COMMONWEALTH EDISON COMPANY

BYRON/BRAIDWOOD STATIONS UNITS 1 AND 2

SYSTEM DESIGN DESCRIPTION

FOR

CONTAINMENT SPRAY (CS)

Frank L. Bruckner 10/1/96
Preparer---Byron/Date

10/1/96
Preparer---Braidwood/Date

W.J. Feimster 10/28/96
Reviewer/Date

K. Passmore 10/31/96
Approver/Date

Identification No	Project Nos	Dated	Rev. No.	Dated
SDD-CS-01-BB	4391/2-45 4683/4-45	11-4-87	0	N/A
SDD-CS-01-BB	N/A		1	

Rev. No.	Reason For Change	Pages Changed	Prepared By/ Date	Reviewed By/ Date	Approved By/ Date
0	Initial Issue	N/A			
1	Design Review	All			

Table of Contents

Containment Spray
System Design Description

1.0 SUMMARY

The Containment Spray (CS) System, consisting of a spray subsystem and an additive subsystem, serves to mitigate the consequences of a loss of coolant accident or a main steam line break inside containment, by injecting a water spray into the containment atmosphere. The containment spray system may be used to aid safety by performing one or more of the following functions:

1. Containment Post-Accident Pressure Suppression
2. Containment Post-Accident Heat Removal
3. Containment Atmosphere Post-Accident Fission Product Removal
4. Post-Accident Mixing of Containment Atmosphere
5. Post-Accident Containment Sump Chemistry Control

The CS System is initiated only during an accident or prescribed testing condition. The CS System delivers chemically treated water to the spray rings mounted in the containment dome such that during atomization the above design features are met.

The CS System consists of two independent 100% capacity trains with no common discharge headers (other than the pump test header return to the RWST). Each train consists of a Containment Spray Pump (CSP), an Eductor, three Spray Rings with nozzles, the Containment Recirculation Sump and the piping and valves which connect them. Two additional components which are shared by each train are the Spray Additive Tank (SAT) and Refueling Water Storage Tank (RWST). Control and Instrumentation features are provided to monitor the condition and performance of the system as well as provide input to the control system and the Engineered Safeguards Features (ESF) Systems.

The CS System physically interfaces with several systems which also provide a supporting function during normal operation. The RWST, which is part of the Safety Injection (SI) System (an emergency safety system), is functionally part of the CS System in that it is connected to the CS System at all times. The RWST provides support to the CS System during the injection mode of CS System operation. The RHR System, which also interfaces with the SI System, shares the suction source from the containment recirculation sumps during the ECCS mode of operation. The Nitrogen (NT) System is connected to the CS System to provide a cover gas blanket for the SAT. Two additional systems which play more of a supporting function rather than an interfacing function are the Instrument Air (IA) System and the Auxiliary Power System. These as well as the above mentioned interfacing systems will be discussed in detail in Section 5.0.

2.0 FUNCTIONS

The primary safety function of the Containment Spray System is to ensure the removal of iodine from the containment atmosphere to limit offsite and site boundary radiological doses to values below those set by 10CFR100. It also must ensure that containment has both depressurization and cooling capabilities available in the event of a LOCA or steam line break.

3.0 SYSTEM DESIGN DESCRIPTION

3.1 Mechanical System Boundaries

The boundaries of the Containment Spray System and certain other systems are called the Containment Spray Boundary. This denotes the limits within which borated fluid can travel when the system is isolated either manually or by a Engineered Safeguards Features (ESF) actuation. The boundaries are generally ASME Section III Class 2 piping and pressure vessels, normally closed valves and/or automatic isolation valves. The CS System boundaries at the interfaces with the Safety Injection System (which in turn interfaces with the Residual Heat Removal System) are motor operated isolation gate valves (with the exception of the CS Pump test line that is isolated by a locked-closed valve). The RHR System, which also interfaces with the SI System, shares the suction source from the containment recirculation sumps during the Emergency Core Cooling (ECCS) mode of operation. This design feature ensures the proper system fluid interface during ECCS operation. The Liquid Radioactive Waste System bounds the CS System via closed manual valves. This safety class interface is bounded per ANSI/ANS-51.1 code case 6(a), where; "Class 2 or 3 piping totally inside or outside the primary containment and not connected to the Reactor Coolant Pressure Boundary (RCPB) to any less stringent class, the interface is at the less stringent class connection to one administratively closed valve." This design allows system fluid leakoff to the Auxiliary Building Drain System as required. The Nitrogen System also bounds the CS System via a normally open pressure control valve. This feature ensures proper pressure for the SAT to prevent degradation of the NaOH in the SAT.

3.2 Flow Paths

The CS System has no normal plant operating flow paths, but rather has two system accident flow path conditions, injection and recirculation. Additionally, it has a system testing flow path condition.

3.2.1 Accident Flow Path

In the event of a LOCA, the immediate function of the CS System is to reduce temperature and pressure as well as reduce elemental iodine and fission products in the containment atmosphere. This is accomplished via the following two flow phases:

3.2.1.1 **Injection Phase**

Borated water at ambient temperature is taken from the Refueling Water Storage Tank (RWST) via suction from the Containment Spray Pumps (CSP's). The borated water is chemically treated with sodium hydroxide delivered from the Spray Additive Tank. The CSP's discharge the chemically treated water to the Containment Spray Ring headers where it is atomized and sprayed into the containment atmosphere. A small percentage of the spray volume does not reach the operating floor; this area includes the refueling cavity, the main steam vertical pipe chase and the regenerative and excess letdown heat exchanger compartments. The water which reaches the operating floor is collected in the containment sump. If the RWST reaches the Lo-3 level prior to the SAT Lo-2 level, the containment sump becomes the source of CS water and the NaOH eduction continues. This ensures that the SAT provides enough NaOH to the overall sump water mixture (see Section 6.2).

NaOH addition will occur until the LO-2 level setpoint is reached in the Spray Additive Tank. At that time, the Spray Additive Tank is manually isolated from the CS eductor suction.

3.2.1.2 **Recirculation Phase**

The CS System recirculation phase is initiated when the level in the RWST decreases to the LO-3 setpoint. Upon this occurrence, the CS System suction source is manually switched over from the RWST to the containment recirculation sump. The discharge flow path during the recirculation phase is identical to that in the injection mode. Further NaOH addition may occur during the recirculation phase, depending on the addition rate during injection. The CS system is run for a minimum of 2 hours after NaOH isolation. This ensures that the sump water is well-mixed and rinses any components that may have been exposed to high pH during the injection mode.

3.2.2 **Testing**

Testing of the CS System is accomplished by taking normal suction from the RWST by the CSP. The CSP discharges recirculating water back to the RWST via a 6" test line connected to the pump discharge header. The pump test starting circuitry has interlocks to ensure that valves CS007A/B and CS040A/B are closed and that valve SI001A/B is open. These interlocks prevent water admission to the spray rings, prevent NaOH addition to the pump discharge and ensure a flow path for the pump. Quarterly ASME pump runs are performed to verify that pump degradation has not occurred. The NaOH addition ability of the system is tested by injecting a

specified flow rate of primary water through valves CS026A/B, while throttle valves CS018A and CS018B (or CS021A and CS021B) are adjusted to the desired water flow rate equivalent to the required NaOH flow rate. The spray rings are tested by inducing compressed air through flanges connected to the headers. This test is performed to ensure that there are no nozzle obstructions.

3.3 System Design Data

The Containment Spray System is designed to limit containment pressure, remove elemental iodine from the containment atmosphere by washing the atmosphere and control the containment sump pH during a loss-of coolant accident (LOCA). The Containment Spray System, in conjunction with its interfacing and support systems, is required to: maintain containment pressure below 50.0 psig, accommodate a decontamination factor of 100 for containment recirculation sump solution temperatures between 150° and 212°F, maintain the equilibrium sump pH solution between 8.0 and 11.0, and limit the site and offsite boundary doses to values below those set by 10CFR100. Design Data for the system and its components are listed and discussed in the remainder of this Section.

3.3.1 Design Parameters

CS System design parameters are listed in Table 3.1. This table is separated into overall CS System design and normal system operating parameters. These values are the best estimate mechanical design conditions (limiting) which are expected during the operation of the system. These values are conservative parameters which have been used to provide additional margin to the CS System design.

3.3.2 Design Limitations and Considerations

The CS System design is required to accommodate and incorporate various considerations and limitations. Discussion relative to this subject is presented in the following subsections.

3.3.2.1 Seismic Design and Load Combinations

The entire CS System except the test-recirculating line must be designed to withstand the postulated Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) when combined with operational and accident loads. Specific system load combinations are displayed respectively in the Byron and Braidwood Piping Design Specification for the Containment Spray System (DS-CS-01-BY and DS-CS-01-BR).

3.3.2.2 Separation Requirements

Redundancy of components, as well as separation and independence of the redundant components is required as one of the design basis features of systems required for plant safety. The CS system incorporates this basis by physically, electrically and mechanically separating the system into two independent trains. The support systems for each train incorporate a similar separation. The CS system utilizes two redundant Safety Category I (Class 1E) ESF Electrical Divisions. The two redundant ESF Divisions are physically and electrically separated in accordance with IEEE Standards 279-1971 "Criteria For Protection System For Nuclear Power Generating Stations" and 384-1974 "IEEE Trial-use Standard For Independence of Class 1E Equipment and Circuits." The system is physically isolated via prescribed distances to prevent postulated damage due to jet impingement effects resulting from breaks.

3.3.2.3 Environmental Qualification

Various CS system components are located in harsh environments and as a result are subject to environmental qualification requirements. Electrical components that perform safety functions and those which are connected to Class 1E ESF electrical divisions, without isolation, require qualification. Active mechanical components are also required to be qualified. The EQ requirements and related reference documents are identified in the CS system portion of the Safety-Related Component List (SRCL).

3.3.2.4 Protection Against High/Moderate Energy Line Break

The CS system is required after a LOCA and Main Steam Line Break (MSLB). All CS system equipment, instrumentation and cables, with exception of two independent sets of spray headers and nozzles, that are required for safe shutdown are located in the Auxiliary Building. The spray headers, and nozzles are inside containment. Due to the physical location of the system, postulated damage resulting from a LOCA or jet impingement will not occur to the CS system. "Byron Confirmation of Design Adequacy for Jet Impingement Effects Report" demonstrates that the CS system will fulfill its intended safety function for a postulated accident scenario.

3.3.2.5 Overpressure Limitations

Overpressurization protection for the CS system is provided. This result is due to the fact that the CS system is open to the containment atmosphere and the maximum anticipated operating pressure/temperature is below the design pressure/temperature.

Also, the CS system contains no pressure relieving devices such as safety valves, or relief valves, thus concern for system secondary design pressure is not considered. Overpressure protection for the Spray Additive Tank is also provided by virtue of the fact that the internal design pressure of the SAT is much higher than the maximum pressure which could occur in the SAT. In addition, a pressure relief device is provided on the nitrogen supply to the SAT.

3.3.2.6 CS System Temperature

The CS system valves and piping maintain a general design temperature of 200°F with the exception of the piping extending from the Spray Additive Tank which is rated at a temperature of 120°F to 150°F. Individual CS component ratings may be found in Section 4.0 of this document. The maximum operating temperature to which the CS system pipe lines were analyzed are provided on the CS system piping line list.

The containment recirculation sump solution temperatures range between 150°F and 212°F. Similarly as above, specific containment sump solution temperatures may be sought via the CS system piping line list.

The design temperature of the instrument sensing lines is designed to be the same as the process line or equipment to which they are connected, up to and including the first isolation valve. Instrument sensing lines for which flow is maintained, are designed to have a design temperature equal to the process line design temperature.

3.3.2.7 CS System Pressure

The CS system valves and piping maintain a general design pressure of 275 psig. Individual CS component ratings may be found in Section 4.0 of this document. The maximum operating pressure to which the CS system pipe lines were analyzed at are provided on the CS System piping line list.

The Spray Additive Tank has a nitrogen blanket above the solution to exclude oxygen from the tank. The maximum tank pressure is documented in the Overpressure Protection Report, and is based on pressure variations with changes in the ambient temperature. The resulting expansion of the nitrogen gas and increased vapor pressure of the solution result in a maximum tank pressure of 5.08 psig. The Spray Additive Tank is qualified to an internal design pressure of 15 psig, which is much greater than the maximum tank pressure.

3.4 System Performance Characteristics

The CS system performance characteristics are listed in Table 3.1 for overall system operation. The CS system ensures that requirements for containment atmosphere cleaning are met.

The rest of this page is intentionally left blank.

Table 3. 1

Overall System Design Parameters

Number of spray trains available per unit	1 of 2
Spray flow rate, w/o Eductor flow rate	
Train A, gpm	3285
Train B, gpm	3795
Containment recirculation equilibrium sump pH (minimum)	8.0
Decontamination factor for iodine removal during injection	100
Nozzle spray flow (each), gpm	15
Nozzle Δ P, psig	40
Spray fall height, ft.	154
Number of eductors available per unit	1 of 2
Eductor flow rate, gpm (approximately)	130
30% NaOH maximum flow rate, gpm	55 - 60
36% NaOH maximum flow rate, gpm	53 - 58
30% NaOH minimum flow rate, gpm (for the required spray pH range of 8.5-10.5)	19
Maximum net containment free volume, cu. ft.	2.8×10^6
Max Unsprayed containment volume, %	15.41%
Min Unsprayed containment volume, %	12.66%
Maximum Design Temperature, °F (line list)	200
Maximum Design Pressure, psig (line list)	275
Spray pump discharge pressure, psig	190
Spray Additive Tank volume, gal. (minimum prior to spray actuation)	4,000

Refueling Water Storage Tank volume, % (minimum prior to safeguards actuation)	89
Maximum Spray pH EQ limit	10.5^^
Spray pH during Injection	8.5 - 10.5^^
Sump pH during Recirculation per Tech Specs	8 - 11.0

^^ Once the containment sump becomes the suction source for the CS pumps, the pH may be higher than the spray pH if NaOH addition is still occurring.

4.0 COMPONENT DESIGN DESCRIPTION

The CS system contains several major safety-related components. These components are listed and briefly described in this Section. Additional information, if required, can be found on design drawings or instruction and maintenance documents as referenced.

4.1 Containment Spray Pumps

Each CS system train (A and B) contains one Containment Spray Pump (CSP). These pumps are vertical shaft, centrifugal pumps. The pumps themselves, as well as the parts contained within the pumps, which come in contact with the spray fluid, are made of austenitic stainless steel or other corrosion resistant material. The pumps are ASME Section III, Safety Category 1, Quality Group 3 components. The pumps are located outside the secondary shield wall and therefore protected from LOCAs and jet impacts. The pumps are required for safe shutdown subsequent to a high energy line break inside containment only. Pump A is located in Hazard Zone 11.2B-1 and 11.2B-2 for Units 1 and 2, respectively. Pump B is also located in Hazard Zone 11.2C-1 and 11.2C-2, respectively. Both pumps are considered active components and are environmentally qualified harsh. The pumps are maintained in constant standby condition and are aligned to take suction from the RWST. During injection phase, the pumps are required to pump borated water from the RWST to the spray ring headers. Likewise during recirculation phase, the pumps take borated water from the containment recirculation sump and deliver it to the spray ring headers. The pumps are required to be operated for a minimum of 2 hours following a LOCA and are available for longer operation if required. The CS pumps do not have to be stopped when transferring from the RWST as the source of water to the containment recirculation sump as the source of water, provided that the RWST Lo-3 level has not been reached. The actuation and interlocks involved in valve and pump operation are described in Section 4.8.

The pumps are electric motor driven, able to operate at a long-term ambient temperature of 122°F. The ambient temperature is maintained by cubicle coolers consisting of fans and coils which utilize Essential Service Water (SX) as the cooling medium. The pump motors are classified Safety Category I (Class 1E).

The CS Pump parameters are listed below: -

CS Pump Design Parameters:

Tag Numbers:	1/2CS01PA, 1/2CS01PB
Type:	Vertical Centrifugal
Number per plant:	4 - 2 per unit
Minimum Design Capacity including Eductor flow, gpm:	
Pump A	3415
Pump B	3925
Developed Head, ft of Water:	450
NPSH (Required/Available), ft:	22.5
Normal Pressure, psig:	190
Design Temperature, °F:	200
Fluid Type:	Borated Water
Primary Material:	Austenitic Stainless Steel (pump casing), Martensitic Stainless Steel (impeller)
Safety Classification:	Safety Category I
Quality Group:	B
Seismic Category:	Seismic Category I

CS Pump Motor Design Parameters:

Type:	Induction
Horsepower:	600
Voltage:	4000V
Phase:	3
RPM:	1780 (at rated Load)
Frequency:	60 Hz
Safety Classification:	Class 1E

4.2 Spray Additive Tank (SAT)

The CS system contains one Spray Additive Tank (SAT) which is shared by both CS system trains (A and B). The SAT is a 5000 gallon capacity vertical cylindrical tank fabricated from austenitic stainless steel. The tank is considered a pressure vessel and is classified a ASME Section III, Safety Category I, Quality Group B component. The tank is located outside the containment and therefore protected from LOCA and jet impacts.

The tank is required for safe shutdown subsequent to high energy line break inside containment only. The tank is located on elevation 364' in Hazard Zone 11.3-1 for Unit 1 and 11.3-2 for Unit 2. The tank is considered a passive component and is environmentally qualified harsh. The tank supplies NaOH solution to be educted into the borated water from the RWST or the containment recirculation sump. This caustic solution is mixed by the CS

eductors and atomized via the spray rings to maintain a minimum pH of 8.5 in the containment atmosphere. The tank has level indicators which transmit annunciation to the main control board. The SAT instrumentation is discussed in Section 4.8. To prevent degradation of the NaOH solution, a nitrogen blanket of approximately 1.0 psig is applied to the SAT. Control valve (CS036) maintains pressure at 0.4 to 0.8 psig to protect the SAT from overpressurization by the Nitrogen Gas System. A low pressure relief device is provided as back-up to the control valve. Also two, vacuum relief valves set at -0.02 to 0.0 psig prevent a vacuum condition in the tank and protect it against external pressurization.

The Spray Additive Tank parameters are listed below:

Spray Additive Tank Design Parameters:

Tag Numbers	:	1/2 CS01T
Type	:	Vertical, cylindrical
Number per plant	:	2 - 1 per unit
Capacity, gals.	:	5000
Design Pressure, psig (Internal/External)	:	15 psig/Vacuum @ 4 psia
Design Temperature, °F	:	100
Operating Pressure, psig (Normal)	:	1.0
Primary Material	:	Austenitic Stainless Steel
Fluid	:	30 - 36% NaOH in Water Nitrogen Blanket
Safety Classification	:	Safety Category I
Quality Group	:	B
Seismic Category	:	Seismic Category I

4.3 Eductors

Each independent, redundant pumping train is provided with a liquid jet eductor. The eductor is similar to a stainless steel venturi tube. The eductor is a ASME Section III, Safety Category I Quality Group B component. The eductor is located outside containment and therefore protected from LOCAs and jet impacts.

The eductor is required for safe shutdown subsequent to high energy line break inside containment only. Eductors CS01SA/CS01SB are located in Hazard Zones 11.2B-1 and 11.2C-1 for Unit I and in Hazard Zones 11.2B-2 and 11.2C-2 for Unit 2, respectively. Both eductors are considered passive components and are environmentally qualified harsh. The eductors are used to add 30% - 36% sodium hydroxide (NaOH) solution to the spray flow during the CS system injection phase. As water flows through the restrictive section of the venturi tube, its velocity is increased and its pressure is decreased. The line from the SAT is connected at this low pressure area such that NaOH solution is induced into the spray water flow.

Valve CS018A and B or CS021A and B are prepositioned to ensure a sodium hydroxide solution flow rate between 55 - 60 gpm of 30% NaOH (53 - 58 gpm of 36% NaOH). This is set while simulating a SAT at high level and eductor motive flow

conditions equal to the values determined during the pre-operational tests (at design total flow of 3415 gpm/3925 gpm A train/B train).

One eductor delivering 30% NaOH solution is capable of forming the 8.0 pH solution of final sump for containment fission product and iodine reduction.

Flow indication and control for flow elements signaling the eductors is discussed in Section 4.8.

The CS Eductor parameters are listed below:

Eductor Design Parameters:

Tag Numbers	:	1/2 CS01SA, 1/2 CS01SB
Number per plant	:	4 - 2 per unit
Design Pressure, psig	:	275
Design Temperature, psig	:	200
Design Flow (Motive Fluid), gpm	:	212^
Operating Flow (Motive Fluid), gpm ~	:	130
Maximum Design Flow (30% NaOH), gpm	:	55 - 60
Maximum Design Flow (36% NaOH), gpm	:	53 - 58
Minimum Design Flow (30% NaOH), gpm	:	19
Equivalent H_2O flow rate (max, 30% NaOH)	:	68 - 74 gpm
Primary Material	:	Austenitic Stainless Steel
Safety Classification	:	Safety Category I
Quality Group	:	B
Seismic Category	:	Seismic Category I
Specific gravity for 30% NaOH Solution	:	1.3279

^ actual eductor motive flow is lower than initial design flow, and has been found to be acceptable (approximately 130 gpm / as determined during Pre-Operational testing)

4.4 Spray Rings and Nozzles

Each of the CS system trains include three ring-type spray headers mounted in the ceiling of the Containment Building. Each of the rings are made of ASME Section III, Safety Category I Quality Group B austenitic stainless steel piping. All risers and ring headers are supported to withstand loads resulting from Safe Shutdown Earthquake (SSE) as well as operating loads. Each of the rings are designed as follows:

Ring Number	Mean Radius	Nominal Pipe Diameter (Inches)	Number of Nozzles	Designation of Pump Delivering Fluid to the Ring
1	13 ft. 0 inch	4	39	Pump A
2	23 ft. 6 inches	6	51	Pump B
3	34 ft. 1/2 inch	6	60	Pump A
4	45 ft. 9 inches	6	90	Pump B
5	56 ft. 7-1/2 inches	8	120	Pump A
6	64 ft. 9 inches	8	112	Pump B

Spray rings 1, 3 and 5 are supplied by spray pump CS01PA via a 10 inch riser pipe. Restricting orifices in the supply lines to spray rings 3 and 5 control flow such that flow to each spray ring is proportional to the number of nozzles on the ring. Spray rings 2, 4 and 6, which are supplied by spray pump CS01PB, are designed with similar restriction orifices for flow control.

Each of the 472 spray nozzles, 219 in train A and 253 in train B, is of swirl chamber design, having no moving parts. Flow through the nozzle at the design operating point is at least 15 gpm, coincident with a design differential pressure (psid) across the nozzle of 40 pounds per square inch. The Sauter (surface to volume ratio) mean diameter of the spray drops produced by the nozzle at the design pressure drop across the nozzle are designed to be approximately 1000 microns on test.

Flow indication of water being sent to the spray rings is discussed in Section 4.8.

The Spray Rings and Nozzles design parameters are listed below:

Spray Rings and Nozzle Design parameters

Number of Rings	:	6 per unit
Train A	:	3 Rings, numbered 1,3,5
Train B	:	3 Rings, numbered 2,4,6
Nozzle Manufacturer	:	Sprayco
Number of Nozzles per Unit:		
Train A		219
Train B		253
Sauter	:	1000 microns
Operating Design Flow, gpm	:	15
Operating Design ΔP, psid	:	40
Primary Material	:	Austenitic Stainless Steel
Fluid	:	Borated Water
Safety Classification	:	Safety Category I
Quality Group	:	B
Seismic Category	:	Seismic Category I

4.5 Refueling Water Storage Tank (RWST)

The CS system is physically aligned to the Safety Injection system's Refueling Water Storage Tank (SI01T). The RWST is shared by both CS system trains (A and B) during the CS system's design conditions. The RWST is a 500,000 gallon capacity vertical cylindrical tank. The tank is constructed of concrete and lined with austenitic stainless steel. The tank is considered a Seismic Category I structure and designed as such. A Safety Category II (Non-IE) electric heater prevents freezing of the borated water (2300-2500 ppm boron solution of boric acid) in winter months. The tank is required for Safe Shutdown subsequent to high energy line break inside containment only. The tank is located in Hazard Zones 16.1-1 and 16.1-2 for Units I and 2, respectively. The RWST is considered a passive component. The tank is the normal source of borated water for the CS system and the Emergency Core Cooling system. During CS system operation, the RWST delivers borated water to the CS pumps for injection and testing phases only. For further discussion of the RWST, and its automatic switching features and level monitoring system instrumentation and interlocks, see the Emergency Core Cooling system Design Descriptions in the UFSAR.

The RWST design parameters are listed below:

RWST Design Parameters:

Tag Numbers	:	1/2 SIO1T
Type	:	Vertical, cylindrical
Number per plant	:	2
Capacity, total gal.	:	500,000
Minimum Volume Required, %	:	89
Design Pressure, psig	:	Atmospheric
Design Temperature, °F	:	200
Minimal Temperature, °F	:	35
Maximum Temperature, °F	:	100
Primary Material	:	
Exterior	:	Concrete
Interior	:	Stainless Steel
Fluid	:	2300-2500 ppm Boron Solution (nom ·al)
Safety Classification	:	Sa Category I
Quality Group	:	B
Seismic Category	:	Seismic Category I

4.6 Containment Recirculation Sumps

Two recirculation sumps, one per train, are provided inside the containment at elevation 367' to collect the spray and other incident water within the containment. The temperature within the sump ranges from 150° to 212°F. The sumps are a source of spray water during the CS system recirculation mode. The sumps also provide suction to the residual heat removal pumps, during required pump actuation. The sumps are equipped with screens. Level instrumentation is discussed in detail in the Primary Containment Isolation System Design Description (SDD-PC-01-BB).

4.7 Valves

The major CS system valves which will be discussed herein are those valves located outside containment and utilized for safe shutdown. The CS system valves are designed to ASME Section III, Safety Category I, Seismic Category I, and Quality Group B requirements unless otherwise noted on design drawings.

a. **Containment Spray Pump RWST Suction Valve (CS001A/B)**

These valves are isolation valves used for safe shutdown. The valves are located in Hazard Zones 11.3-1 for Unit 1 and 11.3-2 for Unit 2. The valves are physically located on the suction lines from the RWST to the CS pump. The valves are normally open and are required to close for switchover during CS recirculation phase. The valves and their motors are required for accident mitigation and are considered active. The valves are environmentally qualified harsh.

b. **Containment Spray Header Isolation Valves (CS007A/B)**

These valves are isolation valves used for safe shutdown. The valves are located in Hazard Zones 11.3-1 for Unit 1 and 11.3-2 for Unit 2. The valves are physically located downstream of the CS pump discharge just outside of containment. The valves are normally closed during normal plant operation such that the CS pumps can recirculate water from the RWST for testing. During an accident the valves are actuated to open such that borated water may be discharged to the CS spray rings. The valves and motor operators are required to operate for accident mitigation and are considered active. The valves are environmentally qualified harsh.

c. **Containment Spray Pump Suction Valve from Recirculation Sump (CS009A/B)**

These valves are isolation valves used for safe shutdown. The valves are located in Hazard Zone 11.2B-1 and 11.2C-1 for Unit 1 and 11.2B-2 and 11.2C-2, respectively for Unit 2. The valves are physically located downstream of the CS recirculation sump and on the suction side of the CS pump. The valves are normally closed vaives. The valves are actuated to open to align the CS system for taking water from the recirculation sump. Interlocks exist between these and the containment sump isolation valve (SI8811A/B). The interlock ensures that the RHR loop inlet isolation valve (RH8702A/B) valve is closed and the containment sump isolation valve (SI8811A/B) is open prior to opening the containment sump suction valve. The valves and motor operators are required to operate for accident mitigation and are considered active. The valves are environmentally qualified harsh.

d. **Containment Spray Eductor Motive Fluid Valve (CS010A/B)**

These valves are air-operated valves used for safe shutdown. The valves are located in the Hazard Zones 11.2B-1 and 11.2C-1 for Unit 1 and 1142B-2 and 11.2C-2, respectively for Unit 2. The valves are physically located at the inlet side of the eductor and at the discharge of the containment spray pumps. The valves are normally maintained in the open position during normal plant operation. Regardless of the initial position of these valves, receipt of CS actuation signal from ESF signals opens the valves to ensure proper eductor flow.

e. **Sodium Hydroxide (NaOH) Eductor Supply Valve (CS019A/B)**

These valves are motor operated isolation valves used for safe shutdown. The valves are located in Hazard Zones 11.2B-1 and 11.2C-1 for Unit 1 and 11.2B-2 and 11.2C-2, respectively for Unit 2. The valves are physically located on the supply line from the SAT to the inlet side of the eductor. The valves are normally closed during plant normal operation. Upon ESF signal the valves are actuated to the open position to provide NaOH to the eductor. Failure of the valves to open will prevent auto starting of the associated CS pump. When the Spray Additive Tank reaches the Lo-2 level setpoint, the valves are manually closed. The valves and motor operators are required to operate for accident mitigation and are considered active. The valves are environmentally qualified harsh.

f. **Eductor NaOH Supply Throttle Valve (CS018A/B or CS021A/B)**

These valves are manual operated, normally open or throttled, locked in position, globe valves. These valves are not required for safe shutdown. They are located in the caustic addition line at the inlet side of the eductor. Either valve (CS018A/B or CSO21A/B) maybe locked-in-position to accommodate the desired NaOH flow rate to the eductor during injection phase. The calculated desired 30% NaOH flow rate is 55 - 60 gpm for injection phase. The function of these valves is to allow for adjusting the NaOH flow rate to the system to achieve an acceptable spray pH. This flow rate is established with a simulated full SAT and an eductor motive flow from Pre-Operational tests at design flow (3315 gpm A train, 3925 gpm B train). The required minimum long term sump pH of 8.0 is achieved under worst case condition by ensuring that the full volume of the SAT (Lo to Lo-2 level setpoints, or at least 2326 gallons of 30 wt% NaOH) has been injected into containment. Thus the concern of controlling a specified flow rate between 55 and 60 gpm becomes inconsequential to the fact of ensuring that enough caustic is added to maintain proper pH levels in the final sump mixture.

4.8 Instruments, Controls, Alarms and Protection Devices

4.8.1 Containment Sprays

A control switch and a test switch are provided for each pump on the main control board (MCB). Pump operation can be transferred to and manually controlled from the switchgear cabinet. Cubicle cooler fans will auto start on a pump start signal. Interlocks are provided to SafeguardsTest Cabinet circuitry.

Each pump can be started under any of the following three modes:

(1) Injection Mode: A containment spray actuation signal from the ESF Actuation System (ESFAS) logic will start the pump provided that the containment spray eductor spray additive valve (CS019) is open. Pump auto-start, auto-start failure and pump trip annunciation is provided on the MCB.

(2) Recirculation Mode: Operation of the pump control switch to the CLOSE position will start the pump provided suction is lined up from the containment recirculation sump and not from the RWST (SI8811 and CS009 open).

(3) Test Mode: Operation of the control switch to the CLOSE position will start the pump provided that; the isolation valve to the containment ring headers (CS007) is closed; the isolation valve for recirculation back to the RWST (SI001) is open; the manual isolation valve between the Spray Additive Tank and the eductor (CS040) is closed; and the test switch on the MCB is in the TEST position. Pump status is indicated at the MCB and on a MCB monitor light box at the switchgear panel.

To monitor pump performance a watt-hour meter is provided on the switchgear cabinet and an ammeter and circuit test switch are provided on the MCB.

Pump suction and discharge pressure and motor bearing temperature can be monitored by the plant computer.

4.8.2 Containment Spray Discharge Header Isolation Valves (CS007)

A control switch is provided on the main control board for each valve. Each valve is opened automatically by a containment spray actuation signal from the ESFAS. Each valve can be manually opened with its control switch provided that the test switch for the CS pump on the MCB is in the NORMAL position and at least 30 seconds have elapsed since the CS pump has been operated. Valve status is indicated on the MCB and on a MCB monitor light. An alarm actuates if the valve fails to open with the containment spray actuation signal.

4.8.3 Sodium Hydroxide (NaOH) Eductor Supply Valves (CS019)

A control switch is provided on the Main Control Board for each valve. Automatic opening of the valve occurs when a containment spray actuation signal is received from the ESFAS. Manual opening of the valve using the control switch is possible when the test switch associated with the corresponding CS pump is placed in the TEST position. Valve status is indicated on the MCB and on a MCB monitor light. An alarm actuates if the valve fails to open with the containment spray actuation signal.

4.8.4 Containment Spray Pump Suction Valves from Recirculation Sumps (CS009)

A control switch is provided on the main control board for each valve. Each valve can be opened provided that: the containment recirculation sump isolation valve is open and the RHR pump suction valve from the loop hot legs is closed. The purpose of these interlocks is to ensure that neither RWST water nor reactor coolant can be drained to the containment sump through this valve. Valve status is provided on the MCB and on a MCB monitor light box.

4.8.5 Containment Spray Pump RWST Suction Valves (CS001)

A suction valve is provided for each containment spray pump. A control switch is provided on the Main control board for each valve. Each valve can be opened provided that the containment spray pump suction valve from the containment recirculation sump is closed. Interlocks to SI system valves (SI8811A/B) are provided by the valve limit switches. Valve status is indicated on the MCB and on a MCB monitor light box.

4.8.6 Containment Spray Eductor Motive Fluid Valves (CS010)

An air-operated valve is provided for each eductor suction from the discharge of the containment spray pump. The valve fails open on loss of air. A control switch is provided on the main control board for each valve. The valve is normally maintained in the open position. Regardless of the initial position of this valve, receipt of a containment spray actuation signal opens the valve. Valve status is indicated on the MCB and on a MCB Monitor Light Box.

4.8.7 Spray Additive Tank Level Instrumentation

The Spray Additive Tank has two safety-related Lo-2 level indicating lights (one ESF Division 11, 21 and the other, ESF Division 12, 22) on the MCB. This provides safety-related indication on the MCB of Lo-2 level in the Spray Additive Tank.

Additional Safety Category II (non-safety-related) instrumentation for the Spray Additive Tank consists of (1) level indicators on the MCB and on the local control panel.

4.8.8 Containment Spray System Flow Instrumentation

Containment spray ring flow, eductor suction flow, and spray additive flow is indicated by Safety Category II (non-safety-related) indicators on the MCB. Low spray additive flow is annunciated on the MCB. Annunciation will occur if 40 seconds have elapsed since a containment spray actuation signal and spray additive flow is still low.

4.8.9 Containment Pressure Alarms

Containment Spray (CS) system actuation due to high containment pressure is discussed in detail in the Primary Containment Isolation System Design Description (SDD-PC-01-BB).

5.0 SYSTEM INTERFACES

Interfaces with each system are described separately in the below Sections. Appendix 9.1 identifies the plant condition in which the below systems interface with the CS system. For additional information or interfaces with safety-related systems, see the respective system's System Design Description.

5.1 Safety Injection (SI) System

The SI system is used to supply cool borated water from the Refueling Water Storage Tank (RWST) to the CS system in the event of a LOCA or a prescribed testing condition. The SI system is connected to the CS system by a 24 inch header leading from the RWST to a 14 inch suction line off of the CS pumps. The CS pumps are normally maintained in alignment with the RWST for immediate CS pump head injection. The SI interface is isolated by a motor operated gate valve.

5.2 Residual Heat Removal (RH) System

The CS system boundaries at the interfaces with the Safety Injection system, which in turn interfaces with the Residual Heat Removal system, are motor operated isolation gate valves (with the exception of the CS pump test line that is isolated by a locked-closed valve) through a 16 inch line which connects the RHR and CS pumps to the containment recirculation sumps. The RHR system, which also interfaces with the SI system, shares the suction source from the containment recirculation sumps during the recirculation mode of Emergency Core Cooling (ECCS) operation. This design feature ensures the proper system fluid interface during ECCS operation. During switchover from injection phase to recirculation phase, the RHR pumps take suction from the containment recirculation sumps, cools the water in the RHR heat exchanger, sends the water into the breached RCS, and the water returns to the containment sump.

5.3 Nitrogen (NT) System

The NT System is connected to the CS system via 1" connection from the NT supply to the Containment Spray Additive Tank (SAT). This connection provides a nitrogen blanket to eliminate ambient air contact with the sodium hydroxide contained within the SAT.

5.4 Instrument Air (IA) System

The IA system is a support system used in pneumatic instrumentation of the CS system. The CSOIOA/B valves in the eductor motive fluid lines are normally open air operated valves. The loss of instrument air to these valves allow them to fail in an open safe position.

5.5 Auxiliary Power (AP) System

The AP system is a support system used to power various components in the CS system. The motors of spray pumps 1A (2A) and 1B (2B) are powered from 4.16 KV ESF buses 141 (241) and 142 (242) respectively. The major motor operated valves CSO01A/B, CS007A/B, CS009A/B and CS019A/B are powered from the 480 V AC ESF buses. A backup support power source for the Auxiliary Power system is provided by the Diesel Generator system, via two diesel generators through ESF buses.

6.0 OPERATING DESCRIPTION

6.1 System Operating Modes

The CS system has two primary phases of operation associated with accident and/or abnormal conditions. Each of these phases are described in this Section.

6.1.1 Normal Operation

The CS system provides no direct support to the reactor plant during normal plant operation. The system is maintained in a constant stand-by condition that allows instantaneous system initiation upon a accident and/or abnormal response. In this configuration, those portions of the system that are not in operation, or interface with normally idle systems, are aligned to provide necessary pressure and flow boundaries. The CS system's standby alignment provides minimum active component operation during an accident and/or abnormal response.

Portions of the CS system, as required, are released from "stand-by readiness" only to meet specific Station Technical Specification testing/surveillance requirements. These requirements are commitments which are scheduled and performed to ensure the integrity of the CS system.

6.2 Accident/Abnormal System Operation

6.2.1 CS System Injection Phase

The CS system is designed such that in an unlikely event that the MCB ESFAS receives a two-out-of-four coincidence of a Hi-3 containment pressure signal (approximately 20 psig) or a manual containment spray actuation signal, the CS system will initiate injection phase of operation. The CS007A/B valves, which allow pump discharge to the containment spray rings, and the eductor NaOH supply isolation valves, CS019A/B, will simultaneously open. The CS pumps will start after the CS019A/B valves are open. The CS pumps will take suction from the RWST, through normally open motor-operated isolation valves CSO01A/B. This process will occur within a period of 25 seconds unless offsite power to the ESF buses has been lost. If offsite power has been lost, coincident with LOCA, the CS pumps will be sequenced to start upon receipt of a safety injection signal and restoration of bus voltage, by the diesel engine generator load sequencer. The sequencing of the diesel generator load sequencer to the CS pumps will then take approximately 50 seconds. The valve motor-operators will start immediately upon receipt of a Hi-3 signal when power is available.

In parallel with the above sequencing, prepositioned valves CS018A/B or CSO21A/B ensure a flow rate of between 55 - 60 gpm of 30% sodium hydroxide (NaOH), or 53 - 58 gpm of 36% NaOH from the SAT is provided to the suction of the eductor. This flow is mixed with flow from the RWST at the CS pump suction. This blended flow of chemically treated water is then discharged to spray rings. Orifices in the lines to the spray rings ensure sufficient flow will be diverted to the spray rings such that each ring nozzle will produce a spray flow of 15 gallons per minute. The cool chemically treated water condenses the steam in the containment atmosphere reducing containment temperature and

pressure. The water descends downward and is collected in the containment sump.

This process continues until the RWST's Lo-3 level alarm annunciates. At this time the operators will align the Containment Spray suction to the containment recirculation sump by opening the CS009 valve and then closing the CS001 valve. The eduction of NaOH may continue with the source of water as the containment sump until the SAT Lo-2 level alarm annunciates. This ensures sufficient NaOH has been added into containment to provide a final sump pH of 8.0 -10.5. At this time the NaOH tank is isolated. The containment spray system will operate for at least two hours following a LOCA. The two hour timing will commence when the SAT is isolated. If the initiating event is a MSLB, the SAT will be isolated upon Operator identification of the MSLB and after isolation of the faulted steam generator.

6.2.2 CS System Recirculation Phase

The recirculation phase of containment spray is that time when the CS pump is taking a suction from the containment recirculation sump following injection of the NaOH. The containment spray is run for a minimum of 2 hours following a LOCA to ensure that the various sources of water have been adequately mixed so that the final pH is between 8.0 and 10.5. The iodine removal was achieved during the injection phase. The expected long term sump pH of 8.0 to 10.5 will minimize iodine re-evolution (>7 per SRP 6.5.2 Revision 1). This pH will also reduce the probability of stress-corrosion cracking of austenitic stainless steel components (minimum 7.0 per BTP MTEB 6-1). The spray of sump water during the recirculation phase (no further addition of NaOH) will tend to wash off any of the containment spray water during the injection phase that had a pH higher than 10.5 (see 6.2.3 below). This will reduce the final pH on these components to less than 10.5. In order to achieve recirculation of containment spray, the eductor NaOH supply line is isolated, and the system is allowed to run. The CS system is taking suction from the sump at this time and discharging through the spray rings.

It is important to note that CS cannot be terminated until all of the following conditions are met:

1. Containment pressure is less than 15 psig.
2. Spray Additive Tank Lo-Lo level lights lit. (LOCA only)
3. Spray operating time is at least 2 hours. (LOCA only)

6.2.3 CS System pH Response

The containment spray pH may vary during the event. The containment spray pumps will initially see a back pressure due to the elevated containment pressure. The flow rates in Table 3.1 assume a containment pressure of 50 psig. Therefore, the flow of water will increase as the pressure in containment is decreased. This will cause the eductor motive flow to decrease slightly which will decrease the amount of NaOH added, thus slightly decreasing the pH of the spray. Additionally, as the NaOH tank empties, the flow rate of NaOH will decrease due to decreased head pressure from the Spray Additive Tank. This also slightly decreases the spray pH.

When the containment spray pumps begin to use the containment sump as a source of water the eductor may still be adding NaOH to water that already contains NaOH This will cause the spray pH to increase. These variances are discussed below.

To resolve these competing variances, the eductor throttle valve for NaOH (CS018, CS021) has been set for 55-60 gpm of 30% NaOH at high SAT level, using the equivalence of 68-74 gpm of water. This will provide for an actual pH in the A train (3415 gpm total flow) of slightly less than 10.5. The B train pH would be lower since it will have higher borated water flow rate (3925 gpm) and the same NaOH addition rate. The eductor motive flow will be as determined in the Pre-Operational tests while the pump is delivering a total flow of 3415 gpm (A train), 3925 gpm (B train). These flow rates are minimums expected while the containment is at 50 psig. The other changing parameters (decreasing containment back pressure and correspondingly increasing total CS flow rate, lower eductor motive flow rate, lower SAT level) will provide for a lower pH, while the RWST is supplying the system.

When the source of containment spray water is switched from the RWST to the containment sump, the eductor will be adding NaOH to water that already contains NaOH. This will cause the pH to increase. The increase will be based on the actual flow rates prior to (and present at) the time of switchover. However, this value is bounded by a maximum pH of 11.4, which assumes no increase in source water flow rate, and no decrease in NaOH flow rate. 11.4 is the pH of the spray water in the final minute of injection, assuming all the NaOH previously injected had mixed uniformly and made it to the recirculation sump to be source water. The duration of this phase of increased pH would be from a few minutes (one train of ECCS and two trains of CS in operation) to up to 41 minutes (two trains of ECCS and one train of CS in operation).

If the NaOH flow rate decreases (due to reduction of eductor motive flow and NaOH tank level drop), then the duration of the pH higher than 10.5 will be longer, but the magnitude of being above 10.5 will be less. The NaOH injection flow rate to achieve a minimum pH of 8.5 (minimum allowable per SRP 6.5.2, rev 1) would be 19 gpm, conservatively using the B train maximum flow rate of 3925 gpm; if the flow rate were

increased to 4600 gpm (maximum recorded runout). If the NaOH flow rate started at 55 - 60 gpm (spray pH of 10.5) as initially set, and quickly dropped to 19 gpm (spray pH of 8.5), the duration of injection would be approximately 2 hours before enough NaOH is added to the sump to obtain a sump pH of 8.0. This is not expected, but bounds the review of minimum NaOH injection. These conditions will provide for improved iodine removal, due to higher spray pH, during recirculation and establish the same final sump pH as the high flow case (since final sump pH is based on volume of SAT added to sump, not the rate at which it is added), and are therefore acceptable.

The examples above bound the worst case calculated pH and duration. The actual pH profile cannot be easily calculated and therefore, these worst case values have been reviewed. Both cases are acceptable with regard to iodine removal, and final sump pH. However, with regards to pH of the injection spray, the Equipment Qualification of components in containment was performed assuming a maximum spray pH of 10.5. It is acceptable to have spray water with a pH higher than 10.5 for short periods of time as long as the high pH water is washed down with water with a pH lower than 10.5. The containment spray system will be run for a minimum of 2 hours in the scenario (LOCA) where high pH can occur. The pH and duration represented above have been reviewed and are not a concern for either the environmental qualification of equipment or hydrogen generation inside containment. This increase in spray pH beyond the maximum EQ limit of 10.5 is acceptable based on the fact that sensitive components are protected from chemical spray, as well as the fact that the duration of high pH spray is short. In addition, electrical cables have jacket material that exhibit excellent chemical resistance to NaOH at high temperatures. Revised hydrogen generation rates based on high pH show that the hydrogen concentration inside containment remain below the 4% limit given in Regulatory Guide 1.7.

7.0 SYSTEM PROTECTION FROM PLANT INCIDENTS

7.1 Loss-Of-Offsite Power (LOOP)

The design of the CS system accommodates loss-of-offsite power by providing power from the Class 1E buses or Station batteries for the system functions required for safe shutdown. The power sources are redundant and separated and are designed in accordance with IEEE Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," and 384-1974 IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."

7.2 Fire Protection

The CS system's Safety Category I (safety-related) components and piping have been designed to withstand the affects of postulated fire conditions. The system has

been reviewed for separation of safe shutdown cables and components to insure that postulated fires will not prevent safe shutdown. Specific information may be obtained in the Byron/Braidwood Fire Protection Report.

7.3 High/Moderate Energy Line Break (HELB/MELB)

Protection against high/moderate energy line breaks is afforded by basic geometric CS system separation and redundant design. Since all CS system components with exception of the two independent sets of spray headers and nozzles, are in the Auxiliary Building, jet impingement inside containment will not impair the safe shutdown function of the CS system. Specific requirements of the CS system and components can be found in the Byron/Braidwood HELB/MELB calculations as well as "Byron 1-Confirmation of Design Adequacy for Jet Impingement Effects."

7.4 Seismic Events

The safety-related portion of the CS system is designed and supported to remain intact following the design Operating Basis Earthquake and Safe Shutdown Earthquake. The active equipment is designed to remain functional after these events. Component(s) qualification by test or design is documented as referenced in the CS portion of the project's Safety-Related Component List (SRCL).

7.5 Flood Protection

The CS system is designed to withstand the maximum probable flood plant scenarios. Details relative to CS system submersible components and water sprays affecting the CS system are respectively described in the Byron and Braidwood Flooding Calculations entitled, "Confirmation of Safe Shutdown Capability After Auxiliary Building Flooding."

8.0 SAFETY CRITERIA

The Containment Spray system and its components, with exception of the test/recirculating line are classified as Safety Category I, ASME Section III, Quality Group B (Class 2), as shown on the system design drawings. Instrument sensing lines are designed to the same ASME Code Class as the process line, up to and including the first isolation valve. References to the components Hazard Zones and Environmental Qualification Report may be sought via the CS system portion of the Project Safety-Related Component List (SRCL).

9. 0 REFERENCES

1. BYRON Pre-op Test Results, R-232, p. 57 for 1B & R-232, P. 54 for 1A

2. BYRON Pre-op Test p. 114 for 2A & p. 119 for 2B

3. CS-RS-83, Rev. 0, dated 7/7/83, BYRON/BRAIDWOOD Calculation of Equivalent Water Flow Rates for 55 gpm of 30% NaOH solution.

4. BYR-96-119, Rev. 0, dated 8/8/96, BYRON/BRAIDWOOD Calculation of flow rates of 36% by wt NaOH based on 55-60 flow rate of 30% of NaOH.

5. BYR-96-160, Rev. 0, dated 8/12/96, BYRON/BRAIDWOOD Calculation of Estimated Flow Rate of 36 Wt % Sodium Hydroxide Solution at Varying Tank Levels.

6. BYR-96-051, Rev. 1, dated 3/28/96, BYRON Calculation of back pressure readings for CSAT Hi & Lo-2 setpoints

7. BYR-96-051, Rev. 0, dated 3/25/96, Byron Calculation of CS Eductor Flow Test Pressure Determination

8. NED-M-MSD-201, Rev. 0, dated 3/22/96, BRAIDWOOD Evaluation of Containment Spray Test Flow rates (Correction Factor).

9. BYR-96-060, Rev. 0, dated 3/28/96, BYRON Calculation of NaOH Addition Rates for Containment Spray Injection pH of 8.5 to 10.5.

10. BYR96-061, Rev. 0, dated 3/29/96, BYRON Calculation of Minimum & Maximum Acceptable Test Water Flow Rates for the CS Eductor.

11. BRW-96-342-M, Rev. 0, dated 09/04/96, BYRON/BRAIDWOOD Calculation of Maximum CS pH when the CS pump is taking a suction from the Containment Recirculation sump and NaOH from the CSAT is added to the CS pump flow.

12. ATD-0356, Rev. 2, dated 9/20/96, BYRON/BRAIDWOOD Post-LOCA Containment Sump minimum pH.

13. NDIT # BYR-96-061, Rev.0, dated 3/27/96, BYRON Transmittal of Containment Spray Additive Eductor Flow Test Reference Test Conditions.

14. BYR96-113, Rev. 0, dated 3/5/96, Byron/Braidwood Increase in the Internal Design Pressure of Spray Additive Tanks 1/2CS01T and 1/2CS02T.

Nuclear Design Information Transmittal

☒ Safety-Related ☐ Non-Safety-Related ☐ Regulatory Related	Originating Organization: ☒ ComEd ☐ Other (specify) ______	NDIT No. *BYR-96-?09, Rev. 0*
Station: *Byron/Braidwood* Unit(s): *All* Design Change Authority No.: *n/a* System Designation: *CS*		Page *1* of *3* To: *Steve Gould/Tyrone Stevens*

Subject:

Containment Spray Additive eductor flow test, reference test conditions.

Mark S. Bruckner	S&L	Mark S. Bruckner	10/10/96
Preparer	Position	Preparer's Signature	Date
W. J. Feimster	Lead Mechanical	W.J. Feimster	10-15-96
Reviewer	Position	Reviewer's Signature	Date

Status of information: ☒ Approved for Use ☐ Unverified ☐ Engineering Judgment

Method and Schedule of Verification for Unverified NDITs: *N/A*

Description of Information:

The information provides the test conditions at which the flowrate of the Spray Additive system eductor (as referenced in Technical Specification 4.6.2.2.d) should be tested.

Purpose of Issuance:

To transmit revised necessary information for the performance of CS Eductor Flow Test (1/2BVS 6.2.2.d-1 of Byron and 1/2BwVS6.2.2.d-1 of Braidwood)

Source of Information:

See references

Distribution:

Per DDL, J. Feimster, L. Wehner, A. Ferko, S. Gould, T. Stevens, H. Singh , B. Acas

File No.: *4.02.0201* **CHRON No.:** *N/A*

ATTACHMENT B, PART 2

COMED NUCLEAR DESIGN INFORMATION TRANSMITTAL	NDIT No. BYR-96-209, Rev. 0
	Page 2 of 3

As a result of a comprehensive design review for the Containment Spray (CS) System which was done for Byron and Braidwood, it has been determined that the surveillance tests should be re-performed, even though the present system configuration is acceptable. This re-performance centers mainly around the performance testing of the CS eductors, and requires that the Spray Additive Tank flow be re-established based on testing at both hi and low tank levels.

In order to determine the correct boundary conditions for eductor flow performance testing in Technical Specification 4.6.2.2.d (55 gpm of 30 wt% NaOH +5,-0; 68 gpm water +6,-0), a review was made of the requirements of the NaOH injection system. From the ANS standard (Reference 1) and UFSAR system descriptions (Reference 2) the Spray Additive subsystem is used for fission product removal and sump chemistry control. Sump chemistry control is not in question as it pertains to NaOH addition rates, since the overall volume of NaOH which enters the sump is predetermined regardless of the addition rate. This is assured by operating procedures which require a SAT level during normal operations between Hi and Lo-1 alarms and that, upon CS initiation, the CS pumps will educt NaOH from the Spray Additive Tank (SAT) until it reaches the Lo-2 setpoint. Only the eductor flow rates for fission product removal will be reviewed by this NDIT (as well as EQ limits).

From Reference 1, calculations of iodine removal are sensitive to pH (in NaOH additive systems) in that the partition factor is directly related to pH (per Reference 1, Figure 8.3-1). Partition coefficient is defined as the equilibrium ratio of iodine in the liquid phase to the concentration in the gas phase. This table provides that the same partition factor is allowed for NaOH solutions with a pH range from 8.5 to 11. Therefore, from an iodine removal perspective, the design points of pH would be from 8.5 to 11. [Note: A spray solution with a lower pH than 8.5 could be demonstrated to be acceptable, but this is not being pursued at this time].

EQ engineers were consulted concerning the maximum allowable pH values during the NaOH addition phase of CS operation. References 6 and 7 establish the normal basis of containment spray as being less than or equal to 10.5, while Reference 9 demonstrates that the peak spray pH could be as high as 11.43 (assuming failure of SAT isolation valve CS019 to close and an upper limit NaOH concentration of 36 wt%). This peak value and associated time frame have been justified from an EQ standpoint, and is documented in Reference 10. Conservatively, for purposes of this NDIT, 10.5 will be used.

From these final minimum and maximum pH values, 8.5 to 10.5, limiting flowrates of 30 wt% NaOH injection have been evaluated to determine the sensitivity of the Tech Spec allowable flows on the spray solution pH. Calculations performed by Sargent and Lundy Air and Water Quality Division personnel (Reference 3) revealed that the limiting upper bound pH of 10.5 corresponds to a 30 wt% NaOH flowrate of approximately 65 gpm (which is above the Tech Spec allowable range of 55-60 gpm). This is at worse case pump flow and RWST concentration. Conversely, to achieve 8.5 pH, a 30 wt% NaOH flowrate of approximately 19 gpm would be required (again assuming worst case pump flow and RWST concentration). 30 wt% NaOH was specified since the relationship of flow for 30 wt% NaOH and water is prescribed in Tech Spec 4.6.2.2.d. From this evaluation, the Tech Spec required flowrates (55 gpm +5,-0 of 30 wt% NaOH) are associated with and bound the maximum NaOH injection. The minimum required flowrate would be much less (19 gpm).

Testing on 3/25/96 (BVS 4.6.2.2.d-1) and review of preoperational tests (Reference 5) indicate an impact on educted flow by the motive flow through the eductor. To assure the eductor flow is representative of actual accident /startup test conditions, the eductor motive flow rates which were recorded during startup testing (Reference 5) should be re-established by throttling the CS035 valve during the surveillance.

Maximum NaOH flow:

The boundary conditions for the Technical Specification 4.6.2.2.d value of eductor water flow applies to the maximum case of NaOH injection, and therefore the eductor throttle valve should be set:

1. for a Tech Spec water flow of 68 to 74 gpm (by reading 62 to 67 gpm on FI-CS015/16) (Reference 11),

2. at eductor motive flow conditions, equal to preoperational data (Reference 5) by throttling the CS035 valve to flow rates at Byron: for U-1, 135 gpm; 2A, 133 gpm; 2B, 130 gpm; at Braidwood: for U-1,130 gpm, U-2,140 gpm,

3. while simulating a Hi-level setpoint in the SAT (30 wt% NaOH, removing vacuum effects, and adding N2 blanket +1.0 psi): for Byron, A trains 7.3 psi, B trains 6.9 psi (Reference 4).

4. These values should be embodied in future surveillances, so that controlled reference points are established in monitoring eductor flow.

Minimum NaOH flow:

The minimum NaOH flow rate is not considered a Technical Specification requirement, but will be compared with the overall design basis. The following one-time testing of the minimum system performance will be done (either under a Temporary Change or an SPP). This testing encompasses simulating the Lo-2 SAT level and the minimum and maximum preoperational test eductor motive flow rates. These tests will represent high containment pressure and low containment pressure. This test consists of 2 cases, as described below:

CASE 1- design pump flow:

Further evaluation of system performance shall be evaluated based on the eductor flow at minimum 30 wt% NaOH injection by measuring eductor flow (and NOT adjusting the eductor NaOH flow throttle valve from maximum setting) while simulating:

1. an eductor motive flow approximating preoperational test design flow conditions (Reference 5)(CS035 valve set for those values provided in item 2 for Maximum flow testing above),

2. while simulating a SAT at the Lo-2 level: for Byron, A trains 1.1 psi, B trains 0.5 psi. The NaOH flow should be at least 19 gpm (Reference 3)(by reading 22 gpm water flow on FI-CS015(16)(Reference 11)).

CASE 2 - maximum pump flow:

As containment pressure decreases during an event, the CS pump flow rate will increase, and eductor motive flow will decrease. Preoperational data shows the 1A to be the most affected. One-time validation of NaOH flow should be performod on the 1A train, while simulating:

1. an eductor flow approximating preoperational test maximum CS pump flow conditions (Reference 5); CS035 valve set at Byron for train 1A, 125 gpm; at Braidwood for train 1A, 120 gpm.

2. while simulating a SAT at the Lo-2 level: for Byron, 1.1 psi. The NaOH flow should be at least 20 gpm (by reading 23 gpm water flow on FI-CS015). [Expected value derived from ratioing design CS flow (3925 gpm) over maximum 1A CS flow (4125 gpm)(Reference 5, R-232) times minimum NaOH flow (19 gpm)(Reference 3) and similarly increasing the indicated reading.]

References:

1. ANS-56.5-1979.

2. UFSAR, Section 6.5.

3. Calculation BYR 96-060.

4. Calculation BYR 96-051.

5. Preoperational tests: Byron, 2.17.10, 2.17.60, Retests R-191, R-232; Braidwood, BWPT-CS-10 rev. 0 (Unit 1), BWPT-CS-50 rev. 0 (Unit 2), Retest BWPT-CS-10 rev. 1 (Unit 1).

6. EQ Program Design Basis Document, PMED-BB-EQ-DBD-00.

7. IEEE-323-1974, Table 1.

8. Calculation BRW-96-071

9. Calculation BRW-96-342-M, Rev. 0, dated 09/04/96.

10. Byron Letter BYRON-96-5134, "Evaluation of Increased Containment Spray pH for Environmental Qualification of Byron and Braidwood Station Equipment".

11. Calculation NED-M-MSD-201, Rev. 0, "Evaluation of Containment Spray Test Flowrate".

BYRON/BRAIDWOOD UFSAR (DRP) DRAFT REVISION PACKAGE REQUEST/TRACKING SHEET

DRP # 6-077 Affected Section(s); Table(s); Figure(s): SEE ATTACHED

STATION/UNIT (CIRCLE)
BY1 BY2 BW1 BW2 [B/B]

Originator: MARK BRUCKNER / Mark Bruckner 11/19/96
(please print name) (signature) (date)

Company: S&L Dept/Div: SEC Phone Ext.: 2842 Location: BYR

TYPE OF CHANGE:

____ **Facility Change** (MOD,MPC,SSCR,Etc.)
X **Technical Change** New Safety Issues, Procedures, Etc.
____ **Editorial Change** (Typos, Etc.)

10CFR50.59 Attachment: X **Evaluation** ____ **Screening**

Description and Reason for Change (Attach marked up pages)
A CS SYSTEM DESIGN BASIS REVIEW WAS PERFORMED. THE REVISIONS RESULTED FROM THAT REVIEW.

Supporting Documentation (List all ECNs, Calcs, Drawings, Letters, Etc. Include attachments where appropriate):
CALCULATIONS: BYR-96-113 R/0; BYR-96-060 R/0; BRW-96-342-M/BYR-96-170 R/0; BRW-96-438-M/BYR-96-169 R/0; EQER 00-96-008. CALCULATION ATD-0356 R/2.

Date & Schedule for Facility Changes: N/A

Unit	Facility Change No.	Scheduled	Outage	Actual	Outage
BY1		/ /		/ /	
BY2		/ /		/ /	
BW1		/ /		/ /	
BW2		/ /		/ /	

Comments:

(Final)

(1227AA/WPF/042294)

| PMED EPED SPED CID HVAC

| CQD ATD N A R WEST

| STATUS: ______ Completed

| ______ On Hold (explain)

| ______________________________

| ______________________________

| ______________________________

| ______ Rejected

(explain)

| ______________________________

| ______________________________

| ______________________________

| INCORPORATED INTO UFSAR REV.___

| REMARKS______________________

| ___________________________

| ___________________________

| ___________________________

| ___________________________

DRAFT

event of having a LOCA coincident with a loss of offsite power (LOOP) in one unit, the supply and exhaust fans powered from that unit are tripped and charcoal booster fans started. The supply fan and exhaust fan associated with the second unit continue to operate. Two hours after the above event, the supply and exhaust fans associated with the LOCA/LOOP unit may be manually restarted at the operator's discretion.

All harsh Class 1E equipment associated with this equipment is environmentally qualified as shown in Reference 3. All Class 1E electrical equipment associated with the cubicle coolers and auxiliary building HVAC system satisfies IEEE 279-1971 and IEEE 308-1971 design criteria.

A failure of any equipment component is audibly and visibly annunciated in the main control room. The operator can manually start and stop the standby system from the main control room.

In the event of a single failure of one of the cubicle coolers, the safety-related function is performed by the other ESF division pump and cooler, and safe shutdown of the reactor is not affected.

In the event of a single failure of an auxiliary building HVAC system supply or exhaust fan, the safety-related function is performed by one of the other ESF division supply or exhaust fans and safe shutdown of the reactor is not affected.

3.11.4.5 Containment

The equipment located within the containment which is required to safely shut down the reactor is served by the reactor containment fan cooler (RCFC) system which is described in detail in Subsections 6.2.2 and 9.4.8.

The 100% redundant RCFC units are designed to remove the heat generated by a loss-of-coolant accident. The electrical equipment associated with the RCFC units are Class 1E and are environmentally qualified to the postaccident environment as shown in Reference 3.

A single failure of the RCFC units will not impair safe shutdown of the reactor since 100% redundancy has been provided.

3.11.5 Estimated Chemical and Radiation Environment

The chemical compositions and pH values for reactor coolant for purposes of this discussion are listed in Table 3.11-3. The ~~composition and~~ resulting (long term) pH of the liquid in containment sumps ~~are as follows:~~ Insert

~~a. both trains running with one educator operating; the solution will have 0.87 pound of NaOH per pound of B with a resulting pH of 8.5.~~

start new paragraph with Insert C here.

P. 1 of 36
DRP 6-077

Start new paragraph with Insert D here.

b. With A train running only, the solution will have 1.41 pound of NaOH per pound of B with a resulting pH of 9.02.

c. With everything running, the solution will have 1.315 pound of of NaOH per pound of B with a resulting pH of 8.95.

The hydrogen generation as a result of core radiolysis, radiolysis of sump water, and the control of hydrogen buildup within the containment are discussed in Subsection 6.2.5.

The organic materials inside the containment and the material released due to the radiation exposure are discussed in Subsection 6.1.2.

The design radiation environment for each area of the plant is listed in Table 3.11-2, for both normal operation and design-basis accident conditions.

The values listed represent gamma plus beta integrated doses. Safety-related equipment (Class 1E) which can withstand the specified radiation levels is chosen based on its location in the plant.

Specifications for the equipment purchased state that a gamma irradiation test to the specified radiation level is acceptable for meeting the specified radiation level beta plus gamma requirement.

The calculation of the design-basis accident is presented in Subsection 15.6.5. All source data and assumptions are presented there.

Source terms and chemical environments for which the NSSS scope equipment is qualified are described in Appendix A to Reference 1.

3.11.6 Operability Requirements

Specific postaccident operability requirements for each device are developed from the guidelines which are given in Table 3.11-4.

The operability requirement for each piece of Class 1E equipment is the length of time the equipment is required to remain functional during accident mitigation. A margin of at least 1 hour of equipment operating time has been included in the qualification program for each piece of applicable Class 1E equipment.

DRAFT

LIST OF TABLES (Cont'd)

DRAFT

P. 3 of 36
DRP 6-077

CHAPTER 6.0 - ENGINEERED SAFETY FEATURES

LIST OF FIGURES

DRAFT

P. 4 of 36
DRP 6-077

DRAFT

associated components, and control of the use of sensitized stainless steels can be found in Appendix A.

6.1.1.2 Composition, Compatibility, and Stability of Containment and Core Spray Coolants

The containment spray system is designed to ~~deliver, with only one eductor delivering 30% NaOH solution, with all pumps operating, enough NaOH~~ to the containment to form ~~8.5~~ pH solution when combined with the ~~refueling water and~~ spilled reactor coolant water ~~after~~ the refueling water storage tank ~~has been emptied~~ (see Subsection 6.5.2). The probability of stress-corrosion cracking of ~~austenitic stainless steel components~~ is therefore minimized.

Most components in the containment are fabricated of austenitic stainless steel. These materials are compatible with the NaOH solution, with the exception of galvanized steel and aluminum. The amount of hydrogen generated within the containment by corrosion of materials can be neglected, as described in Subsection 6.2.5.3.2. To prevent degradation of the sodium hydroxide, an inert gas is maintained within the spray additive tank. A relief valve is provided to prevent overpressurization of the tank.

The vessels used for storing ESF coolants include the accumulators, the containment spray additive (sodium hydroxide) tank, and the refueling water storage tank.

The ESF coolant is stored in a stainless-steel-lined concrete refueling water storage tank. The chloride ion concentration of borated water coolant stored in this tank normally is less than 0.15 ppm, therefore stress corrosion cracking of the lined stainless steel or ESF components through which the coolant circulates is very unlikely.

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.

The accumulators are vessels filled with borated water and pressurized with nitrogen gas. The nominal boron concentration~~, boric acid,~~ is ~~2000~~ ppm. Samples of the solution in the accumulators are taken periodically for checks of boron concentration. Principal design parameters of the accumulators are listed in Table 6.3-1.

The refueling water storage tank is a source of borated cooling water for injection. The nominal boron concentration~~, as boric acid,~~ is ~~2000~~ ppm, which is below the solubility limit at freezing. The temperature of the refueling water is maintained above freezing. Further information on the refueling water

DRAFT

The quantity (weight and volume) of uncovered cable and cable in conduit or closed cable trays are as follows:

a. Uncovered

Weight (W) = 11,359.31 pounds

Volume (V) = 81.96 cubic feet

b. Covered

W = 75,061.53 pounds

V = 586.49 cubic feet.

A breakdown of cable diameters and associated conductor cross sections is shown on Table 6.1-5.

The insulation and jacket materials are also indicated on Table 6.1-5.

There is no wood or asphalt inside the containment.

6.1.3 Postaccident Chemistry

In the event of an accident, sodium hydroxide and boric acid solutions will be present in the containment sump; the presence of sodium hydroxide in the sump solution will reduce the probability of stress corrosion cracking of austenitic stainless steels by maintaining the long term sump solution pH above 8.0. ~~The time history of the pH of the aqueous phase in the containment sump is given in Figure 6.1-3.~~

There are two independent safety grade sumps in the containment which are used to recycle ESF fluids. The only significant source of low pH fluids is a possible leak of borated reactor coolant. The boric acid content of this water is very low, and as a result, the pH of the coolant will be only slightly less than 7.0. In the event of a LOCA, the reactor coolant pH will be ~~diluted~~ increased by the addition containment spray. A sufficient quantity of NaOH is added ~~used in the spray~~ to maintain the pH of liquids in the containment above 8.0 ~~8.5~~. This pH level can be maintained even in the event of a maximum break size LOCA, and the concurrent failure of one of the two safety grade containment spray systems. The containment spray systems are designed so that each division fully covers the containment, thereby ensuring that all reactor coolant spillage ~~is neutralized~~, when combined with the spray, has a minimum pH of 8.0.

6.1.3.1 Steamline Break Inside Containment

In the event of a main steamline break inside the containment concurrent with failure of the isolation valve to close in the faulted steamline, there would be backflow from piping which is external to the containment. Low steamline pressure setpoints would be reached within approximately 5 seconds after the break

P.6 of 36
DRP 6-077

DRAFT

occurs, and the three remaining main steamline isolation valves and the main feedwater isolation valves would require an additional 5 seconds for closure. In addition, steam would be released from the steam generator via a 1.4-ft^2 flow restrictor located within the vessel discharge nozzle. Peak containment pressure resulting from this break is 36.9 psig, which would cause actuation of containment spray and caustic eduction. ~~Figure 6.1-1 shows the amount of liquid that is accumulated in the containment basement versus time, along with pH, which is expected to be constant at 10.0. The figure is based upon both containment spray~~ pumps delivering borated water ~~containing 2000 ppm of boron as B-10, buffered to 10.0 pH by means of 30% caustic addition, to the six spray rings at the design flow rate. It is also based upon all four reactor containment fan coolers operating and condensing steam at their combined total design rate of 6,840 lb/min, until all steam that has been released and flashed to the containment atmosphere has been condensed.~~ After the type of break has been ascertained, the ~~containment spray pumps~~ can be ~~stopped~~ (secured) by operator action.

(Handwritten: Once the containment pressure has decreased below 15 psig, the CS pumps may also be secured. / Caus. educt)

Although there may be up to 1.50 ppm of ammonia in the steam resulting from decomposition of morpholine or from direct feed of ammonia, this has no significant effect upon pH of condensed steam containment spray mixture as it accumulates in the containment sump.

6.1.3.2 Main Feedwater Line Break Inside Containment

In the event of a main feedwater line failure inside the containment concurrent with failure of the isolation valve to close in the faulted line, but with the feedwater regulator valve located in the turbine building assumed to close within 10 seconds after the break occurs, the resulting peak containment pressure will be less than the pressure at which containment spray is actuated. Therefore, the accumulation of liquid in the containment basement will be the amount of liquid discharged from the feedwater line, plus water and steam released from the feedwater nozzle via a restricting orifice located in the nozzle. It is assumed that all four reactor containment fan coolers will condense flashed steam at their total design rate of 6,840 lb/min. ~~The quantity of liquid that will accumulate within the containment basement and pH of the liquid versus time are shown in Figure 6.1-2.~~ The following chemical composition of the liquid is expected:

Free hydroxide, ppm as $CaCO_3$	less than 0.15
Ammonia, ppm	less than 0.25

In addition, there will be trace quantities of other substances such as silica, sodium and chlorides.

Insert E

6.1.3.3 Loss-of-Coolant Accident

In the event of a pipe break of a reactor coolant loop, both safety injection and containment spray will be initiated. ~~The highest final pH will result when both ECCS and containment spray trains are actuated with 30% caustic solution being educted into each containment spray pump suction at the rate of 55 gal/min. The lowest final pH will result when both ECCS and containment spray trains are activated but one caustic supply valve fails to open. Figure 6.1-3 (Sheet 1) indicates volume of liquid accumulation in the containment basement and pH of the solution for the first case in which the final pH is highest, and Figure 6.1-3 (Sheet 2) indicates similar information for the second case in which the final pH will be at a minimum.~~ The systems function in the same manner regardless of whether one or two ECCS/containment spray trains are in operation. The residual heat removal pumps will be semiautomatically transferred to the recirculation mode when ~~approximately 260,000 gallons of borated water have been pumped into the containment from~~ the refueling water storage tank. The charging and safety injection pumps are then manually aligned for the recirculation mode. The containment spray pumps will continue to operate with ~~caustic eduction~~ until the RWST ~~empty alarm is sounded when a total of approximately 415,000 gallons of borated water have been pumped.~~ The operator will then manually ~~remove~~ the containment spray pump ~~from service in the injection mode.~~ ~~The~~ final sump solution will always be at a pH of ~~8.5~~ or greater.

(Handwritten annotations: "suction from the RWST"; "reaches the Lo-2 level setpoint"; "reaches the Lo-level setpoint"; "align"; "suction from the RWST to the recirculation sump."; "Caustic eduction will continue until the spray additive tank reaches the Lo-2 level, regardless of CS pump suction source."; "This ensures that the"; "8.0"; "The spray pH will vary from a minimum of 8.5 to a maximum of 11.4. See Section 6.5.2 for further discussion of spray")

6.1.4 References

1. WCAP-7803, "Behavior of Austenitic Stainless Steel in Post Hypothetical Loss of Coolant Environment."

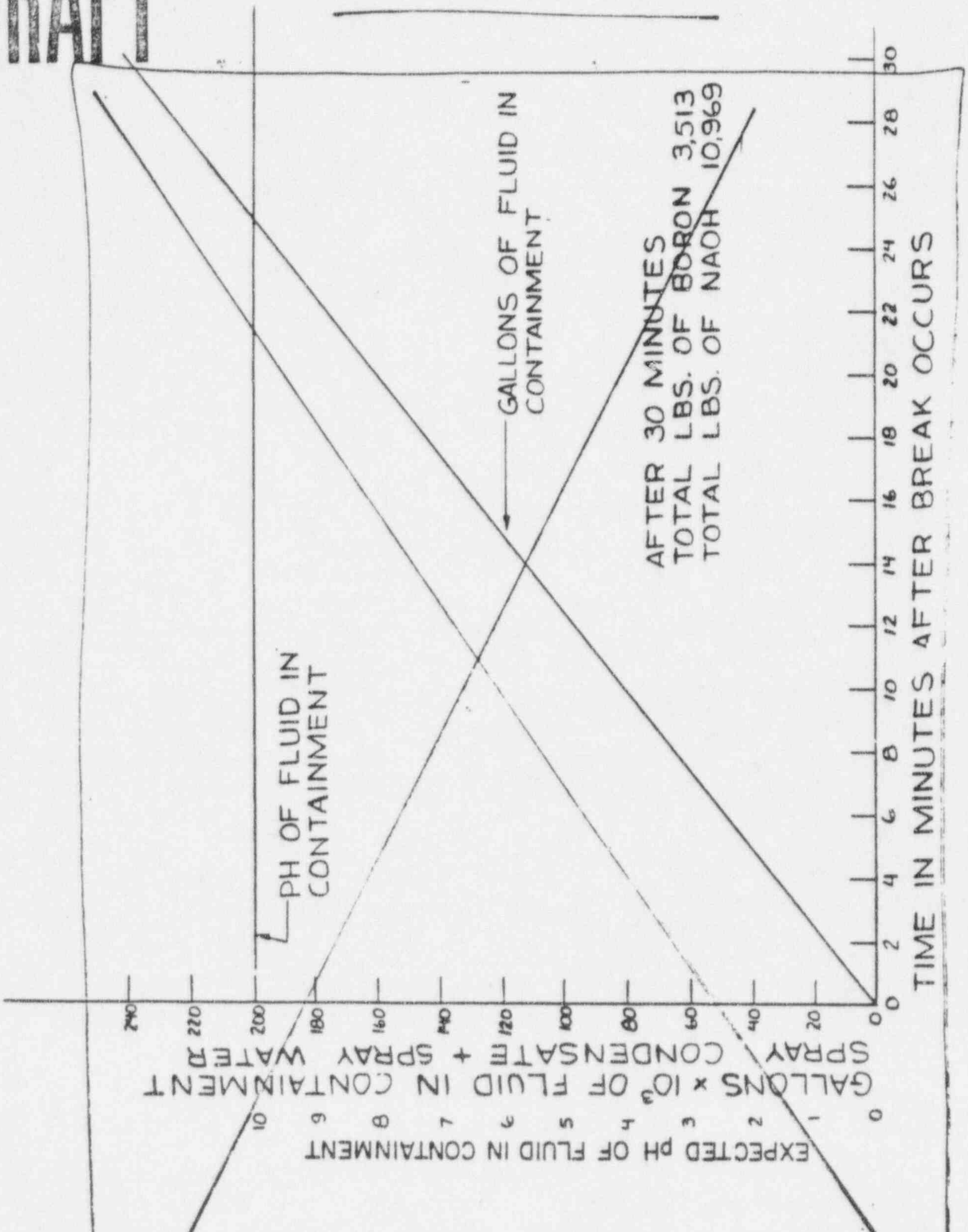
2. L. F. Picone, "Evaluation of Protective Coatings for Use in Reactor Containment," WCAP 7825, December 1971.

3. "Radiation Effects on Organic Materials," R. Bolt and J. Carroll, Academic Press, 1963.

4. "Study of Radiolysis of Epichloryhydrin by an Electrical Conducting Method," V. Zhiklarer, et al. (Institute of Physical Chemistry, Kier, 1973), abstract only in Nuclear Science Abstracts, 28, No. 12, Item 29672, 1973.

DRAFT

Delete figure



NOTE:

1. BOTH CONTAINMENT SPRAY AND RCFC TRAINS IN SERVICE
2. ACCIDENT IDENTIFIED AND CONTAINMENT SPRAY INJECTION IS STOPPED BY OPERATOR ACTION AT 30 MINUTES AFTER ACCIDENT

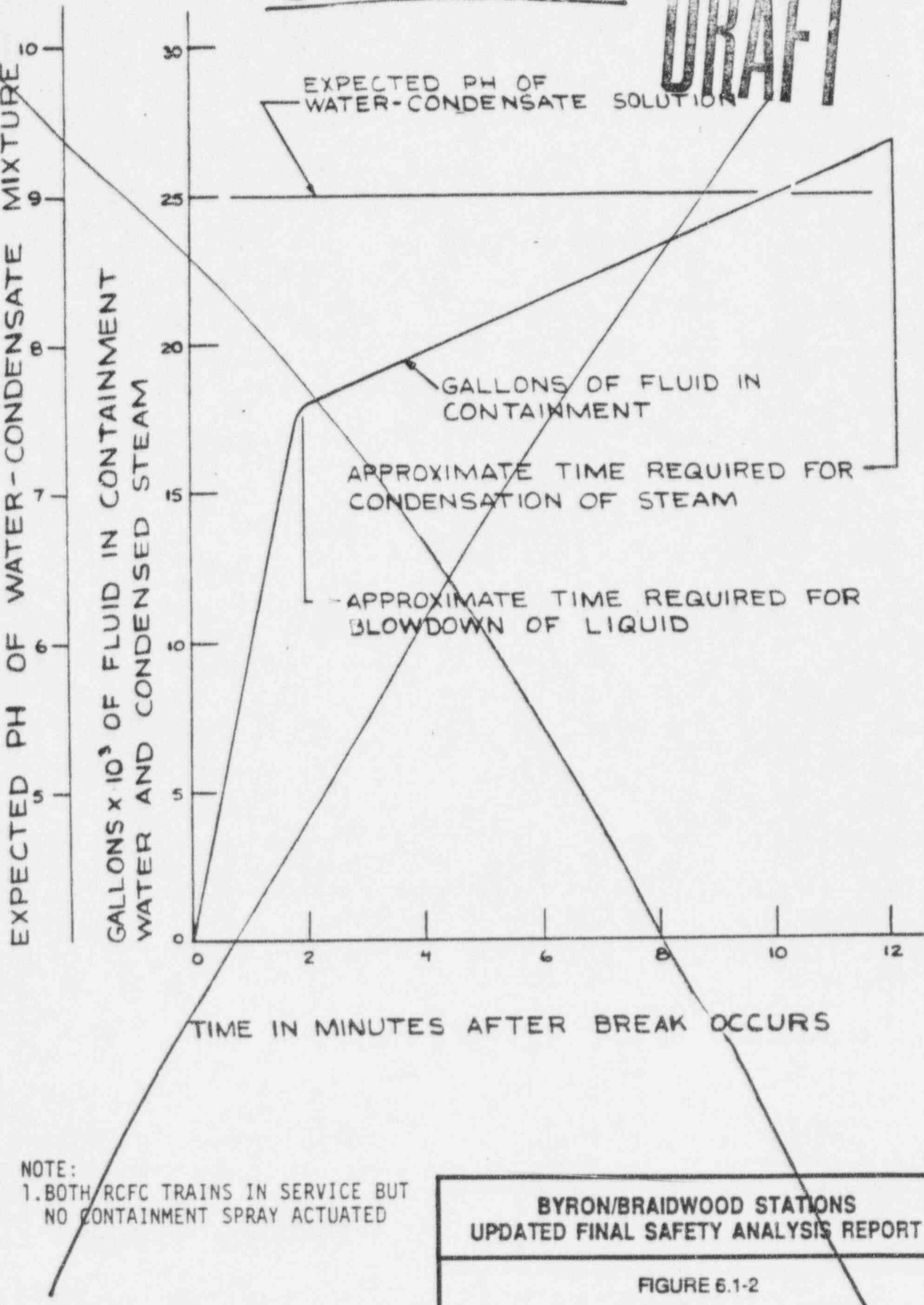
BYRON/BRAIDWOOD STATIONS
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 6.1-1

FLUID AMOUNT AND pH VS. TIME, MAIN STEAMLINE BREAK INSIDE CONTAINMENT

Delete figure

DRAFT



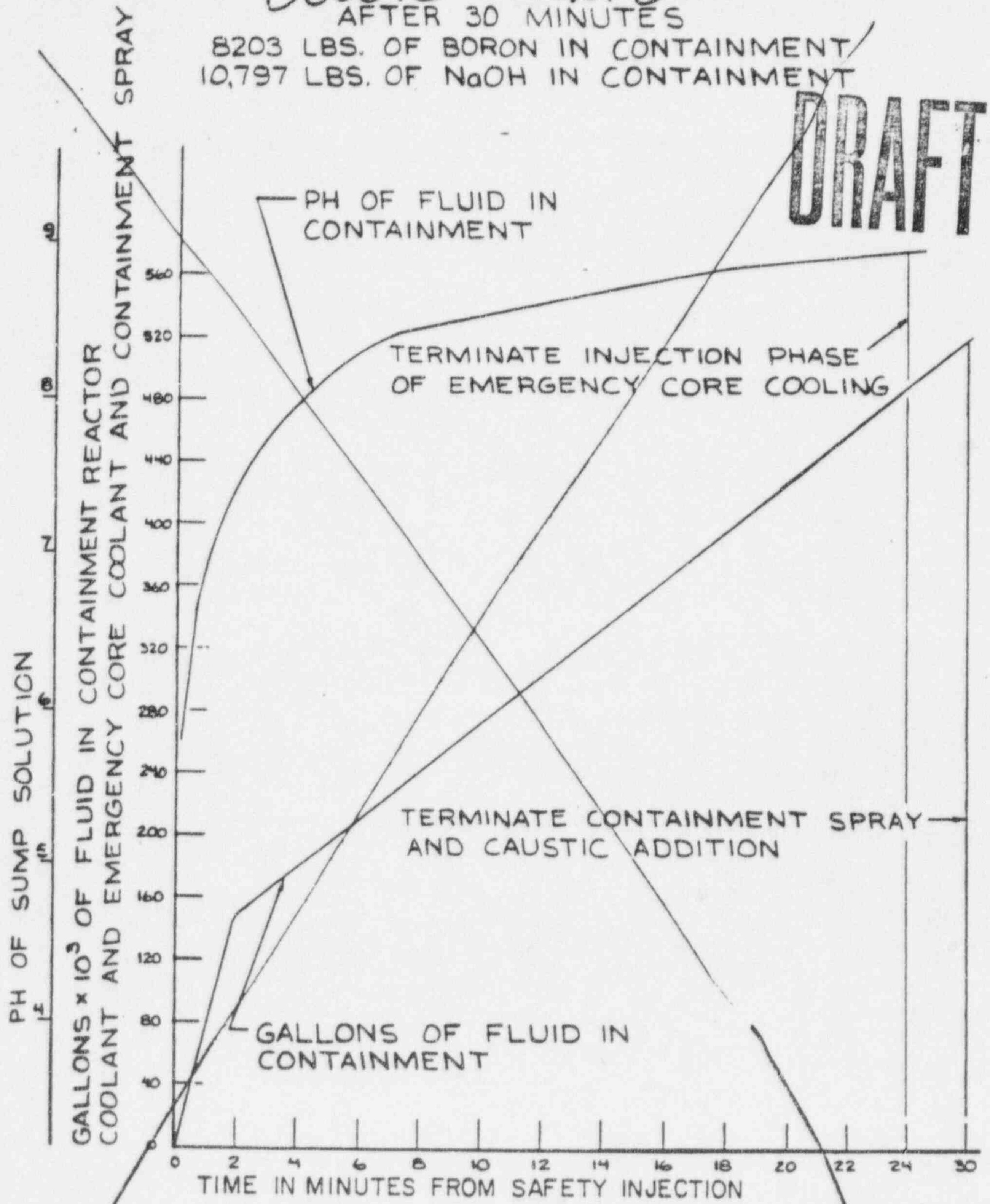
NOTE:
1. BOTH RCFC TRAINS IN SERVICE BUT NO CONTAINMENT SPRAY ACTUATED

BYRON/BRAIDWOOD STATIONS
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 6.1-2

FLUID AMOUNT AND pH VS. TIME, MAIN FEEDWATER LINE BREAK INSIDE CONTAINMENT

DELETE FIGURE



NOTE:
1. BOTH EMERGENCY CORE COOLING AND CONTAINMENT SPRAY TRAINS IN SERVICE

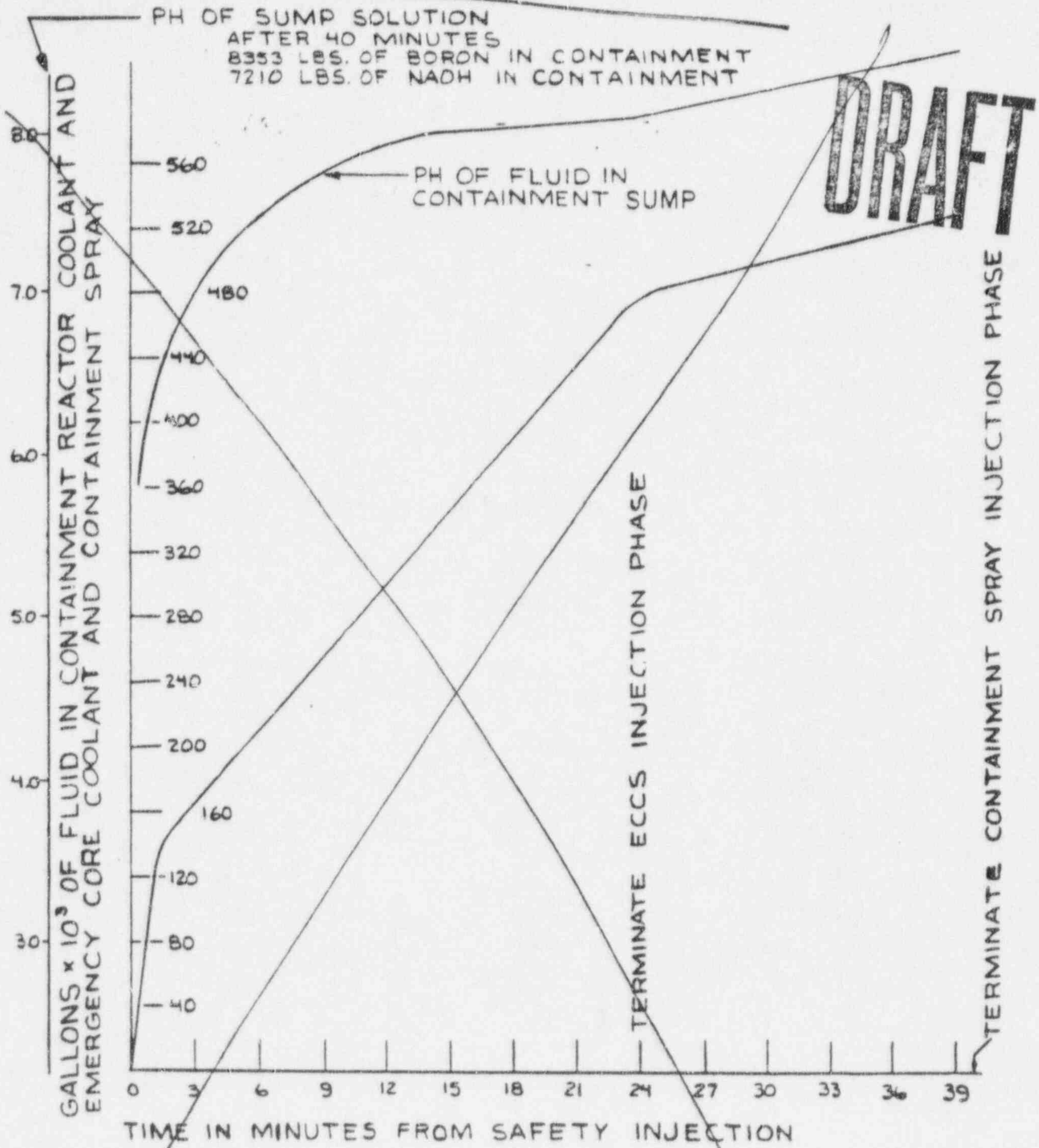
BYRON/BRAIDWOOD STATIONS
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 6.1-3

FLUID AMOUNT AND pH VS. TIME, LOCA
(SHEET 1 OF 2)

P. 11 of 36
DRP 6-077

DELETE FIGURE



NOTE:
1. BOTH EMERGENCY CORE COOLING AND CONTAINMENT SPRAY TRAINS IN SERVICE, BUT VALVE IN CAUSTIC SUPPLY LINE FAILED TO OPEN

BYRON/BRAIDWOOD STATIONS
UPDATED FINAL SAFETY ANALYSIS REPORT

FIGURE 6.1-3

FLUID AMOUNT AND pH VS. TIME, LOCA
(SHEET 2 OF 2)

DRAFT

6. The main control room display/recording requirements of Regulatory Guide 1.97 are met for containment sump level.

Reactor support concrete temperatures are indicated inside containment. Reactor support liquid coolant, utilizing component cooling water, may be provided if the need is indicated by the concrete temperature indicators.

Refer to Section 7.3 for design details.

6.2.2 Containment Heat Removal System

The containment heat removal system consists of the reactor containment fan cooler system and the containment spray system. The reactor containment fan cooler system has no emergency function other than containment heat removal, while the primary function of the containment spray system is the removal of iodine and other radionuclides from the containment atmosphere.

The containment spray system is designed to operate following a LOCA to reduce the elemental iodine concentration of the containment atmosphere and to raise the pH of the containment sump by adding NaOH, to ensure that the iodine removed from containment atmosphere will be retained in the sump solution. ~~The objectives are completed in approximately 30 minutes, at which time the spray injection phase is terminated. The~~ system is ~~then~~ isolated from the RWST and plant valves are aligned for ~~recirculation~~ operation. (It should be noted that after 30 minutes most of the heat removal from containment is provided by the reactor containment fan coolers, which are safety grade for Byron/Braidwood.) Sprays are not required for long-term heat removal. Nevertheless, the containment sprays will be operated for at least 2 hours following a LOCA before they are terminated.

[Handwritten margin notes: "with suction from the recirculation sump"; "When the RWST rea[ches] the Lo-3 level, t[he] CS pump"; "When the required quantity of NaOH has been added to the recirculation sump, the spray additive tank is isolated."]

The RHR, CV, and SI systems are designed to operate following a LOCA to cool the reactor core. These systems are switched from injection to recirculation ~~at approximately 30 to 40 minutes~~ and remain in operation for the remainder of the accident. Additional fuel clad failure is not postulated while these systems are operating.

[Handwritten margin note: "When RWST reach[es] the L[o] level,"]

The containment spray system is discussed in Subsection 6.5.2, and the performance of both the reactor containment fan cooler system and the containment spray system under the design-basis loss-of-coolant accident condition is evaluated in Subsection 6.2.1.1.

The containment heat removal system rejects heat to the ultimate heat sink. Containment analyses to support the design bases of the ultimate heat sink are described in Subsection 9.2.5.

DRAFT

TABLE 6.2-54

ACTIVE HEAT SINK DATA

FOR MINIMUM POST-LOCA CONTAINMENT PRESSURE

I	Containment Spray System Parameters	
	A. Maximum spray system flow, total	~~8525~~ 7600 gpm
	B. Fastest post-LOCA initiation of spray system assuming offsite power loss at start of LOCA	35 sec
II	Containment Atmosphere Recirculation Fan Coolers	
	A. Maximum number of fan coolers operating	4
	B. Fastest post-LOCA initiation assuming offsite power loss at start of LOCA	15 sec
	C. Performance data	

See Figure 6.2-25 for fan cooler temperature versus heat load curve.

DRAFT

these functions manual isolation valves are under administrative control which require them to be locked in the correct position (i.e., locked open, locked closed, or locked in place) to support ECCS operation.

The following manual valves are utilized as maintenance isolation valves and are located so that no single valve can isolate both trains of ECCS equipment:

SI8921 A/B	Safety injection pump discharge
CV8471 A/B	Charging pump suction
CV8485 A/B	Charging pump discharge
RH8724 A/B	Residual heat removal pump discharge

The following manual valves are utilized as throttling valves in the injection branch paths of high and intermediate head ECCS pumps. These valves are located inside containment and are common to redundant pump subsystems. If incorrectly positioned, these valves could affect ECCS flow rates to the reactor coolant system. Pump runout protection is provided by properly sized orifices located in the injection lines.

SI8810 A/B/C/D	Charging pump to cold legs
SI8816 A/B/C/D	Safety injection pump to hot legs
SI8822 A/B/C/D	Safety injection pump to cold legs

In addition to the above itemized valves, there are other ECCS manual valves which, through mispositioning, can degrade the performance of the ECCS in mitigating an accident. These valves, listed below, are under administrative control commensurate with their function in the ECCS. Additionally, all of these valves, with the exception of CV8479A and B, have computer point inputs providing position indication that could be used to monitor availability of ECCS.

CV8479A & B	Centrifugal charging pump recirculation
SI8963	Return to RWST from accumulator fill line
CS002A & B	Containment spray pump suction
CS004A & B	Containment spray pump discharge
CS035A & B	Containment spray eductor ~~water suction~~ motive flow supply
CS021A & B	Containment spray eductor NaOH ~~suction~~ supply
CS018A & B	Containment spray eductor NaOH ~~suction~~ supply
CS040A & B	Containment spray eductor NaOH ~~suction~~ supply
CS017A & B	Containment spray eductor NaOH ~~suction~~ supply

DRAFT

6.5.2 Containment Spray Systems

The containment spray systems are designed to remove fission products, primarily elemental iodine, from the containment atmosphere for the purpose of minimizing the offsite radiological consequences following the design-basis loss-of-coolant accident. At the same time, the spray water serves to nominally reduce containment temperature and pressure during the injection phase.

6.5.2.1 Design Bases

The containment spray system is designed to reduce the pressure in the containment atmosphere at a rate which will ensure that the design leakage is not exceeded and to remove sufficient iodine from the containment atmosphere to limit, in the unlikely event of a LOCA, the offsite and site boundary doses to values below those set by 10 CFR 100.

The spray system is designed to provide a sufficient quantity of ~~deliver, with only one eductor delivering~~ 30% to 36% NaOH solution ~~but with all pumps operating, enough NaOH~~ to the containment to form a minimum 8.0 ~~8.5~~ pH solution when combined with the ~~refueling water and~~ spilled reactor coolant water, the safety injection accumulator inventory and ~~after~~ the refueling water storage tank inventory ~~has been emptied.~~ The containment spray system consists of two entirely independent subsystems such that the aforementioned requirements can be met in the event of a single active failure in either of the subsystems.

All components of the containment spray system except the test/recirculating line are Safety Category I and Quality Group B and are protected from missiles which could result from a loss-of-coolant accident. All risers and ring headers are supported to withstand loads resulting from the safe shutdown earthquake as well as operating loads. A seismic dynamic analysis has been performed on the system.

The following criteria apply to the spray nozzles:

a. The Sauter (surface to volume ratio) mean diameter of the spray drops produced by the nozzle at the design pressure drop across the nozzle must be approximately 1000 microns or less.

b. The pressure nozzle used is of a swirl chamber design, without any internal parts, such as swirl vanes, etc., which would be subject to clogging.

c. Flow through the nozzle at the design operating point is at least 15 gpm.

DRAFT

6.5.2.2 System Design (for Fission Product Removal)

The containment spray system has been divided into two independent 100% capacity pumping systems with no common headers. A single active failure in either of the two pumping systems will therefore not affect the operation of the other subsystem. A single-failure analysis is presented in Table 6.5-1. The system diagram (Figure 6.5-1) illustrates equipment redundancy, flowpaths, and system operation.

The containment spray system includes six ring-type spray headers each having the following radii, pipe diameter, number of nozzles, and served by the pump indicated:

Ring Number	Mean Radius	Nominal Pipe Diameter in.	Number of Nozzles	Designation of Pump Delivering Fluid to the Ring
1	13 feet 0 inch	4	39	"A" Pump
2	23 feet 6 inches	6	51	"B" Pump
3	34 feet 1/2 inch	6	60	"A" Pump
4	45 feet 9 inches	6	90	"B" Pump
5	56 feet 7-1/2 inches	8	120	"A" Pump
6	64 feet 9 inches	8	112	"B" Pump

There are no cross connections between the "A" and "B" spray headers. Rings 1, 3, and 5 are supplied via a single 10-inch riser pipe with restricting orifices in laterals supplying rings 3 and 5 to assure that the flow to each ring is proportionate to the number of nozzles supplied. Similarly, rings 2, 4, and 6 are supplied via a single 10-inch riser pipe with restricting flow orifices in laterals supplying rings 4 and 6. The plan view of the spray headers showing nozzle location and orientation is given in Figures 6.5-2, 6.5-3, and 6.5-4.

The "A" pump is designed to deliver 15 gpm to each of 219 spray nozzles, plus approximately 130 gpm of motive fluid to the eductor, ~~when operating in the injection and caustic eduction phase,~~ at a containment pressure of 50 psig. The "B" pump under like conditions is designed to deliver 15 gpm to each of 253 spray nozzles plus approximately 130 gpm of motive fluid to the eductor. The pump ratings are therefore 3415 and 3925 gpm for the "A" and "B" pumps respectively, at 450 feet total developed head.

In the event of a high-high-high (Hi-3) containment pressure signal (corresponding to approximately 20 psig), the containment spray pumps will start immediately, the CS007, the CS019,

P.17 of 36
DRP 6-017

DRAFT

and the CS010 valves will open immediately if they are not previously in the open position, provided that offsite power to the ESF buses has not been lost. Otherwise, upon receipt of a safety injection signal and restoration of bus voltage, the containment spray pumps will be sequenced to start by the diesel engine generator load sequencer, providing the Hi-3 signal is present. The valve motor operators will start immediately upon receipt of an Hi-3 signal if power is available.

The refueling water storage tank (RWST) (containing ~~2000~~ 2300-2500 ppm of boron ~~as boric acid~~) for each unit has a capacity of 458,000 gallons. Low-level switches are provided to automatically open the containment sump isolation valves, SI8811 A and B, on two-out-of-four logic sensing a Lo-2 level with ~~and~~ the presence of a safety injection signal. It should be noted that manual reset of safety injection does not defeat the automatic opening of the SI8811 A and B valves. The RHR pumps are thereby transferred to the recirculation mode automatically without stopping them. The charging pumps and safety injection pumps are then manually changed to the recirculating mode (see Subsection 6.3.2.8). ~~Containment spray injection and caustic eduction at the rate of 55-60 gpm per eductor of 30% to 36% NaOH solution will continue until 415,000 gallons have been pumped into the containment and the empty level alarm of the RWST is annunciated.~~ (P) Heat tracing the spray additive tanks and piping is not necessary to prevent crystallization of the 30% to 36% sodium hydroxide solution. The spray additive tank also has a nominal 1 psig nitrogen cover blanket applied to eliminate ambient air contact with the solution.

~~Containment spray and injection is then transferred to the recirculation mode. Containment pump suction is switched from the RWST to the containment recirculation sump.~~

~~Based upon one of the containment spray pumps supplying a total of 219 nozzles and the other a total of 253 nozzles, each at a net flow rate of 15 gpm per nozzle, the following rated maximum and minimum flow rates from the refueling water storage tanks will occur:~~

The containment spray pump continues to take suction from the RWST until the Lo-3 level is reached. The CS pump suction is then manually transferred to the recirculation sump. NaOH addition continues, regardless of pump suction source, until the spray additive tank Lo-2 level is reached. The spray additive tank is then manually isolated from the CS eductor.

DRAFT

Pumps	Quantity	Capacity Each (gpm)	Maximum Flow Rates, No Active or Passive Failures (gpm)	Minimum Flow Rates Failure of Power to One ESF Bus (gpm)
Containment spray				
Pump 1	1	3285*	3285*	3285*
Pump 2	1	3795*	3795*	
Safety injection	2	650	1300	650
Residual heat removal	2	3000	6000	3000
Centrifugal charging	2	550	1100	550
Total maximum and minimum flows			15,480	7485

~~*Exclusive of 130 gpm required for educting caustic.~~

The worst-case condition postulates failure of one (CS019) valve to open that admits NaOH solution to the suction of one of the containment spray pumps. ~~, but with all pumps operating under maximum flow conditions indicated above. ECCS injection in this case will be terminated after 24 minutes, but containment spray injection and caustic addition utilizing only one containment spray pump will be continued for an additional 16 minutes.~~

Under this worst case with only one eductor in effective service, ~~but with all pumps running,~~ sufficient NaOH (is delivered) to the containment to form (a minimum 8.0) ~~8.5~~ pH sump solution when ECCS injection fluid (from the refueling water storage tanks, and accumulators) is combined with spilled reactor coolant. ~~This pH level is necessary to attain an iodine partition coefficient greater than 4 x 10^3 which will result in a decontamination factor of 100 in the containment atmosphere for sump solution temperatures between 150° and 212°F.~~ (The pH of this solution is sufficiently high to assure that significant iodine re-evolution will not occur.)

Regulatory Guide 1.1 addresses the recirculation mode in which temperatures of the pumped fluid are at a maximum. The recirculation mode dictates the design for residual heat removal and containment spray pump suction piping because during the injection phase there is 50 to 90 feet of positive head available from the refueling water storage tank acting on the suction of these pumps. Moreover, the water in the RWST is at vapor pressure of 0.8153 psig maximum, and an additional 31 feet of available NPSH is derived from the difference between vapor pressure and atmospheric pressure.

DRAFT

The residual heat removal pumps require approximately 11 feet of NPSH at 3000 gal/min design capacity and approximately 19 feet of NPSH at runout capacity of 5000 gal/min. The containment spray "B" pump requires approximately 19 feet of NPSH at 3925 gal/min design capacity and approximately 22 feet of NPSH at 4600 gal/min runout capacity. Since the "B" train containment spray pump is of higher capacity than the "A" train pump, and the line size and equivalent feet of pipe are about the same for both the trains, the NPSH required versus available is most critical for the "B" train containment spray pump. Values of NPSH required are indicated as approximate because there are slight variations between pumps of duplicate design.

Allowing no credit for the water standing in the basement of the containment but assuming that the recirculation sump is full, the static head available is 377.0 feet (containment basement elevation) minus 346 feet, 7-7/8 inches (centerline of containment spray pump), or 30 feet, 4-1/8 inches net static head available.

Based upon both the RHR and containment spray "B" Pump operating under runout conditions, friction losses between the sump and pump inlet are conservatively calculated to be 3.58 feet. The resultant NPSH available is approximately 26.8 feet.

This analysis assumed that the liquid in the recirculation sump is at its vapor pressure at all times, thus there is no need to deliberately continue a high containment pressure condition to satisfy pump NPSH requirements.

~~It is calculated that the "A" pump will oper... at approximately 4300 gpm and the "B" pump at 4600 gpm while in the recirculation mode.~~ The sump solution satisfies NPSH requirements of the pumps ~~at the above flow rates~~ with adequate margin to assure satisfactory pump operation ~~concurrent with RHR pump runout at the rate of 5000 gpm~~ and CS pump runout at the rate of 4600 gpm.

Containment sump water temperature is not monitored for postaccident analysis. Although identified in Regulatory Guide 1.97 as an important parameter, containment sump water temperature indication would only be useful to determine if adequate NPSH is available to the CS or RHR pumps during the recirculation mode. By design, cavitation of these pumps will not occur even at containment saturation peak water temperature. The B/B design complies with Regulatory Guide 1.1 which states that, "Emergency core cooling and containment heat removal systems should be designed so that adequate net positive suction head (NPSH) is provided to system pumps assuming maximum expected temperatures of pumped fluids and no increase in containment pressure from that present prior to postulated loss of coolant accidents." Containment sump water temperature is therefore not a parameter required to indicate proper operation of the CS or RHR systems when in the recirculation mode.

DRAFT

(following a LOCA)

Containment spray operation will continue for a minimum of 2 hours. After 2 hours of operation, containment spray may be terminated if containment pressure is less than 15 psig and the spray additive tank has reached the Lo-2 level.

Suction lines to each pump are provided with guard pipes and suction valve protection chambers up to and including the first valve outside the containment for passive failure protection.

Both pumps and all motor-operated valves are supplied with power from the emergency diesel generators in the event of a loss of offsite power. Failure of a single diesel generator or emergency bus will affect one subsystem only.

Spray Engineering Company of Burlington, Massachusetts, 1713A nozzles meet the requirements stated in the design basis. The following listed figures illustrate the characteristics of this nozzle when spraying into a chamber at atmospheric pressure and normal ambient temperature and humidity:

a. Figure 6.5-5, Diameter of spray envelope versus height when spraying vertically downward.

b. Figure 6.5-6, Diameter of spray envelope versus height when spraying horizontally.

c. Figure 6.5-7, Diameter of spray envelope versus height when spraying downward at a 45° angle.

The above figures are predicated upon a 40 psi drop across each nozzle with a resulting flow of 15.2 gpm per nozzle. Pressure versus flow characteristics of this nozzle are illustrated in Figure 6.5-8.

In determining the number of spray nozzles required and their configuration, the effects of density of the containment atmosphere must be considered. The reduction factors to be applied to spray envelope diameter as a function of containment saturation temperature are shown in Figure 6.5-9.

To prevent degradation of the sodium hydroxide, an inert atmosphere is maintained within the spray additive tank by means of a nominal 1 psig nitrogen blanket. A relief valve is provided to prevent overpressurization of the tank.

The components for this system are as follows:

(P) Following a MSLB, containment spray operation may be terminated after containment pressure is less than 15psig. NaOH addition is secured when the event is identified as a MSLB.

a. Containment Spray Pumps

Number - two per unit

Type - Vertical centrifugal

Material - Stainless steel

DRAFT

Capacity "A" pump - 3415 gpm

Capacity "B" pump - 3925 gpm

Net developed head - 450 feet

b. Spray Additive Tank

Number - one per unit

Material - Stainless steel

Volume - 5000 gallons

Fluid - 30% to 36% NaOH in water

Cover gas - Nitrogen

Design pressure - 1.3 psig

Design temperature - 100°F

c. Eductors

Number - two per unit

Design Pressure - approximately 300 psig

Design Temperature - 300°F

~~(Actual flow~~

~~Design flow - 130 gpm at pressure connection~~

(Actual flow rate was determined during Pre-Operational Testing)

Design flow - 55-60 gpm ~~at suction connection~~ (of 30% NaOH)

Material - Stainless steel

d. Spray Nozzles

Material - Stainless steel

Type - Sprayco

6.5.2.3 Design Evaluation

An extensive research and development program has been conducted as part of the NRC's Reactor Safety Program to determine the iodine removal effectiveness of the chemical spray systems. Containment spray experiments were performed in the 1350 ft^3 vessel of the Nuclear Safety Pilot Plant (NSPP) at ORNL and were supported by additional containment spray experiments in the large 25-foot-diameter by 66.7-foot-high (26,500 ft^3) vessel (approximately one-fifth the scale of a typical 1000 MWe nuclear reactor) of the Containment Systems Experiment (CSE) at BNWL. Since the containment spray tests

DRAFT

from the injection to the recirculation mode of operation will be manually initiated and completed.

The containment spray pumps do not have to be stopped when transferring from the injection mode to the recirculation mode of operation provided that the RWST has not reached the Empty level. A summary of the sequence of events leading up to and during switchover follows.

The RWST level is initially one volume inaccuracy below the low alarm setpoint. ~~RWST outflow during injection is 18,200 gpm. ECCS switchover begins at one volume inaccuracy below the low low alarm setpoint. The volume consumed prior to switchover is 257,454 gallons and requires 14.15 minutes.~~ ECCS switchover is initiated when the RWST Lo-2 alarm annunciates and is ~~given in Table 6.3-13. It requires 305 seconds (5.08 minutes) and consumes 101,000 gallons assuming two trains and worst single ECCS failure. Following completion of ECCS switchover, the outflow from the RWST is 14,400 gpm and continues until 22.1 minutes have elapsed, consuming an additional 40,752 gallons.~~ discussed in Section 6.3.

Spray switchover is initiated when the RWST Lo-3 alarm annunciates. ~~begins at 22.06 minutes, and is completed when 22.8 minutes have elapsed, consuming an additional 10,000 gallons.~~ Upon recognition of the RWST Lo-3 alarm, the operator opens the CS009 and closes the CS001. At this time all ECCS and containment spray pumps have a long-term suction supply of water. Any further delay in the containment spray switchover will not jeopardize the performance of the safeguards pumps. ~~See Table 6.5-3~~.

Upon initiation of containment spray, the operator monitors the spray additive tank level; on a LO-2 level, the containment spray eductor spray additive valve for each operating train is closed. In the event of a single failure of the containment spray eductor spray additive valve to open, the pump in the train with the failed valve will not autostart. ~~In this mode of operation, the cumulative volume used at the time ECCS switchover is complete is 262,496 gallons.~~ While the ECCS pumps are operating from the recirculation sump, the one operating spray pump continues to take suction from the RWST until the RWST reaches the Lo-3 level. ~~level is one volume inaccuracy above the nominal empty alarm setpoint. This occurs at 31.7 minutes.~~ At this time the spray pump is switched to the recirculation mode. ~~Spray switchover is complete at 32.4 minutes.~~

In order to obtain the long-term required minimum sump pH of 8.0, ~~in the event of a spray eductor valve failure,~~ a minimum of 2326 ~~2577~~ gallons of 30% ~~to 36%~~ NaOH (2248 gallons of 36% NaOH) is ~~may be~~ required to be delivered to containment from the spray additive tank. ~~After 32.4 minutes, another 1023 gallons is required to be added.~~ This is ~~can be~~ accomplished by continuing caustic addition ~~for another 14.5 minutes~~ while the spray pump is taking suction from the sump. ~~See Table 6.5-4.~~ The volume of the spray additive tank from the LO to LO-2 level setpoints is equivalent to 2766 gallons.

INSERT A

Operator Actions

The parameter~~s~~ used by the operator to determine when to initiate containment spray switchover to recirculation ~~are:~~ is RWST lev

P. 23 of 36
DRP 6-077

DRAFT

~~a. spray additive tank level, and~~

~~b. RWST level.~~

Regardless of what the single failure is or when it occurs, the above parameters ~~are~~ is the only indicators the operator needs to determine when to initiate switchover. ~~A permissive from the limit switches on valve CS019 is used to preclude automatic pump operation.~~

Eductor flows are stopped when the spray additive tank level indicates that the required amount of NaOH has been added to achieve the required final pH in the containment sump. This ensures that at least 2766 gallons of 30% to 36% NaOH is added. There is a status lamp indicator to show when the low-low level has been reached. There is also an annunciator alarm. This quantity ensures that the required pH is achieved under worst case conditions of maximum reactor coolant and RWST boration. In the ~~abnormal~~ case where the spray additive level alarm does not initiate before the RWST ~~"Empty"~~ alarm initiates, spray switchover is initiated when the RWST ~~"Empty"~~ alarm initiates, and NaOH addition continues until the spray additive tank Lo-2 level is reached. Two series of operations are required to be accomplished by the operator to complete spray switchover: opening of the containment spray pump suction valve to the recirculation sump; and, closing of the containment spray pump suction valve to the RWST. ~~Each valve has a maximum opening and closing time of 30 seconds, so the total switchover can be accomplished in a maximum of 60 seconds.~~

Lo-2 Lo-3 Lo-3

6.5.2.4 Tests and Inspections

6.5.2.4.1 Preoperational Test Program

The preoperational test program has been conducted. The pump discharge was routed through the test recirculating line back to the refueling water storage tank (RWST) or routed directly into the refueling cavity inside containment. The valve operating and pump starting times, the pump and eductor delivery rates, and valves adjusted to ensure proper flows through the eductors, were recorded. The eductors were tested with demineralized water instead of sodium hydroxide, and the test values were adjusted for the appropriate sodium hydroxide flow rates. The actual eductor motive fluid flow rates were determined at this time.

6.5.2.4.2 Reliability Tests and Inspections

Routine periodic testing of the containment spray components and support systems are performed per ASME Section XI requirements. Remote operated valves are cycled to verify operability and inspected for leakage. The pumps are tested using the recirculation line to the RWST.

DRAFT

system testing, a visual inspection of pump seals, valve packings, flanged connections and relief valves is made to detect leakage and confirm that no significant deterioration is occurring in the containment spray system.

All testing of the containment spray system components may be done while the unit is in operation except for air testing of the nozzles, which should be accomplished when the reactor is shut down.

6.5.2.5 Instrumentation Requirements

The containment spray system is provided with the instrumentation and controls to permit the monitoring and actuation of the system from outside the containment.

The containment spray pumps and motor-operated valves can be actuated either automatically or manually. Automatic actuation signals are generated in the solid-state protection system cabinets. Both spray subsystems will be actuated by a Hi-3 containment spray signal. Actuation includes starting both pumps, and opening all valves required for system operation. Manual actuation is from control switches on the main control board.

Indicating lights are provided on the main control board and on the ESF status panels to show the status of the pumps and the position of the valves. Main control board monitor lights are provided to show the status of the pumps and valves as an operator aid in evaluating system response subsequent to automatic safeguard actuation. Alarms on the main control board are provided for pump automatic trip, pump automatic start, pump fail to start and valves fail to open.

Refueling water storage tank level is indicated on the main control board, and alarms are provided for high, low, low-low, and ~~empty tank~~ low-low-low levels.

Spray additive tank level is indicated locally and on the main control board, and alarms are provided for high, low, and low-low tank levels. There is also a status lamp indicator and annunciator for low-low tank level located on the main control board.

During preoperational testing, either adjustable manual valves CS018A or CS021A and CS018B or CS021B in the caustic line was set (utilizing water and correcting for specific gravity) and locked in position at the desired 30% to 36% NaOH rate of flow to the eductor (55-60 gpm). In addition, the actual motive fluid flow rate to the eductor for each spray system was determined. These flow rates are used during system testing. Main control board flow indicators are provided for pump discharge, pump to eductor recirculation, and eductor NaOH suction, and an alarm is provided for NaOH injection flow failure.

The temperature of the pump motor bearings is monitored. Ammeters are provided on the main control board to monitor motor current.

Design details of the containment spray controls and instrumentation are presented in Section 7.3.

6.5.2.6 Materials

All components in the containment spray system which come into contact with spray solution during either the injection or recirculation phase are fabricated of ~~austenitic~~ stainless steel. All containment materials are compatible with the NaOH solution with the exception of galvanized steel and aluminum. These materials are discussed in Subsection 6.2.5.

6.5.3 Fission Product Control Systems

The primary containment fission product control systems during normal plant operating conditions consist of the containment charcoal filter units and the containment normal and miniflow purge systems. For further discussion of these systems, refer to Subsections 9.4.8 and 9.4.9.

The system which operates following a design-basis accident to remove fission products is the containment spray system. For further discussion of this system, refer to Subsection 6.5.2.

DRAFT

TABLE 6.5-3

~~SINGLE FAILURE - WORST CASE ECCS~~

ELAPSED TIME (MINUTES)	PHASE OF ACCIDENT	CUMULATIVE VOLUME USED (GAL)
0	Begin injection	0
14.15	Begin ECCS switchover	257,454
19.23	ECCS switchover complete	359,000
22.1*	Begin spray switchover	400,000
22.8	Spray switchover complete	410,000
24.17	Spray additive addition complete	--

*At this time, all of the safeguard pumps have an adequate long-term suction supply of water. Any further delay in closing the RWST to containment spray pump valves will not jeopardize the performance of the containment spray pumps.

Table intentionally deleted.

P. 27 of 36
DRP 6-077

DRAFT

TABLE 6.5-4

SINGLE FAILURE - WORST CASE CONTAINMENT SPRAY SYSTEM

ELAPSED TIME (MINUTES)	PHASE OF ACCIDENT	CUMULATIVE VOLUME USED (GAL)
0	Begin injection	0
14.15	Begin ECCS switchover	257,454
19.23	ECCS switchover complete	279,878
32.86*	Begin spray switchover	424,234
32.4	Spray switchover complete	426,533
46.9	Spray additive addition complete	--

*The containment spray pumps and ECCS pumps have an adequate long term suction supply of water. Any further delay in closing the RWST to containment spray pump valves will not jeopardize the performance of the containment spray pumps.

Table intentionally deleted.

P. 28 of 36

DRP 6-077

DRAFT

7.3.1.1.12.3.8 Environmental Considerations

Temperature, pressure, humidity, and radiation dosage are considered in the selection of various instruments, controls and devices for the RCFC units. These are described in detail in Sections 3.11 and 9.4.

7.3.1.1.12.3.9 Operational Considerations

The RCFC is required during both normal and abnormal station operating conditions. The automatic circuitry is designed to start the emergency equipment as described in Section 9.4.

7.3.1.1.12.4 Design Basis

The generating station condition which requires the RCFC units to activate is the ESF actuation signal.

IEEE Standard 279-1971 requirements are discussed in Subsection 7.3.2.2.12.

7.3.1.1.13 Containment Spray System Operation

Containment spray system component description and design information are presented in Subsection 6.5.2. Only instrumentation and controls and their operation are described in this subsection.

a. Containment Spray Pumps

A control and test transfer switch is provided for each pump on the main control board.

Each containment spray pump can be started under any the following three conditions:

1. Automatically: A ~~high~~ containment ~~pressure~~ spray actuation (Hi- signal from the ESF actuation system (ESFAS) logic will start the pump, provided that the associated NaOH eductor supply valve (CS019) is open. Pump auto start, auto start failure and pump trip are annunciated on the main control board.

2. Manually: Operation of the control switch to the CLOSE position will start the pump provided that the suction is lined up from the containment recirculation sump and not from the refueling water storage tank (SI8811 and CS009 open).

3. Manually in test mode: Operation of the control switch to the CLOSE position will start the pump provided that; the isolation valve to the containment ring headers (CS007) is closed; the isolation valve for recirculation back to the RWST (SI001) is open; the isolation valve between the spray additive tank and the eductor (CS040) is closed; and the transfer switch on the main control board is in the TEST position.

p. 29 of 36
DRP 6-077

DRAFT

Two chromel-constantan thermocouples are provided for each motor to measure bearing temperature which is monitored by the computer.

An ammeter is provided on the main control board for each pump to measure motor current.

A pressure gauge is provided in each pump suction and discharge line to provide pressure indications locally.

b. Containment Spray ~~Pump~~ Discharge Header Isolation Valve (CS007)

A control switch is provided on the main control board for each valve.

Each valve can be opened automatically by the containment spray signal from the ESFAS.

Each valve can be manually opened with its control switch provided that the NORMAL-TEST transfer switch for the spray pump on the main control board is in the NORMAL position and at least 30 seconds have elapsed since the spray pump has been operated.

Limit switches on each valve provide valve position indication on the main control board. An ~~alarm~~ annunciator on the main control board indicates if the valve failed to open on an automatic signal.

c. Sodium Hydroxide (NaOH) Eductor ~~Suction~~ Supply Valve (CS019)

A control switch is provided on the main control board for each valve. Automatic opening of the valve occurs when a containment spray actuation signal is received from the ESFAS. Manual opening of the valve using the control switch is possible when the test switch associated with the corresponding spray pump is placed in the TEST position.

Limit switches on each valve provide annunciator valve position on the main control board. An ~~alarm~~ indicates ~~if the~~ valve failed to open on an automatic signal. Failure of the valve to open will prevent auto start of the associated CS pump on an ESF actuation signal.

d. Containment Spray ~~Pump~~ Suction Valve from Recirculation Sump (CS009)

A control switch is provided on the main control board for each of the valves. Each valve can be opened provided that: the containment recirculation sump isolation valve (SI8811) is open, and the RHR pump suction valve from the loop hot legs (RH8701/2) are closed. The purpose of these interlocks is to ensure that neither RWST water nor reactor coolant can be drained to the containment sump through this valve.

Limit switches on each valve provide position indication on the main control board.

e. Containment Spray Pump RWST Suction Valve (CS001)

One suction valve is provided for each spray pump. A control switch is provided on the main control board for each valve. Each valve can be opened provided that the containment spray pump suction valve from the containment recirculation sump (CS009) is closed.

Limit switches on each valve provide position indication on the main control board.

f. Containment Spray Eductor (Motive Fluid Flow) Valve (CS010)

An air-operated valve is provided for ~~each~~ eductor (motive flow) ~~suction~~ from the discharge of the containment spray pump. The valve fails open on loss of air.

A control switch is provided on the main control board for each valve. The valve is normally maintained in the open position.

Regardless of the initial position of this valve, receipt of a containment spray actuation signal from the ESFAS (opens the valve) ~~forces the valve into the open position~~ to ensure proper eductor (motive) flow.

Limit switches on each valve provide position indication on the main control board.

g. Additional containment spray system alarms on the main control board annunciation system are provided as follows:

1. Low flow alarm in the NaOH suction line to the eductor following a containment spray initiate signal.

DRAFT

2. High, low, and ~~empty~~ low-low level alarms are provided for the spray additive tank. (Hi, Hi-2, Hi-3)

3. High containment pressure alarms are provided from four redundant pressure monitors which also initiate the containment spray actuation signal.

h. Testing of the operability of the containment spray system is referred to in Subsection 6.5.2.4 and Chapter 16.0.

7.3.1.1.14 <u>Diesel Fuel Oil System</u>

Diesel fuel oil system components and design information are presented in Subsection 9.5.4. Only instrumentation and controls and their operation are described in this subsection.

a. <u>Diesel Generator Diesel Oil Supply</u>

The diesel oil supply for the standby diesel generators consists of four 25,000-gallon diesel oil storage tanks for Unit 1 diesels, two 50,000-gallon diesel oil storage tanks for Unit 2 diesels, two diesel oil transfer pumps, and one 500-gallon diesel oil day tank per diesel generator.

Each diesel oil storage tank is provided with local level indication and a low level alarm in the main control room.

Each diesel oil transfer pump is provided with a control switch on the associated diesel-generator engine control panel. A selector switch is provided to select the A or B diesel oil transfer pump. Both diesel oil transfer pumps start automatically when the diesel generator starts. When the diesel generators are not running, a low level in the diesel oil day tank will auto-start the transfer pump which has been selected.

Each 500-gallon diesel oil day tank is provided with local level indication and a low level alarm on the diesel-generator engine control panel.

Controls and instruments are supplied from the same ESF bus as the diesel generator it serves.

b. <u>Diesel-Driven Auxiliary Feedwater Pump Diesel Oil Supply</u>

The diesel oil supply for the diesel-driven auxiliary feedwater pump consists of a 500-gallon diesel oil day tank. The diesel oil day tank is provided with

DRAFT

ATTACHMENT A6.5

IODINE REMOVAL EFFECTIVENESS EVALUATION

OF CONTAINMENT SPRAY SYSTEM

DRAFT

Insert F

DRAFT

INSERT A

The containment spray pH will vary during system operation. At the initiation of containment spray, the CS pumps will be taking a suction from the RWST. The resulting pH of the RWST and NaOH mixture will be between 8.5 and 10.5. When the CS pumps are aligned to take suction from the containment sump, the eductors may still be in operation and adding NaOH to the pump flow. This will result in a maximum pH of 11.4. When NaOH addition is secured and the CS pump suction is from the recirculation sump, the spray pH will be the same as the sump pH (8.0-10.5). The effects of these pH values on Equipment Qualification and hydrogen generation have been evaluated and found acceptable. Below is a detailed description of the effects on pH caused by CS system operation.

The containment spray pumps will initially see a back pressure due to the elevated containment pressure. The flow of water into containment will increase as the pressure in containment is decreased. This will cause the eductor motive flow to decrease slightly which will decrease the amount of NaOH educted, thus, slightly decreasing the pH of the spray. Additionally, as the NaOH tank empties, the flow rate of NaOH will decrease due to decreased head pressure from the spray additive tank. This also slightly decreases the spray pH.

As discussed above, when the containment spray pumps begin to use the recirculation sump as a source of water, the eductor may still be adding NaOH to water that already contains NaOH. This will cause the spray pH to increase. These variances are discussed below.

To resolve these competing variances, the NaOH eductor throttle valve (CS018, CS021) has been set for 55-60 gpm of 30% NaOH at high SAT level (using the equivalence of 68-74 gpm of water) and an eductor motive fluid flow rate as determined in the Pre-Operational tests when the CS pump was delivering a total flow of approximately 3415 gpm (A train) and approximately 3925 gpm (B train). This will provide for an actual pH in the A train of approximately 10.5. The B train pH would be lower since it will have higher borated water flow rate and the same NaOH addition rate. These flow rates are minimums expected while the containment is at 50 psig. The other changing parameters (decreasing containment back pressure and correspondingly increasing total CS flow rate, lower eductor motive fluid flow rate, lower SAT level) will provide for a lower pH, while the RWST is supplying the system.

When the source of containment spray water is switched from the RWST to the recirculation sump (LOCA only), the eductor will be adding NaOH to sump water that has already been treated with NaOH. This will cause the pH to increase. The increase will be determined by the actual flow rates prior to and present at the time of switchover. However, this value is bounded by a maximum pH of 11.4. This pH assumes no increase in CS pump flow rate and no associated decrease in NaOH flow rate due to decreasing containment pressure. The pH of 11.4 occurs in the final minute of NaOH addition, when it is assumed that all the NaOH previously added had mixed uniformly and made it to the recirculation sump. The duration of this phase of increases pH would be from a few minutes (one train of ECCS and two trains of CS in operation) up to approximately 61 minutes (two trains of ECCS and one train of CS in operation) assuming worst case failures.

If the NaOH flow rate decreases (due to reduction of eductor motive fluid flow rate and NaOH tank level drop), then the duration of the pH being higher than 10.5 will be longer, but the magnitude of the pH being above 10.5 will be less. The NaOH injection flow rate to achieve a minimum spray pH of 8.5 (minimum allowable per SRP 6.5.2, revision 1) would be approximately 19 gpm using the B train pump flow rate of 3925 gpm. If the NaOH flow rate started at 55-60 gpm as initially set, and then quickly dropped to 19 gpm, the duration of required NaOH addition would take approximately two hours. This is not expected, but bounds the review of minimum NaOH addition. These conditions will provide for improved iodine removal due to a higher spray pH. In addition, these conditions will result in the same final sump pH since the

DRAFT

INSERT A cont'd

sump pH is determined by the quantity of NaOH added, not the rate at which it is added. Therefore, these conditions are acceptable.

The examples above bound the worst case calculated pH and high pH duration. The actual pH profile cannot be easily calculated. Therefore, these worst case values will be reviewed. Both cases are acceptable with respect to iodine removal and final sump pH. However, with respect to the pH of the spray, the Equipment Qualification of components in containment was performed assuming a maximum spray pH of 10.5. The pH and duration described above have been reviewed with respect to hydrogen generation and Equipment Qualification and have been found acceptable.

INSERT B

will be between 8.0 and 10.5. The pH is independent of the number of ECCS and CS pumps in operation. It is dependent on the borated water quantity and concentration in the RWST, RCA and safety injection accumulators and the concentration and quantity of NaOH educted from the spray additive tank.

INSERT C

The pH of the liquid in the containment spray system is determined by the CS pump suction source and the quantity of NaOH educted by the CS system. During the onset of containment spray when the CS pump suction is from the RWST and NaOH is being educted from the spray additive tank, the pH will be between 8.5 and 10.5. This is ensured by positioning of the CS018/CS021 valves and by the spray additive tank NaOH concentration. When NaOH is being educted while the CS pump suction is from the recirculation sump, the spray pH may be as high as 11.4. During operation with the CS pump suction from the recirculation sump without NaOH addition, the spray pH will be the same as the recirculation sump pH (8.0 - 10.5).

INSERT D

The Equipment Qualification of components in containment was performed assuming a maximum spray pH of 10.5. It is acceptable to have spray water with a pH higher than 10.5 for a short duration. The pH and duration described above have been reviewed with regard to Equipment Qualification and hydrogen generation and have been found acceptable.

The pH of the CS system is discussed in detail in Section 6.5.2.

INSERT E

The pH of the final sump solution is independent of the number of trains of ECCS and CS pumps in operation. The final sump pH is determined by the quantity of water and concentration of boron in the RWST, the RCS and the SI accumulators and the quantity of water and concentration of NaOH educted from the containment spray additive tank. The pH of the spray solution is determined by the CS pump suction source and the quantity of NaOH educted from the spray additive tank.

DRAFT

INSERT F

The following evaluation assumed a spray pH of "...no greater than 9.8 at all times..." and listed a pH of 9.8 in the Input Parameters and Results Table. The operation of the CS system is such that the pH of the spray fluid varies from ≥ 8.5 to ≤ 11.4.

The iodine removal constant, λ_s, that is determined in the following evaluation is dependent upon the spray pH in that the iodine partition coefficient, H, is determined by the pH. ANS-56.5-1979 Figure 8.3-1 shows that the same partition coefficient is allowed for NaOH solutions with a pH from 8.5 to 11. In addition, WCAP-12635 states that iodine removal efficiency is greatly enhanced at pH values greater than 8.5. Since the allowed partition coefficient is constant over the range of pH's created by the CS system, with the exception of 11.0 to 11.4, and since iodine removal efficiency increases at pH values greater than 8.5, (11.0-11.4) the results of the evaluation will remain unchanged since the allowed partition coefficient is constant over the range of CS operation.

The Rest are Supporting Documentation

for

B/B UFSAR

DRP # 6 - 077

CONTAINMENT SPRAY --- DESIGN BASIS MATRIX

PURPOSE: The primary safety function of the CS system is to ensure the removal of iodine from the containment atmosphere to limit offsite and site boundary radiological doses to values below those set by 10CFR100. It also must ensure that containment has both depressurization and cooling capabilities available in the event of a LOCA or steam line break.

SAT DESIGN PARAMETERS:

During the injection phase the tank releases NaOH solution into the borated water from the RWST. This addition is mixed by the CS eductors to maintain sump pH of 8.0. A nitrogen blanket of ~0.6 psig at Byron and 0.5 psig at Braidwood is applied to the SAT. Currently, the control valve, CS036, maintains pressurization by the nitrogen gas system at Braidwood. (Byron will have the same operating conditions as Braidwood per NDIT# BYR-96-147). Two vacuum relief valves are set at -0.02 to 0.0 psig to prevent a vacuum condition in the tank and protect it against underpressurization.

EDUCTOR DESIGN PARAMETERS:

The eductors are used to add 30 - 36 wt% NaOH solution to the spray flow during the cs system injection phase. As water flows through the restrictive section of the venturi tube, its velocity is increased and its pressure is decreased. The line from the SAT is connected at this low pressure area so that the solution is induced into the spray water flow. CS018A/B (at Byron) or CS021A/B (at Braidwood) are pre-positioned to maintain a 30 wt% sodium hydroxide solution flow rate at 55 - 60 gpm.

EDUCTOR SUCTION FLOW VALVE (CS018A/B OR CS021A/B):

Either valve maybe locked in position to accommodate the desired 55 -60 gpm of NaOH to the eductor during injection phase. The required pH is achieved under worst case condition by ensuring that at least 2,326 gallons of 30% NaOH (per ATD-356, Rev. 1) has been added to the sump.

DESIGN PARAMETERS	**Final Resolution (Reference)**	**STANDARD REVIEW PLAN** (SRP Section 6.5.2, Rev. 2, 12/88)	**ComEd UFSAR (Section 6.5.2)**
System Design Parameters:			
# of spray trains availabie per unit	1 of 2 (per SDD-CS-01-BB, Rev.0, Table 3.1)	GDC 38,39, 40, 41, 42, 43	1 of 2
Pump Spray flow rate, *w/o Eductor flow rate are:*			
Train A, gpm	3285 (per SDD-CS-01-BB, Rev.0, Table 3.1)	Not Provided	3285
Train B, gpm	3795 (per SDD-CS-01-BB, Rev.0, Table 3.1)	Not Provided	3795
Spray pH during **Injection**	8.5 - 10.5 (per SRP, R/1)	8.5 -11.0 (ANSI/ANS 56.5-1979)	9.8 (Attachment 6.5-A)
Sump pH during **Recirculation**	8.0 - 11.0 (7 min as required by BTP MTEB 6-1per Byron SER Section 6.1.1 (4), 2/82)	8.5 -9.5 (the system should be capable of raising the sump pH to a value exceeding **6.5** w/ 4 hrs after the LOCA to minimize stress corrosion of stainless steel.	8.07 8.0-11.0 per Tech Specs. Bases 3/4.6.2-2
		BRANCH TECH. POSITION MTEB 6-1 (p. 6.1.1-13, 7/81) CMEB criteria for pH level of post-accident emergency coolant water to REDUCE the probability of STRESS-CORROSION CRACKING of ss. Minimum **pH = 7.0** Sump pH during Recir. 7.0-9.5. If pH>7.5 is used, consider H2 generation problem from corrosion of Al in the contmt.	
Decontamination factor (using sump solution) Iodine Partition Coefficient	100 (ANSI/ANS 56.5-1979) >4,000 (ANSI/ANS 56.5-1979)	100 (ANSI/ANS 56.5-1979) 5,000 (ANSI/ANS 56.5-1979)	100 >4,000 (p. 6.5-24)
# of Spray Nozzles:			
Train A	219 (per SDD-CS-01-BB, Rev.0, Section 4.4)	Not Provided	219
Train B	253 (per SDD-CS-01-BB, Rev.0, Section 4.4)	Not Provided	253
Nozzle spray design flow	15 (per SDD-CS-01-BB, Rev.0,	Not Provided	15

DESIGN PARAMETERS	Final Resolution (Reference)	STANDARD REVIEW PLAN (SRP Section 6.5.2, Rev. 2, 12/88)	ComEd UFSAR (Section 6.5.2)
(each), gpm	Section 4.4)		
Nozzle spray dp, psig	40 (per SDD-CS-01-BB, Rev.0, Section 4.4)	Not Provided	40
Spray fall height, ft	154 (per UFSAR Table A6.5-1)	Not Provided	154
# of **Eductors** available per unit	1 of 2 (per SDD-CS-01-BB, Rev.0, Section 4.3)	1 of 2	1 of 2
Eductor flow rate, gpm (approximately)	**130** (per SDD-CS-01-BB, Rev.0, Section 4.3)	Not Provided	~130 at press. connection
NaOH flow rate, gpm	**55-60 for 30% NaOH** (per UFSAR Sect. 6.5.2.2) **53-58 for 36% NaOH (per Calc. BYR96-160 rev. 0)**	Not Provided (SRP provides DF only)	55-60 at suction connection
Maximum net containment free volume, ft^3	2.76×10^6 (per UFSAR Table A6.5-1)	Not Provided	2.76×10^6
Unsprayed contmt volume, %	max. 15.41% min. 12.66% (UFSAR Sect. 6.5)	Not Provided (requires that spray coverage be maximized)	max. 15.41%, min. 12.66% (Sect. 6.5)
Maximum Design Temp., F	200 (per line list)	Not Provided	300
Maximum Design Pressure, psig	275 (per line list)	Not Provided	300
Spray pump discharge press., psig	450 ft. TDH (per I/R pump curves N-1027/28/ 29/30)	Not Provided	Not Provided
Spray Additive Tank			
Volume, gal. (min. prior to spray actuation)	4,000 (per SDD-CS-01-BB, Rev.0, Table 3.1)	Not Provided	4,000
Required Level	78.6% - 90.3% (Tech Spec min/max values)	Not Provided	Not Provided

DESIGN PARAMETERS	**Final Resolution (Reference)**	**STANDARD REVIEW PLAN** (SRP Section 6.5.2, Rev. 2, 12/88)	**ComEd UFSAR (Section 6.5.2)**
Required Concentration of NaOH Solution	30 - 36 wt % (per UFSAR Sect. 6.5)	Not Provided	30% - 36%
RWST volume, gal. (min. prior to safeguards actuation)	412,114 (per SITH-1, R/3	Not Provided	458,000 w/ 2000 ppm
Piping Extending from the SAT to the Eductor is rated at	120^0F to 150^0F (per SDD-CS-01-BB, Rev.0, Sect. 3.3.2.6)	Not Provided	Not Provided
Contmt Recirc. Sump Solution temp. range	150 - 212 F (per SDD-CS-01-BB, Rev.0, Table 3.1)	Not Provided	150-212
*			*3
Containment Spray Pump			
Type:	Vertical, Centrifugal (per SDD-CS-01-BB, Rev.0, Sect. 4.1)	Not Provided	Vertical, Centrifugal
# per unit	2 (per SDD-CS-01-BB, Rev.0, Sect. 4.1)	Single Failure Criteria requirement only	2
Min. Design Capacity **including Eductor flow, gpm:**			
Pump A	3415 (per Pump Vendor Curves # N-1027/29)	Not Provided	3415
Pump B	3925 (per Pump Vendor Curves # N-1028/30)	Not Provided	3925
Developed Head, ft of Water	450 (per Pump Vendor Curves)	Not Provided	450
NPSH (required/available)	19 / 26.8 (per Pump Vendor Curve #)	Not Provided	~19' for B 26.8' for A
Normal / Design Pressure, psig	190 (per SDD-CS-01-BB, Rev.0, Sect. 4.1)	Not Provided	Not Provided
Classification	S/R, IB (per ANSI/ANS-18.2 and ANS-51.1)	Not Provided	S/R, IB
Maximum temp. , F	200 (per line list)	Not Provided	Not Provided
SPRAY ADDITIVE TANK:			

DESIGN PARAMETERS	Final Resolution (Reference)	STANDARD REVIEW PLAN (SRP Section 6.5.2, Rev. 2, 12/88)	ComEd UFSAR (Section 6.5.2)
Type	vertical, cylindrical (per Graver Tank Drawing NL10753 Rev. 15)	Not Provided	vertical, cylindrical
# per unit	1 (per SDD-CS-01-BB, Rev.0, Sect. 4.2)	Single Failure Criteria requirement only	1
Fluid type	30 -36 wt% NaOH (per UFSAR Sect. 6.5)	NaOH solutions, TSP, borated water, pure water, hydrazine	30 -36 wt% NaOH
Capacity, gal	5,000 (per SDD-CS-01-BB, Rev.0, Sect. 4.2)	Not Provided	5,000
Design Pressure, psig (internal/external)	15 internal/ vacuum external (per Calculation BYR96-185 Rev. 0)	Not Provided	1.3
Design Temperature, F	100 (per SDD-CS-01-BB, Rev.0, Sect. 4.2)	Not Provided	100
Operating Pressure, psig (normal)	Braidwood ~0.5 Byron ~0.6 (per SDD-CS-01-BB, Rev.0, Sect. 4.2)	Not Provided	1.3 (design)
Operating Temp, F	Ambient	Not Provided	100 (design)
Vacuum Relief Valve	2 set @ -0.02 to 0.0 psig (per GPE Dwg. LO 240-497, S&L Valve Data Sht. S-0122)	non-vented atms. tank requires redundant vacuum reliefs	2 set at -1.3 psig
Relief Valve-Overpressure Protection	1 relief valve set at 1 psig (per valve data sheet S0106, no valve dwg. available)	Should be in accordance w/ ASME Section III, class 2 per ANSI 56.5-1979-the relief devices shall be set to relieve pressure at the lowest design press. of the system subject to the pressure source.	1 relief
Cover Gas	Nitrogen (per SDD-CS-01-BB, Rev.0, Sect. 4.2)	Specifies only that an inert cover gas should be provided for solutions which may deteriorate upon exposure to air.	Nitrogen (design pressure 1.3 psig)
classification	S/R IB (per ANSI/ANS 18.2 and ANS 51.1)	SR ASME Section III, class 2 per ANS	Not Provided
Eductors:			

DESIGN PARAMETERS	Final Resolution (Reference)	STANDARD REVIEW PLAN (SRP Section 6.5.2, Rev. 2, 12/88)	ComEd UFSAR (Section 6.5.2)
# per unit	2 (per SDD-CS-01-BB, Rev.0, Sect. 4.3)	Not Provided	2
Design pressure, psig	275 (per line list)	Not Provided	300
Design Temperature, F	200 (per line list)	Not Provided	~300
Design Motive Flow , gpm	212 (per Design Spec F/L-2899	Not Provided	130 @ pressure connection
Operating Motive Flow, gpm	~ 130 (per Design Spec F/L-2899)	Not Provided	Not Provided
Suction Fluid NaOH Concentration, %	30 -36 wt% (per UFSAR Sect. 6.5)	Not Provided	30-36 wt%
Design Suction flow, gpm	55 - 60 (per UFSAR Sect. 6.5.2.2)	Not Provided	55-60
Specific Gravity	1.3279 (based on 30 wt%, per Cameron)	Dependent upon the spray solution type listed above	Not Provided
Viscosity (design), cp	10 (based on 30 wt%, per Cameron)	Dependent upon the spray solution type listed above	Not Provided
Operating temp	Ambient	Not Provided	Not Provided
Classification	ASME III, Class 2 (per ANSI/ANS 18.2, ANS 51.1 UFSAR Sect. 6.3, SRCL)	ASME Section III, class 2 per ANS	Not Provided
Spray pH	8.5-10.5 (per SRP, R/I)	8.5 - 11.0	9.8 (UFSAR Table a.6.5-1)

*1. Instrument Sensing lines w/ flow is designed to have a design temp equal to the process line design temp.

*2. The CS pumps are required to operate a minimum of 2 hrs following a LOCA, but are available for longer period if required

*3. CS is required for minimum operation of 2 hrs. It can be stopped when the containment pressure < 15 psig.

OPERATIONAL DESIGN BASIS

System designed to deliver:

a) Enough 30% by weight NaOH solution to form a 8.55 pH solution when combined with RCS leakage and all RWST water. pH control minimizes effect of Chloride and caustic stress corrosion.

b) System will satisfy design requirements with one eductor and both CS pumps operable.

SAFETY DESIGN BASIS

1. Reduce pressure in Cnmt atmosphere at a rate to prevent exceeding design leak rate.
2. Remove sufficient Iodine from Cnmt atmosphere to limit site and offsite boundary doses below 10CFR100 requirements.
3. Components (except test / recirculating lines) are Safety Catagory I and Quality Group B.
4. Components protected from missiles that could be generated by a LOCA
5. Ring header and risers are designed for Safe Shutdown Earthquake.

$$I_2 + 2OH^- = I^- + IO^- + H_20$$

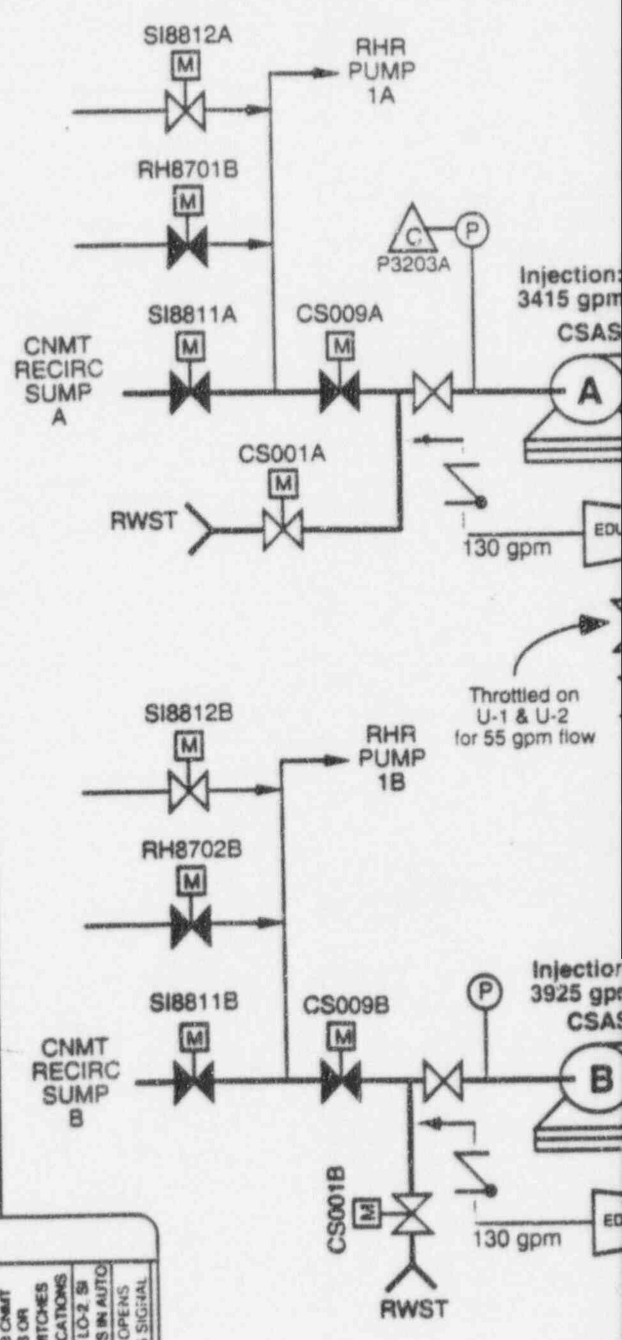
EMPTY ALARM:

Empty alarm and 125vdc status lights at 17.4%.

To close CS019's:

a) Reset CS Signal

b) Manually close CS019's



CS SYSTEM INTERLOCKS

	TEST SWITCH	C/S IN A/T OR A/C	C/S TO CLOSE	C/S TO OPEN	CS001A/B CLOSED	CS007A/B CLOSED	CS009A/B CLOSED	CS009A/B OPEN	CS019A/B OPEN	CS040A/B CLOSED	RH8701A/ RH8702B CLOSED	SI001A/B OPEN	SI8811A/B OPEN	SI8812A/B CLOSED	BRKR OPEN > 30 SEC's	HIGH-3 CNMT PRESS OR 2/2 SWITCHES 1/2 LOCATIONS	RWST LO-2, SI and C/S IN AUTO	AUTO OPENS ON CS SIGNAL
CS PUMP AUTO START		■							■							■		
CS PUMP MANUAL START			■					■					■					
CS PUMP TEST START	TEST					■				■		■						
OPEN CS009A/B				■							■		■					
OPEN CS001A/B				■			■											
OPEN CS007A/B	NORM			■											■			■
OPEN CS019A/B	TEST			■														■
MANUAL OPEN SI8811A/B				■	■						■			■				
AUTO OPEN SI8811A/B																	■	
CLOSE CS001A/B OR CS009A/B			■															
OPEN CS010A/B																		■

TECH SPECS

3.6.2.1 Containment Spray

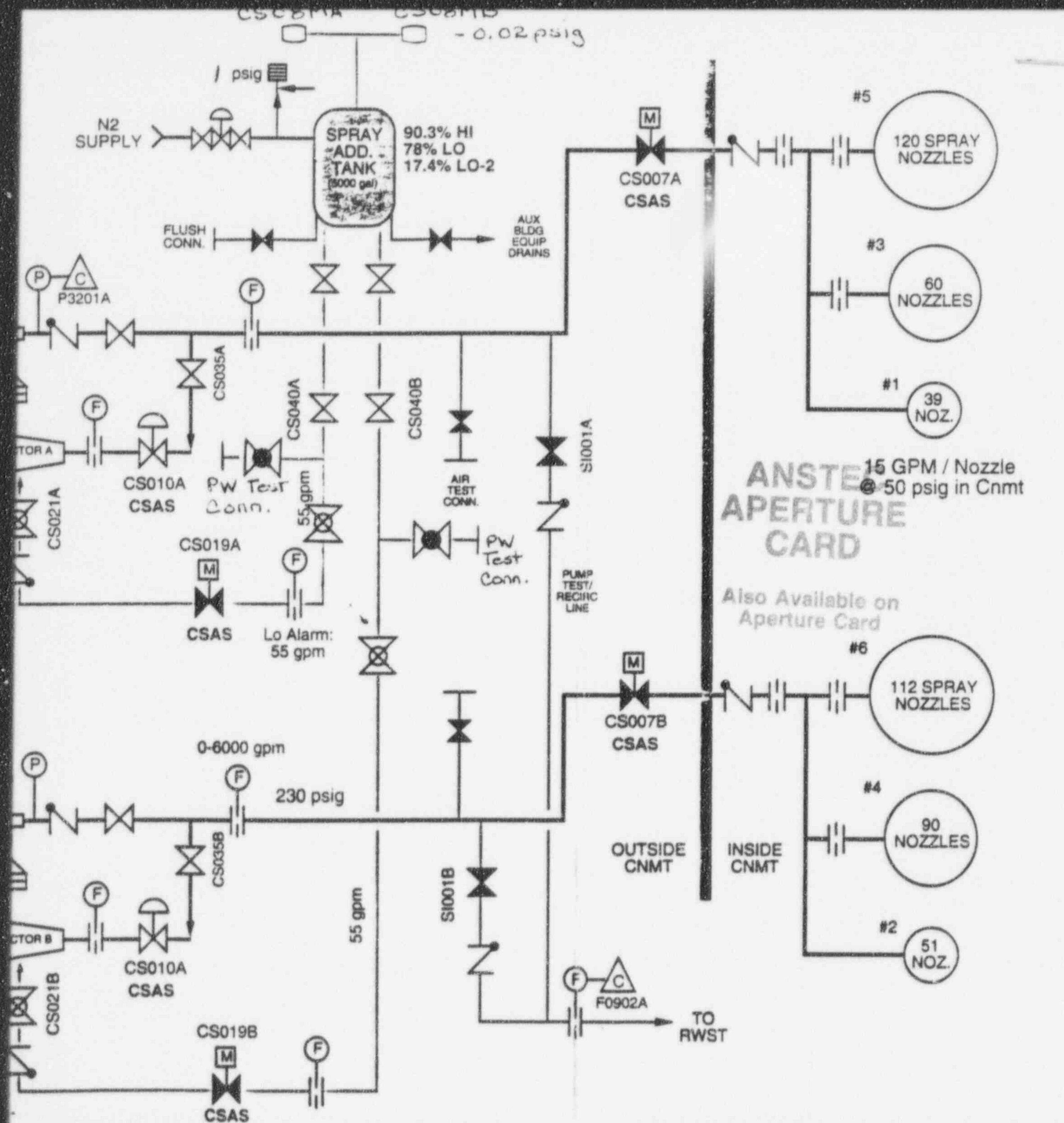
2 CS systems operable with each from RWST and transferring suctio

3.6.2.2 Spray Additive Syste

Tank level between 78.6 and 90.3 by weight NaOH solution. Two edu NaOH to CS pp flow (both 7 days

3.6.3 Containment Isolatio

CS007A/B shall be operable (Mod 30 seconds



ystem

apable of taking suction

n to Cnmt sump (7 days)

m

of between 30% and 36%

ctors capable of educting

n Valves

s 1-4), Isolation time:

DESIGN FLOWS

A Pump; Recirc: 4200 gpm
Injection: 3415 gpm

B Pump; Recirc: 4600 gpm
Injection: 3925 gpm

INITIATION OF CS SIGNAL

1. CS007A(B) Opens
2. CS019A(B) Opens
3. CS Pumps start only when the CS019A(B) valves are open
4. CS010A(B) gets a confirmatory open signal.

CS ACTUATION SIGNALS

1. Cnmt Hi-3 Pressure (>20# 2/4)
2. Manual (2/2 @ 1/2 locations)

CS TERMINATION

1. Cnmt Pressure < 15 psig **AND**
2. Operating > 2 hours (LOCA only)

CS-1, CONTAINMENT SPRAY
AUG 23, 1992, REV. 0
FOR TRAINING USE ONLY

9611260251-01