposition on the ground.

Radioactive material contained in a plant structure is assumed to be a negligible radiation shine source to the offsite dose receptors relative to the dose associated with immersion in the radioactive plume (i.e., environmental cloud) released from the facility. To evaluate the conservatism present in this modeling when using an alternative source term, the post-LOCA reactor containment building shine doses at the EAB and at the outer boundary of the LPZ were compared to the post-LOCA offsite immersion/inhalation doses. As shown in Table 4.2-3, the EAB and LPZ doses due to containment shine are at least three orders of magnitude (a factor of 1,000) smaller than the EAB and LPZ doses due to immersion in the radioactive plume released from the containment.

TABLE 4.2-3: SIGNIFICANCE OF PLANT STRUCTURE SHINE DOSE

POST-LOCA CONTAINMENT LEAKAGE RADIATION SOURCE	AST TEDE DOSE (REM)
Maximum 2-hour EAB dose due to immersion and inhalation	3.651E+00 ~~3.547E+00~~
Maximum 2-hour EAB dose due to Containment Building shine	1.206E-03 ~~1.204E-03~~
Event duration LPZ dose due to immersion and inhalation	2.377E-01 ~~2.309E-01~~
Event duration LPZ dose due to Containment Building shine	1.799E-09 ~~1.810E-09~~

Section 4.3 CONTROL ROOM DOSE MODEL

SONGS Units 2 and 3 share a combined control room. RG 1.183 Regulatory Position 4.2 provides guidance to be used in determining the TEDE for persons located in the control room. Section 4.3.1 addresses the applicability of this guidance to the SONGS Units 2 and 3 AST dose analyses as it relates to the control room dose exposure parameters. Section 4.3.2 addresses the applicability of the RG 1.183 guidance as it relates to the control room response to radiation sources that may cause exposure to control room personnel.

Section 4.3.1 Control Room Dose Exposure Parameters

The characteristics of the control room dose exposure parameters as modeled in the AST dose analyses are summarized in Table 4.3-1.

TABLE 4.3-1: CONTROL ROOM DOSE EXPOSURE PARAMETERS

CONTROL ROOM PARAMETER	MODELED VALUE
CR dose acceptance criterion, Rem TEDE	5
Committed effective dose equivalent (CEDE) dose conversion factors	Per FGR-11
Effective dose equivalent (EDE) dose conversion factors	Per FGR-12
CR occupancy factors, percent of time present in CR	
0 to 1 day	100
1 to 4 days	60
4 to 30 days	40
CR breathing rate, event duration, m^3/second	3.5E-04

Consistent with RG 1.183 Regulatory Position 4.2.2, the radioactive material releases and radiation levels modeled in the control room dose analyses are determined using the same source term, transport, and release assumptions used for determining the EAB and LPZ TEDE values. These parameters are detailed in the later sections of this license amendment request that describe the various accident scenarios. These parameters do not result in non-conservative results for the control room.

Consistent with RG 1.183 Regulatory Position 4.2.7, the control room doses are calculated using the dose conversion factors identified in RG 1.183 Regulatory Position 4.1 for use in offsite dose analyses. The control room dose calculations determine the TEDE, which is the sum of the CEDE from inhalation and the DDE from external exposure. Consistent with RG 1.183 Regulatory Position 4.1.4, the EDE from external exposure is used in lieu of DDE in determining the contribution of external dose to the TEDE. The calculation of the CEDE and EDE components of the TEDE consider all radionuclides identified in Section 4.1 of this license amendment request, including progeny from the decay of parent radionuclides, that are significant with regard to dose consequences and the released radioactivity.

Consistent with RG 1.183 Regulatory Position 4.1.2, the AST analyses model CEDE dose conversion factors taken from the column headed "effective" in Table 2.1 of Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion".

Consistent with RG 1.183 Regulatory Position 4.1.4, the AST analyses model EDE dose conversion factors taken from the column headed "effective" in Table III.1 of Federal Guidance Report 12, "External Exposure to Radionuclides in Air, Water, and Soil."

Consistent with RG 1.183 Regulatory Position 4.2.7, the DDE from photons (i.e., the EDE) is corrected for the difference between finite cloud geometry in the control room and the semi-infinite cloud assumption used in calculating the dose conversion factors. The Bechtel LocaDose code used in this analysis employs the following RG 1.183 Equation 1 to correct the semi-infinite cloud dose, DDE_{∞}, to a finite cloud dose, DDE_{finite}, where the control room is modeled as a hemisphere that has a volume, V, in cubic feet, equivalent to that of the control room:

$$DDE_{finite} = (DDE_{\infty} \times V^{0.338}) / 1173$$

Consistent with RG 1.183 Regulatory Position 4.4, as an AST dose analysis acceptance criterion the postulated control room dose is evaluated to ensure that that it does not exceed the 5 Rem TEDE criterion established in 10 CFR 50.67.

Consistent with RG 1.183 Regulatory Position 4.2.6, the control room dose receptor for the AST analyses is the hypothetical maximum exposed individual who is present in the control room for 100% of the time during the first 24 hours after an event, 60% of the time between 1 and 4 days, and 40% of the time from 4 days to 30 days. These occupancy factors are not modeled in the ARCON96 atmospheric dispersion factors discussed in Section 4.4 of this license amendment request.

Consistent with RG 1.183 Regulatory Position 4.2.6, for the duration of any event, the breathing rate of the hypothetical maximum exposed individual who is present in the control room is assumed to be 3.5E-04 cubic meters per second.

Consistent with RG 1.183 Regulatory Position 4.2.5, credit is not taken for the control room personnel use of personal protective equipment (e.g., protective beta radiation resistant clothing, eye protection, or self-contained breathing apparatus [SCBA]) or prophylactic drugs (i.e., potassium iodide [KI] pills).

Section 4.3.2 Control Room Response to Radiation Sources

Consistent with RG 1.183 Regulatory Position 4.2.3, the models used to transport radioactive material into and through the control room, and the shielding models used to determine radiation dose rates from external sources, are structured to provide suitably conservative estimates of the exposure to control room personnel. The control room response to these radiation sources is discussed in this section.

Consistent with RG 1.183 Regulatory Position 4.2.1, the AST dose analyses consider the following sources of radiation that may cause exposure to control room personnel:

- Contamination of the control room atmosphere by the intake or infiltration of radioactive material contained in the radioactive plume released from the facility,
- Contamination of the control room atmosphere by the intake or infiltration of airborne radioactive material from areas and structures adjacent to the control room envelope,
- Radiation shine from the external radioactive plume released from the facility,
- Radiation shine from radioactive material in the reactor containment building,
- Radiation shine from radioactive material in systems and components inside or external to the control room envelope.

The characteristics of the control room as modeled in the AST dose analyses are summarized in Table 4.3-2.

TABLE 4.3-2: CONTROL ROOM MODEL PARAMETERS

CONTROL ROOM PARAMETER	NOMINAL VALUE	MODELED VALUE
CR net free volume, cubic feet	266,920	266,920
CR unfiltered outside air inleakage, event duration		
ingress and egress, cfm	not applicable	10
Boundary and system inleakage, cfm	132	990
total unfiltered inleakage, cfm	not applicable	1,000
CR Normal mode of operation		
unfiltered outside air makeup, cfm	5820	6402
filtered outside air makeup, cfm	0	0
filtered CR air recirculation, cfm	0	0
Control Room Emergency Air Cleanup System (CREACUS) initiation time		
Safety Injection Actuation Signal (SIAS) induced Control Room Isolation Signal (CRIS), seconds	< 10	0
High CR Heating, Ventilation, and Air-Conditioning (HVAC) intake radiation induced CRIS, seconds	120.0	180
CREACUS Emergency mode of operation, one train operation		
filtered outside air makeup, cfm	2,050	2,200
filtered CR air recirculation, cfm	33,505	29,934
CREACUS Emergency mode of operation, two train operation		
filtered outside air makeup, cfm	4,100	4,400
filtered CR air recirculation, cfm	67,010	59,869
CREACUS Emergency mode of operation, Emergency Ventilation Supply (EVS) filter efficiencies		
Elemental iodine, percent removal	> 90	0
organic iodide, percent removal	> 90	0
Particulate iodine and aerosols, percent removal	> 99.95	0
CREACUS Emergency mode of operation, Emergency Air Conditioner (EAC) filter efficiencies		
elemental iodine, percent removal	> 99	95
organic iodide, percent removal	> 99	95
Particulate iodine and aerosols, percent removal	> 99.95	99

Section 4.3.2.1 Control Room Intake and Infiltration of Contaminated Air

Only the west side of the control room envelope is exposed to the radioactive plumes released from the facility. The adjacent areas and structures to the north, south, and east of the CRE, and the adjacent areas and structures above and below the CRE, do not contain activity release points. These adjacent areas and locations can only become contaminated with air introduced via intake or infiltration of radioactive material contained in the radioactive plumes released from the facility. Consequently, the resultant activity concentrations in the adjacent areas and structures will be less contaminated than any radioactive plume. For this reason, the AST dose analyses conservatively assume that all

intake and infiltration (i.e., inleakage) into the CRE is from the radioactive plumes released from the facility as they pass west of the control room envelope.

The control room Normal Mode Heating, Ventilation, and Air Conditioning (HVAC) outside air intake is located near the northwest corner of the control room envelope, and the control room emergency air cleanup system (CREACUS) Emergency Mode HVAC outside air intakes are located near the northwest and southwest corners of the control room envelope. Per the ARCON96 atmospheric dispersion analysis detailed in Section 4.4, the maximum atmospheric dispersion factor for any activity release location to any of these three outside air intakes is modeled in the evaluation of contaminated air intake and infiltration (i.e., inleakage).

Section 4.3.2.1.1 Control Room Isolation Signal

Consistent with RG 1.183 Regulatory Position 4.2.4, the AST analyses credit engineered safety features (ESF) that mitigate airborne radioactive material within the control room, such as control room isolation actuated by ESF signals and radiation monitors.

The control room Normal Mode HVAC systems can be shifted to CREACUS Emergency Mode, which is an operational mode in which the control room is isolated and pressurized to protect operational personnel from radiation exposure. The CREACUS Emergency mode of operation can be actuated either automatically following a Control Room Isolation Signal (CRIS) or manually. The CRIS may be generated automatically by a Safety Injection Actuation Signal (SIAS) or by the detection of high radioactivity concentrations in the control room outside air inflow.

A SIAS-induced CRIS is credited in the evaluation of the LOCA. A SIAS-induced CRIS is capable of initiating CREACUS Emergency mode of operation within 10 seconds. The SIAS is generated in response to high containment pressure within seconds of the onset of the LOCA event. Since the gap release activity is not released into the containment until 30 seconds after the onset of the LOCA event, and since a SIAS induced CRIS is capable of initiating CREACUS Emergency mode of operation in less than 30 seconds, the AST LOCA model credits CREACUS Emergency mode of operation initiation at time zero (i.e., prior to the arrival of any contaminated air reaching the control room outside air intakes) due to a SIAS-induced CRIS.

Per LCS 3.3.100, Table 3.3.100-2, a high radiation induced CRIS is to be generated and the normal HVAC outside air dampers are to be closed, within 120.0 seconds. The non-LOCA and FHA dose analyses conservatively assume that a high-radiation-induced CRIS initiates the CREACUS Emergency mode of operation at 180 seconds.

Section 4.3.2.1.2 Control Room Unfiltered Inleakage

The AST dose analyses model the introduction of an assumed 1,000 cfm of unfiltered outside air into the CRE beginning at time zero and continuing for the event duration. This inleakage rate includes 10 cfm as a reasonable estimate for ingress and egress, and an assumed 990 cfm for inleakage via other paths. The 10 cfm estimate for ingress and egress inleakage is consistent with guidance provided in RG 1.197 (Reference 13) Regulatory Position 2.5.

The CRE inleakage testing to verify actual inleakage was conducted from May 18, 2004 to May 25, 2004. As described in SCE's letter to the NRC dated September 17, 2004, CRE inleakage testing has shown the actual inleakage via other paths, including uncertainty, is less than 990 cfm.

Section 4.3.2.1.3 Control Room HVAC Flow Rates and Filtration

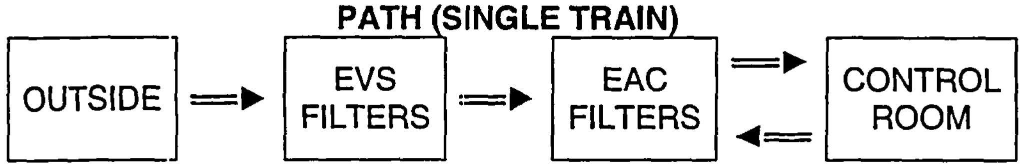
During the control room Normal Mode of HVAC operation, there is no filtered outside air makeup flow nor is there filtered control room air recirculation flow.

During the control room Normal Mode of HVAC operation, the AST dose analyses model an outside air makeup flow rate that is conservatively greater than the nominal outside air makeup flow rate. The outside air introduced into the control room during the normal mode of operation is unfiltered. The total unfiltered inleakage rate of 1,000 cfm is added to this Normal Mode of operation unfiltered outside air makeup flow rate.

Consistent with RG 1.183 Regulatory Position 4.2.4, the AST dose analyses credit ESFs that mitigate airborne radioactive material within the control room. Such features include control room pressurization, and intake and recirculation filtration.

The CREACUS Emergency mode of operation is facilitated by two 100% redundant subsystems. As shown in Figure 4.3-1, for each CREACUS Emergency mode of operation flow path, the control room outside makeup air passes through intake filters of an emergency ventilation supply (EVS) unit and then through recirculation filters of an emergency air conditioner (EAC) unit prior to being discharged into the control room envelope.

FIGURE 4.3-1: CREACUS EMERGENCY MODE OF OPERATION FLOW PATH (SINGLE TRAIN)



During the CREACUS Emergency mode of operation, the AST dose analyses model an outside air makeup flow rate that is conservatively greater than the nominal outside air makeup flow rate. The outside air introduced into the control room is filtered. Consistent with the current SONGS Units 2 and 3 licensing basis, filtration credit is not taken for outside air iodine and particulate removal by the EVS unit filters. Filtration credit is only taken for outside air makeup iodine and particulate removal by the EAC unit filters. The total unfiltered inleakage rate of 1,000 cfm is added to this CREACUS Emergency mode of operation flow rate.

During the CREACUS Emergency mode of operation, the AST dose analyses model a control room recirculation flow rate that is conservatively smaller than the nominal recirculation flow rate. This flow rate is calculated by subtracting the maximum outside air inflow rate entering the EAC unit from the minimum total flow rate (i.e., outside air inflow rate plus control room recirculation air flow rate) through the EAC unit.

Consistent with the current SONGS Units 2 and 3 licensing basis, filtration credit is taken for iodine and particulate removal by the EAC filters. The EAC charcoal filters are credited with the removal of 95 percent of the elemental iodine and organic iodide in the HVAC air flow. The EAC HEPA filters are credited with the removal of 99 percent of the particulate iodine and other aerosols in the HVAC air flow.

In the AST dose analyses the potential exists for one or two trains of HVAC to function during the CREACUS Emergency mode of operation. The SONGS Units 2 and 3 current licensing basis models Operator action at eight hours to secure one of the two trains of CREACUS that are modeled as being in operation at the onset of an event. To evaluate the conservatism present in this modeling when using an AST source term, the post-LOCA containment leakage path was evaluated for three scenarios: (1) one CREACUS train operating throughout the event, (2) two CREACUS trains operating throughout the event, and (3) two CREACUS trains operating for the first eight hours, and a single CREACUS train operating for the remainder of the event. As shown in Table 4.3-3, the first scenario with its operation of a single CREACUS train throughout the event results in the largest control room dose. For this reason, the AST dose analyses conservatively assume the failure of one CREACUS train and model single CREACUS train operation throughout an event.

TABLE 4.3-3: CONTROL ROOM CREACUS MODEL OPTIONS

CONTROL ROOM CREACUS MODEL	LOCA CONTAINMENT LEAKAGE TEDE DOSE (REM)
Single CREACUS train operation throughout the event	9.482E-01~~9.112E-01~~
Two CREACUS train operation throughout the event	7.574E-01~~7.303E-01~~
Two CREACUS train operation for 8 hours, one CREACUS train operation thereafter	7.939E-01~~7.650E-01~~

Section 4.3.2.2 Environmental Cloud Gamma Radiation Shine Model

Consistent with RG 1.183 Regulatory Position 4.2.1, the AST dose analyses consider exposure to control room personnel due to radiation shine from the external radioactive plume (i.e., environmental or outside cloud shine). The following discussion elaborates on the modeling described in SONGS Units 2 and 3 UFSAR Appendix 15.10B.

Activity releases to the environment from sources such as post-LOCA containment building leakage will result in the formation of a radioactive cloud. Radioactivity concentrations in the radioactive cloud surrounding the control room are the product of the building leak rate and the control room atmospheric dispersion factor.

For conservatism it is assumed that this cloud surrounds the control room, entering adjacent areas that are not part of the control room envelope. Gamma radiation from this cloud can penetrate the control room ceiling and walls resulting in a whole body gamma dose to control room personnel. The cloud is modeled as a cylinder with a 4000 foot radius and a 4000 foot height. The radius and height values ensure that dose contributions from the outer portions of the cloud are considered. The radioactivity present in the outside cloud is assumed to be uniformly distributed in the cylindrical source.

The environmental cloud radiation shine dose is the maximum dose calculated at one of several dose receptors modeled within the control room board area.

Shielding modeled between the control room dose receptors and the outside cloud include the concrete containment structures that lie within the 4000 foot radius cloud, the concrete safety equipment building wall adjacent to the control building, the control room concrete walls, floor and ceiling, the auxiliary/radwaste building outer concrete walls, floors and roof, several of the internal control room fire partition walls, and the air spaces between these walls, floor and ceilings.

Section 4.3.2.3 Control Room Filter Gamma Radiation Shine Model

Consistent with RG 1.183 Regulatory Position 4.2.1, the AST dose analyses consider exposure to control room personnel due to radiation shine from radioactive material in the CREACUS filters inside the CRE (i.e., control room filter shine). The following discussion elaborates on the modeling described in SONGS Units 2 and 3 UFSAR Appendix 15B, Section 15B.5.

The activity released to the environment during an event and dispersed to the CREACUS outside air intake is assumed to accumulate onto the CREACUS filters for the duration of an activity release. For those events in which the release terminates prior to 30 days (e.g., fuel handling accident), the activity

accumulated on the charcoal filter is allowed to decay for the remainder of the 30-day event duration to facilitate determination of a 30-day control room dose.

As previously shown in Figure 4.3-1, for each CREACUS Emergency mode of operation flow path, the control room outside makeup air passes through intake filters of an EVS intake unit and then through recirculation filters of an EAC unit prior to being discharged into the CRE. Per Section 4.3.2.1, the AST dose analyses conservatively assume the failure of one CREACUS train and model single CREACUS train operation throughout an event.

In determining the filter shine dose, the charcoal and HEPA filters of the EVS intake units are assumed to be 100 percent efficient at removing iodine and particulates from the incoming air, thereby maximizing the shine dose from the EVS intake unit filters. In reality, iodine and particulates that are not trapped on the intake filters (such as the activity present in the 1,000 cfm of unfiltered air inleakage) will eventually be trapped on the charcoal and HEPA filters of the downstream EAC recirculation unit. The EAC recirculation units are located in the vicinity of the EVS intake units, with an EAC recirculation unit filter direct shine to control room pathway geometry that is similar to that of the EVS intake unit filters. Consequently, the results of the EVS intake unit filter shine dose calculation address the EAC recirculation unit filter shine.

To address the potential shine from unfiltered inleakage that is eventually trapped on the EAC recirculation unit filters, the filter shine model includes an additional 1,000 cfm of contaminated outside air inflow to the CREACUS air intake flow rate. The CREACUS filter shine dose is the maximum dose calculated at one of several dose receptors modeled within the control room board area.

Shielding modeled between the control room dose receptors and the CREACUS filter units include the control room fire partition walls and the air spaces between these walls.

Section 4.3.2.4 Containment Building Gamma Radiation Shine Model

Consistent with RG 1.183 Regulatory Position 4.2.1, the AST dose analyses consider exposure to control room personnel due to radiation shine from radioactive material in the reactor containment building (i.e., direct containment shine). The following discussion elaborates on the modeling described in SONGS Units 2 and 3 UFSAR Appendix 15.10B.

The containment is modeled by an equivalent volume cylindrical source having a diameter of 150 feet and a height of 129.25 feet. The radioactivity in the containment is modeled as being uniformly distributed in the cylindrical source.

The containment radiation shine dose is the maximum dose calculated at one of several dose receptors modeled within the control room board area.

Shielding modeled between the control room dose receptors and the containment air includes the 1/4-inch steel containment liner, the 4-foot concrete containment wall and the 3-foot 9-inch concrete containment dome. No credit is taken for shielding afforded by the internal containment concrete structure. The penetration building lies between the containment and the control building. Modeled shielding includes the 2-foot penetration building concrete wall and the adjacent 2-foot 6-inch control building concrete wall, a 2-inch fire partition wall that separates the control room from the cable riser gallery adjacent to the penetration building, and the air spaces between these walls.

Section 4.3.2.5 Post-LOCA Piping Gamma Radiation Shine Model

Consistent with RG 1.183 Regulatory Position 4.2.1, the AST dose analyses consider exposure to control room personnel due to radiation shine from radioactive material in recirculation loop piping outside the CRE (i.e., piping shine). The following discussion elaborates on the modeling described in SONGS Units 2 and 3 UFSAR Appendix 15B, Section 15B.5.

This piping is modeled as a series of finite length shielded cylinders filled with post-LOCA containment sump recirculation liquid radiation source. The piping shine model considers those pipes in the Auxiliary Building Penetration Area that are outside the containment penetration area shield walls at plant elevation 30-foot (i.e., at the same plant elevation as the control room). The dose contributions from other pipes that are either behind the shield walls or below the 30-foot concrete floor are much less than the dose contributions from the modeled pipes.

The piping shine dose is the maximum dose calculated at one of several dose receptors modeled within the control room board area.

Shielding modeled between the control room dose receptors and the piping includes Auxiliary Building walls and floor slabs, the concrete wall separating the control room from the cable riser gallery, the steel door in the concrete wall separating the cable riser gallery from the Penetration Area, and the air spaces between these walls, floor and ceilings.

Section 4.4 ARCON96 ATMOSPHERIC DISPERSION ANALYSIS

UFSAR Section 2.3.4.2 and UFSAR Appendix 15B.5 discuss the Current Licensing Basis (CLB) methodology used in evaluating atmospheric dispersion between the post-accident containment building release point and the control room outside air ventilation intakes. The CLB applies the atmospheric dispersion factors for the release from the containment to the control room HVAC intakes for all potential release points. The CLB methodology for evaluating this atmospheric dispersion utilizes the Murphy-Campe diffuse source point receptor model.

Per RG 1.183 Regulatory Position 5.3, atmospheric dispersion values for the control room that were approved by the staff during initial facility licensing or in subsequent licensing proceedings (i.e., the CLB) may be used in performing the AST radiological analyses.

The limiting condition for Control Room Habitability (CRH) is the event configuration that results in the maximum consequences to the control room operators. Per RG 1.196 (Reference 14) Regulatory Position 2.3.2, determining the limiting condition for CRH requires consideration of the location of the activity release points for the various accidents relative to the control room intakes.

Although RG 1.183 allows continued use of the CLB atmospheric dispersion values, to comply with the guidance of RG 1.196 it is necessary to calculate atmospheric dispersion values between the various post-accident release points and the control room outside air ventilation intakes. The new atmospheric dispersion analysis uses the ARCON96 computer program and guidance provided in RG 1.194. This section summarizes the ARCON96 analysis.

Section 4.4.1 ARCON96 Background Information

The ARCON96 computer program was developed for the U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation by Pacific Northwest National Laboratory (PNNL) for potential use in control room habitability assessments. This code is documented in NUREG/CR-6331 Revision 1 (Reference 15), which includes a user's guide, a programmer's guide, and a description of the technical basis for the code. The ARCON96 code uses hourly meteorological data and recently developed methods for estimating dispersion in the vicinity of buildings to calculate relative concentrations at control room intakes that would be exceeded no more than 5 percent of the time. RG 1.194 provides guidance on the use of the ARCON96 computer program for determining atmospheric relative concentrations to be used in design basis evaluations of control room radiological habitability.

Bechtel Power Corporation (BPC) originated the ARCON96 calculations under contract to Southern California Edison. The ARCON96 code was obtained by

BPC, and is maintained as Bechtel Standard Computer Program (SCP) number EV138. Bechtel SCPs are those computer programs that have been developed, validated, documented and controlled in accordance with Bechtel Engineering Department procedures so that they may be used without detailed description and validation in a calculation package.

Section 4.4.2 Summary of Evaluated Release Point to Intake Combinations

The ARCON96 computer program with the guidance of RG 1.194 has been used to determine the atmospheric dispersion factors for a combination of nine activity release point locations and three control room ventilation outside air intake locations. The release point locations are:

- Main plant vent
- Containment shell diffusion
- Containment equipment hatch
- Main Steam Safety Valves (MSSV)
- Atmospheric Dump Valves (ADV)
- Steam Line Break Outside Containment (SLB-OC)
- Auxiliary Feedwater (AFW) Turbine steam discharge
- Refueling Water Storage Tank (RWST) Vent
- Fuel Handling Building

The three control room ventilation outside air intake locations are:

- Control room normal air intake
- Control room Unit 2 emergency air intake
- Control room Unit 3 emergency air intake

Each of the 27 release-to-intake combinations has been investigated. Release locations from both of SONGS Units 2 and 3 are considered.

Section 4.4.3 Meteorological Data Input

The ARCON96 atmospheric dispersion analysis uses actual site hourly meteorological data spanning ten full years from 1993 through 2002. Full year meteorology is used to eliminate bias due to seasonal fluctuations. RG 1.194 Regulatory Position 3.1 states that 5 years of hourly observations are considered to be representative of long-term trends at most sites. The use of ten years of meteorological data satisfies this recommendation, while enhancing the statistical

basis for the calculated control room atmospheric dispersion factors due to the expanded meteorological data set.

The input meteorological data identify invalid data by coding such data as either "999" or "9999". In each year, more than 99 percent of the lower level wind speed data are valid. Overall, about 99.8 percent of the lower level wind speed data are valid. Except for year 1994, more than 95 percent of each year's upper level wind speed data are valid. Overall, about 96.5 percent of the upper level wind speed data are valid. Therefore, the meteorological input is representative. The meteorological tower's lower wind instrument is at elevation 10 meters. The meteorological tower's upper wind instrument is at elevation 40 meters.
The meteorological data was converted to the ARCON96 format presented in NUREG/CR-6331 Section 4.4.2 and RG 1.194 Appendix A, Table A-1.

Consistent with RG 1.194 Regulatory Position 3.1, wind direction is expressed as the direction from which the wind is blowing (i.e., the upwind direction from the center of the site) referenced from true north. A north wind (wind from the north) is entered as 360 degrees, and a south wind is entered as 180 degrees.

Consistent with RG 1.194 Regulatory Position 3.1, atmospheric stability is entered as a number from 1 through 7. A stability class of 1 represents extremely unstable conditions, and a stability class of 7 represents extremely stable conditions. Atmospheric stability classes are determined from the ΔT given in the meteorological data.

Section 4.4.4 Non-Meteorological Data Input

RG 1.194 Appendix A Table A-2 discusses input parameters for ARCON96. Per Table 4.4-1, the ARCON96 analysis complies with the regulatory guidance presented in Table A-2.

The following subsections summarize the ARCON96 non-meteorological data input for each of the release point and receptor location combinations.

Table 4.4-1: ARCON96 Input Parameters for Design Basis Assessments

Parameter	Acceptable Input	Comments
Lower Measurement Height, meters	Use the actual instrumentation height when known. Otherwise, assume 10 meters.	Used actual measurement height, which is 10 meters above bluff grade. The bluff grade is above the plant grade.
Upper Measurement Height, meters	Use the actual instrumentation height when known. Otherwise, use the height of the containment or the stack height, as appropriate. If wind speed measurements are available at more than two elevations, the instrumentation at the height closest to the release height should be used.	Used actual measurement height of 40 meters above the bluff grade.

Parameter	Acceptable Input	Comments
Wind Speed Units	Use the wind speed units that correspond to the units of the wind speeds in the meteorological data file.	The raw meteorological data expresses wind speeds in miles per hour. However, these data are pre-processed to convert the wind speeds to meters per second in the resulting meteorological input files. The ARCON96 input files (*.RSF) are set for wind speeds in units of meters per second. Thus, the units used for wind speeds in the analysis are applied consistently.
Release Height, meters	Use the actual release heights whenever available. Plume rise from buoyancy and mechanical jet effects may be considered in establishing the release height if the analyst can demonstrate with reasonable assurance that the vertical velocity of the release will be maintained during the course of the accident. If actual release height is not available, set release height equal to intake height.	As clarified below, actual release heights above plant grade are used. For the containment diffuse area source, the release is assumed to be from the containment mid-height of 80.5 feet above grade (i.e., Elevation 110.5'). This elevation allows for unimpeded flow above the Auxiliary Building roof. Because the control room intakes are on the Auxiliary Building wall opposite the Unit 2 and Unit 3 containments, the release cloud can only flow to the intakes by first passing over the Auxiliary Building roof. This assumption is consistent with the NRC recommendation to set the release height for a diffuse area source at the vertical center of the projected plane of the above-grade cross-sectional area perpendicular to the line of sight from the building center to the control room intake (Regulatory Guide 1.194, section 3.2.4.5). (There is also a pathway between the containment and the intakes via grated openings into the Turbine Building and then into the corrugated metal-sided passageway west of the Auxiliary Building. This pathway is longer and more tortuous than the pathway over the Auxiliary Building roof; therefore, it is not used.)

Parameter	Acceptable Input	Comments
		Steam from a steam line break outside containment (SLB-OC) is assumed to be released via the blowout panels mounted on the roof of the respective Main Steam Isolation Valve (MSIV)/Main Feedwater Isolation Valve (MFIV) enclosure directly above the main steam line. The χ/Qs for an MSSV release credit plume rise due to jet effects in accordance with section 6.0 of RG 1.194.
Building Area, meters^2	Use the actual building vertical cross-sect onal area perpendicular to the wind direction. Use default of 2000 m^2 if the area is not readily available. Do not enter zero. Use 0.01 m^2 if a zero entry is desi·ed. Note: This building area is for the building(s) that has the largest impact on the building wake within the wind direction window. This is usually, but need not always be, the reactor containment. With regard to the diffuse area source option, the building area entered here may be different from that used to establish the diffuse source.	The cross-sectional area of the containment is used for all release points except for the Fuel Handling Building (FHB). For the FHB release, the FHB east cross-section area and one half of the containment cross-section area are ~~is~~ used. Only one half of the containment is conservatively considered since it is partially offset from the release to intake axis. All other intervening buildings, such as the auxiliary building, are conservatively ignored.
Vertical Velocity, meters/seconds	Note: the vent release model should not be used for DBA accident calculations. For stack release calculations only, use the actual vertical velocity if the licensee can demonstrate with reasonable assurance that the value will be maintained during the course of the accident (e.g., addressed by technical specifications), otherwise, enter zero. If the vertical velocity is set to zero, ARCON96 will reduce the stack height by 6 times the stack radius for all wind speeds. If this reduction is not desired, the stack radius should also be set to zero.	The vent release model is not used for DBA accident calculations. For all vent stack releases, the vertical velocity is set to zero.

Parameter	Acceptable Input	Comments
Stack Flow, meters^3/s	Use actual flow if it can be demonstrated with reasonable assurance that the value will be maintained during the course of the accident (e.g., addressed by technical specifications). Otherwise, enter zero. The flow is used in both elevated and ground-level release modes to establish a maximum χ/Q value. This value is significant only if the flow is large and the distance from the release point to the receptor is small.	Stack flow is set to zero in all cases.
Stack Radius, meters	Use the actual stack internal radius when both the stack radius and vertical velocity are available. If the stack flow is zero, the radius should be set to zero.	Stack radius is set to zero in all cases.
Distance to Receptor, meters	Use the actual straight line horizontal distance between the release point and the control room intake. For ground-level releases, it may be appropriate to consider flow around an intervening building if the building is sufficiently tall that it is unrealistic to expect flow from the release point to go over the building. Note: If the distance to receptor is less than about 10 meters, ARCON96 should not be used to assess relative concentrations.	The actual straight line horizontal distance between the release point and the control room intake is used in all cases other than the Containment Equipment Hatch release. Except for the Containment Equipment Hatch release, flow around intervening buildings is not considered. The Equipment Hatches are on the opposite side of the Containment structure from the Control Room Intakes and are located at ground level. The top of the Containment is 161 feet above plant grade and the top of equipment hatch is 17.5 feet above plant grade; therefore, it is unrealistic to expect flow from the Equipment Hatch to go over the Containment building. The Equipment Hatch to receptor distances are measured as the shortest path around the Containment ("taut string length"), as allowed by section 3.4 of RG 1.194. No source-receptor distance is less than 10 meters.
Intake Height, meters	Use the actual intake height. If the intake height is not available for ground level releases, assume the intake height is equal to the release height. For elevated releases, assume the height of the tallest site building.	The actual heights at the centerline of the control room intakes are used.
Elevation Difference, meters	Use zero unless it is known that the release heights are reported relative to different grades or reference datum.	The release and receptor heights are reported with respect to the same grade datum.

Parameter	Acceptable Input	Comments
Direction to Source, degrees	Use the direction FROM the intake back TO the release point. (Wind directions are reported as the direction from which the wind is blowing. Thus, if the direction from the intake to the release point is north, a north wind will carry the plume from the release point to the intake.) Note: some facilities have a "plant north" shown on site arrangement drawings that is different from "true north." The direction entered must have the same point of reference as the wind directions reported in the meteorological data. For ground level releases, if the plume is assumed to flow around a building rather than over it, the direction may need to be modified to account for the redirected flow. In this case, the χ/Q should be calculated assuming flow around and flow over (through) the building and the higher of the two χ/Q s should be used.	SONGS' ~~met.~~ meteorological data ~~is~~ are given relative to true north. SONGS' site arrangement drawings do have a "Plant North" designation that is 57 degrees west of "true north;" consequently, source-to-receptor directions entered into the ARCON96 code are corrected to model true north as the point of reference. For the scenario of an equipment hatch release, the χ/Q is calculated assuming flow both around and over (through) the containment building, and the higher of the χ/Q values is used.
Surface Roughness Length, meters	Use a value of 0.2 in lieu of the default value of 0.1 for most sites. (Reasonable values range from 0.1 for sites with low surface vegetation to 0.5 for forest covered sites.)	Used value of 0.2. SONGS is a seaside site with low surface vegetation.
Wind Direction Window, degrees Code Default	Use the default window of 90 degrees (45 degrees on either side of line of sight from the source to the receptor).	Used 90 degrees.
Minimum Wind Speed, meters/second Code Default	Use the default wind speed of 0.5 m/s (regardless of the wind speed units entered earlier), unless there is some indication that the anemometer threshold is greater than 0.6 m/s.	Used the default wind speed of 0.5 m/s. The minimum SONGS site meteorological tower wind speed reported is 0.3 mph, or 0.13 m/s. Thus, the anemometer threshold is less than 0.6 m/s.
Averaging Sector Width Constant Code Default	Although the default value is 4, a value of 4.3 is preferred. (A future revision to ARCON96 will change the default to 4.3)	Used 4.3.
Initial Diffusion Coefficients, meters	These values will normally be set to zero. If the diffuse source option is being used, see Regulatory Position 2.2.4.	For containment releases, a diffuse source is modeled in accordance with Regulatory Guide 1.194, section 3.2.4.4. For the steam line break outside containment, the releases from the MSIV/MFIV enclosure are modeled as an area source in accordance with Regulatory Guide 1.194, section 3.2.4.7.

Parameter	Acceptable Input	Comments
Hours in Averages Code Default	Use the default values.	Used the default values.
Minimum Number of Hours Code Default	Use the default values.	Used the default values.

Section 4.4.4.1 Control Room HVAC Intakes

Three control room HVAC intake locations are modeled in the ARCON96 analysis:

- Control room normal air intake
- Control room Unit 2 emergency air intake
- Control room Unit 3 emergency air intake

The center of the control room normal air intake is at plant elevation 35.50 feet (10.82 meters). The center of each control room emergency air intake is at plant elevation 43.00 feet (13.11 meters).

Section 4.4.4.2 Main Plant Vent Release

Atmospheric dispersion between the main plant vent and the control room HVAC intakes is modeled as a point source using the ARCON96 ground level release option.

The plant vent release height is at plant elevation 206 feet (62.79 meters).

For the plant vent release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-2 presents the separation distances and wind directions that characterize the releases from the two plant vent activity release point locations to the three control room HVAC intake locations.

TABLE 4.4-2: PLANT VENT TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 Plant Vent	Normal Air Intake	62.83	348
U2 Plant Vent	U2 emergency air intake	60.18	351
U2 Plant Vent	U3 emergency air intake	101.6	329
U3 Plant Vent	Normal Air Intake	98.15	96
U3 Plant Vent	U2 emergency air intake	101.6	97
U3 Plant Vent	U3 emergency air intake	60.18	75

The results of the ARCON96 analysis show that the Unit 2 plant vent to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). The resultant 95th percentile control room atmospheric dispersion factors for this release path are presented in Section 4.4.5.

Section 4.4.4.3 Containment Shell Release

Atmospheric dispersion between the containment shell (surface) and the control room HVAC intakes is modeled as an area (diffuse) source using the ARCON96 ground level release option.

Consistent with RG 1.194 Sections 3.2.4.4 and 3.2.4.5, the height and width of the area source (i.e., the containment shell surface) are taken as the maximum vertical and horizontal dimensions of the above-grade building cross-sectional area perpendicular to the line of sight from the building center to the control room intake. The initial horizontal diffusion coefficient ($\sigma_{y,0}$) is determined to be 8.06 meters, based on the 158.66 foot containment diameter. The initial vertical diffusion coefficient ($\sigma_{z,0}$) is determined to be 8.18 meters, based on the 161.00 foot containment above-grade height.

The containment shell diffuse release is assumed to be from its mid-height of 80.5 feet (24.54 meters) above grade. This elevation allows for unimpeded flow above the Auxiliary Building roof. Because the control room intakes are on the Auxiliary Building wall opposite the U2 and U3 containments, the release cloud will flow to the intakes by first passing over the Auxiliary Building roof. This assumption is consistent with the RG 1.194 Section 3.2.4.5 recommendation to set the release height for a diffuse area source at the vertical center of the projected plane of the above-grade cross-sectional area perpendicular to the line of sight from the building center to the control room intake.

For the containment shell release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-3 presents the separation distances and wind directions that characterize the releases from the two containment shell release point locations to the three control room HVAC intake locations:

TABLE 4.4-3: CONTAINMENT TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 Containment	Normal Air Intake	38.6	348
U2 Containment	U2 emergency air intake	36	351
U2 Containment	U3 emergency air intake	77.4	329
U3 Containment	Normal Air Intake	74	96
U3 Containment	U2 emergency air intake	77.4	97
U3 Containment	U3 emergency air intake	36	75

The results of the ARCON96 analysis show that the Unit 2 containment shell to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). The resultant 95th percentile control room atmospheric dispersion factors for this release path are presented in Section 4.4.5.

Section 4.4.4.4 Containment Equipment Hatch Release

Atmospheric dispersion between the containment equipment hatch and the control room HVAC intakes is modeled as an area (diffuse) source using the ARCON96 ground level release option.

The Containment Equipment Hatch is a large circular opening through the containment wall. The equipment hatch meets the conditions for a diffuse source as set forth in RG 1.194 Section 3.2.4.8: (1) the release from the hatch will be essentially equally dispersed over the entire opening, and (2) assumptions of mixing, dilution and transport within Containment necessary to meet condition 1 are supported by the interior containment arrangement. Consistent with RG 1.194 Section 3.2.4.4, the initial horizontal and vertical diffusion coefficients ($\sigma_{y,0}$ and $\sigma_{z,0}$) are each determined to be 0.97 meters, based on the clear 19-foot diameter of the hatch opening.

The Unit 2 and 3 Containment Equipment Hatches are on the opposite side of their respective Containment structures from the control room air intakes. The containment equipment hatch diffuse release is assumed to be from its mid-height at plant elevation 38.00 feet (11.58 meters). The top of the Containment is 161 feet above grade; therefore, it is unrealistic to expect flow from the Equipment Hatch to go over the Containment building. The Equipment Hatches to receptor distances are measured as the shortest path around the Containment ("taut string length"), as allowed by RG 1.194 Section 3.4. To determine the taut string length, a tangent is drawn from each intake to the side

of the containment closest to the equipment hatch. That distance is added to the length of the arc around the containment from the tangent line intersection to the centerline of the hatch.

As requested by RG 1.194 Appendix A Table A-2, since the plume is assumed to flow around the containment building rather than over it, the atmospheric dispersion value is calculated assuming flow both around and over (through) the building, and the higher of the atmospheric dispersion values is used.

For the containment equipment hatch release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-4 presents the separation distances and wind directions that characterize the releases from the two containment equipment hatch release point locations to the three control room HVAC intake locations:

TABLE 4.4-4: CONTAINMENT EQUIPMENT HATCH TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction Over / Around Containment (degrees, North = 0)
U2 Ctmt Equip. Hatch	Normal Air Intake	98.1	353 / 11
U2 Ctmt Equip. Hatch	U2 emergency air intake	96.8	355 / 15
U2 Ctmt Equip. Hatch	U3 emergency air intake	126.9	336 / 343
U3 Ctmt Equip. Hatch	Normal Air Intake	124	89 / 82
U3 Ctmt Equip. Hatch	U2 emergency air intake	126.9	90 / 83
U3 Ctmt Equip. Hatch	U3 emergency air intake	96.8	71 / 51

The results of the ARCON96 analysis show that the Unit 2 equipment hatch to Unit 2 emergency air intake release path modeling flow over (through) the containment building has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor) during the 8 to 24 hour time period. For all other time periods, the results of the ARCON96 analysis show that the Unit 2 equipment hatch to Unit 2 emergency air intake release path modeling flow around the containment building has the more conservative atmospheric dispersion. The atmospheric dispersion factors for this release are a conservative composite of these two flow paths. The resultant 95th percentile control room atmospheric dispersion factors are presented in Section 4.4.5.

Section 4.4.4.5 Main Steam Safety Valve (MSSV) Stack Release

Atmospheric dispersion between the MSSV stack and the control room HVAC intakes is modeled as a point source using the ARCON96 ground level release

option. Consistent with RG 1.194 Section 6.0 (and as justified in the following text), a reduction factor of 5 is applied to the ARCON96 results to allow credit for buoyant plume rise in determining the control room atmospheric dispersion factors associated with the energetic release from MSSVs.

Each reactor has two sets of nine MSSV stacks arrayed around a Main Steam Isolation Valve (MSIV). As an average location, the center of the MSIV (X and Y dimensions only) is modeled as the MSSV release location. MSIV 8205 is located north of the Unit 2 containment centerline (south for Unit 3). MSIV 8204 is located south of the Unit 2 containment centerline (north for Unit 3).

The MSSV release height is at plant elevation 73.42 feet (22.38 meters).

For the MSSV release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-5 presents the separation distances and wind directions that characterize the releases from the MSSV release point locations (i.e., Unit 2 MSSVs centered at MSIVs 8204 and 8205, and Unit 3 MSSVs centered at MSIVs 8204 and 8205) to the three control room HVAC intake locations:

TABLE 4.4-5: MSSV TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 MSSV 8204	Normal Air Intake	35.71	339
U2 MSSV 8204	U2 emergency air intake	32.65	343
U2 MSSV 8204	U3 emergency air intake	78.96	318
U2 MSSV 8205	Normal Air Intake	60.17	322
U2 MSSV 8205	U2 emergency air intake	56.54	323
U2 MSSV 8205	U3 emergency air intake	105.87	314
U3 MSSV 8204	Normal Air Intake	75.25	107
U3 MSSV 8204	U2 emergency air intake	78.96	108
U3 MSSV 8204	U3 emergency air intake	32.65	83
U3 MSSV 8205	Normal Air Intake	102.08	112
U3 MSSV 8205	U2 emergency air intake	105.87	112
U3 MSSV 8205	U3 emergency air intake	56.54	103

The results of the ARCON96 analysis show that the Unit 2 MSSVs centered at MSIV 8204 to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor).

RG 1.194 allows credit for buoyant plume rise in determining the Control Room atmospheric dispersion factors associated with an energetic release from main

steam safety valves. RG 1.194 Section 6.0 states that in lieu of mechanistically addressing the amount of buoyant plume rise:

> "...the ground level χ/Q value calculated with ARCON96 (on the basis of the physical height of the release point) may be reduced by a factor of 5. This reduction may be taken only if (1) the release point is uncapped and vertically oriented and (2) the time-dependent vertical velocity exceeds the 95th-percentile wind speed (at the release point height) by a factor of 5."

The MSSVs are uncapped and vertically oriented, thereby satisfying the first criterion required for plume rise credit per RG 1.194, Section 6.0.

Since the MSSV stack exit is at plant elevation 73.4 ft and grade is at plant elevation 30 ft, the height of the stack exit above grade is 43.4 ft, or 13.2 meters. This is reasonably close to the height of the lower meteorological tower wind measurement instrumentation at 10 meters; therefore, the MSSV stack exit velocity is compared with the 95th percentile 10-m wind speed of 5.5~~5.8~~ m/s.

For purposes of calculating the minimum flow velocity at the exit of the MSSV stack, the following conservative assumptions are made:

1. All MSSVs lift at the lowest set pressure of all the valves.
2. The pressure in the MSSV stack is equal to the maximum backpressure.
3. No credit is taken for head loss due to elevation changes or pipe friction.
4. No credit is taken for expansion of the steam through the stack.

The calculated minimum MSSV stack exit velocity is 72 meters/second. This exit velocity exceeds five times the 95th percentile wind speed (i.e., exceeds 5 x ~~5.8~~ 5.5 m/s = ~~29~~ 27.5 m/s); thereby satisfying the second criterion required for plume rise credit per RG 1.194 Section 6.0.

Since both criteria are satisfied, the ground level atmospheric dispersion factors calculated with ARCON96 (on the basis of the physical height of the release point) for MSSV releases are reduced by a factor of 5. The resultant 95th percentile control room atmospheric dispersion factors for the MSSV release path with credit for plume rise are presented in Section 4.4.5.

Section 4.4.4.6 Atmospheric Dump Valve (ADV) Stack Release

Atmospheric dispersion between the ADV and the control room HVAC intakes is modeled as a point source using the ARCON96 ground level release option. Per RG 1.194 Section 6.0 (and as justified in the following text), a reduction factor of 5 may be applied to the ARCON96 results to allow credit for buoyant plume rise in determining the Control Room atmospheric dispersion factors associated with the energetic release from atmospheric dump valves.

Each reactor has two ADV stacks. ADV 606 is located north of the Unit 2 containment centerline (south for Unit 3). ADV 607 is located south of the Unit 2 containment centerline (north for Unit 3).

The ADV release height is at plant elevation 113.92 feet (34.72 meters).

For the ADV release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-6 presents the separation distances and wind directions that characterize the releases from the ADV release point locations (i.e., Unit 2 ADVs 606 and 607, and Unit 3 ADVs 606 and 607) to the three control room HVAC intake locations:

TABLE 4.4-6: ADV TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 ADV 606	Normal Air Intake	57.45	325
U2 ADV 606	U2 emergency air intake	53.88	326
U2 ADV 606	U3 emergency air intake	102.76	315
U2 ADV 607	Normal Air Intake	37.69	343
U2 ADV 607	U2 emergency air intake	34.84	348
U2 ADV 607	U3 emergency air intake	79.66	321
U3 ADV 606	Normal Air Intake	98.98	111
U3 ADV 606	U2 emergency air intake	102.76	111
U3 ADV 606	U3 emergency air intake	53.88	100
U3 ADV 607	Normal Air Intake	75.99	104
U3 ADV 607	U2 emergency air intake	79.66	105
U3 ADV 607	U3 emergency air intake	34.84	78

The results of the ARCON96 analysis show that the Unit 2 ADV 607 to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor).

RG 1.194 allows credit for buoyant plume rise in determining the Control Room atmospheric dispersion factors associated with an energetic release from atmospheric dump valves. RG 1.194 Section 6.0 states that in lieu of mechanistically addressing the amount of buoyant plume rise:

> "...the ground level χ/Q value calculated with ARCON96 (on the basis of the physical height of the release point) may be reduced by a factor of 5. This reduction may be taken only if (1) the release point is uncapped and vertically oriented and (2) the time-dependent vertical velocity exceeds the 95th-percentile wind speed (at the release point height) by a factor of 5."

The ADVs are uncapped and vertically oriented, thereby satisfying the first criterion required for plume rise credit per RG 1.194 Section 6.0.

Since the ADV stack exit is at plant elevation 113.92 ft and grade is at plant elevation 30 ft, the height of the stack exit above grade is 83.92 ft, or 25.6 meters. Since the ADV stack exit is closer in height to the upper meteorological tower wind measurement instrumentation at 40 meters than to the lower meteorological tower wind measurement instrumentation at 10 meters, the ADV stack exit velocity is compared with the 95th percentile 40-m wind speed of 6.4 ~~6.8~~ m/s.

The accident analyses assume that an ADV is operated manually; therefore, the flow velocity at the ADV stack exit will decrease over time, as the steam generator blows down. Thus, in order to credit plume rise in an ADV release dose analysis, the period for which the ADV stack exit vertical flow velocity exceeds five times the 95th percentile upper level wind speed of ~~6.8~~ 6.4 m/s (i.e., exceeds 5 x ~~6.8~~ 6.4 m/s = ~~34~~ 32 m/s) would need to be determined.

Since the second criterion is not necessarily satisfied for the duration of a dose analysis, the ground level atmospheric dispersion factors calculated with ARCON96 (on the basis of the physical height of the release point) for ADV releases may or may not be reduced by a factor of 5 for the duration of a dose analysis. The resultant 95th percentile control room atmospheric dispersion factors for the ADV release path with and without credit for plume rise are presented in Section 4.4.5. The use of the lower values crediting plume rise will be evaluated on an event-specific basis.

Section 4.4.4.7 Steam Line Break Outside Containment (SLB-OC) Release

Atmospheric dispersion between the steam line break outside containment and the control room HVAC intakes is modeled as an area (diffuse) source using the ARCON96 ground level release option.

The SLB-OC is postulated to occur outboard of the main steam line restraint/anchor downstream of the main steam isolation valve. Thus, the location of the postulated break is in the walkway between the east wall of the Turbine Building and the Main Steam Isolation Valve/Main Feedwater Isolation Valve (MSIV/MFIV) enclosure structures. The enclosure structures are open to the walkway, which is then open to the atmosphere above. Several blowout panels are present on the roofs of the enclosure structures. There are also blowout panels on the walls of the MSIV/MFIV enclosure. The blowout panels open during a large SLB-OC to protect the enclosure structures from overpressurizing. Thus, depending on the size of the steam line break, there are multiple pathways for steam blowdown.

Steam from an SLB-OC is assumed to be released via the blowout panels mounted on the roof of the respective MSIV/MFIV enclosure directly above the main steam line. For a small SLB-OC, the pressure may not exceed the relief setting of the blowout panels; in such an instance, steam will escape via the enclosure opening to the walkway between the enclosure and the Turbine Building. For a large SLB-OC, steam may also escape via the roof blowout panel above the main feedwater line and via the enclosure wall-mounted blowout panels. Nevertheless, the assumption that the release is solely via the roof blowout panels is conservative, because it results in a smaller flow area, which means a smaller initial horizontal diffusion coefficient, than if all the potential vent paths were considered.

The SLB-OC release via the roof blowout panels meets the conditions for a diffuse source in RG 1.194 Section 3.2.4.7, which states that the application of the diffuse area source model to determine atmospheric dispersion factors for multiple (i.e., 3 or more) roof vents is:

> "...appropriate for configurations in which (1) the vents are in close arrangement, (2) no individual vent is significantly closer to the control room intake than the center of the area source, (3) the release rate from each vent is approximately the same, and (4) no credit is taken for plume rise."

Condition 1 is satisfied since the 3 roof-mounted blowout panels directly above each main steam line are in close proximity with each other (spaced from 2.0 to 3.5 feet apart). Condition 2 is satisfied since no individual blowout panel is significantly closer to the control room intake than the center of the area source. Although there are other vent paths (i.e., through the enclosure opening adjacent to the walkway, the roof-mounted blowout panels over the main feedwater lines, and the wall-mounted blowout panels), it is conservative for purposes of determining control room atmospheric dispersion factors to minimize the initial dispersion area by accounting only for the area source presented by the blowout panels above the main steam lines. Condition 3 is satisfied since the steam is assumed to rise evenly through the three adjacent blowout panels. Condition 4 is satisfied since no credit is taken for plume rise. Therefore, the SLB-OC release meets the conditions for a diffuse source per Regulatory Guide 1.194, Section 3.2.4.7.

The area width is measured across the area formed by the three blowout panels mounted on the roof of the MSIV enclosure perpendicular to the line of sight from the MSIVs to the respective control room intake. Table 4.4-7 presents the initial horizontal diffusion coefficients ($\sigma_{y,0}$) that characterize the releases from the SLB-OC release point locations. Consistent with RG 1.194 Section 3.2.4.7, because the blowout panel openings are in a horizontal configuration on the MSIV enclosure roof, there is no initial vertical dispersion coefficient (i.e., $\sigma_{z,0}$ is zero).

The distance between the SLB-OC release point and the control room intakes is measured from the closest point on the perimeter of the roof blowout panels above the MSIVs, as allowed by Section 3.2.4.7 of RG 1.194.

The SLB-OC release height via the MSIV/MFIV enclosure roof blowout panels is at plant elevation 63.50 feet (19.35 meters).

For the SLB-OC release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-7 presents the separation distances, wind directions and initial horizontal diffusion coefficients ($\sigma_{y,0}$) that characterize the releases from the SLB-OC release point locations (i.e., Unit 2 North and South MSIV/MFIV enclosure roof blowout panels, and Unit 3 North and South MSIV/MFIV enclosure roof blowout panels) to the three control room HVAC intake locations:

TABLE 4.4-7: SLB-OC TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)	$\sigma_{y,0}$ [$\sigma_{z,0} = 0$] (meters)
U2 N Panels	Normal Air Intake	58.5	322	0.96
U2 N Panels	U2 emergency air intake	54.9	323	0.96
U2 N Panels	U3 emergency air intake	104.2	314	0.99
U2 S Panels	Normal Air Intake	32.3	339	0.56
U2 S Panels	U2 emergency air intake	29.3	343	0.54
U2 S Panels	U3 emergency air intake	76.9	318	0.7
U3 N Panels	Normal Air Intake	100.4	112	0.99
U3 N Panels	U2 emergency air intake	104.2	112	0.99
U3 N Panels	U3 emergency air intake	54.9	103	0.96
U3 S Panels	Normal Air Intake	73.2	107	1.42
U3 S Panels	U2 emergency air intake	76.9	108	1.44
U3 S Panels	U3 emergency air intake	29.3	83	1.12

The results of the ARCON96 analysis show that the Unit 2 South MSIV/MFIV enclosure structure (housing Unit 2 MSIV 8204) roof blowout panels to Unit 2 emergency air intake release path have the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). The resultant 95th percentile control room atmospheric dispersion factors for this release path are presented in Section 4.4.5.

Section 4.4.4.8 Auxiliary Feedwater (AFW) Turbine Stack Release

Atmospheric dispersion between the AFW turbine stack and the control room HVAC intakes is modeled as a point source using the ARCON96 vent release option.

The AFW turbine stack is located near the south wall of the Unit 2 refueling water storage and condensate storage tank farm (north wall for Unit 3).

The AFW turbine stack release height is at plant elevation 59 feet (17.98 meters).

For the AFW turbine stack release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-8 presents the separation distances and wind directions that characterize the releases from the two AFW turbine stack activity release point locations to the three control room HVAC intake locations:

TABLE 4.4-8: AFW TURBINE STACK TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 AFW Turbine Stack	Normal Air Intake	86.89	332
U2 AFW Turbine Stack	U2 emergency air intake	83.53	333
U2 AFW Turbine Stack	U3 emergency air intake	130.22	322
U3 AFW Turbine Stack	Normal Air Intake	126.57	104
U3 AFW Turbine Stack	U2 emergency air intake	130.22	104
U3 AFW Turbine Stack	U3 emergency air intake	83.53	93

The results of the ARCON96 analysis show that the Unit 2 AFW turbine stack to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). The resultant 95th percentile control room atmospheric dispersion factors for this release path are presented in Section 4.4.5.

Section 4.4.4.9 Refueling Water Storage Tank (RWST) Vent Release

Atmospheric dispersion between the RWST vent and the control room HVAC intakes is modeled as a point source using the ARCON96 vent release option.

There are two RWST tanks for each unit (T005 and T006). The two tanks are located in the Units 2 and 3 refueling water storage and condensate storage tank farms, which are mirror images of each other. Unit 2 RWST T005 is located northeast of the Unit 2 containment centerline (southeast for Unit 3). Unit 2

RWST T006 is located northwest of the containment centerline (southwest for Unit 3).

The RWST release location is assumed to be the center of the roof vent on each RWST. These vents are offset from the center of the tank roofs. The Unit 2 RWST T005 and T006 vent release height is at plant elevation 71.57 feet (21.81 meters). The Unit 3 RWST T005 and T006 vent release height is at plant elevation 71.73 feet (21.86 meters).

For the RWST vent release, only the cross-sectional area of the containment is used to determine the building wake area. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area of 2123.33 square meters is the projected area of the containment cylindrical lower portion and the containment upper dome portion.

Table 4.4-9 presents the separation distances and wind directions that characterize the releases from the four RWST vent activity release point locations (i.e., Unit 2 RWSTs T005 and T006, and Unit 3 RWSTs T005 and T006) to the three control room HVAC intake locations:

TABLE 4.4-9: RWST TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 RWST T005	Normal Air Intake	106.66	330
U2 RWST T005	U2 emergency air intake	103.23	331
U2 RWST T005	U3 emergency air intake	150.24	322
U2 RWST T006	Normal Air Intake	103.79	327
U2 RWST T006	U2 emergency air intake	100.26	327
U2 RWST T006	U3 emergency air intake	148.21	319
U3 RWST T005	Normal Air Intake	146.59	104
U3 RWST T005	U2 emergency air intake	150.24	104
U3 RWST T005	U3 emergency air intake	103.23	95
U3 RWST T006	Normal Air Intake	144.51	106
U3 RWST T006	U2 emergency air intake	148.21	107
U3 RWST T006	U3 emergency air intake	100.26	99

The results of the ARCON96 analysis show that the Unit 2 RWST T006 vent to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor) for the 0 to 2 hour time period. For time periods after 2 hours, the results of the ARCON96 analysis show that the Unit 2 RWST T005 vent to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion. The atmospheric dispersion factors for this release are a conservative composite of these two flow paths. The resultant 95th percentile control room atmospheric dispersion factors for these release paths are presented in Section 4.4.5.

Section 4.4.4.10 Fuel Handling Building (FHB) Release

Atmospheric dispersion between the fuel handling building and the control room HVAC intakes is modeled as a point source using the ARCON96 vent release option.

The Units 2 and 3 FHBs are each located to the east of the Units 2 and 3 containment buildings. The FHB release location is assumed to be the spent fuel cask hatch over the south end of the Unit 2 railroad access bay (north end of Unit 3 bay). This hatch is larger and closer to the control room air intake locations than the smaller cask hatch over the opposite ends of the respective railroad bays. The centerline of the spent fuel cask is south and east of the Unit 2 containment centerline (north and east of the Unit 3 containment centerline).

The FHB spent fuel cask hatch release height is at plant elevation 63.50 feet (19.35 meters).

For the FHB release, the fuel handling building east cross-section area and one half of the containment cross-section area is used. Only one half of the containment is conservatively considered since it is partially offset from the release to intake axis. All other intervening buildings, such as the auxiliary building, are conservatively ignored. The building wake area for the FHB release is 2076.78 square meters.

Table 4.4-10 presents the separation distances and wind directions that characterize the releases from the two FHB activity release point locations to the three control room HVAC intake locations:

TABLE 4.4-10: FHB TO CONTROL ROOM MODELING

Release Point	Control Room Receptor	Separation Distance (meters)	Wind Direction (degrees, North = 0)
U2 FHB	Normal Air Intake	91.82	20
U2 FHB	U2 emergency air intake	91.06	23
U2 FHB	U3 emergency air intake	112	356
U3 FHB	Normal Air Intake	109.73	68
U3 FHB	U2 emergency air intake	112	70
U3 FHB	U3 emergency air intake	91.06	43

The results of the ARCON96 analysis show that the Unit 2 FHB to Unit 2 emergency air intake release path has the more conservative atmospheric dispersion (i.e., the maximum atmospheric dispersion factor). The resultant 95th percentile control room atmospheric dispersion factors for this release path are presented in Section 4.4.5.

Section 4.4.5 ARCON96 Results – 95th Percentile Control Room Atmospheric Dispersion Factors

For each of the release locations, the maximum atmospheric dispersion factor from either unit to any of the three control room air intakes is determined. The resultant 95th percentile control room atmospheric dispersion factors are presented in Table 4.4-11.

As discussed in Section 4.4.4.5, the control room atmospheric dispersion factor results for the MSSV stack release include credit for plume rise. MSSV plume rise credit may be modeled for any accident with an MSSV release.

The control room atmospheric dispersion factor results for the ADV stack release are presented with and without credit for plume rise. The determination of whether ADV plume rise credit can be taken must be determined on an accident-specific basis.

Control room occupancy factors are not included in the 95th percentile atmospheric dispersion factors reported in Table 4.4-11. Control room occupancy factors are modeled as separate input parameters to the dose analyses.

TABLE 4.4-11: 95th Percentile Control Room χ/Qs (sec/m^3) [without CR Occupancy Factors]

Time Interval	Main Plant Vent	Containment Shell	Equipment Hatch	ADV (no plume rise credit)	ADV (with plume rise credit)
0 to 2 hrs	~~1.14E-03~~ 1.15E-03	~~9.94E-04~~ 1.01E-3	~~7.99E-04~~ 8.01E-04	3.70E-03	7.40E-04
2 to 8 hrs	~~6.11E-04~~ 6.23E-04	~~6.32E-04~~ 6.41E-04	~~6.30E-04~~ 6.35E-04	~~1.97E-03~~ 1.99E-03	~~3.94E-04~~ 3.98E-04
8 to 24 hrs	~~2.10E-04~~ 2.14E-04	1.77E-04	~~1.77E-04~~ 1.78E-04	~~6.86E-04~~ 6.95E-04	~~1.37E-04~~ 1.39E-04
1 to 4 days	~~2.20E-04~~ 2.22E-04	~~2.34E-04~~ 2.36E-04	2.23E-04	~~6.97E-04~~ 7.04E-04	~~1.39E-04~~ 1.41E-04
4 to 30 days	~~1.98E-04~~ 2.02E-04	~~2.18E-04~~ 2.20E-04	2.03E-04	~~6.33E-04~~ 6.34E-04	1.27E-04

Time Interval	MSSV (with plume rise credit)	SLB-OC	AFW Turbine Exhaust	RWST	Fuel Handling Building
0 to 2 hrs	~~1.21E-03~~ 1.22E-03	~~7.74E-03~~ 7.78E-03	~~8.55E-04~~ 8.60E-04	~~5.65E-04~~ 5.67E-04	~~9.45E-04~~ 9.48E-04
2 to 8 hrs	~~7.48E-04~~ 7.52E-04	~~4.79E-03~~ 4.81E-03	~~3.60E-04~~ 3.70E-04	~~2.17E-04~~ 2.25E-04	~~7.48E-04~~ 7.61E-04
8 to 24 hrs	~~2.50E-04~~ 2.48E-04	1.62E-03	1.56E-04	~~8.67E-05~~ 8.84E-05	~~1.93E-04~~ 1.92E-04
1 to 4 days	2.86E-04	1.83E-03	~~1.60E-04~~ 1.61E-04	~~8.88E-05~~ 8.97E-05	~~2.64E-04~~ 2.65E-04
4 to 30 days	2.60E-04	1.68E-03	1.30E-04	~~7.33E-05~~ 7.37E-05	2.43E-04

Section 4.5 LOSS OF COOLANT ACCIDENT ANALYSIS

Regulatory Guide 1.183 Appendix A provides assumptions for use in evaluating the radiological consequences of a LOCA. These assumptions supplement the guidance provided in the main body of RG 1.183.

The SONGS Units 2 and 3 LOCA is characterized by the following activity release paths:

- Containment leakage
- Engineered Safety Feature (ESF) recirculation loop leakage
- Refueling Water Storage Tank (RWST) release
- Post Accident Sampling System (PASS) leakage

The SONGS Units 2 and 3 LOCA is also characterized by the following gamma radiation shine dose contributors which are discussed in Section 4.3:

- Environmental cloud gamma radiation shine
- Control room filter gamma radiation shine
- Containment building gamma radiation shine
- Post-LOCA piping gamma radiation shine

The characteristics of the LOCA model are summarized in Table 4.5-1.

This Section presents the assumptions, design input, methodology employed in evaluating, and the radiological consequences of each of the SONGS Units 2 and 3 LOCA dose contributors.

TABLE 4.5-1: LOCA DOSE ANALYSIS PARAMETERS

LOCA PARAMETER	MODELED VALUE
Dose acceptance criteria, Rem TEDE	
Control Room	5
EAB	25
LPZ	25
Containment leakage parameters	per Table 4.5-2
ESF system leakage parameters	per Table 4.5-8
RWST release parameters	per Table 4.5-9
PASS leakage parameters	per Table 4.5-10
Offsite dose evaluation model	per Section 4.2
Control Room dose evaluation model	per Section 4.3

Section 4.5.1 Containment Leakage

Regulatory Guide 1.183 Appendix A provides assumptions for use in evaluating the radiological consequences of the containment leakage pathway for a LOCA.

These assumptions supplement the guidance provided in the main body of RG 1.183.

This Section presents the assumptions, design input, and methodology employed in evaluating the radiological consequences of the SONGS Units 2 and 3 LOCA containment leakage path. The characteristics of the LOCA containment leakage model are summarized in Table 4.5-2.

The control room and offsite doses associated with containment leakage are summarized in Section 4.5.7.

TABLE 4.5-2: LOCA CONTAINMENT LEAKAGE ANALYSIS PARAMETERS

LOCA CONTAINMENT LEAKAGE PARAMETER	MODELED VALUE
LOCA source term	
Reactor core isotope inventory at shutdown, curies	per Section 4.1
Timing of core activity release into containment	
Gap release phase	0.5 to 30 minutes
Early in-vessel phase	0.5 to 1.8 hours
Core inventory fraction released into containment, gap release phase	
Noble gases (Xe, Kr)	0.05
Halogens (I, Br)	0.05
Alkali Metals (Cs, Rb)	0.05
Other Elements	0.00
Core inventory fraction released into containment, early in-vessel phase	
Noble gases (Xe, Kr)	0.95
Halogens (I, Br)	0.35
Alkali metals (Cs, Rb)	0.25
Tellurium metals (Te, Sb, Se)	0.05
Barium, Strontium (Ba, Sr)	0.02
Noble metals (Ru Rh, Pd, Mo, Tc, Co)	0.0025
Cerium group (Ce, Pu, Np)	0.0005
Lanthanides (La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am)	0.0002
Chemical form of Iodine released into containment, percent of iodine	
Cesium iodide (CsI) (particulate iodine)	95.00
Elemental iodine	4.85
Organic iodide	0.15
Containment net free volume, cubic feet	
Total	2.284E+06
Sprayed volume	1.907E+06
Unsprayed volume	3.770E+05
Containment mechanical air mixing	
Number of operating emergency cooling unit (ECU) trains	1
Number of operating emergency cooling units	2 ECUs per train
Emergency cooling unit flow rate, ft^3/minute per ECU	31,000
Number of operating dome air circulator unit (DACU) trains	1
Number of operating dome air circulator units	~~2~~1 DACU~~s~~ per train
Dome air circulator unit flow rate, ft^3/minute per DACU (not credited)	0~~37,000~~

LOCA CONTAINMENT LEAKAGE PARAMETER	MODELED VALUE
Natural deposition (plateout) removal of airborne radionuclides	Per Section 4.5.1.3
Containment spray removal of airborne radionuclides	Per Section 4.5.1.3
Containment leakage rate, ft^3/minute	
0 to 1 day, Total leakage	1.6
0 to 1 day, Sprayed volume leakage	1.34
0 to 1 day, Unsprayed volume leakage	0.26
1 to 30 days, Total leakage	0.8
1 to 30 days, Sprayed volume leakage	0.67
1 to 30 days, Unsprayed volume leakage	0.13
Atmospheric Dispersion Factors for the Containment Leakage release via the Containment Shell to Control Room, seconds/m^3	per Section 4.4

Section 4.5.1.1 Containment Leakage Source Term

Regulatory Guide 1.183 Appendix A Section 1 states that acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in RG 1.183 Regulatory Position 3.

Consistent with RG 1.183 Regulatory Position 3.4 and its Table 5, the core isotopes released into the containment are grouped into chemically similar groups. The elements of each group are as listed in Table 4.5-2 Consistent with RG 1.183 Regulatory Position 3.2, the core inventory release fractions, by radionuclide groups, for the gap release and early in-vessel phases for DBA LOCAs are as listed in Table 4.5-2.

Consistent with RG 1.183 Regulatory Position 3.2, the core inventory release fractions are applied to the equilibrium reactor core isotope inventory at shutdown as described in Section 4.1.

Consistent with RG 1.183 Regulatory Position 3.3 and its Table 4, the onset and duration of the sequential gap release and early in-vessel release phases for the LOCA are as specified in Table 4.5-2. The gap release phase begins at 30 seconds and the early in-vessel release phase begins at 30 minutes. Although the gap release duration is to be 30 minutes, it is conservatively assumed to end at 30 minutes so that there is no overlap with the start of the early in-vessel release phase (i.e., the gap release phase is modeled with a duration of 29 minutes and 30 seconds). The activity released from the core during each release phase is modeled as increasing in a linear fashion over the duration of the phase.

Consistent with RG 1.183 Appendix A Section 2, an evaluation of post-LOCA containment sump pH has considered the effect of acids and bases created during the LOCA event (e.g., radiolysis products). As discussed in Section 4.5.1.3.4, the containment sump pH is at a value of 7 or greater at the start of the LOCA when iodine evolution from the containment sump is a concern, and for

worst case conditions the containment sump pH is not lower than approximately 6.9 at the end of 30 days. Consistent with RG 1.183 Appendix A Section 2, since the containment sump pH is controlled at a value of 7 or greater during the release of radioiodine to the containment, the chemical form of radioiodine released to the containment is assumed to be 95 percent cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide.

Consistent with Regulatory Guide 1.183 Appendix A Section 2, with the exception of elemental and organic iodine and noble gases, fission products are assumed to be in particulate form (i.e., subject to particulate spray and deposition removal as well as by HEPA filtration).

Section 4.5.1.2 Containment Leakage Activity Release Model

Consistent with RG 1.183 Appendix A Section 3.1, the radioactivity released from the fuel is assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment. The activity release is terminated at the end of the early in-vessel phase.

Consistent with RG 1.183 Appendix A Section 3.2, reduction in containment airborne radioactivity by natural deposition within the containment is credited. As discussed in Section 4.5.1.3, the removal of iodines and aerosols by natural processes is calculated using the models presented in Standard Review Plan (SRP) Section 6.5.2 and NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments" (Reference 16).

Consistent with RG 1.183 Appendix A Section 3.3, reduction in containment airborne radioactivity by the containment spray system is credited. As discussed in Section 4.5.1.3, removal of iodines and aerosols by containment sprays are calculated using the models presented in SRP Section 6.5.2 and NUREG/CR-5966 "A Simplified Model of Aerosol Removal by Containment Sprays" (Reference 17).

Consistent with RG 1.183 Appendix A Section 3.3, the containment building atmosphere is not considered a single, well-mixed volume because the containment sprays cover less than 90% of the containment net free air volume. The total primary containment net free air volume of 2,284,000 cubic feet consists of a sprayed volume of 1,907,000 cubic feet (83.5 percent) and an unsprayed volume of 377,000 cubic feet (16.5 percent).

Consistent with RG 1.183 Appendix A Section 3.7, the containment is assumed to leak at the peak pressure technical specification leak rate of 0.1 percent of the containment air weight per day for the first 24 hours of the LOCA event. Consistent with RG 1.183 Appendix A Section 3.7, after the first 24 hours, the containment leak rate is halved to 0.05 percent of the containment air weight per day.

The containment leakage is assumed to originate from the containment sprayed and unsprayed regions in flow rates that are proportional to the total volume of each region. A well-mixed containment is necessary to justify this modeling. The Containment Emergency Cooling Units (ECUs or air coolers) and the Containment Dome Air Circulator Units (DACUs) provide the necessary air mixing action. Due to an assumed failure, only one of the two Containment ECU trains and one of the two Containment DACU trains are modeled as being operational. The containment ECUs and DACUs are assumed to start operation one minute after the start of the LOCA. Assuming that the air mixing removal of containment unsprayed region activity can be approximated by an exponential relationship, 99 percent of the contaminated air in the containment unsprayed region will be replaced with air from the sprayed region within ~~13~~ 28 minutes, ensuring well-mixing of the containment air with ~~more than 8~~ approximately 4 change-outs of the containment unsprayed region activity prior to the cessation of activity releases at the conclusion of the early in-vessel phase.

The containment mini-purge represents a potential containment airborne activity release path to the environment. Per TS LCO 3.6.3 Surveillance Requirement 3.6.3.2, the 8-inch mini-purge valves are closed except when the valves are open for pressure control, As-Low-As-Reasonably Achievable (ALARA), or air quality considerations for personnel entry, or for surveillances that require the valves to be open. Consistent with the guidance of RG 1.183 Appendix A Section 3.8, because the containment is not routinely purged with the mini-purge system, activity releases through the containment 8-inch mini-purge valves are not analyzed.

The containment purging system represents another potential containment airborne activity release path to the environment. Per TS LCO 3.6.3 Surveillance Requirement 3.6.3.1, the 42-inch purge valves are sealed closed. Consistent with the guidance of RG 1.183 Appendix A Section 7, since the installed containment purging system is not credited in any design basis analysis, activity releases through the containment 42-inch purge valves are not evaluated.

The activity released from the containment is transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. Section 4.4 and its Table 4.4-11 present the San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors used for the containment shell to control room release pathway. No credit is taken for radioactive decay of the isotopes during this atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

Section 4.5.1.3 Containment Aerosol and Elemental Iodine Removal

Consistent with RG 1.183 Appendix A Sections 3.2 and 3.3, reductions in containment airborne radioactivity by natural deposition within the containment and by the containment spray system are credited. This section discusses the modeling employed in determining the aerosol and iodine natural deposition and spray removal rates in the containment sprayed and unsprayed regions.

Section 4.5.1.3.1 addresses the natural deposition of aerosols, including particulate iodine (i.e., cesium iodide). Section 4.5.1.3.2 addresses the natural deposition of elemental iodine. Natural deposition is not considered for the removal of organic iodide and noble gases.

Section 4.5.1.3.3 addresses the spray removal of aerosols, including particulate iodine. Section 4.5.1.3.4 addresses the spray removal of elemental iodine. Spray removal is not considered for the removal of organic iodide and noble gases.

Section 4.5.1.3.5 presents the combined time-dependent natural deposition plus spray removal rates in the containment sprayed and unsprayed regions for elemental iodine, halogens and other particulates.

Section 4.5.1.3.1 Containment Natural Deposition of Aerosols

Consistent with RG 1.183 Appendix A Section 3.2, reduction in containment airborne aerosol radioactivity by natural deposition is credited in the SONGS Units 2 and 3 AST dose analyses. The SONGS natural deposition analysis uses a simplified natural deposition model for aerosols developed by Powers et.al. in NUREG/CR-6189 for the different types of reactors and various operating power levels using a Monte Carlo uncertainty analysis. The results of these analyses for PWR design basis accidents are summarized in correlations provided in NUREG/CR-6189 Table 36. Per RG 1.183 Appendix A Section 3.2, the NUREG/CR-6189 model is incorporated into the RADTRAD analysis code of NUREG/CR-6604.

The aerosol natural deposition removal rates for the gap release and the early in-vessel release phases for the different time periods are conservatively calculated using the Powers model with 10th percentile natural deposition correlations (i.e., minimum deposition) and the analysis models the core rated thermal power of 3438 MWt specified in Section 4.1.1. These deposition rates are weighted by each chemical group release rate reflecting the core release fractions and release phase durations specified in Table 4.5-2, as required by NUREG/CR-6604 Section 2.2.2.1.2. The resultant aerosol natural deposition rates for halogens, alkali metals, and other particulates are shown in Table 4.5-3.

TABLE 4.5-3: AEROSOL NATURAL DEPOSITION REMOVAL RATES

TIME PERIOD (hours)	HALOGENS 10th PERCENTILE NATURAL DEPOSITION REMOVAL RATE (1/hour)	ALKALI METALS 10th PERCENTILE NATURAL DEPOSITION REMOVAL RATE (1/hour)	OTHER PARTICULATES 10th PERCENTILE NATURAL DEPOSITION REMOVAL RATE (1/hour)
0 to 0.5	2.94E-02	2.94E-02	N/A
0.5 to 1.8	3.95E-02	4.17E-02	3.12E-02
1.8 to 3.8	8.93E-02	8.93E-02	8.93E-02
3.8 to 13.8	1.16E-01	1.16E-01	1.16E-01
13.8 to 22.2	8.60E-02	8.60E-02	8.60E-02
22.2 to 720	0.00E+00	0.00E+00	0.00E+00

Section 4.5.1.3.2 Containment Natural Deposition of Elemental Iodine

Consistent with RG 1.183 Appendix A Section 3.2, reduction in containment airborne elemental iodine radioactivity by natural deposition is credited in the SONGS Units 2 and 3 AST dose analyses. The SONGS natural deposition analysis uses a model provided in NUREG-0800 SRP Section 6.5.2.

Removal of elemental iodine by wall deposition is estimated using the methodology of SRP 6.5.2 Section III.4.c.(1). Input to this methodology includes a mass transfer coefficient, the wetted surface area inside containment, and the containment building net free volume.

The mass transfer coefficient is modeled with a value of 0.137 cm/sec, consistent with the value of 4.9 m/hr recommended by SRP 6.5.2 Section III.4.c.(1).

As discussed in NUREG/CR-0009 Section 5.1.2, the natural deposition model for elemental iodine assumes that the bulk gas in the containment atmosphere is well-mixed by natural convection, by steam flows, and by spray operations. Therefore, all surfaces within the containment are available for elemental iodine aerosol deposition. The wetted surface area modeled for natural deposition is the surface area of 601,519 square feet that is used for the passive heat sinks in the containment pressure/temperature response analyses for LOCA and Main Steam Line Break (MSLB).

The total primary containment net free air volume of 2,284,000 cubic feet is the sum of the containment sprayed and unsprayed volumes.

Based on these parameters, the resultant elemental iodine natural deposition rate is 4.26 inverse hours.

Section 4.5.1.3.3 Containment Spray Removal of Aerosols

Consistent with RG 1.183 Appendix A Section 3.3, reduction in containment airborne aerosol radioactivity by the Containment Spray System (CSS) is credited in the SONGS Units 2 and 3 AST dose analyses. The SONGS spray removal analysis uses a simplified spray removal model for aerosols that was developed by Powers et.al. in NUREG/CR-5966 using a Monte Carlo uncertainty analysis. Per RG 1.183 Appendix A Section 3.3, the NUREG/CR-5966 model is incorporated into the RADTRAD analysis code of NUREG/CR-6604.

The aerosol spray removal model input parameters are the CSS spray water flux, the fall height of the spray droplets, and the aerosol mass fraction, which is defined as the aerosol mass in the atmosphere at a given time divided by the total aerosol mass released into the compartment atmosphere until this time.

The CSS has two phases of operation, an injection phase and a recirculation phase. During the injection phase the CSS draws water from the refueling water storage tank until this tank source is exhausted. Following the injection phase, the CSS enters the recirculation phase where water is drawn from the containment sump and recirculated through the CSS. The minimum flow rate per spray header is 1,606 gpm during the injection phase and 1,991 gpm during the recirculation phase. The SONGS spray removal analysis conservatively models the lower injection phase flow rate, rounded down to 1,600 gpm per spray header, throughout the CSS operation. The lower flow rate and resultant spray flux minimizes the activity removal by the sprays and maximizes the airborne radionuclide concentrations. For further conservatism, the SONGS spray removal analysis assumes that only one of the two CSS headers is in operation.

The Powers model is valid for spray water fluxes ranging from 0.001 to 0.25 cm^3 H_20/ cm^2-s. The total spray flux for the SONGS Units 2 and 3 spray system has been determined to fall within this applicability range. The spray flux is 0.00615 cm^3 H_20/ cm^2-s based on a minimum spray system flow rate for one spray header of 1,600 gpm, and the circular floor coverage area for the containment inner diameter of 150 feet.

The Powers model is valid for fall heights ranging from 500 to 5,000 cm. The range of fall heights for the SONGS Units 2 and 3 spray system has been determined to fall within this applicability range. The SONGS Units 2 and 3 containment spray system is designed with multiple spray rings at varying heights within the containment. The fall height of the spray droplets from the various rings to the operating floor ranges from a minimum of 2,433 cm to a maximum of 3,611 cm.

Per NUREG/CR-5966 page 99, the value of the aerosol removal coefficient at an aerosol mass fraction of 0.9 is indicative of the initial rate of decontamination when aerosol is first exposed to the action of a spray.

Unique aerosol spray removal rates were calculated for each spray ring in each of the two CSS spray headers. The calculations address the fact that each spray ring is located at a different height with its own unique spray flux due to different coverage areas and number of spray nozzles per spray ring. The aerosol spray removal rates were conservatively calculated for an aerosol mass fraction of 0.9 using the Powers model with 10th percentile spray removal correlations (i.e., minimum deposition). The aerosol spray removal rates for each ring in a spray header were then summed together, and the lowest header value of 4.73 inverse hours for an aerosol mass fraction of 0.9 was determined.

The aerosol spray removal rate will vary from the value of 4.73 inverse hours as a function of the aerosol mass fraction. The Powers model was originally developed for a puff release of aerosol into a system. In those cases where there is a continuous release, such as the AST LOCA with its gap and early in-vessel releases, the injected aerosols will continually renew the aerosol size distribution. For this reason, the aerosol mass fraction has been modeled with a constant value of one until the release stops at 1.8 hours. The SONGS spray removal analysis applies the Powers model equations to determine the elapsed time since the end of the in-vessel phase to reach a given aerosol mass fraction, and the aerosol spray removal rate corresponding to that aerosol mass fraction.

The Bechtel LocaDose code is used in the AST dose analyses. The LocaDose code treats the aerosol spray removal rates as constants for any given time period. Therefore, to model the time dependency, average aerosol spray removal rates have been calculated for specified LocaDose code time periods. The resultant average aerosol spray removal rates are shown in Table 4.5-4.

TABLE 4.5-4: AEROSOL SPRAY REMOVAL RATES

TIME PERIOD (hours)	AEROSOL 10th PERCENTILE SPRAY REMOVAL RATE (1/hour)
0 to 1.8	5.15
1.8 to 2	3.79
2 to 3.8	1.32
3.8 to 4	0.79
4 to 8	0.62
8 to 13.8	0.52
13.8 to 24	0.50
24 to 48	0.50
48 to 96	0.50
96 to 720	0.50

Section 4.5.1.3.4 Containment Spray Removal of Elemental Iodine

Consistent with RG 1.183 Appendix A Section 3.3, reduction in containment airborne elemental iodine radioactivity by the CSS is credited in the SONGS Units 2 and 3 AST dose analyses. The SONGS spray removal analysis uses a model provided in NUREG-0800 SRP Section 6.5.2, "Containment Spray as a Fission Product Cleanup System" that is based on NUREG/CR-0009, "Technological Bases for Models of Spray Washout of Airborne Contaminants in Containment Vessels".

Elemental iodine removal rates by sprays are calculated using the Bechtel REMOVE code, which incorporates the models of SRP 6.5.2 and NUREG/CR-0009. The removal rates are calculated as a function of time. Spray removal rates are calculated for each spray header and each ring individually, and then added together to determine an overall elemental iodine spray removal rate.

Input to the Bechtel REMOVE code includes the CSS characteristics as described in Section 4.5.1.3.3. As in the aerosol spray removal analysis, the SONGS elemental iodine spray removal analysis conservatively assumes that only one of the two containment spray system headers is in operation, and it is operating at 1,600 gpm throughout the CSS injection and recirculation phases.

A spectrum of drop sizes produced by the containment spray system nozzle is used in the REMOVE code model to determine a spray removal rate constant. The SONGS containment spray system is designed with SPRACO 1713A nozzles. The drop size distribution for this nozzle is built into the Bechtel REMOVE code.

The elemental iodine spray removal rates are dependent on the temperature of the air-steam mixture in the containment. A parametric study was performed to determine the appropriate temperatures to model that will result in conservative removal rate estimates. The study temperatures ranged from the minimum containment air temperature of 89.9 degrees Fahrenheit (32.2 C) to the maximum containment air temperature of 267.4 degrees Fahrenheit (130.8 C), as determined in the containment pressure/temperature response analysis for the LOCA. The elemental iodine removal rate was found to increase with temperature until about 100 C, and then decrease with further increasing temperature. Within the studied temperature range, the maximum removal rate is 5.314 inverse hours, and the minimum removal rate is 4.569 inverse hours, for a ratio of 1.2 between these extremes. Since the removal rates determined in the spray removal calculation are dependent on a post-LOCA environment that may be revised due to changes in the reactor system or steam generator characteristics, the resultant removal rates calculated with the Bechtel REMOVE code for modeling in the AST containment leakage dose analysis have been conservatively reduced by a factor of 1.2.

The elemental iodine spray removal rates are calculated as a function of time for two phases, the CSS injection phase and the CSS recirculation phase. Input to the Bechtel REMOVE code includes the partition coefficient of iodine between the water and air.

The CSS injection phase begins with initiation of spray and lasts from a minimum of approximately 20 minutes (with two CSS trains in operation) to a maximum of approximately 40 minutes (with one CSS train in operation). During the injection phase, borated water from the RWST is used in the spray system. Consistent with NUREG/CR-0009 page 61, a partition coefficient (i.e., liquid concentration divided by gas concentration) of 200 for boric acid solutions is modeled.

The CSS recirculation phase begins at the end of the CSS injection phase. During the recirculation phase the spray system draws water from the containment sump. The partition coefficients of iodine between the water and air during the recirculation phase are calculated with the Bechtel ICONC code, using the methodology developed by L.P. Parsly in ORNL-TM-2412 Part IV. Key input parameters for this methodology include the containment sump water temperature and pH, the volumes of the gaseous and liquid phases, the initial iodine inventory in the containment sump water, and the elemental iodine equilibrium constants K1 and K3.

The partition coefficient increases with increasing containment sump water temperature. The containment sump water temperature varies with time during the CSS recirculation phase. Therefore, for each time interval of interest, the minimum containment sump water temperature for that time interval has been conservatively modeled.

The partition coefficient increases with increasing containment sump pH. Therefore, the minimum containment sump pH level of 7 has been conservatively modeled. SONGS Units 2 and 3 TS LCO 3.5.5 provides for periodic surveillances of the ECCS Trisodium Phosphate (TSP) Dodecahydrate to ensure compliance with the Standard Review Plan 6.5.2 requirement of a pH of at least seven by the onset of recirculation after a LOCA. The required amount of TSP has been calculated based upon the extreme cases of water volume and pH possible in the containment sump. Combustion Engineering Owners Group (CEOG) Task 1178 evaluated the effect of non-traditional acid formers on postaccident containment sump pH for CEOG plants, including SONGS. The evaluation showed that for worst-case conditions, the inclusion of additional acid formers resulted in a slightly lower containment sump pH (approximately 6.9) at the end of 30 days. The evaluation concluded that this pH will continue to ensure that radioiodines remain in the sump solution and are not re-evolved to the containment atmosphere.

The volume of the gaseous phase is the containment free air volume of 2.284E+06 ft^3. The volume of the liquid phase is 46,647 ft^3, representing the minimum containment emergency sump volume available at the start of the

post-LOCA CSS and Safety Injection System (SIS) recirculation mode of operation. The minimum sump volume is appropriate for this calculation since larger liquid volumes will retain more iodine thus increasing the partition coefficient.

The initial iodine inventory in the containment sump water is 2.03 moles, based on the elemental iodine available for release during the gap and the early in-vessel phases.

The elemental iodine equilibrium constants K1 and K3 are obtained from Tables 1 and 2 of ORNL-TM-2412 Part IV.

Unique elemental iodine spray removal rates were calculated for each spray ring in each of the two CSS spray headers. The calculations address the fact that each spray ring is located at a different height with its own unique spray flux due to different coverage areas and number of spray nozzles per spray ring. The elemental iodine spray removal rates for each ring in a spray header were then summed together, and the lowest header value at each time interval was determined.

The resultant elemental iodine spray removal rates and decontamination factors are presented in Table 4.5-5. The tabulated removal rates include the previously discussed reduction factor of 1.2.

Per Standard Review Plan 6.5.2 Section III.4.c.(1), the elemental spray removal rate is limited to a maximum value of 20 inverse hours. The elemental iodine spray removal analysis predicts CSS recirculation phase elemental iodine removal rates in excess of 20 inverse hours during the first 4 hours of the LOCA. Table 4.5-5 reflects this SRP 6.5.2 limitation.

TABLE 4.5-5: ELEMENTAL IODINE SPRAY REMOVAL RATES

TIME PERIOD (hours)	ELEMENTAL IODINE SPRAY REMOVAL RATE (1/hour)	ELEMENTAL IODINE DECON. FACTOR (unitless)
Prior to start of CSS injection phase	0.00	N/A
Duration of CSS injection phase	1.02	110
Start of CSS recirculation phase to 2 hours	20.00	170
2 to 4	20.00	160
4 to 8	18.86	140
8 to 13.8	16.01	110
13.8 to 24	12.99	84
24 to 48	10.09	64
48 to 96	7.83	48
96 to 720	3.78	25

Section 4.5.1.3.5 Combined Natural Deposition Plus Containment Spray Removal Rates

The preceding sections present the natural deposition and containment spray removal rates. In this section the individual removal rates are combined into total containment removal rates for use in Bechtel LocaDose code dose assessment calculations. Individual removal rates as a function of time for four groups are determined: elemental iodines, particulate iodines including other halogens, alkali metals, and all other particulates.

The total removal rate is calculated by combining the individual removal rates from the following sources:

1. The aerosol natural deposition rates per Section 4.5.1.3.1
2. The elemental iodine natural deposition rate per Section 4.5.1.3.2
3. The aerosol spray removal rates per Section 4.5.1.3.3
4. The elemental iodine spray removal rates per Section 4.5.1.3.4

Removal rates are determined for the sprayed and the unsprayed containment regions. In the sprayed containment region the total removal rate consists of a combination of natural deposition and spray removal. In the unsprayed containment region the total removal rate consists only of the natural deposition rates. The resultant total containment removal rates are shown in Tables 4.5-6 and 4.5-7.

Aerosol natural deposition removal is assumed to begin coincident with the start of the gap release phase at 30 seconds.

CSS injection phase aerosol and elemental iodine removal are assumed to begin with the onset of full flow containment spray, which is conservatively modeled as beginning one minute after the start of the LOCA.

The CSS recirculation phase is entered when the ESF recirculation system begins operation. The ESF recirculation system circulates containment sump liquid via the High Pressure Safety Injection (HPSI), Low Pressure Safety Injection (LPSI), and CSS pumps following a Recirculation Actuation Signal (RAS). This analysis assumes only one train of CSS is in operation, and that the onset of CSS recirculation mode of operation is thereby delayed until 42 minutes after the start of the LOCA. This assumption is conservative since the CSS injection phase spray removal rates for elemental iodine are much lower than the removal rates during CSS recirculation phase. Therefore, a longer CSS injection phase results in slower removal of elemental iodines from the containment atmosphere.

The containment spray is assumed to operate for four hours after the onset of the LOCA. This ensures that a significant portion of the aerosol and elemental iodine

releases are removed from the containment atmosphere. Since there is no Decontamination Factor (DF) cut-off for spray removal of aerosols, limiting the spray operation to a maximum of four hours results in conservative estimates of the airborne activity in the containment. The elemental iodine DF cutoff values are reached prior to four hours.

After four hours, the sprayed region is modeled with the unsprayed region natural deposition removal rates.

TABLE 4.5-6: CONTAINMENT SPRAYED REGION REMOVAL RATES

TIME PERIOD	ELEMENTAL IODINE REMOVAL RATE (1/hour)	ELEMENTAL IODINE DECON. FACTOR (unitless)	PARTICULATE IODINE AND HALOGENS REMOVAL RATE (1/hour)	ALKALI METALS REMOVAL RATE (1/hour)	OTHER PARTICULATES REMOVAL RATE (1/hour)
0 to 0.5 minutes	0	N/A	0	0	0
0.5 to 1 minute	4.26	110	0.0294	0.0294	0
1 to 5 minutes	5.28	110	5.18	5.18	5.15
5 to 20 minutes	5.28	110	5.18	5.18	5.15
20 to 30 minutes	5.28	110	5.18	5.18	5.15
30 to 42 minutes	5.28	110	5.19	5.19	5.18
42 minutes to 1 hour	24.26	170	5.19	5.19	5.18
1 to 1.8 hours	24.26	170	5.19	5.19	5.18
1.8 to 2 hours	24.26	170	3.88	3.88	3.88
2 to 3.8 hours	24.26	160	1.41	1.41	1.41
3.8 to 4 hours	24.26	160	0.91	0.91	0.91
4 to 8 hours	4.26	140	0.116	0.116	0.116
8 to 13.8 hours	4.26	110	0.116	0.116	0.116
13.8 to 22.2 hours	4.26	84	0.086	0.086	0.086
22.2 to 24 hours	4.26	84	0	0	0
1 to 2 days	4.26	64	0	0	0
2 to 4 days	4.26	48	0	0	0
4 to 30 days	4.26	25	0	0	0

TABLE 4.5-7: CONTAINMENT UNSPRAYED REGION REMOVAL RATES

TIME PERIOD	ELEMENTAL IODINE REMOVAL RATE (1/hour)	ELEMENTAL IODINE DECON. FACTOR (unitless)	PARTICULATE IODINE AND HALOGENS REMOVAL RATE (1/hour)	ALKALI METALS REMOVAL RATE (1/hour)	OTHER PARTICULATES REMOVAL RATE (1/hour)
0 to 0.5 minutes	0	N/A	0	0	0
0.5 to 1 minute	4.26	110	0.0294	0.0294	0
1 to 5 minutes	4.26	110	0.0294	0.0294	0
5 to 20 minutes	4.26	110	0.0294	0.0294	0
20 to 30 minutes	4.26	110	0.0294	0.0294	0
30 to 42 minutes	4.26	110	0.0395	0.0417	0.0312
42 minutes to 1 hour	4.26	170	0.0395	0.0417	0.0312
1 to 1.8 hours	4.26	170	0.0395	0.0417	0.0312
1.8 to 2 hours	4.26	170	0.0893	0.0893	0.0893
2 to 3.8 hours	4.26	160	0.0893	0.0893	0.0893
3.8 to 4 hours	4.26	160	0.116	0.116	0.116
4 to 8 hours	4.26	140	0.116	0.116	0.116
8 to 13.8 hours	4.26	110	0.116	0.116	0.116
13.8 to 22.2 hours	4.26	84	0.086	0.086	0.086
22.2 to 24 hours	4.26	84	0	0	0
1 to 2 days	4.26	64	0	0	0
2 to 4 days	4.26	48	0	0	0
4 to 30 days	4.26	25	0	0	0

Section 4.5.2 ESF Recirculation Loop Leakage

The ESF recirculation loop circulates containment sump water outside of the containment via the SIS and CSS pumps following receipt of a RAS. Per RG 1.183 Appendix A Section 5, ESF systems that recirculate sump water outside of the primary containment are assumed to leak during their intended operation. This release includes leakage through valve packing glands, pump shaft seals, flanged connections, and other similar components.

Regulatory Guide 1.183 Appendix A provides assumptions for use in evaluating the radiological consequences of the ESF recirculation loop leakage pathway for a LOCA. These assumptions supplement the guidance provided in the main body of RG 1.183.

This Section presents the assumptions, design input, and methodology employed in evaluating the radiological consequences of SONGS Units 2 and 3 LOCA ESF recirculation loop leakage path. The characteristics of the LOCA ESF recirculation loop leakage model are summarized in Table 4.5-8.

The control room and offsite doses associated with ESF leakage are summarized in Section 4.5.7.

TABLE 4.5-8: LOCA ESF RECIRCULATION LOOP LEAKAGE ANALYSIS PARAMETERS

LOCA ESF RECIRCULATION LOOP LEAKAGE PARAMETER	MODELED VALUE
Timing of core activity release into containment sump	
Gap release phase	instantaneous at time zero
Early in-vessel phase	instantaneous at time zero
Core inventory fraction released into containment sump	
Noble gases (Xe, Kr)	0
Halogens (I, Br)	0.40
Alkali metals (Cs, Rb)	0.30
Tellurium metals (Te, Sb, Se)	0.05
Barium, Strontium (Ba, Sr)	0.02
Noble metals (Ru, Rh, Pd, Mo, Tc, Co)	0.0025
Cerium group (Ce, Pu, Np)	0.0005
Lanthanides (La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am)	0.0002
ESF recirculation loop dilution volume, cubic feet	46,647
ESF recirculation loop leakage rate to the environment, ft^3/minute	
0 to 20 minutes	0
20 minutes to 30 days	7.00E-03
ESF recirculation loop leakage flashing fractions and partition coefficients	
Iodine isotopes flashing fraction, percent	10
Noble gases (Xe, Kr) partition coefficient	1.0E-06
Particulate isotopes partition coefficient	1E+06
Chemical form of iodine released to environment, percent of iodine	
Cesium iodide (CsI) (particulate iodine)	0
Elemental iodine	97
Organic iodide	3
ESF Leakage release point (Main Plant Vent) to Control Room Atmospheric Dispersion Factors, seconds/m^3	per Section 4.4

Section 4.5.2.1 ESF Leakage Source Term

Regulatory Guide 1.183 Appendix A Section 1 states that acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in RG 1.183 Regulatory Position 3.

Consistent with RG 1.183 Regulatory Position 3.4, the core isotopes released into the containment are grouped into chemically similar groups in accordance with RG 1.183 Table 5. The elements of each group are as listed in Table 4.5-8. Consistent with RG 1.183 Regulatory Position 3.2, the core inventory release

fractions are applied to the equilibrium reactor core isotope inventory at shutdown as described in Section 4.1.

Consistent with RG 1.183 Appendix A Section 5.1, all fission products, with the exception of noble gases, released from the fuel to the containment during the gap and early in-vessel activity release phases are assumed to instantaneously and homogeneously mix in the primary containment sump coincident with the start of the LOCA. The dose analysis conservatively assumes that all fission product activity is released to the containment sump prior to the start of ESF recirculation operation at 20 minutes, which is sooner than the conclusion of the in-vessel activity release phase at 1.8 hours.

The AST ESF leakage dose analysis assumes that the ESF recirculation loop dilutes the core activity release into a volume of 348,946 gallons (46,647 cubic feet). This volume represents the minimum containment emergency sump volume available at the start of the post-LOCA SIS and CSS recirculation mode of operation. The modeling of the minimum sump volume conservatively maximizes the ESF recirculation loop activity concentration.

Consistent with Regulatory Guide 1.183 Appendix A Section 2, with the exception of elemental and organic iodine and noble gases, fission products are assumed to be in particulate form (i.e., subject to HEPA filtration).

Section 4.5.2.2 ESF Leakage Activity Release Model

Consistent with RG 1.183 Appendix A Section 5.2, the ESF leakage is assumed to start at the earliest time the recirculation flow starts in the ESF recirculation system, and end at the latest time the releases from these systems are terminated. Per the containment pressure/temperature response analysis for the LOCA event, the CSS and SIS recirculation mode of operation begins as early as 20.2 minutes after the start of the LOCA for a two-train recirculation mode. This start time has been conservatively rounded down to 20 minutes after the start of the LOCA for use in the AST ESF leakage dose analysis. The ESF leakage is assumed to continue for the duration of the 30-day LOCA event.

The maximum expected leakage rates from all components in the recirculation systems are 1,770 cc/hr from the HPSI system, 3,000 cc/hr from the LPSI system, and 1,180 cc/hr from the CSS. Consistent with RG Guide 1.183 Appendix A, Section 5.2, the modeled ESF recirculation loop leakage rate of 11,900 cc/hr (7.00E-03 cfm) represents two times the sum of the simultaneous maximum expected leakage from these systems.

The ESF leakage AST dose analysis assumes that 10 percent of the iodine in the ESF Recirculation Loop leakage flashes to vapor and is therefore capable of migrating to the outside environment. The ten percent flashing fraction is consistent with the guidance of RG 1.183 Appendix A Section 5.5, which states

that if the water temperature is less than 212 Fahrenheit, then 10 percent of the iodine in the leakage is assumed to become airborne unless a smaller amount is justified based on actual sump pH history and ventilation rates. Per the containment pressure/temperature response analysis for the LOCA event, the temperature of the containment sump liquid has been reduced to below 212 Fahrenheit when the CSS and SIS recirculation mode of operation begins at 20 minutes.

Consistent with RG 1.183 Appendix A, Section 5.6, the composition of iodine available for release to the environment is assumed to be 97% elemental iodine, 3% organic iodide, and 0% particulate iodine.

Consistent with RG 1.183 Appendix A Section 5.3, all particulate isotopes in the recirculating liquid are retained in the liquid phase. Radioactive decay of some particulate isotopes in the recirculating liquid yields noble gas isotopes. In the dose program model, a particulate partition coefficient (i.e., liquid concentration divided by gas concentration) of 1.0E+06 is used in order to retain particulates within the recirculating liquid where noble gas daughters are then formed by decay.

Per RG 1.183 Appendix A Section 5.3, with the exception of iodine, all radioactive materials in the recirculating liquid are retained in the liquid phase. This guidance implies that a release of noble gases (krypton and/or xenon) via the ESF leakage need not be considered (most likely because noble gas isotopes present in the containment sump water would be released into the containment air prior to being recirculated). However, noble gas isotopes are formed by the decay of other isotopes that are present in the ESF recirculating liquid. Therefore, the ESF leakage AST dose analysis conservatively assumes that 100 percent of the noble gases in the ESF Recirculation Loop leakage will become airborne (i.e., a noble gas partition coefficient of 1.0E-06).
Once airborne, the noble gases can migrate to the outside environment.

The activity released from the ESF leakage into the Penetration Areas and Safety Equipment Building is exhausted to the environment via the main plant vent, and transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. Section 4.4 and its Table 4.4-11 present the San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors used for the main plant vent to control room release pathway. No credit is taken for radioactive decay of the isotopes during this atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

Section 4.5.3 RWST Release

The ESF recirculation loop circulates containment sump water outside of the containment via the SIS and CSS pumps following receipt of a RAS. Per RG 1.183 Appendix A Section 5, ESF systems that recirculate sump water outside of the primary containment may leak through valves isolating interfacing systems, including the RWST.

Regulatory Guide 1.183 Appendix A provides assumptions for use in evaluating the radiological consequences of ESF leakage to the RWST and its subsequent release pathway to the environment. These assumptions supplement the guidance provided in the main body of RG 1.183.

This Section presents the assumptions, design input, and methodology employed in evaluating the radiological consequences of SONGS Units 2 and 3 LOCA RWST release path. The characteristics of the LOCA RWST release model are summarized in Table 4.5-9.

The control room and offsite doses associated with the RWST release are summarized in Section 4.5.7.

TABLE 4.5-9: LOCA RWST RELEASE ANALYSIS PARAMETERS

LOCA RWST RELEASE PARAMETER	MODELED VALUE
Timing of core activity release into containment sump	
Gap release phase	instantaneous at time zero
Early in-vessel phase	instantaneous at time zero
Core inventory fraction released into containment sump	
Noble gases (Xe, Kr)	0
Halogens (I, Br)	0.40
Alkali metals (Cs, Rb)	0.30
Tellurium metals (Te, Sb, Se)	0.05
Barium, Strontium (Ba, Sr)	0.02
Noble metals (Ru, Rh, Pd, Mo, Tc, Co)	0.0025
Cerium group (Ce, Pu, Np)	0.0005
Lanthanides (La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am)	0.0002
ESF recirculation loop dilution volume, cubic feet	46,647
RWST dilution volumes, cubic feet per tank	
RWST air region volume	35,880
RWST water region volume	7,345

LOCA RWST RELEASE PARAMETER	MODELED VALUE
RWST inflow due to ESF pump mini-flow isolation valve leakage	
Mini-flow valve leakage flashing fraction, percent	10
Mini-flow valve leakage rates, cfm	
Total mini-flow leakage rate to the RWST	
0 to 20 minutes	0
20 minutes to 30 days	0.4010
Mini-flow valve leakage rate to the RWST water region	
0 to 20 minutes	0
20 minutes to 30 days	0.3609
Mini-flow valve leakage rate to the RWST air region	
0 to 20 minutes	0
20 minutes to 30 days	0.0401
RWST water region inflow due to RWST discharge check valve leakage, cfm	
0 to 1.08 hours	0
1.08 to 2 hours	1.2859
2 to 8 hours	1.2778
8 to 24 hours	0.9622
24 to 96 hours	0.5103
96 to 119.72 hours	0.1078
119.72 to 720 hours	0
Partition coefficients between ESF recirculation loop and RWST air region	
Iodine	1.0
Particulates	1E+06
Mixing and partition coefficients between RWST air and water regions	
Mixing rate between RWST air and water regions, cfm	0.4010
Iodine partition coefficient	200
Noble gases (Xe, Kr) partition coefficient	1E-06
Particulates partition coefficient	1E+06
RWST air region release rate to the environment, cfm	
0 to 20 minutes	0
20 minutes to 1.08 hours	0.4010
1.08 to 2 hours	1.6869
2 to 8 hours	1.6788
8 to 24 hours	1.3632
24 to 96 hours	0.9113
96 to 119.72 hours	0.5088
119.72 to 720 hours	0.4010
Chemical form of Iodine released to environment, percent of iodine	
Cesium iodide (CsI) (particulate iodine)	0
Elemental iodine	97
Organic iodide	3
RWST release via RWST vent to Control Room Atmospheric Dispersion Factors, seconds/m^3	per Section 4.4

Section 4.5.3.1 RWST Release Source Term

The RWST release source term is the same as the ESF leakage source term described in Section 4.5.2.1.

ESF back-leakage into the RWST occurs after the RWST water level has drained down, and a RAS has been generated. In evaluating the post-LOCA RWST release AST dose consequences, the most conservative scenario for leakage out of the RWST is when the RWST air volume is minimized (and the water volume is maximized). Minimizing the air volume will minimize dilution of the activity entering the RWST air space prior to its release to the atmosphere.

The RWST level setpoint for a RAS is 18.5% ± 3.8%. The minimum RWST air volume occurs when RAS is quickly initiated at the 22.3% upper tolerance of the RWST level setpoint. At this setpoint, the RWST minimum air volume is 35,880 cubic feet, and the RWST maximum water volume is 7,345 cubic feet.

Section 4.5.3.2 RWST Activity Release Model

During the ESF recirculation operation, ESF leakage may enter the RWST via various pathways. The pathways are dependent on whether the LOCA occurs with or without an assumed Diesel Generator (DG) failure. Due to the time dependency associated with the pathway leakage rates, the Current Licensing Basis reports the maximum 0 to 2 hour EAB dose for the scenario of the post-LOCA RWST release with an assumed DG failure, and the maximum event duration control room and LPZ doses for the scenario of the post-LOCA RWST release without an assumed DG failure. The AST RWST release dose analysis evaluated the two leakage scenarios and determined that the variable 2-hour window EAB dose and the event duration control room and LPZ doses are more severe for the scenario of the post-LOCA RWST release without an assumed DG failure rather than with an assumed DG failure. The characteristics of the RWST release without an assumed DG failure are detailed in this section.

Two ESF leakage pathways to the RWST characterize the scenario of a RWST release without an assumed DG failure. The first pathway is RWST air region inflow due to ESF pump minimum flow (mini-flow) isolation valve leakage. The second pathway is RWST water region inflow due to RWST discharge check valve leakage. ESF leakage to the RWST for potential release paths with three or more normally closed isolation valves in series is assumed to be negligible.

Section 4.5.3.2.1 RWST Inflow Due to ESF Pump Mini-Flow Isolation Valve Leakage

The SIS and CSS pumps minimum flow return paths to the RWST are isolated following a RAS by two sets of 4-inch mini-flow isolation valves. Valves

1204-HV-9306 and 9307 are in series in one flow path, and valves 1204-HV-9347 and 9348 are in series in a second flow path. The maximum allowable leakage rate for each of the valves is 0.75 gpm. Consequently, for either path with its two valves in series, the maximum allowable path leakage rate is assumed to be 0.75 gpm. For the scenario of a LOCA without an assumed DG failure, the total leakage rate past the valves in the two parallel flow paths is 1.5 gpm. Consistent with RG 1.183 Appendix A, Section 5.2, the modeled ESF recirculation loop leakage rate of 3.0 gpm (0.4010 cfm) represents two times the sum of the simultaneous maximum allowable leakage from these systems. The 0.4010 cfm leakage past the mini-flow isolation valves is released into the RWST air space.

Consistent with RG 1.183 Appendix A Section 5.2, ESF leakage to the RWST is assumed to start at the earliest time the recirculation flow starts in the ESF recirculation system, and end at the latest time the releases from these systems are terminated. Per the containment pressure/temperature response analysis for the LOCA event, the CSS and SIS recirculation mode of operation begins as early as 20.2 minutes after the start of the LOCA for a two-train recirculation mode. This start time has been conservatively rounded down to 20 minutes after the start of the LOCA for use in the AST RWST release dose analysis. The ESF leakage and coincident RWST release to the environment are assumed to continue for the duration of the 30-day LOCA event.

The RWST release AST dose analysis assumes that 10 percent of the iodine in the ESF Recirculation Loop leakage into the RWST air space flashes to vapor. The ten percent flashing fraction is consistent with the guidance of RG 1.183 Appendix A Section 5.5, which states that if the water temperature is less than 212 Fahrenheit, then 10 percent of the iodine in the leakage is assumed to become airborne unless a smaller amount is justified based on actual sump pH history and ventilation rates. Per the containment pressure/temperature response analysis for the LOCA event, the temperature of the containment sump liquid has been reduced to below 212 Fahrenheit when the CSS and SIS recirculation mode of operation begins at 20 minutes.

To address the 10 percent ESF leakage flashing, 10 percent of the ESF pump mini-flow leakage is modeled as entering the RWST air region, and 90 percent of the ESF pump mini-flow leakage is modeled as entering the RWST water region.

Section 4.5.3.2.2 RWST Inflow Due to RWST Discharge Check Valve Leakage

Following a RAS, each of the two RWSTs is isolated from the ESF recirculation loop by an RWST isolation valve located near the RWST. In the event that the isolation valve fails to close following a RAS, an RWST discharge check valve (1204-MU-001 or 1204-MU-002) is the only barrier between the containment and the RWST.

The maximum allowable leakage rate through both check valves is 5 gpm. Consistent with RG 1.183 Appendix A, Section 5.2, the modeled ESF recirculation loop leakage rate of 10 gpm represents two times the maximum allowable leakage. The leakage past the check valves is released into the RWST water space.

Should the check valve leak, a certain amount of containment sump water will enter the line and start moving toward the RWST. The flow rate is simply the leak rate of the check valve, but the speed at which the hot water from the sump moves toward the RWST depends on the pressure differential between the post-LOCA containment and the RWST and on the temperature difference between the cold RWST water and the hot containment sump water.

A valve seat leak analysis has determined that with the RWST isolation valve open and the check valve leaking at 10 gpm, the sump water will reach the RWST isolation valve and enter the RWST in approximately 1.08 hours after the start of the LOCA. Neglecting the effect of thermal buoyancy (i.e., assuming instant cooling of the leaking sump water to the RWST temperature) would extend the travel time to approximately 8.7 hours.

As the LOCA event progresses, the containment pressure decreases, and the leakage rate past the check valve decreases. Table 4.5-9 summarizes the time-dependent RWST water region inflow due to RWST discharge check valve leakage. The RWST water region inflow due to RWST discharge check valve leakage is maximized by modeling the post-LOCA containment pressure and temperature history that yields the highest containment pressure. Eventually, the driving force for the check valve leakage ends.

Section 4.5.3.2.3 Mixing of RWST Water and Air Activity Inventories

Because the iodine concentrations in the RWST air space and water space are not at their equilibrium values at the onset of ESF recirculation loop leakage, the mixing rate between the RWST water and air regions will impact the dose consequences.

At equilibrium conditions, the ratio of the iodine concentration in the RWST water space to the iodine concentration in the RWST air space is defined by an iodine partition coefficient (i.e., liquid concentration divided by gas concentration). Per NUREG/CR-0009, the partition coefficient is numerically determined by the physical sorption of I_2 and by rapid ionization reactions that occur in solution. Per NUREG/CR-0009 page 61, for borated solutions (such as the RWST) a partition coefficient of 200 is achievable. Therefore, a partition coefficient of 200 can be used to establish the equilibrium between the iodine concentrations in the RWST air and water spaces.

As RWST water and air region mixing occurs, the ratio of the iodine concentration in the RWST water space to the iodine concentration in the RWST air space tends to a partition coefficient of 200. Mixing is facilitated by the turbulence added to the RWST water by the RWST discharge check valve leakage into the RWST water space, by the turbulence added to the RWST water by the mini-flow valve leakage into the RWST air space that drops down into the RWST water, and by the thermal gradients associated with the RWST water warmed by the introduction of the hot ESF leakage fluid relative to colder RWST air. Per NUREG/CR-0009 page 64, very small thermal sources are sufficient to mix a large vessel.

The higher the mixing rate between the air space and water space, the more rapid the approach to equilibrium. Initially the RWST air activity concentration is greater than when at equilibrium conditions. Minimizing the mixing rate delays the transfer of iodine activity from the RWST air region to the RWST water region, thereby conservatively maximizing the RWST air activity available for leakage to the environment. In the RWST leakage AST analysis, the mixing rate between the RWST air and water spaces is conservatively modeled as the mini-flow valve leakage rate into the RWST. No credit is taken for RWST air and water space mixing associated with the RWST inflow due to RWST discharge check valve leakage. No credit is taken for mixing by thermal gradients.

Consistent with RG 1.183 Appendix A Section 5.3, all particulate isotopes in the recirculating liquid are retained in the liquid phase. Radioactive decay of some particulate isotopes in the RWST liquid space yields noble gas isotopes. A particulate partition coefficient (i.e., liquid concentration divided by gas concentration) of 1.0E+06 is used in order to retain particulates within the RWST liquid space where noble gas daughters are then formed by decay.

Per RG 1.183 Appendix A Section 5.3, with the exception of iodine, all radioactive materials in the recirculating liquid are retained in the liquid phase. This guidance implies that a release of noble gases (krypton and/or xenon) via the RWST release need not be considered (most likely because noble gas isotopes present in the containment sump water would be released into the containment air prior to being recirculated). However, noble gas isotopes are formed by the decay of other isotopes that are present in the RWST liquid. Therefore, the RWST release AST dose analysis conservatively assumes that 100 percent of the noble gases formed by the decay of the isotopes in the RWST liquid will become airborne (i.e., a noble gas partition coefficient of 1.0E-06). Once airborne, the noble gases can migrate to the outside environment.

Section 4.5.3.2.4 RWST Releases to the Environment

Consistent with RG 1.183 Appendix A, Section 5.6, the composition of iodine available for release to the environment from the RWST air space is assumed to be 97% elemental iodine, 3% organic iodide, and 0% particulate iodine.

The activity released from the RWST is exhausted to the environment via the RWST vent, and transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. Section 4.4 and its Table 4.4-11 present the San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors used for the RWST vent to control room release pathway. No credit is taken for radioactive decay of the isotopes during this atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

Section 4.5.4 Post-Accident Sampling System (PASS) Leakage

PASS licensing requirements were deleted from the SONGS Units 2 and 3 Technical Specifications per Unit 2 License Amendment 178 and Unit 3 License Amendment 169. Currently, the PASS is maintained at SONGS Units 2 and 3 for severe accident management only. The PASS is capable of analyzing samples of containment air, containment sump water, and reactor coolant.

Until such time that the PASS is isolated from post-LOCA radiation sources, portions of the PASS that are outside of the containment present the potential for a release path due to leakage through valve packing glands, pump shaft seals, flanged connections, and other similar components. Should a design modification be implemented to isolate PASS and thereby eliminate the potential release paths, the dose contribution from PASS leakage will be removed from the LOCA dose analysis.

Although RG 1.183 Appendix A does not provide a specific requirement to evaluate PASS leakage, the SONGS Units 2 and 3 AST dose analysis has applied related RG 1.183 Appendix A ESF leakage guidance to an evaluation of the radiological consequences of the PASS leakage activity release path for a LOCA.

This Section presents the assumptions, design input, and methodology employed in evaluating the radiological consequences of SONGS Units 2 and 3 LOCA PASS leakage path. The characteristics of the LOCA PASS leakage model are summarized in Table 4.5-10.

The control room and offsite doses associated with PASS leakage are summarized in Section 4.5.7.

TABLE 4.5-10: LOCA PASS LEAKAGE ANALYSIS PARAMETERS

LOCA PASS LEAKAGE PARAMETER	MODELED VALUE
Timing of core activity release into reactor coolant system	
Gap release phase	instantaneous at time zero
Early in-vessel phase	instantaneous at time zero
Core inventory fraction released into reactor coolant system	
Noble gases (Xe, Kr)	1.00
Halogens (I, Br)	0.40
Alkali metals (Cs, Rb)	0.30
Tellurium metals (Te, Sb, Se)	0.05
Barium, Strontium (Ba, Sr)	0.02
Noble metals (Ru, Rh, Pd, Mo, Tc, Co)	0.0025
Cerium group (Ce, Pu, Np)	0.0005
Lanthanides (La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am)	0.0002
Reactor coolant system dilution volume, cubic feet	10,179
PASS leakage rate to the environment, ft^3/minute	
0 to 30 minutes	0
30 minutes to 30 days	4.12E-04
PASS leakage partition coefficients and flashing fractions	
Iodine isotopes flashing fraction, percent	10
Noble gases (Xe, Kr) partition coefficient	1.0E-06
Particulate isotopes partition coefficient	1E+06
Chemical form of Iodine released to environment, percent of iodine	
Cesium iodide (CsI) (particulate iodine)	0
Elemental iodine	97
Organic iodide	3
PASS Leakage release point (Main Plant Vent) to Control Room Atmospheric Dispersion Factors, seconds/m^3	Per Section 4.4

Section 4.5.4.1 PASS Leakage Source Term

The PASS samples containment sump liquid, reactor coolant, and containment air. The PASS leakage AST dose analysis assumes that reactor coolant is the PASS fluid leaking during the LOCA. Reactor coolant has been modeled since the reactor coolant iodine activity concentration is greater than the containment sump liquid or containment air iodine activity concentration.

Regulatory Guide 1.183 Appendix A Section 1 states that acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in RG 1.183 Regulatory Position 3.

Consistent with RG 1.183 Regulatory Position 3.4, the core isotopes released into the reactor coolant are grouped into chemically similar groups in accordance with RG 1.183 Table 5. The elements of each group are as listed in

Table 4.5-10. Consistent with RG 1.183 Regulatory Position 3.1, the core inventory release fractions are applied to the equilibrium reactor core isotope inventory at shutdown as described in Section 4.1.

All fission products released from the fuel to the reactor coolant are assumed to instantaneously and homogeneously mix in the reactor coolant coincident with the start of the LOCA.

The AST PASS leakage dose analysis assumes that the reactor coolant dilutes the core activity release into a volume of 10,179 cubic feet. This volume has conservatively omitted the primary side volume that is present in an assumed 2,000 plugged U-tubes in each of the two original steam generators.

Consistent with Regulatory Guide 1.183 Appendix A Section 2, with the exception of elemental and organic iodine and noble gases, fission products are assumed to be in particulate form (i.e., subject to HEPA filtration).

Section 4.5.4.2 PASS Leakage Activity Release Model

Consistent with RG 1.183 Appendix A Section 5.2, the PASS leakage is assumed to start at the earliest time that PASS sampling could start, and end at the latest time the releases from the PASS are terminated. Although the PASS is currently maintained for severe accident management only, this analysis assumes the PASS leakage begins 30 minutes after the start of the LOCA. Chemistry Procedures address the steps associated with collecting a post-LOCA reactor coolant sample. One procedure requires the Nuclear Chemistry Technician to obtain permission from the affected unit Control Operator to operate the PASS. A second procedure addresses steps that must be taken prior to operation of the PASS during accident conditions. These steps include requesting that Health Physics survey the PASS laboratory, assembling the Chemistry sampling team, and implementing health physics requirements. These actions should require more than the 30 minute delay assumed prior to PASS operation. The PASS leakage is assumed to continue for the duration of the 30-day LOCA event.

The maximum expected leakage rate from all components in the PASS is 350 cc/hr. Consistent with RG 1.183 Appendix A, Section 5.2, the modeled PASS leakage rate of 700 cc/hr (4.12E-04 cfm) represents two times the maximum expected leakage from the PASS.

The PASS leakage AST dose analysis assumes that 10 percent of the iodine in the PASS leakage flashes to vapor and is therefore capable of migrating to the outside environment. The ten percent flashing fraction is consistent with the guidance of RG 1.183 Appendix A Section 5.5, which states that if the water temperature is less than 212 Fahrenheit, then 10 percent of the iodine in the leakage is assumed to become airborne. Per the PASS Technical Manual,

Sample Vessel Heat Exchanger SA1212ME752 is used to cool the reactor coolant sample flow from the maximum reactor coolant temperature to allow for low temperature (120 Fahrenheit) sample analysis. The bulk of the PASS reactor coolant leakage from PASS sample station fittings will be at a low temperature.

Consistent with RG 1.183 Appendix A, Section 5.6, the composition of iodine available for release to the environment is assumed to be 97% elemental iodine, 3% organic iodide, and 0% particulate iodine.

Consistent with RG 1.183 Appendix A Section 5.3, all particulate isotopes in the reactor coolant are retained in the liquid phase. Radioactive decay of some particulate isotopes in the reactor coolant yields noble gas isotopes. In the Bechtel LocaDose code model, a particulate partition coefficient (i.e., liquid concentration divided by gas concentration) of 1.0E+06 is used in order to retain particulates within the reactor coolant where noble gas daughters are then formed by decay.

The PASS leakage AST dose analysis conservatively assumes that 100 percent of the noble gases (krypton and/or xenon) either initially present or formed by the decay of the isotopes in the PASS reactor coolant leakage will become airborne (i.e., a noble gas partition coefficient of 1.0E-06) and migrate to the outside environment.

The activity released from the PASS leakage into the Radwaste Building is exhausted to the environment via the main plant vent, and transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. Section 4.4 and its Table 4.4-11 present the San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors used for the main plant vent to control room release pathway. No credit is taken for radioactive decay of the isotopes during this atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

Section 4.5.5 LOCA EAB and LPZ Model

Regulatory Guide 1.183 Regulatory Position 4.1 provides guidance to be used in determining TEDE for persons located at or beyond the boundary of the exclusion area, including the outer boundary of the low population zone. Section 4.2 addresses the applicability of this guidance to the SONGS Units 2 and 3 AST LOCA dose analysis as it relates to the offsite dose exposure parameters.

As discussed in Section 4.2, the LOCA dose analysis considers the dose consequences of inhalation and immersion. Radioactive material contained in a

plant structure is assumed to be a negligible radiation shine source to the offsite dose receptors relative to the dose associated with immersion in the radioactive plume released from the facility.

Consistent with RG 1.183 Regulatory Positions 4.1.5, 4.1.6 and 4.4 and Table 6, the LOCA event radiological criterion for the EAB and for the outer boundary of the LPZ is 25 Rem TEDE.

Section 4.5.6 LOCA Control Room Model

Regulatory Guide 1.183 Regulatory Position 4.2 provides guidance to be used in determining the total effective dose equivalent for persons located in the control room. Section 4.3 addresses the applicability of this guidance to the SONGS Units 2 and 3 AST LOCA dose analysis as it relates to the control room dose exposure parameters.

The CREACUS Emergency mode of operation can be actuated either manually or automatically following a CRIS. The CRIS may be generated automatically by a SIAS or by the detection of high radioactivity concentrations in the control room outside air inflow. Per Section 4.3.2.1.1, the LOCA model credits CREACUS Emergency mode of operation initiation at time zero (i.e., prior to the arrival of any contaminated air reaching the control room outside air intakes) due to a SIAS-induced CRIS.

As discussed in Section 4.3, the LOCA dose analysis considers the dose consequences of inhalation, immersion, and radiation shine from the environmental (or outside) cloud, the control room emergency HVAC filters, the post-LOCA piping, and the containment building.

Consistent with RG 1.183 Regulatory Position 4.4, as an AST dose analysis acceptance criterion the postulated control room dose is evaluated to ensure that it does not exceed the 5 Rem TEDE criterion established in 10 CFR 50.67.

Section 4.5.7 LOCA Dose Consequences

The resulting LOCA offsite and control room operator doses are listed in Tables 4.5-11 and 4.5-12. The analysis demonstrates that the LOCA event 25 Rem TEDE radiological criterion for the EAB and for the outer boundary of the LPZ is met. The analysis also demonstrates that the LOCA event 5 Rem TEDE radiological criterion for the control room is met.

TABLE 4.5-11: LOCA RELEASE PATH DOSE CONSEQUENCES

DOSE RECEPTOR	CONTAINMENT LEAKAGE DOSE (REM TEDE)	ESF LEAKAGE DOSE (REM TEDE)	RWST RELEASE DOSE (REM TEDE)	PASS LEAKAGE DOSE (REM TEDE)	PIPING SHINE DOSE (REM TEDE)
Control Room (30-day accident duration)					
Immersion and Inhalation	~~7.341E-01~~ 7.505E-01	~~4.697E-01~~ 4.791E-01	~~8.420E-01~~ 8.732E-01	~~1.461E-01~~ 1.490E-01	-
Control Room Filter Shine	~~1.469E-01~~ 1.527E-01	~~7.55E-02~~ 7.701E-02	~~1.263E-01~~ 1.310E-01	~~2.02E-02~~ 2.060E-02	-
Environmental Cloud Shine	~~4.443E-02~~ 4.456E-02	~~3.44E-03~~ 3.509E-03	~~1.134E-03~~ 1.176E-03	~~3.31E-03~~ 3.376E-03	-
Containment Building Shine	~~4.304E-04~~ 4.310E-04	-	-	-	-
Piping Shine	-	-	-	-	1.06E-01
TOTAL	~~9.259E-01~~ 9.482E-01	~~5.487E-01~~ 5.596E-01	~~9.694E-01~~ 1.005E+00	~~1.696E-01~~ 1.730E-01	1.06E-01
Exclusion Area Boundary (Maximum 2-hour dose)	~~3.548E+00~~ 3.652E+00 (0.6 to 2.6 hrs)	3.398E-01 (0.4 to 2.4 hrs)	1.103E+00 (94 to 96 hrs)	1.370E-01 (0.5 to 2.5 hrs)	-
Low Population Zone (30-day accident duration)	~~2.309E-01~~ 2.377E-01	2.381E-01	1.311E+00	6.897E-02	-

TABLE 4.5-12: LOCA DOSE CONSEQUENCES

DOSE RECEPTOR	LOCA DOSE (REM TEDE)	ACCEPTANCE CRITERION (REM TEDE)
Control Room (30-day accident duration)	~~2.7~~ 2.8	5
EAB (Maximum 2-hour dose)	~~5.1~~ 5.2	25
LPZ (30-day accident duration)	~~1.8~~ 1.9	25

Section 4.6 FUEL HANDLING ACCIDENT INSIDE CONTAINMENT (FHA-IC) ANALYSIS

Regulatory Guide 1.183 Appendix B provides assumptions for use in evaluating the radiological consequences of an FHA-IC. These assumptions supplement the guidance provided in the main body of RG 1.183.

This Section presents the assumptions, design input, methodology employed in evaluating, and the radiological consequences of, the SONGS Units 2 and 3 FHA-IC. The characteristics of the FHA-IC model are summarized in Table 4.6-1.

TABLE 4.6-1: FHA-IC ANALYSIS PARAMETERS

FHA-IC PARAMETER	MODELED VALUE
Dose acceptance criteria, Rem TEDE	
Control Room	5
EAB	6.3
LPZ	6.3
FHA-IC source term	
Decay time after reactor shutdown, hours	72
Average fuel rod isotope inventory at 72 hours, curies/rod	per Section 4.1
Radial peaking factor applied to all failed fuel rods	1.75
Number of failed fuel rods - in dropped fuel bundle	16
Number of failed fuel rods - in impacted fuel bundles	210
Core fission product fractions in fuel rod gaps	
Iodine-131	0.08
Krypton-85	0.10
Other noble gases (Krypton, Xenon)	0.05
Other Halogens (Iodine, Bromine)	0.05
Alkali Metals (Cesium, Rubidium)	0.12
Fraction of gap activity released to the refueling water	1.00
Minimum water depth above reactor vessel flange (and above the damaged fuel rods), feet	23
Refueling water decontamination factors	
Iodines (effective DF)	200
Noble Gases	1
Particulates	Infinite
Iodine composition above the refueling water, percent of iodine	
Elemental iodine	57
Organic iodide	43

FHA-IC PARAMETER	MODELED VALUE
Containment model	
Containment dome air circulators	not modeled
Engineered Safety Features Actuation System (ESFAS) - containment purge isolation signal (CPIS)	not modeled
ESFAS – containment isolation actuation signal (CIAS)	not modeled
Containment personnel airlock closure	not modeled
Containment equipment hatch closure	not modeled
Activity release duration from containment, hours	2
Containment net free volume without dome, cubic feet	1.422E+06
Containment air exhaust flow rate, ft^3/minute	82,000
Offsite dose evaluation model	per Section 4.2
Control Room dose evaluation model	per Section 4.3
FHA-IC Release Points to Control Room Atmospheric Dispersion Factors, seconds/m^3	per Section 4.4

Section 4.6.1 FHA-IC Source Term

The fuel handling accident inside containment involves the inadvertent dropping of a fuel assembly during fuel handling operations inside the reactor vessel, and the consequent rupture of fuel pins in both the dropped and impacted fuel assemblies. Consistent with RG 1.183 Appendix B Section 1.1, the number of fuel rods damaged during the accident is based on a conservative analysis that considers the most limiting case. UFSAR Section 15.10.7.3.9 details the structural evaluation of dropped fuel assembly damage. Per the UFSAR, a maximum of 226 fuel rods will fail as a result of a vertical drop of a fuel assembly on to the fuel bundles remaining in the partially loaded core. The 226 failed fuel rods represent 16 failed fuel rods in the dropped fuel assembly and 210 failed fuel rods in the impacted fuel assemblies.

Table 4.1-3 presents the fission product inventory of an average fuel rod in the reactor core. Consistent with the guidance of RG 1.183 Regulatory Position 3.1, to account for differences in power level across the core, a radial peaking factor of 1.75 is applied to the Table 4.1-3 average fuel rod isotope inventory to determine the activity inventory in each of the 226 failed fuel rods as described in Section 4.1.3. Consistent with RG 1.183 Regulatory Position 3.1, the FHA-IC dose analysis models 72 hours of radioactive decay prior to the event, which is consistent with the minimum decay time required by SONGS Units 2 and 3 LCS 3.9.101 prior to movement of irradiated fuel in the reactor vessel.

Consistent with RG 1.183 Appendix B Section 1.2, the fission product release from the breached fuel is based on RG 1.183 Regulatory Position 3.2. Consistent with RG 1.183 Footnote 11, the release fractions are acceptable for use since the fuel has a peak burnup of less than 62,000 MWD/MTU, and a

maximum linear heat generation rate that does not exceed 6.3 kw/ft peak rod average power for burnups exceeding 54 GWD/MTU.

All gap activity in the damaged rods is instantaneously released into the refueling water. Radionuclides that are considered are xenons, kryptons, iodines, bromines, cesiums, and rubidiums. Cesium and rubidium are particulates that are retained in the refueling pool water; therefore, these radionuclides do not contribute to the FHA doses.

Consistent with RG 1.183 Appendix B Section 1.3, the chemical form of radioiodine released from the fuel to the refueling water is assumed to be 95 percent cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. The CsI released from the fuel is assumed to completely dissociate in the refueling water and instantaneously re-evolve as elemental iodine. Consequently, the chemical form of radioiodine in the refueling water, prior to application of a decontamination factor, is 99.85 percent elemental iodine and 0.15 percent organic iodide.

Per Units 2 and 3 Technical Specification LCO 3.9.6, during movement of irradiated fuel assemblies within containment, the refueling water level above the top of the reactor vessel flange shall be greater than or equal to 23 feet. Since the damaged fuel assemblies would be lower than the reactor vessel flange, the water depth above the damaged fuel would be greater than 23 feet. Consistent with RG 1.183 Appendix B Section 2, the 23 foot water depth requirement allows for an overall effective decontamination factor of 200 (i.e., 99.5% of the total iodine released from the damaged rods is retained by the water). The difference in decontamination factors for elemental (99.85%) and organic iodine (0.15%) species results in the iodine above the water being composed of 57% elemental and 43% organic species.

Consistent with RG 1.183 Appendix B Section 3, the retention of noble gases in the refueling water is negligible (i.e., decontamination factor of 1). Particulate radionuclides are assumed to be retained by the refueling water (i.e., infinite decontamination factor).

Section 4.6.2 FHA-IC Activity Release Model

Per SONGS Units 2 and 3 TS LCO 3.9.3, the containment personnel airlock may, under certain conditions be open during core alterations and movement of irradiated fuel in containment. In addition, SONGS Units 2 and 3 have submitted license amendment request PCN-534 that will allow the containment equipment hatch to be open during Mode 6 core alterations and movement of irradiated fuel in containment. Consistent with RG 1.183 Appendix B Section 5.3, since the containment may be open during fuel handling operations, the radioactive material that escapes from the refueling water to the containment is assumed to

be released to the environment over a 2-hour time period (i.e., containment closure is not modeled during the FHA-IC event).

Consistent with the 2-hour release model requirement, the FHA-IC AST dose analysis does not model the generation of an Engineered Safety Features Actuation System (ESFAS) containment purge isolation signal (CPIS) or containment isolation actuation signal (CIAS). The containment purge is assumed to remain operational throughout the FHA-IC event. The containment personnel airlock and the containment equipment hatch are assumed to remain open throughout the FHA-IC event.

The containment air volume dilutes the gaseous activity released from the damaged fuel rods. During Mode 6 refueling operations there is no SONGS Units 2 and 3 TS requirement for the containment dome air circulators or containment cooling train fans to be operable. Therefore, no credit is taken for activity dilution within the air of the containment dome space.

The FHA-IC AST dose analysis does not model a reduction in the amount of radioactive material available for release from the containment by any containment engineered safety feature. In addition, airborne activity removal by containment purge filters is not credited.

The release of activity to the environment within the required 2-hour time period is established by specifying a containment air exhaust flow rate that ensures that at least 99.9 percent of the airborne activity will be released to the environment.

Activity released during the FHA-IC event is transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. Activity may be released to the environment via the containment purge system or as leakage through containment penetrations, including the containment personnel airlock or the containment equipment hatch. Leakage from the containment personnel airlock would be exhausted via the main plant vent. Table 4.6-2 presents the San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors for these release pathways as discussed in Section 4.4. Since one set of atmospheric dispersion factors does not consistently yield less dispersion than the others over time, a composite maximum of the three release points is utilized for assessing control room dose consequences. No credit is taken for radioactive decay of the isotopes during atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

TABLE 4.6-2: FHA-IC CR ATMOSPHERIC DISPERSION FACTORS

FHA-IC to CR 95th Percentile Atmospheric Dispersion Factors (seconds/m^3)				
Time Interval	Containment Shell Release Point	Equipment Hatch Release Point	Plant Vent Stack Release Point	Modeled Value
0 to 2 hours	~~9.94E-04~~ 1.01E-03	~~7.99E-04~~ 8.01E-04	~~1.14E-03~~ 1.15E-03	~~1.14E-03~~ 1.15E-03
2 to 8 hours	~~6.32E-04~~ 6.41E-04	~~6.30E-04~~ 6.35E-04	~~6.11E-04~~ 6.23E-04	~~6.32E-04~~ 6.41E-04
8 to 24 hours	1.77E-04	~~1.77E-04~~ 1.78E-04	~~2.10E-04~~ 2.14E-04	~~2.10E-04~~ 2.14E-04
1 to 4 days	~~2.34E-04~~ 2.36E-04	2.23E-04	~~2.20E-04~~ 2.22E-04	~~2.34E-04~~ 2.36E-04
4 to 30 days	~~2.18E-04~~ 2.20E-04	2.03E-04	~~1.98E-04~~ 2.02E-04	~~2.18E-04~~ 2.20E-04

Section 4.6.3 FHA-IC EAB and LPZ Model

Regulatory Guide 1.183 Regulatory Position 4.1 provides guidance to be used in determining the TEDE for persons located at or beyond the boundary of the exclusion area, including the outer boundary of the low population zone. Section 4.2 of this license amendment request addresses the applicability of this guidance to the SONGS Units 2 and 3 AST FHA-IC dose analysis as it relates to the offsite dose exposure parameters.

As discussed in Section 4.2, the FHA-IC dose analysis considers the dose consequences of inhalation and immersion. Radioactive material in the containment is assumed to be a negligible radiation shine source to the offsite dose receptors relative to the dose associated with immersion in the radioactive plume released from the facility.

Consistent with RG 1.183 Regulatory Positions 4.1.5, 4.1.6 and 4.4 and Table 6, the FHA-IC event radiological criterion for the EAB and for the outer boundary of the LPZ is 6.3 Rem TEDE.

Section 4.6.4 FHA-IC Control Room Model

RG 1.183 Regulatory Position 4.2 provides guidance to be used in determining the total effective dose equivalent for persons located in the control room. Section 4.3 addresses the applicability of this guidance to the SONGS Units 2 and 3 AST FHA-IC dose analysis as it relates to the control room dose exposure parameters.

The CREACUS Emergency mode of operation can be actuated either automatically following a CRIS or manually. The CRIS may be generated automatically by a SIAS or by the detection of high radioactivity concentrations in the control room outside air inflow. Per Section 4.3.2.1.1, the FHA-IC model credits CREACUS Emergency Mode of operation initiation 3 minutes following

the start of the event, due to detection of high radioactivity concentrations in the control room outside air inflow.

As discussed in Section 4.3, the FHA-IC dose analysis considers the dose consequences of inhalation, immersion, and radiation shine from the environmental (or outside) cloud, the control room emergency HVAC filters, and the containment building.

Consistent with RG 1.183 Regulatory Position 4.4, as an AST dose analysis acceptance criterion the postulated control room dose is evaluated to ensure that that it does not exceed the 5 Rem TEDE criterion established in 10 CFR 50.67.

Section 4.6.5 FHA-IC Dose Consequences

The resulting FHA-IC offsite and control room operator doses are listed in Table 4.6-3. The analysis demonstrates that the FHA-IC event 6.3 Rem TEDE radiological criterion for the EAB and for the outer boundary of the LPZ is met. The analysis also demonstrates that the FHA-IC event 5 Rem TEDE radiological criterion for the control room is met.

TABLE 4.6-3: FHA-IC DOSE CONSEQUENCES

DOSE RECEPTOR	FHA-IC DOSE (REM TEDE)	ACCEPTANCE CRITERION (REM TEDE)
Control Room (30-day accident duration)	0.3	5
EAB (Maximum 2-hour dose -- 0.0 to 2.0 hours)	0.8	6.3
LPZ (30-day accident duration)	< 0.1	6.3

Section 4.7 FUEL HANDLING ACCIDENT INSIDE FUEL HANDLING BUILDING (FHA-FHB) ANALYSIS

Regulatory Guide 1.183 Appendix B provides assumptions for use in evaluating the radiological consequences of an FHA-FHB. These assumptions supplement the guidance provided in the main body of RG 1.183.

This Section presents the assumptions, design input, methodology employed in evaluating, and the radiological consequences of, the SONGS Units 2 and 3 FHA-FHB. The characteristics of the FHA-FHB model are summarized in Table 4.7-1.

TABLE 4.7-1: FHA-FHB ANALYSIS PARAMETERS

FHA-FHB PARAMETER	MODELED VALUE
Dose acceptance criteria, Rem TEDE	
Control Room	5
EAB	6.3
LPZ	6.3
FHA-FHB source term	
Decay time after reactor shutdown, hours	72
Average fuel rod isotope inventory at 72 hours, curies/rod	per Section 4.1
Radial peaking factor applied to all failed fuel rods	1.75
Number of failed fuel rods	60
Core fission product fractions in fuel rod gaps	
Iodine-131	0.08
Krypton-85	0.10
Other noble gases (Krypton, Xenon)	0.05
Other Halogens (Iodine, Bromine)	0.05
Alkali Metals (Cesium, Rubidium)	0.12
Fraction of gap activity released to the fuel storage pool	1.00
Minimum water depth above damaged fuel rods, feet	23
Fuel storage pool decontamination factors	
Iodines (effective DF)	200
Noble Gases	1
Particulates	infinite
Iodine composition above the fuel storage pool, percent of iodine	
Elemental iodine	57
Organic iodide	43
Fuel Handling Building model	
ESFAS - Fuel Handling [building] Isolation Signal (FHIS)	not modeled
Post-Accident Cleanup Units (PACUs)	not modeled
Activity release duration from FHB, hours	2
FHB net free volume, cubic feet	365,305
FHB air exhaust flow rate, ft^3/minute	22,000
Offsite dose evaluation model	per Section 4.2
Control Room dose evaluation model	per Section 4.3

FHA-FHB PARAMETER	MODELED VALUE
FHA-FHB Release Points to Control Room Atmospheric Dispersion Factors, $seconds/m^3$	per Section 4.4

Section 4.7.1 FHA-FHB Source Term

The FHA-FHB involves the inadvertent dropping of a fuel assembly during fuel handling operations, and the consequent rupture of fuel pins in the dropped assembly. Consistent with RG 1.183 Appendix B Section 1.1, the number of fuel rods damaged during the accident is based on a conservative analysis that considers the most limiting case. UFSAR Section 15.7.3.4.2.2 details the structural evaluation of dropped fuel assembly damage. Per the UFSAR, a maximum of 60 fuel rods will fail as a result of a fuel assembly drop in the spent fuel pool.

Table 4.1-3 presents the fission product inventory of an average fuel rod in the reactor core. Consistent with the guidance of RG 1.183 Regulatory Position 3.1, to account for differences in power level across the core, a radial peaking factor of 1.75 is applied to the Table 4.1-3 average fuel rod isotope inventory to determine the activity inventory in each of the 60 failed fuel rods as described in Section 4.1.3. Consistent with RG 1.183 Regulatory Position 3.1, the FHA-FHB dose analysis models 72 hours of radioactive decay prior to the event, which is also consistent with the minimum decay time required by SONGS Units 2 and 3 LCS 3.9.101 prior to movement of irradiated fuel in the reactor vessel.

Consistent with RG 1.183 Appendix B Section 1.2, the fission product release from the breached fuel is based on RG 1.183 Regulatory Position 3.2. Consistent with RG 1.183 Footnote 11, the release fractions are acceptable for use since the fuel has a peak burnup of less than 62,000 MWD/MTU, and a maximum linear heat generation rate that does not exceed 6.3 kw/ft peak rod average power for burnups exceeding 54 GWD/MTU.

All gap activity in the damaged rods is instantaneously released into the fuel storage pool. Radionuclides that are considered are xenons, kryptons, iodines, bromines, cesiums, and rubidiums. Cesium and rubidium are particulates that are retained in the spent fuel pool water; therefore, these radionuclides do not contribute to the FHA doses.

Consistent with RG 1.183 Appendix B Section 1.3, the chemical form of radioiodine released from the fuel to the fuel storage pool is assumed to be 95 percent cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. The CsI released from the fuel is assumed to completely dissociate in the fuel storage pool water and instantaneously re-evolve as elemental iodine. Consequently, the chemical form of radioiodine in the fuel storage pool, prior to application of a decontamination factor, is 99.85 percent elemental iodine and 0.15 percent organic iodide.

Per Units 2 and 3 TS LCO 3.7.16, during movement of irradiated fuel assemblies in the fuel storage pool, the fuel storage pool water level shall be at least 23 feet over the top of the irradiated fuel assemblies seated in the storage racks. As noted in the LCO 3.7.16 Bases, there would be less than 23 feet of water above the top of a dropped single bundle laying horizontally on top of the spent fuel racks. However, as also noted in the LCO 3.7.16 Bases, when the potential of a dropped fuel assembly exists (which is when fuel is being moved) a water level is maintained that would ensure that there would be greater than 23 feet above the fuel assembly laying on top of the racks. This increased water level is required by Units 2 and 3 TS LCO 3.9.6 when the fuel storage pool is connected to the refueling cavity and by station procedures whenever fuel is being moved.

Consistent with RG 1.183 Appendix B Section 2, the 23 foot water depth requirement allows for elemental and organic iodine decontamination factors of 500 and 1, respectively, giving an overall effective decontamination factor of 200 (i.e., 99.5% of the total iodine released from the damaged rods is retained by the water). This difference in decontamination factors for elemental (99.85%) and organic iodine (0.15%) species results in the iodine above the water being composed of 57% elemental and 43% organic species.

Consistent with RG 1.183 Appendix B Section 3, the retention of noble gases in the water in the fuel storage pool is negligible (i.e., decontamination factor of 1). Particulate radionuclides are assumed to be retained by the water in the fuel storage pool (i.e., infinite decontamination factor).

Section 4.7.2 FHA-FHB Activity Release Model

Consistent with RG 1.183 Appendix B Section 4.1, the radioactive material that escapes from the fuel storage pool to the FHB is released to the environment over a 2-hour time period (i.e., FHB closure is not modeled during the FHA-FHB event).

Consistent with the 2-hour release model requirement, the FHA-FHB AST dose analysis does not model the generation of an ESFAS fuel handling [building] isolation signal (FHIS). The FHB normal ventilation exhaust is assumed to remain in operation throughout the FHA-FHB event.

The FHB air volume dilutes the gaseous activity released from the damaged fuel rods.

The FHA-FHB AST dose analysis does not model a reduction in the amount of radioactive material available for release from the FHB by the fuel handling building Post-Accident Cleanup Unit (PACU) filter system. The FHB PACU system consists of two independent, redundant trains that each consists of

charcoal and HEPA filters for the removal of airborne gaseous and particulate activity following an FHA.

The release of activity to the environment within the required 2-hour time period is established by specifying a FHB air exhaust flow rate that ensures that at least 99.9 percent of the gaseous activity will be released to the environment.

Activity released during the FHA-FHB event is transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. Activity may be released to the environment via the FHB normal ventilation exhaust system through the main plant vent, or as leakage through FHB penetrations (e.g., doors). Table 4.7-2 presents the San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors for these release pathways as discussed in Section 4.4. Since one set of atmospheric dispersion factors does not consistently yield less dispersion than the others over time, a composite maximum of the two release points is utilized for assessing control room dose consequences. No credit is taken for radioactive decay of the isotopes during atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

TABLE 4.7-2: FHA-FHB CR ATMOSPHERIC DISPERSION FACTORS

FHA-FHB to CR 95th Percentile Atmospheric Dispersion Factors (seconds/m^3)			
Time Interval	FHB Release Point	Main Plant Vent Release Point	Modeled Value
0 to 2 hours	~~9.45E-04~~9.48E-04	~~1.14E-03~~1.15E-03	~~1.14E-03~~1.15E-03
2 to 8 hours	~~7.48E-04~~7.61E-04	~~6.11E-04~~6.23E-04	~~7.48E-04~~7.61E-04
8 to 24 hours	~~1.93E-04~~1.92E-04	~~2.10E-04~~2.14E-04	~~2.10E-04~~2.14E-04
1 to 4 days	~~2.64E-04~~2.65E-04	~~2.20E-04~~2.22E-04	~~2.64E-04~~2.65E-04
4 to 30 days	2.43E-04	~~1.98E-04~~2.02E-04	2.43E-04

Section 4.7.3 FHA-FHB EAB and LPZ Model

Regulatory Guide 1.183 Regulatory Position 4.1 provides guidance to be used in determining the TEDE for persons located at or beyond the boundary of the exclusion area, including the outer boundary of the low population zone. Section 4.2 addresses the applicability of this guidance to the SONGS Units 2 and 3 AST FHA-FHB dose analysis as it relates to the offsite dose exposure parameters.

As discussed in Section 4.2, the FHA-FHB dose analysis considers the dose consequences of inhalation and immersion. Radioactive material in the FHB is assumed to be a negligible radiation shine source to the offsite dose receptors

relative to the dose associated with immersion in the radioactive plume released from the facility.

Consistent with RG 1.183 Regulatory Positions 4.1.5, 4.1.6 and 4.4 and Table 6, the FHA-FHB event radiological criterion for the EAB and for the outer boundary of the LPZ is 6.3 Rem TEDE.

Section 4.7.4 FHA-FHB Control Room Model

RG 1.183 Regulatory Position 4.2 provides guidance to be used in determining the TEDE for persons located in the control room. Section 4.3 addresses the applicability of this guidance to the SONGS Units 2 and 3 AST FHA-FHB dose analysis as it relates to the control room dose exposure parameters.

The CREACUS Emergency mode of operation can be actuated either automatically following a CRIS or manually. The CRIS may be generated automatically by a SIAS or by the detection of high radioactivity concentrations in the control room outside air inflow. Per Section 4.3.2.1.1, the FHA-FHB model credits CREACUS Emergency mode of operation initiation 3 minutes following the start of the event, due to detection of high radioactivity concentrations in the control room outside air inflow.

As discussed in Section 4.3, the FHA-FHB dose analysis considers the dose consequences of inhalation, immersion, and radiation shine from the environmental (or outside) cloud, and the control room emergency HVAC filters. Radiation shine from contaminated air in the FHB is considered negligible due to the presence of numerous intervening concrete walls and the geometric attenuation due to the distance between the FHB and the control room.

Consistent with RG 1.183 Regulatory Position 4.4, as an AST dose analysis acceptance criterion the postulated control room dose is evaluated to ensure that that it does not exceed the 5 Rem TEDE criterion established in 10 CFR 50.67.

Section 4.7.5 FHA-FHB Dose Consequences

The resulting FHA-FHB offsite and control room operator doses are listed in Table 4.7-3. The analysis demonstrates that the FHA-FHB event 6.3 Rem TEDE radiological criterion for the EAB and for the outer boundary of the LPZ is met. The analysis also demonstrates that the FHA-FHB event 5 Rem TEDE radiological criterion for the control room is met.

TABLE 4.7-3: FHA-FHB DOSE CONSEQUENCES

DOSE RECEPTOR	FHA-FHB DOSE (REM TEDE)	ACCEPTANCE CRITERION (REM TEDE)
Control Room (30-day accident duration)	< 0.1	5
EAB (Maximum 2-hour dose -- 0.0 to 2.0 hours)	0.2	6.3
LPZ (30-day accident duration)	< 0.1	6.3

Section 4.8 MAIN STEAM LINE BREAK (MSLB) ANALYSIS

RG 1.183 Appendix E provides assumptions for use in evaluating the radiological consequences of a Pressurized Water Reactor (PWR) MSLB. These assumptions supplement the guidance provided in the main body of RG 1.183.

A MSLB may occur either inside or outside containment. A steam line break inside containment will release contaminated steam via the break location to the containment air space, where it will be diluted within the containment net free air volume and then slowly leaked to the outside environment at the design basis containment leakage rate. A more severe scenario is that of a steam line break outside containment (SLB-OC) that will release contaminated steam via the break location directly to the environment. This section evaluates a SLB-OC event consistent with the guidance in RG 1.183 Appendix E.

The SONGS Units 2 and 3 CLB evaluates pre-trip and post-trip return-to-power steam line break events. The pre-trip SLB event may result in fuel failure (i.e., clad damage). The post-trip SLB event does not result in fuel failure. This section specifically evaluates a pre-trip SLB-OC event.

The transient response of the pre-trip SLB-OC event is analyzed using the CENTS computer code for the NSSS response, including mass releases and steam generator tube uncovery, and the CETOP computer code for the DNBR response.

This Section presents the assumptions, design input, methodology employed in evaluating, and the radiological consequences of, the SONGS Units 2 and 3 pre-trip SLB-OC. The characteristics of the pre-trip SLB-OC model are summarized in Table 4.8-1.

TABLE 4.8-1: PRE-TRIP SLB-OC ANALYSIS PARAMETERS

PRE-TRIP SLB-OC PARAMETER	MODELED VALUE
Dose acceptance criteria, Rem TEDE	
Control Room	5
EAB	25
LPZ	25
SLB-OC source term	
Core isotope inventory at reactor shutdown, curies	per Section 4.1
Failed Fuel (clad damage), percent of core	10
Radial peaking factor	1.75
Core fission product fractions in fuel rod gaps	
Iodine-131	0.08
Krypton-85	0.10
Other noble gases (Krypton, Xenon)	0.05
Other Halogens (Iodine, Bromine)	0.05
Alkali Metals (Cesium, Rubidium)	0.12

PRE-TRIP SLB-OC PARAMETER	MODELED VALUE
Initial Primary Coolant Activity Profile Initial Secondary Coolant Activity Profile	per Section 4.1 per Section 4.1
Dilution Volumes and Masses Reactor Coolant dilution volume, cubic feet Reactor Coolant dilution mass, grams Secondary dilution water mass, lbm	 10,179 2.015E+08 1.59E+05
Primary-to-Secondary leakage rate, gpm per Steam Generator (SG)	0.5
SG Water to Steam flashing fractions and partition coefficients SG tube uncovery period, seconds Iodine flashing factor during SG tube uncovery, percent Iodine partition coefficient Noble gases (Xe, Kr) partition coefficient Particulate isotopes partition coefficient	 0 to 6,621 20 100 1E-06 500
Steam Line Break Mass Release, lbm 0 to 16.3 seconds 16.3 seconds to shutdown cooling at 13,659 seconds	 115,103 0
Main Steam Safety Valve (MSSV) Mass Release, lbm 0 to 30 minutes 30 minutes to 2 hours 2 hours to shutdown cooling at 13,659 seconds	 47,553 555.5 0
Atmospheric Dump Valve (ADV) Mass Release, lbm 0 to 30 minutes 30 minutes to 2 hours 2 hours to shutdown cooling at 13,659 seconds	 0 374,719 356,610
Auxiliary Feedwater (AFW) Steam Turbine Mass Release, lbm 0 to 30 minutes 30 minutes to 2 hours 2 hours to shutdown cooling at 13,659 seconds	 8,078 64,522 78,944
Iodine composition released to the environment, percent of iodine Elemental iodine Organic iodide	 97 3
Offsite dose evaluation model	per Section 4.2
Control Room dose evaluation model	per Section 4.3
SLB-OC Release Points to Control Room Atmospheric Dispersion Factors, seconds/m^3	per Section 4.4

Section 4.8.1 Pre-Trip SLB-OC Source Term

The pre-trip SLB-OC transient analysis is characterized by fuel failure (i.e., clad damage). Using the current licensing basis deterministic DNBR fuel failure prediction methodology, the radiological consequences for the pre-trip SLB-OC event have been characterized by no more than 7 percent fuel failure with a Core Operating Limits Supervisory System (COLSS) Required Overpower Margin (ROPM) of 123 percent power. Application of the DNB statistical convolution methodology described in Section 4.1.4 will result in a gain in COLSS DNBR

plant operating margin of 6% (to 117% ROPM) for an equivalent amount of fuel failure as described in Table 4.8-2. The methodology used to offset predicted fuel failure with COLSS required DNBR plant operating margin is per the standard NRC approved Westinghouse methodology for Combustion Engineering digital protection plants as discussed in Section 5.5.4 of the NRC-approved SONGS Reload Analysis Methodology Topical Report SCE-9801-P-A. The pre-trip SLB-OC AST dose analysis conservatively assumes 10 percent fuel failure to bound future operating cycle fuel failure predictions.

Table 4.8-2
Typical SONGS Pre-Trip SLB-OC Fuel Failures

COLSS Required Overpower Margin (% Power)	117	119	121	123
Deterministic Fuel Failure (%)	21.7	16.0	11.3	6.4
Statistical Convolution Fuel Failure (%)	6.9	4.5	2.8	1.6

Consistent with RG 1.183 Appendix E Section 2, because more than minimal fuel damage is postulated, the pre-trip SLB-OC AST activity release model does not address primary coolant iodine spiking.

The 10 percent fuel failure estimate is applied to the reactor core fission product inventory presented in Table 4.1-3. Consistent with the guidance of RG 1.183 Regulatory Position 3.1, to account for differences in power level across the core, a radial peaking factor of 1.75 is also applied as described in Section 4.1.3.

Consistent with RG 1.183 Appendix E Section 1, the fission product release from the breached fuel is based on RG 1.183 Regulatory Position 3.2. Consistent with RG 1.183 Footnote 11, the release fractions are acceptable for use since the fuel has a peak burnup of less than 62,000 MWD/MTU, and a maximum linear heat generation rate that does not exceed 6.3 kw/ft peak rod average power for burnups exceeding 54 GWD/MTU.

Consistent with RG 1.183 Appendix E Section 3, the activity released from the fuel is instantaneously and homogeneously released into the reactor coolant system. Radionuclides that are considered are xenons, kryptons, iodines, bromines, cesiums, and rubidiums.

The initial reactor coolant concentration prior to the introduction of the fission product release from the breached fuel is assumed to be at the maximum TS LCO 3.4.16 limiting condition as specified in Section 4.1.

The AST pre-trip SLB-OC dose analysis assumes that the reactor coolant dilutes the core activity release into a volume of 10,179 cubic feet. This volume has conservatively omitted the primary side volume that is present in an assumed 2,000 plugged U-tubes in each of the two steam generators.

Consistent with RG 1.183 Appendix E Section 4, the chemical form of radioiodine released from the steam generators to the environment is 97 percent elemental and 3 percent organic.

Section 4.8.2 Pre-Trip SLB-OC Activity Release Model

Activity is introduced into the secondary side via steam generator tube leakage. Consistent with RG 1.183 Appendix E Section 5.1, the pre-trip SLB-OC AST dose analysis models a primary-to-secondary leak rate into any single steam generator of 0.5 gallon/minute consistent with the maximum leak rate allowed by TS LCO 3.4.13.

The initial secondary side activity concentration prior to the introduction of the primary-to-secondary leakage is assumed to be at the maximum TS LCO 3.7.19 limit of 0.10 μCi/gm dose equivalent Iodine-131.

Consistent with RG 1.183 Appendix E Sections 5.5.1 and 5.6, the primary-to-secondary leakage is assumed to mix with the secondary water without flashing during periods of total tube submergence. The tubes in one steam generator are uncovered from 17.3 seconds to 6,620 seconds after the break. The tubes in the other steam generator are uncovered from 17.2 seconds to 6,621 seconds after the break. The pre-trip SLB-OC AST dose analysis conservatively assumes that the tubes in both steam generators are uncovered from 0 seconds to 6,621 seconds.

Consistent with RG 1.183 Appendix E Sections 5.5.1 and 5.6, during periods where the tubes are uncovered, a portion of the primary-to-secondary leakage flashes to vapor based on the thermodynamic conditions in the reactor coolant and the secondary coolant. The maximum flashing fraction is 14.41%, which occurs at the start of the event. Conservatively, the pre-trip SLB-OC AST dose analysis models a bounding flashing fraction of 20% during periods of steam generator tube uncovery.

The portion of primary-to-secondary leakage that flashes to steam enters the steam generator steam space, with no credit taken for iodine scrubbing.

Consistent with RG 1.183 Appendix E Section 5.5.3, the unflashed portion of primary-to-secondary leakage mixes with the bulk water. Consistent with RG 1.183 Appendix E Section 5.5.4, an iodine partition coefficient (i.e., liquid concentration divided by gas concentration) of 100 is modeled when evaluating the vaporization of the secondary side water (steam generator liquid). Consistent with RG 1.183 Appendix E Section 5.4, all noble gases released from the primary coolant are released to the environment without reduction or mitigation.

The SONGS Units 2 and 3 steam generators have a maximum full-power steam generator moisture carryover (steam quality) of 0.20 percent. The pre-trip

SLB-OC AST dose analyses address this carryover by modeling a particulate isotope partition coefficient of 500 when evaluating the vaporization of the secondary side water.

Activity is released to the environment via the steam line break location, the MSSVs, the ADVs, and the AFW turbine exhaust.

Consistent with the guidance in Branch Technical Position (BTP) MEB 3-1 Section B.1.b, the SLB-OC is modeled downstream of a MSIV. A break upstream of a MSIV is not postulated since the SONGS Units 2 and 3 design complies with the BTP MEB 3-1 (ASME Section III and design stress and fatigue limit requirements) for crediting break exclusion zones.

The release through the break begins at time zero and is terminated at 16.3 seconds, the time when MSIVs are fully closed. The total mass release through the break is 104,639 lbm, consisting of inventory loss from both steam generators, and main feedwater flow for duration of 3.83 seconds. The pre-trip SLB AST dose analysis increased the break mass release predicted by the pre-trip SLB mass release analysis by 10 percent to 115,103 lbm to provide margin for any potential increased mass release that may be determined in future cycle-specific transient analysis.

The MSSV and ADV mass releases are as shown in Table 4.8-1. The pre-trip SLB AST dose analysis increased the MSSV and ADV mass release predicted by the pre-trip SLB mass release analysis by 10 percent to provide margin for any potential increased mass release that may be determined in future cycle-specific transient analysis. The MSSV mass release begins when the MSSVs open at 1,200 seconds and terminates when the MSSVs close at 1,822 seconds. The ADV mass release begins when the ADVs are opened (by operator action) at 30 minutes, and stay open for the duration of the event. The pre-trip SLB-OC AST dose analysis models the mass releases as being from the MSSV from 1,200 seconds to 1,800 seconds and from the ADVs from 1,800 seconds until the end of the event. This is conservative since, as shown in Section 4.4, the ADV atmospheric dispersion factors are greater than the MSSV atmospheric dispersion factors, thus resulting in higher doses.

The time intervals during which the steam turbine AFW pump is operating, and the mass released during those intervals, are as shown in Table 4.8-1. Two periods of AFW operation are modeled. The first is from 89 seconds to 748 seconds. The second is from 1,921 seconds to the end of the event. The pre-trip SLB AST dose analysis increased the AFW steam turbine mass release predicted by the pre-trip SLB mass release analysis by 10 percent to provide margin for any potential increased mass release that may be determined in future cycle-specific transient analysis.

The pre-trip SLB-OC event is terminated when shutdown cooling is initiated at 13,659 seconds. After this time all steam releases from both steam generators cease.

Activity released during the pre-trip SLB-OC event is transported by atmospheric dispersion to the control room HVAC intake and to the offsite EAB and LPZ dose receptors. San Onofre site-specific 95th percentile meteorology atmospheric dispersion factors for the pre-trip SLB-OC release pathways are discussed in Sections 4.2 and 4.4 for the offsite and control room dose receptors, respectively. No credit is taken for plume rise dispersion associated with the ADV release pathway. No credit is taken for radioactive decay of the isotopes during atmospheric dispersion transit to the control room or offsite dose locations. Consistent with RG 1.183 Regulatory Positions 4.1.7 and 4.2.2, no correction is made for depletion of the effluent plume by deposition on the ground.

Section 4.8.3 Pre-Trip SLB-OC EAB and LPZ Model

RG 1.183 Regulatory Position 4.1 provides guidance to be used in determining the TEDE for persons located at or beyond the boundary of the exclusion area, including the outer boundary of the low population zone. Section 4.2 of this license amendment request addresses the applicability of this guidance to the SONGS Units 2 and 3 AST pre-trip SLB-OC dose analysis as it relates to the offsite dose exposure parameters.

As discussed in Section 4.2, the pre-trip SLB-OC dose analysis considers the dose consequences of inhalation and immersion.

Consistent with RG 1.183 Regulatory Positions 4.1.5, 4.1.6 and 4.4 and Table 6, the SLB event radiological criterion for the EAB and for the outer boundary of the LPZ is 25 Rem TEDE for an event scenario with fuel damage.

Section 4.8.4 Pre-Trip SLB-OC Control Room Model

RG 1.183 Regulatory Position 4.2 provides guidance to be used in determining the TEDE for persons located in the control room. Section 4.3 of this license amendment request addresses the applicability of this guidance to the SONGS Units 2 and 3 AST pre-trip SLB-OC dose analysis as it relates to the control room dose exposure parameters.

The CREACUS Emergency mode of operation can be actuated either automatically following a CRIS or manually. The CRIS may be generated automatically by a SIAS or by the detection of high radioactivity concentrations in the control room outside air inflow. Per Section 4.3.2, the pre-trip SLB-OC model credits CREACUS Emergency mode of operation initiation 3 minutes following

the start of the event, due to detection of high radioactivity concentrations in the control room outside air inflow.

As discussed in Section 4.3, the pre-trip SLB-OC dose analysis considers the dose consequences of inhalation, immersion, and radiation shine from the environmental (or outside) cloud, and the control room emergency HVAC filters.

Consistent with RG 1.183 Regulatory Position 4.4, as an AST dose analysis acceptance criterion the postulated control room dose is evaluated to ensure that that it does not exceed the 5 Rem TEDE criterion established in 10 CFR 50.67.

Section 4.8.5 Pre-Trip SLB-OC Dose Consequences

The resulting pre-trip SLB-OC offsite and control room operator doses are listed in Table 4.8-3. The analysis demonstrates that the SLB event 25 Rem TEDE radiological criterion for the EAB and for the outer boundary of the LPZ is met. The analysis also demonstrates that the SLB event 5 Rem TEDE radiological criterion for the control room is met.

TABLE 4.8-3: PRE-TRIP SLB-OC DOSE CONSEQUENCES

DOSE RECEPTOR	PRE-TRIP SLB-OC DOSE (REM TEDE)	ACCEPTANCE CRITERION (REM TEDE)
Control Room (30-day accident duration)	~~2.1~~2.2	5
EAB (Maximum 2-hour dose -- 0.0 to 2.0 hours)	4.1	25
LPZ (30-day accident duration)	0.1	25

5.0 REGULATORY SAFETY ANALYSIS

5.1 No Significant Hazards Consideration

Southern California Edison (SCE) has evaluated whether or not a significant hazards consideration is involved with the proposed amendments by focusing on the three standards set forth in 10CFR50.92, "Issuance of Amendment," as discussed below:

1. Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No.

   The proposed changes to the Facility Operating Licenses for San Onofre Units 2 and 3 credit an Alternative Source Term (AST) for the design basis radiological site boundary and control room dose analyses. This change represents full scope implementation of the AST as described in Regulatory Guide 1.183. The proposed changes to the Facility Operating Licenses also expand the allowed use of fuel failure estimates by Departure from Nucleate Boiling (DNB) statistical convolution methodology from only the reactor coolant pump sheared shaft event to the Updated Final Safety Analysis Report (UFSAR) Chapter 15 non-Loss-of-Coolant-Accident (LOCA) events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel. The proposed changes reflect the parameters used in the radiological consequences calculations for the LOCA, Fuel Handling Accident inside containment (FHA-IC), Fuel Handling Accident in the Fuel Handling Building (FHA-FHB) and pre-trip Steam Line Break Outside Containment (SLB-OC).

   The purpose of this proposed change is to change the design requirements for the Control Room Envelope (CRE). This proposed change will allow an increase in the assumed amount of unfiltered air inleakage through the CRE. Currently, design basis radiological consequence analyses assume CRE inleakage of 0 cfm, plus an assumed 10 cubic feet per minute (cfm) inleakage due to ingress and egress into the Control Room. Analyses to support this change demonstrate acceptable post-accident dose consequences in the Control Room assuming 990 cfm of CRE inleakage (plus 10 cfm due to ingress and egress for a total of 1000 cfm).

   This proposed change does not affect the precursors for accidents or transients analyzed in Chapter 15 of the San Onofre Units 2 and 3 UFSAR. Therefore, there is no increase in the probability of accidents previously evaluated. The probability remains the same because the accident analyses performed involve no change to a system, component

or structure that affects initiating events for any UFSAR Chapter 15 accident evaluated.

A re-analysis of the UFSAR Chapter 15 LOCA, SLB-OC, FHA-IC, and FHA-FHB events was conducted with respect to radiological consequences. This re-analysis was performed in accordance with AST methodology provided in Regulatory Guide (RG) 1.183 and with ARCON96 atmospheric dispersion methodology provided in RG 1.194. The reanalysis consequences were expressed in terms of Total Effective Dose Equivalent (TEDE) dose.

Implementation of the AST methodology, as described in 10CFR50.67, specifies control room, exclusion area boundary (EAB), and low population zone (LPZ) dose acceptance criteria in terms of TEDE dose. The dose acceptance criteria for specific events are specified in RG 1.183. The revised analyses for all evaluated events meet the applicable RG 1.183 TEDE dose acceptance criteria for AST implementation.

The previous dose calculations analyzed the dose consequences to thyroid and whole body as a result of postulated design basis events. The previous control room dose calculations were shown to be within the regulatory limits of 10CFR50 Appendix A General Design Criterion 19 with respect to thyroid, beta-skin and whole body dose. The previous LOCA and SLB offsite dose calculations were shown to be within the regulatory limits of 10CFR100.11 with respect to thyroid and whole body dose. The previous FHA-IC and FHA-FHB offsite dose calculations were shown to be well within (i.e., less than 25 percent of) the regulatory limits of 10CFR100.11 with respect to thyroid and whole body dose.

RG 1.183 Footnote 7 provides a means to compare the thyroid and whole body dose results of the previous calculations with the TEDE results of the AST calculations. This methodology requires multiplying the previous thyroid dose by 0.03 and adding the product to the previous whole body dose. The resultant "effective" TEDE is then compared to the AST TEDE result. This comparison is presented in Table 5-1.

The Table 5-1 comparison shows a decrease in dose consequences when evaluated using AST methodology for all but the LOCA offsite dose receptors. The LOCA EAB dose using AST methodology has increased due to the requirement to calculate the maximum 2-hour window EAB dose versus the previous requirement to calculate the 0 to 2 hour window EAB dose. The LOCA LPZ dose using AST methodology has increased primarily due to changes in the AST Refueling Water Storage Tank (RWST) iodine transport model. Although the LOCA EAB and LPZ doses using AST methodology have increased, they remain significantly below the 25 Rem TEDE offsite dose acceptance criterion.

Table 5-1 – Comparison of Previous and AST Doses		
Event – Dose Receptor	**"Effective" TEDE of Previous Dose Analyses (Rem)**	**AST TEDE (Rem)**
FHA-IC		
Control Room	1.0	2.7 E-01
EAB	2.0	8.0 E-01
LPZ	5.6 E-02	2.3 E-02
FHA-FHB		
Control Room	3.7 E-01	7.3 E-02
EAB	6.6 E-01	2.1 E-01
LPZ	1.9 E-02	6.1 E-03
LOCA		
Control Room	4.5	~~2.7~~2.8
EAB	3.7	~~5.1~~5.2
LPZ	1.2	~~1.8~~1.9
SLB-OC		
Control Room	Not evaluated	~~2.1~~2.2
EAB	8.0	4.1
LPZ	Not evaluated	0.1

The proposed changes do not increase the probability of an accident previously evaluated. The proposed changes result in dose consequences that, if compared to previous ones, are in most cases decreased and in other cases only slightly increased (using guidance in footnote 7 of RG 1.183). However, the dose consequences of the revised analyses are below the AST regulatory acceptance criteria.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of any accident previously evaluated.

2. Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

The implementation of this proposed change does not create the possibility of an accident of a different type than was previously evaluated in the UFSAR. The proposed change credits the AST for the design basis radiological site boundary and control room dose analyses and expands the allowed use of fuel failure estimates by DNB statistical convolution methodology from only the reactor coolant pump sheared shaft event to the UFSAR Chapter 15 non-LOCA events that assume a loss of flow (i.e., a loss of AC power) and that fail fuel.

The changes proposed do not change how Design Basis Accident (DBA) events were postulated nor do the changes themselves initiate a new kind of accident with a unique set of conditions. The changes proposed are based on a re-analysis of offsite and control room doses for four design basis accidents. The revised analyses are consistent with the regulatory guidance established in RG 1.183. The revised analyses utilize the most current understanding of source term timing and chemical forms. Through this re-analysis, no new accident initiator or failure mode was identified.

Therefore, this proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed change involve a significant reduction in a margin of safety?

Response: No.

The implementation of this proposed amendment does not reduce the margin of safety. The alternative source term radiological dose consequence analyses utilize the regulatory acceptance criteria of 10 CFR 50 Appendix A General Design Criterion (GDC) 19 and 10 CFR 50.67, as specified in RG 1.183. These acceptance criteria have been developed for the purpose of use in design basis accident analyses such that meeting these limits demonstrates adequate protection of public health and safety. An acceptable margin of safety is inherent in these licensing limits. The radiological analyses results remain within these regulatory acceptance criteria.

Therefore, there is no significant reduction in the margin of safety as a result of the proposed amendment.

Based on the above, SCE concludes that the proposed amendments present no significant hazards consideration under the standards set forth in 10CFR50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified.

5.2 Applicable Regulatory Requirements/Criteria

<u>GDC 19</u>

Control Room – A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration

of the accident. Equipment at appropriate locations outside the control room shall be provided (1) with a design capability for prompt hot shutdown of the reactor, including necessary instrumentation and controls to maintain the unit in a safe condition during hot shutdown, and (2) with a potential capability for subsequent cold shutdown of the reactor through use of suitable procedures. Applicants for and holders of construction permits and operating licenses under this part who apply on or after January 10, 1997, applicants for design certifications under part 52 of this chapter who apply on or after January 10, 1997, applicants for and holders of combined licenses under part 52 of this chapter who do not reference a standard design certification, or holders of operating licenses using an alternative source term under §50.67 shall meet the requirements of this criterion, except that with regard to control room access and occupancy, adequate radiation protection shall be provided to ensure that radiation exposures shall not exceed 0.05 Sv (5 rem) total effective dose equivalent (TEDE) as defined in §50.2 for the duration of the accident.

10CFR50, Appendix A, General Design Criterion 19 requires that the control room be designed such that the radiological dose to the operators following a design basis accident be less than 5 rem whole body, or its equivalent to any part of the body.

GDC-19 is the current licensing basis for the San Onofre Units 2 and 3 control room. Radiological consequences of design basis accidents are currently shown to be less than the criterion of 5 rem whole body, or its equivalent to any part of the body. Following approval of this license amendment request, the provisions of GDC-19 will continue to apply to San Onofre Units 2 and 3 except that with regard to control room access and occupancy, adequate radiation protection shall be provided to ensure that radiation exposures shall not exceed 0.05 Sv (5 rem) total effective dose equivalent (TEDE) as defined in §50.2 for the duration of the accident.

<u>10CFR100.11(a)</u>

...(1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.
(2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure....

Paragraphs (a)(1) and (a)(2) of 10CFR100.11 describe the current accident analysis dose acceptance criteria for the exclusion area boundary and the low population zone for San Onofre Units 2 and 3. Following approval of this license amendment request, the dose acceptance criteria for the exclusion area boundary and low population zone will be the 25 rem TEDE criteria specified by 10CFR50.67.

10CFR50.67

> (a) Applicability. The requirements of this section apply to all holders of operating licenses issued prior to January 10, 1997, and holders of renewed licenses under part 54 of this chapter whose initial operating license was issued prior to January 10, 1997, who seek to revise the current accident source term used in their design basis radiological analyses.
> (b) Requirements. (1) A licensee who seeks to revise its current accident source term in design basis radiological consequence analyses shall apply for a license amendment under §50.90. The application shall contain an evaluation of the consequences of applicable design basis accidents previously analyzed in the safety analysis report.
> (2) The NRC may issue the amendment only if the applicant's analysis demonstrates with reasonable assurance that:
> (i) An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE).
> (ii) An individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE).
> (iii) Adequate radiation protection is provided to permit access to and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 0.05 Sv (5 rem) total effective dose equivalent (TEDE) for the duration of the accident.

Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," provides guidance to licensees of operating power reactors on acceptable applications of alternative source terms. Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," describes methods acceptable to the NRC staff for determining atmospheric relative concentration (χ/Q) values that will be used in control room radiological habitability assessments performed in support of applications for license amendment requests. The LOCA, FHA-IC, FHA-FHB, and SLB-OC were re-analyzed consistent with the guidance of RGs 1.183 and 1.194.

Using the methods described in RG 1.183 and 1.194, the results of the new analyses for the LOCA, FHA-IC, FHA-FHB, and SLB-OC meet the criteria of 10 CFR 50.67 as shown in Table 5-2. These results demonstrate that the 10CFR50.67 dose acceptance criteria for exclusion area boundary, low population zone, and control room are met for these four events. In addition, the analysis results described in Section 4 above also show that the exclusion area boundary and low population zone dose acceptance criteria from Regulatory Guide 1.183, Table 6 are met.

Table 5-2 – Comparison of AST Doses with AST Dose Criteria

Event – Dose Receptor	AST TEDE (Rem)	AST TEDE Dose Acceptance Criteria (Rem)
FHA-IC		
Control Room	0.3	5
EAB	0.8	6.3
LPZ	< 0.1	6.3
FHA-FHB		
Control Room	< 0.1	5
EAB	0.2	6.3
LPZ	< 0.1	6.3
LOCA		
Control Room	~~2.7~~2.8	5
EAB	~~5.1~~5.2	25
LPZ	~~1.8~~1.9	25
SLB-OC		
Control Room	~~2.1~~2.2	5
EAB	4.1	25
LPZ	0.1	25

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

6.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10CFR20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational

radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10CFR51.22(c)(9). Therefore, pursuant to 10CFR51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

7.0 REFERENCES

1. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors" July 2000

2. Generic Letter 2003-01, "Control Room Habitability," dated June 12, 2003

3. Letter from A. E. Scherer (SCE) to Document Control Desk (NRC), dated September 17, 2004, Subject: Response to Generic Letter 2003-01, "Control Room Habitability" Tracer Gas Test Results, San Onofre Nuclear Generating Station Units 2 and 3

4. Letter from A. E. Scherer (SCE) to Document Control Desk (NRC), dated August 5, 2003, Subject: Response to Generic Letter 2003-01, "Control Room Habitability," San Onofre Nuclear Generating Station Units 2 and 3

5. NUREG 0737, "Post-TMI Requirements"

6. Letter from L. Raghavan (NRC) to Harold B. Ray (SCE), dated March 26, 2001, Subject: "San Onofre Nuclear Generating Station, Units 2 and 3, Issuance of Amendments on Post-Accident Sampling Program"

7. Regulatory Guide 1.195, "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactor," May 2003

8. Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," June 2003

9. NUREG/CR-6604, USNRC, April 1998. S.L. Humphreys et al., "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation"

10. K.F. Eckerman et al., "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Federal Guidance Report 11, EPA-520/1-88-020, Environmental Protection Agency, 1988

11. NUREG/CR-1413, D. C. Kocher, May 1980, "A Radionuclide Decay Data Base-Index and Summary Table"

12. K.F. Eckerman and J.C. Ryman, "External Exposure to Radionuclides in Air, Water, and Soil," Federal Guidance Report 12, EPA-402-R-93-081, Environmental Protection Agency, 1993

13. Regulatory Guide 1.197, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," May 2003

14. Regulatory Guide 1.196, "Control Room Habitability at Light-Water Nuclear Power Reactors," May 2003

15. NUREG/CR-6331, Revision 1, USNRC, May 1997, J. V. Ramsdell, Jr., and C.A. Simonen, "Atmospheric Relative Concentrations in Building Wakes"

16. NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments"

17. NUREG/CR-5966 "A Simplified Model of Aerosol Removal by Containment Sprays"

18. CENPD-183-A, "C-E Methods for Loss of Flow Analysis", June 1984 (PROPRIETARY)

ATTACHMENT A

ACRONYMS

ACRONYMS

Acronym	Meaning
ADV	Atmospheric Dump Valve
AFW	Auxiliary Feedwater
AST	Alternative Source Term
BPC	Bechtel Power Corporation
CEDE	Committed Effective Dose Equivalent
CEOG	Combustion Engineering Owner's Group
CIAS	Containment Isolation Actuation Signal
CLB	Current Licensing Basis
COLR	Core Operating Limits Report
COLSS	Core Operating Limits Supervisory System
CPIS	Containment Purge Isolation Signal
CR	Control Room
CRE	Control Room Envelope
CREACUS	Control Room Emergency Air Cleanup System
CRH	Control Room Habitability
CRIS	Control Room Isolation Signal
CSS	Containment Spray System
DACU	Dome Air Circulator Unit
DBA	Design Basis Accident
DDE	Deep Dose Equivalent
DE I-131	Dose Equivalent Iodine-131
DF	Decontamination Factor
DG	Diesel Generator
DNB	Departure from Nucleate Boiling
DNBR	Departure from Nucleate Boiling Ratio
$\bar{E}$	Average Disintegration Energy
EAB	Exclusion Area Boundary
EAC	Emergency Air Conditioner
ECCS	Emergency Core Cooling System
ECU	Emergency Cooling Unit
EDE	Effective Dose Equivalent
EPIP	Emergency Planning Implementing Procedure
EQ	Environmental Qualification
ESF	Engineered Safety Features
ESFAS	Engineered Safety Features Actuation System
EVS	Emergency Ventilation Supply
FGR	Federal Guidance Report
FHA	Fuel Handling Accident
FHA-FHB	Fuel Handling Accident in the Fuel Handling Building
FHA-IC	Fuel Handling Accident – Inside Containment

FHB	Fuel Handling Building
FHIS	Fuel Handling Isolation Signal
GL	Generic Letter
HPSI	High Pressure Safety Injection
HVAC	Heating, Ventilation, and Air-Conditioning
IMSF-SF	Increased Main Steam Flow with Single Failure
LCO	Limiting Condition for Operation
LCS	Licensee Controlled Specification
LOCA	Loss of Coolant Accident
LPSI	Low Pressure Safety Injection
LPZ	Low Population Zone
MFIV	Main Feedwater Isolation Valve
MSIV	Main Steam Isolation Valve
MSLB	Main Steam Line Break
MSSV	Main Steam Safety Valve
PACU	Post-Accident Cleanup Unit
PASS	Post-Accident Sampling System
PNNL	Pacific Northwest National Laboratory
PWR	Pressurized Water Reactor
RAS	Recirculation Actuation Signal
RG	Regulatory Guide
ROPM	Required Overpower Margin
RPF	Radial Peaking Factor
RWST	Refueling Water Storage Tank
SAFDL	Specified Acceptable Fuel Design Limit
SCE	Southern California Edison
SCP	Standard Computer Program
SIAS	Safety Injection Actuation Signal
SIS	Safety Injection System
SLB	Steam Line Break
SLB-OC	Steam Line Break – Outside Containment
SONGS	San Onofre Nuclear Generating Station
SRP	Standard Review Plan
TEDE	Total Effective Dose Equivalent
TID	Technical Information Document
TS	Technical Specification
TSP	Tri-Sodium Phosphate
UFSAR	Updated Final Safety Analysis Report

ATTACHMENT B

LIST OF REGULATORY COMMITMENTS

LIST OF REGULATORY COMMITMENTS

1. Following approval of this license amendment request, future revisions to UFSAR Chapter 15 design basis accident control room and offsite radiological consequence analyses will be performed using AST methodology.

2. Following approval of this license amendment request, the manual dose calculation methodology as described in Emergency Planning Implementation Procedures (EPIPs) and other Emergency Planning guidance documents will be revised to reflect AST methodology.

3. Raddose V dose assessment software will be evaluated by June 30, 2005, to determine what specific changes may be warranted in order to maintain consistency with the manual dose assessment calculation methodology.

4. Following approval of this license amendment request, future revisions to Accident Monitoring setpoint calculations will reflect the AST source term.

5. Following approval of this license amendment request, SCE will provide the revised UFSAR sections to the NRC as part of its normal UFSAR update required by 10 CFR 50.71(e).