**The Light company** Houston Lighting & Power P.O. Box 1700 Houston, Texas 77001 (713) 228-9211

August 28, 1986
ST-HL-AE-1710
File No.: G12.188/G9.1

Mr. Vincent S. Noonan, Project Director
PWR Project Directorate #5
U. S. Nuclear Regulatory Commission
Washington, DC 20555

South Texas Project
Units 1 and 2
Docket Nos. STN 50-498, STN 50-499
FSAR Changes Related to Deletion of
Containment Spray Sump Additive Tank

Dear Mr. Noonan:

On June 18, 1986, Houston Lighting & Power Company (HL&P) personnel had a telephone discussion with your Mr. P. Kadambi and several members of the NRC staff regarding elimination of the South Texas Project (STP) Units 1&2 sump additive tank from the containment spray system (CSS) design. The elimination of this tank will result in a minimum long term pH of the containment sump of 7.5 which is lower than the lower end of the pH range of 8.5-10.5 recommended in the Standard Review Plan (SRP). However, as explained below, the offsite and control room accident doses were confirmed to be less than the allowable limits.

A reanalysis of the offsite dose was performed using current source term methodology (100% noble gases, 50% Halogens) and the lower sump pH. During the ECCS injection phase, the containment spray was assumed to begin at the time calculated for the system to fill with water and begin spraying which is 2.34 minutes. The pH during this phase is the same as is currently evaluated in the FSAR (i.e. half of the flow at a pH of 8.0 and half at a pH of 9.0). At the end of the injection phase, the spray additive tank is isolated thereby maintaining a maximum sump pH below 10.5.

Since the long term pH of the sump will be a minimum of 7.5 (rather than the SRP recommended limit of 8.5) after injection, this value was used to determine the maximum decontamination factor (DF) for elemental iodine removal by the sprays. The maximum DF was found to be 12.28 using the equation in Section III.4.c of SRP 6.5.2 (NUREG-0800). This DF was used as the point when elemental iodine removal via sprays was assumed to stop (~.2 hours). Elemental iodine removal via plateout was assumed to continue until a total DF of 100 (this includes the DF of 12.28 from spray removal) was reached. In addition, particulate iodine removal via the sprays was assumed to continue until a DF of 100 was reached on the particulate iodine concentration.

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The offsite and control room doses were confirmed to be less than the allowable 10CFR100 and 10CFR50, Appendix A (GDC19) limits. HL&P has concluded that the offsite doses and the spray effects on equipment qualification are acceptable. Therefore, the sump additive tank is not required and will not be installed.

As a result of this design change, STP estimates a cost savings of approximately $400,000 in Engineering costs, $143,000 in hardware cost and $265,000 in construction cost for a total approximate saving of $808,000.

We request that the NRC review this change as soon as possible in order not to impact project schedule.

If you should have any questions on this matter, please contact Mr. M. E. Powell at (713) 993-1328.

Very truly yours,

M. R. Wisenburg
Manager, Nuclear Licensing

MEP/LRS/bl

Attachment: Annotated FSAR Pages to Section 6.1.1, 6.1.3, 6.2.2, 6.5.2, 7.6, 15.6.5, Tables 6.4-2 and 7.1-2, Figures 6.5-1 and 7.6-9, and NRC Questions 22.11, 122.20, 312.07, 12 & 13.

L1/NRC/ts

cc:

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The solubility limit for this concentration is approximately 41%. The spray additive tanks are located in the FHB which is maintained above 65°F during normal plant operation.

Information regarding the selection, procurement, testing, storage, and installation of nonmetallic thermal insulation, and demonstrating that the leachable concentrations of chloride, fluoride, sodium, and silicate are comparable to the recommendations of RG 1.36, is contained in Section 5.2.3.

The welding materials used for joining the ferritic base materials of the ESF conform to or are equivalent to ASME material specifications SFA 5.1, 5.2, 5.5, 5.17, 5.18, 5.20, 5.28, and 5.30. The welding materials used for joining nickel-chromium-iron alloy in similar base material combination and in dissimilar ferritic or austenitic base material combination conform to ASME material specifications SFA 5.11 and 5.14. The welding materials used for joining the austenitic stainless steel base materials conform to ASME material specifications SFA 5.4 and 5.9. The welding materials used for joining copper or copper-alloy base material conform to ASME Material Specifications SFA 5.6 and 5.7. These materials are tested and qualified to the requirements of the ASME Code and are used in procedures which have been qualified to these same rules. The methods utilized to control delta ferrite content in austenitic stainless steel weldments are discussed in Section 5.2.3. 40 40

The procedures utilized to avoid hot cracking (fissuring) during weld fabrication and assembly of austenitic stainless steel components of the ESF are the same as those used for the reactor coolant pressure boundary. Therefore, discussion of the procedures is found in Section 5.2.3.

Use of aluminum will be minimized in the Containment. Galvanized steel inventory is given in Table 6.1-2.

6.1.1.2 <u>Composition, Compatibility, and Stability of Containment Spray Coolants</u>. The pH of the Containment spray will be adjusted during the injection mode by the addition of a ~~34~~ 30 to ~~36~~ 32 weight-percent sodium hydroxide solution to provide a minimum pH of ~~8.5~~ 7.5. A discussion of the NaOH addition design basis is provided in Section 6.2.2.2.2. ~~In no case will the solution pH fall outside the range of 8.5 to 10.5.~~ 3 33 Q312.13

Radiolytic decomposition of water will occur, but boric acid and sodium hydroxide will not be affected by radiation. No pyrolytic decomposition of boric acid or sodium hydroxide is expected.

The vessels used for storing ESF coolants include the accumulators and the refueling water storage tank. 3

The accumulators are carbon steel clad with austenitic stainless steel. Because of the corrosion resistance of these materials, significant corrosive attack on the storage vessels is not expected. 3

The accumulators are vessels filled with borated water and pressurized with nitrogen gas. The nominal boron concentration, as boric acid, is 2,500 ppm. Samples of the solution in the accumulators are taken periodically for checks of boron concentration. 2

The refueling water storage tank is a source of borated cooling water for injection. The ~~nominal~~ minimum boron concentration, as boric acid, is 2,500 ppm. The tank cubicle is maintained above 50°F, thus ensuring that the boric acid remains soluble. 33

In order to ensure materials compatibility during storage, the 30 ~~34~~- to 32 ~~36~~-weight-percent sodium hydroxide chemical additive is contained in stainless steel tanks.

The spray additive solution is not corrosive to the stainless steel components of the system with which it comes into contact. The spray and sump solutions will tend to severely corrode aluminum alloys, but will not attack stainless steel or Cu-Ni alloys.

### 6.1.2 Organic Materials

Organic materials located inside the Reactor Containment Building (RCB) are limited to coating materials on painted surfaces, electrical cable insulation, and lubricating oils and greases. There are no significant amounts of other organic materials, such as wood or asphalt, located inside the RCB.

#### 6.1.2.1 Protective Coatings

Certain coatings that are in common industrial use may deteriorate in the post-accident environment and may contribute substantial quantities of foreign solids and residue to the containment sump. Consequently, protective coatings used inside the containment have been tested and selected to assure that they will withstand nuclear, chemical, and physical conditions of a DBA, as required by Regulatory Guide (RG) 1.54 and ANSI N101.2-1972. The tests are performed by independent laboratories and show that no significant decomposition or radiolytic or pyrolytic failures will occur during a DBA. Inorganic zinc, epoxy, and modified phenolic systems are the most desirable of the generic types evaluated. This evaluation considers resistance to radiation, temperature, pressure and chemical conditions anticipated during a loss-of-coolant accident (LOCA). 29

Steel and concrete surfaces inside the RCB with protective coatings can be grouped into three categories:

1. Major surfaces: This category includes large surfaces such as the containment liner, structural steel, large uninsulated equipment and equipment supports, pipe whip restraints, polar crane, and concrete surfaces receiving epoxy surfacer systems.

   Coatings for major surfaces are selected in accordance with the requirements of Section 4 of ANSI N101.2 and applied per RG 1.54, thus assuring that the majority of protective coatings inside the RCB will remain intact in the post-accident environment. 31 32 29

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6.1.2.2 <u>Cable Insulation</u>. Cable insulation in the RCB is qualified to IEEE 383-1974 requirements and consists of 282,000 pounds of ethylene propylene rubber (EPR), polyethylene (XLPE), and hypalon. 33

6.1.2.3 <u>Oils and Greases</u>. Significant quantities of lube oils used inside the Containment are located in the reactor coolant pumps, with approximately 265 gallons per pump. Other pumps require only approximately 1 gallon of lube oil each or are grease lubricated and represent an insignificant amount, as noted below.

Oil-lubricated pumps

| | |
|---|---|
| 4 reactor coolant pumps | 265 gallons/pump |
| 2 reactor coolant drain tank pumps | 1 gallon/pump |
| 2 normal sump pumps | 1 gallon/pump |
| 1 equipment drain sump pump | 1 gallon/pump |

Grease-lubricated pumps

3 Residual Heat Removal System pumps 33

All oils are contained in sealed reserviors and are not exposed to the outside environment. When oil changes are effected, the used oil is drained directly into waste oil sumps outside the Containment prior to disposal.

In the event that small leaks might occur during operation, all pumps are equipped with drip pans placed and secured to prevent possible oil drops from coming into contact with adjacent piping or equipment.

6.1.2.4 <u>Decomposition Products</u>. An insignificant amount of radiolytic decomposition in the reactor coolant pump lube oil will occur during operation; however, the effect on oil properties, and the hydrogen generated by the reaction, are negligible.

Under DBA conditions, the Containment spray and sump water react with those surfaces coated with zinc-rich primer that are not epoxy topcoated. This reaction results in the generation of hydrogen. Further details are provided in Section 6.2.5.

### 6.1.3 Postaccident Chemistry

Following a DBA, the pH of the fluid inside Containment remains between 7.5 ~~8.5~~ and 10.0 ~~10.5~~ following completion of caustic injection by the Containment Spray System, as described in Section 6.~~5~~2.2. 33

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## TABLE 6.1-1

## ENGINEERED SAFETY FEATURES MATERIALS

### Materials Employed for Safety Injection and Containment Spray Systems Components

| **Component** | | **Material** | |
|---|---|---|---|
| Pumps | | | |
| High-Head Safety Injection, Low-Head Safety Injection, and Containment Spray Pumps: | | | |
| Shaft | | A-276 TP 410 | |
| Impeller, Stage 1, | Flights | A-240 TP 304 | |
| | Hubs | A-276 TP 304 | |
| | Remaining stages | A-296 CA40 | |
| Outer Barrel, | | | |
| | Top Flange | SA-182 F304 | 52 |
| | Top Cylinder | SA-182 F304 | |
| | Suction Nozzle | SA-182 F304 | |
| | Bottom Cylinder | SA-358, TP304; Class 1, Welded | |
| | Cap | SA-182 F304 | |
| ~~Containment Spray~~ e | | | |
| Residual Heat Exchangers | | | |
| Tube Sheets | | SA516 Gr. 70 with 304 stainless steel cladding | |
| Tubes | | SA249 Type 304 | |
| Heads | SHELL SIDE | SA516 Gr. 70 | |
| | TUBE SIDE | SA240 Type 304 | |
| Nozzle Necks: | SHELL SIDE | SA-106-B(SMLS) | 33 |
| | TUBE SIDE | SA-312 Type 304 | |
| Shells: | SHELL SIDE | SA516 Gr. 70 | |
| | TUBE SIDE | SA240 Type 304 | |
| Flanges: | TUBE SIDE | SA182 Gr. F304 | |
| | SHELL SIDE | SA105 | |
| Valves | | | |
| Containing Radioactive Fluids: | | | |
| Pressure-Containing Parts | | SA182 Type 316 or 304 | |
| Seating Surfaces | | Stellite No. 6 or equivalent | |
| Stems | | Type 630 and 410 or 17-4PH stainless | |
| Tanks | | | |
| Spray Additive Tanks | | SA240 Type 304 | |

## TABLE 6.1-1 (Continued)

## ENGINEERED SAFETY FEATURES MATERIALS

| Component | Material | |
|---|---|---|
| **Valves** (Continued) | | |
| Containing Nonradioactive, Boron-Free Fluids: | | |
| Pressure-Retaining Parts | SA105, SA182 Type 304 or 316 | |
| **Stems** | Type 630, 410 or 17-4PH stainless | |
| **Relief Valves** | | 33 |
| Bodies | SA351 Gr. CF8M | |
| All Nozzles, Discs, Spindles, and Guides | SA479 Type 316 or SA193 Gr. B6 or Type 410 or 416 Stainless or Stellite or Inconel or Monel | |
| Bonnets | SA351 Gr. CF8M or SA216 Gr. WCB | |
| **Piping** | | |
| All Piping in Contact with Borated Water | SA312, Gr. TP304, 304L, 316, or 316L;<br>SA 376 Gr.<br>TP 304 or 316<br>SA 358 TP316L, CL.1 welded | 52 |
| All Piping not in Contact with Borated Water | A106 Gr. B<br>SA106 Gr. B | 2 |

### Materials Employed for Electric Hydrogen Recombiners

| | | |
|---|---|---|
| **Outer Structure** | SA240 Type 304 | |
| **Inner Structure** | Incoloy-800 | 33 |
| **Heater Element Sheath** | Incoloy-800 | |

### Materials Employed for Containment System

| | | |
|---|---|---|
| **Reinforcing Steel** | ASTM A615, Gr. 60 | |
| **Containment Liner** (Greater than 5/8" thick) | ASME - SA516 Gr. 60 | 52 |
| (5/8" and less thick) | ASME - SA285 Gr. A | |

8. The CHRS is designed to accommodate the Operating Basis Earthquake (OBE) within stress limits of applicable codes and to withstand the Safe Shutdown Earthquake (SSE) without loss of function. 38

9. The CHRS and the RHRS are protected from the effects of missiles and postulated pipe ruptures without loss of safety function (see Sections 3.5 and 3.6). 38

10. The CHRS is designed to permit periodic inspection of the system, including important subsystems and components. 38

#### 6.2.2.1.2 Containment Emergency Sump Design Bases:

The Containment emergency sump meets the following design bases:

1. Sufficient capacity and redundancy to satisfy the single-failure criteria. To achieve this, each CSS/ECCS train draws water from a separate Containment emergency sump. 38

2. Capable of satisfying the flow and net positive suction head (NPSH) requirements of the ECCS and the CSS under the most adverse combination of credible occurrences. This includes minimizing the possibility of vortexing in the sump.

3. Minimizes entry of high-density particles (specific gravity of 1.05 or more) or floating debris into the sump and recirculating lines.

4. Sumps are designed in accordance with RG 1.82, proposed revision 1, May 1983. 38

6.2.2.1.3 Fission Product Removal Design Basis: The Spray Additive Subsystem is:

1. Designed to add sodium hydroxide to the Containment spray solution to remove iodine from the Containment atmosphere and ensure ~~a minimum~~ an equilibrium sump solution pH of ~~(later).~~ 7.5 to 10.0.

2. Designed such that it will tolerate a single active failure.

3. Designed to accommodate the OBE within stress limits of applicable codes and to withstand the SSE without loss of function.

4. Designed to assist in reducing offsite exposures resulting from a DBA to less than the limits of 10CFR100 by rapidly reducing the airborne elemental iodine concentration in the Containment following a DBA. 38 38

5. Classified SC 3.

### 6.2.2.2 System Design Description.

6.2.2.2.1 Reactor Containment Fan Cooler System Description: The RCFC System is shown on Figure 6.2.2-4. The RCFC units are designed to remove heat from the Containment during both normal operation and accident conditions. System operation and design requirements that are associated with the normal

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water. The sodium hydroxide is added to the spray water until the spray additive tank is empty or until the RWST water reacnes low-low level, whichever occurs first.

The CSS is actuated by a Containment Hi-3 pressure signal. Manual operation is not required during any mode of operation, but the ability to operate the system from the control room is provided. Descriptions of the actuation system are provided in Section 7.3. The setpoints ~~(see Chapter 16)~~ are established at a level to prevent inadvertent operation of the system and yet provide assurance that the design pressure of the Containment is not exceeded.

Insert 1

A steam line break or LOCA generates a SI signal, which starts the DGs as described in Section 6.2.2.2.1. ~~With a LOOP,~~ the ESF load sequencers allow the starting of the CSS pumps between 15 and 17 seconds following the ~~DG breaker closure.~~ start of the load sequencing If the Containment Hi-3 signal is not received by 17 seconds, the starting of the CSS pumps is delayed to 40 seconds following the ~~DG breaker closure.~~ start of the load sequencing After this delay period, receipt of a Containment HI-3 signal starts the CSS pumps. The actuation of the CSS discharge valves to the spray headers and the valves in the outlets of the additive tanks is delayed one second following the ~~DG breaker closure~~ start of the load sequencing with LOOP, after which receipt of a Containment HI-3 signal opens the valves; without LOOP the valves open immediately on receipt of the HI-3 signal. 38

~~Without a LOOP, the CSS pumps are sequenced as above without the ten second delay for DG starting. The CSS valves open upon receipt of the Containment Hi-3 signal without delay.~~

The transit time for the water to reach the last nozzle and for full spray to be developed is a maximum of 54.1 seconds following the starting of the CSS pumps and opening of the CSS pump discharge valve. The CSS pump discharge valve maximum opening time is fifteen seconds. 44 38 44

On actuation, approximately 5 percent of each spray pump discharge flow is diverted through each spray additive eductor to draw sodium hydroxide from the tanks. This sodium hydroxide solution then mixes with the liquid entering the pump suction, and the resulting spray solution is suitable for removal of iodine from the Containment atmosphere. Q312.12

6.2.2.2.2.1 Component Descriptions - Tables 3.2.A-1 and 3.2.B-1 lists safety classification, seismic category, and code requirements for the CSS and Spray Additive Subsystem components. The load combinations and transients to which these components are designed are discussed in Section 3.9. Environmental qualification of the components is discussed in Section 3.11. Seismic qualification is discussed in Section 3.10. 38 38

The RWST serves as a source of borated cooling water for initial spray operation and safety injection. During refueling operations, the RWST is aligned to fill the refueling canal and the refueling cavity for refueling operations. During normal operation, the RWST is aligned to the suction connections of the ECCS pumps and CSS pumps. 38

6.2.2.2.2.1.1 Containment Spray Pumps - The Containment spray pumps are the vertical centrifugal type, driven by electric motors. The pumps are designed to perform at rated capacity against a total head composed of Containment design pressure, spray nozzle elevation head, line losses, and spray nozzle pressure losses. Adequate NPSH is available with a minimum level in the RWST during the injection phase. A discussion of NPSH requirements is provided in Section 6.2.2.3.5. 38

Insert 1 to page 6.2-35

With a LOOP, the ESF load sequencers delay sequencing of loads until closure of the DG breaker. Without a LOOP, the sequencers begin sequencing of loads onto offsite power immediately, as discussed in Section 8.3.

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6.2.2.2.2.1.2 <u>Spray Additive Tanks</u> - The stainless steel tanks contain a sufficient 30-32 ~~(later)~~ weight-percent of sodium hydroxide solution to bring the Containment sump fluid to a minimum equilibrium pH of 7.5 ~~(later)~~ upon mixing with the borated water from the RWST, the accumulators, and the reactor coolant. This assures continued iodine removal and retention effectiveness of the Containment sump water during the recirculation phase. A blanket of pressurized nitrogen is maintained in the three tanks. 38

6.2.2.2.2.1.3 <u>Spray Additive Eductor</u> - Sodium hydroxide is added to the spray liquid by a liquid jet eductor, a device that uses the kinetic energy of a pressurized liquid to entrain another liquid, mix the two, and discharge the mixture against a pressure head. The pressurized liquid in this case is the spray pump discharge, which is used to entrain the sodium hydroxide solution and discharge the mixture back into the suction of the spray pumps. The eductors are designed to limit the sodium hydroxide in the spray mixture to a maximum pH of 10.5.

6.2.2.2.2.1.4 <u>Spray Nozzles</u> - The CSS spray nozzles are distributed on spray ring headers located in the uppermost part of the Containment in such an array that the maximum volume of the Containment is sprayed. The spray nozzles are hollow-cone type, with a 3/8-in-diameter orifice, and are fabricated from stainless steel. The nozzle atomizing capability is discussed in Section 6.5.2. 38

6.2.2.2.2.1.5 <u>Spray Headers</u> - A plan view of the Containment spray headers is shown on Figure 6.2.2-3. Spray nozzle location and orientation are also shown.

~~The STP is provided with~~ Four concentric Containment spray headers ~~in each~~ are provided. ~~RCBs~~ Piping to the spray headers from the Containment spray pumps and valving arrangement assures delivery of 100 percent of the required spray flow assuming any single active failure.

38

The spray pattern is determined using Spraco 1713-A nozzles. The spray headers are located as high as possible in the Containment without allowing interruption of spray pattern by impingement on the dome. 38

6.2.2.2.3 <u>Containment Emergency Sump Description</u>: The Containment emergency sumps are represented on the piping diagrams for the Safety Injection System (see Figures 6.3-1 through 6.3-~~24~~3) and are illustrated in Figure 6.2.4-2. There are three independent sumps to serve as reservoirs and provide suction to the ECCS and CSS pumps during the recirculation phase post-DBA. Each sump is stainless steel lined and is covered with a two-stage steel-framed screen composed of: 5 Q22. 13 38

1. Grating of stainless steel with a 4-in. by 1-3/16-in. opening (80 percent open area).

2. Screen of stainless steel plate with 1/4-in.-diameter perforations at 5/16-in. center-to-center (58 percent open area).

The sump assemblies are protected by a removable stainless steel cover. The screen and stainless steel cover are bolted to the floor over the sump. The sumps are located at Elevation -11 ft 3 in. The sumps are physically 5 Q22. 13

separated from each other with no high-energy piping in the area. The floor around the emergency sumps slopes away from them and toward normal sumps located in the area. The drains from the upper levels of the Containment Building do not terminate in the immediate area of the sumps. 5 Q22.13

The sump structures are designed to withstand the SSE without loss of structural integrity.

Water entering the suction pipe at the bottom of the sump may contain a negligible amount of small particles (less than 1/4-in. in diameter). These particles cannot clog the containment spray nozzles (3/8-in. orifice diameter) which are the smallest restrictions found in any system served by the sump. 38

At the beginning of the recirculation phase, the minimum water level above the Containment floor is approximately 3.6 ft. In accordance with RG 1.82, proposed revision 1, May 1983, the sump screens are designed to limit flow velocities to 0.2 ft/sec. The velocity is limited to permit high-density particles to settle out on the floor and minimize the possibility of clogging the screens. 38

Most potential sources of debris are remote from the emergency sumps and are separated by shield walls or other partitions. Debris may be pieces of piping, insulation, or concrete and paint chips. The possibility of debris reaching the sump screens is remote. Further, the possibility of paint chips peeling off has been minimized by requiring proper surface preparation and by painting large surface components such as the Containment liner, RCS supports, floors, and structural steel with coatings which have been qualified under DBA conditions. 38

The insulation types used in the RCB are stainless steel reflective, blanket fiberglass, fully encapsulated inorganic bulk, and bulk sheathed in stainless steel. Most of the stainless steel reflective insulation is used on the reactor vessel. Most of the blanket fiberglass type is used on the piping. Fully encapsulated inorganic bulk is used for some CCWS and SG blowdown lines. Bulk insulation sheathed in stainless steel and bound with stainless steel straps is used on the CCWS supply and return lines to the RCFCs for antisweat purposes. 38

The Containment emergency sumps will be periodically inspected as delineated in the Technical Specifications. 5 Q22.13 27

### 6.2.2.3 Design Evaluation.

6.2.2.3.1 Reactor Containment Fan Cooler System Performances: The design characteristics of an RCFC are given in Table 6.2.2-2 and represent the minimum required functional capability of the cooling unit. The RCFCs are designed to meet these specifications. To assure the performance capability of the air cooling units, the manufacturers have developed analytical methods and models for design selection and for assessing the performance of the selected design. The analytical model used is presented herein.

The analytical model simulates the heat and mass transfer process in a cross-flow HX with extended surfaces or fins.

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within the secondary shield wall and below the operating floor. For the Containment volume outside the secondary shield wall, the mixing is accomplished as follows:

1. A portion of the supply air (2,000 ft$^3$/min per RCFC) is discharged outside the secondary shield wall, where it rises through various levels to be finally picked up through the RCFC return air risers. 38

2. A major portion of the recirculated air is returned to the RCFC through the return air risers, which are located at the polar crane rail level. The rising air with the action of the spray assures mixing of the Containment atmosphere above the operating floor.

Based on Containment spray and a minimum of three RCFCs in operation (total of 160,500 ft$^3$/min), the following is the sprayed volume and rate of mixing of each of the major Containment compartments: 32

1. The Containment dome compartment volume of 882,500 ft$^3$ is considered a sprayed volume. 38

2. The volume from the operating floor to the Containment spring line is 1,431,000 ft$^3$, of which 1,425,400 ft$^3$ is considered sprayed. 38 2 Q31 7

3. The region inside the secondary shield wall below El. 19'-0" consists of 281,500 ft$^3$, of which 5000 ft$^3$ is sprayed. Ninety-six percent of the total RCFC flow is delivered to this compartment, resulting in an exchange rate of approximately 61 volume changes per hour. 38

   Most of the air flows upward through the grating at El. 19'-0" into the loop compartments. A portion of the flow is through relief openings in the secondary shield wall due to pressurization. 38

4. The volume of the compartment inside the secondary shield wall including the refueling cavity between El. 19'-0" and El. 68'-0" is 232,000 ft$^3$, of which 219,600 ft$^3$ is considered sprayed. This region vents approximately 94 percent of the air discharged to region 3 above. Most of this air rises and is returned to the RCFC System through the return air risers at El. 130 ft. 38

5. The volume of the compartment in the annulus space between El. 68' and (-) 11'-3" is 734,200 ft$^3$, of which 209,600 ft$^3$ is considered sprayed. Air flow in this area is limited and is comprised of flow from inside the secondary shield wall and also from above El. 68' through grating. Approximately 10 percent of the total RCFC discharge flow circulates through this region to the ring duct at El. 2'. 38

Figure 6.2.2-13 and 6.2.2-14 show the RCFC and related ductwork. Figures 6.2.2-6 through 6.2.2-12 illustrate the CSS spray coverage at various elevations in the containment. Table 6.2.2-5 provides estimates of the spray mass flow rates in the individual regions identified above. 38

6.2.2.3.5 <u>Pump Net Positive Suction Head Requirements</u>: The minimum available NPSH for the CSS pumps is such that an adequate margin is maintained between the required and the available NPSH for both the injection and recirculation phases, ensuring the proper operation of the CSS. Recirculation operation gives the limiting NPSH requirements for the CSS pumps.

# Table 6.2.2-5

## Spray Mass Flow Rates

The spray mass flow rates for the various regions are as follows:

| | |
|---|---|
| Containment Dome Area | 29,840 lb/min |
| From Operating Floor (EL 68') To The Springline (EL 153') | 29,840 lb/min |
| Inside The Secondary Shield Wall Below El 19' | 304 lb/min |
| Inside The Secondary Shield Wall Between EL 19' And EL 68' Including The Refueling Cavity | 9,631 lb/min |
| Outside The Secondary Shield Wall | |
| EL 52' to EL 68' | 6,818 lb/min |
| EL 19' to EL 52' | 6,810 lb/min |
| EL (-)2' to EL 19' | 2,352 lb/min |
| Below EL (-)2' | 1,825 lb/min |

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The nozzles can be tested using the available air test connections. A special test tap is available to provide testing capability to ensure unrestricted flow.

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The spray eductors are tested individually by opening the valves in the miniflow lines and the valve in the eductor test line, closing the valve to the spray additive tank, and running the respective pump. The operator observes the eductor suction flow during the test. (The eductors have no moving parts. Each of these lines is provided with a flow meter. Instrumentation is also available for spray pump suction and discharge pressures and discharge flowrate.

The motor operated spray pump discharge isolation valves can be opened periodically for testing. 38

The spray additive tank isolation valves can be opened periodically for testing. The contents of the tank are periodically sampled to determine that the required solution composition is maintained.

Any abnormalities discovered during the surveillance testing will be corrected in accordance with the time requirements specified in the Technical Specifications.

6.2.2.4.3 Environmental Qualification Test of Motors: Discussed in Section 3.11.

6.2.2.5 Instrumentation Requirements.

6.2.2.5.1 Containment Spray System: Instrumentation and associated logic circuitry employed for initiation of the CSS are discussed in Section 7.3.

Containment spray injection is initiated either manually from the control room or on coincidence of two sets out of four Hi-3 Containment pressure signals. The spray actuation signal starts the spray pumps (start permissive is also required from the sequencer) and opens the discharge valves to the spray headers and the spray additive tank (SAT) outlet valves. ~~The recirculation phase of spray operation is actuated by control logic which receives the initiation signal (low-low) from the RWST level transmitter. This logic opens the Containment sump isolation valves allowing the ECCS and CSS pumps to take suction from the Containment sump. The low-low level signal from each spray additive tank closes its respective outlet valve automatically.~~ 38

Insert 2 →

The following describes the instrumentation that is used for monitoring the system during normal and post-LOCA operating conditions:

1. Containment Emergency Sump Water Level - Each sump is provided with a level transmitter which gives control room indication through the Qualified Display Processing System. 38

2. Refueling Water Storage Tank Level - Three level transmitters are provided with control room indication for each transmitter. An annunciator alarm is provided for high, low, low-low, and empty conditions. The low-low signal is provided for automatic switchover to the recirculation mode of CSS and ECCS operation, and isolation of the SAT outlet valves. 38

# Insert 2 to page 6.2-42

The recirculation phase of spray operation is actuated by the automatic recirculation signal, which is the SI signal concurrent with a low-low RWST level signal from the RWST level transmitter associated with the actuation train. This signal opens the containment sump isolation valves allowing the ECCS and CSS pumps to take suction from the containment sump. The RWST low-low level signal closes the Spray Additive Tank outlet valve for the actuation train. In addition, the low-low level signal from each SAT closes its respective outlet valve automatically, if not already closed in response to an RWST low-low level.

3. Containment Spray Pump Pressure - Each pump is provided with local suction and discharge pressure indicator.

4. Containment Spray Pump Flow - Each pump is provided with a discharge flow transmitter and control room flow indicator. An annunciator alarm is provided for low flow. 38

5. System Flow Testing Instruments - A local flow indicator is provided on the line joining the eductor motive fluid outlet and the eductor suction line. A local flow indicator is provided on the recirculation flow line back to the RWST for testing the containment spray pumps.

6. Spray Additive Tank Level - Each tank is provided with a level transmitter and control room level indicator. An annunciator alarm for high and low level is provided. 38

7. Spray Additive Tank Pressure - Each tank is provided with a pressure transmitter and a control room pressure indicator. An annunciator alarm for high and low pressure is provided. 38

8. Spray Additive Tanks Nitrogen Supply Header Pressure - The Supply header is provided with a local pressure indicator. 38

9. Containment Pressure ~~and Temperature~~ - Six Containment pressure transmitters with control room indication provided through the Qualified Display Processing System ~~and a temperature indicator~~ are employed as diverse instruments to indicate the effectiveness of the system in cooling the Containment atmosphere. Temperature indication, although nonqualified, may also be used in determining the cooling effectiveness. 38

6.2.2.5.2 Reactor Containment Fan Cooler System: Instrumentation and associated logic circuitry employed for initiation of the RCFC System are discussed in Section 7.3.

The following describes the instrumentation that is used for monitoring the system during normal and post-LOCA operating conditions:

1. Cooling Water Temperature - Each cooling water loop is provided with a temperature sensor. Temperature monitoring is provided in the control room. 32

2. Cooling Water Flow - Each cooling water loop is provided with a flow transmitter and control room indicator.

3. Cooler Air Temperature - Each air cooler is provided with a temperature sensor on the inlet and outlet. Temperature indicators are provided in the control room.

4. Fan - Each fan is provided with an indicating, differential pressure switch. The switch provides an annunciator alarm in the control room and is also monitored on the Emergency Response Facilities (ERF) computer. 38

5. Each fan motor assembly is provided with a vibration sensor and control room alarm. 38

## TABLE 6.2.2-1

## CONTAINMENT SPRAY SYSTEM - DESIGN PARAMETERS INCLUDING SPRAY ADDITIVE SUBSYSTEM)

| | | |
|---|---|---|
| **Containment Spray Pump** | | |
| Type | Vertical centrifugal | |
| Quantity | 3 | |
| Design pressure, psig | 495 | |
| Design temperature, °F | 300 | |
| Design flowrate, gal/min | 1,900 | |
| Design head, ft | 560 | |
| **Eductors** | | |
| Quantity | 3 | |
| Eductor inlet fluid | Borated water | |
| Operating fluid | Borated water | |
| Operating temperature | 265 °F (Max) | |
| Eductor suction fluid | ~~(later)~~ 30-32 wt % NaOH in $H_2O$ solution | |
| Suction fluid Specific gravity | ~~(later)~~ 1.339 - 1.360 | 38 |
| Operating temperature | Temperature of spray additive tank | |
| normal max/min | 104°F/65°F | |
| accident | 120°F | |
| **Spray Additive Tanks*** | | |
| Number | 3 | |
| Total volume, gal | 1,750 | |

---

* During normal conditions, there is a nitrogen gas blanket. During the accident, the tank pressure will fall below atmospheric pressure.

TABLE 6.2.2-1 (Continued)

CONTAINMENT SPRAY SYSTEM - DESIGN PARAMETERS
INCLUDING SPRAY ADDITIVE SUBSYSTEM)

**Spray Additive Tanks** (Continued)

| | | |
|---|---|---|
| Minimum required additive volume, gal | ~~1,314~~ 1008 | 38 |
| ~~Minimum~~ NaOH concentration, wt % | ~~Later~~ 30-32 | 38 |
| Design temperature, °F | 200 | |
| External design pressure, psig | 15 | |
| Internal design pressure, psig | 100 | |
| Operating temperature, °F | ~~Ambient~~ | |
| Normal ~~Accident~~ (max/min) | (104°F/65°F) | 38 |
| Accident (max) | 120°F | 38 |
| Material | Stainless steel | |

6.5.2.1 Design Bases. The design bases of the CSS for removing iodine from the Containment atmosphere are:

1. GDC 41, as related to Containment atmosphere cleanup.

2. GDC 42, as related to inspection of Containment atmosphere cleanup systems.

3. GDC 43, as related to testing of Containment atmosphere cleanup systems.

4. The CSS is capable of functioning effectively with the single failure of any active component in the system, any of its subsystems, or any of its support systems.

5. The CSS is designed to obtain adequate coverage of the Containment volume in order to limit (in conjunction with other safeguards systems) the offsite thyroid doses to a limit less than that established by 10CFR100, using the assumptions in RG 1.4.

6. The spray nozzles are designed to minimize the possibility of clogging and to produce droplet sizes effective for iodine absorption. 3

7. The pH of the injection spray is in the range of ~~(later)~~ 7.5 to 10.5. The equilibrium pH of the Containment sump is ~~(later)~~ 7.5 to ~~9.5.~~ 10.0 38

6.5.2.2 System Design. The CSS design is discussed in detail in Section 6.2.2.

Sodium hydroxide solution is added to the Containment spray solution to raise the pH of the spray solution and the sump solution to values consistent with the above design basis #7. The effects of the increased pH levels are to increase the iodine removal capability of the spray and the iodine retention in the sump. 38

Before the refueling water storage tank is emptied, the Containment spray pump suctions are switched automatically to the Containment emergency sumps. At the same time the SAT outlet valves are isolated.

The number of nozzles and the nozzle spacing on each header is given in Section 6.2.2. A schematic of the headers illustrating the nozzle orientations is given on Figure 6.2.2-3. A description of the spray additive system is provided in Section 6.2.2.2.2. 38

The total free volume of the Containment and the portion unsprayed are given in Table 6.5-2; the spray uniformly covers approximately 77 percent of the total Containment free volume. The regions covered by the Containment spray are discussed in Section 6.2.2.3.4.

The system meets the redundancy requirements of an ESF ~~S~~ystem and satisfies the system performance requirements despite the most limiting single active failure. Included in the performance requirements is consideration of maximum concentration and volumes for the post-LOCA Containment sump water sources. 38

The chronology of events for system operation is discussed in Section 6.2.2. 27

6.5.2.3 Design Evaluation. The CSS is an ESF system employed to reduce pressure and temperature in the Containment following a postulated LOCA. For this purpose, subcooled water is sprayed into the Containment atmosphere through a large number of nozzles from spray headers located in the Containment dome.

The large spray drop surface to Containment volume ratio enables the spray to effectively remove fission products postulated to have been dispersed in the Containment atmosphere. 38 (Radioiodine in its various forms is the fission product of primary concern in the evaluation of a LOCA.) The major benefit of the CSS is its capacity to remove iodine from the Containment atmosphere. To enhance ~~ennce~~ this iodine absorption capacity of the spray, the spray solution is 27 adjusted to an alkaline pH which promotes iodine hydrolysis to nonvolatile forms.

According to the known behavior of elemental iodine in highly dilute solutions, the hydrolysis reaction 3

$$I_2 + OH^- \rightleftarrows HIO + I^-$$

proceeds nearly to completion (Ref. 6.5.2-1) at pH>8. The iodine form is highly soluble, and HIO readily undergoes additional reactions to form iodate.

The overall reaction is:

$$3I_2 + 3H_2O \rightleftarrows 5HI + HIO_3$$

Values for the spray removal half-life of the elemental iodine in a typical Containment are on the order of minutes or less. Most of the iodine released to the Containment is assumed to be elemental form. The remainder is assumed to be in the organic and the particulate form. As discussed above, the 38 Containment spray is very effective in removing airborne elemental iodine. No credit is taken for spray removal of the organic ~~or particulate~~ form~~s~~ of iodine. However, the particulate iodine ~~would be~~ was removed by the spray, but at a rate much lower than for elemental iodine.

6.5.2.3.1 Containment Spray Elemental Iodine Removal Model: Containment spray iodine removal performance was determined using the spray model developed by Westinghouse Electric Corporation (Westinghouse). This model includes the effects of spray drop-size distribution, droplet coalescence, and liquid phase mass transfer resistance. Its use results in conservative values of spray iodine removal constants when compared with test results.

6.5.2.3.1.1 Method of Calculation - The elemental iodine removal capability of the Containment spray is described in terms of individual spray droplets. The behavior of the aggregate spray is related to the behavior of the individual drops by means of a drop size distribution function. An advantage to using this microscopic approach is the ability to derive the model 38 from first principles. Thus, the model is free of scaling factors which would be required to extrapolate laboratory data to a full-size Reactor Containment.

6.5.2.3.1.2 Drop-Size Distribution - The drop-size distribution used in the model is based on data obtained from measurements of the actual size distribution from the Spraco 1713A nozzle for a 40 psi pressure drop. 38

Analysis of these drop-size measurements shows that the drop-size distribution from this nozzle may be represented by a continuous distribution function, which is used as the input to the computer code. The spray drop size distribution is shown in Figure 6.5-2.

6.5.2.3.1.3 Condensation - As the spray solution enters the high-temperature Containment atmosphere, steam condenses on the spray drops. The amount of condensation is easily calculated by a mass and energy balance of the drop: 38

$$m + m_c = m'$$

$$mh + m_c h_g = m'h_f$$

where:

m and m' = Mass of the drop before and after condensation, lb

$m_c$ = Mass of condensate, lb

h = Initial enthalpy of the drop, Btu/lb

$h_g$ and $h_f$ = Saturation enthalpy of water vapor and liquid, Btu/lb

The increase in each drop diameter in the distribution, therefore, is given by:

$$\left(\frac{d'}{d}\right)^3 = \frac{v_f}{v} \cdot \frac{h_{\textcircled{g}} - h}{h_{fg}}$$

where:

$v_f$ = Specific volume of liquid at saturation, $ft^3/lb$

v = Specific volume of the drop before condensation, $ft^3/lb$

$h_{fg}$ = Latent heat of evaporation, Btu/lb

$h_g$ = Enthalpy of steam at saturation, Btu/lb

d = Drop diameter before condensation, cm

d' = Drop diameter after condensation, cm

The increase in drop size due to condensation is expected to be complete in a few feet of fall for the majority of drop sizes in the distribution. More detailed calculations by Parsly (Ref. 6.5.2-2) show that even for the largest drops in the distribution, thermal equilibrium is reached in less than half of the available drop fall height. The change in the drop-size distribution due to condensation was conservatively modeled by a step increase to the equilibrium size immediately after the drops emerge from the nozzle.

affected most. This is expected since these sizes have the highest density of drop population. Due to the considerably larger volumes of the larger diameter drops, however, the increase in the larger drop population is not very pronounced.

The resulting change in drop-size distribution is taken into consideration in the mass transfer model described below.

6.5.2.3.4 Mass Transfer Model: Containment spray system performance is evaluated using a spray model developed by Westinghouse. The model considers the effects of spray drop size distribution, droplet coalescence, gas and liquid phase mass transfer resistance, drop trajectories, and condensation of steam of drops.

The CIRCUS (Calculation of Iodine Removal in the Containment Using Spray) computer code is used to analyze the elemental iodine removal effectiveness of the Containment spray system. 38

The model used to determine iodine removal capability is the complete mixing model wherein the mass transfer resistance in the liquid phase of the drops is neglected, i.e., mixing within the drops is assumed to eliminate any concentration gradient. A description of the mathematical model is provided in Ref. 6.5.2-3.

6.5.2.3.5 Experimental Verification of the Model. To demonstrate that the model described above conservatively estimates actual spray performance, 38 the Westinghouse model was applied to the test runs made at Oak Ridge National Laboratory (ORNL) and Battelle Northwest Laboratories. Comparison of the results of these tests with the above-described spray removal model shows the spray removal model to be conservative in all cases.

6.5.2.3.6 Spray Performance Evaluation.

6.5.2.3.6.1 Spray Iodine Removal During The Injection Phase: The spray iodine removal analysis is based on the conservative CSS parameters outlined in Table 6.5-2. The total Containment volume and sprayed volume are consistent with those values used for the LOCA offsite dose analysis described in Section 15.6.5. The Containment temperature and pressure used for this analysis are consistent with the design values outlined in Section 6.2.

During the injection phase the spray solution pH is maintained between ~~(later)~~ 7.5 and 10.5 based on conservative parameters listed in Tables 6.5-3 and 6.5-4. 38

The elemental iodine removal constant for the CSS, using the model described above together with the parameters given in Table 6.5-2, is ~~20.3~~ 18.8 hr$^{-1}$.

~~In calculating the design base radiological consequences for the LOCA, the elemental iodine removal constant of 20.3 is not used. Instead, the guidelines of Ref. 6.5.2-4 are followed. It is assumed that half of the core inventory of iodine is released to the Containment and half of this iodine immediately plates out on surfaces in the Containment. The remaining airborne elemental iodine is assumed subject to a removal term of 10 hr$^{-1}$.~~ 38

At the beginning of the injection phase, the sump contains borated water which has a pH of approximately 5.5. As sodium hydroxide is added to the sump solution by the Containment sprays, the pH quickly increases to the alkaline range ~~(later)~~ despite the addition of large volumes of borated water to the sump. ~~(see Figure 6.5-1) which is based on the assumptions and parameters listed in Table 6.5-3. This sump solution supports a decontaimination factor (DF) of (later) for the removal of elemental iodine from the Containment atmosphere by the sprays. No further iodine removal credit is taken once the DF of (later) is reached.~~ Using the most conservative assumption (see Table 6.5-3), the minimum sump pH at the end of the injection phase is 7.5 (see Figure 6.5-1). The transfer of the sodium hydroxide solution from the spray additive tanks to the Containment sump is ~~not~~ complete at the end of the injection phase. ~~The remaining sodium hydroxide solution is added to the Containment sprays during the recirculation phase.~~ Insert X

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38

6.5.2.3.6.2 ~~Recirculation Phase: At the end of the injection phase the suction for the Containment spray pumps is switched from the refueling water storage tank (RWST) to the Containment sump. Initially, the recirculation phase Containment spray will be at a pH of (later) which is the minimum pH of the sump solution when using the assumptions and parameters in Table 6.5-3. After the sump solution temperature decreases to approximately 160°F, the remainder of the sodium hydroxide solution is blended with the recirculating sump solution by the eductor. The eductor design ensures that the recirculation spray does not exceed pH of 10.5 when using the assumptions and parameters in Table 6.5-4. After the transfer of the spray additive to the Containment is complete, the final sump pH is between (later) and 9.5 (see Figure 6.5-1). With the pH above (later) in the sump, the elemental iodine DF limit increased to (later).~~

6.5.2.4 Tests and Inspections. The tests and inspections of the CSS are described in Section 6.2.2.4.

6.5.2.5 Instrumentation Requirements. The instrumentation application of the CSS is given in Section 6.2.2.5.

6.5.2.6 Materials. The materials used in the CSS are discussed in Section 6.1.1.

### 6.5.3 Fission Product Control Systems

Refer to Sections 6.2.2 and 6.5.2 for a discussion of the CSS. Credit is taken for the CSS as a fission product removal system.

6.5.3.1 Primary Containment. For discussion of the primary Containment structural and functional design and of the Containment systems, refer to the following sections:

| | |
|---|---|
| Concrete Containment | 3.8.1 |
| Containment Functional Design | 6.2.1 |
| Containment Heat Removal Systems | 6.2.2 |
| Containment Isolation System | 6.2.4 |

Spray Iodine Particulate Removal: The particulate spray removal ~~term~~ was developed using the methodology described in reference 6.5.2-5.

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Insert X (pg. 6.5-9)

H Following a design basis steam line break inside the Containment, the pH of the water in the Containment sump is always alkaline ~~never less than 7.0~~ due to the secondary side water having a specified minimum pH of 8.8. The addition of a sodium hydroxide solution via the Containment Spray System increases the pH. The maximum pH will be less than 10.5, which is the maximum spray pH during injection.

## REFERENCES

### Section 6.5:

6.5.1-1 Burchsted, C. A., and A. B. Fuller, "Design, Construction, and Testing of High Efficiency Air Filtration Systems for Nuclear Application," Oak Ridge National Laboratory Report No. ORNL-NSIC-65 (1970).

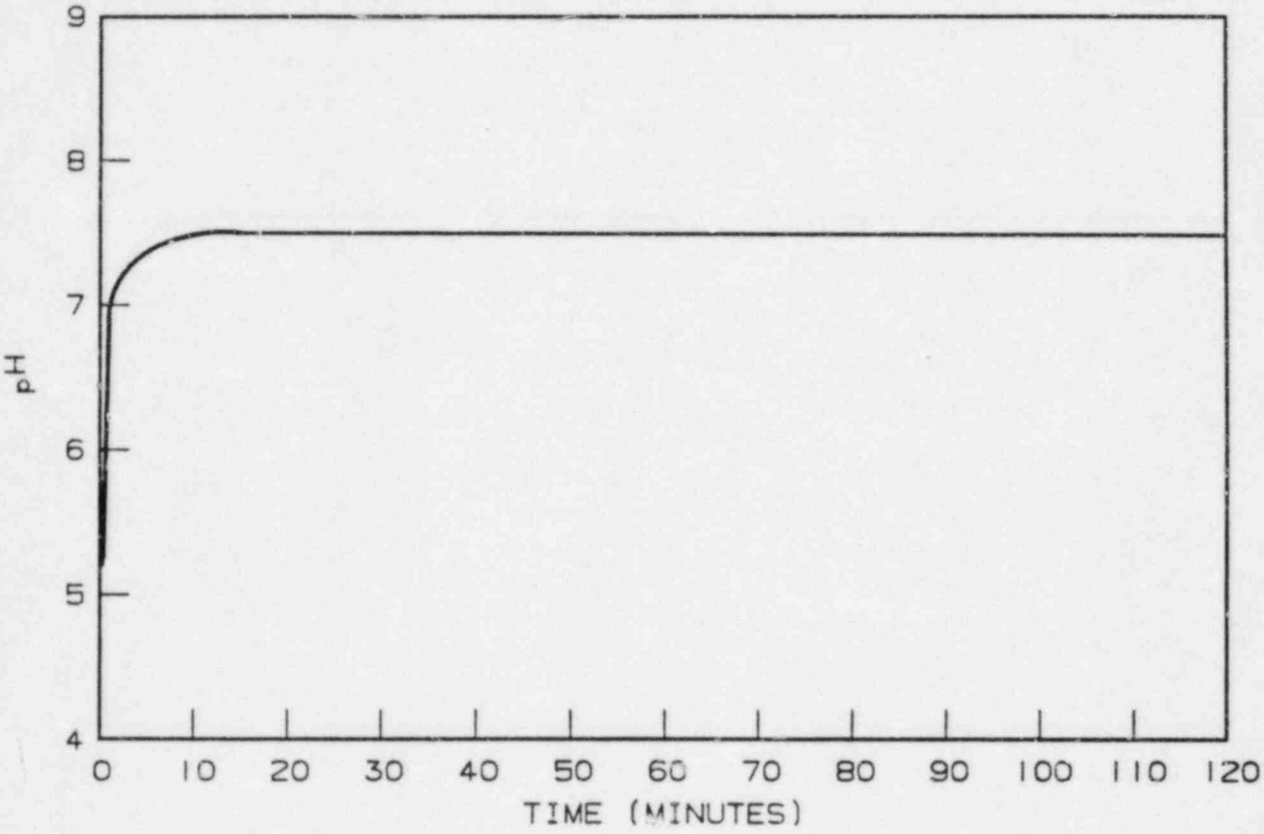
6.5.2-1 Styrikovich, M. A., et al., "Transfer of Iodine from Aqueous Solutions to Saturated Vapor," <u>Atomnaya Energiya,</u> Vol. 17, No. 1 (July 1964), pp. 45-49, (translation in UDC - 621.039.562.5).

6.5.2-2 Parsly, L. F., Jr., "Design Considerations of Reactor Containment Spray Systems - Part VI: The Heating of Spray Drops in Steam-Air Atmospheres," ORNL-TM-2412, Pt. 6 (1969).

6.5.2-3 Sanford, M.O. and E.V. Somers, "Iodine Removal by Spray in the Joseph M. Farley Station Containment," Westinghouse Electric Report No. WCAP-8376 (1974). 38

6.5.2-4 NRC Staff, "Standard Review Plan for the review of Safety Analysis Reports for Nuclear Power Plants," NUREG-75/087 (Sept. 1975), Section 6.5.2.

6.5.2-5 NUREG/CR-0009, "Technological Bases for Models of Spray washout of Air-borne Contaminants in Containment vessels.



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CONTAINMENT SUMP pH vs TIME

Figure 6.5-1

## TABLE 6.5-2

## INPUT PARAMETERS AND RESULTS OF SPRAY IODINE REMOVAL ANALYSIS

| | | |
|---|---|---|
| Power (102% of rated core power) | 3876 MWt | |
| Containment pressure | ~~48~~ 37.5 psig | |
| Containment temperature | ~~275~~ 307 °F | |
| Total Containment free volume | $3.56 \times 10^6$ ft$^3$ | 38 |
| Unsprayed Containment free volume | 23% | |
| Spray fall height | 136 ft | |
| Net spray flow (~~2~~ 3 pumps) | ~~3,600~~ ~~4,470~~ 4530 gal/min | |
| Spray solution pH (1) | ~~9.2~~ Half flow at pH = 8.0<br>Half flow at pH = 9.0 | |
| Elemental iodine $\lambda_s^{(2)}$ ~~(hr$^{-1}$)~~ | ~~20.3~~ 18.8 | 38 |

Note : (1) The limiting single failure is that of a spray additive tank discharge valve failing to open which can result in two separate pH levels simultaneously due to the three spray pumps discharging to two headers.

(2) The value of $\lambda_s$ given here represents its calculated value; however, offsite dose calculations utilize a more conservative value (see Table 15.6-10).

## TABLE 6.5-3

### Input Parameters ~~and Results of Analysis~~ to Determine ~~Maximum~~ Minimum pH for Sump Solution and Spray

| | |
|---|---|
| ~~Hi~~ High head safety injection pump flow, gal/min | ~~later~~ 1600 |
| ~~Lo~~ Low head safety injection pump flow, gal/min | ~~later~~ 2900 |
| Containment spray pump flow, gal/min | ~~later~~ 2800 |
| Number of pumps in operation | |
| ~~Hi~~ High head SI pump | ~~later~~ 3 |
| ~~Lo~~ Low head SI pump | ~~later~~ 3 |
| Containment spray pump | ~~later~~ 3 |
| Eductor suction flow, ~~maximum (1)~~ gal/min (1) | ~~later~~ 20 |
| ~~minimum~~ | ~~later~~ |
| ~~Spray additive tank volume, each of two, gal~~ | ~~later~~ |
| Concentration of NaOH in spray additive solution, wt. % | ~~later~~ 30 |
| Number of Spray Additive Tanks delivering (2) | 2 |
| RWST deliverable volume, gal | ~~later~~ 486,100 |
| RWST boron concentration, ppm | ~~later~~ 2700 |
| Accumulator water volume, each of 3, ~~ft³~~ gal | ~~later~~ 9193 |
| Accumulator boron concentration, ppm | ~~later~~ 2600 |
| Reactor coolant system water mass, ~~lb~~ lb | ~~later~~ 626,000 |
| Reactor coolant boron concentration, ppm | ~~later~~ 1550 |
| ~~Time after initiation of LOCA that sump solution temperature drops to 160°F, min~~ | ~~later~~ |

38

Note: (1) Flowrate is at the beginning of the delivery and is Conservatively low. The flowrate decreases as the level in the tank falls.

(2) Single failure is that one spray additive tank outlet isolation valve fails to open.

~~Note:~~

~~1. With motive fluid temperature above 160°F, zero suction flow is assumed.~~

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## TABLE 6.5-4

### Input Parameters ~~and Results of Analysis~~ to Determine Maximum pH for Sump Solution and Spray

| | | |
|---|---|---|
| High ~~Hi~~head safety injection pump flow, gal/min | ~~later~~ 800 | |
| Low ~~Lo~~head safety injection pump flow, gal/min | ~~later~~ 1900 | |
| Containment spray pump net flow, gal/min | ~~later~~ ~~1490~~ 1510 | |
| Number of pumps in operation | | |
| High ~~Hi~~head SI pump | ~~later~~ 3 | |
| Low ~~Lo~~head SI pump | ~~later~~ 3 | |
| Containment spray pump | ~~later~~ 3 | |
| Eductor suction flow, ~~maximum~~ ~~(1)~~ gal/min(1) | ~~later~~ 51 | |
| ~~minimum~~ | ~~later~~ | |
| Spray additive tank volume, each of ~~two~~ three, gal | ~~later~~ 1395 | |
| Spray additive tank volume delivered during injection phase, each of three, gal | 660 | |
| Concentration of NaOH in spray additive solution, wt. % | ~~later~~ 32 | |
| Number of spray additive tanks delivering(2) | 3 | |
| RWST deliverable volume, gal | ~~later~~ 359,200 | 38 |
| RWST boron concentration, ppm | ~~later~~ 2500 | |
| Accumulator volume, each of 3, ~~$ft^3$~~ gal | ~~later~~ 8770 | |
| Accumulator boron concentration, ppm | ~~later~~ 2400 | |
| Reactor coolant system water mass, ~~g~~ lb | ~~later~~ 626,000 | |
| Reactor coolant boron concentration, ppm | ~~later~~ 10 | |
| ~~Time after initiation of LOCA that sump solution temperature drops to 160°F, min~~ | ~~later~~ | |

Note: (1) Flowrate is at the beginning of delivery and is conservatively high. The flowrate decreases as the level in the tank falls.

(2) Single failure is that one spray additive tank isolation valve fails to close at the end of the injection phase.

~~Note:~~

~~1. With motive fluid temperature above 160°F, zero suction flow is assumed.~~

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## Question 312.07

In order to independently evaluate the fraction of the containment volume covered by the spray we request the following information:

1) Provide plan and elevation drawings showing the fully developed spray patterns within the containment.

2) Indicate the sprayed and unsprayed volumes within the regions identified in Section 6.2.2.3.4 and estimate the spray mass flow rate in each of these regions.

## Response

See revised Section 6.2.2.3.4, Table 6.2.2-5, and ~~and new~~ Figures ~~6.3.3-6~~ 6.2.2-6 through 6.2.2-12.

~~The spray mass flow rates for the various regions are as follows:~~

| | |
|---|---|
| ~~Containment Dome Area~~ | ~~29,840 lb/min~~ |
| ~~From Operating Floor (EL 68') To The Springline (EL 153')~~ | ~~29,840 lb/min~~ |
| ~~Inside The Secondary Shield Wall Below El 19'~~ | ~~304 lb/min~~ |
| ~~Inside The Secondary Shield Wall Between EL 19' And EL 68' Including The Refueling Cavity~~ | ~~9,631 lb/min~~ |
| ~~Outside The Secondary Shield Wall~~ | |
| ~~EL 52' to EL 68'~~ | ~~6,818 lb/min~~ |
| ~~EL 19' to EL 52'~~ | ~~6,810 lb/min~~ |
| ~~EL (-)2' to EL 19'~~ | ~~2,352 lb/min~~ |
| ~~Below EL (-)2'~~ | ~~1,825 lb/min~~ |

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Question 312.12

The ratio of spray additive flow to borated water flow determines the pH of the spray solution. Provide the magnitude of this ratio. What procedures will be used to verify (during pre-operational and routine testing) that the two flow rates would indeed be maintained at this ratio?

Response

6.2.2.2.2

~~The eductor is designed so that approximately 5 percent of the flow from each spray pump is diverted for addition of NaOH such that the resulting spray mixture does not exceed a pH of 10.5. The Spray Additive Tank isolation valve opens automatically on a Containment HI Hi-3 pressure signal, which also initiates Containment Spray System operation, and closes automatically when the tank contents are depleted. The tanks are sized such that, even with a failure of one of the three spray trains, there is sufficient NaOH to bring the containment sump fluid to a minimum pH of (later). at the end of the injection phase or when the SAT contents are depleted whichever occurs first.~~ 38

6.2.2.4.2
14.2.12.2(79)

~~As described in Section 6.2.2.4.2, the spray eductors can be tested individually by opening the valves in the miniflow and eductor test lines and running the respective spray pumps. Each of these lines is provided with a flow meter, and instrumentation is also available for spray pump suction and discharge pressures and discharge flowrate. During preoperational testing (described in Section 14.2.12.2), the eductor is verified to be operable by pumping the Spray Additive Tank contents to the RWST (via the mainiflow line). This is part of the Containment Spray System testing which also verifies all controls, alarms, and interlocks, including tank level instrumentation and alarms and automatic valve actuation. During periodic testing, the Spray Additive Tank isolation valve is closed while the other portions of the eductor piping are tested. The availability of this remaining section of eductor piping may be confirmed by draining a small amount of fluid from the tank through the sample line valve.~~ 38

The ratio of spray additive flow to borated water flow is addressed in Section 6.2.2.2.2. See Sections 6.2.2.4.2 and 14.2.12.2 (79) for routine and preoperational testing requirements, respectively.

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## Question 312.13

It does not appear that heat tracing is provided in the chemical additive tank, even though the NaOH solution may have a concentration greater than 30 weight percent. Provide your reason for the omission of heat tracing, or provide suitable design changes.

## Response

~~The NaOH solution in the Spray Additive Tanks is maintained between concentration of~~ 30-32 ~~(later) weight percent. The solubility limit for this concentration is approximately~~ 41°F ~~(later). The Spray Additive Tanks are located in a heated building (the Fuel Handling Building) that is maintained above 65 F during normal plant operation.~~ 38

See Section 6.1.1.2 for the spray additive chemistry.

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## Question 122.20

For all postulated design basis accidents involving release of water into the Containment Building, estimate the time-history of the pH of the aqueous phase in each drainage area of the building. Identify and quantify all soluble acids and bases within the Containment.

## Response

~~Following a design basis loss-of-coolant accident, the pH of the water in the Containment emergency sump is rapidly raised above 7.0 by the injection of a sodium hydroxide solution through the Containment Spray System. At the end of the injection phase of the accident, the containment sump solution pH is at or above~~ 7.5 ~~(later) and, as there are no significant amounts of additional soluble acids or bases located within the Containment, the pH should remain stable at this value. The estimated time history of the Containment sump solution pH following a design basis loss-of-coolant accident is shown in Figure 6.5-1.~~ 39

~~Following a design basis steam line break inside the Containment, the pH of the water in the Containment sump is~~ always alkaline ~~never less than 7.0 due to the secondary side water having a specified minimum pH of 8.8. The addition of a sodium hydroxide solution via the Containment Spray System increases the pH. The maximum pH will be less than 10.5, which is the maximum spray pH during injection.~~

See Section 6.5.2.3.6.1.

TABLE 7.1-2 (Continued)

PLANT COMPARISON

| ALL OTHER SYSTEMS REQUIRED FOR SAFETY | DIFFERENCES FROM COMANCHE PEAK NUCLEAR STATION |
|---|---|
| 1. Switchover from Injection to Recirculation (Section 7.6.4) | 1A. Comanche Peak uses 4 RWST transmitters and a 2/4 coincidence logic to initiate the automatic switchover after an accident which generates an SI signal.<br>STP uses 3 level transmitters; each transmitter interfaces with one train of pumps (1/1 logic) to initiate the automatic switchover to recirculation (coincident SI signal required). |
| | 1B. On Comanche Peak, only the RHR pump suctions are automatically switched from the RWST to the Containment sumps. Manual actions are necessary to transfer the pump suctions for the safety injection, centrifugal charging and containment spray pumps from the RWST. On STP, because of the ECCS/CSS pump suction design, all pumps are automatically switched to sump suction on RWST low-low level (coincident SI signal required). Only manual closure of the RWST outlet valves is needed thereafter, to back up the check valves also provided. The RWST low-low level signal closes the Spray Additive Tank outlet isolation valves. |
| 2. Containment Hydrogen Monitoring System (Section 7.6.5) | 2A. Comanche Peak uses 2 analyzers to monitor Containment hydrogen concentrations in both units. Four sample points are monitored in each Containment, with 2 points monitored by one analyzer and 2 points monitored by the other analyzer.<br>STP analyzers are completely separate between the units. Each unit has 2 separate analyzers, with each analyzer capable of monitoring 4 sample points (manually selected.) |

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These normally open motor-operated valves have ESF monitoring alarms indicating a mispositioning with regard to their emergency core cooling function. In addition, an annunciator system, as discussed in Section 6.3.5.5, is provided to alert the operator when an accumulator discharge isolation valve is closed when the RCS pressure is above the P-11 setpoint. 29 Q430 18N

When the reactor is at power, except during the tests described above, these valves are open and power to the valve operator is locked out. During plant shutdown, the accumulator valves are in a closed position. To prevent an inadvertent opening of these valves during that period, the accumulator valve breakers should be opened. Refer to Section 6.3.5.5 for discussion on power lock-out for these valves. Administrative control is again required to ensure that these valve breakers are closed during the prestartup procedures. 43

### 7.6.4 Switchover From Injection To Recirculation

The automatic signal for switchover to recirculation from the injection phase during LOCA is derived from the Refueling Water Storage Tank (RWST) low-low level signal coincident with the latched Safety Injection (SI) signal. This signal is provided by the Solid State Protection System (SSPS). The functional logic diagram showing this feature is presented in Figure 7.6-9. Open-closed status lights are provided on the main control board for each miniflow valve, Containment sump isolation valve, and RWST isolation valves. 43

The automatic switchover signal actuates the following ECCS components: 14 Q032.36

1. Close the high head and the low head SI pumps miniflow motor-operated valves (MOV) when the automatic signal is generated and the Main Control Board (MCB) manual switches for the miniflow MOVs are in the automatic position. Refer to Figure 7.6-4 for the logic diagram.

2. Open the Containment sump isolation MOVs when the automatic signal is generated and the appropriate signals showing closure of the miniflow valves are received. Refer to Figure 7.6-5 for the logic diagram. 43

3. Initiate alarm in the main control room to notify the operator that switchover has commenced.

Further information regarding the switchover from the injection mode to the recirculation mode is given in Section 6.3.2.8. Also, during on-line test of the automatic recirculation switchover signal, the test switchover signal is blocked as long as the RWST isolation valve is open. Interlocking between testing and closure of the RWST isolation valve (XSI0001 A, B and C) is provided in the Safeguards Test Cabinets. 43

Additionally, the SIS includes an interlock which prevents the RWST isolation valves from being opened when the MCB manual switch is turned by operator action to open unless the corresponding sump isolation valve is closed (See Figure 7.6-6). 43

7.6.4.1 <u>Analysis of Switchover to Recirculation from Injection Phase During LOCA</u>. This automatic feature assures that minimal operator action is required for 13 hours after an accident. This is further discussed in Section 6.3.2.8. Functionally, the switchover to recirculation from injection phase 43

(During the switchover, the spray additive tank isolation valves are closed by the RWST low-low level signal when the MCB switches are in the auto position (refer to Figure 7.6-14 for the logic 7.6-5 diagram).

7.6.6.5 Volume Control Tank Low-Low Level Interlock. The Volume Control Tank (VCT) low-low level interlock uses the two VCT level transmitters to sense low-low level and controls the two VCT outlet isolation valves and the two suction valves from the Refueling Water Strange Tank (RWST) to the charging pumps. These valves are shown on Figure 9.3.4-3 as XCV0113A, XCV0112B, XCV0112C and XCV0113B. This control system insures that the charging pumps always have a source of fluid during normal plant operation and protects them against loss of net positive suction head (NPSH) and consequent cavitation damage. Upon reaching the low-low level setpoint in the VCT, the RWST suction valve is opened and the VCT outlet isolation valve is closed, transferring suction from the VCT to the RWST. (This same action is performed upon receipt of the SI signal.)

The VCT low-low level interlock signal for each pair of valves is channelized into independent and redundant protection sets, to improve reliability. Valves XCV0112B and XCV0112C are powered from Train C Class 1E sources and receive the low-low level signal from LT-112 in Protection Set IV via actuation Train C. Valves XCV0113A and XCV0113B are powered from Train B Class 1E sources and receive their signal from LT-113 in Protection Set III via actuation Train B.

The logic diagrams for the VCT outlet isolation valves and RWST suction valves to the charging pumps are shown on Figures 7.6-12 and 7.6-13 respectively. When the main control board switch is in the AUTO position, each RWST suction valves is opened upon receipt of the low-low level signal (or the SI signal). 43 Each VCT outlet isolation valve is closed upon receipt of the signals; the interlock also prevents each VCT outlet isolation valve from closing unless its corresponding RWST suction valve to the charging pumps is open.

7.6.6.6 Spray Additive Tank Low-Low Level Interlock. The spray additive tank low-low level interlock closes the tank's isolation valve when the fluid level is below a preset value. The purpose of this interlock is to preclude nitrogen (the tank cover gas) from being drawn into the suction of the containment spray pumps (via the eductor). The spray additive tank isolation valve also receives the RWST low-low level signal to ensure proper spray and sump pH.

The spray additive tank low-low level interlock signal for each valve is channelized into independent redundant protection sets. Containment spray pump A and the tank A isolation valve are powered ~~form~~ from Train A Class 1E power sources; the valve is closed by the tank's Protection Set I level transmitter via actuation Train A. Similarly the B pump and valve are powered from Train B sources; the valve is closed by the Protection Set III level transmitter (on tank B) via actuation Train B. The C pump and valve are powered from Train C sources; the valve is closed by the Protection Set IV level transmitter (on tank C) via actuation Train C.

The logic diagram for the spray additive tank isolation valve is shown on Figure 7.6-14. When the main control board switch is in the AUTO position, each valve is opened upon receipt of the containment spray actuation signal; the valve is the closed upon receipt of the spray additive tank low-low level signal.

7.6.6.7 CVCS Seal Injection Isolation Valves Charging Header Pressure Interlock. The charging header pressure interlock closes the CVCS seal water injection Containment isolation valves when the Containment

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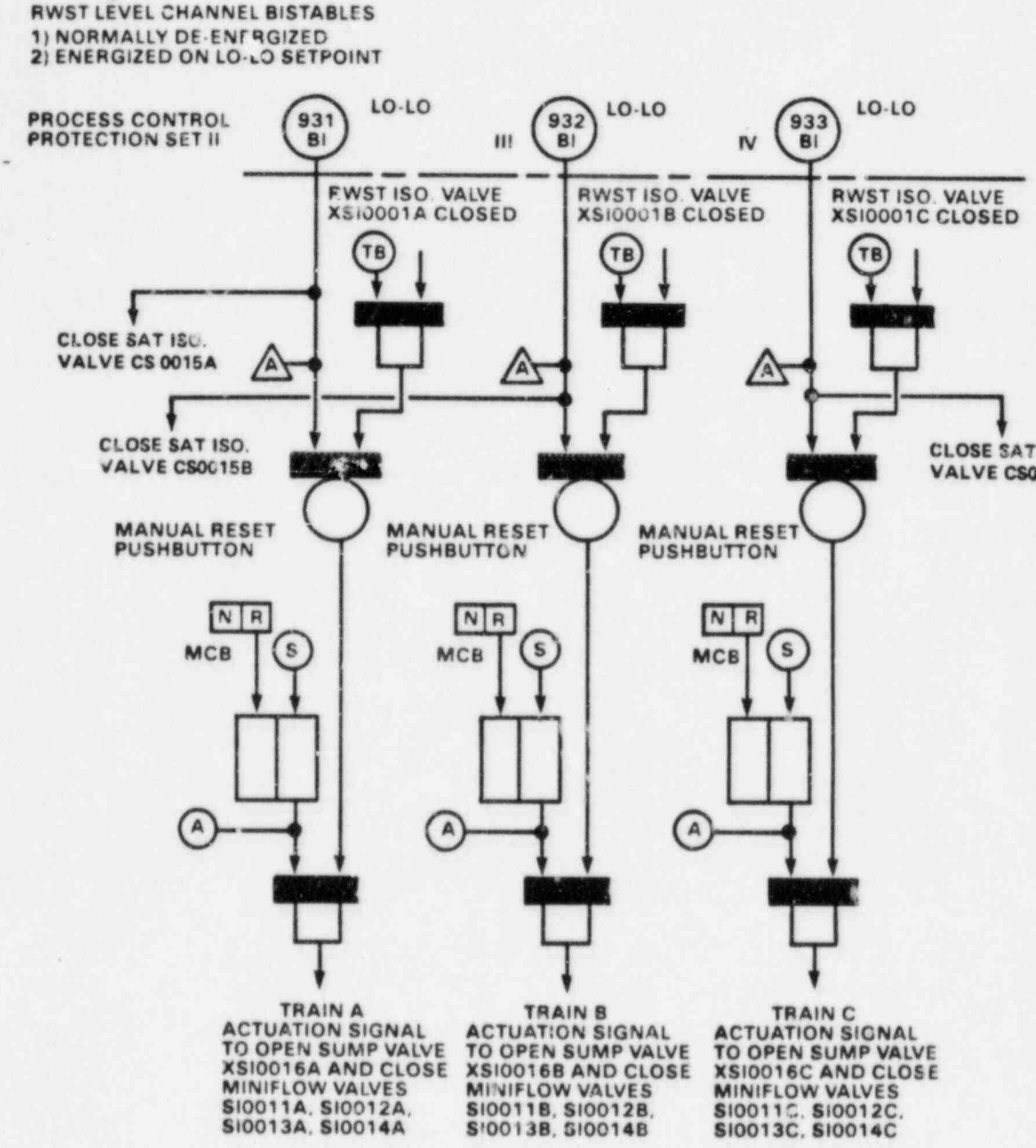

LEGEND:

(TB) TEST BUTTON
△A ANNUNCIATOR WINDOW (COMMON)
(A) ACTUATION SIGNAL LAMP
(S) SAFETY INJECTION SIGNAL

**SOUTH TEXAS PROJECT**
**UNITS 1 & 2**

FUNCTIONAL LOGIC DIAGRAM FOR SWITCHOVER TO RECIRCULATION SHOWING LO-LO RWST LEVEL AUTOMATIC ACTUATION SIGNAL

Figure 7.6-9

Figure 7.6-14 will be made available once it has been updated.

The Containment leak rate to the atmosphere used in the analysis is the design basis leak rate which will be indicated in the Technical Specifications. For the first 24 hours following the accident, the leak rate is assumed to be 0.30 percent per day while for the remainder of the 30 day period the leak rate is assumed to be 0.15 percent per day. This Containment leakage is assumed to leak directly to the environment. |45 |27

The total free volume of the Containment has been calculated to be 3.58 million ft$^3$. Part of this volume is covered by the Containment spray, while some is not. The major portion of the unsprayed volume is within the secondary shield wall below the operating floor. The unsprayed volume has been calculated as approximately 840,000 ft$^3$. |45 |45

The transfer rate between the sprayed and unsprayed regions is assumed to be limited to the forced convection induced by the Reactor Containment Fan Cooler (RCFC) units. The number of units assumed in operation and the total mixing flow are presented in Table 15.6-10. This assumed minimum flowrate conservatively neglects the effects of natural convection, steam condensation and diffusion, although these effects are expected to enhance the mixing rate between the sprayed and unsprayed volumes. The majority of the RCFC air supply, except a small portion discharged to the dome, is discharged to the space within the secondary shield wall, where it is relieved to the balance of the Containment volume through the vent areas. The RCFC units are described more fully in Sections 6.2.2 and 6.2.5.

For fission products other than iodine, the only removal processes considered are radioactive decay and leakage. Iodine is assumed to be removed by radioactive decay and leakage, plateout, and also by the Containment Spray System (CSS). The effectiveness of the Containment spray for the removal of the iodine in the Containment atmosphere and the model used to determine the iodine removal efficiency are discussed in Section 6.5.2. Only the elemental and particulate iodine forms ~~is~~ are assumed to be effectively removed by the spray. A spray removal rate of 18.6 hr$^{-1}$ is assumed, until the airborne elemental iodine is reduced by a factor of ~~88~~ 12.28. After this time, the elemental spray removal rate is assumed to be zero, however, plateout and particulate removal continues until a DF of 100 is reached. The sprays are considered effective only in the sprayed region of the Containment. |52

15.6.5.3.1.3 Containment Leakage Doses - Doses resulting from activity leakage from the Containment have been calculated using the models presented in Appendix 15.B. The thyroid, whole-body gamma and skin beta doses are presented in Table 15.6-11 for the Exclusion Zone Boundary (EZB) distance of 1,430 meters and the outer boundary of the Low Population Zone (LPZ) at 4,800 meters.

15.6.5.3.2 ESF Leakage Contribution: A potential source of fission product leakage following a LOCA is the leakage from ESF components which are located in the Fuel-Handling Building (FHB). This leakage may be postulated to occur during the recirculation phase for long-term core cooling and Containment cooling by sprays. The water contained in the Containment sumps is used after the injection phase and is recirculated by the ECCS pumps and the Containment spray pumps. |45

15.6.5.3.2.1 Fission Product Source Term - Since most of the radioiodine released during the LOCA would be retained by the Containment sump water, due to operation of the CSS and the ECCS, it is conservatively assumed that 50 percent of the core iodine inventory is introduced to the sump water to be recirculated through the external piping systems. 45

Because noble gases are assumed to be available for leakage from the Containment atmosphere and are not readily entrained in water, the noble gases are not assumed to be part of the source term for this contribution to the total LOCA dose.

15.6.5.3.2.2 Leakage Assumptions - The amount of water in the Containment sumps at the start of recirculation is the total of the RCS water and the water added due to operation of the engineered safeguards, i.e., the ECCS and CSS. This amount has been calculated to be 512,494 gallons. This value is conservatively low to maximize iodine concentration in the sump water. 45

The ECCS recirculation piping and components external to the Containment are designed in accordance with applicable codes and are described in Section 6.3. The CSS is described in Section 6.2.2 and 6.5.2. 45

The maximum potential recirculation loop leakage is tabulated in Table 15.6-12. Each recirculation subsystem includes a high-head safety injection (HHSI) pump, a low-head safety injection (LHSI) pump, a residual heat exchanger, the Containment sump, and associated piping and valves. Thus three separate subsystems are provided for recirculation as well as for injection, each of which is adequate for long-term cooling.

Since three redundant subsystems are available during recirculation, leakage for any component in any subsystem can be terminated by shutting down the LHSI and HHSI pump associated with that subsystem and by closing the appropriate pump suction and discharge isolation valves. 45

Maximum potential recirculation leakages are indicated in Table 15.6-12. The leakage rate assumed for dose calculation purposes is conservatively twice the leakage rate given in Table 15.6-12. 45

The iodine partition factor applicable for this leakage is assumed to be 0.1. 45

15.6.5.3.2.3 ESF Leakage Doses - The iodine activity, once released to the atmosphere of the FHB, is assumed to be quickly transported by the ventilation system through the exhaust filters and released to the environment at ground level. The iodine filtration efficiency is assumed to be 95 percent. 45

The offsite doses due to the recirculation leakage are presented in Table 15.6-11 for the EZB of 1,430 meters for the initial two hour period and the LPZ outer boundary distance of 4,800 meters for the 30-day duration of the accident.

15.6.5.3.3 Containment Purge Contribution: In the event of a LOCA coincident with the containment supplementary purge system in operation, the purge is assumed to be isolated within 23 ~~25~~ seconds following LOCA initiation. During normal power operation, the containment supplementary purge system vents the containment at 5,000 ft³/min. However, for this analysis the maximum flow rate due to the pressure spike inside the Containment was used (88,900 ft³/min). The containment purge system is described in Section 9.4. 45

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## TABLE 15.6-10

## PARAMETERS USED IN ANALYSIS OF LOSS-OFF-COOLANT ACCIDENT OFFSITE DOSES

| Parameter | | |
|---|---|---|
| Core thermal power, MWt | 3,800 | |
| Containment model | 2 volume<br>(spray and unsprayed) | |
| Activity released to containment and available for leakage | | |
| noble gases | 100% core activity<br>Table 15.A-1 | |
| iodines | 50% core activity<br>Table 15.A-1 | 51 |
| Form of iodine activity | | |
| elemental | 95.5% | |
| organic | 2.0% | 51 |
| particulate | 2.5% | |
| Containment free volume, $ft^3$ | | |
| total | $3.58 \times 10^6$ | |
| unsprayed | $8.40 \times 10^5$ | |
| Containment leakage rate, % per day | | 45 |
| 0-24 hours | 0.30 | |
| 1-30 days | 0.15 | |
| Number of RCFC units operating | 3 of 6 | |
| Mixing rate between sprayed and unsprayed region, $ft^3$/min | 160,500 | |
| ~~Containment spray~~ Removal coefficients | | 51 |
| elemental, $hr^{-1}$ | 18.6 | |
| organic, $hr^{-1}$ | 0.0 | |
| particulate, $hr^{-1}$ | 6.13 | |
| plate out, $hr^{-1}$ | unsprayed - 7.06<br>sprayed - .634 | 51 |
| Assumed ~~CSS~~ iodine DF | | |
| elemental (spray stops at a DF of 12.28) | ~~88~~ 100 | |
| organic | -- | |
| particulate | 100 | |

## TABLE 15.6-10 (Continued)

## PARAMETERS USED IN ANALYSIS OF LOSS-OFF-COOLANT ACCIDENT OFFSITE DOSES

| Parameter | | |
|---|---|---|
| Spray additive delivery to Containment: time after initiation of LOCA, minutes | 2.34 | 51 |
| Activity assumed mixed in Containment sump water available for ESF leakage | | |
| noble gases | None | |
| iodines | 50% core activity<br>Table 15.A-1 | |
| ESF system leakage rate assumed, cc/hr | Twice that of Table 15.6-12 | |
| Amount of water in which mixing of iodine occurs, gallons | 512,494 | 45 |
| Iodine partition factor for leakage | 0.1 | |
| FHB filtration efficiency, percent | 95 | |
| Supplementary purge rate, scfm | 88,900 | |
| Time before isolation of purge, seconds | ~~25e~~ 23 | |
| Meteorology | 5 percentile<br>Table 15.B-1 | |
| Dose model | Appendix 15.B | |

## TABLE 15.6-11

## DOSE RESULTING FROM LARGE BREAK LOSS-OF-COOLANT ACCIDENT

| Parameter | | |
|---|---|---|
| **Containment Leakage Doses** | | |
| Exclusion Zone Boundary* 0-2 hr | | |
| thyroid, rems | 1.~~105~~ 255 x $10^2$ | |
| whole-body gamma, rems | 2.1~~4~~ 9 | |
| skin beta, rems | 1.1~~25~~ 4 | |
| Low Population Zone* 0-30 days | | 51 |
| thyroid, rems | 58.~~58~~ 63 | |
| whole body gamma, rems | 6.~~78~~ 8 x $10^{-1}$ | |
| skin beta, rems | 4.~~26~~ 3 x $10^{-1}$ | |
| **ESF Leakage Doses** | | |
| Exclusion Zone Boundary* 0-2 hr | | |
| thyroid, rems | 2.18 x $10^{-1}$ | |
| whole-body gamma rems | 6.81 x $10^{-4}$ | |
| skin beta, rems | 1.94 x $10^{-4}$ | |
| Low population Zone 0-30 days | | |
| thyroid gamma rems | 3.61 x $10^{-1}$ | |
| whole-body gamma, rems | 3.73 x $10^{-4}$ | |
| skin beta, rems | 1.3 x $10^{-4}$ | |
| **Containment Purging Doses** | | |
| Exclusion Zone Boundary* 0-2 hr | | |
| thyroid, rems | 17.00 | |
| whole-body gamma rems | 9.2 x $10^{-3}$ | |
| skin beta, rems | 6.6 x $10^{-3}$ | |
| Low population Zone 0-30 days | | 51 |
| thyroid, rems | 2.2 | |
| whole-body gamma, rems | 1.16 x $10^{-3}$ | |
| skin beta, rems | 8.4 x $10^{-4}$ | |
| **Total Doses** | | |
| Exclusion Zone Boundary* 0-2 hr | | |
| thyroid, rems | ~~1.28~~ 1.43 x $10^2$ | |
| whole-body gamma, rems | 2.~~15~~ 2 | |
| skin beta, rems | 1.~~13~~ 15 | |
| Low population Zone 0-30 days | | |
| thyroid, rems | 6.1~~1~~ 2 x $10^1$ | 51 |
| whole-body gamma, rems | 0.68 | |
| skin beta, rems | 0.43 | |

* Exclusion Zone Boundary is at 1,430 m. Outer boundary of Low Population Zone is at 4,800 m.

TABLE 6.4-2 (Continued)

CONTROL ROOM DOSE ANALYSIS

Results

| Operator dose, 0-30 day period (rem): | Thyroid | Whole-Body Gamma | Skin Beta | |
|---|---|---|---|---|
| Containment leakage | 13.~~13~~ 01 | 1.5 | 18.7 | |
| ESF leakage | 1.63 | $5.0 \times 10^{-5}$ | $3.1 \times 10^{-4}$ | |
| Containment purging | 0.036 | $5.4 \times 10^{-5}$ | $8.2 \times 10^{-4}$ | 51 |
| direct dose from Containment | --- | 0.11 | --- | 38 |
| direct dose from cloud of released fission products | --- | 0.82 | --- | |
| Iodine filter loading | --- | $2.21 \times 10^{-3}$ | --- | |
| Total | 14.~~80~~ 68 | 2.43 | 18.7 | |

Question 022.11

The response to Request No. 022.5 assumes a maximum closure time for the supplementary containment purge subsystem (18-inch) isolation valves of 25 seconds. It is our position that the closure time for the valves should not exceed 5 seconds (see BTP CSB 6-4, Item B.1.f). Revise your FSAR accordingly.

Response

As part of the response to Request No. 022.5, two analyses were presented in order to demonstrate the adequacy of the Supplementary Containment Purge Subsystem. These analyses were calculations of the radiological consequences of a postulated Loss-of-Coolant-Accident (LOCA) concurrent with operation of the Supplementary Purge Subsystem and analysis of the reduction in containment pressure resulting from the partial loss of containment atmosphere during the accident for ECCS backpressure determination. For both of these analyses, a total isolation time of 23 ~~25~~ seconds was assumed. This assumed isolation time conservatively bounds the time required for valve closure, instrument delay, and diesel generator start (assuming loss of offsite power).

The Supplementary Containment Purge Subsystem motor operated isolation valve closure time, is 10 seconds or less while the pneumatic valves have a closure time of 5 seconds or less. The results of the analyses performed in response to Request No. 022.5 have demonstrated the adequacy of the present Supplementary Containment Purge Subsystem isolation valve design. 53