

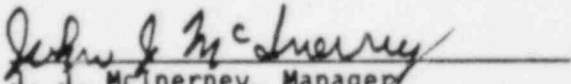
WCAP-10975

SPRAY ADDITIVE TANK DELETION  
ANALYSIS FOR THE SAN ONOFRE  
NUCLEAR GENERATING STATION  
UNITS 2 AND 3

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## TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1.0	INTRODUCTION SUMMARY AND CONCLUSIONS	1-1
1.1	Introduction	1-1
1.1.1	Background	1-1
1.1.2	Objectives	1-2
1.2	Summary of SAT Deletion Analysis	1-3
1.3	Conclusions	1-4
2.0	SPRAY COVERAGE AND DEPOSITION SURFACE EVALUATION	2-1
2.1	Selection of Surface Information	2-1
2.2	Development of Deposition Surface Data	2-1
2.3	Final Surface Areas Considered for Elemental Radioiodine Removal	2-1
3.0	EVALUATION OF THE USE OF TRISODIUM PHOSPHATE (TSP)	3-1
3.1	Development of pH Curves with Varying Amounts of TSP and Boron	3-1
3.2	Determination of TSP Quantities Required	3-1
3.3	Selection and Justification of the Long Term Sump Solution pH	3-4
3.4	Factors Affecting Adsorption and Desorption of Iodine	3-6
4.0	DEVELOPMENT OF RADIOIODINE REMOVAL COEFFICIENTS AND DECONTAMINATION FACTORS	4-1
4.1	Elemental Iodine Spray Removal	4-1
4.2	Particulate Iodine Spray Removal	4-2
4.3	Elemental Iodine Deposition Removal	4-3
4.4	Iodine Retention Limits in Sump Solution	4-4

WESTINGHOUSE PROPRIETARY CLASS 3

TABLE OF CONTENTS  
(Continued)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
5.0	DOSE ANALYSES	5-1
5.1	Original Dose Analysis Consistency Verification	5-1
5.2	Conservative Dose Analysis with SAT Deletion	5-1
5.3	Identification of Conservatisms	5-1
5.4	Modified Dose Analysis	5-2
6.0	EFFECTS OF REVISED CONDITIONS ON HYDROGEN GENERATION AND EQUIPMENT QUALIFICATION	6-1
6.1	Effects on Hydrogen Production From Zinc and Aluminum Corrosion	6-1
6.2	Equipment Qualification	6-3
7.0	TECHNICAL SPECIFICATIONS	7-i
7.1	Description of Proposed Changes	7-1
7.2	Safety Analysis	7-2
7.3	Safety and Significant Hazards Determination	7-4
7.4	Proposed Specifications	7-4
8.0	REFERENCES	8-1
APPENDIX A	PARAMETERS AND INFORMATION USED IN SONGS 2 & 3 SAT DELETION ANALYSIS	A-1

## LIST OF TABLES

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
2-1	Spray and Deposition Surface Areas	2-3
2-2	Summary of Spray and Deposition Surface Areas	2-13
2-3	Modified Spray and Deposition Surface Areas	2-14
5-1	Parameters Used in Dose Analyses	5-4
5-2	Post-LOCA Thyroid Doses Due to Containment Leakage (REM)	5-9
7.1	Calculated Thyroid Dose (REM)	7-6

## LIST OF FIGURES

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
3-1	Adjustment of Boric Acid Solution pH With TSP	3-8
6-1	Hydrogen Generation (By Source) and Removal Analysis - Post LOCA	6-5
6-2	Hydrogen Production Rate Constants for Zinc Corrosion	6-6

1.0 INTRODUCTION, SUMMARY AND CONCLUSIONS

1.1 Introduction

The Spray Additive Tank (SAT), which contains 40 to 44 weight percent sodium hydroxide has been a source of annoyance since its incorporation into nuclear power plants for control of radioiodine and pH in the post-Loss of Coolant Accident (LOCA) environment. Performing the SAT related tests and maintenance required by the Technical Specifications is a resource drain, and handling of sodium hydroxide requires special precautions due to its hazardous nature. There have been cases of sodium hydroxide contamination of ion exchange resins which necessitated their replacement, and SAT dilution resulting in Technical Specification violations. In addition, SAT discharge valves that were inadvertently left closed following maintenance have resulted in Nuclear Regulatory Commission (NRC) enforcement actions and fines.

This report describes the analyses and evaluations which were performed to demonstrate that elimination of the spray additive results in relatively minor impact to the radiological consequences of a postulated loss of coolant accident and that the doses are within the 10CFR100 guidelines.

1.1.1 Background

Historically, following a design-basis LOCA, caustic containment spray (pH 8.5 to 10.5) was needed to meet the offsite dose guidelines of 10CFR100 due to the conservative assumptions and methodologies used by the NRC to calculate offsite thyroid doses.

Analyses performed by Westinghouse utilizing recent changes in NRC methodology (Standard Review Plan 6.5.2, Rev. 1) (Reference 1), combined with knowledge gained from recent studies on the behavior of iodine in the post-LOCA environment, have demonstrated the relatively minor role of the spray additive in meeting the dose guidelines of 10CFR100.

The removal of the SAT introduces the need for adjusting the pH of the Emergency Core Cooling System (ECCS) solution. To minimize chloride-induced stress corrosion cracking of austenitic stainless steel components and to minimize the hydrogen produced by the corrosion of galvanized surfaces and zinc-based paints, the long-term pH of the ECCS solution should be in the range of 7.0 to 9.5. Since the pH of the boric acid ECCS solution, without spray additive, will be approximately 4.0, baskets containing trisodium phosphate will be added to the containment to raise the ECCS pH into the required range.

The SAT removal analysis for the San Onofre Nuclear Generating Station (SONGS) Units 2 & 3 will not take credit for a change in the iodine source term. The need for basic pH containment spray for fission product control was based on the following assumptions: iodine removal capability of the spray is enhanced at pH values greater than 8.0 and gaseous elemental iodine is the dominant species released from the reactor core (as stated in TID-14844) (Reference 2). While a considerable number of iodine-behavior studies indicate that the form of iodine will be non-volatile iodides, this SAT deletion analysis for SONGS 2 & 3 will be based upon the "TID" source terms.

#### 1.1.2 Objectives

The prime objective of this analysis is to provide justification, and obtain NRC concurrence, that the spray additive and therefore the spray additive tank is not required.

Supporting objectives to meeting this primary objective are as follows:

1. Evaluate the use of trisodium phosphate (TSP) for post-accident long term pH control of the ECCS recirculation water.
2. Evaluate the potential for chloride induced stress corrosion cracking.

3. Perform dose analyses to demonstrate the minor effects of SAT deletion on the radiological consequences of postulated accident conditions.
4. Determine the impact of SAT deletion on hydrogen generation and equipment qualification.
5. Determine the necessary changes to the FSAR descriptions and technical specifications to reflect the removal of the spray additive.

#### 1.2 Summary of SAT Deletion Analysis

The SAT Deletion Analysis began with the gathering of general information and specific parameters relevant to the analysis. Most of the information was obtained from the updated SONGS 2 & 3 Final Safety Analysis Report (FSAR) (Reference 3). This information is presented in Appendix A.

[ ]<sup>(a,c)</sup> The spray coverage was taken to be 80.6 percent of the containment volume as stated in the FSAR. [ ]

] <sup>(a,c)</sup>

An evaluation of the use of TSP for long term pH control of the ECCS recirculation solution was then performed. Selection and justification of the long term sump solution pH was determined and with information on appropriate tank volumes, boric acid concentrations and TSP titration curves, the TSP requirements were calculated.



[

] (a,c) These removal terms contained many conservatisms. Using these calculated coefficients, along with other necessary parameters, a conservative dose analysis was performed. The resulting doses were near those originally presented in the FSAR. Some of the conservatisms were then removed and a modified dose analysis was performed with resulting doses being lower than the FSAR values.

To complete the analysis, an evaluation was made of the effects of the revised conditions on hydrogen generation and equipment qualifications and the necessary changes to the plant technical specifications were determined.

### 1.3 Conclusions

The fundamental conclusion from this analysis is that the spray additive tank can be removed from the SONGS Units 2 & 3 without significantly affecting the radiological consequences of a postulated LOCA and the calculated doses will remain within the 10CFR100 guidelines. Additional conclusions are:

1. TSP is a good candidate for long term pH control in the ECCS recirculation solution.

2. [

] (a,c)

3. [

] (a,c)

2.0 SPRAY COVERAGE AND DEPOSITION SURFACE EVALUATION

2.1 Selection of Surface Information

[

](a,c)

2.2 Development of Deposition Surface Data

[

](a,c)

2.3 Final Surface Areas Considered for Elemental Radioiodine Removal

[

](a,c)

[

](a,c)

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 1 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		(a.c)	Uncertainty In Area (%)
			Total (Nom.)			
Containment Building						
Liner Plate	Carbon Steel	Zinc Base	81,070**			± 1
Hatches	Carbon Steel	Zinc Base	460			± 2
Locks	Carbon Steel	Zinc Base	160			± 2
Internal Structures						
Steam Generator Compartment Walls	Concrete	Epoxy	34,586			± 3
Steam Generator Compartment Wall Embeds	Carbon Steel	Zinc Base	6,914			± 10
Refueling Canal Walls Below EL 63.5 Ft.	Concrete	Epoxy	11,050			± 2
Refueling Canal Walls Above 63.5 Ft.	Concrete	Epoxy	5,500			± 2
Refueling Canal Liner Plate	Stainless Steel	None	9,200			± 2
Reactor Head Laydown Area Liner Plate	Stainless Steel	None	288			± 5
Other Interior Walls	Concrete	Epoxy	1,890			± 5

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 2 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		Uncertainty In Area (%)
			Total (Nom.)	(a,c)	
Floors Slabs (Other than basemats)	Concrete	Epoxy	17,480		± 5
Floor Slab Decking	Carbon Steel	Zinc Base	23,240		± 5
Steam Generator Pedestals	Concrete	Epoxy	1,210		± 5
Lifting Devices					
Internals Lifting Rig	Stainless Steel	None	1,368		+10 - 0
Fuel Transfer Uprighter System	Stainless Steel	None	205		±10
Refueling Machine & CEA Change Mechanism	Carbon Steel	Zinc Base	2,345		±10
Vessel Head Lifting	Carbon Steel	Zinc Base	1,913		+35 - 5
Polar Crane	Carbon Steel	Zinc Base	52,636		± 5
Maintenance Crane	Carbon Steel	Zinc Base	392		± 5
Supports					
Reactor Vessel Supports	Carbon Steel	Zinc Base	101		+35 - 5
Reactor Vessel Head Cable Tray Supports	Carbon Steel	Zinc Base	5,878		±10

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 3 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		(a.c)	Uncertainty In Area (%)
			Total (Nom.)			
Steam Generator Supports	Carbon Steel	Zinc Base	415			±10
Pressurizer Supports	Carbon Steel	Zinc Base	976			±10
Reactor Coolant Pump Supports	Carbon Steel	Zinc Base	6,600			±10
Safety Injection Tank Supports	Carbon Steel	Zinc Base	611			± 5
Quench Tank Supports	Carbon Steel	Zinc Base	746			± 5
Reactor Coolant Drain Tank Supports	Carbon Steel	Zinc Base	115			± 5
Fan Cooler Supports	Carbon Steel	Zinc Base	910			± 2
Structural Members (Exposed)	Carbon Steel	Zinc Base	87,428			±10
Storage Racks						
Stud Storage	Carbon Steel	Zinc Base	25			±10
Gratings, Ladders, Etc.						
Ladders, Stairways and Railings	Carbon Steel	Zinc Base	2,855			± 7

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 4 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		Uncertainty In Area (%)	
			Total (Nom.)	(a,c)		
Grating, Heavy Duty	Carbon Steel	Zinc Base	34,046		± 5	
Grating, Lightweight	Carbon Steel	Zinc Base	5,554		±10	
Emergency Sump Covers, Grating, Trash Rack, Etc.						
Top Deck	Carbon Steel	Zinc Base	520		±10	
Trash Rack	Carbon Steel	Zinc Base	260		±10	
Coarse Screen	Stainless Steel	None	314		±10	
Fine Screen	Stainless Steel	None	314		±10	
Electrical Equipment						
Cable Termination Enclosure	Carbon Steel	Zinc Base	2,312		+18 - 0	
Cable Trays	Galv. Steel	Zinc	15,716		+10 - 5	
Cable Tray Hangers	Galv. Steel	Zinc	19,710		+10 - 5	
Junction Boxes	Galv. Steel	Zinc	329		+25 - 5	
Pull Boxes	Galv. Steel	Zinc	1,147		+25 - 5	
Metal Part of Lighting Fixtures	Carbon Steel	Zinc Base	458		+10 - 0	

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 5 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		Uncertainty In Area (%)
			Total (Nom.)	(a,c)	
Glass Part of Lighting Fixtures	Glass	None	264		+10 - 0
Cables (Copper Sheathed)	Copper	None	2,596		+10 - 0
Cable Support Frame	Carbon Steel	Zinc Base	2,048		+15 - 0
Cable Bulk Head Connector Plate	Carbon Steel	Zinc Base	146		+ 5 - 0
Cable Junction Boxes	Galv. Steel	Zinc	44		+ 5 - 0
Flexible Conduits & Connectors	Stainless Steel	None	5,036		+ 5 - 0
Conduit Supports	Galv. Steel	Zinc	3,790		+20 -10
Conduits	Galv. Steel	Zinc	6,054		+20 -10
Conduit Clamps	Galv. Steel	Zinc	17		± 5
Cables	Polyethylene	None	15,163		+35 - 0
MI Cables	SS-Copper	None	825		+20 - 0
Instrument Insert Plates	Carbon Steel	Zinc Base	56		+10
Instrument Mounting Plates	Carbon Steel	Zinc Base	200		+10



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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 6 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		(a,c)	Uncertainty In Area (%)	
			Total (Nom.)				
Instruments	Carbon Steel	Zinc Base	104			+10	
Instruments	Stainless Steel	None	30			+10	
Instrument Sensing Lines	Stainless Steel	None	149			+10	
Piping Support Equipment							
Pipe Supports	Carbon Steel	Zinc Base	15,525				+10
Pipe Restraints	Carbon Steel	Zinc Base	2,200				+75
Pipe Support Embedment Plates	Carbon Steel	Zinc Base	1,565				+10
Piping Penetrations	Stainless Steel	None	406				± 0
Piping Penetrations	Carbon Steel	Zinc Base	406				± 0
Piping Penetration Sleeves	Carbon Steel	Zinc Base	156				± 5
Components							
Reactor Coolant Pump Motors	Carbon Steel	Zinc Base	3,720				+15
Hydrogen Recombiners	Stainless Steel	None	180				+25 - 0

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 7 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		(a,c)	Uncertainty In Area (%)
			Total (Nom.)			
Fan Coolers, Normal	Carbon Steel	Zinc Base	3,506			± 0
Fan Coolers, Emergency	Carbon Steel	Zinc Base	2,826			± 0
Reactor Cavity Cooling Units	Carbon Steel	Zinc Base	170			± 0
CEDM Cooling Units	Carbon Steel	Zinc Base	2,968			± 0
Piping Penetration Sleeves	Carbon Steel	Zinc Base	2,619			±10
Air Filtration Units	Carbon Steel	Zinc Base	1,194			± 0
Dome Circulators	Carbon Steel	Zinc Base	380			± 0
Safety Injection Tanks						
Shell	Carbon Steel	Zinc Base	890			± 5
Head	Carbon Steel	Zinc Base	218			± 5
Quench Tank						
Shell	Stainless Steel	None	190			± 5
Head	Stainless Steel	None	70			± 5
Reactor Coolant Drain Tank	Stainless Steel	None	325			± 0

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 8 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		Uncertainty In Area (%)
			Total (Nom.)	(a,c)	
Reactor Coolant Drain Tank Pumps	Stainless Steel	None	22		± 0
Uninsulated, Cold-Fluid-Filled Piping and Fittings					
Component Cooling Water System	Carbon Steel	Zinc Base	3,734		±10
Nuclear Service Water System	Stainless Steel	None	274		±10
Fire Protection System	Carbon Steel	Zinc Base	627		±10
Nitrogen System	Stainless Steel	None	274		±10
Containment Spray System	Carbon Steel	Zinc Base	925		± 2
Safety Injection System	Stainless Steel	None	240		± 2
Volume Control System	Stainless Steel	None	8		± 2

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 9 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		(a,c)	Uncertainty In Area (%)	
			Total (Nom.)				
Fuel Pool Cooling System	Stainless Steel	None	230			± 2	
Uninsulated Gas Filled or Drained Pipe and Fittings							
Containment Spray System	Stainless Steel	None	925			± 2	
Instrument Air System	Stainless Steel	None	112			± 2	
Service Air System	Carbon Steel	Zinc Base	178			± 2	
Gaseous Radwaste System	Stainless Steel	None	77			± 2	
HVAC							
Ducting and Dampers	Carbon Steel	Zinc Base	10,223				± 2
Ducting and Dampers	Stainless Steel	None	11,131				± 2

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TABLE 2-1

SPRAY AND DEPOSITION SURFACE AREAS (Sheet 10 of 10)

REFERENCE: SONGS 2 & 3 FSAR TABLE 6.2-14

Item	Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		Uncertainty In Area (%)
			Total (Nom.)	(a,c)	
Reactivity Cavity Ventilator Tunnel Liners	Carbon Steel	Zinc Base	3,023		± 2
Duct Support Steel	Carbon Steel	Zinc Base	3,956		±10
Insulation Canning Plate					
Main Steam Piping	Stainless Steel	None	3,700		± 5
Main Feedwater Piping	Stainless Steel	None	2,500		± 5
Reactor Coolant Piping	Stainless Steel	None	2,400		± 5
Steam Generators	Stainless Steel	None	8,800		± 5
Reactor Coolant Pumps	Stainless Steel	None	1,290		± 5
Pressurizer	Stainless Steel	None	1,190		± 5

\*For conservatism, to account for area uncertainties, minimum values are used

\*\*Conservative estimate of containment area: 65% above operating deck (sprayed), 20% below operating deck (unsprayed), and 15% in the flooded region.

1  
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TABLE 2-2

SUMMARY OF SPRAY AND DEPOSITION SURFACE AREAS

(BASED ON SONGS 2 & 3 FSAR TABLE 6.2-14)

Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )		(a,c)
		Total (Nom.)		
Carbon Steel	Zinc Base Paint	382,503		
Concrete	Epoxy	71,716		
Stainless Steel	None	51,248		
Galvanized Steel	Zinc	46,807		
Glass	None	264		
Copper	None	2,596		
Polyethylene	None	15,163		
SS-Copper	None	825		
		571,122		

\*For conservatism, to account for area uncertainties, minimum values are used.

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TABLE 2-3

MODIFIED SPRAY AND DEPOSITION SURFACE AREAS  
(FOR CALCULATION OF IODINE DEPOSITION LAMBDA)

Material	Assumed Coating	Surface Area (Ft <sup>2</sup> )	(a,c)
Carbon Steel and Galvanized Steel	Zinc Base		
Concrete and Carbon Steel	Epoxy		
Stainless Steel	None		

\*For conservatism, to account for area uncertainties, minimum values are used.

## 3.0 EVALUATION OF THE USE OF TRISODIUM PHOSPHATE (TSP)

## 3.1 Development of pH Curves with Varying Amounts of TSP and Boron

Titration curves for TSP in boric acid solution (supplied by SCE), which were generated for SONGS 1 for boric acid concentrations of 3175, 3750, and 4300 ppm boron, [

](a,c) The results are shown in Figure 3-1.

## 3.2 Determination of TSP Quantities Required

In the updated version of the SONGS 2 & 3 FSAR, Section 6.3.3.4.3, water volumes and boron concentrations are given for the post-LOCA long term cooling (LTC) plan and are as follows:

	<u>WT. % H<sub>3</sub>BO<sub>3</sub></u>	<u>ppm BORON</u>	<u>LBS. LIQUID</u>
RCS	0.68	1,190	425,271 Min.*
RWST	1.32	2,300	4,088,800 Max.
SIT	1.32	2,300	447,000 Max.
BAST	12.0	21,000	129,200 Max.**

\*Starting with minimum RCS volume, maximizes the boron concentration when all other sources are injected into the RCS.

\*\*The tank capacity is 231,470 lbs. but injection is terminated in 2 hours which results in 129,200 lbs. being injected. This time period is based on an evaluation of boron stratification concerns.

The maximum boron concentrations in the RWST and SIT should be set at 3500 ppm to accommodate any future change. With this adjustment, the composite concentration of boron was found to be [ ](a,c) ppm as shown below.



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	<u>LBS. LIQUID</u>		(a,c)
RCS	425,271		
RWST	4,088,800		
SIT	447,000		
BAST	<u>129,200</u>		
Total	5,090,271		

Referring to the titration curves, Figure 3-1, a boron concentration of [ ]<sup>(a,c)</sup> ppm (or mg/l) total in the sump water would require [ ]<sup>(a,c)</sup> ppm (or mg/l) adjustment concentration of TSP to maintain a minimum pH of [ ]<sup>(a,c)</sup>. Multiplying this by the total weight of liquid shows that [ ]<sup>(a,c)</sup> pounds of TSP would be required. If the usual commercial form of TSP is used, which contains 12 hydrates, a total of about [ ]<sup>(a,c)</sup> pounds would be required since this form only contains 43.13 percent anhydrous TSP.

TSP requirements can also be determined for other pH levels by using Figure 3-1. For example, to maintain a minimum pH of [ ]<sup>(a,c)</sup> in the sump water containing [ ]<sup>(a,c)</sup> ppm boron, a concentration of [ ]<sup>(a,c)</sup> ppm TSP would be required. Likewise, for a pH of [ ]<sup>(a,c)</sup>, a TSP concentration of [ ]<sup>(a,c)</sup> ppm would be needed. The total TSP requirements, then, would be about [ ]<sup>(a,c)</sup> pounds anhydrous ([ ]<sup>(a,c)</sup> pounds hydrated) and approximately [ ]<sup>(a,c)</sup> pounds anhydrous ([ ]<sup>(a,c)</sup> pounds hydrated) respectively.

In order to determine the maximum pH which would result from using the above quantities of TSP, minimum volumes and boron concentrations should be considered. Liquid quantities were adjusted for the RWST and SIT using information from FSAR Tables 6.5-3 and 6.3-2. The RCS and BAST liquid quantities were assumed to remain the same. For boron concentrations, the RCS was assumed to decrease to [ ]<sup>(a,c)</sup> ppm, a minimum of [ ]<sup>(a,c)</sup> ppm was used for the RWST and SIT (FSAR Table 6.3-2), and the BAST value was assumed to be unchanged. These values are shown below.

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	LBS LIQUID	
	MAXIMUM	MINIMUM
RCS	425,271	425,271
RWST	4,088,800	2,567,776
SIT	447,000	415,710
BAST	<u>129,200</u>	<u>129,200</u>
TOTAL	5,090,271	3,537,957

[ ]<sup>(a,c)</sup>

The composite boron concentration is found to be [ ]<sup>(a,c)</sup> ppm. The maximum to minimum liquid weight ratio is [ ]<sup>(a,c)</sup>. Therefore, [ ]<sup>(a,c)</sup> ppm TSP in the maximum liquid would result in [ ]<sup>(a,c)</sup> times [ ]<sup>(a,c)</sup> or approximately [ ]<sup>(a,c)</sup> ppm TSP in the minimum amount of liquid. Referring to Figure 3-1, [ ]<sup>(a,c)</sup> ppm TSP with [ ]<sup>(a,c)</sup> ppm boron gives a pH of about [ ]<sup>(a,c)</sup>. Using this same basis, the minimum pH values of [ ]<sup>(a,c)</sup> and [ ]<sup>(a,c)</sup> (with maximum liquid weights and boron concentrations) would result in maximum pH values of about [ ]<sup>(a,c)</sup> and [ ]<sup>(a,c)</sup> respectively for minimum liquid weights and boron concentrations.

Assuming a maximum boron concentration in the RWST and SIT of [ ]<sup>(a,c)</sup> ppm and [ ]<sup>(a,c)</sup> in the BAST as anticipated, the composite sump water would contain [ ]<sup>(a,c)</sup> ppm boron and require a TSP adjustment concentration of about [ ]<sup>(a,c)</sup> ppm for a minimum pH of [ ]<sup>(a,c)</sup>. This translates to a requirement of [ ]<sup>(a,c)</sup> pounds of anhydrous TSP or [ ]<sup>(a,c)</sup> pounds of TSP with 12 hydrates. With these same conditions of boron concentrations, [ ]<sup>(a,c)</sup> pounds of hydrated TSP would result in a minimum pH of [ ]<sup>(a,c)</sup> and [ ]<sup>(a,c)</sup> pounds of hydrated TSP would result in a minimum pH of [ ]<sup>(a,c)</sup>.

Assuming the minimum boron concentrations in the RWST and SIT of [ ]<sup>(a,c)</sup> ppm and [ ]<sup>(a,c)</sup> in the BAST as anticipated, the composite sump water would contain [ ]<sup>(a,c)</sup> ppm boron. With this boron concentration and the minimum liquid as shown above, the [ ]<sup>(a,c)</sup> determined for pH [ ]<sup>(a,c)</sup> in the maximum liquid would result in about [ ]<sup>(a,c)</sup> ppm TSP in the minimum liquid and

yield a pH of [ ]<sup>(a,c)</sup>. Under these conditions, the [ ]<sup>(a,c)</sup> pounds of hydrated TSP considered above would result in maximum pH values in minimum liquid of [ ]<sup>(a,c)</sup>, respectively.

Other combinations of boron concentrations may be considered to optimize the TSP requirements. The use of anhydrous TSP may also be advantageous and should be considered to reduce the mass of TSP required.

The TSP could be placed in baskets in areas which would ensure proper dissolving of the material. One location would be around the periphery of the containment in the region which is flooded during recirculation.

### 3.3 Selection and Justification of the Long Term Sump Solution pH

The long-term pH of the sump solution is selected to maximize iodine retention and minimize the potential for chloride induced stress corrosion cracking of stainless steel. The following is a description of the selection process and justification for a pH in the range of [ ]<sup>(a,c)</sup>.

The SAT Deletion Analysis for the San Onofre Units assumes that the primary elemental iodine control mechanism in the post-LOCA containment is deposition on containment surfaces rather than the more traditional removal by containment sprays. Since sprays are not used for elemental iodine control, the discussion in SRP 6.5.2 regarding spray pH, iodine partition and decontamination of the containment atmosphere is not directly applicable.

[

] <sup>(a,c)</sup>

Based on iodine control by surface deposition, a solution pH in the range of [ <sup>(a,c)</sup> ] is indicated rather than a minimum of 8.5 as recommended by the SRP.

To determine the solution pH that would provide the greatest assurance of no chloride stress corrosion cracking, the following references were consulted:

1. Standard Review Plan 6.1.1
2. Branch Technical Position MTEB 6-1
3. Westinghouse Electric Corporation WCAP-7798-L, 1971
4. Westinghouse Electric Corporation Standard Information Package Volume 5-1, Rev. 2, 1977

The recommendations of the above references are summarized in the table that follows.

SUMMARY OF RECOMMENDATIONS  
TO MINIMIZE CHLORIDE CRACKING

<u>Ref. #</u>	<u>Recommendation</u>	<u>Comment</u>
1.	Min. pH of 7.0, range of 7 to 9.5	
2.	Min. pH of 7.0, range of 7 to 9.5	References Ref. 3
3.	Min. pH of 7.0, recommends 7.5 or higher	
4.	Min. pH of 8.0, range of 8 to 10	

Based on the above assumption that the pH range of 7 to 9.5 provides adequate assurance of no chloride cracking and that the NRC guidelines (Ref. 1 and 2) appear to be based on the work of Westinghouse (Ref. 3), a pH in the range of [ <sup>(a,c)</sup> ] was chosen.

In conclusion, a pH in the range of [ ]<sup>(a,c)</sup> satisfies the requirements of minimizing the potential for chloride stress corrosion of stainless steel and maximizing iodine retention in the sump solution while, as shown in Section 6.1, also keeping hydrogen production at a minimum.

### 3.4 Factors Affecting Adsorption and Desorption of Iodine

Deposition of iodine on containment surfaces depends upon the deposition velocity, the desorption velocity and the ultimate surface loading capacity. These parameters are a function of surface material, surface roughness, and temperature. A discussion of these parameters follows.

#### Surface Loading

In general, surface loadings increase when steam is present and decrease with increasing temperature. A single monolayer of  $I_2$  deposited on a surface equals  $0.3 \mu\text{g}/\text{cm}^2$  of iodine. Most surfaces are capable of loadings many times greater than this. In fact, loadings greater than  $10^4$  monolayers have been observed on reacting surfaces and up to 10 monolayers on inert surfaces. For the San Onofre containment, assuming all surfaces have the same affinity for iodine, the average surface loading is approximately [ ]<sup>(a,c)</sup>  $\mu\text{g}/\text{cm}^2$ . [ ]<sup>(a,c)</sup>

#### Deposition Velocity

Deposition velocity is a function of surface material, roughness and temperature. Deposition velocity tends to increase in the following order: glass < plastic < metal < paint. Deposition increases with surface roughness for surfaces where the adsorption is physical and increases with increasing temperature up to the point where desorption competes to reduce the net deposition velocity. For some metals, there is little desorption at temperatures less than  $150^\circ\text{C}$ . For paint, the amount of irreversibly adsorbed iodine has been observed to vary between 35 and 100% of the initial loading. For the zinc based and epoxy coatings assumed for SCE, the percent of

irreversibly retained iodine is reported to be approximately [  $\frac{1}{2}$  ]<sup>(a,c)</sup>, respectively.

Where surfaces are cold enough to permit condensation, the deposition velocity tends to become less dependent on temperature and more dependent upon the water film on the surface. The water film increases both the deposition velocity and the loading capacity. Both of these effects can be attributed to iodine hydrolysis.

FIGURE 3-1  
ADJUSTMENT OF BORIC ACID  
SOLUTION pH WITH TSP

a,c

4.0 DEVELOPMENT OF RADIOIODINE REMOVAL COEFFICIENTS  
AND DECONTAMINATION FACTORS

In summary, the first cut removal coefficients are as follows:

For elemental iodine spray removal

$$\lambda_s = [ \quad ]^{(a,c)}$$

$$\lambda_s = 0.0 \quad \text{for boric acid spray} > 2500 \text{ ppm boron}$$

For particulate iodine removal

$$\lambda_p = [ \quad ]^{(a,c)} \text{ HR}^{-1} \text{ until DF of } [ \quad ]^{(a,c)} \text{ is reached}$$

$$\lambda_p = [ \quad ]^{(a,c)} \text{ HR}^{-1} \text{ after DF of } [ \quad ]^{(a,c)} \text{ is reached}$$

For elemental iodine deposition

$$\lambda_n [ \quad ]^{(a,c)}$$

$$\lambda_n [ \quad ]^{(a,c)}$$

4.1 Elemental Iodine Spray Removal

The elemental iodine spray removal term ( $\lambda_s$ ) was determined using the Westinghouse "CIRCUS" computer code (Reference 4). Input parameters to the code included plant power, containment free volume, fraction of containment volume sprayed, containment temperature, spray flow rate, fall height, spray temperature, etc. Using a spray concentration for boron of [  $\quad$  ]<sup>(a,c)</sup> For higher boron concentrations  $\lambda_s$  will be assumed to be zero since the NRC, in Section 6.5.2 of the Standard Review Plan (NUREG-0800), does not recognize boric acid concentrations greater than 2500 ppm boron in the spray.



4.2 Particulate Iodine Spray Removal

The particulate iodine removal term ( $\lambda_p$ ) was calculated in accordance with NUREG-CR-0009 (Reference 5) which gives:

$$\lambda_p = \frac{3hF}{2V} \frac{E}{d}$$

where

- h = Drop Fall Height
- F = Spray Flow Rate
- V = Volume Sprayed
- E = Single Drop Collection Efficiency
- d = Drop Diameter

From the SCE SAT deletion list of parameters (Appendix A):

h = 81.5 ft.  
 F = 1750 gpm  
 V =  $1.907 \times 10^6$  ft.<sup>3</sup> ( $0.806 \times 2.366 \times 10^6$ )

From NUREG-CR-0009:

$$\frac{E}{d} = 0.1 \text{ cm}^{-1} \text{ for } C/C_0 \geq 0.01$$

$$\frac{E}{d} = 0.01 \text{ cm}^{-1} \text{ for } C/C_0 < 0.01$$

where  $C/C_0$  = Ratio of present concentration to initial concentration

The particulate removal constants were calculated to be:

$$\lambda_p = [ \dots ]^{(a,c)}$$

$$\lambda_p = [ \dots ]^{(a,c)}$$

Thus  $\lambda_p = [ \dots ]^{(a,c)}$

4.3 Elemental Iodine Deposition Removal

The elemental iodine deposition coefficients were calculated using the spray coverage and deposition surfaces previously determined.

These removal rate constants were calculated in accordance with NUREG-CR-0009 which gives:

$$\lambda_n = \frac{k_g A}{V}$$

- where  $\lambda_n$  = Removal rate constant due to surface deposition (Sec<sup>-1</sup>)
- $k_g$  = Average mass transfer coefficient (cm/sec)
- A = Surface area for wall deposition (cm<sup>2</sup>)
- V = Volume of contained gas (cm<sup>3</sup>)

Revising this equation for use with desired units gives:

$$\lambda_n = 118 \frac{k_g A}{V}$$

- with  $\lambda_n$  in HR<sup>-1</sup>
- $k_g$  in cm/Sec
- A in FT<sup>2</sup>
- V in FT<sup>3</sup>

The values used for mass transfer coefficients were derived from those given in NUREG-CR-0009 (Reference 5) and BMI-1865 (Reference 6) by taking [ ]<sup>(a,c)</sup> of the values judged to be applicable for the various surfaces. A value of [ ]<sup>(a,c)</sup> cm/sec was added to the deposition velocities in the sprayed region in accordance with NUREG-CR-0009. The results are as follows:

Coefficient

- $k_g$  (zinc base)
- $k_g$  (epoxy)
- $k_g$  (stainless steel)

[ ]<sup>(a,c)</sup>

Values for the sprayed and unsprayed areas of zinc base, epoxy, and stainless steel surfaces were those derived previously and are as follows:

<u>Surface</u>	[	(a,c)
Zinc base		
Epoxy		
Stainless Steel		

The following volumes were used in the calculations:

$$V \text{ (Sprayed Region)} = 1,907,000 \text{ ft}^3$$

$$V \text{ (Unsprayed Region)} = 459,000 \text{ ft}^3 \text{ which includes (for conservatism) about } 82,000 \text{ ft}^3 \text{ which is eventually flooded.}$$

The following results were obtained for the elemental iodine surface deposition removal rate constants:

$$\begin{matrix} \lambda_n [ & ]^{(a,c)} \\ \lambda_n [ & ]^{(a,c)} \end{matrix}$$

#### 4.4 Iodine Retention Limits in Sump Solution

Partition coefficients and decontamination factors (DF) are developed from the Standard Review Plan (NUREG-0800), Section 6.5.2, using the following relationship:

$$DF = 1 + \frac{V_s}{V_c} H$$

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where DF = Ratio of the total iodine in the sump liquid and containment atmosphere to that in the containment atmosphere

H = Equilibrium iodine partition coefficient (this is obtained from Figure 6.5.2-1 of SRP section 6.5.2)

$V_s$  = Volume of liquid in containment sump and sump overflow (82,000 ft<sup>3</sup> used here)

$V_c$  = Containment net free volume less  $V_s$  (2,366,000 - 82,000 = 2,284,000 ft<sup>3</sup> used in this analysis)

Decontamination factors for selected pH levels were calculated to be:

<u>pH</u>	<u>Partition Coefficient</u>	<u>DF</u>
6.5 or less	50	2.8
7.5	500	19
8.0	1600	58
8.5 or greater	5000	180

## 5.0 DOSE ANALYSES

### 5.1 Original Dose Analysis Consistency Verification

The radiological consequences of a postulated Loss of Coolant Accident (LOCA) are determined by the use of the Westinghouse TITAN computer code.

Prior to using the TITAN code for the SAT deletion case, a consistency checkout was performed using the parameters given in Table 5-1, Column 1. The doses calculated are in close agreement with those determined by Bechtel (see Table 5-2, Column 1).

### 5.2 Conservative Dose Analysis with SAT Deletion

Considering the same case as discussed above, except taking into account the assumptions associated with SAT deletion and utilizing the more favorable dose conversion factors from Regulatory Guide 1.109 (Reference 7) for off-site doses as well as for the control room dose, the TITAN code was used to determine a first cut dose analysis for the SAT deletion case. The parameters used are presented in Column 2 of Table 5-1.

Only the thyroid doses, which are the controlling doses, due to the containment leakage of radioiodines during the postulated LOCA were calculated. The doses determined are presented in Table 5-2, Column 2.

### 5.3 Identification of Conservatisms

The following conservatisms were incorporated in the SAT Deletion Analysis of Section 5.2.

1. Surface areas used in this analysis were developed from SONGS 2 and 3 FSAR Table 6.2-14 which includes uncertainty percentages. Minimum surface area values were used which are about 8 percent lower than the nominal values on the average.

2. The areas of glass, copper, and polyethylene surfaces were not included in the analysis.
3. The smallest reported deposition velocity for each type of surface coating was used in determining the iodine deposition removal term.
4. The elemental iodine deposition coefficient was reduced further by a factor of  $[ ]^{(a,c)}$ .
5. The volume term used in calculating the iodine deposition coefficient in the unsprayed region includes 82,000 FT<sup>3</sup> which is eventually flooded.
6. The spray removal coefficient for elemental iodine was set at zero for the dose calculations.
7. A decontamination factor cutoff for deposition and particulate iodine removal was set at  $[ ]^{(a,c)}$  in the dose calculations.
8. The duration of spray operation was limited to two hours in the dose calculations.

#### 5.4 Modified Dose Analysis

For the Modified Dose Analysis, a number of the conservatisms identified in Section 5.3 were removed or reduced. These include:

1. The DF limit for removal of elemental iodine is increased from  $[ ]^{(a,c)}$  (after a DF of  $[ ]^{(a,c)}$  the lambda is reduced).
2. The DF limit for removal of particulate iodine is increased from  $[ ]^{(a,c)}$  (after a DF of  $[ ]^{(a,c)}$  the lambda is reduced).
3. The deposition lambdas are increased to reflect nominal surface areas instead of minimums.

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4. The deposition lambdas are recalculated using reduced conservatism ( $[ ]^{(a,c)}$  of the deposition velocity).
5. The spray duration is increased from 2 to  $[ ]^{(a,c)}$  hours.

Many of the conservatisms are left intact. The parameters used are presented in Table 5-1, Column 3. The doses determined are presented in Table 5-2, Column 3.

TABLE 5-1

## PARAMETERS USED IN DOSE ANALYSES

<u>Parameter</u>	<u>Analysis With Spray Additive</u>	<u>First Cut SAT Deletion Analysis</u>	<u>Modified SAT Deletion Analysis</u>
1. Fraction of Core Radiiodines Initially Airborne in the Containment, %	25 (from R.G. 1.4)	50 (from NUREG- 0800)	(a)
2. Activity Released to Containment Atmosphere, Ci			
Isotope			
I-131	$2.24 \times 10^7$	$4.48 \times 10^7$	(a)
I-132	$3.32 \times 10^7$	$6.65 \times 10^7$	(a)
I-133	$5.15 \times 10^7$	$1.03 \times 10^8$	(a)
I-134	$6.0 \times 10^7$	$1.20 \times 10^8$	(a)
I-135	$4.72 \times 10^7$	$9.45 \times 10^7$	(a)
3. Iodine Species Split, %			
a. Elemental	91	95.5	(a)
b. Organic	4	2	(a)
c. Particulate	5	2.5	(a)
4. Containment Volume, ft <sup>3</sup>	$2.366 \times 10^6$	(b)	(b)
5. Containment Leakage Rate, Vol. %/day			
a. 0 - 24 hr.	0.1	(b)	(b)
b. 1 - 30 days	0.05	(b)	(b)



TABLE 5-1 (Continued)

## PARAMETERS USED IN DOSE ANALYSES

<u>Parameter</u>	<u>Analysis With Spray Additive</u>	<u>First Cut SAT Deletion Analysis</u>	<u>Modified SAT Deletion Analysis</u>
6. Fan Coolers			
a. Number of units	2	(b)	(b)
b. Flow rate, CFM	31,000	(b)	(b)
7. Iodine Removal Constants, hr <sup>-1</sup>			
a. Elemental iodine spray deposition (sprayed region) deposition (unsprayed region)	4.8 NA NA	[ ]	(a,c)
b. Organic iodine	0.0		
c. Particulate iodine	0.22		
8. Iodine Decontamination Factors			
a. Elemental iodine spray deposition	100 NA	[ ]	(a,c)
b. Organic iodine	1.0		
c. Particulate iodine	5000		
9. Fraction of Containment Volume Sprayed, %	100	[ ]	
10. Duration of spray operation, hr	≥39	2	[ ] (a,c)

TABLE 5-1 (Continued)

## PARAMETERS USED IN DOSE ANALYSES

<u>Parameter</u>	<u>Analysis With Spray Additive</u>	<u>First Cut SAT Deletion Analysis</u>	<u>Modified SAT Deletion Analysis</u>
11. Atmospheric Dispersion Factors (5% level $x/Q$ ), $\text{sec}/\text{m}^3$			
a. Exclusion Area Boundary			
0 - 2 hrs	$2.72 \times 10^{-4}$	(b)	(b)
b. Low Population Zone			
0 - 8 hrs	$7.72 \times 10^{-6}$	(b)	(b)
8 - 24 hrs	$4.74 \times 10^{-6}$	(b)	(b)
1 - 4 days	$3.67 \times 10^{-6}$	(b)	(b)
4 - 30 days	$2.67 \times 10^{-6}$	(b)	(b)
c. Control Room - includes occupancy factor			
0 - 8 hrs (occ. factor = 1.0)	$3.1 \times 10^{-3}$	(b)	(b)
8 - 24 hrs (occ. factor = 1.0)	$1.8 \times 10^{-3}$	(b)	(b)
1 - 4 days (occ. factor = 0.6)	$5.9 \times 10^{-4}$	(b)	(b)
4 - 30 days (occ. factor = 0.4)	$9.6 \times 10^{-5}$	(b)	(b)
12. Breathing Rate for Off-Site Dose Determination, $\text{m}^3/\text{sec}$			
0 - 8 hrs	$3.47 \times 10^{-4}$	(b)	(b)
8 - 24 hrs	$1.75 \times 10^{-4}$	(b)	(b)
1 - 30 days	$2.32 \times 10^{-4}$	(b)	(b)
13. Breathing Rate for Control Room Dose Determination, $\text{m}^3/\text{sec}$			
	$3.47 \times 10^{-4}$	(b)	(b)

TABLE 5-1 (Continued)

## PARAMETERS USED IN DOSE ANALYSES

<u>Parameter</u>	<u>Analysis With Spray Additive</u>	<u>First Cut SAT Deletion Analysis</u>	<u>Modified SAT Deletion Analysis</u>
14. Inhalation Dose Conversion Factors for Off-Site Dose Determination, rem/Ci	(TID-14844)	(R.G. 1.109)	
I-131	$1.48 \times 10^6$	$1.49 \times 10^6$	(a)
I-132	$5.35 \times 10^4$	$1.43 \times 10^4$	(a)
I-133	$4.00 \times 10^5$	$2.69 \times 10^5$	(a)
I-134	$2.5 \times 10^4$	$3.73 \times 10^3$	(a)
I-135	$1.25 \times 10^5$	$5.6 \times 10^4$	(a)
15. Inhalation Dose Conversion Factors for Control Room Dose Determination, rem/Ci			
I-131	$1.49 \times 10^6$	(b)	(b)
I-132	$1.43 \times 10^4$	(b)	(b)
I-133	$2.69 \times 10^5$	(b)	(b)
I-134	$3.73 \times 10^3$	(b)	(b)
I-135	$5.6 \times 10^4$	(b)	(b)
16. Control Room Volume, ft <sup>3</sup>	293,300	(b)	(b)
17. Control Room Unfiltered Inleakage, CFM	0.0	(b)	(b)

TABLE 5-1 (Continued)

## PARAMETERS USED IN DOSE ANALYSES

<u>Parameter</u>	<u>Analysis With Spray Additive</u>	<u>First Cut SAT Deletion Analysis</u>	<u>Modified SAT Deletion Analysis</u>
18. Control Room Filtered Air Intake, CFM			
0 - 8 hrs	4400	(b)	(b)
> 8 hrs	2200	(b)	(b)
19. Control Room Inleakage Filtration Efficiency <sup>(e)</sup>			
a. Elemental Iodine	0.35	(b)	(b)
b. Organic Iodine	0.95	(b)	(b)
c. Particulate Iodine	0.99	(b)	(b)
20. Control Room Recirculation Flow, CFM			
0 - 8 hrs	63,800	(b)	(b)
> 8 hrs	31,900	(b)	(b)
21. Control Room Recirculation Filtration Efficiency			
a. Elemental Iodine	0.95	(b)	(b)
b. Organic Iodine	0.95	(b)	(b)
c. Particulate Iodine	0.95	(b)	(b)

a. Same as Column 2, First Cut SAT Deletion Analysis.

b. Same as Column 1, Analysis With Spray Additive.

c. Value is reduced by [

](a,c)

d. Value is reduced by [

](a,c)

e. These values reflect the passage through the recirculation filter only. No credit is taken for the intake filter.

TABLE 5-2

POST-LOCA THYROID DOSES DUE  
TO CONTAINMENT LEAKAGE (REM)

	<u>Analysis With Spray Additive</u>	<u>Conservative SAT Deletion Analysis</u>	<u>Modified SAT Deletion Analysis</u>	<u>10CFR100 Guidelines</u>
Exclusion Area Boundary (0 - 2 hours)	86.0	76.2	57.7	300
Low Population Zone (0 - 30 days)	11.5	12.2	8.7	300
Control Room (0 - 30 days)	10.1	12.1	8.7	30*

\* Dose limit guideline per NUREG-0800 Section 6.4.

## 6.0 EFFECTS OF REVISED CONDITIONS ON HYDROGEN GENERATION AND EQUIPMENT QUALIFICATION

### 6.1 Effects on Hydrogen Production from Zinc and Aluminum Corrosion

The corrosion rates of zinc and aluminum are functions of solution pH. Deletion of the spray additive will decrease the pH of the injection spray from approximately 10 to 4 and decrease the equilibrium pH of the sump solution from approximately 9.5 to [ ]<sup>(a,c)</sup>. In general, decreasing pH reduces the corrosion of aluminum and tends to increase the corrosion of zinc. A discussion of aluminum and zinc corrosion follows.

#### Aluminum Corrosion

Based on the guidance of References 8 and 9, the corrosion rate of aluminum is seen to be a strong function of pH, with the rate decreasing with decreasing pH. Corrosion in solutions with pH in the range of 4 to 5 is insignificant. Figure 6-1 (copy of FSAR Figure 6.2-63) shows the hydrogen contribution from aluminum to be extremely small; hence, any further decrease in aluminum corrosion will not significantly reduce the aggregate hydrogen production.

#### Zinc Corrosion

Based on Reference 10, the corrosion of zinc is a function of pH and temperature, and temperature is by far the more influential parameter. The following equation is suggested (Reference 10) to predict the hydrogen production rate constant, k:

$$K = \exp (-8.07 - 2.84x_3 - 0.229x_1x_3 - 0.177x_1x_2x_3)$$

$$\text{where } x_1 = \frac{\text{pH} - 7}{3} \quad \text{for } 4 \leq \text{pH} \leq 10$$

$$x_2 = \frac{\text{ppm Boron} - 3000}{1000} \quad \text{for } 2000 \text{ ppm} \leq \text{ppm Boron} \leq 4000 \text{ ppm}$$

$$x_3 = [ (1/T) - 0.0027 ] / 0.0004$$

T = absolute temperature

and  $k = \text{scm/m}^2 - \text{hr}$

The following cases were evaluated:

1. Current FSAR, pH = 10, 2500 ppm Boron
2. SAT Deletion injection spray, pH = 4, 3500 ppm Boron
3. SAT Deletion recirculation spray, pH = [                    ]<sup>(a,c)</sup> ppm Boron
4. SAT Deletion recirculation spray, pH = [                    ]<sup>(a,c)</sup> ppm Boron
5. SAT Deletion recirculation spray, pH = [                    ]<sup>(a,c)</sup> ppm Boron

The results of these cases are shown in Figure 6-2. Figure 6-2.a compares the corrosion rate for pH 4 and pH 10. The graph shows an increase in the long-term corrosion rate for pH 4 versus pH 10. This condition would exist only if the sump solution pH were not adjusted upward into the range of [                    ]<sup>(a,c)</sup>. Figure 6-2.b compares the corrosion rates for pH 10, [                    ]<sup>(a,c)</sup>. There is no significant difference in these corrosion rates. Hence, with the sump solution pH raised into the range of [                    ]<sup>(a,c)</sup>, the long term hydrogen production rate, due to zinc corrosion, will be the same as the rate presented in the FSAR for pH 10.0.

Conclusion

[

]<sup>(a,c)</sup>

## 6.2 Equipment Qualification

Deletion of the SAT will not affect equipment qualification (EQ) and the existing EQ will be applicable to SAT Deletion.

The primary concerns of equipment qualification are protection of the stainless steel components of the emergency core cooling system (ECCS) from chloride-induced stress corrosion cracking (CISCC), failures of electrical components required to operate post-LOCA, and failures of containment coatings which could jeopardize the ECCS by flaking or peeling off, clogging the emergency sump and other flow paths, and thus restrict the flow of emergency core cooling water. A discussion of these aspects of EQ follows.

### Protection of Stainless Steel

To minimize occurrence of CISCC, Standard Review Plan 6.1.1 with BTP-MTEB 6-1 (Reference 1) requires that the pH of the sump solution be in the range of 7 to 9.5. However, the time required to make the pH adjustment is not specified. The available references recommend that the pH adjustment be made within the range of 4 (Reference 11) to 48 (Reference 12) hours. The SONGS pH adjusting system, using TSP, will begin the adjustment immediately. The sump solution pH adjustment will be completed within 2 hours. Thus, the proposed use of TSP for pH adjustment, for the SONGS units, is seen to satisfy the most stringent time and pH requirements.

### Testing of Electrical Components

One of the prime objectives for electrical equipment testing is to determine the ability of the seals to exclude the containment environment from the interior of the component. To maximize the challenge to the seal materials, high pH sprays have been traditionally used for testing. The typical pH range is from approximately 8 to as high as 11.

The chemical environment for the SONGS units with SAT Deletion and TSP addition is far less severe than the typical environment.



Testing of Containment Coatings

Coatings are used in the containment to provide corrosion protection for metals and to aid in the decontamination of surfaces during normal operation. In addition, the SONGS units with SAT Deletion will utilize containment surfaces for fission product retention post-LOCA. Coatings that peel off post-LOCA may not be available for fission product deposition.

Like electrical equipment, coatings are also tested with a high pH solution to maximize the potential deterioration of the coating. Coatings also show better resistance to mild acid solutions (pH 4 to 5) than to alkaline solutions (Reference 13).

Conclusion

[

](a,c)

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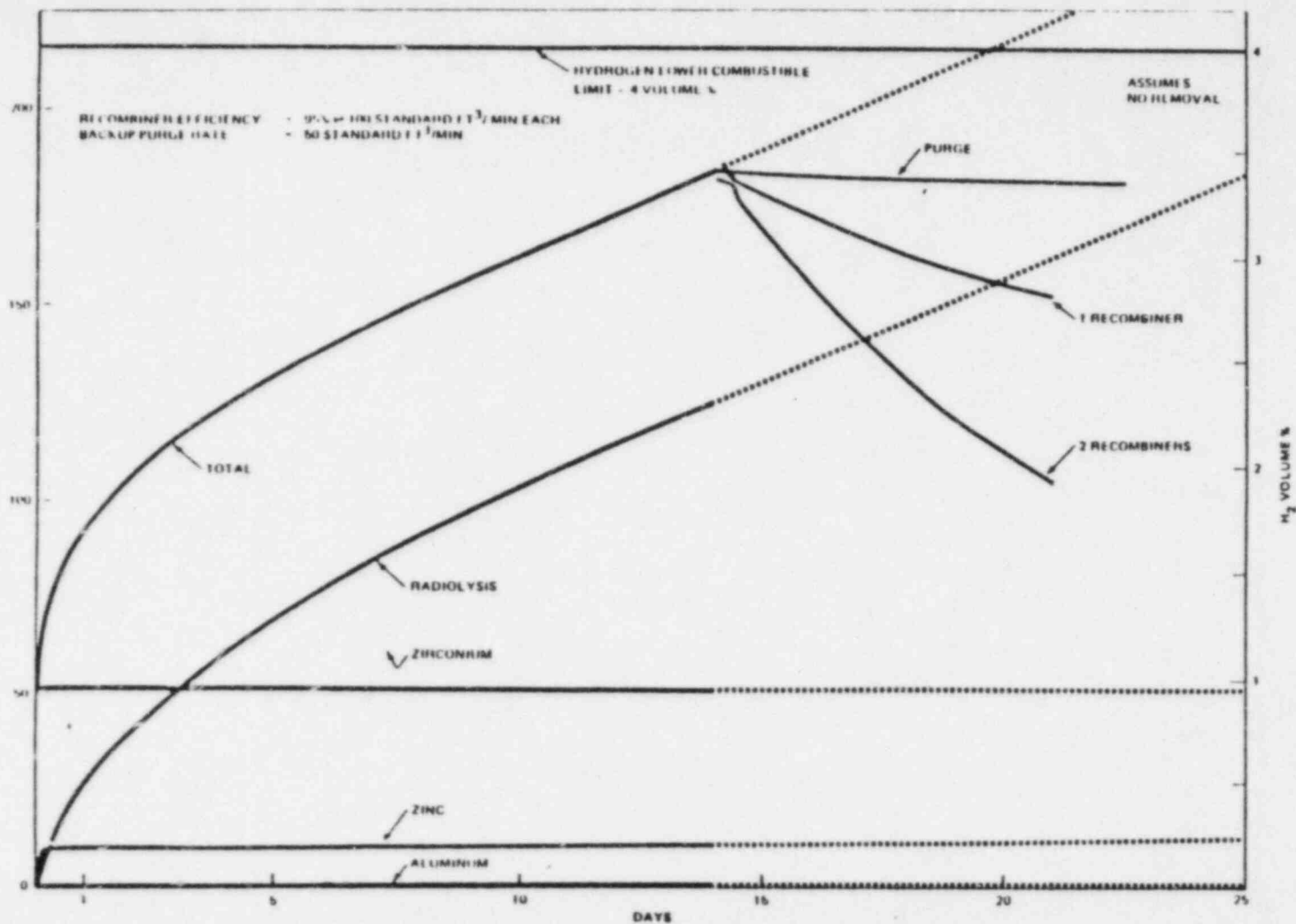


FIGURE 6-1

6-5

Updated

SAN ONOFRE  
NUCLEAR GENERATING STATION  
Units 2 & 3

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HYDROGEN GENERATION (BY  
SOURCE) AND REMOVAL  
ANALYSIS - POST LOCA

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Figure 6.2.6.1

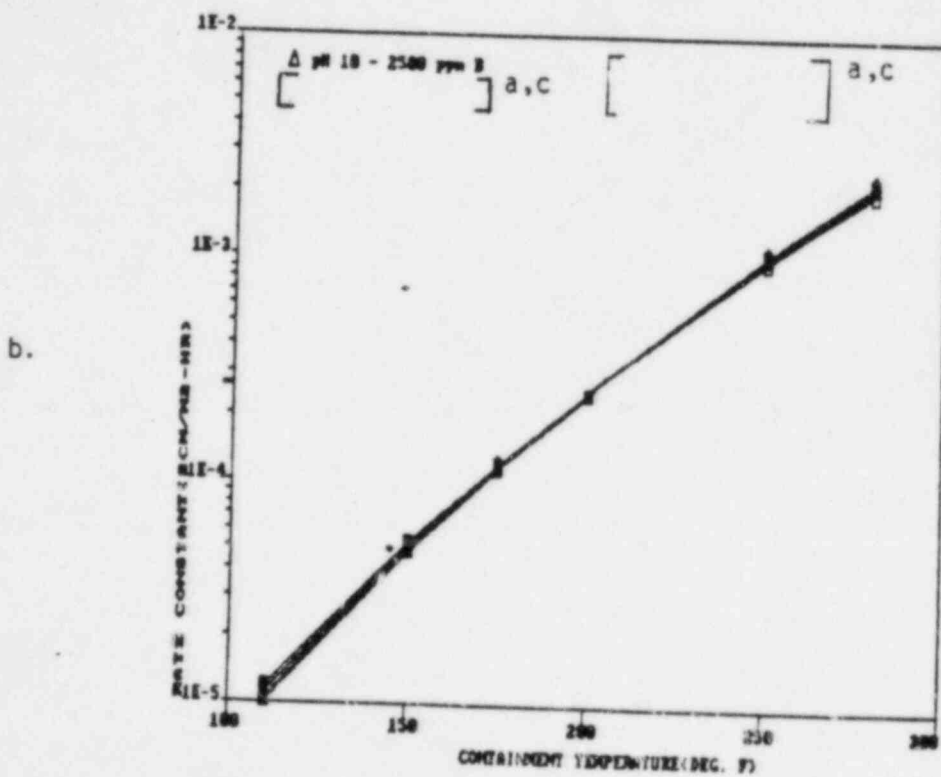
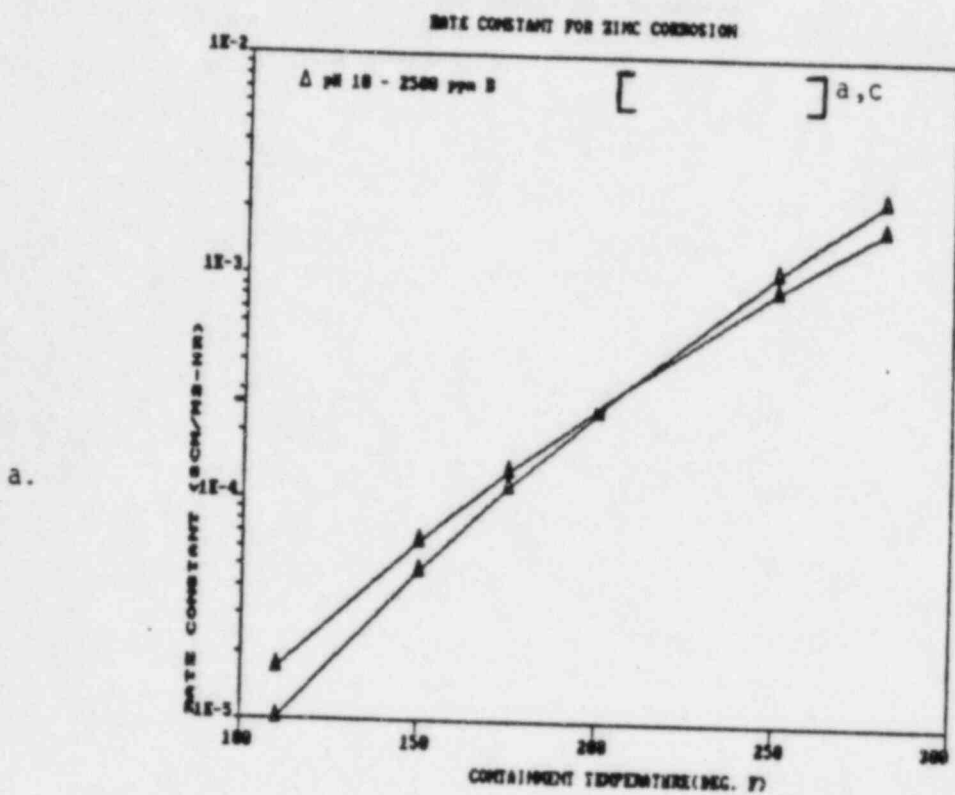


FIGURE 6-2 HYDROGEN PRODUCTION RATE CONSTANTS FOR ZINC CORROSION

## 7.0 TECHNICAL SPECIFICATIONS

### 7.1 Description of Proposed Changes

The proposed change would delete, in its entirety, Technical Specification 3/4.6.2.2 "Iodine Removal System", and replace it with a new Technical Specification requiring trisodium phosphate in the containment emergency sump area.

Technical Specification 3/4.6.2.2, "Iodine Removal System" requires that a spray additive tank, containing at least 1456 gallons of between 40 and 44% by weight of NaOH solution, and two chemical addition pumps be operable in Modes 1, 2, and 3. The original purpose of this Iodine Removal System was to ensure that in the event of a LOCA a sufficient amount of NaOH will be added to the containment spray to raise the pH to between 8 and 9 during the initial phase of the spray. The effects of the increased pH levels are to increase the iodine removal capability of the spray and the iodine retention in the sump.

An additional function of the NaOH in the Iodine Removal System, during the long term recirculation phase, is to maintain the pH level of sump at  $\geq 7.0$  to minimize the potential for chlorine induced stress corrosion cracking of austenitic stainless steel.

Justification for the deletion of the Spray Additive Tank and the Iodine Removal System of Technical Specification 3/4.6.2.2 is provided in the analysis of this report. This analysis utilized recent changes in NRC methodology (NUREG-0800, Section 6.5.2, Rev. 1), combined with knowledge gained from recent studies on the behavior of iodine in the post-LOCA environment, to demonstrate that the deletion of the Spray Additive Tank does not significantly change the calculated offsite thyroid doses. Thus the pH of the containment spray does not need to be increased during the initial phase of containment spray during a LOCA.

However, in the post-LOCA recirculation phase, the Emergency Core Cooling System (ECCS) solution pH must be increased to  $\geq 7.0$  to minimize chloride

induced stress corrosion cracking of austenitic stainless steel components, maximize the retention of iodine in the containment sump, and to minimize the hydrogen produced by the corrosion of galvanized surfaces and zinc based paints. To accomplish this increase in the ECCS solution pH, a new Technical Specification is proposed to replace Technical Specification 3.6.2.2. this new Technical Specification requires the presence of a specified amount of trisodium phosphate in the containment area. The analysis in this report has shown that this amount of trisodium phosphate will maintain long term pH control in the ECCS recirculation solution, thereby minimizing the potential for chloride stress corrosion and maximizing iodine retention in the sump solution.

## 7.2 Safety Analysis

The proposed changes discussed above shall be deemed to involve a significant hazards consideration if there is a positive finding in any of the following areas:

1. Will operation of the facility in accordance with this proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No

The plant systems, in which a change is proposed, are intended to respond to and mitigate the effects of a LOCA. The proposed changes have no effect on the probability of the occurrence of a LOCA.

As concluded in this report, the deletion of the Iodine Removal System, and its replacement with a sump pH control system will not significantly affect the radiological consequences of a postulated LOCA and the calculated doses will remain well within the 10CFR100 guidelines. In addition, the use of TSP for a long term recirculation phase pH control meets all the requirements for control of chloride stress corrosion and maximizes iodine retention in the sump solution.

WESTINGHOUSE PROPRIETARY CLASS 3

2. Will operation of the facility in accordance with this proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No

The substitution of a passive system for an active system for the mitigation of the consequences of a postulated LOCA actually reduces the potential radiological consequences of an accident due to the failure of the active Iodine Removal System.

3. Will operation of the facility in accordance with the proposed change involve a reduction in a margin of safety.

Response: No

The radiological consequences of a postulated LOCA will not increase relative to the 10CFR100 guidelines, nor will the potential for chloride stress corrosion increase.

The Commission has provided guidance for determining whether a significant hazards consideration exists by providing certain examples (48 FR 14870) of amendments that are considered not likely to involve significant hazards consideration. Example VI relates to a change which either may result in some increase in the probability or consequences of a previously-analyzed accident or may in some way reduce a safety margin, but where the results of the change are clearly within all acceptance criteria with respect to the system or component specified in the Standard Review Plan (SRP).

SRP Section 6.5.2 (Rev. 1) discusses the acceptance criteria of the Containment Spray as a Fission Product Cleanup System. The only impact that the proposed Technical Specification change has on this system is the deletion of the use of NaOH in the initial containment spray phase following a postulated LOCA, and the substitution of trisodium phosphate for NaOH in the

sump solution during the long term recirculation phase. As shown in Table 7-1, depending on the degree of conservatism in this analysis, the deletion of the Spray Additive Tank may slightly increase or decrease the calculated thyroid dose at the LPZ, and will in all cases reduce the thyroid dose at the Exclusion Area Boundary. It should be noted that in all cases there is significant margin between the calculated thyroid doses and the limits defined in 10CFR100, and this margin is essentially independent of whether the Spray Additive Tank is operable, or if the SAT is deleted and the Sump pH Control System is operable.

Also, there is essentially no change in the potential for chloride stress corrosion, the generation of hydrogen or the environmental qualification of equipment. Therefore, the proposed change meets the SRP acceptance criteria, and is similar to example VI.

### 7.3 Safety and Significant Hazards Determination

Based on the above Safety Analysis, it is concluded that: (1) the proposed change does not constitute a significant hazards consideration as defined by 10CFR50.92; and (2) there is reasonable assurance that the health and safety of the public will not be endangered by the proposed change; and (3) this action will not result in a condition which significantly alters the impact of the station on the environment as described in the NRC Final Environmental Statement.

### 7.4 Proposed Specifications

Following are the proposed specifications for both Units 2 and 3:

CONTAINMENT SYSTEMS

RECIRCULATION FLOW PH CONTROL

LIMITING CONDITIONS FOR OPERATION

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3.6.2.2 The recirculation flow pH control system shall be operable with a minimum of 15,400 lbs. (256 cu. ft.) of trisodium phosphate (w/12 hydrates), or equivalent, available in the storage racks in the containment.

APPLICABILITY: Modes 1, 2, and 3

ACTION:

With less than the required amount of trisodium phosphate available, restore the system to the correct amount within 72 hours or be in at least HOT STANDBY within the next 6 hours and in HOT SHUTDOWN within the following 6 hours.

SURVEILLANCE REQUIREMENTS

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- 4.6.2.2 The recirculation flow pH control system shall be demonstrated operable during each refueling outage by:
- a. Visually verifying that the TSP storage racks have maintained their integrity and the TSP containers contain a minimum of 15,400 lbs. (256 cu. ft.) of TSP (w/12 hydrates) or equivalent.
  - b. Verifying that when a sample of less than 3.03 grams of trisodium phosphate (w/12 hydrates) or equivalent, selected at random from one of the storage racks inside of containment, is submerged, without agitation, in at least 1 litre of  $120 \pm 10$  degrees-F borated demineralized water borated to at least 2482 ppm boron, allowed to stand for 4 hours, then decanted and mixed, the pH of the solution is greater than or equal to 7.0.

BASES

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3/4.6.2.2 RECIRCULATION FLOW PH CONTROL SYSTEM

The operability of the recirculation flow pH control system ensures that there is sufficient trisodium phosphate available in containment to guarantee a sump pH of  $\geq 7.0$  during the recirculation phase of a postulated LOCA. This pH level is required to minimize the potential for chloride stress corrosion of austenitic stainless steel. The specified amount of TSP will result in a recirculation phase pH of 7.2 assuming complete dissolution and maximum allowed boric acid concentrations from the borated water sources. Similarly, surveillance 4.6.2.2 will produce a pH of 7.2. The specified temperature of  $120 \pm 10$  degrees-F for the surveillance is based is consistent with expected long term recirculation phase sump temperature reported in the FSAR.



## WESTINGHOUSE PROPRIETARY CLASS 3

TABLE 7-1

## CALCULATED THYROID DOSE (REM)

	With Spray Additive Tank (SAT) and <u>Na OH</u>	SAT Deletion Conservative <u>Case</u>	SAT Deletion Modified <u>Case</u>	<u>10CFR100 Guidelines</u>
Exclusion Area Boundary (0-2 hrs)	86.0	76.2	57.7	300
Low Population Zone (0-30 days)	11.5	12.2	8.7	300

8.0 REFERENCES

1. "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants", NUREG-0800.
2. "Calculation of Distance Factors for Power and Test Reactor Sites", TID-14844.
3. Final Safety Analysis Report for the San Onofre Nuclear Generating Station, Units 2 & 3, updated.
4. "CIRCUS Computer Code - Calculation of Vapor Phase Elemental Iodine Removal in the Reactor Containment by Chemical Additive Spray", WCAP-8659.
5. "Technological Bases for Models of Spray Washout of Airborne Contaminants in Containment Vessels", NUREG/CR-0009.
6. "Fission-Product Deposition and its Enhancement Under Reactor Accident Conditions: Deposition on Containment - System Surfaces", BMI-1865.
7. "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", Regulatory Guide 1.109.
8. "Corrosion Study for Determining Hydrogen from Aluminum and Zinc During Post Accident Conditions", WCAP-8776 (Non-Proprietary).
9. "Hydrogen Releases from Corrosion of Aluminum and Zinc", BNL-NUREG-24532.
10. "The Relative Importance of Temperature, pH and Boric Acid Concentration on Rates of H<sub>2</sub> Production from Galvanized Steel Corrosion", NUREG-/CR-2812.
11. "Calculational Error Affecting the Design Performance of a System for Controlling pH of Containment Sump Water Following a LOCA", IE Bulletin 77-04.

8.0 REFERENCES (Continued)

12. "Chemistry Criteria and Specifications", Westinghouse Standard Information Package, Volume 5-1, (Proprietary Class 2).
13. "Evaluation of Protective Coatings for Use in Reactor Containment", WCAP-7198-L (Proprietary Class 2).

WESTINGHOUSE PROPRIETARY CLASS 3

APPENDIX A

PARAMETERS AND INFORMATION USED IN SONGS 2&3  
SAT DELETION ANALYSIS

I. General Information

- A. SAR sections (latest revision) describing the radiological consequence evaluation of a LOCA, the containment spray system, the control room, and post-LOCA hydrogen production and control.

This information is presented in the following sections of the San Onofre 2&3 FSAR (updated):

- 15.6.3.3 - Loss of Coolant Accident (LOCA)
- 15.6.3.3.5 - Radiological Consequences  
Pages 15.6-50 through 15.6-66
- 6.2.2 - Containment Heat Removal Systems
  - 6.2.2.1 - Containment Spray System  
Pages 6.2-209 through 6.2-236
  - 6.2.2.2 - Containment Emergency Fan Coolers  
Pages 6.2-236 through 6.2-241
- 6.5.2 - Containment Air Purification and Cleanup -- Iodine Removal System, Pages 6.5-9 through 6.5-28
- 6.4 - Habitability Systems  
Pages 6.4-1 through 6.4-23
- 6.2.5 - Combustible Gas Control in Containment  
Pages 6.2-272 through 6.2-293

- B. Containment drawings showing the spray header and nozzle layout.

This information is shown in FSAR Figure 6.2-51. However, the latest certified construction drawing, approximately 18 inches by 24 inches in size, was provided by SCE in the June 19, 1985 transmittal.

II. Specific Information

The following information was obtained from the SONGS 2&3 FSAR (updated).

A. Containment Spray System

1. Spray flow rate.  
1750 gal/min - Page 6.2-213, Table 6.2-29
2. Duration of spray injection phase.  
Minimum of 20 minutes - Pages 6.2-216 and 6.5-14
3. Time delay, if any, to begin spray recirculation.  
None - Page 6.2-216, Part B

WESTINGHOUSE PROPRIETARY CLASS 3

4. Boron concentration in the refueling water.  
2500 ppm maximum will be used per SCE advice (E-Mail 3-8-85) even though 2300 PPM is given on Pages 6.3-56 and 6.5-12. Boron concentrations of 3000, and 3500 ppm were also considered
5. Titration curves for TSP in boric acid solution.  
This information was not found in the SONGS 2&3 FSAR. This information was provided by SCE in the June 19, 1985 transmittal.
6. Spray fall height.  
81.5 feet - Pages 6.5-12 and 6.5-23

B. Containment

1. Net free volume.  
 $2.366 \times 10^6 \text{ ft}^3$  - Pages 6.5-12 and 6.5-23
2. Fraction of volume that is sprayed.  
80.6 percent - Pages 6.5-12, 6.5-23, and 6.5-24
3. Leak rate.  
0.1 percent per day from 0 to 24 hours  
0.05 percent per day from 1 to 30 days  
Page 15.6-52, Table 15.6-22
4. Minimum number of containment coolers required for accident recovery and air flow rate per cooler. Any filters?  
Quantity - 2, flow rate - 31,000 CFM at 60 psig each  
Pages 6.2-238, 6.2-239 and 6.5-12.  
No filters
5. Location of fan cooler suction and discharge.  
Figure 6.2-59. Additional drawings were supplied by SCE in the June 19, 1985 transmittal.
6. Maximum water inventory in sump following a LOCA.  
From Page 6.3-56:  
RCS - 425,271 lbs.  
RWST - 4,088,800 lbs.  
SIT - 447,000 lbs.  
BAST - 129,200 lbs.  
Total - 5,090,271 lbs. = 610,000 gals.
7. Inventory of all surfaces ( $\text{ft}^2$ ), location (above or below op. deck, submerged or above water), and type of coating, i.e., galvanized, zinc base, epoxy or phenolic paint. Include paint manufacturer and trade name.

The information given in Tables 6.2-12, 6.2-13, 6.2-14 and 6.2-38 will be used for deposition surface evaluation. Information in FSAR Section 6.1 will also be used.

C. Source Term

1. Core equilibrium iodine inventory.

I-131 thru 135, curies

I-127 and I-129, kg

The design basis values for I-131 through 135 in Table 15.6-22 will be used. I-127 and I-129 are only used for filter loading and estimates will be used.

D. Control Room

1. HVAC flow diagram and description of operation.  
Figures 6.5-1 and 6.5-2 will be used along with the description in Subsection 9.4.2.
2. Air flow rates and filter efficiencies for intake and recirculation units for post accident operation.  
The values in Table 15B-5 will be used. Additional information was supplied by SCE in the June 19, 1985 transmittal.
3. Any time delays to switch from normal operating mode to accident mode?  
No time delays found in the FSAR. SCE advised that time delays are negligible in the June 19, 1985 transmittal.
4. Free volume.  
293,300 ft<sup>3</sup> - Table 15B-5.

E. Site Parameters

X/Q (sec/m<sup>3</sup>)

0-2 hour at site boundary

0-2, 2-8, 8-24, 24-96, 96-720 hours at the outer boundary of the low population zone and at the control room air intake.

The atmospheric dispersion factors given in Table 15B-4 at the 5% level will be used.

F. Hydrogen Production

1. Hydrogen production rate equations.  
The information presented in Tables 6.2-38 and 6.2-40 and Figures 6.2-63 and 6.2-64 will be used for production rates. Equations are not necessary.
2. Containment temperature transient used in hydrogen analysis.  
The information contained in Tables 6.2-9 and 6.2-25 and Figures 6.2-2 through 6.2-6 will be used.
3. Containment volume percent H<sub>2</sub> vs. time.  
Figure 6.2-63 will be used.

WESTINGHOUSE PROPRIETARY CLASS 3

4. Hydrogen accumulation vs. time for aluminum corrosion and for zinc corrosion.  
Figures 6.2-63 and 6.2-64 will be used.

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