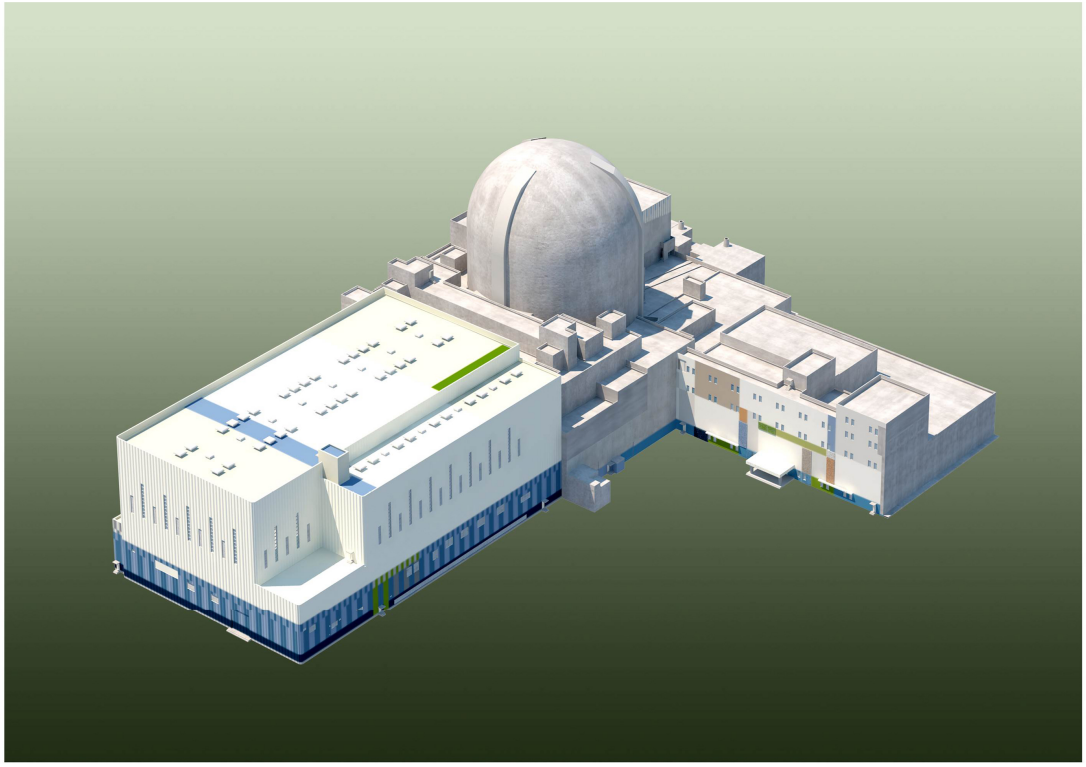
APR1400
DESIGN CONTROL DOCUMENT TIER 2

CHAPTER 6
ENGINEERED SAFETY FEATURES

APR1400-K-X-FS-14002-NP
REVISION 0
DECEMBER 2014



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ACRONYM AND ABBREVIATION LIST

AAC	alternate alternating current
ABCAEES	auxiliary building controlled area emergency exhaust system
ACU	air cleaning unit
AEB	Atomic Energy Bureau
AHU	air handling unit
ASHRAE	America Society of Heating, Refrigeration, and Air-Conditioning Engineers
BAMP	boric acid makeup pump
BAST	boric acid storage tank
CAREM	code-accuracy-based realistic evaluation method
CCWS	component cooling water system
CEA	control elements assembly
CFS	cavity flooding system
CHMS	containment hydrogen monitoring system
CHRS	containment heat removal system
CIAS	containment isolation actuation signal
CILRT	containment integrated leakage rate test
CIS	containment isolation system
CIV	containment isolation valve
CM	containment monitoring
COL	combined license
CRE	control room envelope
CREACS	control room emergency makeup air cleaning system
CREVAS	control room emergency ventilation actuation signal
CRF	carryout rate fraction
CS	containment spray

CSAS	containment spray actuation signal
CSHX	containment spray heat exchanger
CSP	containment spray pump
CSS	containment spray system
CVCS	chemical and volume control system
DBA	design basis accident
DEDLSB	double ended discharge leg slot break
DEHLSB	double ended hot leg slot break
DESLSB	double ended suction leg slot break
DLM	diffusion layer model
DVI	direct vessel injection
EAB	exclusion area boundary
ECC	emergency core cooling
ECCS	emergency core cooling system
ECSBS	emergency containment spray backup subsystem
ECWS	essential chilled water system
EDG	emergency diesel generator
EDT	equipment drain tank
EOB	end of blowdown
EOPR	end of post-reflood
EOR	end of reflood
EQ	environmental qualification
ERVC	external reactor vessel cooling
ESF	engineered safety feature
ESFAS	engineered safety features actuation system
ESR	electro-hydraulic actuated spring return
ESWS	essential service water system

FHAEES	fuel handling area emergency exhaust system
FMEA	failure modes and effects analyses
GDC	general design criteria
GOTHIC	generation of thermal-hydraulic information for containment
GSI	Generic Safety Issue
GWMS	gaseous waste management system
HAZ	heat-affected zone
HELB	high-energy line break
HEPA	high efficiency particulate air
HI	hydrogen igniter
HVAC	heating, ventilation, and air conditioning
HVT	hold-up volume tank
ICI	in-core instrumentation
IEEE	Institute of Electrical and Electronics Engineers
IRWST	in-containment refueling water storage tank
ISI	in-service inspection
IWSS	in-containment water storage system
LB	large break
LBB	leak-before-break
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
LPZ	low population zone
M&E	mass and energy
MCR	main control room
MFIV	main feedwater isolation valve
MFLB	main feedwater line break
MOV	motor operated valve

MSIS	main steam isolation signal
MSIV	main steam isolation valve
MSLB	main steam line break
NPSH	net positive suction head
NRC	Nuclear Regulatory Commission
NSSS	nuclear steam supply system
PACU	package air conditioning unit
PAR	passive autocatalytic recombiner
POSRV	pilot operated safety relief valve
PSI	preservice inspection
PSR	pneumatic actuated spring return
RCFC	reactor containment fan cooler
RCP	reactor coolant pump
RCPB	reactor coolant pressure boundary
RCS	reactor coolant system
RDT	reactor drain tank
RG	Regulatory Guide
RMI	reflective metal insulation
RSR	remote shutdown room
SCP	shutdown cooling pump
SCS	shutdown cooling system
SDS	safety depressurization system
SER	safety evaluation report
SG	steam generator
SGTR	steam generator tube rupture
SI	safety injection
SIAS	safety injection actuation signal

SIFT	safety injection filling tank
SIS	safety injection system
SIT	safety injection tank
SLB	steam line break
SRP	Standard Review Plan
SSC	systems, structures, and components
SSE	safe shutdown earthquake
TCD	thermal conductivity degradation
TEDE	total effective dose equivalent
TSC	technical support center
TSP	tri-sodium phosphate

CHAPTER 6 – ENGINEERED SAFETY FEATURES

6.0 Engineered Safety Features

Engineered safety features (ESFs) mitigate the consequences of design basis accidents (DBAs) by maintaining long-term core cooling and the integrity of the containment building and by limiting offsite releases of radioactive materials. This section describes the following ESFs of the APR1400:

a. Containment systems

b. Safety injection systems

c. Habitability systems

d. Fission product removal and control systems

The components in ESF systems are safety-related and fabricated to standards that are commensurate with the importance of their safety functions in conformance with 10 CFR 50.55a (Reference 1).

ESF systems meet the following General Design Criteria (GDC) from Appendix A of 10 CFR Part 50 (Reference 2).

a. GDC 1: The ESF components are fabricated of materials selected in accordance with the applicable portions of ASME Section III, Division 1 or Division 2 (References 3 and 4), or an ASME Code Case in NRC Regulatory Guide (RG) 1.84 (Reference 5).

b. GDC 4: The containment and ESF components are designed to accommodate the environmental and dynamic effects associated with normal plant operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents (LOCAs).

c. GDC 14: The ESF systems in the reactor coolant pressure boundary (RCPB) are designed, fabricated, erected, and tested so as to have a low probability of causing abnormal leakage, of rapidly propagating failure, and of causing gross rupture.

d. GDC 31: The ESF systems in the RCPB are designed with sufficient margin to provide reasonable assurance that when stressed under operating, maintenance, testing, and postulated-accident conditions, the boundary behaves in a non-brittle manner and the probability of a rapidly propagating fracture is minimized.

e. GDC 35: The ESFs are designed to provide abundant emergency core cooling to transfer heat from the reactor core following any loss of reactor coolant at a rate that (1) prevents fuel and clad damage that could interfere with continued effective core cooling and (2) limits the clad metal-water reaction to a negligible amount of hydrogen. The safety function of ESFs can be accomplished assuming a single failure.

f. GDC 41: The containment hydrogen control system controls the concentration of hydrogen in the containment atmosphere following postulated accidents to provide reasonable assurance that containment integrity is maintained.

The ESF systems described in this chapter are those that limit the consequences of an accidental release of radioactive fission products from the reactor coolant system. This chapter identifies the functional requirements, demonstrates how the functional requirements conform with applicable regulatory requirements and available regulatory guidance, and demonstrates how the ESF design meets or exceeds the functional requirements.

6.0.1 Engineered Safety Feature Material

The material selection and fabrication of ESF components are described in Section 6.1. The ESF materials are selected for compatibility with core cooling coolants and containment sprays.

6.0.2 Containment Systems

The APR1400 containment building consists of a leak-tight cylindrical shell and hemispherical dome equipped with a steel liner plate to accommodate the pressure and temperature conditions resulting from the high-energy pipe breaks of the primary or secondary system and to provide reasonable assurance that no significant release of the radioactive material reaches the environment.

The APR1400 containment is designed and built to safely accommodate the maximum pressure of 4.218 kg/cm^2G (60 psig) to provide reasonable assurance that the containment integrity is maintained during any postulated-accident conditions.

The principal containment systems, which are described in Section 6.2, are as follows:

a. Containment heat removal system (CHRS)

b. Containment isolation system (CIS)

c. Containment hydrogen monitoring and control system

The containment spray system (CSS), discussed in Subsection 6.2.2, maintains the temperature below a maximum value and reduces the containment temperature and pressure following a postulated DBA. The heat removal capacity of the CSS in conjunction with other acceptably defined active or passive heat sinks is sufficient to prevent exceeding containment design pressure and temperature and to reduce containment pressure to at least half the calculated peak pressure in 24 hours for a LOCA or main steam line break (MSLB).

The function of the CIS, which is described in Subsection 6.2.4, is to provide containment isolation to allow the normal or emergency passage of fluids through the containment boundary while preserving the integrity of the containment boundary. The CIS prevents or limits the escape of fission products that could result from postulated accidents. Containment isolation provisions are designed so that fluid lines penetrating the containment boundary are isolated in the event of an accident. The isolation minimizes the release of radioactivity to the environment.

The function of the containment hydrogen monitoring and control system, which is described in Subsection 6.2.5, is to monitor and control the hydrogen in containment during and after a DBA. In the event that hydrogen is detected in containment, passive autocatalytic recombiners (PARs) or hydrogen igniters (HIs) are used to preclude local detonations in the containment that could jeopardize containment integrity or damage essential equipment.

The APR1400 containment penetrations and isolation barriers are designed to permit periodic leakage rate testing.

6.0.3 Safety Injection Systems

The safety injection system (SIS) provides core cooling in the event of an accidental release of radioactive fission products from the reactor coolant system (RCS), particularly as a result of a LOCA.

The SIS also provides reasonable assurance of an adequate shutdown margin by injecting borated water directly into the reactor vessel and provides continuous long-term cooling of the core by the recirculation of the borated water from the in-containment refueling water storage tank (IRWST) back to the reactor core.

6.0.4 Habitability System

The habitability systems are provided to allow control room operators to remain in the control room and take actions to operate the plant safely under normal conditions, and maintain it in a safe condition under abnormal conditions, including a LOCA.

The control room habitability systems protect control room operators from gas releases and smoke from a fire outside the control room. Materials and facilities are provided to permit operators to remain in the control room envelope for an extended period.

6.0.5 Fission Product Removal and Control Systems

The APR1400 post-accident, safety-related containment fission product removal and control system, which is described in Section 6.5, provides removal processes inside the

containment, containment boundary, and containment isolation system. Removal processes include various aerosol removal processes that remove airborne particulates and iodine from the containment atmosphere following a postulated DBA. The containment boundary and isolation systems control the release of radioactivity from the containment to provide reasonable assurance that the leakage fraction that may reach the environment is below limits. The APR1400 fission product removal and control system consists of the following:

a. Control room emergency makeup air cleaning system (CREACS)

b. Auxiliary building controlled area emergency exhaust system (ABCAEES)

c. Fuel handling area emergency exhaust system (FHAEES)

d. Containment spray system

e. Containment vessel

The CREACS is a part of the control room heating, ventilation, and air conditioning (HVAC) system and is described in Section 6.4 and Subsection 9.4.1. The ABCAEES is part of the auxiliary building controlled area HVAC system and is described in Subsection 9.4.5. The FHAEES is part of the fuel handling area HVAC system and is described in Subsection 9.4.2. The containment spray system is described in Subsection 6.2.2.

6.0.6 In-service Inspection of Class 2 and 3 Components

The in-service inspection of ASME Section III Class 2 and 3 components is described in Section 6.6 and meets the requirements of 10 CFR 50.55a(g) (Reference 1).

6.0.7 In-containment Water Storage System

The in-containment water storage system (IWSS), described in Section 6.8, provides the water collection, delivery, storage, and heat sink functions inside the containment during normal operation and accident conditions. The IWSS comprises the IRWST, holdup volume tank (HVT), and cavity flooding system (CFS).

The IRWST is a safety-related source of borated water for emergency core cooling in the event of a LOCA and is a source of water for containment cooling and for core melt cooling in the event of a severe accident. The HVT serves as a low-collection point in the containment and receives water from pipe breaks and containment spray during accident conditions. The CFS floods the reactor cavity in the event of a severe accident and covers core debris in the reactor cavity with water.

6.0.8 References

1. 10 CFR 50.55a, "Codes and Standards", U.S Nuclear Regulatory Commission.

2. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants", U.S. Nuclear Regulatory Commission.

3. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

4. ASME Boiler and Pressure Vessel Code, Section III, Division 2, "Code for Concrete Containments," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

5. Regulatory Guide 1.84, "Design, Fabrication, and Material Code Case Acceptability ASME Section III," Rev. 36, U.S. Nuclear Regulatory Commission, August 2014.

6.1 Engineered Safety Features Materials

Material selection and fabrication of ESF components are described in this section. The materials used in ESF systems are selected for compatibility with core cooling coolants and containment spray solution.

6.1.1 Metallic Materials

The ASME Code that applies to the design and fabrication of the piping and components is specified in Chapter 3. For materials, later editions or addenda of the ASME Code are used as permitted by the ASME Code if the edition or addenda are approved by 10 CFR 50.55a.

6.1.1.1 Materials Selection and Fabrication

ESF materials are selected for compatibility with core cooling coolants and containment spray solution.

Principal ESF pressure-retaining materials are listed in Table 6.1-1. ESF pressure-retaining materials meet the applicable material requirements of ASME Section III (Reference 1) and conform to the applicable ASME Section II (Reference 2) material specifications. The material specifications for ESF pressure-retaining materials meet the requirements of ASME Section III, Class 2; Article NC-2000 for Quality Group B, ASME Section III, Class 3; Article ND-2000 for Quality Group C; and ASME Section III for containment pressure boundary components. The materials used in containment penetrations meet the requirements of ASME Section III, Division 1, Articles NC-2000 or NE-2000.

Principal ESF materials inside the containment that are exposed to the containment spray solution are listed in Table 6.1-2. These materials are chosen to be compatible with the chemical solutions in the containment spray. The materials used in ESF component construction are reviewed for acceptability prior to release for material procurement. Corrosion of materials in the containment is minimized in accordance with the recommendations of U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG)

1.7 (Reference 3) by restricting the use of zinc and aluminum and prohibiting the use of mercury.

The integrity of the safety-related components of the ESF systems is maintained during all stages of component manufacture and reactor construction as follows:

a. Significant sensitization during fabrication and assembly of austenitic stainless steel components of ESF systems is avoided as follows:

   1) All raw austenitic stainless steel, both wrought and cast, used to fabricate pressure-retaining components of the ESF is supplied in the annealed condition as specified in ASME Section II. ESF systems do not use furnace-sensitized materials.

   2) Duplex, austenitic stainless steels containing certain quantity of delta ferrite (weld metal, cast metal, weld deposit overlay) are not considered unstabilized because these alloys do not sensitize (i.e., form a continuous network of chromium-iron carbides). Alloys in this category are:

CF3, CF3M, CF8, CF8M	Cast stainless steels (delta ferrite) are controlled to 8 % to 30 %, 8 % to 20 % for normal operating temperatures above 260 °C (500 °F) or 8 % to 14 % for high molybdenum content (not less than 2 %) statically cast stainless steels with normal operating temperatures above 260 °C (500 °F)
308, 309, 312, 316	Singly and combined stainless steel weld filler metals (control of weld filler metal delta ferrite content is described in Subsection 5.2.3.4)

   3) In duplex austenitic/ferritic alloys, chromium-iron carbides are precipitated preferentially at the ferrite/austenite interface during exposure to temperatures ranging from 427 to 816 °C (800 to 1,500 °F). This precipitate morphology precludes intergranular penetrations associated with sensitized Type 300 series stainless steels exposed to oxygenated or otherwise faulted environments.

4) The delta ferrite content of austenitic stainless steel weld metal is controlled in accordance with the recommendations of NRC RG 1.31 (Reference 4), as described in Subsection 5.2.3.4. Austenitic stainless steel materials subjected to sensitizing conditions are tested in accordance with NRC RG 1.44. Non-sensitization of austenitic stainless steel materials are verified in accordance with ASTM A262 (Reference 5), Practices A or E. The sensitization of heat-affected zone (HAZ) for austenitic stainless steels is avoided by careful control of the following conditions:

   a) Maximum heat input: 23.6 kJ/cm (60 kJ/in)

   b) Maximum interpass temperature: 177 °C (350 °F)

   d) Maximum carbon content: 0.065 percent

b. Contaminants that are capable of causing stress corrosion cracking are controlled as follows:

   1) Cleanliness and contamination protection is provided for components that are controlled for contamination during fabrication, shipment, and storage as recommended in ASME NQA-1 (Reference 6).

   2) Contamination of Type 300 series austenitic stainless steels by compounds that can alter the physical or metallurgical structure and properties of the material is avoided during all stages of fabrication. Painting of Type 300 series stainless steels is prohibited. Internal surfaces of completed components are cleaned to the extent that grit, scale, corrosion products, grease, oil, wax, gum, adhered or embedded dirt, and extraneous material are not visible to the unaided eye. Degreasing solvents such as acetone, isopropyl alcohol, and trisodium phosphate (TSP) are used on metallic surfaces. Water used for cleaning is inhibited with 30 to 100 ppm hydrazine. The specification for water quality is in accordance with Table 3.4.1 of ASME NQA-1 (Reference 6), Subpart 2.1. To prevent halide-induced intergranular corrosion that can occur in an aqueous environment with significant quantities of dissolved oxygen, flushing water is inhibited through

additions of hydrazine. Onsite and pre-operational cleaning of ESF components is in accordance with the recommendations of ASME NQA-1.

c. Cold-worked austenitic stainless steel is not normally used for pressure boundary applications. However, if it is necessary to use cold-worked austenitic stainless steel, such cold-work is processed and documented during each fabrication process. Reasonable assurance of the integrity of the steel structure is provided by conducting an augmented in-service inspection. Cold-worked austenitic stainless steels have a maximum 0.2 percent offset yield strength of 620 MPa (90,000 psi) to reduce the probability of stress corrosion cracking in ESF systems.

d. All non-metallic insulation materials installed on stainless steel ESFs conform to NRC RG 1.36 (Reference 7).

e. When nickel-chromium-iron alloys are used as ESF materials, only Alloy 690 is selected. Alloy 690 has improved stress-corrosion cracking resistance.

f. Fracture toughness properties of ESF materials meet the requirements of ASME Section III, Subarticles NC/ND/NE-2300.

g. Grinding is performed with resin or rubber bonded aluminum oxide or silicon carbide wheels that have not previously been used on any materials other than Type 300 series stainless alloys. Grinding wheels bonded with rubber compositions that include halides or sulfur are not used on austenitic stainless steels.

The ESF system is designed with a consideration of the deterioration of materials in service from pipe wall thinning by corrosion, erosion, mechanical abrasion, or other environmental effects.

The recommendations of NRC RG 1.50 (Reference 8) and ASME Section III Appendix D are applied to weld fabrication. The minimum preheat temperature meets ASME Section III, Appendix D, Article D-1000. The maximum interpass temperature used for the low alloy steels that require impact testing is 260 °C (500 °F).

Moisture control on low hydrogen welding materials conforms to the requirements of ASME Section III.

Welder performance qualification for areas with limited accessibility conforms with the recommendations of NRC RG 1.71 (Reference 9).

6.1.1.2 Composition and Compatibility of Core Cooling Coolants and Containment Sprays

Controlled water chemistry is maintained within the RCS. RCS water chemistry is specified to minimize corrosion. RCS water chemistry specification is shown in Table 5.2-5. Water chemistry limits are determined at a level comparable to the guidelines in the Electric Power Research Institute (EPRI), "PWR primary water chemistry guidelines" (Reference 10). Control of the reactor coolant chemistry is the function of the chemical and volume control system (CVCS), which is described in Subsection 9.3.4.

Water from the in-containment refueling water storage tank (IRWST), which serves as the long-term water source for containment spray system, is controlled to maintain a pH range during a loss-of-coolant accident (LOCA).

6.1.1.2.1 Compatibility of Construction Materials with Core Cooling Coolants and Containment Sprays

To minimize the corrosion of the stainless steel in the containment during a LOCA, long-term post-LOCA pH control of IRWST water is provided by granular TSP, which is stored in baskets in the holdup volume tank (HVT). The stainless steel baskets have a solid top and bottom with mesh sides to provide reasonable assurance of dissolution when submerged in water. The pH control is described in Subsection 6.5.2.3.2. Surfaces in the IRWST that are in direct contact with borated water are lined with stainless steel.

The materials used in the fabrication of mechanical and structural components inside the containment are selected to minimize corrosion and hydrogen generation resulting from contact with spray solutions. The use of aluminum and zinc is minimized in the containment to minimize the yield of hydrogen gas through the chemical reaction with the emergency core cooling or containment spray solutions used in the containment.

Combustible gas control in containment through the use of passive autocatalytic recombiners is addressed in Section 6.2.5.

The surface area of aluminum inside containment that can be exposed by the spray water is limited by design to less than 281.8 m^2 (3,034 ft^2).

6.1.1.2.2 Controls for Ferritic Steel and Stainless Steel

Subsection 6.1.1.1 describes the control of sensitized stainless steel, cleaning and contamination protection, cold-worked stainless steel, non-metallic insulation, welder qualification, and weld fabrication. The manufacture and construction of ESF components and structures conform with the provisions of NRC RGs 1.31, 1.36, 1.44 (Reference 11), 1.50, and 1.71.

6.1.1.2.3 Composition, Compatibility and Stability of Containment and Core Coolants

The IRWST has 2,373.5 m^3 (627,000 gal) of borated water available to meet LOCA and long-term post-LOCA coolant needs. The IRWST water is borated to at least 4,000 ppm boric acid, and pH is raised above 7 with the TSP basket per Branch Technical Position 6-1 (Reference 12) for reducing the probability of stress-corrosion cracking of austenitic stainless steel components.

All systems located inside containment such as the reactor coolant system (RCS) and portions of the CVCS, SIS, CSS, and shutdown cooling system (SCS) have reflective metal insulation (RMI). Major equipment in the above systems includes the reactor coolant pumps (RCPs), steam generators, pressurizer, letdown heat exchanger, regenerative heat exchanger, reactor drain tank, and the reactor vessel. No other type of insulation, including fibrous insulation is used inside the containment. However, the portions of some of the above systems that are outside the containment have non-metallic insulation for plant personnel protection. The use of non-metallic insulation is in accordance with NRC RG 1.36.

6.1.2 Organic Materials

Organic materials including wood, clothes, plastics, lubricants, and asphalt are not used inside the containment.

The protective coatings used inside the containment, Service Level I, have been demonstrated to withstand design basis conditions and meet the guidance in NRC RG 1.54 (Reference 13).

Any particulate debris of appreciable size that occurs either settles to the bottom of the HVT or is trapped by the filter screen at the bottom of the IRWST.

The coatings are able to withstand the harsh conditions of high pressures and temperatures from a combined postulated LOCA and main steam line break (MSLB).

Service Level I coatings, as defined in ASTM D5144-08 (Reference 14), apply to all coatings on structures, equipment, and components inside the containment where the failure of the coatings could adversely affect the operation of post-accident fluid systems and impair a safe shutdown.

The selection of Service Level I coatings is based on ASTM Standards D 5144-08, ASTM D3911-08 (Reference 15), and ASTM D3843-08 (Reference 16). The coatings protect the surfaces of facilities, equipment, and components against corrosion and contamination during plant operation.

The substrate requiring Service Level I coating systems are listed below. A list of applicable coatings per substrates is given in Table 6.1-3.

a. Ferrous metal surfaces

   Exposed surfaces of the containment liner plates, equipment hatch and personnel airlocks, structural steels, and miscellaneous steels.

b. Concrete surface

Indoor surfaces of concrete walls, ceilings, and floors that require protection from a corrosive atmosphere, chemical attack and wear, irradiation, radioactive materials, and the decontamination processes and provide for general maintenance and abrasion service.

The practice of quality assurance for protective coatings applied to the inside of the containment satisfies the requirements of 10 CFR Part 50 Appendix B, ASME NQA-1-2008, and ASTM D3843-00. The records of manufacture's product identity certification, shipping and receiving, warehousing, applicator's material identification, surface preparation and coating application, inspector qualification, daily coating work inspection, and inspector and applicator training are monitored to ensure the quality of Service Level I coatings.

As required in the NRC maintenance rule 10 CFR 50.65, the coating program to monitor effectiveness of maintenance for Service Level I coatings includes materials, storage, equipment, application, inspection, and training. The combined license (COL) applicant is to identify the implementation milestones for the coatings program (COL 6.1(1)).

6.1.3 Combined License Information

COL 6.1(1) The COL applicant is to identify the implementation milestones for the coatings program.

6.1.4 References

1. ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Facility Components,” The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

2. ASME Boiler and Pressure Vessel Code, Section II, “Materials,” The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda

3. Regulatory Guide 1.7, “Control of Combustible Gas Concentrations in Containment,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

4. Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," Rev. 4, U.S. Nuclear Regulatory Commission, October 2013.

5. ASTM A262, "Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels."

6. ASME Section III, NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications," The American Society of Mechanical Engineers, the 2008 Edition with the 2009 Addenda.

7. Regulatory Guide 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel," U.S. Nuclear Regulatory Commission, February 1973.

8. Regulatory Guide 1.50, "Control of Preheat Temperature for Welding of Low-Alloy Steel," Rev. 1, U.S. Nuclear Regulatory Commission, March 2011.

9. Regulatory Guide 1.71, "Welder Qualification for Areas of Limited Accessibility," Rev. 1, U.S. Nuclear Regulatory Commission, March 2007.

10. EPRI Report 1014986, "PWR Primary Water Chemistry Guidelines," Rev. 6, Electric Power Research Institute, December 2007.

11. Regulatory Guide 1.44, "Control of the Processing and Use of Stainless Steel," Rev. 1, U.S. Nuclear Regulatory Commission, March 2011.

12. NUREG-0800, Standard Review Plan, BTP 6-1, "pH for Emergency Coolant Water for Pressurized Water Reactors," U.S. Nuclear Regulatory Commission.

13. Regulatory Guide 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, October 2010.

14. ASTM D5144, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants," American Society for Testing and Materials, 2008.

15. ASTM D3911, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions," American Society for Testing and Materials, 2008.

16. ASTM D3843, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities," American Society for Testing and Materials, 2008.

Table 6.1-1 (1 of 5)

Principal Engineered Safety Feature Pressure Retaining Material Specifications

ESF Component	Material	Class, Grade, or Type
Containment		
Containment liner plate	SA-516 SA-240	Gr. 60 or 70 Type 304
Penetrations		
Head Fitting	SA-182 SA-350 SA-516 SA-240	Gr. F22 Class 3 Gr. LF2 Gr. 60 Type 304
Pipe	SA-106 SA-312	Gr. B, C Gr. TP304, TP304L, Gr. TP316L
Sleeve	SA-516	Gr. 70
	SA-333	Gr. 6
Containment Spray System CS/SC Pump		
Pressure casting	SA-351	Gr. CF3 or CF3M Gr. CF8 or CF8M
Pressure forgings	SA-182	Gr. F304 or F304L/LN Gr. F316 or F316L/LN
Tubes and pipes	SA-213 SA-312	Gr. TP304 or TP304L Gr. TP316 or TP316L
Closure stud bolts	SA-193	Gr. B7 or B8
	SA-638	Gr. 660
	SA-564	Type 630 COND. H1100
Closure stud nuts	SA-194	Gr. 7 or 8
	SA-638	Gr. 660
	SA-564	Type 630 COND. H1100

Table 6.1-1 (2 of 5)

ESF Component	Material	Class, Grade, or Type
CS/CS Mini-flow/SC/SC Mini-flow Heat Exchanger		
Pressure plates	SA-240	Type 304, 304L, 316, 316L
	SA-516	Gr. 60, 70
Pressure forgings	SA-105	-
	SA-182	Gr. F304, F304L, F316, F316L
	SA-266	Gr. 2
	SA-350	Gr. LF1, LF2
Tubes and pipes	SA-106	Gr. B
	SA-213 SA-312	Gr. TP304, TP304L, TP316, TP316L
Closure bolts	SA-193	Gr. B6, B7, B8, B16
Closure nuts	SA-194	Gr. 2, 2H, 4, 8, 8M, 16
Piping		
Class 1 piping	Table 5.2.3-1	-
Class 2 piping	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L

Table 6.1-1 (3 of 5)

ESF Component	Material	Class, Grade, or Type
Valves		
Class 1 valves	Table 5.2-2	-
Class 2 valves	Material for Class 2 valves are the same as for Class 1 (Table 5.2-2)	-
Fitting / flange	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L
	SA-182	Gr. F304, F304L
	SA-479	Type 304, 304L
Emergency Core Cooling System Safety Injection Pump		
Pressure casting	SA-351	Gr. CF3 or CF3M Gr. CF8 or CF8M
Pressure forgings	SA-182	Gr. F304 or F304L/LN Gr. F316 or F316 L/LN
	SA-508	Gr. 3 Cl.1
Tubes and pipes	SA-213 SA-312	Gr. TP304 or TP304L Gr. TP316 or TP316L
Closure stud bolts	SA-193	Gr. B6 or B7
	SA-638	Gr. 660
Closure stud nuts	SA-194	Gr. 6 or 7
	SA-638	Gr. 660
Cladding, buttering	Type 308L/309L stainless steel strip electrode	-

Table 6.1-1 (4 of 5)

ESF Component	Material	Class, Grade, or Type
Accumulator (SIT)		
Pressure plates	SA-516	Gr. 60 or 70
Pressure forgings	SA-105	-
	SA-182	Gr. F304, F304L, F316, or F316L
	SA-350	Gr. LF1 or LF2
Pipes	SA-312	Gr. TP304, TP304L, TP316, and TP316L
Closure bolts	SA-193	Gr. B6, B7, B8, B16
Closure nuts	SA-194	Gr. 2, 2H, 4, 8, 8M or 16
Piping		
Class 1 piping	Table 5.2-2	-
Class 2 piping	SA-312 SA-358	Gr. TP304, TP304L Gr. 304, 304L
Valves		
Class 1 valves	Table 5.2-2	
Class 2 valves	Material for Class 2 valves are the same as for Class 1 (Table 5.2-2)	-
Fitting / flange	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L
	SA-182	Gr. F304, F304L
	SA-479	Type 304, 304L

Table 6.1-1 (5 of 5)

ESF Component	Material	Class, Grade, or Type
ESF Filter System		
	Subsection 6.5.1	
Weld Filler Material		
	SFA-5.1	E7016, E7018
	SFA-5.4	E308-15, E308-16, E308L-15, E308L-16 E309L-16
	SFA-5.5	E9018-B3
	SFA-5.9	ER308, ER309, ER308L ER309L
	SFA-5.11	ENiCrFe-7
	SFA-5.14	ERNiCrFe-7, ERNiCrFe-7A
	SFA-5.18	ER70S-2, ER70S-6
	SFA-5.28	ER90S-B3

Table 6.1-2 (1 of 3)

Principal Engineered Safety Features Materials
Exposed to Core Coolant and Containment Spray

ESF Component	Material	Class, Grade, or Type
Containment		
Containment liner plate	SA-516 SA-240	Gr. 60 or 70 Type 304
Penetrations		
Head Fitting	SA-182 SA-350 SA-516 SA-240	Gr. F 22 Class 3 Gr. LF2 Gr. 60 Type 304
Pipe	SA-106 SA-312	Gr. B, C Gr. TP304, TP304L, Gr. Tp316L
Sleeve	SA-516	Gr. 70
	SA-333	Gr. 6
Containment Spray System		
Piping		
Class 1 piping	Table 5.2-2	-
Class 2 piping	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L
Valves		
Class 1 valves	Table 5.2-2	
Class 2 valves	Material for Class 2 valves are the same as for Class 1 (Table 5.2-2)	-
Fitting / flange	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L
	SA-182	Gr. F304, F304L
	SA-479	Type 304, 304L

Table 6.1-2 (2 of 3)

ESF Component	Material	Class, Grade, or Type
Emergency Core Cooling System		
Accumulator (SIT)		
Pressure plates	SA-516	Gr. 60, 70
Pressure forgings	SA-105	-
	SA-182	Gr. F304, F304L, F316, F316L
	SA-350	Gr. LF1, LF2
Internal parts	SA-240	Type 304, 304L, 316, 316L
	SA-182	Gr. F304, F304L, F316, F316L
Pipes	SA-312	Gr. TP304, TP304L, TP316, TP316L
Closure bolts	SA-193	Gr. B6, B7, B8, B16
Closure nuts	SA-194	Gr. 2, 2H, 4, 8, 8M, 16
Piping		
Class 1 piping	Table 5.2-2	-
Class 2 piping	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L
Valves		
Class 1 valves	Table 5.2-2	
Class 2 valves	Material for Class 2 valves are the same as for Class 1 (Table 5.2-2)	
Fitting / flange	SA-312	Gr. TP304, TP304L
	SA-358	Gr. 304, 304L
	SA-182	Gr. F304, F304L
	SA-479	Type 304, 304L

Table 6.1-2 (3 of 3)

ESF Component	Material	Class, Grade, or Type
ESF Filter System		
	Subsection 6.5.1	
Weld Filler Material		
	SFA-5.1	E7016, E7018
	SFA-5.4	E308-15, E308-16, E308L-15, E308L-16 E309L-16
	SFA-5.5	E9018-B3
	SFA-5.9	ER308, ER309, ER308L, ER309L
	SFA-5.11	ENiCrFe-7
	SFA-5.14	ERNiCrFe-7, ERNiCrFe-7A
	SFA-5.18	ER70S-2, ER70S-6
	SFA-5.28	ER90S-B3

Table 6.1-3

Coating Material Used in the Containment Structure

Surface To Be Coated	Type of Coating
Containment liner plate, equipment hatch and personnel airlock and structural miscellaneous steel	Inorganic zinc / epoxy
Equipment and components having a surface temperature of less than 93.3 °C (200 °F)	Epoxy primer / epoxy top coat
Equipment and components having a surface temperature of 93.3 °C (200 °F) to 398.9 °C (750 °F)	Inorganic zinc
Concrete ceiling, wall, and floor	Epoxy primer / epoxy surface / epoxy top coat

6.2 Containment Systems

The containment systems include the prestressed concrete containment, containment spray (CS) system, containment air purification and cleanup systems, containment isolation system, and containment combustible gas control system. This section provides the design limits and evaluations necessary to demonstrate that these systems operate as required.

6.2.1 Containment Functional Design

The APR1400 containment building consists of a cylindrical shell and dome with a steel liner plate. The containment is designed as an essentially leak-tight barrier that accommodates the calculated temperature and pressure conditions resulting from the complete spectrum of postulated breaks, up to and including a double-ended slot break in the reactor coolant system or secondary system piping.

The containment is designed to withstand the environmental and dynamic effects associated with both normal plant operation and postulated accidents (GDC 4). In addition, the containment and its associated systems establish a barrier against the uncontrolled release of radioactivity to the environment, and incorporate sufficient margin in its design so that conditions important to safety are not exceeded throughout postulated accidents (GDC 16).

The CS system, containment heat removal system (CHRS) and associated in-containment refueling water storage tank (IRWST) rapidly reduce the containment pressure following a loss-of-coolant accident (LOCA) or secondary system piping rupture and maintain containment pressure within acceptable levels. As a result, the containment accommodates, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from a design basis accident (DBA) (GDC 38, GDC 50).

The containment functional design described herein is also required in lower-mode operations (Mode 3 through Mode 5) as postulated accidents at lower modes could still release radioactive material and increase the containment pressure and temperature. The design containment integrity analyses are performed at Mode 1 or 2 since the total energy

from the reactor coolant, secondary system metal, and decay heat is greater than that at lower modes of operation.

This section pertains to the aspects of containment design, testing, and analysis relevant to accident mitigation. A physical description of the containment and its design criteria, as related to construction techniques, static loads, and seismic loads is addressed in Section 3.8.

6.2.1.1 Containment Structure

6.2.1.1.1 Design Bases

The containment design basis requires that the release of radioactive materials subsequent to an accident does not result in doses in excess of the values specified in 10 CFR 50.34. Following a DBA, the containment is designed to withstand the accident's pressure and temperature without exceeding the design leakage rate of 0.1 percent volume for the first 24 hours and half of this design leakage rate thereafter. Containment leakage testing is described in Subsection 6.2.6. A description of the radiological consequences of the DBA is documented in Chapter 15.

The containment design pressure of 4.218 kg/cm^2G (60 psig) is based on the worst-case LOCA and bounds all of the postulated secondary system piping rupture events for peak containment pressure. A design margin of 10 percent is taken into account in the determination of this value. In addition, the containment heat removal system is designed with sufficient heat removal capability to maintain containment pressure to less than 50 percent of the calculated peak pressure within 24 hours after the postulated accident.

6.2.1.1.1.1 Postulated Accident Conditions

Table 6.2.1-1 summarizes the spectrum of postulated pipe breaks considered in the determination of the containment design peak pressure and temperature. The maximum calculated containment pressure and temperature as well as the maximum external pressure are listed in Table 6.2.1-2. Table 6.2.1-3 lists the containment's key design parameters.

The final analytical results are summarized in Table 6.2.1-2 and Figures 6.2.1-1 through 6.2.1-19. The calculations account for uncertainties and tolerances regarding the containment volume and its heat removal capability biased to maximize the peak pressure and temperature conditions. For conservatism, a loss of offsite power (LOOP) is assumed for the LOCA events whereas offsite power is considered available in secondary system piping breaks. The results demonstrate that the containment free volume and heat removal systems are adequate to maintain containment conditions below the design limits; assuming a worst single failure condition in addition to one train of the heat removal system out of service.

The containment is designed and constructed to withstand a broad spectrum of seismic event as described in Sections 3.2 and 3.8. The maximum calculated post-accident pressure and temperature are 3.592 kg/cm^{2}G (51.09 psig) and 167.45 °C (333.41 °F) respectively as documented in Table 6.2.1-2.

6.2.1.1.1.2 Mass and Energy Release

Tables 6.2.1-4 through 6.2.1-18 provide the mass and energy (M&E) release data for the postulated design accidents listed in Table 6.2.1-1. Subsections 6.2.1.3 and 6.2.1.4 describe the computer codes and assumptions used in the development of these M&E release tables.

6.2.1.1.1.3 Capability for Energy Removal from the Containment

Following a postulated break, the bulk of the energy released to the containment is removed from the containment atmosphere and transferred into the IRWST via the CS system spray droplets. During the entire accident, the IRWST serves as a water source for the CS system. Each train of the CS system rejects IRWST water energy to the component cooling water system (CCWS) through the CS heat exchanger (CSHX). The CCWS energy is transferred to the ultimate heat sink through the essential service water system (ESWS).

For the containment peak pressure and temperature analysis, the CS system is assumed affected by the most restrictive single active failure, resulting in minimum heat removal capability. This minimum heat removal capacity is demonstrated capable of reducing the

post-accident pressure below the containment design limit and to less than 50 percent of the calculated peak pressure within 24 hours of a postulated accident. Further descriptions of the single failure application to ESF systems are provided in Subsections 6.2.1.1.3.2, 6.2.1.1.3.3, and 6.2.1.4.2.

6.2.1.1.1.4 Bases for Containment Depressurization Rate

The containment depressurization rate following the design-basis LOCA meets the GDC 38 requirements that the calculated offsite doses be lesser than the guideline values in 10 CFR 50.34 at the containment design leakage rate. The containment design leakage is established as the minimum practicable rate based on a consideration of the reactor power level, site characteristics, type of containment, iodine removal capability, constructability, and testability. The validity of the established design leakage rate is verified by an analysis of the offsite radiological consequences of the DBA LOCA as described in Subsection 15.6.5

6.2.1.1.1.5 Bases for Analysis of Minimum Containment Pressure

An analysis of the minimum containment pressure following a LOCA is performed to confirm the core reflood capability of the safety injection (SI) systems under conservative assumptions that maximize the heat removal effectiveness of ESF systems, structural heat sinks, and other potential heat removal processes. Subsection 6.2.1.5 describes the assumptions and bases for the minimum containment pressure analysis.

6.2.1.1.2 Design Features

The containment building is a right circular cylinder/hemispherical dome prestressed concrete structure built on a safety-related basemat. Inside, the entire structure is lined with leak-tight steel plate membrane. The building's inside dimensions are 45.72 m (150 ft) in diameter and approximately 76.66 m (251.5 ft) in height. The wall and dome are 1.37 m (4 ft. 6 in) and 1.22 m (4 ft.) thick, respectively. A 6.0 mm (0.25 in) thick liner plate is attached to the inner surface of the containment wall and dome. A description of the containment structure and respective drawings are provided in Section 3.8.

Located at the bottom of the containment, at El. 81 ft., the IRWST is a reinforced concrete structure with a stainless steel inside liner. The IRWST provides continuous subcooled water for the SI and CS to cool the containment in the event of abnormal events such as a LOCA or secondary system piping rupture. Section 6.8 describes the in-containment water storage system (IWSS).

6.2.1.1.2.1 Protection against External Pressure Loads

Inadvertent operation of the CS system, containment purge, and containment fan cooler systems could potentially result in a significant containment external pressure loading. The APR1400 containment is designed to withstand an external pressure loading of 0.28 kg/cm2G (4.0 psig) relative to ambient pressure. An evaluation and associated analyses demonstrate that the containment structure integrity is maintained under maximum external pressure-loading conditions; see Subsection 6.2.1.1.3.5.

6.2.1.1.2.2 Potential Water Traps Inside Containment

The evaluation of the IRWST upstream effect is a review of the flow paths leading to the IRWST to identify flow paths that could result in blocking the return water that could challenge the IRWST minimum water level. The evaluation also includes identifying holdup volumes, such as recessed areas and enclosed rooms where trapped water volumes do not return to the IRWST. All of the hold-up volumes were taken into account in the minimum water level evaluation of the IRWST.

Holdup volumes are divided into two groups: Hold-up water on the way to the IRWST and the inactive pool volume. Detail holdup volume capacities are listed in Table 6.8-2 and the schematic of potential water traps in containment is shown in Figure 6.2.1-20. The groups are defined as follows:

a. Hold-up volume on the way to the IRWST

   In a LOCA, the IRWST water returns from the containment spray nozzles and broken pipe. The water on the way to the IRWST decreases the initial IRWST water level. The following are the source of hold-up water on the way to the IRWST:

1) Containment spray suspended water in the containment atmosphere

2) Containment spray steam water

3) Initial filling water for system and CS system pipe

4) Condensate water on the various surfaces

5) Water stream on the El. 100 ft in floor

6) Water stream on the refueling cavity floor

b. Inactive pools volume

An inactive pool volume is defined as a holdup volume that entraps return water that does not contribute to recovering the IRWST water level. The following are considered as inactive pool volumes:

1) Hold-up volume tank water volume that fills up to a level that can flow back into the IRWST through the spillways

2) Reactor cavity and in-core instrumentation (ICI) cavity volume

3) Containment drain sump volume

4) ICI cavity sump volume

In the refueling cavity, two 25.4 cm (10 in) drain lines are connected to the bottom of the containment. The refueling cavity collects approximately 9 percent of the containment main spray flow and would fill up except for the two floor drains. The water sprayed on the refueling cavity area is finally gathered to the lowest parts of the refueling cavity, which can hypothetically hold thousands of cubic feet of water if its drain is blocked. The 25.4 cm (10 in) drains are open with no covers, grates, or screens so the minimum flow restriction in the cavity drain line flow path is the inner diameter of the 10-inch drain line. Debris would need to be at least 250.0 mm (10 in) wide to bridge the opening and cause

blockage. Smaller debris would just pass straight through. Debris would also need to be planar to adequately seal the opening. A crumpled piece of RMI would not seal the opening.

The IRWST is designed to provide adequate water level to SI and CS/SC pumps. In addition, in consideration of the static head and suction line pressure drop, the evaluation of the available NPSH assumes that the vapor pressure of the liquid in the IRWST is equal to the containment ambient pressure. This assumption provides reasonable assurance that the actual available NPSH is always greater than the calculated NPSH. The minimum water level of the IRWST provides the basis for estimating static head in the NPSH evaluation as described in Section 6.3 and Subsection 6.5.2.

The minimum water level of the IRWST during a LOCA is calculated by subtracting the hold-up volume from the initial water volume in the IRWST and adding the water volume of three SI tanks. The minimum water level was determined to be 1.52 m (5 ft) above the IRWST bottom (at El. 81 ft) and this value is used in the NPSH evaluation.

6.2.1.1.3 Design Evaluation

A containment response analysis is performed to demonstrate the containment's integrity to postulated accident conditions. The APR1400 uses a simplified and distinct containment model using the Generation of Thermal-Hydraulic Information for Containment (GOTHIC) computer code (Reference 2) to calculate the containment pressure and temperature response following the M&E release from primary and secondary system pipe ruptures. This section presents a description of the analysis methodology and containment response calculations following a postulated LOCA and secondary system pipe rupture.

6.2.1.1.3.1 Description of Containment Analysis Methodology

The GOTHIC computer code (version 8.0) is selected to develop the APR1400 containment model since it is widely used to perform containment pressure and temperature (P/T) response analyses in the nuclear industry. The code is suitable to predict the containment pressure and temperature response to the M&E release following high-energy line breaks such as reactor coolant, main steam, and main feedwater piping. Besides the containment response analysis, GOTHIC is used to calculate the M&E release during the decay heat

phase for a large break LOCA. This subsection provides an overview of the GOTHIC computer code and the calculation methods and models used in the containment response analysis.

GOTHIC Computer Code Overview

GOTHIC (Reference 2) is a general-purpose thermal-hydraulic computer code often used in the design, licensing, safety and analysis of nuclear power plant containments. The code was developed by Numerical Applications (NAI), a Division of Zachry Nuclear Engineering Inc. with support from the Electric Power Research Institute (EPRI). The GOTHIC computer code is maintained under a 10 CFR Part 50 Appendix B, quality assurance program. The use of GOTHIC for the licensing analysis of the containment response to high-energy line breaks is well known in the nuclear industry and has been subsequently approved by the NRC for several plant applications.

APR1400 Containment Model

The principal sub-models in the containment response analysis include containment nodalization, break fluid modeling for M&E release, heat structure modeling of passive heat sinks and active heat removal system modeling. The following sections describe the model characteristics and conservatism of the assumed initial conditions. The methodology for containment response analysis is described in detail in Reference 3.

a. Containment nodalization

   The APR1400 containment building is modeled in GOTHIC using two lumped-parameter volumes: the containment atmosphere region and the IRWST region, with a flow path connecting the two volumes. This modeling approach is based on building design representing physical separation of the IRWST from the containment atmosphere region. The calculated containment free volume is conservatively minimized to maximize calculated peak pressure and temperature (Reference 3).

b. Break flow

The containment pressure and temperature response following a LOCA M&E release is affected by the phase separation of the break fluid. During blowdown, the break fluid is assumed to be released as liquid droplets. These droplets quickly reach thermal equilibrium with the containment atmosphere as they fall to the containment floor. The superheated drops produce additional steam in the containment atmosphere through evaporation cooling and a consequential containment pressure increase.

During the LOCA reflood and post-reflood phase, the break fluid is discharged as steam, hot spillage, and cold spillage. The discharged steam mixes immediately with the containment atmosphere. The hot spillage, discharged from the SG side of the pipe rupture, is conservatively assumed to flow directly to the containment floor without contacting the containment atmosphere and subsequently to the IRWST. Similarly, the cold spillage flows directly to the IRWST. Based on sensitivity analyses, the droplet discharge is assumed terminated at the end of the blowdown period (Reference 3).

c. Containment passive heat sinks

Following a LOCA or a secondary system pipe rupture, some of the break's energy is dissipated by the internal passive heat sinks. In the APR1400 containment GOTHIC model, most of the structures exposed to the containment atmosphere are considered as passive heat sinks and modeled as one-dimensional thermal conductors. The surface area and thickness of each passive heat sink is developed from plant drawings and specifications. The minimum surface area, which considers appropriate uncertainties for on odd shapes, is determined to maximize the containment pressure and temperature response. Parts A and B of Table 6.2.1-23 present dimension of each passive heat sink and material thermophysical data, respectively.

Each thermal conductor is composed of multiple material layers as appropriate. The containment shell concrete, air gap, steel liner, and painted surfaces are taken into account. The interface resistance between the concrete and the liner plate is conservatively set high by assuming conduction through the air gap and underestimating the heat absorption by the passive heat sinks. In addition, the

heat structure's conduction calculation mesh spacing is set sufficiently small to ensure accurate calculation of the thermal gradient through the structure.

Following a LOCA and a secondary system pipe rupture, the GOTHIC model surfaces in contact with the containment atmosphere are subject to condensation heat. The direct heat transfer option with a diffusion layer model (DLM) heat transfer coefficient is used to calculate the condensation heat transfer. The use of the Direct/DLM option for condensation heat transfer has been accepted by the NRC for peak containment pressure and temperature analysis (Reference 4).

The GOTHIC natural convection option is chosen for wall convection heat transfer on containment passive heat sinks. Radiation heat transfer from the containment atmosphere to the containment structures is conservatively excluded since radiation heat transfer has a negligible impact on the containment pressure response calculation.

Figures 6.2.1-16 through 6.2.1-19 depict the condensing heat transfer coefficients as a function of time for the most severe cold leg, hot leg, and secondary system piping ruptures considered in the analysis.

d. Containment active heat sinks

The APR1400 containment active heat sink comprises the CS nozzles and CS heat exchangers. The GOTHIC model consists of a flow path to transport IRWST water through the CS heat exchanger to the containment building's spray nozzles. The subcooled water is delivered to the containment atmosphere as liquid droplets via a GOTHIC spray nozzle component.

GOTHIC calculates the heat and mass transfer between droplets and vapor using a mechanistic condensation (or evaporation) model. The droplet size is assumed as a Sauter mean diameter of 1,000 μm (0.04 in) from nozzle's design specifications and droplet size sensitivity analyses (Reference 3).

The APR1400 CS heat exchanger is modeled using a GOTHIC heat exchanger component. The CS heat exchanger model uses a design fixed UA value and a

shell side (component cooling water system) flow boundary condition at a conservatively assumed water flow rate and temperature. The CS heat exchanger input data are developed from the design specification sheets of the APR1400 CS heat exchanger and summarized in Table 6.2.1- 21.

6.2.1.1.3.2 Containment Response Analyses to Loss-of-Coolant Accidents

In the event of a LOCA, a large amount of the reactor coolant released to containment flashes to steam and rapidly increases the containment's pressure and temperature. The impact of this M&E release on the containment building is analyzed to provide reasonable assurance that the containment peak pressure remains below its design pressure with acceptable margin.

Typically, the severity of the containment pressure and temperature response is a function of the RCS pipe break size and location. The spectrum of analysed LOCA break sizes and locations used to determine the DBA are summarized in Table 6.2.1-1.

Assumptions and Input Parameters

An inherent assumption in the LOCA containment response analysis is a loss of offsite power (LOOP). A LOOP delays the actuation of the CS system by the time required to start the emergency diesel generator (EDG). Table 6.2.1-22 shows the CS pump actuation data as a function of offsite power availability.

Following the LOCA/LOOP, an EDG single failure is postulated. A LOCA/LOOP with an EDG failure results in minimum SI flow from the loss of a SI train, as well as loss of a CS pump For the maximum SI cases, all of the SI pumps are assumed available with no EDG failure; a CS pump single failure is conservatively assumed to minimize the containment cooling. Subsection 6.2.1.3 addresses the LOCA M&E release with maximum and minimum SI.

The major assumptions for the LOCA containment response analysis are listed below:

a. The blowdown-phase break fluid is uniformly dispersed as droplets and mixes with the containment atmosphere; the droplets reach thermal equilibrium with the

containment atmosphere then fall to the containment floor due to gravitational settling.

b. The IRWST pool surface area is assumed as zero to isolate the relatively cool IRWST water from the containment atmosphere. The interfacial mass and heat transfer is assumed to occur only between the vapor and droplets in the containment and IRWST vapor space.

c. The non-condensable gas in the SI tanks is released directly to the containment atmosphere after the end of blowdown (EOB).

The analysis input parameters are based on plant-specific data and assumptions as described above. A conservative prediction of the containment response to a spectrum of LOCA breaks is assured by considering the upper or lower bounding values of the containment initial conditions, geometric parameters, and thermodynamic properties to yield the maximum containment pressure results. Sensitivity analyses are performed to verify the conservatism of initial values such as pressure, temperature and relative humidity. The initial conditions used on the LOCA containment response analyses are summarized in Table 6.2.1-20. These values are chosen from the upper and lower bounding limits that encompass the limiting conditions for operation (LCO) specified in the Technical Specifications.

Analyses and Results

Containment response analyses to five LOCA events are performed: two cases of a reactor coolant pump (RCP) suction leg piping break with maximum and minimum SI, two cases of the RCP discharge leg piping break with maximum and minimum SI flow, and one case of the hot leg piping break with maximum SI. Containment response analyses are extended up to 1 million seconds to include all the relevant phases of the transient.

As shown in Figures 6.2.1-1 through 6.2.1-5, following the LOCA, the containment pressure and temperature increase at a rapid rate from the large RCS M&E release. The increase in containment pressure triggers a containment pressure high-high signal at approximately 4 seconds (2.5 seconds for hot leg break). The containment pressure

continues to rise until the EOB. An early containment peak pressure occurs near the time of EOB followed by the SI tanks' nitrogen gas release into containment.

The break's M/E release stops at the EOB but returns as the reactor core is recovered with SI water, resulting in a momentary decrease in containment pressure early in the reflood phase. In cold leg breaks, the bulk of the SI water flows through the affected SG rapidly removes the secondary side energy, resulting in increase of pressure and temperature again. After the containment pressure reaches its high-high setpoint, and following a time delay as listed in Table 6.2.1-22, the CS pump starts the supply of subcooled IRWST water to the CS nozzles. For cold leg breaks, the containment pressure reaches an overall peak during this reflood or post-reflood phase.

The residual SG secondary energy gradually decreases until SGs pressure reaches thermal equilibrium with the containment pressure. The continuous CS cooling, along with the decrease in the rate of energy release from the SG secondary side and core decay heat, results in a slow containment pressure decay during the remainder of the post-reflood phase.

The sequence of events for each LOCA case is shown in Part C of Tables 6.2.1-4 through 6.2.1-8. The containment pressure, temperature, and IRWST water temperature response histories are depicted in Figures 6.2.1-1 through 6.2.1-5.

A summary of the containment LOCA response analyses is tabulated in Part A of Table 6.2.1-19. Part A of Table 6.2.1-38 lists the system/component energy distribution prior to the LOCA and subsequent periods such as at the EOB, end-of reflood (EOR), end of post-reflood (EOPR) and at the time of first and second peak pressure.

The installed instrumentation to monitor and record containment atmosphere pressure, temperature, and IRWST water temperature is described in Subsection 7.5.2.

Conclusions

The containment pressure and temperature response to LOCA events are analyzed to determine the relavant APR1400 DBA. The results show that the double-ended discharge leg slot break (DEDLSB) with maximum SI flow is the limiting LOCA case in containment

response analyses. Thus, DEDLSB with maximum SI system capabilities with no EDG single failure is determined as the containment design basis LOCA.

As listed in Table 6.2.1-2, the DBA LOCA calculated peak pressure is 3.59 kg/cm^{2}G (51.09 psig). This limiting peak pressure bounds all the secondary system piping breaks addressed and listed in Part B of Table 6.2.1-19. The calculated LOCA peak temperature is 134.59 °C (274.27 °F).

A containment response analysis following a DBA LOCA is also performed to consider the impact from thermal conductivity degradation (TCD) of the fuel pellets. The containment peak pressure of the TCD analysis is 0.3 psi higher than the case without TCD consideration. The TCD case peak pressure remains below the containment design limit, thus ensuring containment integrity at these conditions. A detailed description of the TCD effects on the containment integrity analysis is provided in Reference 5.

Consistent with the requirements of GDC 15 and 50, it has been demonstrated that the APR1400 containment design pressure provides more than a 10 percent margin (14.8 percent) above the maximum calculated peak pressure. The calculated containment pressure at 24 hours, 1.795 kg/cm^{2}G (25.54 psig), is 42.35 percent of the peak calculated pressure for the limiting LOCA and thus meets the requirements of GDC 38.

Throughout the LOCA, the containment temperature remains at saturated conditions. Per Reference 3, the DBA LOCA peak saturation temperature of 134.59 °C (274.25 °F), which is higher than the maximum calculated surface temperature of all the containment internal structures including liner plate, is less than the containment design temperature of 143.3 °C (290.0 °F).

6.2.1.1.3.3 Analysis of Containment Response to Secondary System Piping Ruptures

This subsection describes the containment response analysis following a postulated main steam line break (MSLB) event. Containment response analyses to various combinations of power level, break size, and break location were performed to determine the limiting MSLB from a containment peak temperature and pressure standpoint. The bases for the selection of break size, power level, and single failure are discussed in Subsection 6.2.1.4 and listed in Table 6.2.1-1.

The MSLB M&E release data used in the containment response calculation are given in Tables 6.2.1-9 through 6.2.1-18. The methodology, computer codes, and assumptions used for the M&E release analysis are presented in Subsection 6.2.1.4. Additional description of the computer code and methodology for MSLB containment response analyses are provided in Reference 3.

Assumptions and Input Parameters

The MSLB M&E release with offsite power available leads to a more severe containment response than those with LOOP conditions. In the APR1400 MSLB containment analysis, offsite power is assumed available to maximize heat transfer to the secondary side of the affected SG. Thus, unlike the LOCA analysis, the MSLB analysis requires no CS initiation time delay for EDG startup; see Table 6.2.1-22.

The major assumptions in the MSLB containment response analysis are as follow:

a. The discharge fluid is superheated steam that instantaneously mixes and reaches thermal equilibrium with the containment atmosphere.

b. The IRWST pool surface area is assumed as zero to isolate the relatively cool IRWST water from the containment atmosphere.

Assumptions for reactor operating conditions, secondary system isolation and single failures are described in Subsection 6.2.1.4.

The MSLB containment response analyses, including inputs and initial conditions, are biased to maximize the containment temperature since the MSLB containment peak pressure is bounded by the DBA LOCA (Reference 3). Sensitivity analyses are performed to verify the conservatism of initial conditions. Table 6.2.1-20 lists the assumed initial conditions for the MSLB containment response analysis.

Analyses and Results

Using the containment model described in Subsection 6.2.1.1.3.1 and the M&E release data described in Subsection 6.2.1.4, a total of 10 MSLB cases covering various power levels

and break sizes are postulated. The MSLB M&E release continues until the operator manually terminates auxiliary feedwater flow to the affected SG. All of the MSLB containment response analyses are executed for 1 million seconds.

Following a MSLB, the containment temperature and pressure rise rapidly due to the large influx of steam from the break. The break flow drops abruptly at approximately 10 seconds into the accident as the intact SG's steam release is terminated by MSIV closure. Once the containment high-high pressure setpoint is reached, the CS pump delivers IRWST subcooled water to the spray nozzles with a 90-second time delay. Liquid droplets from the CS nozzles rapidly condense the steam atmosphere and cool the superheated containment to saturation temperature. Therefore, the containment reaches its peak temperature just prior to CS flow initiation and cools to saturated conditions for the remainder of the transient.

The sequence of events for each analyzed case is shown in Part C of Tables 6.2.1-9 through 6.2.1-18. Containment pressure and temperature transient data are depicted in Figures 6.2.1-6 through 6.2.1-15. The limiting MSLB condensing heat transfer coefficient transient data are shown in Figure 6.2.1-19. The MSLB analysis results are summarized in Part B of Table 6.2.1-19. The MSLB energy inventories and distribution within containment are tabulated in Part B of Table 6.2.1-38.

Conclusions

The containment response to MSLB accidents is analyzed to determine peak temperature and pressure. The results indicate that the limiting MSLB for peak temperature corresponds to a double-ended rupture of the main steam line (break area 0.849 m^2 (9.134 ft^2)) at 102 percent power level concurrent with an MSIV single failure. The calculated maximum containment temperature and pressure for this case are 167.45 °C (333.41 °F) and 3.137 kg/cm^2G (44.62 psig) respectively.

The MSLB containment temperature exceeds the saturation temperature for a period prior to CS actuation, as shown in Figures 6.2.1-6 through 6.2.1-15. However, this superheated condition has an insignificant impact on containment integrity because it lasts less than 2 minutes and the superheated vapor condenses rapidly after coming into contact with the subcooled surface of structures within the containment. Thus, the surface temperature of

the containment exposed structures does not exceed the containment saturation temperature following an MSLB.

The calculated MSLB maximum saturation temperature of 133.59 °C (272.47 °F), used as the reference surface temperature for containment internal structures, is no greater than the containment design temperature of 143.3 °C (290.0 °F).

6.2.1.1.3.4 Failure Modes and Effects Analysis

The failure modes and effects analyses (FMEA) of the SI and the CS systems demonstrate that redundancy of equipment permits at least one system's train to function after either a single active or passive failure.

The most restrictive failure in the containment heat removal system has been determined as a loss of one EDG or one CS pump. The FMEA of the CS system and SI system are listed in Table 6.3.2-2.

6.2.1.1.3.5 Inadvertent Operation of the Containment Heat Removal Systems

Containment systems that may lower the containment pressure to less than the external atmosphere pressure following inadvertent operation include the spray, purge and fan cooler systems. The limiting event for minimum containment pressure design has been determined to be inadvertent actuation of the CS system. In comparison, the pressure reduction effect due to the inadvertent operation of the reactor containment fan cooler (RCFC) units is negligible since its cooling water temperature is higher than the minimum IRWST water temperature assumed in the inadvertent CS actuation.

Consideration is also given to inadvertent operation of the containment normal purging system (i.e., operation of the exhaust train with the supply train isolated), but the maximum feasible internal vacuum for this case is limited to a few inches of water gauge based on the exhaust fan operating curve.

The decrease in containment internal pressure from an inadvertent operation of the CS system with the containment purge valves open is negligible. However, a significant containment pressure reduction can occur following CS system actuation in a sealed

containment with all the purge valves closed. Consequently, the worst-case event for the determination of maximum containment external pressure is the inadvertent operation of the CS system into a sealed containment. The main parameters affecting the resultant external pressure are the containment initial pressure, temperature, and relative humidity as well as the spray water temperature.

The analysis of the maximum containment external pressure as a result of inadvertent spray actuation is based, conservatively, on no heat transfer from the containment structure, no volume reduction due to the addition of spray water, and disregarding all of the heat sources within containment. Dalton's Law is applied to determine the final containment pressure.

The assumed initial conditions for this analysis are listed in Table 6.2.1-24. For conservatism, a minimum initial pressure and maximum initial temperature are assumed to minimize the containment steam and air mass at the start of the transient. A maximum relative humidity decreases the initial ratio of non-condensing gases to steam. Finally, assuming a minimum spray water temperature, which determines the containment atmosphere temperature after spray actuation, produces higher negative pressure. The analysis methodology is described in detail in Reference 3.

Following a limiting containment pressure reduction event, the calculated maximum external pressure of 0.25 kg/cm^2G (3.54 psig) is less than the external design pressure of 0.28 kg/cm^2G(4.0 psig).

In accordance with the requirements of GDC 38 and 50, it has been demonstrated that the APR1400 containment design external pressure provides more than a 10 percent margin (11.43 percent) above the calculated maximum external pressure.

6.2.1.2 Containment Subcompartments

6.2.1.2.1 Design Basis

Subcompartment structures within the containment building are designed to withstand the transient differential pressures loads, jet impingement forces, and pipe whip forces occurring due to a postulated pipe break. Openings are used in over-pressurized

subcompartments to keep the differential pressures below structural design limits. The RCS, reactor vessel, and steam generator inside the containment are designed not to threaten the integrity of the internal structures due to asymmetric dynamic loads by the potential high-energy line break (HELB) transferred through the component support structures. Asymmetric pressure loads due to a HELB are considered in the component supports design.

The characteristics of a postulated HELB in each subcompartment are determined in accordance with the pipe rupture criteria described in Subsection 3.6.2. The accident that results in the maximum differential pressure on subcompartment walls is the subcompartment DBA. The pipe breaks in each subcompartment are shown in Table 6.2.1-25.

The determination of break locations and the dynamic effects associated with the pipe rupture is described in Subsection 3.6.2. If some piping segments are classified as leak-before-break (LBB), it is not necessary to analyze the dynamic effects of a postulated pipe rupture and subcompartment pressurization. The LBB analysis is described in Subsection 3.6.3.

The APR1400 does not consider pipe restraints to limit the break area of postulated HELBs for the containment subcompartments design.

6.2.1.2.2 Design Features

This subsection describes the design features of subcompartment structures related to the analysis model such as the high-energy pipe layout, break location, vent path, and location of major components.

Reactor Cavity

Because the LBB concept is applied to the RCS piping, dynamic effects caused by RCS piping rupture in the reactor cavity do not need to be considered. Hence, no design features for pressure venting are provided. The LBB analysis of the RCS piping is described in Subsection 3.6.3.1.

Steam Generator Subcompartment

The steam generator subcompartment is a reinforced concrete structure that serves to support the enclosed equipment and provide radiation shielding. A steam generator subcompartment is open toward the containment dome and encloses one steam generator, two reactor coolant pumps, other smaller equipment, and high-energy lines including RCS main loop, feedwater economizer, feedwater downcomer, steam generator blowdown line, pressurizer surge line, and main steam line. The subcompartment is symmetrical about the vertical plane that passes the centerline of the reactor vessel and the two steam generators.

DBAs in the steam generator subcompartment are pipe breaks in the economizer nozzle, downcomer nozzle, and blowdown nozzle and are the potential sources of pressurization in the steam generator subcompartment.

Because the LBB concept is applied to the RCS main loop and the pressurizer surge line, the dynamic effects of an RCS main loop break and pressurizer surge line break are not considered. The LBB analysis of the line is described in Subsection 3.6.3.1.

The steam generator subcompartment has four access openings. Two openings are at the bottom floor (El. 100 ft), and the other two are at El. 114 ft and El. 135 ft. The open top and these four openings are assumed to be the vent paths to the containment atmosphere in the steam generator subcompartment analysis.

The horizontal section view of steam generator subcompartment is shown in Figure 6.2.1-21.

Pressurizer Subcompartment

The pressurizer subcompartment is open to the containment dome and is a reinforced concrete structure that serves to support the enclosed equipment and provide radiation shielding. High-energy lines are routed in the subcompartment, such as the pressurizer spray line, pilot-operated safety relief valve (POSRV) discharge lines, and the pressurizer surge line.

DBAs in the pressurizer subcompartment are pipe breaks in the spray nozzle and POSRV discharge line and are the potential sources of pressurization in the pressurizer subcompartment.

Because the LBB concept is applied to the pressurizer surge line, the dynamic effects of a pressurizer surge line break are not considered. The LBB analysis of the surge line is described in Subsection 3.6.3.1.

The pressurizer subcompartment has three vent paths to the containment atmosphere. One opening is the access door at El. 136 ft 8.75 in. The other two openings are the open top and the opening under the pressurizer.

The horizontal section view of the pressurizer subcompartment is shown in Figure 6.2.1-22.

Pressurizer Spray Valve Subcompartment

The pressurizer spray valve subcompartment is a reinforced concrete structure that is sealed except for the access door and one vent opening. The subcompartment encloses and supports pressurizer spray piping and valves and provides radiation shielding against outside exposure. The DBA in the subcompartment is a postulated break in the pressurizer spray piping, which is considered a potential source of pressurization in the pressurizer spray valve subcompartment.

The access door and the vent opening are assumed to be vent paths from this subcompartment to the annulus in the pressurizer spray valve subcompartment analysis.

A plan view of the pressurizer spray valve subcompartment is shown in Figure 6.2.1-23.

Regenerative Heat Exchanger Subcompartment

The regenerative heat exchanger subcompartment is a reinforced concrete structure that is sealed except for the access door. It encloses and supports the heat exchanger and associated piping and provides radiation shielding against outside exposure. The DBA in the subcompartment is a postulated break in the chemical and volume control system

(CVCS) letdown line, and is considered a potential source of pressurization in the regenerative heat exchanger subcompartment.

The sectional view of regenerative heat exchanger subcompartment is shown in Figure 6.2.1-24.

Letdown Heat Exchanger and Valve Subcompartments

The CVCS letdown heat exchanger subcompartment is a reinforced concrete structure that encloses and supports the letdown heat exchanger and associated piping and provides radiation shielding against outside exposure. The DBA in the letdown heat exchanger subcompartment is a postulated break in the CVCS letdown line and is considered a potential source of pressurization in the subcompartment.

The letdown heat exchanger subcompartment has one access door and one vent opening.

The CVCS letdown heat exchanger valve subcompartment is a reinforced concrete structure that encloses and supports the letdown valve and associated piping and provides radiation shielding against outside exposure. The DBA in the letdown heat exchanger valve subcompartment is a postulated break in the CVCS letdown line and is considered a potential source of pressurization in the subcompartment.

The letdown heat exchanger valve subcompartment has one access door and one vent opening.

The plan views of the letdown heat exchanger and valve subcompartments are shown in Figure 6.2.1-25.

6.2.1.2.3 Design Evaluations

The computer program COMPARE-MOD1A (Reference 6) is used to perform the short-term subcompartment pressure transient analysis.

The volume thermodynamics and flow equations are for a homogeneous mixture, assumed to be in thermodynamic equilibrium. One hundred percent of the water entrainment for the

vent flow is assumed by the COMPARE-MOD1A code vent flow modeling. Flows between volumes are based on a one-dimensional solution of the momentum equation that includes an accounting for the effects of inertia. The compressible homogeneous flow model is used for vent critical flow. The sonic or subsonic flow through the vent is determined by the COMPARE-MOD1A code. The code uses the vent critical flow model, which meets Acceptance Criteria 3 of NUREG-0800, Section 6.2.1.2 (Reference 40).

The subcompartment nodalization models are based primarily on the flow-restricting structures or obstacles such as doorways, vent paths, gratings, piping, and major equipment within the subcompartment. The nodes for the subcompartment models are selected so the boundaries of nodes coincide with the positions of obstructions, which can cause significant pressure losses. By choosing the system component and the flow-restricting structures as the modeling boundary, the calculated pressure differences and dynamic loads are maximized for the conservative result. No significant pressure losses are assumed to occur within the nodes compared to the pressure loss at the node boundaries. Nodal model sensitivity studies that include increasing the number of nodes until the differences between the calculated peak pressures are small are conducted to verify the nodalization scheme. The nodal models of the subcompartment for each break case, as described in Subsection 6.2.1.2.2, are shown in Figures 6.2.1-21 through 6.2.1-25. Tables 6.2.1-26 through 6.2.1-30 show the nodal input data of each subcompartment.

The flow path descriptions for the analysis of pressure transients in the subcompartments are given in Tables 6.2.1-31 through 6.2.1-35. Specification of the flow conditions (choked or unchoked) for all vent flow paths up to the time of peak pressure are also shown in these tables.

The initial thermodynamic conditions are selected to maximize the resultant differential pressure. Air at the maximum allowable temperature, minimum absolute pressure, and 0 percent relative humidity are assumed for conservatism. Tables 6.2.1-26 through 6.2.1-31 show the initial conditions of each subcompartment.

Loss coefficients are determined in a conservative manner as follows:

a. The friction loss coefficient is calculated using a friction length, hydraulic diameter, and conservative wall friction factor.

b. The expansion loss coefficient and contraction loss coefficient are conservatively assumed to be 1.0 and 0.5, respectively.

c. The turning loss coefficient is calculated assuming a mitre bend.

Information about high-energy lines within each subcompartment that are assumed to rupture is shown in Table 6.2.1-25.

The conservative time-dependent M&E release data are calculated. For the two-phase fluid, the Moody critical flow model is used (Reference 7). For the subcooled water, the Henry-Fauske critical flow model is used (Reference 8). For the cases that are range from the subcooled water condition to the saturated water or two-phase condition, the larger value between two correlations is selected. These correlations are approved by NRC for the subcompartment analysis. Flow discharge coefficient is conservatively assumed to be 1.0. The M&E release data for the postulated pipe breaks are tabulated in Table 6.2.1-36.

A design margin of 40 percent is considered in the design of the subcompartment structure. Calculated peak differential pressures with the design margin are provided as inputs to the structural design. The pressurizer and steam generator inside containment are designed to avoid threatening the integrity of internal structures from a potential high-energy line break that is transferred to the component support structures and that results in asymmetric dynamics loads. Asymmetric pressure loads are included in the component support design. The time-dependent pressure responses, which are used to evaluate the effects on structures and equipment on representative nodes in the subcompartments, are shown in Figures 6.2.1-26 through 6.2.1-31, and a maximum differential pressure of each node in the subcompartments is provided in Table 6.2.1-26 through 6.2.1-31.

6.2.1.3 Mass and Energy Release Analyses for Postulated Loss-of Coolant Accidents

LOCA M&E release analyses are categorized as the following time periods: blowdown, refill, reflood, post-reflood, and decay heat period.

a. The blowdown period extends from time zero until the primary system depressurizes and equalizes with the containment pressure. During blowdown,

most of the initial primary coolant is released to the containment as a two-phase mixture. Following blowdown, the water for releases is supplied from the safety injection system (SIS).

There is an important distinction between hot leg breaks and cold leg breaks for LOCA post-blowdown analyses. For a hot leg break, the majority of the SIS-supplied water leaving the core can vent directly to the containment without passing through a steam generator. Therefore, there is no mechanism for releasing the steam generator energy to the containment for a hot leg break, and only the blowdown period is considered. For cold leg breaks like discharge leg break and suction leg break, the water passes through a steam generator before reaching the containment so the post blowdown releases to the containment are considered for cold leg breaks.

b. The first post-blowdown period is refill. During refill, the SIS water refills the bottom of the reactor vessel to the bottom of the core. This period is conservatively omitted from the analysis.

c. The second post-blowdown period is the reflood period. During reflood, SIS water floods the core. Reflood is assumed to end when the liquid level in the core is 0.6096 m (2 ft) below the top of the active core. During reflood, a significant amount of the SIS water entering the core is postulated to be carried out of the core by the steaming action of the core-to-coolant heat transfer process. This fluid then passes through a steam generator where reverse (i.e., secondary to primary) heat transfer heats it before it reaches the containment. The residual steam generator secondary energy is sufficient to convert all of this fluid to superheated steam during the initial part of the reflood period. Subsequently, as the steam generators are cooled by this process, there is not enough heat transfer to boil all of the fluid passing through the tubes. This causes the break flow to change from pure steam to two-phase.

As the entire NSSS cools, the flow to the containment becomes eventually subcooled because the safety injection water is subcooled. The onset of the two-phase release to the containment may or may not occur before the end of reflood; typically, this occurs close to the end of the reflood. The potential

release of subcooled fluid to the containment does not occur during reflood when conservative system parameters are used.

d. The third post-blowdown period is the post-reflood period. During this period, the dominant process is the continued cooling of the steam generators by the SIS water leaving the core. The release to the containment during this period becomes generally two phase in the earlier stage of this period as the cooling of the steam generators continues. The post-reflood ends when the affected steam generator reaches the containment temperature.

e. The final post-blowdown period is the decay heat period, which begins at the end of post-reflood. During the decay heat period, the dominant mechanisms for release rates are the generation of the decay heat and the cooling of all NSSS metal. The decay heat period ends when the containment pressure and the environment pressure are essentially equal.

LOCA M&E release is analyzed using the computer codes CEFLASH-4A and FLOOD3 for the categorized time periods. The CEFLASH-4A computer code is used for the analysis of the blowdown period, and the FLOOD3 computer code is used for the analysis of the reflood period. The code descriptions of all significant equations and correlations for the M&E calculations during the blowdown and reflood (or post-reflood) periods of a LOCA are provided in References 9 and 10, respectively.

The containment analysis is performed subsequent to the M&E analysis using the computer code GOTHIC, which calculates containment pressure and temperature during the whole period of LOCA transient. The codes are described in References 2, 11, and 12.

Detailed descriptions of the methodology of a LOCA M&E release, including the methodology of the containment pressure and temperature analysis, are provided in Reference 3.

6.2.1.3.1 Mass and Energy Release Data

The pipe break is assumed to occur at the one of the three locations as follows.

a. Double-ended suction leg slot break (DESLSB) in the suction leg of the RCP

b. Double-ended discharge leg slot break (DEDLSB) in the discharge leg of the RCP

c. Double-ended hot leg slot break (DEHLSB) in the hot leg of the RCS

The break type is assumed to be a slot break that has the break area equivalent to the double-ended break. The largest break area (i.e., double-ended break area) is limiting in a large break LOCA.

M&E release data for the suction leg, discharge leg, and hot leg break cases are given in Part A of Tables 6.2.1-4 through 6.2.1-8. For cold leg breaks (pump suction and discharge), some of the post-blowdown SIS water is postulated to spill directly to the containment floor whenever the reactor vessel annulus is full. The vessel spillage data associated with these breaks are also given in Part A of Tables 6.2.1-4 through 6.2.1-8.

6.2.1.3.2 Energy Sources

The following sources of generated and stored energy in the RCS and secondary coolant system are considered:

a. Primary coolant

b. Secondary coolant

c. Primary walls (including reactor internals)

d. Secondary walls

e. Safety injection water

f. Core power

g. Decay heat

For the conservative analysis, the assumptions about the energy sources are biased to maximize the stored energy.

For considering the stored energy in the coolant, the initial RCS water volumes are conservatively calculated based on the maximum manufacturing tolerances of the reactor vessel and steam generator tubes. Volume expansion of the loop components from cold to hot operating conditions is also considered for the primary and secondary coolant stored energy. The initial water volume in the pressurizer includes an allowance for level instrumentation error. This makes the maximized pressurizer water volume, which includes the maximized stored energy.

For considering the stored energy in the primary and secondary walls, the large specific heat and heat conductivity of carbon steel are conservatively assumed for all of the walls in the RCS.

The core stored energy may be increased slightly by thermal conductivity degradation (TCD). However, the effect of TCD on the M&E release is negligible. The results are described in Reference 5.

For considering the energy in the safety injection water, the liquid break flow is assumed to be mixed with the water in IRWST. The mixed water is taken and discharged into the direct vessel injection (DVI) by SI pumps, which increases the energy in the safety injection water.

The initial power level assumed in the analyses consists of the core power and an additional RCP power. The initial core power is assumed to be 102 percent, which includes the instrumentation error. The higher power level is conservative for LOCA containment pressure calculations.

For the core decay heat curve as a fraction of the initial power level following the accident, a 20 percent conservatism factor is used for the first 1,000 seconds, followed by a 10 percent factor. The normalized decay heat curve is shown in Figure 6.2.1-32.

Initial conditions in the reactor coolant system are given in Table 6.2.1-20. It shows various stored energies in the RCS and containment at the initial time. A tabulation of

sources and amounts of stored energy is given in Table 6.2.1-38. The items of energy sources are broken down into the detail specific sources.

6.2.1.3.3 Description of Blowdown Model

Blowdown M&E release rates are calculated using the CEFLASH-4A computer code. A description of the CEFLASH-4A code, including the conservatisms in modeling, is given below. This section includes the justification of the heat transfer correlations. The following assumptions are used in selecting input data for the code. Detailed descriptions of the assumptions of blowdown model are provided in Reference 3.

a. The CEFLASH-4A code model of the heat transfer in a node allows only one wall per node.

b. The wall representation in CEFLASH-4A is based on the total heat capacitance of all the RCS walls for effective heat transfer.

c. The conservative conductivity of carbon steel rather than that of stainless steel is used for the entire wall.

d. Wall surface heat transfer coefficients are assumed to be infinite.

e. All primary water volumes are conservatively increased by including water level instrumentation error, pressure and temperature expansion of volume.

f. Two-phase heat transfer correlation (Jens Lottes) is used for the core-to-coolant heat transfer whenever the flow through the core is not pure steam.

g. Heat transfer across the steam generator tubes is modeled with the same heat transfer coefficient in both the forward and reverse directions.

h. The turbine stop valves are assumed to close at 0.01 second. This is conservative because it keeps energy within the NSSS, which is a source of energy for containment pressurization.

i. The main feedwater isolation valves (MFIVs) are assumed to be closed only after the generation of a main steam isolation signal (MSIS), which occurs very rapidly. As an additional conservatism, the feedwater is assumed to be added at the end of the blowdown so that the steam generator secondary temperatures are not lowered by the relatively cold feedwater.

j. Auxiliary feedwater flow is conservatively omitted because its temperature (4 °C (40 °F) to 49 °C (120 °F)) is cold relative to both blowdown and reflood conditions.

6.2.1.3.4 Description of Core Reflood Model

Reflood M&E release rates are calculated using the FLOOD3 computer code. Heat transfer is conservatively modeled for core, vessel walls, vessel internals, loop metal, steam generator tubes, steam generator secondary, and steam generator secondary walls. The conservatisms in the model are as follows. Detail descriptions of the assumptions of reflood model are provided in Reference 3.

a. The containment back pressure during reflood is assumed to be constant for the input of FLOOD3 code.

b. A one-dimensional heat transfer model is used for all wall-heat transfer calculations. This is demonstrated in Reference 13 where comparisons of one-dimensional models and otherwise identical two-dimensional models show that one-dimensional modeling is more conservative.

c. A nucleate boiling heat transfer coefficient is used to model the heat transfer from the steam generator tubes to the primary coolant. This coefficient represents an upper limit and is conservatively used at all times throughout the tubes.

d. For the reflood, a conservative Nusselt condensation heat transfer coefficient is used in conjunction with the tube area for high heat transfer.

e. The thermal resistance corresponding to the steam generator tubes is 0.000077 $(kcal/m^2\text{-}hr\text{-}°C)^{-1}$ (0.000376 $(Btu/hr\text{-}ft^2\text{-}°F)^{-1}$). This value is also used in calculating secondary-to-primary heat transfer.

f. The carryout rate fraction (CRF) used during the reflood is based on the guideline in NUREG-0800, Section 6.2.1.3 (Reference 14).

g. Reflood is assumed to terminate when the 3.2 m (10.5 ft) quench level in the core is reached.

h. As conservatism for the available energy sources, 120 percent of the standard decay heat curve in Figure 6.2.1-32 is used up to 1,000 seconds, and 110 percent is used after 1,000 seconds.

i. For the suction leg and discharge leg cases, credit is taken for the condensation of approximately 42 percent of the total steam flow when the annulus is full and the high safety injection tank (SIT) flow is injected. No credit is taken for the condensation after the SITs empty or the turndown to low SIT flow by the fluidic device.

6.2.1.3.5 Description of Post Reflood Model

The post-reflood model is identical to the reflood model except that at the end of the reflood, the CRF is changed from 0.8 to 1.0. The change conservatively increases the system flow rates due to the increased CRF. The flow rates are further enhanced by the fact that the core liquid height is now constrained at the 3.2 m (10.5 ft) level, which maximizes the available driving head between the annulus level and the core in the flooding equation. All of the heat transfer coefficients are kept at the values used for the reflood analysis. Condensation is analyzed as previously described; however, there is insufficient spillage for complete thermodynamic condensation of the steam so that credit for condensation is not taken.

6.2.1.3.6 Description of Decay Heat Phase Model

The final phase of the large break LOCA is a relatively stable period characterized by decay heat release. This period extends from the EOPR and the M&E release rate is calculated based on the thermal conditions from the EOPR for the cold leg breaks or the EOB for the hot leg break.

LOCA M&E are released to the containment using a flow boundary condition in the GOTHIC containment model until the EOPR (or EOB for hot leg break). Thereafter, GOTHIC directly calculates the break flow from the RCS until the end of transient.

The constituent energy sources that are considered in the decay heat phase are as follows:

a. Core decay heat

b. RCS and SGs fluid stored energy

c. RCS and SGs metal sensible energy

The M&E release rates during the decay heat phase for all of the analyses cases are presented in Tables 6.2.1-4 through 6.2.1-8. The detailed description of the analysis methods used for M&E release calculation during the decay heat phase is provided in Reference 3.

6.2.1.3.7 Single Active Failure Analysis

Two potential failures are considered as a single failure in the LOCA M&E analysis: the failure of one SI pump or the failure of one EDG. The potential failures result in a decrease in the safety injection flow and eventually degrade the emergency core cooling system (ECCS) performance to cool down the core. In the LOCA mass and energy analysis, the single failure is assumed for the minimum safety injection flow and no failure is assumed for the maximum safety injection flow.

Another failure in containment system is considered as single failure, the failure of one train of containment spray. The failure reduces the capability to suppress the containment

pressure, which results in higher containment pressure during the LOCA transient. In the case with maximum safety injection, the failure of one train of CS system is assumed. In the case with minimum safety injection, the failure of one train of CS system is assumed too due to the failure of one EDG.

The limiting case is determined by the case analyses with the maximum and minimum safety injection flow. This case analysis with the maximum and minimum safety injection flow is performed at the three break locations.

The cases presented in Tables 6.2.1-4 through 6.2.1-7 show the mass/energy source terms with maximum safety injection (no pump failure or no power source failure) and minimum safety injection (failure of one emergency diesel generator). In the case with maximum safety injection, the failure of one train of CS system is assumed. In the case with minimum safety injection, the failure of one train of CS system is assumed due to the failure of one emergency diesel generator. Because the peak containment pressure is a function of both the release rates and the containment parameters, the various types of single failure are estimated to determine the limiting single failure for the analysis.

6.2.1.3.8 Metal-Water Reaction

According to 10 CFR Part 50, Appendix K, the additional source energy from the metal-water reaction should be considered in the LOCA M&E analysis. A bounding calculation, not dependent on the Appendix K metal-water correlation, assumes the maximum allowable 1 percent zirconium water reaction. The 1 percent metal-water reaction produces 0.351 x 10^6 kcal (1.3933 x 10^6 Btu). This energy is less than 0.6 percent of the total amount of energy released up to the time of peak containment pressure during the limiting LOCA. This metal-water reaction energy makes the increase of 0.24 percent of the containment peak pressure. Even if this bounding metal-water reaction is assumed to occur, the metal-water reaction energy will have little effect on the containment pressures. The quantitative results of the metal-water reaction analysis are provided in Reference 3.

The maximum fuel clad temperature is only 808.2 ^{o}C (1,486.7 ^{o}F) during the limiting LOCA transient. This fuel clad temperature is not high enough to enable the metal-water reaction to occur in this analysis. Therefore, the metal-water energy is not included in the mass/energy source terms in Tables 6.2.1-4 through 6.2.1-8.

6.2.1.3.9 Energy Inventories

The energies in the RCS system and containment system are redistributed as a LOCA proceeds. The distributions of the stored energy for the LOCA cases listed in Table 6.2.1-1 are provided in Table 6.2.1-38.

6.2.1.3.10 Additional Information Required for Confirmatory Analysis

Reactor vessel pressure versus time for the LOCA cases listed in Table 6.2.1-1 are given in Part B of Tables 6.2.1-4 through 6.2.1-8. The chronology of events for the LOCA cases listed in Tables 6.2.1-1 is also given in Part D of Tables 6.2.1-4 through 6.2.1-8. The primary side resistance factors for the FLOOD3 code are shown in Table 6.2.1-39. Curves of safety injection flow versus time are provided in Part C of Tables 6.2.1-4 through 6.2.1-8 and Figures 6.2.1-33 through 6.2.1-36.

6.2.1.4 Mass and Energy Release Analysis for Postulated Secondary System Pipe Ruptures Inside Containment

Following a postulated MSLB or a main feedwater line break (MFLB) inside the containment, the contents of one steam generator (affected) is released to the containment. Most of the contents of the other steam generator (unaffected) are isolated by the MSIV and the MFIV. Containment pressurization following a secondary side rupture depends on how much of the break fluid enters the containment atmosphere as steam. MSLB flow is pure steam or two-phase. MFLB flow is two-phase. With a pure steam blowdown, all of the break flow enters the containment atmosphere. With a two-phase blowdown, part of the liquid in the break flow boils off in the containment and is also added to the atmosphere, while the rest falls to the sump and contributes nothing to containment pressurization. For MSLBs with large break areas, steam cannot escape fast enough from the two-phase region of the affected steam generator, and the two-phase level rises rapidly to the steam line nozzle, resulting in a two-phase blowdown. The duration of this blowdown is short; therefore, little primary-to-secondary heat transfer takes place and the break flow is largely liquid.

For MSLBs with small break areas, steam can escape fast enough from the two-phase region of the affected steam generator so that the level swell does not reach the steam line

nozzle, resulting in a pure steam blowdown. The highest peak containment pressure resulting from an MSLB for a given set of initial steam generator conditions occurs when the break area is maximum at which a pure steam blowdown can occur since entrainment model is not assumed.

The potential for steam generator two-phase level swell following an MSLB increases as power level decreases; therefore, a spectrum of power levels is analyzed to determine which one results in the peak MSLB containment pressure.

The feedwater distribution box is below the steam generator water level; therefore, MFLB cases result in a two-phase blowdown and do not produce peak containment pressures as severe as MSLBs.

To determine the effect of an MSLB on the containment pressure, analyses are performed with SGN-III (described in Appendix 6B of Reference 15) at 102, 75, 50, 20, and 0 percent power. The largest breaks at which a pure steam blowdown can occur are determined. The breaks are conservatively assumed to be at the nozzle of one of the steam generators. The cases analyzed are listed in Table 6.2.1-1.

The APR1400 design has integral flow restrictors in the nozzles of the steam generators. Credit for the flow restrictors is taken in the analysis.

During MSLB events, the MSIS of the engineered safety feature actuation system (ESFAS) closes the MSIVs and the MFIVs. MSIS is generated either by a steam generator low pressure signal or a containment high pressure signal. The MSIVs close in 5.0 seconds, and the MFIVs close in 10.0 seconds. The valve closures are considered in the analysis.

The auxiliary feedwater system is actuated automatically during an MSLB to provide reasonable assurance that a heat sink is always available to the RCS by supplying cold feedwater to maintain an adequate water inventory in the unaffected steam generator. However, no credit is taken for auxiliary feedwater flow to the unaffected steam generator in the MSLB analysis for conservatism.

The total volume of fluid for two steam lines between the MSIVs and a steam generator is assumed to be the maximum in the analysis. The total volume of fluid between the MSIVs and the turbine stop valves is also assumed to be the maximum in the analysis.

There are two MFIVs in each feedwater line. The total volume of fluid between the upstream MFIV and each steam generator is assumed to be the maximum. The flashing of this fluid into the affected steam generator and then into the containment is considered in the analysis. These assumed volumes conservatively exceed the actual design values of the APR1400 volumes.

The sources of energy considered in the MSLB analysis include the stored energy in the (1) affected steam generator's metal, including the steam generator tube, (2) water in the affected steam generator, (3) feedwater transferred to the affected steam generator before the closure of the MFIV, and (4) steam from the unaffected steam generator before the closure of the MSIV. The energy sources that are considered also include the energy transferred from the primary coolant to the water in the affected steam generator during blowdown.

6.2.1.4.1 Mass and Energy Release Data

Mass and energy release data for the MSLB cases listed in Table 6.2.1-1 are given in Tables 6.2.1-9 through 6.2.1-18.

6.2.1.4.2 Single Failure Analysis

Non-class 1E electric power is conservatively assumed to be available because it allows the continuation of reactor coolant pump operation, which maximizes the rate of heat transfer to the affected steam generator, which maximizes the rate of an M&E release. With the availability of Non-class 1E electric power, a postulated diesel generator failure is unnecessary.

There is an MSIV in each main steam line. The MSIVs are designed to close based on a conservative calculation that maximizes the dynamic pressure loading on the valve for all possible flow rates and qualities. Each valve has dual control circuits to provide reasonable assurance of closure even with a single failure in the control system. Each

valve is tested periodically. A single failure in the actuation signal does not prevent valve closure because both trains of MSIS actuation are provided to each MSIV. Any failure would result in the valve going to the closed position so that no additional steam could be added to the containment. Therefore, the failure of an MSIV is not considered a credible event. However, MSIV failure events for MSLB mass and energy analysis are considered.

There are two MFIVs in series in each main feedwater line. If one MFIV fails, the second MFIV provides isolation. All cases analyzed consider the flashing of the fluid in the lines from the upstream MFIVs to the affected steam generator. Therefore, a separate analysis assuming MFIV failure is not needed.

The MSLB data in Tables 6.2.1-9, 6.2.1-11, 6.2.1-13, 6.2.1-15, and 6.2.1-17 are based on a loss of one CSS train. The data in Tables 6.2.1-10, 6.2.1-12, 6.2.1-14, 6.2.1-16, and 6.2.1-18 are based on an MSIV failure.

6.2.1.4.3 Initial Conditions

RCS parameters for a nominal core power of 3,983 MWt are given in Table 6.2.1-20. The steam generator pressure varies from 71.71 kg/cm^{2}A (1,020 psia) (nominal full load) to 77.33 kg/cm^{2}A (1,100 psia) (zero core power). The initial steam generator inventory is calculated assuming manufacturing tolerances, which maximize the initial inventory. The increase in the initial inventory resulting from thermal expansion of the steam generator is included.

6.2.1.4.4 Description of Blowdown Model

The SGN-III digital computer code described in Appendix 6B of Reference 15 is used for the secondary system pipe break analysis. All significant equations, including those for the calculation of primary-to-secondary, core-to-coolant, and metal-to-coolant heat transfer and for the calculation of steam separation and moisture carryover are discussed in Appendix 6B of Reference 15. Experimental justification for all heat transfer coefficients, steam separation velocities, and two-phase flow correlations is provided in Appendix 6B of Reference 15.

Steam line capacity is modeled by performing mass, energy, and volume balances on a steam line node. Figure 6.2.1-37 shows the flow paths into and out of the steam line node. The mass, energy, and volume balances for the steam line node are as follows:

$$\dot{M} = \sum \dot{m}$$

$$\dot{E} = \sum \dot{m}\, h$$

$$\dot{V} = 0$$

Where:

$\sum \dot{m} = \dot{m}_1 + \dot{m}_2 + \dot{m}_4 - \dot{m}_B - \dot{m}_T$ for slot breaks

$\sum \dot{m} = \dot{m}_1 + \dot{m}_2 - \dot{m}_T - \dot{m}_{B2}$ for guillotine breaks (see Figure 6.2.1-37 for subscript definition)

The break flow rate is obtained from the Moody critical flow model for zero flow resistance according to NUREG-0800, Section 6.2.1.4.

The contribution to the containment pressure of the feedwater flow is handled by a feedwater flow addition to the affected steam generator and the boiling off of the feedwater by a primary-to-secondary heat transfer. The feedwater flow is the sum of the pumped feedwater flow before isolation plus the expansion of the fluid in the feedwater line between the affected steam generator and its MFIV. The feedwater flow pumped to the affected steam generator is conservatively modeled as 165 percent of the full-power feedwater flow for the 102 percent and 75 percent power cases, 110 percent of the full-power feedwater for the 50 percent power case, and 55 percent of the full-power feedwater for the 20 percent and 0 percent power cases to account for spiking. No degradation of the feedwater flow occurs until the closure of the MFIVs. For consistency, no feedwater is added to the unaffected steam generator.

Following closure of the MFIVs, there is an inventory of feedwater between the MFIVs and the affected steam generator. As the affected steam generator depressurizes, this inventory starts to boil. As steam in the line expands, this feedwater inventory is pushed into the steam generator and is boiled off by primary-to-secondary heat transfer. The expansion of the feedwater inventory into the affected steam generator is considered in the analysis. The expansion is assumed to be isentropic.

The isentropic expansion of the feedwater downstream of the MFIV is determined in SGN-III. As the affected steam generator depressurizes, the feedwater expands. At first, the feedwater is subcooled, and the fluid that expands into the affected steam generator is pure liquid. Once the steam generator pressure drops below the saturation pressure of the feedwater, flashing starts to occur and the fluid that expands into the steam generator is two-phase. The equations for each phase of the isentropic expansion process are given below:

Subcooled:

$$s_l\ (P_{SG},\ T) = s_o$$

$$M_l\, v_l\ (P_{SG},\ T) = V$$

$$\dot{m} = \frac{(M_l)_t - (M_l)_{t-\Delta t}}{\Delta t}$$

$$\dot{m}h = \dot{m}h_1(P_{SG},\ T)$$

Saturated:

$$M_f\ v_f\ (P_{SG}) + M_g\ v_g\ (P_{SG}) = V$$

$$\frac{M_f s_f(P_{SG}) + M_g s_g(P_{SG})}{M_f + M_g} = s_o$$

$$\dot{m} = \frac{(M_f + M_g)_t - (M_f + M_g)_{t-\Delta t}}{\Delta t}$$

$$\dot{m}\,h = \dot{m}\,\frac{M_f h_f\,(P_{SG}) - M_g hg_f\,(P_{SG})}{M_f + M_g}$$

Symbols:

M	=	feedwater mass, lbm
V	=	volume of feedwater downstream of MFIV, ft^3
P_{SG}	=	pressure of affected SG, psia
T	=	feedwater temperature, °F
h	=	specific enthalpy, Btu/lbm
v	=	specific volume, ft^3/lbm

s = specific entropy, Btu/lbm-°F

$\dot{m}$ = feedwater flow rate from isentropic expansion, lbm/sec

$\dot{m}h$ = feedwater enthalpy rate from isentropic expansion, Btu/sec

t = time, seconds

Δt = time step, seconds

Subscripts:

l = subcooled liquid

f = saturated liquid

g = saturated steam

0 = initial

The MSLB mass and energy data given in Tables 6.2.1-9 through 6.2.1-18 represent the total release to the containment. The mass and energy contributions from the steam lines and feedwater lines are included in Tables 6.2.1-9 through 6.2.1-18. In addition, up to 30 minutes before auxiliary feedwater isolation to the affected steam generator following the MSLB, a constant 3,596 L/min (950 gpm) auxiliary flow to the affected steam generator is assumed and is included in Tables 6.2.1-9 through 6.2.1-18.

6.2.1.4.5 Energy Inventories

Energy balances for MSLB cases listed in Table 6.2.1-1 are provided in Table 6.2.1-38.

6.2.1.4.6 Additional Information Required for Confirmatory Analyses

The flow area of the main steam lines is 0.418 m^2 (4.493 ft^2). For the MSLB analysis, the postulated rupture is assumed to occur at the nozzle of one of the steam generators. Therefore, the flow friction coefficient (fL/D) from the affected steam generator to the break is zero. In the MSLB analysis, the fL/D from the unaffected steam generator to the

break is conservatively assumed to be 10 because the actual fL/D in the APR1400 design is greater than 10. The flow restrictor area is 0.119 m^2 (1.28 ft^2).

Pressure values in the affected and unaffected steam generators for each MSLB case listed in Table 6.2.1-1 are given in Tables 6.2.1-9 through 6.2.1-18.

The chronologies of events for the MSLB cases listed in Table 6.2.1-1 are given in Tables 6.2.1-9 through 6.2.1-18.

Feedwater flow to the affected steam generator for each MSLB case listed in Table 6.2.1-1 is shown in Figures 6.2.1-38 through 6.2.1-47.

6.2.1.5 Minimum Containment Pressure Analysis for Performance Capability Studies of the Emergency Core Cooling System

This subsection presents the analysis on the minimum containment pressure that is used in the ECCS performance analysis, which is presented in Subsection 15.6.5.

6.2.1.5.1 Analytical Models

The calculations reported in this subsection are performed using the realistic evaluation methodology for large break LOCA of the APR1400 described in Reference 16 and are in accordance with NRC RG 1.157 (Reference 17). In the code-accuracy-based realistic evaluation method (CAREM), the RELAP5/MOD3.3/K computer program, a modified version of RELAP5/MOD3.3 (Reference 18), is used for the analysis of the ECCS thermal-hydraulic transient calculation and the cladding temperature calculation. A part of the RELAP/MOD3.3 code's reflood model has been modified to improve the prediction of rods quenching time and to correct coding errors. The minimum containment back pressure and temperature calculations are performed using the CONTEMPT4/MOD5 code (Reference 19).

RELAP5/MOD3.3 is one of the best-estimate safety analysis codes to date. The code has been widely applied in the analysis of system transients of pressurized water reactors, including a postulated large break loss of coolant accident (LBLOCA). The film boiling

heat transfer model of the reflood package of RELAP5/MOD3.3 has been modified based on independent assessment calculations against the FLECHT-SEASET data.

Containment back pressure depends on mass and energy release rates, and thermal-hydraulic phenomena depend on the containment back pressure. CONTEMPT4/MOD5 is a containment analysis code that is used especially for calculating containment back pressures in case of a LOCA. It includes fan and spray cooling system models and passive heat sink models that are essential for the calculation of the containment back pressures following a LOCA. It is equipped with the conservation equations of mass, momentum, and energy and can calculate the mass and energy transfer due to the pressure difference between compartments. It also includes state equation of non-condensable gas and can calculate humidity. Heat conduction can be modeled with diverse boundary heat transfer conditions.

RELAP5/MOD3.3 and CONTEMPT4/MOD5 are merged to exchange the containment back pressure calculated by the CONTEMPT4 and the mass and energy release rate calculated by the RELAP5 in every time step.

6.2.1.5.2 Mass and Energy Release Data

The mass and energy released to the containment for a limiting LBLOCA, 100 percent double-ended guillotine break at the pump discharge leg (1.0 × DEG/PD), are listed as a function of time in Table 6.2.1-40. The quantity of safety injection fluid that spills from the break is described in Subsection 6.2.1.5.6. The analytical models applied in Subsection 15.6.5 best estimate analysis calculate the mass and energy released to the containment. This results are used to the calculation of minimum containment pressure.

6.2.1.5.3 Initial Containment Internal Conditions

The minimum containment temperature, minimum containment pressure, and maximum humidity encountered under limiting normal operating conditions are used for the analysis. The initial containment internal conditions that are used in the analysis are as follows:

Containment temperature	10 °C (50 °F) (minimum value)
Containment IRWST water temperature	10 °C (50 °F) (minimum value)

Containment pressure	1.024 kg/cm^{2}A (14.56 psia) (minimum value)
Relative humidity	90 percent (maximum value)

Each condition is a specified conservative value to minimize the containment pressure, consistent with Branch Technical Position 6-2 (Reference 20).

6.2.1.5.4 Containment Volume

The maximum net free containment volume that is used for the analysis is 101,516 m^3 (3,585,000 ft^3). The maximum net free volume is determined from the gross containment volume minus the volumes of internal structures such as walls and floors, structural steel, major equipment, and piping with a consideration of uncertainty.

6.2.1.5.5 Active Heat Sinks

In order to conservatively consider the heat removal capacity of the containment active heat sinks, the containment sprays and cooling fans are modeled to actuate immediately with the maximum capacity at the time of the postulated LOCA.

The containment atmosphere cooling systems designed as the non-safety-related system are also modeled to actuate immediately at the time of the postulated LOCA. In addition, the minimum temperature of the stored water for the spray cooling system and the cooling water supplied to the fan coolers, based on technical specification limits, are assumed.

The operating parameters for the containment sprays that are used in the analysis are as follows:

Flow rate (total, 4 pumps)	75,706 L/min (20,000 gpm)
Temperature	10.0 °C (50 °F)

The heat removal capacity of reactor containment fan cooler (RCFC) is shown in Figure 6.2.1-48.

6.2.1.5.6 Steam-Water Mixing

The spillage of subcooled ECCS water into the containment provides an additional heat sink as the subcooled ECCS water mixes with the steam in the containment by the steam-water mixing. The spilled SIS water from the broken cold leg is determined by the thermal-hydraulic behavior of the core cooling system. It is considered in the analysis model of CONTEMPT4/MOD5.

6.2.1.5.7 Passive Heat Sinks

The passive heat sinks included in the containment evaluation model are established by identifying structures and components within the containment that are influenced the pressure response. The surface areas and thicknesses of all exposed containment passive heat sink, as well as the thermal properties used for the passive heat sinks, are listed in Table 6.2.1-23. The passive heat sink data are conservatively assumed with minimum paint thickness and maximum structure thickness. Containment air wall is not considered, conservatively.

6.2.1.5.8 Heat Transfer to Passive Heat Sinks

The conservative condensing heat transfer coefficients for heat transfer to the exposed passive heat sinks during the blowdown and post-blowdown phases of the LOCA are applied. The variations in the condensing heat transfer coefficients between the containment atmosphere and the passive heat sinks are calculated as a function of time and are shown quantitatively in Figure 6.2.1-49. The condensation heat transfer coefficient at the surface of thermal structure is calculated by using Tagami and Uchida correlations shown as below:

$$h_{TAGAMI} = 0.607 \times \left(\frac{U}{V \times tp} \right)^{0.62} \text{ in SI unit}$$

Where

U = Total released energy from the primary system during the blowdown period

V = Free volume in the containment

tp = time at the end of blowdown

The heat transfer coefficient during the blowdown period increases linearly from the initial values to a peak value h_{max} and decreases exponentially as shown below. The Uchida heat transfer coefficient is given as the mass ratio function of air and steam:

$$h = h_{stag} + (h_{\max} - h_{stag})e^{-0.025(t-t_p)}$$

$$h_{stag} = 1.2\ h_{UCHIDA}$$

Where

$h_{\max}$ = Four times of calculated condensing heat transfer coefficient at the end of blowdown

6.2.1.5.9 Other Parameters

The minimum containment pressure analysis assumes that the 20.3 cm (8 in) diameter purge system is operating from the time of the LOCA initiation until the isolation valves close, which is after a containment isolation actuation signal. It is conservatively assumed that only dry air is purged from the containment and the maximum mass of air purged is 272.2 kg (600 lbs) for the minimum containment pressure analysis.

6.2.1.5.10 Results

For the limiting large break LOCA, 100 percent double-ended guillotine break at the pump discharge leg, the minimum containment pressure response to be used in the ECCS performance analysis is shown in Figure 6.2.1-50. The responses of the containment atmosphere and IRWST temperatures are shown in Figures 6.2.1-51 and 6.2.1-52, respectively.

The transient containment response is used in the ECCS performance analysis presented in Subsection 15.6.5.

6.2.1.6 Test and Inspections

This section describes the preoperational testing, in-service testing, and inspection of the containment. The primary objective of testing and inspection is to verify the structural integrity and leak-tight integrity of the containment. The testing and inspection requirements for the containment are described in Subsections 3.8.1.7, 3.8.2.7, 6.2.4, and 6.2.6. Section 14.2, the initial test program, also includes preoperational testing requirements.

Requirements for the structural integrity test are described in Subsection 14.2.12.1.119. The structural integrity test is performed in accordance with ASME Section III, Division 2, CC-6000, to verify the structural integrity of the containment including the liner, concrete structures, all electrical and piping penetrations, equipment hatch, personnel airlocks, and post-tensioning. The pressure will be brought up to 115 percent of the containment design pressure in approximately five or more equal increments. In addition, all ASME Class MC components are tested for their structural acceptance and leak rate at the same time of the structural integrity test. The in-service testing and inspection requirements and methods used for the ASME Class MC components and structural integrity test is described in Subsections 3.8.1.7 and 3.8.2.7.

Subsection 6.2.4.4 describes the testing and inspection requirements for containment leakage testing. The containment leakage testing to verify leak-tight integrity of the containment conforms with 10 CFR Part 50, Appendix J, and Option B and follows the guidance of NRC RG 1.163 (Reference 21). The containment leakage testing includes containment integrated leak-rate test, fuel transfer tube leak-rate test, equipment hatch leak-rate test, personnel airlock leak-rate test, electrical penetration leak-rate test, and containment isolation valves leak-rate test. Requirements for the containment leakage testing during the preoperational test period are described in Subsections 14.2.12.1.119 through 14.2.12.1.124. Furthermore, Subsection 6.2.6 describes detailed in-service testing and inspection requirements and methods used for the containment leakage testing.

6.2.1.7 Instrumentation

Instruments provide the continuous indication of containment environment to the control room operators during normal and accident conditions. Instruments are installed to monitor conditions inside the containment and actuate the appropriate safety functions

when an abnormal condition is sensed. Instruments monitor containment pressure, containment water level, and IRWST hydrogen concentration, and containment temperature.

The containment pressure is measured by multiple pressure transmitters located outside the containment. Section 7.3 addresses pressure as an input to the ESFAS. Section 7.5 addresses the safety-related display instrumentation associated with pressure.

One instrument for continuous indication of containment water level is provided in the MCR. Level instruments monitor the water level during normal operation and accident conditions.

One temperature sensor is installed to monitor the IRWST water temperature. The IRWST temperature is indicated and alarmed in the MCR.

The containment airborne radioactivity is monitored by the airborne radioactivity monitoring system. Hydrogen concentration is monitored in the containment by the hydrogen monitoring system. The temperature of the containment is measured by a temperature sensor located inside the containment and displayed in the MCR. The temperature is displayed in the MCR along with high-temperature alarms.

Section 7.3 addresses the instrumentation and controls, including the power supplies, the actuation logic, and the resulting system/component initiation signals, used for the ESFAS actions.

6.2.2 Containment Heat Removal Systems

The CSS is designed to reduce containment pressure and temperature from an MSLB or a LOCA and to remove fission products from the containment atmosphere following a LOCA. The CSS is also designed to provide safety capacity of long-term heat removal following an accident. The fission product removal function is described in Subsection 6.5.2.

The CSS consists of two 100 percent capacity divisions. Each division includes a containment spray pump (CSP), CSHX, containment spray mini-flow heat exchanger, containment spray header, and associated valves.

6.2.2.1 Design Bases

The major functions of the CSS are containment heat removal and fission product removal. The redundant safety-related equipment of the CSS provides these functions considering a single failure.

The heat removal capacity of the CSS is sufficient to prevent exceeding containment design pressure and temperature, and to reduce containment pressure to at least one-half the calculated peak pressure in 24 hours after a LOCA or MSLB.

The mass and energy release rates inside the containment following a LOCA and MSLB are described in Subsections 6.2.1.3 and 6.2.1.4, respectively.

6.2.2.1.1 Compliance with Regulatory Requirements

The CSS design conforms with the following regulatory requirements:

a. GDC 2, “Design Bases for Protection against Natural Phenomena”

b. GDC 4, “Environmental and Dynamic Effects Design Bases”

c. GDC 5, “Sharing of Structures, Systems, and Components”

d. GDC 17, “Electric Power Systems”

e. GDC 38, “Containment Heat Removal”

f. GDC 39, “Inspection of Containment Heat Removal System”

g. GDC 40, “Testing of Containment Heat Removal System”

Compliance with these GDC is described in Section 3.1.

6.2.2.1.2 Reliability Design Bases

The CSS is automatically actuated on the receipt of the containment spray actuation signal (CSAS). The active components of the CSS are normally powered from separate Class 1E buses, which can be energized from the EDG. Each emergency power source is capable of driving all components and instruments associated with one division of the CSS. The onsite Class 1E emergency electric power suppliers are described in Chapter 8.

The CSS is seismic Category I and designed to remain functional in the event of a safe shutdown earthquake (SSE). The CSS is designed with sufficient redundancy to provide reasonable assurance of reliable system operation, assuming a single component failure coincident with a DBA, as shown in Table 6.2.2-3.

Environmental envelopes are specified for system components to provide reasonable assurance of acceptable performance in normal and accidental environments.

The CSS is protected from the dynamic effects of pipe rupture as described in Subsection 3.6.1. The CSS is protected from missiles as described in Section 3.5. The CSS components are capable of functioning in the event of the maximum probable flood or other natural phenomena defined in GDC 2.

Inspection and testing requirements for the CSS are given in Chapter 16 and Subsection 6.2.2.4.

6.2.2.2 System Design

The CSS schematic diagram is shown in Figure 6.2.2-1. Design parameters and applicable codes for the major components are given in Table 6.2.2-2.

The safety-related components of the CSS receive electrical power for their operation from physically and electrically independent and redundant emergency power supply systems as well as normal offsite power supplies. For the unlikely event of a LOCA or MSLB, the CSPs are automatically started by an SIAS or a CSAS. Containment spray flow to the containment does not occur until a CSAS opens the containment spray header isolation valves. The setpoints of SIAS and CSAS are tabulated in Table 7.3-5A.

The CSS is designed to be manually operated from the MCR and the remote shutdown room (RSR). Once the CSPs are started and the valves are opened, the spray water flows into the containment spray headers. These headers contain spray nozzles that break the flow into small droplets, thus enhancing the water's cooling effect on the containment atmosphere. As these droplets fall to the containment floor, they absorb heat until they approach thermal equilibrium with the containment. When the water reaches the containment floor, it drains to the HVT and subsequently back to the IRWST.

Following a LOCA or MSLB, the containment pressure reduces near the atmospheric pressure with the CSS operation. When the containment pressure is reduced sufficiently, the CSS is not required for iodine removal, and the operator determines that the containment spray is no longer required, the operator terminates the CSS operation.

The CSS is designed so that the CSPs and the shutdown cooling pumps (SCPs) are functionally interchangeable when not required to perform their requisite design basis function, assuming a loss of offsite power and single failure. The SCPs are designed to be aligned from the MCR to provide the containment spray. When used in a containment spray configuration, the SCPs are capable of being automatically started by an SIAS or a CSAS.

The CSS is designed to provide a backup to the shutdown cooling system (SCS) for residual heat removal and for cooling of the IRWST during post-accident feed-and-bleed operations using the safety injection system and pressurizer POSRVs.

The CSS is designed to perform its heat removal function without adverse effects on the safety injection system performance.

The emergency containment spray backup subsystem (ECSBS) for severe accident management is provided in the APR1400. The ECSBS is used as an alternate means of providing containment spray in the event of a beyond a DBA in which both CSPs, both SCPs, and/or the IRWST are unavailable. The ECSBS is to be placed in service 24 hours after a severe accident to prevent a catastrophic failure of the containment. The fire engine truck as ECSBS pumping devices is used to deliver water from external water sources to the ECSBS containment spray header after the initiation of a severe accident. Further details of ECSBS are provided in Section 19.2.

6.2.2.2.1 Containment Spray Pumps

The function of the CSPs is to provide flow through the containment spray headers and CSHXs to remove fission product and control containment atmosphere temperature and pressure resulting from a plant accident.

One CSP is provided for each of two 100 percent capacity divisions. The CSPs are vertical, single stage, centrifugal pumps driven by induction motors. The pumps are sized to deliver 20,535.86 L/min (5,425 gpm) at a discharge head of 140.21 m (460 ft). The pump rated flow consists of 100 percent cooling capacity of 18,927.06 L/min (5000 gpm) and pump minimum flow of 1,608.8 L/min (425 gpm). The 100 percent capacity design flow rate is based on 57.54 L/min (15.2 gpm) per main spray of 307 nozzles and 11.36 L/min (3.0 gpm) per auxiliary of 111 nozzles. The CSP discharge head is based on a static head of 72.85 m (239 ft) and pressure losses equivalent to 63.09 m (207 ft) including a margin of 4.27 m (14 ft). The CSP data are provided in Table 6.2.2-2.

Minimum flow orifices are installed in the lines running from the pump discharge, returning back to the pump suction. These paths include a mini-flow heat exchanger and provide reasonable assurance that the pumps will not be deadheaded if they are inadvertently run against a closed system.

Cooling water is provided to the containment spray mini-flow heat exchangers by the component cooling water system. The component cooling water system is described in Subsection 9.2.2.

The CSPs are designed to the same specifications as the SCPs. This makes the CSPs and the SCPs functionally interchangeable and allows each pump to provide a backup when the required function of the pumps is not needed. Alignment of the SCPs to the CSS and alignment of the CSPs to the SCS are accomplished by repositioning several remotely actuated valves located in the pump suction and discharge piping. The alignments permit the SCPs to back up the CSPs during long-term post-LOCA operations when the SCPs are not required for shutdown cooling.

For refueling operation, the CSP is used as an alternate method of filling the refueling pool.

A flow restrictor is provided to minimize the loss of fluid in the event of a gross seal failure. Vent and drain connections are provided. An internal drain to the pump suction is provided in the pump casing. The pump is designed to be completely drained and flushed prior to maintenance, thus reducing radiation levels and doses to plant personnel.

The pressure-retaining portions of the pumps are stainless steel, meeting ASME Section III, Class 2 requirements. The material for all other parts is reviewed for compatibility with its intended service and is approved prior to release for manufacture.

Two CSPs automatically start on a SIAS or a CSAS, and the containment spray header isolation valves automatically open on a CSAS, thus initiating flow to the CSS spray nozzle headers. Initiating signals and controls is described in Chapter 7. Electric power supplies are discussed in Chapter 8.

6.2.2.2.2 Containment Spray Heat Exchangers

The CSHXs are used to remove heat from the containment atmosphere during and after an accident. The units are designed to reduce the containment atmosphere pressure in 24 hours after an accident to half of the calculated peak pressure. The CSHX parameters are given in Table 6.2.2-2.

The CSHXs are used as a backup to the shutdown cooling heat exchangers for IRWST cooling during post-accident operations when the SIS and the pressurizer POSRVs are used for feed-and-bleed cooling of the RCS.

6.2.2.2.3 Containment Spray Piping

Each IRWST suction valve is normally open to provide a reliable water source to the CSPs and to provide reasonable assurance of water full suction piping.

During normal power operation, the CSS piping is water solid up to the IRWST 100 percent water level at elevation 28.3 m (93 ft). A 110-second delay is conservatively assumed between the system initiation and the spray flow through the spray nozzles. The delay time is described further in Subsection 6.2.1.1.3.

The design of the CSS piping and spray nozzle headers considers the effects of water hammer.

6.2.2.2.4 Containment Spray Nozzles

The spray nozzles are attached to and become part of the spray nozzle headers located in the upper portion of the containment building and below the operating floor. The nozzles disperse the spray solution throughout the containment in the form of droplets to increase the heat transfer surface. The main spray nozzle headers with main spray nozzles are arranged to provide the maximum effective coverage of the containment volume.

The auxiliary spray nozzle headers with main and auxiliary spray nozzles are installed below the operating floor to provide post-accident containment atmosphere mixing to prevent high local hydrogen concentration in the containment.

The spray nozzles are nonclogging and produce a hollow cone spray pattern. The orifice sizes of the main and auxiliary spray nozzles are 13.1 mm (0.516 in) and 5.60 mm (0.220 in), respectively.

The nozzles provide a drop size distribution that is determined by testing and found to be suitable for the fission product removal function. The CSS provides a nozzle pressure differential of 2.81 kg/cm^2D (40 psid), which is the nozzle design condition for the drop size distribution. The mass mean drop size produced at this differential pressure is shown in the Table 6.2.2-5. The mean drop size distributions emitted from the nozzle are obtained by testing based on the method described in ASTM E799 (Reference 22).

Figure 6.2.2-2 shows spray nozzle orientation on the spray nozzle headers. Nozzles are oriented to spray downward at 0, 45, 75, or 90 degrees from the vertical. Figure 6.2.2-3 shows spray profiles for the main spray nozzle types at several fall distances. Figure 6.2.2-4 shows the sectional view of the containment providing the main spray nozzle header elevations. Figure 6.2.2-5 provides the containment plan view showing the developed spray patterns on the operating floor at elevation 156 ft during post-LOCA conditions.

6.2.2.2.5 In-containment Refueling Water Storage Tank

The IRWST is a protected, reliable, and safety-related source of borated water for the CS and SI. Section 6.3 describes the SI function for the APR1400 ECCS. The IRWST is also used to fill the refueling pool in support of refueling operations.

The IRWST is also equipped with spargers, which are designed to effectively condense the steam and minimize the loads on the structure.

Section 6.8.2.2.1 describes the IRWST in detail.

6.2.2.2.6 IRWST Sump Strainers

The four independent sets of strainers are located in the IRWST and each strainer is for one of the four SI pumps and for one of two SCPs and two CSPs. These strainers prevent debris from entering the reactor and causing inadequate core or containment cooling.

The IRWST sump strainers are described in Section 6.8.

6.2.2.2.7 Valves

The location of the valves that are used in the containment heat removal systems, along with their type, type of operator, position during the normal operating mode of the plant, type of position indication, and failure position are shown on Figure 6.2.2-1.

6.2.2.2.7.1 Containment Spray Pump Suction Isolation Valves

The containment spray pump suction isolation valves (SI-347, SI-348) are included in the SIS. The valves are normally open motor-operated valves in the CSP suction lines from the IRWST. They are operated from the MCR and RSR and are maintained open during normal and accident conditions. These valves are closed manually if a CSP performs the backup function to a SCP during shutdown cooling operation or a CSS division is isolated from the IRWST to terminate a leak or maintain a CSP or a valve.

6.2.2.2.7.2 Containment Spray Header Isolation Valve

The spray header isolation valves (CS-003, CS-004) are normally closed motor-operated valves that open fully upon receipt of a CSAS. These valves are operated from the MCR and RSR. They are closed if containment isolation is required or when a CSP backups a SCP for shutdown cooling operation, or when the containment spray isolation is required.

6.2.2.2.7.3 Containment Spray Header Block Valve

The spray header block valves (CS-001, CS-002) are normally open motor-operated valves located upstream of the containment spray header isolation valves. The valves are closed to provide double valve isolation of the containment spray headers whenever the CSPs are used in test, shutdown cooling, or IRWST cooling modes of operation.

6.2.2.2.7.4 IRWST Return Line Flow Control Valve

The IRWST return line control valves (CS-005, CS-006) are normally closed motor-operated globe valves located in the CSP test return line back to the IRWST. These valves are used during CSP testing to throttle CSP flow to the design flow rate. When the CSPs are used for shutdown cooling, these valves are used to isolate the RCS pressure boundary. The valves are designed to be opened from the MCR and the RSR to align the CSS for IRWST cooling.

6.2.2.3 Design Evaluation

All components including CSPs with mechanical seals, piping, valves, orifices, and containment spray nozzles are qualified to operate with the post-LOCA fluids for at least 30 days using the qualification guidance of ASME QME-1, 2007, as endorsed by NRC RG 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," Revision 3.

The spray nozzle test program is performed per ASTM E799. Sauter mean diameters of the main spray nozzle sprays and auxiliary spray nozzle sprays are 294 microns and 146 microns, respectively, at the design pressure drop of 2.81 kg/cm^2D (40 psid). The Sauter

mean diameter of 1,000 microns is conservatively assumed for the containment pressure and temperature analysis using GOTHIC code. The droplet of 1,000 microns has 100% effectiveness before it falls to about 12.19 m (40 ft) from the level of spray nozzles, which is shorter than the minimum spray fall height of 32.13 m (105.4 ft) (from the nozzles to the top of the PZR wall).

Containment spray elevation and plane drawings are provided in Figures 6.2.2-4 and 6.2.2-5, respectively. These drawings show spray coverage and overlap. The volume of the containment covered by the sprays is described in Table 6.5-3.

The IRWST sump strainer performance evaluation related to Generic Safety Issue (GSI) - 191 is described Reference 1 and Subsection 6.8.4.5.

The IRWST is the suction source for the SI pumps and CSPs during short-term injection and long-term cooling modes of post-accident operation. As described in Section 6.8, the HVT performs water collection services after an accident. Spillways allow accumulated water in the HVT to spill back into the IRWST, thereby replenishing IRWST water volume during accident operations. The determination of the minimum available NPSHs for the SI pumps and the CSPs are based on the minimum water level in the IRWST during accident conditions. In addition, the following conservative assumptions are made:

a. Fluid conditions in the IRWST are saturated; no credit is taken for an increase in containment pressure.

b. The contribution of the volume of water spillage from the RCS and one safety injection tank is conservatively neglected.

c. With the CSS actuated, the reactor cavity is assumed to be flooded, and the HVT is assumed to be full to just above the level at which water begins to return to the IRWST through the spillways.

d. Spray water is held up on surfaces throughout the containment. Locations of the accumulation of water inside the containment include water held up on horizontal surfaces, clogged floor drains, water held up in containment spray piping, water in

the containment atmosphere, water film on vertical surfaces, puddles trapped on equipment, and the containment free volume filled with steam.

The calculated available NPSH for the SI pumps and CSPs at the maximum expected flow, which is equal to both SI pump and CSP taking suction from the same line, is provided in Table 6.2.2-1. The calculated available NPSH exceeds the required NPSH of an SI pump and CSP from the bottom of IRWST.

A failure modes and effects analysis of the CSS is provided in Table 6.2.2-3 and demonstrates sufficient reliability of the CSS.

The integrated energy content of the containment atmosphere and IRWST water during transients is given in Part A of Table 6.2.1-38. It shows the stored energy content not only at the peak value of the containment pressure but also at the end point of transient of each phase, which includes EOB, EOR, EOPR, and 24 hours after accident initiation. Integrated energy absorbed by the structural heat sinks is also given in Table 6.2.1-38.

6.2.2.4 Tests and Inspections

Preoperational tests are conducted to verify the proper operation of the CSS. The operational tests include the calibration of instrumentation, verification of adequate pump performance, verification of the operability of all associated valves, and verification that the spray headers and spray nozzles are free of obstructions.

The CSS also undergoes preoperational hydrostatic tests conducted in accordance with ASME Section III.

Tests of individual components or the complete CSS are controlled to provide reasonable assurance that plant safety will not be jeopardized and that undesirable transients will not occur.

The preoperational test results are used to perform analyses that confirm that the as-built CSS fulfills operability requirements and provides a level of performance that meets the safety analyses.

Each CSS division is tested to measure the CSP developed differential pressure at a flow rate that is equal to or greater than the pump design flow rate. An analysis is conducted to convert the test results to determine pump performance at design conditions after an accident. The calculated performance is within the limits used to perform safety analyses.

Testing is conducted to confirm that the CSP mini-flow rate in the installed system meets or exceeds the pump vendor's minimum flow requirements.

Testing is conducted to confirm that the CSP return line to the IRWST allows each CSP to operate at a flow rate that is equal to or greater than design flow during in-service testing.

The determination of the available NPSH to the CSP is based on as-built elevations, piping arrangements, and system performance parameters measured during testing. Measured pump suction pressures and flow rates are used in an analysis to demonstrate that adequate available NPSH is provided to each CSP, assuming the following post-accident conditions:

a. Minimum IRWST level during an accident

b. Saturated IRWST fluid conditions

c. As-built piping arrangement for pump inlet piping and components

The calculated minimum available NPSH exceeds the NPSH required by the pump vendor. Table 6.2.2-1 specifies the margin between available and required NPSH.

Testing is performed to demonstrate that an SCP in a division can perform the pumping function of the CSP in the division. The SCP is tested by aligning its suction to the CSP suction and its discharge to the CSP discharge. The SCP provides a flow rate through the CSHX that is equal to or greater than the CSP design flow rate.

The CSS is designed and installed to permit in-service inspection and testing in accordance with ASME Section XI (Reference 23) and ASME OM (Reference 24). The complete schedule for the tests and inspections of the CSS including TSP is described in Chapter 16.

6.2.2.5 Instrumentation Requirements

Containment spray pump operation is automatically initiated by either an SIAS or a CSAS. Containment spray flow to the containment is not provided until a CSAS opens the containment spray header isolation valves. The SIAS and CSAS are part of the engineered safety features actuation system and are described in Section 7.3. An SIAS is automatically generated upon the occurrence of either a low pressurizer pressure signal or a high containment pressure signal. A CSAS is automatically generated upon the occurrence of a high-high containment pressure signal. The CS system operation can also be initiated in the control room by manually initiating a CSAS.

Display instrumentation is available to the operator to allow him to adequately monitor conditions in the containment spray system and to perform any required manual safety functions. The information provided is sufficient to allow the operator to accurately assess the conditions within the containment spray system and in a timely manner perform those actions to maintain appropriate system conditions. In addition, the information provides reasonable assurance of a positive indication that the pumps and valves have actuated and that flows have been established.

The CS system instrumentation is listed in Table 6.2.2-4. Instrumentation identified by Note (2) in the table is provided for post-accident monitoring of system operation.

The following instrumentation is provided:

a. CSP suction and discharge pressure indication is provided in the MCR to allow the operator to monitor CSP operation. An alarm is provided in the MCR to alert the operator to low pump discharge pressure conditions that occur during pump operation. An alarm is also provided in the MCR to alert the operator to low pump suction pressure conditions that occur when the CSP is used for shutdown cooling during reduced RCS inventory operations.

b. CSP flow indication is provided in the MCR to allow the operator to monitor CSP flow during containment spray operation and during shutdown cooling operation using the CSPs. A low-flow alarm is provided to alert the operator when the pump flow rate falls below the flow rate required for shutdown cooling operation.

This alarm allows the operator to take corrective actions to prevent a loss of shutdown cooling flow. The alarm receives a pump status input signal to prevent nuisance alarms.

c. Valve open/close position indication is provided for spray header isolation valves (CS-0003 and CS-0004). The valves are normally closed and receive a signal to open on a CSAS.

d. Valve open/close position indication is provided for spray header block valves (CS-0001 and CS-0002). The valves are administratively controlled in the open position from the control room.

e. Valve open/close position indication and full range 0 to 100 percent position indication is provided for IRWST return line flow control valves (CS-0005 and CS-0006). The valves are normally closed to provide reasonable assurance that the CSPs are aligned to the CS header. During CSP testing, the valve position is throttled to establish the flow rate at the CSP design flow rate.

f. CSP on/off indication is provided in the MCR to identify pump status. A pump status signal is provided to the shutdown cooling low-flow alarm to prevent nuisance alarms when a CSP is used for shutdown cooling.

g. CSP motor current indication is provided in the MCR to allow the operator to monitor pump operation. A low indicated current when the CSPs are aligned for shutdown cooling operation may indicate air entrainment in the pump suction line and the potential loss of shutdown cooling.

h. CS heat exchanger outlet temperature indication is provided in the MCR to monitor heat exchanger performance during containment spray operation.

i. Open/closed position indication is provided in the MCR for the CSP discharge manual isolation valves (CS-1003 and CS-1004). An alarm is provided to alert the operator when a valve is not fully open.

6.2.3 Secondary Containment

The secondary containment is not applicable to the APR1400.

6.2.4 Containment Isolation System

The containment isolation system provides the means of isolating fluid systems that pass through the containment penetrations to confine the release of any radioactivity from the containment following a postulated DBA. The containment isolation system is required to function following a design basis event to isolate non-safety-related fluid systems penetrating the containment. There is no particular system for complete containment isolation, but isolation design is achieved by applying acceptable common criteria to penetrations in many different fluid systems and by using containment pressure to provide a containment isolation actuation signal (CIAS) as described below to actuate appropriate valves.

The containment penetration barriers consisting of the flange closure, personnel airlock and equipment hatch are under administrative control.

6.2.4.1 Design Bases

6.2.4.1.1 Overall Requirements

The design bases for the containment isolation systems include provisions for the following:

a. A double barrier at the containment penetration in the fluid systems that are not required to function following a design basis event.

b. Automatic and leaktight closure of valves required to close for containment integrity following a design basis event to minimize release of any radioactive material.

c. A means of leak testing barriers in fluid systems that serves as containment isolation in accordance with GDC 52 (Reference 34).

d. The capability to periodically test the operability of containment isolation valves.

In conformance to GDC 54 (Reference 36), the piping systems and related components penetrating the containment are provided with leak detection, isolation, and containment capabilities having redundancy, reliability, and performance capabilities that reflect the importance to safety of isolating these fluid systems. The containment leakage test program provides for periodic testing to determine if valve leakage is within allowable limits and to test the operability of the isolation valve and associated components. Isolation valves are located as close as practicable to the containment. All automatic valves are designed with a failure position that provides the position of greater safety in the event of value actuation loss.

Lines that are part of the reactor coolant pressure boundary (RCPB) and penetrate the containment are referred to as Type I and are provided with valves as follows:

a. One locked closed isolation valve inside and one locked closed isolation valve outside containment, or

b. One automatic isolation valve inside and one locked closed isolation valve outside containment, or

c. One locked closed isolation valve inside and one automatic isolation valve outside containment. A check valve is not used as the automatic isolation valve outside containment, or

d. One automatic isolation valve inside and one automatic isolation valve outside containment. A check valve is not used as the automatic isolation valve outside containment.

The above provisions satisfy GDC 55.

Lines that connect directly to the containment atmosphere and penetrate the containment are referred to as Type II and are provided with the following isolation valves:

a. One locked closed isolation valve inside and one locked closed isolation valve outside containment, or

b. One automatic isolation valve inside and one locked closed isolation valve outside containment, or

c. One locked closed isolation valve inside and one automatic isolation valve outside containment. A check valve is not used as the automatic isolation valve outside containment, or

d. One automatic isolation valve inside and one automatic isolation valve outside containment. A check valve is not used as the automatic isolation valve outside containment.

These provisions satisfy GDC 56 (Reference 25).

Lines that penetrate the containment and are not part of the RCPB and are not connected directly to the containment atmosphere are referred to as Type III and have at least one isolation valve, located outside the containment, which is (a) automatic, (b) locked closed, or (c) capable of remote manual operation. A check valve is not used as the automatic isolation valve.

These provisions satisfy GDC 57.

Instrumentation and control sensing lines that penetrate the containment are provided with containment isolation provisions that meet the intent of NRC RG 1.11 (Reference 26) and NRC RG 1.141 (Reference 41).

6.2.4.1.2 Design Features

The following is a summary of containment isolation system design features. Incorporation of these features into the containment isolation system results in a design where the design criteria for containment isolation barriers given above are met:

a. The containment isolation valves and interconnecting piping are designed and constructed to safety Class 2 and seismic Category I standards as defined in NRC RG 1.29 (Reference 27), respectively.

b. The design pressure and temperature of all piping and connected equipment comprising the isolated boundary is greater than the design pressure and temperature of the containment. Relief valves for providing overpressure protection from heat up between closed containment isolation valves have a relief set point equal to the design pressure of the piping.

c. The containment isolation valves and interconnecting piping are protected against missiles.

d. Containment isolation valves and interconnecting piping are protected against the effects of pipe whip and jet impingement.

e. Containment isolation valves are designed to operate under normal environmental conditions and to fulfill their safety-related function under post-accident environmental conditions, consistent with the requirements of Section 3.11.

f. Containment isolation valve and associated penetration piping are qualified in the ASME Section III as Class 2 components, as described in Subsection 3.9.3, and are qualified in accordance with NRC RG 1.26 (Reference 28).

g. Maximum allowable actuation times are imposed on containment isolation valves consistent with their required safety function. Valve closure time is established based on system considerations, but all valves stroke to their designated position as soon as practicable upon actuation. Power-operated valves of 90.0 mm (3.5 in) to 300.0 mm (12 in) in diameter are closed at least within a time determined by dividing the nominal valve diameter by per minute. Valves of 80.0 mm (3 in) and less generally close within 15 seconds. All valves larger than 300.0 mm (12 in) in diameter close within on minute unless an accident radiation dose calculation is performed to show under accident conditions that the longer closure times do not result in radiation releases significant enough that accident dose allowances are exceeded.

h. Valve operators and power sources are selected for containment isolation valves consistent with their required safety function.

i. Instrumentation and control sensing lines that penetrate the containment are provided with containment isolation provisions, which meets the intent of NRC RG 1.11.

j. All containment penetrations not used for accident mitigation or safe shutdown are automatically isolated by a CIAS unless:

   1) The valves are normally locked closed.

   2) The penetrations are normally sealed (e.g., fuel transfer tube).

   3) The lines are needed for RCP operation (RCP seal injection and component cooling water to RCP seal coolers, motors, and lube oil coolers).

   The exception of the lines for RCP operation allows the RCPs to be available for accident mitigation or safe shutdown if offsite power and non-essential support systems are available. These lines are continuously monitored for radiation and can be manually isolated from the MCR.

k. The induced stresses in the pressure retaining components of the CIVs, due to an internal containment pressure of less than or equal to 7.67 kg/cm^2 (109 psig), are within the ASME Section III Factored Load Category.

6.2.4.2 System Design

No single flow diagram shows all of the containment penetrations, but they are shown on appropriate flow diagram for systems. Containment isolation provisions are tabulated in Table 6.2.4-1. The appropriate valve arrangements are illustrated in Figure 6.2.4-1.

All valves that receive an ESFAS are designed and tested with closing time appropriate to the function performed. The sequencing system for loading the onsite emergency

electrical generators is designed to close all valves receiving an ESFAS within seconds of the time the shift to emergency onsite electrical power signal is accomplished.

The CIAS is provided to isolate the process lines penetrating the containment to mitigate the consequences of a release of radioactive material during a LOCA, FWLB, or MSLB. The CIAS is initiated by a high containment pressure signal or a low pressurizer pressure signal. Provisions for manual initiation from the MCR are also required.

The pressure setpoint of the automatic containment isolation activated by the containment pressure rising is established according to the requirement of 10 CFR 50.34(f)(2)(xiv)(D) (i.e., use a containment set point pressure for initiating containment isolation as low as is compatible with normal operation) (Reference 29).

The setpoint (134 cmH_2O (1.9 psig)) for containment isolation is selected as 3.5 percent of allowable containment pressure limit (3.79 kg/cm^2G (54 psig)), which is determined by subtracting pressure margin (10 percent) from the containment design pressure (4.218 kg/cm^2G (60 psig)). This setpoint value is also considering the normal performance tolerance of the pressure instrument channel (35 cmH_2O (0.5 psig)).

As described below, adequate protection is provided for piping, valves, and vessels against dynamic effects and missiles, which could result from plant equipment failures, including a LOCA.

Isolation valves inside the containment are located between the secondary shield wall and the inside containment wall. The secondary shield wall serves as the missile barrier. Any necessary missile barriers for isolation valves and piping, or vessels that provide one of the isolation barriers outside the containment, consist of structural steel or concrete.

Most of the mechanical penetrations are located with the outside containment isolation valve as close as possible to the containment wall in the four mechanical penetration rooms, and the inside containment isolation valve located within containment between the secondary shield wall and inside containment wall. The following outside containment isolation valves are located in spaces other than the four mechanical penetration rooms:

a. The four safety injection and containment spray pump suction isolation valves in the IRWST penetration lines outside containment are located in the auxiliary building valve rooms.

b. The high volume and low volume containment purge system containment isolation valves, which are outside containment, are located in the containment high/low volume supply AHU room.

c. The four main steam lines and four main feedwater lines, due to the nature of their service, have all of their containment isolation valves located within the main steam isolation valve house, with the exception of the main feedwater inside-containment check valves.

d. The four component cooling water (CCW) containment isolation valves outside containment are located in the pipe chases, which are located in quadrant A of the auxiliary building.

The isolation arrangement of the fuel transfer tube consists of a transfer tube closure and a blind flange, enclosing the transfer tube. The fuel transfer tube blind flange is Type-B leak-rate tested in accordance with ANSI/ANS 56.8-1994. The blind flange contains two O-ring grooves and a pressure tap that runs through the blind flange to the annulus between the two O-rings. When assembled prior to reactor operation, the blind flange is bolted to the transfer tube closure and the annulus between the seals is pressurized to provide reasonable assurance that both seals are functioning. The seal is further tested when test pressure is introduced into the containment.

When these tests have been satisfactorily completed, the fuel transfer tube is isolated from the containment. The transfer tube closure and the blind flange are considered to be part of the containment boundary and, therefore, GDC 56 does not apply to the transfer tube penetration and an isolation valve is not required.

A normally locked-closed manual valve is provided on the transfer tube outside the containment. However, its basic function is not to provide containment isolation. At the beginning of refueling, during filling of the refueling pool, this valve is maintained closed

until a common water level is reached in the refueling pool and the spent fuel pool. Then the valve is opened to allow the transfer of fuel.

The equipment hatch consists of an arrangement similar to the fuel transfer tube closure. It has a double seal, which is Type B leak-rate tested in accordance with ANSI/ANS 56.8-1994. Since it is considered part of the containment boundary, GDC 56 does not apply and an isolation valve is not required.

The integrated leak-rate test pressurization penetration consists of an inside containment blind flange and an outside containment manual isolation valve. This line is utilized to pressurize the containment to perform the containment integrated leak-rate test. During outages in which no containment integrated leak-rate test is performed, this penetration is Type C leak rate tested in accordance with ANSI/ANS 56.8-1994. The blind flange is sealed with the manual isolation valve locked closed during normal operation.

Electrical penetrations consist of a gas-sealed or a double O-Ring sealed electrical penetration assembly. Both types are Type B leak rate tested in accordance with ANSI/ANS 56.8-1994 testing requirements by pressurizing the test volume to DBA pressure and measuring either pressure decay or volumetric flow rate required to maintain test DBA pressure. Electrical penetrations are tested further when containment is pressurized for the containment integrated leak-rate test.

In the fluid lines that remain open subsequent to a design basis event, such as lines serving ESF systems, the containment isolation valves are not automatically closed by the CIAS or MSIS.

In accordance with 10 CFR Part 50 Appendix J, Type-C testing is not performed on valves installed within, or parallel to, piping used to provide SIS flow to the RCS for accident mitigation. The safety function of each of these valves is to open or remain open during post-accident operations. The valves are installed in safety Class 2, seismic Category I piping, which is designed to remain filled with water after an accident, thereby providing protection against containment atmosphere leakage. The addition of isolation devices in the SI piping or the sole purpose of Type-C testing would reduce the reliability of the system to perform its principal safety function.

Specifically, motor-operated valves SI-304, SI-305, SI-308, and SI-309 are installed in the suction path from the IRWST to the SI pumps. The valves are status-controlled open during normal operation and maintain an open position to provide a suction source for the SI pumps. The SI pumps remain aligned to the IRWST throughout the period of post-accident operation. Spillways from the HVT provide reasonable assurance that the IRWST inventory is not depleted. This keeps the suction lines filled with water and prevents exposure of the valves to the containment atmosphere.

Motor-operated valves SI-616, SI-626, SI-636, and SI-646 are installed in the SI pump injection lines to the DVI nozzles. The valves are normally closed, but automatically open upon receiving a SIAS. The valves remain open after an accident to provide SI flow to the RCS for inventory control and heat removal. The valves can be throttled to control RCS pressure.

In the event that an SI train is actuated and the motor-operated valves are open, but an SI pump fails to start or stop, the effect of containment pressure conditions downstream of the motor-operated valve is negated by the fact that SI pump suction is aligned to the IRWST, which is also subjected to post-accident containment pressure conditions.

Motor-operated valves SI-602 and SI-603 are installed in parallel to injection line valves SI-626 and SI-646, respectively. The valves are normally closed and remain closed after an accident until they are used to throttle SI pump flow at very low flow rates for post-LOCA RCS pressure control. These valves would continue to be used to provide RCS pressure control during shutdown cooling. The parallel arrangement of the valves with SI-626 and SI-646 subjects them to the same fluid conditions.

Motor-operated valves SI-600 and SI-601 are installed in the SCS lines that are joined with SIS lines containing SI-626 and SI-646, respectively. The piping connection is made outside the containment, downstream of the SI flow measurement orifices. The SCS valves are normally closed and remain closed after an accident until shutdown cooling operations are initiated. The valves remain open to provide shutdown cooling flow to the RCS for decay heat removal to achieve safe shutdown conditions. The classifications of the piping in which the valves are installed are the same as those of the connecting SIS piping. Fluid conditions downstream of the valves are the same as those that exist in the SIS piping.

Provisions made to provide reasonable assurance of the operability of the isolation valve system under an accident environment conform with the requirements for redundancy, independence, and testability. The valve system is designed for pressures equal to or greater than the containment design pressure. A comprehensive testing and inspection program provides reasonable assurance that these components will operate for the time period required in the post-DBA conditions of temperature, pressure, humidity, and radiation, and in seismic phenomena. The DBA environmental conditions are listed in the design specifications for all components that are part of the containment isolation system. Vendor factory testing is performed on a prototype of these components to provide reasonable assurance of adequacy under these conditions.

Air or motor-operated valves are used for the automatic isolation valves. Air-operated valves are designed to assume the fail-safe position upon loss of air. Motor-operated valves are powered from the emergency power sources.

Remote manual control of the automatically actuated containment isolation valves is provided.

Automatic valves are installed in lines that are immediately isolated after an accident. The lines remain in service after an accident and have at least one remote manual valve.

Reasonable assurance of the integrity of the isolation valve system and connecting lines, under the dynamic forces resulting from inadvertent closure while at operating conditions (e.g., main steam lines), is provided by the performance of static and dynamic analysis on the piping, valves and restraints.

Supports and restraints are applied to provide reasonable assurance that the integrity is maintained and that the pipe stresses and support reactions are within allowable limits. Valves in non-safety-related systems where function permits are normally positioned closed to minimize any release following a design basis event and are equipped with valve operators to move the valve rapidly.

Containment isolation valves, operators, and associated I&Cs are environmentally qualified for the normal and post-accident environments in which they are located, as addressed in Section 3.11.

6.2.4.3 Design Evaluation

The containment structure and the containment penetrations form an essentially leak-tight barrier. Allowable leak rates from the containment under design pressure condition are discussed in Subsection 6.2.1. Testing provisions and performance are also discussed in Subsection 6.2.1. Isolation valves outside containment, which are normally open and required to close on a signal to isolate the containment are, designed to fail closed.

In order to provide reasonable assurance that no single, credible failure or malfunction will result in a loss of isolation capability, the closed piping systems, both inside and outside the containment, and various types of isolation valves provide a double barrier.

The isolation valve and actuators are located as close as practicable to the containment and protected from missile damage. This minimizes the potential hazards that could be experienced by the system.

Reasonable assurance of the integrity of the isolation valve system and connecting lines under the dynamic forces resulting from inadvertent closure under operating conditions is provided , based on a static and dynamic analysis.

The supports and restraints are applied such that pipe stresses and support reactions are within allowable limits as defined in Subsection 3.9.3.

A single containment isolation valve is provided in each IRWST suction line to the ESF pumps. The valve is not enclosed in a leak-tight enclosure because all requirements are met as outlined below:

a. The valves are attached to lines that are extensions of containment and enclosed in a valve room adjacent to the containment with provisions for environmental control of any fluid leakage. The IRWST suction lines are shown in Figures 1.2-4 and 1.2-11. The containment isolation valves for these lines are located in the auxiliary building valve rooms, as shown in Figure 1.2-4. The auxiliary building valve rooms have provisions for environmental control of any fluid leakage (i.e., leakage is collected in the sumps shown in Figure 1.2-11, the valve

rooms are maintained at a negative pressure, and all potential radioactive releases are filtered and monitored as discussed in Subsection 9.4.3).

b. The lines from the IRWST are always submerged so no containment atmosphere can impinge upon the valves.

c. The systems that the lines from the IRWST connect to the outside containment are closed systems that meet the appropriate requirements for closed systems.

d. The valves provide a barrier outside containment to prevent loss of IRWST water if a leak develops. The valves are closed remotely from the MCR and the operator can detect which one of the four valves failed to close by indication of high sump water level in the sump located within the quadrant in which the associated ESF equipment and valve is located. Quadrant separation, ESF equipment location, and sumps are shown in Figure 1.2-11.

Although the high volume containment purge system containment isolation valves (supply and exhaust) are required by Technical Specifications to be closed when the reactor coolant system exceeds hot shutdown conditions, a CIAS is provided to them to provide further reasonable assurance of closure. High-volume containment purge system containment isolation valves (supply and exhaust) isolate upon detection of high exhaust effluent radiation levels by a dedicated radiation monitor located in the containment purge system exhaust ducting.

Pneumatically operated low volume containment purge system containment isolation valves (supply and exhaust) are isolated on a CIAS and upon detection of high radiation by a dedicated radiation monitor located in the containment purge system exhaust ducting.

The closure time of the containment isolation valves for the low volume containment purge subsystem is selected and justified by an analysis of:

a. The radiological consequences of a LOCA, assuming appropriate source term for the loss of inventory; and

b. The allowable loss of containment atmosphere while the isolation valves are closing, which affects the value for minimum containment pressure used in evaluating the safety injection system effectiveness.

Reasonable assurance of the closure function of the low volume purge isolation valves is provided by tests or analyses, that demonstrate that the valves would isolate without degrading containment integrity during the dynamic loads of a design basis LOCA. The valves are also analyzed to be closable against ascending differential pressure and dynamic loading of a design basis LOCA.

Penetrations that provide an open path between the containment and the outside environment are isolated on detection of high effluent radiation levels by dedicated radiation monitors. In addition, these penetrations are isolated by a CIAS.

6.2.4.4 Testing and Inspection

Each valve is designed to be tested periodically during normal operation or during shutdown conditions to verify its operability and ability to meet closing requirements.

The isolation valves are tested for leakage both by the vendor prior to installation in the field and again in the field as part of the installation and integrated system testing program in accordance with NEI 94-01 (Reference 30), ANSI/ANS 56.8 (Reference 31), and ASME OM Code Subsections ISTC, ISTC-3620, and ISTC-3630.

Appropriate vent and drain connections are provided for Type A and C tests. The total combined leakage rate for components subject to Type B and C tests as defined by NEI 94-01 and ANSI/ANS 56.8 is limited to 60 percent of the DBA leakage rate. ASME OM Code Subsection ISTC testing analyzes and provides corrective action for containment isolation valves on a per-valve basis, based on valve diameter.

These tests provide periodic verification of the leak-tight integrity of the containment and associated systems. These tests provide reasonable assurance that leakage of the containment isolation system is held within allowable leakage-rate limits. Periodic surveillance is performed to provide reasonable assurance of operability throughout the life of the plant.

Test connections, drains, vents, and pressurizing facility are provided to test each Type C containment isolation valve or barrier for leak-tightness in the accident direction (out of containment), unless it is more conservative to pressurize in the non-accident direction. Air or nitrogen is used as the pressurizing medium.

6.2.5 Combustible Gas Control in Containment

The containment hydrogen control system is designed to control combustible gas, primarily hydrogen gas (H_2), inside the containment within the acceptable limits. Combustible gas is controlled by passive autocatalytic recombiners (PARs) or hydrogen igniters (HIs) with consideration of hydrogen generation during a severe accident.

The containment hydrogen control system consists of 30 PARs and 8 HIs. The PARs and HIs installed within the containment as shown in Figure 6.2.5-1 are designed to control beyond DBA hydrogen concentration in the containment and the IRWST below 10 percent by volume. Table 6.2.5-1 shows the location of the PARs and HIs. The use of hydrogen-generating materials such as aluminum and zinc within containment is minimized to the extent practicable. The 30 PARs and 8 HIs are enough to cover the hydrogen gas due to corrosion from the emergency cooling or containment spray solutions.

6.2.5.1 Design Bases

During a degraded core accident, hydrogen is generated at a greater rate than in a design-basis LOCA. The PARs and HIs are designed to accommodate the hydrogen generation from 100 percent fuel clad metal-water reaction and to limit the uniformly distributed hydrogen concentration in the containment and IRWST below 10 percent by volume, assuming the representative severe accident sequences. These limits are imposed to preclude local detonations in the containment that could jeopardize containment integrity or damage essential equipment.

The containment hydrogen control system is designed in accordance with 10 CFR 50.34(f)(2)(ix), 10 CFR 50.44, GDC 41, GDC 42, GDC 43, and NRC RG 1.7.

The PARs and HIs are installed throughout the containment. HIs as supplementary to the PARs provide an effective means of controlling local hydrogen concentration in

compartments where the hydrogen release rate is greater than the depletion capability of PARs during a certain period of severe accident progression.

The failure modes and effects analyses (FMEA) of containment hydrogen monitoring system (CHMS) are presented in Table 6.2.5-2.

6.2.5.2 System Design

6.2.5.2.1 Provision against Severe Accidents

The PARs and HIs are designed to control or allow adiabatic controlled burning of hydrogen at fairly low concentrations to preclude hydrogen concentration buildup to detonable levels. The system is designed to prevent the global and local hydrogen concentration in the containment and the IRWST from exceeding 10 percent by volume during a degraded core accident with 100 percent fuel clad metal-water reaction in accordance with 10 CFR 50.44(c). The PARs in the containment and IRWST and the HIs in the containment are installed.

The PAR assemblies consist of structures for device and a stainless steel enclosure in which the catalyst is installed. The enclosure is open on the bottom and top and extends above the catalyst elevation to provide a chimney to yield additional lift to enhance the efficiency and ventilation capability of the device. Cartridge type devices are coated with catalytic material and supported by the enclosure. The function of the bores or spaces inside the cartridge is air pass-through. Covers are installed over the chimney to protect the cartridge from containment spray or stagnant water.

For the PARs, provisions are not required because they can operate automatically and their function can be confirmed by technical performance specification. PARs do not need to be grouped because they work independently.

The HIs are ac-powered glow plugs and are powered directly from a step down transformer. Each HI assembly consists of a thick steel enclosure that contains the transformer and all electrical connections and partially encloses the HI. The enclosure satisfies the U.S. National Electrical Manufacturers Association (NEMA) Type 4 specifications for water-tight integrity under various environmental conditions including exposure to water jets.

The sealed enclosure incorporates a heat shield to minimize the temperature rise inside the HI assembly and a spray shield to reduce water impingement on the glow plug from above. The HI assembly is designed to meet seismic Category I requirements.

Although HI is classified as Non-class 1E, the electrical power for HIs is supplied from the Class 1E bus (Train A or B) with the electrical isolation device in order to enhance the reliability of HIs. At loss of offsite power and failure of the emergency diesel generators to start or run (station blackout), the HIs have the alternative power supply from the alternate alternating current (AAC) generator. During a complete loss of ac power including from the AAC generator, the HIs are powered from the DC battery.

The hydrogen burning by HI or the hydrogen recombination heat is not critical for the survivability of critical plant equipment.

Although the containment is designed to distribute the hydrogen concentration uniformly, the hydrogen mixing is promoted and augmented by PAR operations, and if necessary, the PARs and HIs are positioned in areas where hydrogen release and accumulation are expected during severe accidents.

The PARs in the containment and IRWST and the HIs in the containment are designed to withstand severe accident conditions. The PARs and HIs provide reasonable assurance that the equipment can perform its identified function during severe accident conditions as described in Section 19.2.

PARs are considered a 15 percent efficiency reduction for iodine vapor and 10 percent efficiency reduction for cable fire. Thus, a total 25 percent efficiency reduction for the PAR was considered for capacity reduction. The HIs include a consideration of the combustion model of the MAAP computer code.

The PARs and HIs are designed to prevent any significant pocketing of hydrogen in order to minimize the potential for localized hydrogen detonation.

The PARs and HIs are able to withstand the effects of their own operations and are designed to provide reasonable assurance that equipment necessary for achieving and

maintaining a safe shutdown of the plant and containment integrity are capable of performing their functions during and after their exposure to hydrogen burning.

The PARs and HIs are located throughout the containment open volumes and compartments. The following location criteria are used:

a. Flow path requirements

b. Consideration of enclosed spaces

c. Equipment performance efficiency

d. Installation and maintenance

e. Consideration of dynamic effect

For the surveillance test of PARs, a sample of the PAR cartridges or plates is selected and removed from each PAR. Surveillance bench tests are performed on the removed specimens to confirm continued satisfactory performance. The HIs are capable of attaining the surface temperature that is sufficient for igniting hydrogen gases under any environmental conditions including containment spray actuation. The HI configuration, including possible spray shields, is supported by combustion test data.

Because the PAR is self-actuated and does not need a power supply, operator action for the PAR is not needed. The HIs are actuated by manual actuation in the MCR or RSR on indication that the hydrogen concentration exceeds a predetermined setpoint of volume percent or an indication of the beyond DBA. The HIs are capable of a manual trip. Restart of the system on restoration of power is performed by manual actuation.

The PAR is designed to provide reasonable assurance that the gas mixture flows into PAR inlets and thus augments the circulation of gas mixture within the containment to eliminate stagnant pockets of air where hydrogen could accumulate.

The PAR in the IRWST is provided to remove hydrogen produced by sump radiolysis in the IRWST.

6.2.5.2.2 Containment Hydrogen Monitoring System

The CHMS independent of the hydrogen recombiners, performs continuous hydrogen monitoring inside containment for a severe accident. Hydrogen monitoring system is a redundant seismic Category I system and consists of hydrogen analyzer cabinets and monitoring cabinets. A failure of one train does not prevent continuous monitoring of the hydrogen concentration. The hydrogen analyzer cabinet performs sampling, transmission and measurement of the sample. The monitoring cabinet performs data collection, calculation and automatic or manual operation of all analyzers. The monitoring system draws samples from two separate locations through dedicated penetrations (one sample location per division).

The sample lines of this on-line monitoring system are provided with heat tracing to prevent dew condensation and are purged before sampling to ensure that sample are representative. The purge gas is routed back to the containment atmosphere.

Continuous post-accident indication of containment hydrogen concentration is provided in the control room through redundant safety indicators that report the percentage of hydrogen by volume in the containment. Radioactive gas is drawn from the containment by means of a sample pump, into the analysis unit where the sample temperature is lowered. After the gas passed through the measuring cell, it is returned to the containment through a pressure regulating network, which maintains pressure above containment pressure to provide reasonable assurance of the return of the sample gas.

The containment isolation valves of hydrogen monitoring system are opened or closed manually by soft control in the MCR. The containment hydrogen monitor located outside of the containment analyzes the hydrogen concentration in containment air and continuously indicates hydrogen concentration in the MCR.

The hydrogen concentration of the sample gas is analyzed using a thermal conductivity measurement cell by making the containment air sample flow through the measurement cell. The actual wet hydrogen concentration is calculated based on containment pressure and temperature measurement, and the measure value using established gas law equations.

6.2.5.2.3 Alarm and Indication

The continuous indication of hydrogen concentration of containment air is provided in the MCR through redundant measurement channels. The channels are designed to measure 0~30 percent volume of hydrogen in a pressure range of -0.352 kg/cm^{2}G (-5 psig) to the maximum containment design pressure.

6.2.5.2.4 Design Features for Minimization of Contamination

The containment hydrogen control system and the containment monitoring system (CM) are designed with features that meet the requirements of 10 CFR 20.1406 (Reference 32) and NRC RG 4.21 (Reference 33). The basic principles of NRC RG 4.21 and the methods of control suggested in the regulations are delineated in four design objectives and two operational objectives and are discussed in Subsection 12.4.2.

The compliance of the containment hydrogen control system and the containment monitoring system with NRC RG 4.21 (Reference 33) is described in the Subsections 6.2.5.2.4.1 and 6.2.5.2.4.2.

6.2.5.2.4.1 Containment Hydrogen Control System

The containment hydrogen control system is designed to provide control of the combustible gases, mainly hydrogen, inside the containment and the IRWST, to within the acceptable limits through the use of the PARs and HIs located at various locations inside the containment and the use of PARs inside the IRWST. The PARs and HIs are designed to control the hydrogen by hydrogen recombination and hydrogen burning, respectively. There is no piping associated with the PARs and HIs, and the system has no interfaces with non-contaminated systems except electrical power. The containment hydrogen control system is designed to be on standby mode during normal operation. Hence, the containment hydrogen control system provides a low potential to contaminate other areas, facility systems, and the environment during normal operation including anticipated operational occurrences. This design is in conformance with the requirements of NRC RG 4.21.

Prevention/Minimization of Unintended Contamination

The PARs and HIs are designed to control hydrogen by hydrogen recombination and hydrogen burning, respectively. There is no piping associated with the PARs and the HIs, and the system has no interfaces with non-contaminated systems, except electrical power supply, thus minimizing leakage and unintended contamination of the facility and the environment.

Adequate and Early Leak Detection

All components of the containment hydrogen control system are inside the containment or the IRWST and the components operate in atmospheric conditions. There is no leakage from the components and a leak detection system is not required.

Reduction of Cross-Contamination, Decontamination, and Waste Generation

a. The PARs and the HIs are designed with life-cycle planning through the use of nuclear industry-proven materials compatible with the chemical, physical, and radiological environment, thus minimizing waste generation.

b. The PARs and the HIs are located inside containment and the IRWST and are not in contact with contaminated liquid. Hence, decontamination by water is not required.

Decommissioning Planning

The PARs and the HIs are modular units and are designed for the full service life of the plant. The PARs and the HIs are fabricated as individual assemblies for easy removal to the maximum extent practicable.

Operations and Documentation

The PARs are self-actuated and the HIs are actuated manually from the MCR or RSR with adequate instrumentation to the control the operation. This controls the hydrogen

concentration inside the containment and minimizes the potential for fire and explosion hazards that could result the spread of contamination and waste generation.

Site Radiological Environmental Monitoring

The containment hydrogen control system is part of the overall plant and is designed to prevent the buildup of hydrogen concentrations. The containment hydrogen control system does not generate any radioactive materials and is thus not required to be included in site radiological environmental monitoring.

6.2.5.2.4.2 Containment Monitoring System

The Containment Monitoring (CM) system is designed to provide continuous indication of containment environmental measurements including pressure, containment water level, hydrogen concentration in the containment and the IRWST, and containment temperature. Other than pressure and temperature instruments, the CM consists of piping and valves for the hydrogen analyzers that are used to extract air samples from inside the containment and the IRWST for analysis of hydrogen concentrations. After the analysis, the air samples are sent back inside the containment. The hydrogen analyzers are part of the hydrogen monitoring system, which is a subsystem of the CM system. During normal operation, the hydrogen analyzers are on standby mode. The hydrogen analyzers, their piping and valves, therefore have very low potential to contaminate the facility or the environment during normal operation, including AOOs. This design satisfies the requirements of RG 4.21.

Prevention/Minimization of Unintended Contamination

a. All temperature and containment water level instruments are located inside the containment with measurement readout in the MCR for continuous indication of the RCB environment and containment integrity. The monitoring provides reasonable assurance during normal power operation and minimizes the potential for interruption or mishap, thus preventing unintended contamination of the facility and the environment.

b. Four channels of pressure instruments are located close to the containment for more accurate measurements. Readouts are provided in the MCR. This design approach minimizes unintended contamination of the facility and the environment.

c. Two channels of continuous monitoring of containment atmosphere hydrogen concentration are provided. After the analysis, the air samples are sent back inside the containment.

d. The same two channels are also used for continuous monitoring of IRWST hydrogen concentration. After the analysis, the air samples are sent back inside the containment.

Adequate and Early Leak Detection

The CM system is designed to provide continuous indication of containment environment including pressure, containment water level, hydrogen concentration in the containment and the IRWST, and containment temperature. The instruments monitor the containment integrity for safe operation. The instruments do not process or generate any waste that requires leak detection.

Reduction of Cross-Contamination, Decontamination, and Waste Generation

a. The air samples from the containment and the IRWST using for hydrogen monitoring are returned back to the containment. The air is then processed by the low volume purge system. This design approach minimizes the potential for cross-contamination and waste generation.

b. The temperature and water level instruments are located inside the containment for direct measurement. This design approach also minimizes cross-contamination.

Decommissioning Planning

a. The instruments are designed for the full service life, including preventive and periodic replacement of components required for accurate indication.

b. The CM system piping is designed with minimal embedded or buried piping.

Operations and Documentation

a. The CM system is designed to provide containment environmental data for monitoring of the integrity of the containment. Operational procedures and maintenance programs for these instruments are either prepared or to be included as COL information items. Procedures and maintenance programs are to be completed before fuel is loaded for commissioning.

b. Complete documentation of design, construction, design modifications, field changes, and operations is to be maintained by the COL applicant. Documentation requirements are included as a COL Information item.

Site Radiological Environmental Monitoring

The CM system is designed to provide continuous monitoring of containment integrity. The instruments do not process or generate radioactive wastes that contribute to contamination of the facility or the environment. Hence, the CM system is in compliance with RG 4.21. A site-wide radiological environmental monitoring program is to be included to monitor the onsite hydrogeology and the potential effects of operation of the plant by the COL applicant.

6.2.5.3 Design Evaluation

The PARs and HIs are designed to automatically control or allow adiabatic controlled burning of hydrogen at low concentrations to preclude hydrogen concentration buildup to detonable levels. The system is designed to prevent the average hydrogen concentration in the containment from reaching 10 percent by volume during a core accident with 100 percent fuel clad metal-water reaction in accordance with 10 CFR 50.44.

Thirty PARs and 8 HIs are distributed throughout the containment. The PARs reduce hydrogen when the concentration of hydrogen is low (less than 1 percent) and when the concentration of steam is high. The PARs can reduce uniformly distributed hydrogen concentration to 10 percent by volume at the early stage of accident progression. The HIs

are installed where high hydrogen release rates are anticipated or where large amounts of hydrogen can be transferred to other compartments and maintain a hydrogen concentration below 10 percent by volume.

The accuracy of the hydrogen monitor is less than or equal to ±10 percent of the full span. The measured hydrogen concentration is used for operator actions, and the monitor accuracy is sufficient for the actions.

The analysis results using the MAAP code (version 4.0.8) demonstrates that containment integrity is maintained during the combustion of hydrogen and that the containment hydrogen concentration is not greater than 10 percent by volume. The analysis results and equipment survivability of the PARs and HIs are described in Section 19.2.

The hydrogen capacity for severe accident can also accommodate the hydrogen generated during all DBAs since the level of generation rate and total mass for DBA are relatively lower than those of severe accident.

The mixing is achieved by natural convection processes. Natural convection occurs as a result of the temperature difference between the bulk gas space inside the containment and the containment wall. In case of a pipe break at a lower compartment in the containment, the buoyancy force is developed by the density difference between the lower compartment and the upper operating deck. This force causes the steam and air in both regions to mix. Through the operating deck opening, upstream steam in this area drives the mixing in the containment, which is the main physical mixing mechanism. Thus, natural flow supports air mixing in the containment atmosphere. As a result, natural flow causes air mixing in the containment atmosphere.

6.2.5.4 Tests and Inspections

6.2.5.4.1 Preservice Testing

Preoperational tests are conducted to verify the proper operation of the PARs. The preoperational tests are also conducted to verify the fulfillment of the H_2 depletion rate with equal to or larger than the minimum depletion rate shown in the performance warranty.

Preoperational testing and inspection of the HIs are performed after installation and prior to plant startup to verify the operability of the HIs.

The verification confirms that the surface temperature of the HIs meets or exceeds the hydrogen ignition temperature, thereby providing reasonable assurance of the ignition of hydrogen concentrations above the flammability limit.

Preoperational tests are conducted to verify the proper operation of the hydrogen monitoring system. The preoperational tests are also conducted to perform either before or after installation but prior to plant startup to verify performance. The hydrogen monitor test and design criteria, including those listed in NRC RG 1.7, are incorporated into the hydrogen monitor procurement specifications. Following completion of fabrication, the hydrogen monitor acceptance tests are conducted with known samples. The hydrogen monitor is required to reflect operating experience on it. Test results are collected, checked, and evaluated in a report and reviewed to verify the performance capability of the hydrogen monitor.

6.2.5.4.2 In-service Testing

The PARs are designed for surveillance testing by sampling the required number of catalyst cartridges with the PAR in-service inspection equipment at each refueling outage.

Periodic inspection and testing are performed to confirm the continued operability of the HIs. Operability testing consists of energizing the hydrogen igniters and confirming that the surface temperature meets or exceeds the hydrogen ignition temperature, thereby providing reasonable assurance of the ignition of hydrogen concentrations above the flammability limit.

Periodic testing and inspection are performed to confirm the continued operability of the hydrogen monitoring system. The testing and inspection for hydrogen monitor is performed in accordance with the requirement of NRC RG 1.7.

6.2.5.5 Instrumentation Requirements

HI "on-off" status is displayed in the MCR and RSR and the local panel in the auxiliary building. An abnormal or trouble alarm for HIs is provided in the MCR and RSR to warn the operators of malfunctioning HIs. The containment hydrogen monitor continuously indicates hydrogen concentration in the MCR.

6.2.6 Containment Leakage Testing

The reactor containment, containment penetrations, and containment isolation barriers are designed to permit periodic leakage rate testing as required by GDC 52, 53, and 54 (References 34 through 36). The containment integrated leakage rate test (CILRT) conforms with 10 CFR Part 50, Appendix J, Option B (Reference 37), and follows the guidance of NRC RG 1.163. The test is performed in accordance with NEI 94-01 and ANSI/ANS 56.8

Types A, B, and C tests are described in Subsections 6.2.6.1, 6.2.6.2, and 6.2.6.3, respectively.

6.2.6.1 Containment Integrated Leakage Rate Test (Type A)

The design leakage rate for the containment is 0.1 percent free volume per day at the DBA pressure. During the test, the containment is isolated and pressurized in accordance with NEI 94-01 and ANSI/ANS 56.8. The acceptance criteria specified in NEI 94-01 and ANSI/ANS 56.8 for the CILRT include a margin for possible deterioration of the containment leakage integrity during the service intervals between tests. Therefore, the measured leak rate (L_{am} at peak test pressure, P_a) is limited to less than 0.75 of the maximum allowable value (L_a).

The following are required prior to the CILRT performance.

a. Normally, the CILRT is performed following the satisfactory completion of a series of local leakage rate tests. Local leakage rate tests, in which potential leakage paths through the containment boundary (i.e., containment penetrations) are subjected to test conditions similar to those occurring during the CILRT, allow

detection and correction of leak paths through the containment without pressurizing the entire containment structure. These local leakage rate tests are the Type B and C tests described in Subsections 6.2.6.2 and 6.2.6.3.

b. The accessible interior and exterior surfaces of the containment structures and components are inspected for any evidence of structural deterioration that may affect either the containment structural integrity or leak-tightness. Any evidence of structural deterioration is corrected before the Type A test is performed.

c. Following the completion of the Type C tests, the containment isolation valves are positioned to their normal operational position and subsequently repositioned to their post-accident position by normal methods with no accompanying adjustment. The normal and post-accident positions of the containment isolation valves are listed in Table 6.2.4-1.

d. During preoperational testing, a structural integrity test is performed prior to the CILRT.

e. Test instruments are calibrated prior to the CILRT.

The pathways of venting and draining are established as follow:

a. Systems that are isolated following a LOCA are properly isolated, drained, or vented to reflect their worst potential status to provide reasonable assurance that the Type A test results reflect LOCA conditions.

b. Portions of the fluid systems that are a part of the reactor coolant pressure boundary and are opened directly to the containment atmosphere due to the accident conditions.

c. Portions of the closed systems inside the containment that penetrate the containment and could be postulated to rupture as a result of a LOCA are vented to the containment atmosphere.

d. All vented systems are drained of water or other fluids to the extent necessary to provide reasonable assurance exposure of the system containment isolation valves to the containment air test pressure and to provide reasonable assurance that the containment isolation valves are subjected to the maximum post-accident differential pressure.

e. Systems that are required to maintain the plant in a safe condition during the test are operable in their normal mode and need not be vented. However, the containment isolation valves are tested in accordance with Type C test requirements.

f. Systems that are normally filled with water and operating under post-accident conditions, such as the containment heat removal system, are not vented.

g. Portions of the pathways outside containment that are designed to seismic Category I and at least safety Class 2 need not be vented.

h. Exceptions to pathways of venting and draining leakage during CILRT are as specified ANSI/ANS-56.8 and NEI 94-01.

The CILRT is conducted in accordance with ANSI/ANS-56.8 and NEI 94-01. The containment is slowly pressurized with clean air using temporary air compressors and dryers.

When the test pressure is reached, the containment is isolated from its pressure source, and after average containment temperature has been stabilized, the following parameters are recorded at periodic intervals:

a. Containment absolute pressure

b. Dry bulb temperatures

c. Water vapor pressures

d. Outside containment weather conditions

During the test, ventilation inside the containment is operated as necessary to enhance an even air temperature distribution. The test data are processed at periodic intervals during the test to determine test status and leak-tight confidence level. If it appears that the leakage is excessive, the pressure plateau is either maintained on the test or aborted to perform repairs. After a prescribed period, a precisely measured leak-rate is imposed on containment. The known leakage is compared to the leakage data obtained before imposition of the leak rate. The correlation between the two leakages establishes the validity of the containment leakage rate. Containment is then slowly depressurized. Formulas used in computing the integrated leakage rate are based on the formulas in NEI 94-01 and ANSI/ANS 56.8, "Containment System Leakage Testing Requirement."

If the CILRT fails to meet acceptance criteria, the reasons for failure are identified and the test schedule for subsequent tests is adjusted in accordance with CFR 50, Appendix J, Option B, and the guidance of NRC RG 1.163.

The test methods that are used for preoperational and periodic Type A tests are the same except for possible minor differences in the post-operational system alignments.

The operator can perform a periodic check for gross leakage of containment atmosphere during normal operation.

The combined license (COL) applicant is to identify the implementation milestone for the CILRT program (COL 6.2(1)).

6.2.6.2 Containment Penetration Leakage Rate Test (Type B)

Type B leakage rate tests are performed in accordance with NEI 94-01 and ANSI/ANS-56.8. The test pressure, test frequencies, and acceptance criteria are specified. Leakage rates are determined by pressure loss or makeup flow methods.

The following containment penetrations are tested with a Type B test:

a. Personnel airlocks

b. Equipment hatch

c. Seal on the fuel transfer tube flange (containment end)

d. Electrical penetrations

The test pressure for Type B tests is the calculated peak pressure for the containment, P_a. The test equipment utilized to perform the Type B tests is the same equipment used for Type C tests. The combined leakage rate for all Type B and C tests is less than 0.6 L_a. The individual allowable leakage rates and testing performed on the Type B penetrations are described in the Technical Specifications, Chapter 16.

6.2.6.3 Containment Isolation Valve Leakage Rate Test (Type C)

Type C tests are conducted for containment isolation valves as specified in Table 6.2.4-1. The following criteria are used to determine which containment isolation valves will be subjected to the Type C test.

a. The penetrating system provides a direct connection between the inside and outside atmospheres of the containment under normal operation.

b. The system is isolated by containment isolation valves, which close automatically to effect containment isolation in response to a CIAS or CSAS.

c. The system is not connected to the secondary side of the steam generators.

The test equipment to be used during the Type B and C tests consist of a connection to an air supply source, a pressure regulator, an absolute pressure gauge, a flow indicator, and associated valves, or equivalent. Isolation valves are positioned to their post-accident position by the normal method with no accompanying adjustments. Fluid systems are properly drained and vented with the valves aligned to provide a test volume on the isolation valves being tested. For valves that are Type C leak tested, the Type C tests are performed by local pressurization. The pressure is applied in the same direction as that when the valve would be required to perform its safety function, unless it can be determined that a pressure applied in a different direction provides an equivalent or more conservative results.

The test volume is pressurized to the test pressure, P_a, as specified in Technical Specifications. The pressure regulator maintains the test volume at a minimum of P_a. The airflow rate into the test volume is recorded, as is the pressure reading, at the intervals specified on the data form. Fixed test connections used for Type C testing are shown on the respective system flow diagrams.

Type C test methods and techniques are consistent with NEI 94-01 and ANSI/ANS-56.8. The combined leakage rate for all penetrations and valves test are less than 0.6 L_a.

6.2.6.4 Scheduling and Reporting of Periodic Tests

Periodic Type A, B, and C leakage rate tests are performed in which the requirements of the schedule and report contents are in accordance with NRC RG 1.163, which endorses NEI 94-01. The preoperational and periodic Type A, B, and C test report contains a schematic of the leak measuring system, instrumentation used, supplemental test method, and test program.

6.2.6.5 Special Testing Requirements

The APR1400 design does not have a subatmospheric primary containment or a secondary containment or isolation valve seal systems and fluid-filled systems, and there are therefore no special testing requirements beyond the testing described in Subsections 6.2.6.1 through 6.2.6.4.

6.2.7 Fracture Prevention of Containment Pressure Vessel

The ferritic materials of carbon steel liner plate, carbon steel, and low alloy steel attachments and appurtenances identified in ASME Section III, Division 2, meet the fracture toughness criteria of ASME Section III, Division 2, Article CC 2520. The ferritic materials used for attachments and appurtenances identified in ASME Section III, Division 1 (Reference 38), meet the fracture toughness criteria of ASME Section III, Division 1, Article NE 2300 (Reference 39).

6.2.8 Combined License Information

COL 6.2(1) The COL applicant is to identify the implementation milestone for the CILRT program.

6.2.9 References

1. APR1400-E-N-NR-14001-P (Proprietary) & NP (Non-Proprietary), “Design Features to Address GSI-191,” Rev. 0, KHNP, December 2014.

2. GOTHIC Thermal Hydraulic Analysis Package User Manual, Version 8.0(QA), NAI 8907-02, Rev. 20, Numerical Applications, Inc., January 2012.

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Table 6.2.1-1 (1 of 2)

Spectrum of Postulated Accidents

Containment Pressure and Temperature Analyses

Loss-of-Coolant Accident (LOCA)	SIS Condition	Break Area, m^2 (ft^2)
Double Ended Suction Leg Slot Break (DESLSB)	Maximum SI Flow Minimum SI Flow	0.9121 (9.8175) 0.9121 (9.8175)
Double Ended Discharge Leg Slot Break (DEDLSB)	Maximum SI Flow Minimum SI Flow	0.9121 (9.8175) 0.9121 (9.8175)
Double Ended Hot Leg Slot Break (DEHLSB)	N/A	1.7877 (19.2423)
Main Steam Line Break (MSLB)	ESF Condition	Break Area, m^2 (ft^2)
MSLB at 102 % Power	Loss of One CSS Train MSIV Failure	0.849 (9.134) 0.849 (9.134)
MSLB at 75 % Power	Loss of One CSS Train MSIV Failure	0.849 (9.134) 0.849 (9.134)
MSLB at 50 % Power	Loss of One CSS Train MSIV Failure	0.849 (9.134) 0.849 (9.134)
MSLB at 20 % Power	Loss of One CSS Train MSIV Failure	0.818 (8.8) 0.818 (8.8)
MSLB at 0 % Power	Loss of One CSS Train MSIV Failure	0.381 (4.1) 0.381 (4.1)

Table 6.2.1-1 (2 of 2)

Subcompartment Pressure Analyses

Area	Break Area, m^2 (ft^2)
Steam Generator Subcompartment	
Feedwater Economizer Nozzle Break	0.07072 (0.7612)
Feedwater Downcomer Nozzle Break	0.01682 (0.1810)
Steam Generator Blowdown Nozzle Break	0.01682 (0.1810)
Pressurizer Subcompartment	
POSRV Nozzle Break	0.03044 (0.3276)
Pressurizer Spray Nozzle Break	0.00599 (0.0645)
Pressurizer Spray Valve Room	
Pressurizer Spray Line Break	0.003489 (0.03755)
Regenerative Heat Exchanger Room	
CVCS Letdown Line Break	0.001446 (0.01556)
Letdown Heat Exchanger Room	
CVCS Letdown Line Break	0.001446 (0.01556)
Letdown Heat Exchanger Valve Room	
CVCS Letdown Line Break	0.001446 (0.01556)

Table 6.2.1-2

Calculated Values for Containment and Subcompartment Pressure Parameters

Parameter	Design Basis Accident	Peak Calculated Value
Containment Maximum Pressure, kg/cm^2 (psig)	LOCA DEDLSB with Max. SI Flow	3.59 (51.09)
Containment Maximum Atmosphere Temperature, ^{o}C (^{o}F)	MSLB 102 % power with an MSIV Single Failure	167.45 (333.41)
Containment Maximum Saturated Temperature, ^{o}C (^{o}F)	LOCA DEDLSB with Max. SI Flow	134.59 (274.25)
Containment Maximum External Pressure, kg/cm^2 (psig)	Inadvertent Operation of CS System	0.25 (3.54)

Peak Subcompartment Differential Pressure		kg/cm^2 (psid)
SG Subcompartment	Economizer Nozzle Break	0.653 (9.281)
Pressurizer Subcompartment	POSRV Nozzle Break	0.582 (8.284)
Pressurizer Spray Valve Room	Pressurizer Spray Line Break	0.730 (10.388)
Regenerative Heat Exchanger Room	CVCS Letdown Line Break	0.138 (1.964)
Letdown Heat Exchanger Room	CVCS Letdown Line Break	0.070 (0.999)
Letdown Heat Exchanger Valve Room	CVCS Letdown Line Break	0.154 (2.186)

Table 6.2.1-3

Principal Containment Design Parameters

Parameter	Design Value	Margin(1)
Containment		
Internal design pressure, kg/cm^2 (psig)	4.22 (60.0)	14.8 %
External design pressure, kg/cm^2 (psig)	0.28 (4.0)	11.4 %
Containment design temperature, °C (°F)	143.3 (290.0) (2)	8.75 (15.75) (3)
Internal dimension		
Diameter of cylinder, m (ft)	45.72 (150.0)	N/A
Net free volume, m^3 (ft^3) (4)	8.8576×10^4 (3.128×10^6)	-1.0 %
Design leakage rate (% free volume/day)		
First 24 hours	0.1	N/A
After 1 day	0.05	N/A
Subcompartment (5)		
Steam generator, kg/cm^2 (psid)	0.914 (13.0)	40 %
Pressurizer, kg/cm^2 (psid)	0.844 (12.0)	45 %
Pressurizer spray valve, kg/cm^2 (psid)	1.055 (15.0)	44 %
Regen. heat exchanger, kg/cm^2 (psid)	0.211 (3.0)	53 %
Letdown heat exchanger, kg/cm^2 (psid)	0.141 (2.0)	100 %
Letdown heat exchanger valve, kg/cm^2 (psid)	0.281 (4.0)	83 %

(1) Margin between design limit and calculated peak value

(2) Containment design temperature (allowable maximum surface temperature of liner plate in containment).

(3) Difference between the containment design temperature and maximum saturated temperature in LOCA or MSLB accidents

(4) The net free volume does not include the IRWST volume.

(5) Design differential pressure in subcompartment (%)

Table 6.2.1-4 (1 of 23)

Double-Ended Suction Leg Slot Break – Maximum SIS Flow
(0.9121 m^2 (9.8175 ft^2) Total Break Area)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.000	0.00	0.00	0.00	0.00
0.027	35,826.69	78,984.75	310.61	559.13
0.054	35,499.95	78,264.39	310.08	558.18
0.103	35,936.95	79,227.82	309.90	557.85
0.152	49,099.29	108,245.97	310.38	558.72
0.202	47,285.37	104,246.94	311.04	559.91
0.252	45,576.63	100,479.79	311.57	560.85
0.298	44,683.04	98,509.75	311.94	561.52
0.351	44,779.94	98,723.38	312.17	561.94
0.400	44,346.29	97,767.34	312.52	562.56
0.603	43,478.91	95,855.09	313.48	564.30
0.800	44,864.47	98,909.74	314.64	566.38
1.000	42,167.46	92,963.82	315.74	568.36
1.202	40,552.76	89,404.00	317.33	571.22
1.401	38,527.59	84,939.24	319.05	574.33
1.607	38,152.42	84,112.13	320.39	576.73
1.800	37,859.70	83,466.78	321.87	579.40
2.001	37,500.04	82,673.88	323.76	582.80
2.204	35,984.54	79,332.74	325.55	586.03
2.407	33,372.26	73,573.62	326.50	587.73
2.601	31,669.84	69,820.41	327.91	590.27
2.812	30,653.27	67,579.23	330.85	595.57
3.008	29,668.44	65,408.05	334.73	602.56
3.208	28,297.64	62,385.94	340.03	612.09
3.408	26,715.66	58,898.26	346.75	624.19

Table 6.2.1-4 (2 of 23)

Part A. Mass and Energy Release Data (Blowdown Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
3.608	24,966.73	55,042.51	354.00	637.23
3.808	23,497.04	51,802.38	360.32	648.62
4.000	22,127.47	48,782.98	365.48	657.89
4.211	21,436.30	47,259.20	366.85	660.37
4.409	21,008.90	46,316.93	366.71	660.11
4.609	20,598.55	45,412.26	366.16	659.12
4.809	20,267.22	44,681.81	365.67	658.24
5.009	20,051.87	44,207.03	364.92	656.90
5.209	19,841.27	43,742.73	364.35	655.86
5.409	19,815.87	43,686.73	363.56	654.45
5.609	19,693.35	43,416.63	363.47	654.28
5.809	19,144.10	42,205.74	364.81	656.69
6.009	18,734.91	41,303.63	365.84	658.55
6.209	18,566.23	40,931.75	365.82	658.51
6.409	18,595.07	40,995.33	363.92	655.09
6.609	18,479.62	40,740.79	363.55	654.43
6.809	17,933.49	39,536.78	366.91	660.48
7.009	17,132.26	37,770.38	372.47	670.48
7.209	16,620.46	36,642.04	375.29	675.57
7.409	16,372.62	36,095.63	375.88	676.62
7.609	16,206.97	35,730.45	376.05	676.92
7.809	16,191.18	35,695.62	374.41	673.98
8.009	16,125.16	35,550.08	373.73	672.75
8.209	15,915.11	35,086.98	374.73	674.55
8.409	15,680.94	34,570.74	375.85	676.56
8.609	15,427.32	34,011.60	377.17	678.94
8.809	15,141.74	33,381.99	378.82	681.91
9.005	14,809.07	32,648.58	380.75	685.38

Table 6.2.1-4 (3 of 23)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
9.204	14,527.77	32,028.41	382.90	689.26
9.400	14,196.28	31,297.60	385.45	693.86
9.608	13,797.32	30,418.04	387.37	697.31
9.801	13,391.38	29,523.09	391.81	705.30
10.004	13,129.00	28,944.65	395.88	712.62
10.205	12,765.77	28,143.85	399.12	718.46
10.404	12,429.45	27,402.39	401.76	723.21
10.603	11,985.20	26,422.98	406.03	730.90
10.799	11,582.15	25,534.40	412.05	741.74
11.004	11,140.57	24,560.87	417.73	751.96
11.205	10,637.22	23,451.17	423.35	762.07
11.406	10,190.47	22,466.27	428.61	771.53
11.601	9,728.82	21,448.50	433.53	780.39
11.804	9,042.09	19,934.50	445.87	802.61
12.006	8,756.29	19,304.41	452.29	814.16
12.205	8,377.30	18,468.88	457.85	824.18
12.406	8,013.92	17,667.76	463.75	834.79
12.599	7,657.53	16,882.05	469.08	844.38
12.806	7,397.99	16,309.86	475.41	855.78
13.005	7,153.35	15,770.51	476.56	857.85
13.213	6,944.67	15,310.45	475.99	856.84
13.413	6,730.23	14,837.69	477.18	858.98
13.613	6,534.48	14,406.13	479.25	862.71
13.813	6,358.64	14,018.47	480.50	864.96
14.013	6,188.02	13,642.32	481.42	866.61
14.203	5,966.42	13,153.78	482.94	869.34
14.409	5,852.22	12,902.00	478.07	860.57
14.616	5,895.97	12,998.45	457.84	824.16

Table 6.2.1-4 (4 of 23)

Part A. Mass and Energy Release Data (Blowdown Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
14.816	5,885.88	12,976.22	441.01	793.86
15.016	5,839.74	12,874.49	431.85	777.37
15.214	5,717.91	12,605.89	425.51	765.97
15.409	5,579.03	12,299.72	419.00	754.25
15.609	5,389.08	11,880.96	415.55	748.04
15.809	5,183.01	11,426.64	413.16	743.74
16.009	4,939.96	10,890.80	411.96	741.57
16.200	4,374.29	9,643.72	443.96	799.17
16.400	4,198.25	9,255.61	443.34	798.06
16.601	4,077.66	8,989.74	441.21	794.23
16.800	3,932.45	8,669.61	438.05	788.53
17.001	3,815.63	8,412.08	433.55	780.43
17.205	3,707.03	8,172.64	424.86	764.79
17.400	3,576.74	7,885.40	419.56	755.24
17.600	3,431.20	7,564.54	416.49	749.73
17.800	3,384.27	7,461.08	407.89	734.25
18.000	3,343.38	7,370.94	401.24	722.27
18.200	3,122.01	6,882.88	401.21	722.22
18.400	3,066.26	6,759.98	391.83	705.34
18.600	2,962.81	6,531.92	382.50	688.54
18.802	2,774.26	6,116.24	381.33	686.43
18.999	2,608.38	5,750.52	378.21	680.83
19.203	2,546.44	5,613.97	383.68	690.67

Integral Mass and Energy Release at End of Blowdown

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
19.203	304,940.875	672,283.090	110.483	438.461

Table 6.2.1-4 (5 of 23)

Part A. Mass and Energy Release Data (Reflood and Post-reflood Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
19.20	0.00	0.00	0.00	0.00
19.30	66.99	147.69	705.17	1,269.37
19.40	89.74	197.84	704.39	1,267.98
21.40	188.20	414.92	706.66	1,272.06
23.40	443.15	976.98	709.46	1,277.10
25.40	653.90	1,441.61	708.54	1,275.45
27.90	854.83	1,884.59	706.02	1,270.91
28.00	861.36	1,898.99	705.91	1,270.71
28.10	503.31	1,109.62	705.80	1,270.51
28.20	506.33	1,116.27	705.69	1,270.32
32.20	495.32	1,091.99	703.65	1,266.65
36.20	482.35	1,063.40	701.74	1,263.20
40.20	469.72	1,035.56	699.87	1,259.84
44.20	457.41	1,008.43	698.06	1,256.59
48.20	445.46	982.07	696.27	1,253.35
52.20	433.85	956.47	694.47	1,250.12
56.20	422.51	931.49	692.72	1,246.97
60.20	411.46	907.12	691.01	1,243.89
63.60	402.29	886.90	689.57	1,241.30
63.70	402.03	886.32	689.52	1,241.21
63.80	692.50	1,526.72	689.49	1,241.15
63.90	691.55	1,524.61	689.45	1,241.08
65.60	673.65	1,485.15	688.93	1,240.14
67.30	658.82	1,452.46	688.38	1,239.16
69.00	646.15	1,424.53	687.82	1,238.14
70.70	635.81	1,401.72	687.22	1,237.07
72.40	626.95	1,382.20	686.79	1,236.29
74.10	619.36	1,365.47	686.15	1,235.13

Table 6.2.1-4 (6 of 23)

Part A. Mass and Energy Release Data (Reflood and Post-reflood Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
75.80	612.76	1,350.91	685.48	1,233.94
77.50	606.95	1,338.10	684.81	1,232.73
79.20	601.78	1,326.70	684.12	1,231.49
80.90	597.13	1,316.46	683.42	1,230.23
82.90	592.23	1,305.65	681.49	1,226.76
83.00	585.05	1,289.83	668.58	1,203.50
83.10	610.73	1,346.43	679.60	1,223.34
83.20	560.47	1,235.63	669.16	1,204.56
83.30	597.41	1,317.06	668.14	1,202.71
83.40	589.89	1,300.49	668.27	1,202.95
85.40	499.76	1,101.78	670.44	1,206.86
87.40	454.05	1,001.02	671.43	1,208.65
89.40	419.27	924.34	672.14	1,209.92
91.40	389.59	858.91	672.76	1,211.03
93.40	363.41	801.18	673.34	1,212.09
95.40	339.97	749.51	673.92	1,213.12
97.40	318.87	702.99	674.47	1,214.11
99.40	299.77	660.89	675.01	1,215.08
101.40	282.41	622.62	675.53	1,216.03
103.40	266.57	587.69	676.05	1,216.96
105.40	252.05	555.68	676.56	1,217.87
107.40	238.70	526.25	677.05	1,218.77
109.40	226.39	499.10	677.54	1,219.65
110.10	222.30	490.09	677.71	1,219.95
110.20	221.72	488.82	677.74	1,220.00
110.30	221.15	487.55	677.77	1,220.06
111.30	216.37	477.02	676.39	1,217.57
112.30	116.80	257.51	698.56	1,257.48

Table 6.2.1-4 (7 of 23)

Part A. ass and Energy Release Data (Reflood and Post-reflood Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
113.30	209.65	462.21	675.49	1,215.95
114.30	130.05	286.71	692.61	1,246.78
115.30	188.18	414.87	677.48	1,219.54
116.30	261.60	576.73	669.01	1,204.29
117.30	256.62	565.75	668.68	1,203.69
118.30	247.62	545.92	668.71	1,203.75
119.30	234.21	516.34	669.12	1,204.48
120.30	224.89	495.80	669.30	1,204.81
121.30	217.46	479.43	669.39	1,204.97
122.30	212.74	469.02	669.32	1,204.85
123.30	213.77	471.29	668.89	1,204.06
124.90	94.67	208.72	690.29	1,242.59
125.00	76.66	169.01	703.26	1,265.94

Table 6.2.1-4 (8 of 23)

Integral Mass and Energy Release at the End of Reflood and Post-reflood

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
110.20	41,755.23	92,055.00	28.806	114.317
125.00	44,853.70	98,886.00	30.891	122.593

Part A. ass and Energy Release Data (Spillage)

Time (sec)	Integral Mass		Integral Energy	
	kg	Lbm	Million kcal	Million Btu
End of Blowdown at 19.203	0.00	0.00	0.000	0.000
End of Reflood at 110.20	44,613.87	98,357.25	10.694	42.439
End of Post-reflood at 125.00	56,206.13	123,913.96	12.367	49.079

Table 6.2.1-4 (9 of 23)

Part A. Mass and Energy (Steam) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	56.03	123.53	653.58	1176.45
599.9	52.8	116.41	653.25	1175.86
800.0	50.34	110.98	653.02	1175.44
999.0	48.23	106.33	652.84	1175.12
1503.3	44.15	97.33	652.53	1174.55
1996.8	41.12	90.65	652.32	1174.18
4002.6	33.89	74.72	651.91	1173.43
6001.4	30.28	66.76	651.69	1173.04
8000.6	28.11	61.98	651.56	1172.82
9990.3	26.62	58.68	651.48	1172.66
15005.7	24.3	53.58	651.33	1172.4
20011.4	22.88	50.45	651.16	1172.09
40036.7	19.95	43.98	650.42	1170.75
59963.5	18.43	40.64	649.67	1169.4
79990.5	17.48	38.53	649.08	1168.34
100002.0	14.51	31.98	647.91	1166.24
150010.0	12.81	28.25	646.49	1163.68
200018.5	11.71	25.81	645.78	1162.4
400053.2	9.2	20.29	644.5	1160.1
600094.9	7.86	17.32	643.87	1158.97
800141.2	6.98	15.4	643.5	1158.3
1000000.0	6.38	14.06	643.25	1157.86

Integral Mass and Energy(Steam) Release at 24hours after postulated accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,095	1,892,545	4,172,349	1,233.798	4,896.105
1,000,000	10,026,920	22,105,576	6,481.549	25,720.864

Table 6.2.1-4 (10 of 23)

Part A. Mass and Energy (Spillage) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	177.29	390.85	61.98	111.56
599.9	185.21	408.32	72.56	130.6
800.0	190.95	420.98	77.0	138.6
999.0	195.36	430.69	79.87	143.77
1503.3	202.54	446.53	85.32	153.57
1996.8	206.56	455.38	89.73	161.51
4002.6	212.4	468.26	102.2	183.95
6001.4	214.62	473.15	109.38	196.89
8000.6	215.72	475.59	113.68	204.62
9990.3	216.58	477.47	116.26	209.27
15005.7	218.08	480.79	119.07	214.32
20011.4	219.29	483.45	119.55	215.19
40036.7	222.57	490.69	116.79	210.23
59963.5	224.82	495.64	112.91	203.24
79990.5	226.39	499.11	109.68	197.43
100002.0	230.12	507.33	104.29	187.72
150010.0	233.44	514.66	95.1	171.19
200018.5	235.28	518.7	90.4	162.72
400053.2	238.93	526.76	81.43	146.58
600094.9	240.83	530.93	76.5	137.7
800141.2	242.0	33.52	73.4	132.13
1000000.0	242.8	535.29	71.26	128.26

Integral Mass and Energy(Spillage) Release at 24 hours after postulated accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,095	18,940,481	41,756,614	2,154.820	8,551.016
1,000,000	237,863,121	524,398,419	19,724.139	78,271.706

Table 6.2.1-4 (11 of 23)

Part B. eactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
0.000	167.36	2,380.40
0.027	159.52	2,268.90
0.054	147.05	2,091.50
0.103	125.06	1,778.70
0.152	126.83	1,804.00
0.202	126.45	1,798.60
0.252	125.82	1,789.60
0.298	125.29	1,782.10
0.351	123.83	1,761.30
0.400	123.02	1,749.70
0.603	120.51	1,714.00
0.800	118.85	1,690.50
1.000	117.11	1,665.70
1.202	114.64	1,630.50
1.401	112.52	1,600.40
1.607	111.04	1,579.30
1.800	109.75	1,561.00
2.001	108.13	1,538.00
2.204	106.14	1,509.70
2.407	104.53	1,486.80
2.601	104.06	1,480.10
2.812	102.49	1,457.80
3.008	100.88	1,434.90
3.208	99.02	1,408.40
3.408	97.55	1,387.50

Table 6.2.1-4 (12 of 23)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
3.608	95.48	1,358.10
3.808	93.41	1,328.60
4.000	91.91	1,307.30
4.210	90.07	1,281.10
4.409	88.60	1,260.20
4.609	87.41	1,243.20
4.809	86.24	1,226.60
5.009	85.01	1,209.10
6.209	80.24	1,141.30
6.409	79.48	1,130.40
6.609	78.88	1,121.90
6.809	78.27	1,113.30
7.009	77.62	1,104.00
7.209	76.94	1,094.40
7.409	76.32	1,085.50
7.609	75.57	1,074.90
7.809	74.87	1,064.90
8.009	74.23	1,055.80
8.409	72.92	1,037.20
8.809	71.62	1,018.70
9.204	70.32	1,000.20
9.608	69.01	981.57
10.004	67.70	962.86
10.404	66.32	943.31
10.799	64.73	920.61
11.205	62.25	885.43

Table 6.2.1-4 (13 of 23)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
11.601	59.92	852.22
12.006	58.14	826.88
12.205	55.99	796.34
12.406	55.20	785.18
12.599	53.98	767.78
12.806	52.89	752.32
13.005	51.83	737.15
13.213	50.66	720.49
13.413	49.62	705.72
13.613	48.60	691.24
14.816	40.78	579.98
15.016	39.48	561.58
15.214	37.97	540.09
15.409	36.72	522.26
15.609	35.32	502.42
15.809	34.01	483.72
16.009	32.71	465.30
16.200	31.56	448.93
16.400	30.45	433.14
16.601	29.23	415.81
16.800	28.03	398.63
17.001	26.77	380.75
17.205	25.49	362.53
17.400	24.24	344.80
17.600	23.00	327.17
17.800	21.78	309.80
18.000	20.54	292.11
18.200	19.37	275.52

Table 6.2.1-4 (14 of 23)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
18.400	18.22	259.10
18.600	17.10	243.28
18.802	15.99	227.49
18.999	14.94	212.46
19.203	15.92	226.38

Table 6.2.1-4 (15 of 23)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
19.20	4.080	58.000
19.30	4.120	58.590
19.40	4.180	59.510
21.40	4.530	64.410
23.40	6.230	88.590
25.40	8.150	115.870
27.90	10.220	145.340
28.00	10.290	146.340
28.10	10.360	147.320
28.20	10.410	148.060
32.20	10.140	144.220
36.20	9.860	140.200
40.20	9.590	136.350
44.20	9.330	132.690
48.20	9.080	129.180
52.20	8.850	125.830
56.20	8.620	122.630
60.20	8.410	119.570
63.60	8.230	117.070
63.70	8.230	117.000
63.80	8.220	116.890
63.90	8.210	116.740
65.60	8.030	114.210
67.30	7.880	112.120
69.00	7.760	110.340
70.70	7.650	108.870
72.40	7.570	107.640

Table 6.2.1-4 (16 of 23)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
74.10	7.490	106.550
75.80	7.420	105.580
77.50	7.360	104.720
79.20	7.310	103.950
80.90	7.260	103.240
82.90	7.210	102.480
83.00	7.210	102.510
83.10	7.160	101.780
83.20	7.190	102.270
83.30	7.150	101.690
83.40	7.130	101.460
85.40	7.000	99.570
87.40	6.810	96.830
89.40	6.610	94.080
91.40	6.440	91.530
93.40	6.270	89.210
95.40	6.120	87.100
97.40	5.990	85.190
99.40	5.870	83.440
101.40	5.750	81.840
103.40	5.650	80.380
105.40	5.560	79.030
107.40	5.470	77.780
109.40	5.390	76.630
110.10	5.360	76.240
110.20	5.360	76.190
110.30	5.350	76.140

Table 6.2.1-4 (17 of 23)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
111.30	5.180	73.710
112.30	5.330	75.740
113.30	5.040	71.660
114.30	5.240	74.590
115.30	5.000	71.140
116.30	4.820	68.490
117.30	4.760	67.680
118.30	4.710	67.060
119.30	4.680	66.550
120.30	4.650	66.080
121.30	4.610	65.640
122.30	4.590	65.240
123.30	4.560	64.890
124.90	4.640	65.970
125.00	4.750	67.560

Table 6.2.1-4 (18 of 23)

Part B. Reactor Vessel Pressure vs. Time (Decay heat Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
200.0	4.272	60.757
400.0	3.975	56.537
599.9	3.855	54.836
800.0	3.774	53.674
999.0	3.711	52.79
1503.3	3.604	51.266
1996.8	3.537	50.303
4002.6	3.404	48.419
6001.4	3.337	47.46
8000.6	3.298	46.904
9990.3	3.272	46.54
15005.7	3.228	45.912
20011.4	3.178	45.203
40036.7	2.967	42.204
59963.5	2.768	39.374
79990.5	2.623	37.304
100002.0	2.356	33.507
150010.0	2.066	29.381
200018.5	1.934	27.505
400053.2	1.718	24.434
600094.9	1.62	23.042
800141.2	1.565	22.257
1000000.0	1.529	21.749

Table 6.2.1-4 (19 of 23)

Part C. Safety Injection Flow vs. Time (Blowdown Period)

Time (sec)	Safety Injection Tank Flow	
	kg/sec	lbm/sec
0.000	0.00	0.00
0.027	0.00	0.00
13.813	0.00	0.00
14.013	0.00	0.00
14.203	1,281.21	2,824.60
14.409	1,690.48	3,726.90
14.616	1,989.35	4,385.80
14.816	2,357.62	5,197.70
15.016	2,555.71	5,634.40
15.214	2,769.58	6,105.90
15.409	2,934.41	6,469.30
15.609	3,097.38	6,828.60
15.809	3,236.55	7,135.40
16.009	3,362.73	7,413.60
16.200	3,451.73	7,609.80
16.400	3,536.73	7,797.20
16.601	3,639.88	8,024.60
16.800	3,738.76	8,242.60
17.001	3,845.63	8,478.20
17.205	3,957.26	8,724.30
17.400	4,061.17	8,953.40
17.600	4,159.33	9,169.80
17.800	4,253.59	9,377.60
18.000	4,351.61	9,593.70
18.200	4,434.98	9,777.50
18.400	4,517.85	9,960.20
18.600	4,594.41	10,129.00
18.802	4,668.35	10,292.00
18.999	4,740.47	10,451.00
19.203	4,496.26	9,912.60

Table 6.2.1-4 (20 of 23)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
19.203	3,140.51	6,923.66	328.55	724.33
19.303	3,128.73	6,897.71	328.55	724.33
21.303	2,898.47	6,390.06	328.12	723.38
23.303	2,609.51	5,753.00	325.77	718.20
25.303	2,312.95	5,099.22	323.05	712.21
27.303	2,031.18	4,478.00	320.57	706.73
28.003	1,939.29	4,275.41	319.82	705.09
28.103	1,926.52	4,247.28	319.72	704.87
31.603	1,750.66	3,859.57	319.86	705.18
35.103	1,619.26	3,569.87	320.22	705.97
38.603	1,509.04	3,326.87	320.56	706.72
42.103	1,415.35	3,120.33	320.89	707.45
45.603	1,334.88	2,942.92	321.21	708.15
49.103	1,265.14	2,789.18	321.51	708.82
52.603	1,204.31	2,655.06	321.81	709.47
56.103	1,150.94	2,537.40	322.09	710.09
59.603	1,103.87	2,433.64	322.36	710.68
63.603	1,056.60	2,329.42	322.66	711.34
63.703	1,055.50	2,326.99	322.66	711.35
63.803	478.11	1,054.06	322.67	711.37
63.903	478.29	1,054.45	322.68	711.39
68.403	493.13	1,087.18	323.27	712.68
72.903	496.10	1,093.72	323.63	713.49
77.403	493.39	1,087.74	323.89	714.05
81.903	487.90	1,075.64	324.08	714.48
86.403	497.54	1,096.88	324.53	715.47
90.903	515.58	1,136.65	325.14	716.81
95.403	527.71	1,163.41	325.65	717.93
99.903	534.86	1,179.17	326.05	718.83
104.403	538.52	1,187.24	326.39	719.57

Table 6.2.1-4 (21of 23)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
108.903	539.70	1,189.84	326.67	720.18
110.203	539.68	1,189.80	326.74	720.34
111.903	555.69	1,225.09	327.15	721.24
113.603	545.69	1,203.05	327.04	721.01
115.303	559.32	1,233.09	327.41	721.81
117.003	553.48	1,220.23	327.38	721.75
118.703	477.62	1,052.97	326.05	718.82
120.403	563.38	1,242.05	327.75	722.58
122.103	544.49	1,200.40	327.46	721.93
123.803	567.37	1,250.85	328.01	723.13
125.003	552.37	1,217.77	327.76	722.60
129.503	546.45	1,204.72	327.86	722.82
134.003	506.57	1,116.79	327.31	721.61
138.503	544.21	1,199.79	328.23	723.62
143.003	534.02	1,177.31	328.22	723.61
147.503	520.87	1,148.33	328.16	723.47
152.003	520.46	1,147.43	328.32	723.83
156.503	512.85	1,130.66	328.35	723.89
160.503	504.46	1,112.16	328.34	723.87
183.903	465.15	1,025.47	328.40	724.00
207.303	430.33	948.71	328.44	724.10
230.703	399.46	880.66	328.48	724.18
254.103	371.43	818.87	328.51	724.24
277.503	344.67	759.87	328.52	724.26
300.903	319.54	704.46	328.52	724.27
324.303	296.19	652.99	328.52	724.27
347.703	274.34	604.83	328.52	724.28
367.903	256.51	565.52	328.53	724.28
368.003	256.43	565.33	328.53	724.28
368.103	0.00	0.00	328.53	724.28

Table 6.2.1-4 (22 of 23)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
368.203	0.00	0.00	328.53	724.28
398.203	0.00	0.00	328.54	724.32
428.203	0.00	0.00	328.54	724.32
458.203	0.00	0.00	328.54	724.32
488.203	0.00	0.00	328.54	724.32
499.903	0.00	0.00	328.54	724.31
500.003	0.00	0.00	328.54	724.31

Table 6.2.1-4 (23 of 23)

Part D. Chronology of Events

Time (sec)	Event	Values
0.00	Break occurs	-
4.38	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
14.01	Start safety injection tank (SIT) injection	-
19.20	End of blowdown	-
19.21	Start SI pump injection	-
	First peak containment pressure (Blowdown phase)	3.126 kg/cm²G (44.47 psig)
63.70	SIT flow is turned down to low flow by fluidic device in SIT	-
101.91	Peak containment temperature	133.84 °C (272.91 °F)
102.51	Peak containment pressure	3.512 kg/cm²G (49.96 psig)
110.20	End of reflood	
114.38	Start containment spray actuation	
125.0	End of post reflood	-
368.10	Safety injection tank empty	-
57,660.1	Time of depressurization of the containment at 50% of peak pressure	1.756 kg/cm²G (24.97 psig)

Table 6.2.1-5 (1 of 25)

Double-Ended Suction Leg Slot Break – Minimum SIS Flow
(0.9121 m^2 (9.8175 ft^2) Total Break Area)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.000	0.00	0.00	0.00	0.00
0.027	35,826.69	78,984.75	310.61	559.13
0.054	35,499.95	78,264.39	310.08	558.18
0.103	35,936.95	79,227.82	309.90	557.85
0.152	49,099.29	108,245.97	310.38	558.72
0.202	47,285.37	104,246.94	311.04	559.91
0.252	45,576.63	100,479.79	311.57	560.85
0.298	44,683.04	98,509.75	311.94	561.52
0.351	44,779.94	98,723.38	312.17	561.94
0.400	44,346.29	97,767.34	312.52	562.56
0.603	43,478.91	95,855.09	313.48	564.30
0.800	44,864.47	98,909.74	314.64	566.38
1.000	42,167.46	92,963.82	315.74	568.36
1.202	40,552.76	89,404.00	317.33	571.22
1.401	38,527.59	84,939.24	319.05	574.33
1.607	38,152.42	84,112.13	320.39	576.73
1.800	37,859.70	83,466.78	321.87	579.40
2.001	37,500.04	82,673.88	323.76	582.80
2.204	35,984.54	79,332.74	325.55	586.03
2.407	33,372.26	73,573.62	326.50	587.73
2.601	31,669.84	69,820.41	327.91	590.27
2.812	30,653.27	67,579.23	330.85	595.57
3.008	29,668.44	65,408.05	334.73	602.56

Table 6.2.1-5 (2 of 25)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
3.208	28,297.64	62,385.94	340.03	612.09
3.408	26,715.66	58,898.26	346.75	624.19
3.608	24,966.73	55,042.51	354.00	637.23
3.808	23,497.04	51,802.38	360.32	648.62
4.000	22,127.47	48,782.98	365.48	657.89
4.211	21,436.30	47,259.20	366.85	660.37
4.409	21,008.90	46,316.93	366.71	660.11
4.609	20,598.55	45,412.26	366.16	659.12
4.809	20,267.22	44,681.81	365.67	658.24
5.009	20,051.87	44,207.03	364.92	656.90
5.209	19,841.27	43,742.73	364.35	655.86
5.409	19,815.87	43,686.73	363.56	654.45
5.609	19,693.35	43,416.63	363.47	654.28
5.809	19,144.10	42,205.74	364.81	656.69
6.009	18,734.91	41,303.63	365.84	658.55
6.209	18,566.23	40,931.75	365.82	658.51
6.409	18,595.07	40,995.33	363.92	655.09
6.609	18,479.62	40,740.79	363.55	654.43
6.809	17,933.49	39,536.78	366.91	660.48
7.009	17,132.26	37,770.38	372.47	670.48
7.209	16,620.46	36,642.04	375.29	675.57
7.409	16,372.62	36,095.63	375.88	676.62
7.609	16,206.97	35,730.45	376.05	676.92
7.809	16,191.18	35,695.62	374.41	673.98

Table 6.2.1-5 (3 of 25)

Part A. Mass and Energy Release Data (Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
8.009	16,125.16	35,550.08	373.73	672.75
8.209	15,915.11	35,086.98	374.73	674.55
8.409	15,680.94	34,570.74	375.85	676.56
8.609	15,427.32	34,011.60	377.17	678.94
8.809	15,141.74	33,381.99	378.82	681.91
9.005	14,809.07	32,648.58	380.75	685.38
9.204	14,527.77	32,028.41	382.90	689.26
9.400	14,196.28	31,297.60	385.45	693.86
9.608	13,797.32	30,418.04	387.37	697.31
9.801	13,391.38	29,523.09	391.81	705.30
10.004	13,129.00	28,944.65	395.88	712.62
10.205	12,765.77	28,143.85	399.12	718.46
10.404	12,429.45	27,402.39	401.76	723.21
10.603	11,985.20	26,422.98	406.03	730.90
10.799	11,582.15	25,534.40	412.05	741.74
11.004	11,140.57	24,560.87	417.73	751.96
11.205	10,637.22	23,451.17	423.35	762.07
11.406	10,190.47	22,466.27	428.61	771.53
11.601	9,728.82	21,448.50	433.53	780.39
11.804	9,042.09	19,934.50	445.87	802.61
12.006	8,756.29	19,304.41	452.29	814.16
12.205	8,377.30	18,468.88	457.85	824.18
12.406	8,013.92	17,667.76	463.75	834.79
12.599	7,657.53	16,882.05	469.08	844.38
12.806	7,397.99	16,309.86	475.41	855.78
13.005	7,153.35	15,770.51	476.56	857.85
13.213	6,944.67	15,310.45	475.99	856.84

Table 6.2.1-5 (4 of 25)

Part A. Mass and Energy Release Data (Blowdown Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
13.413	6,730.23	14,837.69	477.18	858.98
13.613	6,534.48	14,406.13	479.25	862.71
13.813	6,358.64	14,018.47	480.50	864.96
14.013	6,188.02	13,642.32	481.42	866.61
14.203	5,966.42	13,153.78	482.94	869.34
14.409	5,852.22	12,902.00	478.07	860.57
14.616	5,895.97	12,998.45	457.84	824.16
14.816	5,885.88	12,976.22	441.01	793.86
15.016	5,839.74	12,874.49	431.85	777.37
15.214	5,717.91	12,605.89	425.51	765.97
15.409	5,579.03	12,299.72	419.00	754.25
15.609	5,389.08	11,880.96	415.55	748.04
15.809	5,183.01	11,426.64	413.16	743.74
16.009	4,939.96	10,890.80	411.96	741.57
16.200	4,374.29	9,643.72	443.96	799.17
16.400	4,198.25	9,255.61	443.34	798.06
16.601	4,077.66	8,989.74	441.21	794.23
16.800	3,932.45	8,669.61	438.05	788.53
17.001	3,815.63	8,412.08	433.55	780.43
17.205	3,707.03	8,172.64	424.86	764.79
17.400	3,576.74	7,885.40	419.56	755.24
17.600	3,431.20	7,564.54	416.49	749.73
17.800	3,384.27	7,461.08	407.89	734.25
18.000	3,343.38	7,370.94	401.24	722.27
18.200	3,122.01	6,882.88	401.21	722.22
18.400	3,066.26	6,759.98	391.83	705.34
18.600	2,962.81	6,531.92	382.50	688.54

Table 6.2.1-5 (5 of 25)

Part A. Mass and Energy Release Data
(Blowdown Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
18.802	2,774.26	6,116.24	381.33	686.43
18.999	2,608.38	5,750.52	378.21	680.83
19.203	2,546.44	5,613.97	383.68	690.67

Integral Mass and Energy Release at End of Blowdown

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
19.203	304,940.875	672,283.090	110.483	438.461

Table 6.2.1-5 (6 of 25)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
19.20	0.00	0.00	0.00	0.00
19.30	65.68	144.80	705.18	1,269.39
19.40	87.02	191.85	704.39	1,267.97
21.40	170.74	376.42	706.26	1,271.34
23.40	419.58	925.02	709.42	1,277.03
25.40	619.99	1,366.86	708.76	1,275.85
27.40	778.07	1,715.35	707.06	1,272.79
28.70	857.72	1,890.96	705.73	1,270.38
28.80	863.10	1,902.81	705.62	1,270.19
28.90	503.65	1,110.37	705.52	1,270.00
29.00	505.52	1,114.49	705.44	1,269.86
31.60	498.21	1,098.37	704.10	1,267.45
34.20	489.69	1,079.58	702.84	1,265.19
36.80	481.32	1,061.13	701.61	1,262.97
39.40	473.10	1,043.01	700.39	1,260.78
42.00	465.01	1,025.18	699.21	1,258.65
44.60	457.06	1,007.65	698.04	1,256.54
47.20	449.25	990.44	696.87	1,254.44
49.80	441.62	973.60	695.70	1,252.32
52.40	434.10	957.04	694.53	1,250.23
55.00	426.71	940.73	693.39	1,248.18
57.60	419.43	924.69	692.26	1,246.14
60.20	412.26	908.89	691.15	1,244.15
62.80	405.21	893.35	690.05	1,242.17
63.50	403.34	889.22	689.76	1,241.64
63.60	403.08	888.64	689.71	1,241.55

Table 6.2.1-5 (7 of 25)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
63.70	694.36	1,530.82	689.67	1,241.48
63.80	692.95	1,527.70	689.65	1,241.44
65.80	657.80	1,450.20	689.31	1,240.84
67.80	630.07	1,389.08	688.92	1,240.13
69.80	608.00	1,340.42	688.47	1,239.32
71.80	590.18	1,301.12	687.98	1,238.43
73.80	575.37	1,268.47	687.45	1,237.48
75.80	563.31	1,241.90	686.89	1,236.47
77.80	553.13	1,219.46	686.47	1,235.71
79.80	544.50	1,200.42	685.85	1,234.59
81.80	537.04	1,183.98	685.21	1,233.44
83.80	530.52	1,169.61	684.54	1,232.25
85.80	524.76	1,156.91	683.86	1,231.02
87.80	519.59	1,145.50	683.16	1,229.76
88.90	516.95	1,139.68	672.96	1,211.39
89.00	525.76	1,159.11	680.79	1,225.48
89.10	495.84	1,093.15	669.18	1,204.58
89.20	527.09	1,162.03	668.18	1,202.79
89.30	518.51	1,143.13	668.37	1,203.13
89.50	499.05	1,100.23	668.91	1,204.10
91.50	435.44	959.98	670.65	1,207.24
93.50	397.17	875.61	671.58	1,208.92
95.50	367.63	810.48	672.25	1,210.11
97.50	342.26	754.56	672.83	1,211.17
99.50	319.79	705.03	673.38	1,212.16
101.50	299.61	660.52	673.92	1,213.12
103.50	281.37	620.31	674.44	1,214.07
105.50	264.82	583.83	674.95	1,214.98

Table 6.2.1-5 (8 of 25)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
107.50	249.75	550.60	675.45	1,215.87
109.50	235.97	520.22	675.94	1,216.76
111.50	223.33	492.36	676.42	1,217.62
113.50	211.70	466.73	676.89	1,218.48
115.50	200.98	443.09	677.35	1,219.30
117.00	193.47	426.53	677.70	1,219.93
117.10	192.98	425.46	677.72	1,219.97
117.20	192.50	424.39	677.75	1,220.02
118.20	160.97	354.88	682.73	1,228.99
119.20	433.91	956.61	663.25	1,193.93
120.20	94.59	208.53	701.96	1,263.60
121.20	173.41	382.31	677.72	1,219.96
122.20	132.67	292.49	686.52	1,235.80
123.20	515.95	1,137.48	661.26	1,190.33
124.20	506.65	1,116.98	660.92	1,189.72
125.20	394.68	870.13	662.55	1,192.66
126.20	128.13	282.47	683.18	1,229.79
127.50	101.43	223.61	688.12	1,238.68
127.60	76.44	168.52	702.72	1,264.96

Table 6.2.1-5 (9 of 25)

Integral Mass and Energy Release at the End of Reflood and Post-reflood

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
117.10	43,315.58	95,495.00	29.90	118.66
127.60	45,246.51	99,752.00	31.20	123.84

Part A. Mass and Energy Release Data (Spillage)

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
End of Blowdown at 19.203	0.00	0.00	0.000	0.000
End of Reflood at 117.10	37,408.24	82,471.48	10.018	39.759
End of Post-reflood at 127.60	44,170.94	97,380.76	10.994	43.632

Table 6.2.1-5 (10 of 25)

Part A. Mass and Energy (Steam) Release Data
(Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	55.48	122.32	653.63	1176.53
599.9	52.38	115.47	653.29	1175.92
800.0	50.09	110.44	653.05	1175.49
999.0	48.07	105.97	652.87	1175.16
1503.6	44.06	97.14	652.54	1174.58
1997.0	41.06	90.52	652.33	1174.2
4002.9	33.87	74.66	651.91	1173.43
6001.3	30.26	66.72	651.68	1173.02
8001.1	28.1	61.95	651.54	1172.77
9990.4	26.6	58.65	651.45	1172.61
15005.4	24.29	53.55	651.28	1172.3
20011.0	22.87	50.42	651.09	1171.96
40037.0	19.93	43.94	650.3	1170.54
59962.5	18.41	40.6	649.52	1169.14
79990.4	17.46	38.49	648.93	1168.07
100001.8	14.49	31.94	647.76	1165.97
150010.3	12.8	28.22	646.35	1163.42
200017.9	11.69	25.78	645.64	1162.15
400054.9	9.2	20.27	644.38	1159.88
600095.6	7.85	17.31	643.76	1158.77
800137.2	6.98	15.38	643.39	1158.11
1000000.0	6.37	14.04	643.15	1157.67

Integral Mass and Energy Release(Steam) at 24 hours after postulated accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,098	1,891,367	4,169,752	1,232.912	4,251.253
1,000,000	10,017,996	22,085,902	6,474.679	25,693.601

Table 6.2.1-5 (11 of 25)

Part A. Mass and Energy (Spillage) Release Data
(Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	114.97	253.46	59.55	107.19
599.9	123.26	271.74	70.19	126.35
800.0	129.43	285.34	75.27	135.48
999.0	134.09	295.61	78.45	141.21
1503.6	141.61	312.19	84.11	151.39
1997.0	145.79	321.42	88.59	159.46
4002.9	152.06	335.24	101.15	182.07
6001.3	154.55	340.72	108.32	194.97
8001.1	155.89	343.69	112.55	202.59
9990.4	156.84	345.77	115.07	207.12
15005.4	158.47	349.36	117.71	211.87
20011.0	159.7	352.07	118.05	212.5
40037.0	162.88	359.09	114.98	206.96
59962.5	164.95	363.66	110.95	199.7
79990.4	166.37	366.79	107.64	193.76
100001.8	169.84	374.43	102.19	183.95
150010.3	172.74	380.83	92.98	167.36
200017.9	174.37	384.41	88.27	158.89
400054.9	177.64	391.62	79.29	142.71
600095.6	179.33	395.35	74.35	133.84
800137.2	180.38	397.67	71.26	128.26
1000000.0	181.1	399.26	69.1	124.38

Integral Mass and Energy Release (Spillage) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,098	13,844,968	30,522,931	1,552.633	6,161.346
1,000,000	176,652,675	389,452,484	14,266.077	56,612.367

Table 6.2.1-5 (12 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
0.000	167.36	2,380.40
0.027	159.52	2,268.90
0.054	147.05	2,091.50
0.103	125.06	1,778.70
0.152	126.83	1,804.00
0.202	126.45	1,798.60
0.252	125.82	1,789.60
0.298	125.29	1,782.10
0.351	123.83	1,761.30
0.400	123.02	1,749.70
0.603	120.51	1,714.00
0.800	118.85	1,690.50
1.000	117.11	1,665.70
1.202	114.64	1,630.50
1.401	112.52	1,600.40
1.607	111.04	1,579.30
1.800	109.75	1,561.00
2.001	108.13	1,538.00
2.204	106.14	1,509.70
2.407	104.53	1,486.80
2.601	104.06	1,480.10
2.812	102.49	1,457.80
3.008	100.88	1,434.90

Table 6.2.1-5 (13 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
3.208	99.02	1,408.40
3.408	97.55	1,387.50
3.608	95.48	1,358.10
3.808	93.41	1,328.60
4.000	91.91	1,307.30
4.210	90.07	1,281.10
4.409	88.60	1,260.20
4.609	87.41	1,243.20
4.809	86.24	1,226.60
5.009	85.01	1,209.10
5.209	84.51	1,202.00
5.409	83.78	1,191.60
5.609	82.37	1,171.60
5.809	81.56	1,160.00
6.009	80.92	1,151.00
6.209	80.24	1,141.30
6.409	79.48	1,130.40
6.609	78.88	1,121.90
6.809	78.27	1,113.30
7.009	77.62	1,104.00
7.209	76.94	1,094.40
7.409	76.32	1,085.50
7.609	75.57	1,074.90

Table 6.2.1-5 (14 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
7.809	74.87	1,064.90
8.009	74.23	1,055.80
8.409	72.92	1,037.20
8.809	71.62	1,018.70
9.204	70.32	1,000.20
9.608	69.01	981.57
10.004	67.70	962.86
10.404	66.32	943.31
10.799	64.73	920.61
11.205	62.25	885.43
11.601	59.92	852.22
12.006	58.14	826.88
12.205	55.99	796.34
12.406	55.20	785.18
12.599	53.98	767.78
12.806	52.89	752.32
13.005	51.83	737.15
13.213	50.66	720.49
13.413	49.62	705.72
13.613	48.60	691.24
13.813	47.57	676.65
14.013	46.53	661.87
14.203	45.07	641.07
14.409	43.74	622.06
14.616	42.39	602.96

Table 6.2.1-5 (15 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
14.816	40.78	579.98
15.016	39.48	561.58
15.214	37.97	540.09
15.409	36.72	522.26
15.609	35.32	502.42
15.809	34.01	483.72
16.009	32.71	465.30
16.200	31.56	448.93
16.400	30.45	433.14
16.601	29.23	415.81
16.800	28.03	398.63
17.001	26.77	380.75
17.205	25.49	362.53
17.400	24.24	344.80
17.600	23.00	327.17
17.800	21.78	309.80
18.000	20.54	292.11
18.200	19.37	275.52
18.400	18.22	259.10
18.600	17.10	243.28
18.802	15.99	227.49
18.999	14.94	212.46
19.203	15.92	226.38

Table 6.2.1-5 (16 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
19.20	4.080	58.000
19.30	4.120	58.560
19.40	4.180	59.420
21.40	4.450	63.310
23.40	6.040	85.850
25.40	7.810	111.150
27.40	9.400	133.710
28.70	10.240	145.660
28.80	10.300	146.480
28.90	10.350	147.280
29.00	10.380	147.670
31.60	10.200	145.140
34.20	10.020	142.470
36.80	9.840	139.890
39.40	9.660	137.380
42.00	9.490	134.950
44.60	9.320	132.590
47.20	9.160	130.300
49.80	9.000	128.070
52.40	8.850	125.910
55.00	8.700	123.810
57.60	8.560	121.770
60.20	8.420	119.790
62.80	8.290	117.870

Table 6.2.1-5 (17 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
63.50	8.250	117.360
63.60	8.250	117.290
63.70	8.240	117.190
63.80	8.220	116.960
65.80	7.880	112.150
67.80	7.620	108.430
69.80	7.420	105.510
71.80	7.250	103.160
73.80	7.120	101.230
75.80	7.010	99.650
77.80	6.910	98.340
79.80	6.830	97.200
81.80	6.760	96.210
83.80	6.700	95.340
85.80	6.650	94.560
87.80	6.600	93.860
88.90	6.570	93.500
89.00	6.540	93.080
89.10	6.560	93.360
89.20	6.530	92.870
89.30	6.520	92.700
89.50	6.510	92.600
91.50	6.400	90.960
93.50	6.240	88.740
95.50	6.080	86.530

Table 6.2.1-5 (18 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
97.50	5.940	84.480
99.50	5.810	82.620
101.50	5.690	80.930
103.50	5.580	79.390
105.50	5.480	77.990
107.50	5.390	76.710
109.50	5.310	75.540
111.50	5.240	74.460
113.50	5.170	73.470
115.50	5.100	72.560
117.00	5.060	71.920
117.10	5.050	71.880
117.20	5.050	71.840
118.20	5.070	72.160
119.20	4.800	68.340
120.20	5.040	71.630
121.20	4.870	69.290
122.20	4.950	70.360
123.20	4.580	65.160
124.20	4.500	64.060
125.20	4.550	64.780
126.20	4.740	67.360
127.50	4.650	66.080
127.60	4.730	67.270

Table 6.2.1-5 (19 of 25)

Part B. Reactor Vessel Pressure vs. Time
(Decay heat Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
200.0	4.422	62.894
400.0	4.562	64.889
599.9	4.378	62.273
800.0	4.248	60.419
999.0	4.149	59.012
1504.4	3.981	56.621
1997.8	3.876	55.135
4005.0	3.66	52.063
6003.6	3.544	50.41
8004.3	3.471	49.373
9995.6	3.42	48.648
15005.7	3.332	47.387
20011.7	3.252	46.247
40038.3	2.976	42.328
59965.1	2.751	39.127
79991.5	2.594	36.896
100002.3	2.347	33.387
150010.0	2.067	29.403
200018.4	1.936	27.533
400054.2	1.719	24.455
600092.3	1.621	23.059
800133.9	1.566	22.273
1000000.0	1.53	21.764

Table 6.2.1-5 (20 of 25)

Part C. Safety Injection Flow vs. Time (Blowdown Period)

Time (sec)	Safety Injection Tank Flow	
	kg/sec	lbm/sec
0.000	0.00	0.00
0.027	0.00	0.00
13.813	0.00	0.00
14.013	0.00	0.00
14.203	1,281.21	2,824.60
14.409	1,690.48	3,726.90
14.616	1,989.35	4,385.80
14.816	2,357.62	5,197.70
15.016	2,555.71	5,634.40
15.214	2,769.58	6,105.90
15.409	2,934.41	6,469.30
15.609	3,097.38	6,828.60
15.809	3,236.55	7,135.40
16.009	3,362.73	7,413.60
16.200	3,451.73	7,609.80
16.400	3,536.73	7,797.20
16.601	3,639.88	8,024.60
16.800	3,738.76	8,242.60
17.001	3,845.63	8,478.20
17.205	3,957.26	8,724.30
17.400	4,061.17	8,953.40
17.600	4,159.33	9,169.80
17.800	4,253.59	9,377.60
18.000	4,351.61	9,593.70

Table 6.2.1-5 (21 of 25)

Part C. Safety Injection Flow vs. Time
(Blowdown Period)

Time (sec)	Safety Injection Tank Flow	
	kg/sec	lbm/sec
18.200	4,434.98	9,777.50
18.400	4,517.85	9,960.20
18.600	4,594.41	10,129.00
18.802	4,668.35	10,292.00
18.999	4,740.47	10,451.00
19.203	4,496.26	9,912.60

Table 6.2.1-5 (22 of 25)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
19.203	3,140.51	6,923.67	193.78	427.22
19.303	3,128.73	6,897.71	193.78	427.22
20.303	3,010.38	6,636.79	193.69	427.01
21.303	2,903.09	6,400.25	193.60	426.81
22.303	2,763.24	6,091.93	193.01	425.52
23.303	2,622.04	5,780.65	192.34	424.05
24.303	2,479.59	5,466.59	191.63	422.48
25.303	2,337.51	5,153.36	190.91	420.88
26.303	2,200.04	4,850.28	190.21	419.35
27.303	2,068.76	4,560.86	189.58	417.95
28.803	1,886.53	4,159.11	188.76	416.16
28.903	1,875.13	4,133.97	188.72	416.05
32.003	1,727.89	3,809.36	188.81	416.26
35.103	1,613.41	3,556.98	189.00	416.67
38.203	1,515.40	3,340.89	189.17	417.06
41.303	1,430.60	3,153.95	189.34	417.43
44.403	1,356.61	2,990.84	189.51	417.80
47.503	1,291.61	2,847.52	189.67	418.15
50.603	1,234.14	2,720.82	189.82	418.48
53.703	1,183.10	2,608.31	189.97	418.81
56.803	1,137.59	2,507.96	190.11	419.13
59.903	1,096.84	2,418.13	190.25	419.43
63.003	1,060.23	2,337.42	190.38	419.72
63.503	1,054.67	2,325.16	190.40	419.77
63.603	1,053.57	2,322.73	190.41	419.78
63.703	477.23	1,052.13	190.41	419.79
63.803	477.37	1,052.43	190.42	419.80
69.003	514.32	1,133.89	191.02	421.12
74.203	524.77	1,156.93	191.34	421.84

Table 6.2.1-5 (23 of 25)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
79.403	523.95	1,155.12	191.54	422.28
84.603	518.32	1,142.70	191.68	422.59
89.803	514.40	1,134.07	191.83	422.91
95.003	525.84	1,159.28	192.13	423.58
100.203	536.06	1,181.81	192.42	424.21
105.403	540.89	1,192.47	192.65	424.71
110.603	542.02	1,194.95	192.82	425.11
115.803	540.61	1,191.84	192.97	425.42
117.103	539.96	1,190.41	193.00	425.49
118.103	537.26	1,184.47	193.00	425.49
119.103	521.88	1,150.56	192.86	425.18
120.103	547.83	1,207.75	193.17	425.88
121.103	543.93	1,199.17	193.16	425.85
122.103	536.73	1,183.29	193.11	425.73
123.103	533.91	1,177.07	193.11	425.73
124.103	538.11	1,186.34	193.18	425.89
125.103	541.68	1,194.20	193.25	426.04
126.103	544.03	1,199.39	193.30	426.16
127.603	543.15	1,197.44	193.33	426.23
147.903	526.95	1,161.73	193.65	426.93
168.203	479.60	1,057.35	193.58	426.77
188.503	449.96	992.00	193.64	426.90
208.803	427.63	942.77	193.73	427.09
229.103	399.77	881.35	193.73	427.11
249.403	374.31	825.21	193.74	427.13
269.703	350.80	773.39	193.75	427.14
290.003	328.92	725.15	193.75	427.15

Table 6.2.1-5 (24 of 25)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
310.303	308.41	679.94	193.76	427.16
330.603	289.07	637.28	193.76	427.17
350.903	270.71	596.82	193.76	427.18
368.103	255.85	564.05	193.77	427.18
368.203	255.76	563.86	193.77	427.18
368.303	0.00	0.00	193.77	427.18
368.403	0.00	0.00	193.77	427.18
398.403	0.00	0.00	193.78	427.21
428.403	0.00	0.00	193.78	427.21
458.403	0.00	0.00	193.76	427.16
488.403	0.00	0.00	193.74	427.13
499.903	0.00	0.00	193.75	427.14
500.003	0.00	0.00	193.74	427.12

Table 6.2.1-5 (25 of 25)

Part D. Chronology of Events

Time (sec)	Event	Values
0.0	Break occurs	-
4.38	Containment pressure Hi-Hi setpoint	1.547kg/cm²G (22.0 psig)
14.01	Start safety injection tank (SIT) injection	-
19.20	End of blowdown	-
	Start SI pump injection	-
19.21	First peak containment pressure (Blowdown phase)	3.126kg/cm²G (44.47 psig)
63.70	SIT flow is turned down to low flow by fluidic device in SIT	-
104.21	Peak containment temperature	133.97 °C (273.14 °F)
104.61	Peak containment pressure	3.524kg/cm²G (50.12 psig)
114.38	Start containment spray actuation	-
117.10	End of reflood	-
127.60	End of post reflood	-
368.30	Safety injection tank empty	-
53,253.9	Time of depressurization of the containment at 50 % of peak pressure	1.761kg/cm²G (25.05 psig)

Table 6.2.1-6 (1 of 22)

Double-Ended Discharge Leg Slot Break – Maximum SIS Flow
(0.9121 m^2 (9.8175 ft^2) Break Area)

Part A. Mass and Energy Release Data (Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.000	0.00	0.00	0.00	0.00
0.026	35,570.66	78,420.29	309.67	557.44
0.051	36,255.06	79,929.15	309.62	557.34
0.102	52,155.38	114,983.53	310.08	558.17
0.150	54,241.46	119,582.56	310.69	559.27
0.205	53,118.19	117,106.18	311.20	560.19
0.251	53,000.48	116,846.67	311.46	560.66
0.303	52,555.82	115,866.36	311.68	561.06
0.355	51,903.33	114,427.86	311.78	561.23
0.455	51,283.34	113,060.99	311.86	561.38
0.548	50,839.80	112,083.15	311.87	561.40
0.655	50,335.08	110,970.43	311.89	561.44
0.751	49,799.01	109,788.59	311.92	561.50
0.850	49,295.77	108,679.14	311.98	561.60
0.952	48,985.60	107,995.33	312.09	561.80
1.256	45,974.67	101,357.32	312.52	562.57
1.500	44,806.61	98,782.18	313.10	563.62
1.749	42,469.15	93,628.95	313.84	564.95
2.001	40,547.50	89,392.40	314.75	566.58
2.253	39,075.65	86,147.52	315.77	568.41
2.513	37,917.46	83,594.12	316.79	570.25
2.753	37,135.87	81,871.00	317.79	572.06
3.013	35,641.45	78,576.37	318.70	573.69
3.253	34,354.67	75,739.48	319.39	574.94
3.513	33,446.63	73,737.59	320.70	577.29

Table 6.2.1-6 (2 of 22)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
3.753	32,136.20	70,848.55	322.26	580.11
4.013	30,679.12	67,636.23	324.09	583.39
4.513	28,504.55	62,842.10	327.42	589.38
5.013	26,227.90	57,822.93	331.03	595.89
5.513	24,545.92	54,114.76	337.02	606.67
6.013	21,825.68	48,117.64	349.22	628.64
6.513	17,987.35	39,655.52	376.16	677.13
7.013	13,886.23	30,614.05	428.08	770.59
7.505	12,225.23	26,952.15	454.34	817.86
8.014	11,663.92	25,714.69	459.62	827.36
8.513	11,152.79	24,587.83	461.97	831.59
9.013	10,759.50	23,720.77	463.01	833.46
9.513	9,894.04	21,812.74	479.71	863.53
10.013	8,931.05	19,689.70	504.97	908.99
10.513	8,006.74	17,651.93	528.35	951.08
11.013	6,975.26	15,377.90	556.89	1,002.46
11.513	5,926.46	13,065.67	588.71	1,059.75
12.013	5,345.95	11,785.86	593.54	1,068.43
12.513	6,618.02	14,590.32	460.05	828.14
13.013	7,205.45	15,885.38	405.88	730.62
13.513	7,216.60	15,909.95	378.11	680.64
14.009	7,049.69	15,541.99	356.91	642.47
14.507	6,840.23	15,080.21	336.96	606.56
15.017	6,604.21	14,559.86	319.10	574.41
15.257	6,493.95	14,316.78	311.68	561.06
15.503	6,334.92	13,966.18	305.12	549.25
15.753	6,086.67	13,418.88	297.94	536.33
16.008	6,015.11	13,261.12	289.68	521.46

Table 6.2.1-6 (3 of 22)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
16.257	5,794.29	12,774.28	281.39	506.53
16.505	5,416.53	11,941.46	273.92	493.08
16.753	4,955.88	10,925.90	268.62	483.55
17.007	4,447.82	9,805.81	263.22	473.82
17.251	3,984.08	8,783.44	258.14	464.68
17.500	3,606.06	7,950.04	253.32	456.00
17.750	3,263.42	7,194.64	248.40	447.14
18.000	3,088.10	6,808.13	245.86	442.57
18.249	1,743.93	3,844.73	240.28	432.53
18.509	1,671.14	3,684.24	240.44	432.82
18.752	1,508.29	3,325.24	243.71	438.70
19.002	1,297.66	2,860.86	243.27	437.91
19.254	1,091.70	2,406.81	244.26	439.70
19.508	882.79	1,946.23	247.16	444.92
19.752	678.35	1,495.51	254.14	457.48

Integral Mass and Energy Release at End of Blowdown

	Integral Mass		Integral Energy	
Time (sec)	kg	lbm	Million kcal	Million Btu
19.752	322,456.13	710,897.80	112.812	447.702

Table 6.2.1-6 (4 of 22)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
19.75	0.00	0.00	0.00	0.00
19.85	51.63	113.82	727.51	1,309.58
19.95	61.91	136.49	727.37	1,309.35
21.95	100.88	222.40	726.81	1,308.34
23.95	248.28	547.36	725.99	1,306.87
25.95	348.64	768.62	725.22	1,305.47
27.95	431.74	951.82	724.39	1,303.97
28.05	435.52	960.16	724.35	1,303.91
28.15	254.78	561.70	724.30	1,303.82
28.25	256.67	565.87	724.27	1,303.77
32.25	254.36	560.78	724.01	1,303.29
36.25	251.36	554.15	723.67	1,302.68
40.25	248.11	546.99	723.33	1,302.06
44.25	245.14	540.45	722.98	1,301.45
48.25	242.37	534.33	722.63	1,300.80
49.15	241.76	533.00	722.54	1,300.65
49.25	241.70	532.85	722.53	1,300.64
49.35	416.51	918.25	722.53	1,300.63
49.45	416.37	917.95	722.52	1,300.60
79.45	385.27	849.39	719.51	1,295.20
109.45	356.63	786.23	716.19	1,289.22
139.45	328.46	724.14	712.76	1,283.03
169.45	300.46	662.41	709.36	1,276.92
199.65	272.34	600.41	706.12	1,271.10
199.75	272.25	600.21	706.11	1,271.07
199.85	272.15	600.00	706.10	1,271.06
209.55	272.59	600.97	704.76	1,268.65
218.85	273.05	601.98	703.47	1,266.32

Table 6.2.1-6 (5 of 22)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
228.15	273.65	603.30	702.14	1,263.92
237.45	274.33	604.80	700.76	1,261.45
246.95	275.11	606.51	699.28	1,258.78
247.05	274.94	606.15	685.99	1,234.85
247.15	282.99	623.89	684.93	1,232.95
247.45	275.60	607.59	685.73	1,234.39
247.75	283.60	625.24	678.22	1,220.86
248.35	274.91	606.07	669.86	1,205.82
248.45	274.77	605.77	668.92	1,204.13
251.95	243.76	537.41	653.81	1,176.93
255.65	217.27	478.99	653.81	1,176.93
259.15	203.58	448.83	653.82	1,176.95
262.65	195.38	430.74	653.82	1,176.94
266.15	190.04	418.96	653.81	1,176.92
269.65	186.24	410.59	653.81	1,176.93
273.15	183.33	404.18	653.82	1,176.94
276.65	180.96	398.94	653.81	1,176.93
280.15	178.87	394.35	653.81	1,176.92
281.05	178.37	393.23	653.81	1,176.93
281.15	178.31	393.10	653.82	1,176.95
281.25	178.25	392.98	653.82	1,176.94
283.65	177.23	390.72	653.81	1,176.93
285.15	176.78	389.74	653.81	1,176.93
285.25	175.29	386.44	653.82	1,176.94
285.35	176.58	389.29	653.82	1,176.93
288.85	142.66	314.52	653.82	1,176.95
292.35	164.56	362.79	653.81	1,176.93
295.85	339.62	748.74	653.81	1,176.93

Table 6.2.1-6 (6 of 22)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
299.35	126.94	279.85	653.81	1,176.92
302.85	121.21	267.22	653.80	1,176.91
306.35	258.13	569.09	653.81	1,176.93
309.85	113.77	250.83	653.80	1,176.92
313.35	109.25	240.86	653.81	1,176.93
316.85	206.98	456.31	653.82	1,176.94
320.35	102.22	225.36	653.83	1,176.96
323.85	98.81	217.83	653.82	1,176.95
327.35	184.79	407.40	653.81	1,176.93
330.85	93.68	206.52	653.81	1,176.93
334.35	92.15	203.15	653.82	1,176.95
337.85	124.24	273.90	653.81	1,176.93
341.35	130.69	288.13	653.81	1,176.93
344.85	111.96	246.84	653.81	1,176.93
348.35	72.51	159.86	653.81	1,176.93
351.85	72.00	158.74	653.80	1,176.90
355.35	116.68	257.24	653.81	1,176.92
358.85	62.06	136.83	653.80	1,176.91
360.15	61.54	135.67	653.82	1,176.94
360.25	60.92	134.31	653.81	1,176.92

Table 6.2.1-6 (7 of 22)

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
199.75	58,868.73	129,784.00	42.157	167.303
360.25	89,568.60	197,466.00	62.874	249.519

Part A. Mass and Energy Release Data (Spillage)

Time (sec)	Integral Mass		Integral Energy	
	kg	Lbm	Million kcal	Million Btu
End of Blowdown at 19.752	0.00	0.00	0.000	0.000
End of Reflood at 199.75	92,597.37	204,143.33	9.303	36.919
End of Post-reflood at 360.25	167,154.03	368,513.48	14.869	59.008

Table 6.2.1-6 (8 of 22)

Part A. Mass and Energy (Steam) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
600.0	48.45	106.81	654.62	1178.31
800.0	46.52	102.56	654.29	1177.73
999.0	45.45	100.21	654.04	1177.27
1504.4	42.95	94.7	653.6	1176.47
1997.8	40.53	89.36	653.31	1175.96
4005.0	33.76	74.43	652.69	1174.85
6003.6	30.18	66.54	652.34	1174.22
8004.3	27.99	61.7	652.12	1173.81
9995.6	26.46	58.33	651.96	1173.53
15005.7	24.1	53.13	651.67	1173.01
20011.7	22.65	49.93	651.41	1172.54
40038.3	19.66	43.35	650.45	1170.81
59965.1	18.13	39.97	649.6	1169.27
79991.5	17.17	37.84	648.96	1168.13
100002.3	14.49	31.95	647.87	1166.17
150010.0	12.81	28.25	646.5	1163.7
200018.4	11.71	25.81	645.79	1162.42
400054.2	9.2	20.29	644.51	1160.12
600092.3	7.86	17.32	643.88	1158.98
800133.9	6.98	15.4	643.51	1158.32
1000000.0	6.38	14.06	643.26	1157.87

Integral Mass and Energy Release (Steam) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,100	1,898,431	4,185,325	1,240.804	4,344.599
1,000,000	10,032,626	22,118,155	6,488.479	25,748.366

Table 6.2.1-6 (9 of 22)

Part A. Mass and Energy (Spillage) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
600.0	159.63	351.93	79.76	143.57
800.0	170.72	376.37	80.0	144.0
999.0	180.69	398.34	82.58	148.64
1504.4	197.28	434.93	88.1	158.59
1997.8	204.81	451.53	92.57	166.62
4005.0	211.71	466.74	105.06	189.11
6003.6	213.95	471.68	112.15	201.86
8004.3	215.14	474.3	116.3	209.34
9995.6	216.08	476.37	118.72	213.7
15005.7	217.77	480.09	121.08	217.95
20011.7	219.11	483.06	121.14	218.05
40038.3	222.74	491.06	117.19	210.94
59965.1	225.14	496.35	112.7	202.85
79991.5	226.79	499.98	109.13	196.43
100002.3	230.19	507.49	104.02	187.24
150010.0	233.44	514.65	95.14	171.25
200018.4	235.27	518.69	90.45	162.8
400054.2	238.93	526.75	81.46	146.63
600092.3	240.82	530.93	76.51	137.73
800133.9	242.0	533.52	73.42	132.15
1000000.0	242.8	535.29	71.26	128.27

Integral Mass and Energy Release(Spillage) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,100	18,926,678	41,726,182	2,161.914	8,579.170
1,000,000	237,848,696	524,366,617	19,733.144	78,307.442

Table 6.2.1-6 (10 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
0.000	167.360	2,380.40
0.026	147.360	2,096.00
0.051	131.970	1,877.00
0.102	124.440	1,770.00
0.150	126.550	1,799.90
0.205	123.280	1,753.50
0.251	124.390	1,769.20
0.303	122.240	1,738.60
0.355	121.610	1,729.70
0.455	119.600	1,701.10
0.548	118.700	1,688.30
0.655	117.750	1,674.80
0.751	116.290	1,654.00
0.850	115.400	1,641.40
0.952	114.580	1,629.70
1.256	107.300	1,526.10
1.500	106.660	1,517.00
1.749	101.420	1,442.50
2.001	99.780	1,419.20
2.253	96.330	1,370.10
2.513	95.120	1,352.90
2.753	93.450	1,329.20
3.013	91.670	1,303.90

Table 6.2.1-6 (11 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
3.253	90.120	1,281.80
3.513	88.880	1,264.20
3.753	87.480	1,244.20
4.013	86.210	1,226.20
4.513	84.160	1,197.00
5.013	82.180	1,168.90
5.513	80.350	1,142.80
6.013	78.810	1,120.90
6.513	76.680	1,090.70
7.013	74.800	1,063.90
7.505	71.970	1,023.70
8.014	70.510	1,002.90
8.513	68.090	968.43
9.013	66.110	940.35
9.513	64.050	910.98
10.013	61.900	880.49
10.513	58.870	837.39
11.013	55.490	789.25
11.513	50.790	722.45
12.013	46.480	661.04
12.513	41.990	597.21
13.013	38.250	544.01
13.513	34.690	493.40

Table 6.2.1-6 (12 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
14.009	31.030	441.40
14.507	27.720	394.32
15.017	24.580	349.64
15.257	23.270	330.97
15.503	21.850	310.76
15.753	20.290	288.64
16.008	18.750	266.73
16.257	17.220	244.90
16.505	15.700	223.25
16.753	14.160	201.46
17.007	12.680	180.32
17.251	11.370	161.79
17.500	10.200	145.11
17.750	9.100	129.40
18.000	8.150	115.88
18.249	7.340	104.41
18.509	6.610	94.06
18.752	6.050	86.09
19.002	5.560	79.01
19.254	5.120	72.85
19.508	4.730	67.23
19.752	4.410	62.76

Table 6.2.1-6 (13 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
19.75	4.080	58.000
19.85	4.090	58.170
19.95	4.110	58.390
21.95	4.150	59.030
23.95	4.500	63.980
25.95	4.870	69.300
27.95	5.250	74.630
28.05	5.270	74.890
28.15	5.280	75.150
28.25	5.300	75.380
32.25	5.280	75.060
36.25	5.250	74.670
40.25	5.220	74.270
44.25	5.200	73.900
48.25	5.170	73.550
49.15	5.170	73.480
49.25	5.170	73.470
49.35	5.160	73.460
49.45	5.160	73.450
79.45	5.010	71.260
109.45	4.880	69.360
139.45	4.750	67.620
169.45	4.640	66.020
199.65	4.540	64.570
199.75	4.540	64.570
199.85	4.540	64.560

Table 6.2.1-6 (14 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
209.55	4.540	64.550
218.85	4.540	64.540
228.15	4.540	64.530
237.45	4.540	64.520
246.95	4.540	64.520
247.05	4.540	64.570
247.15	4.530	64.490
247.45	4.530	64.490
247.75	4.530	64.380
248.35	4.520	64.260
248.45	4.520	64.230
251.95	4.490	63.840
255.65	4.490	63.920
259.15	4.500	63.980
262.65	4.500	64.010
266.15	4.500	64.040
269.65	4.510	64.080
273.15	4.510	64.120
276.65	4.510	64.170
280.15	4.520	64.240
281.05	4.520	64.250
281.15	4.520	64.260
281.25	4.520	64.260
283.65	4.520	64.290
285.15	4.520	64.290
285.25	4.520	64.300

Table 6.2.1-6 (15 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
285.35	4.520	64.310
288.85	4.520	64.270
292.35	4.440	63.220
295.85	4.340	61.780
299.35	4.520	64.280
302.85	4.370	62.190
306.35	4.300	61.170
309.85	4.440	63.170
313.35	4.320	61.470
316.85	4.280	60.860
320.35	4.390	62.410
323.85	4.280	60.820
327.35	4.260	60.600
330.85	4.350	61.920
334.35	4.270	60.780
337.85	4.280	60.830
341.35	4.230	60.160
344.85	4.220	60.030
348.35	4.260	60.640
351.85	4.320	61.500
355.35	4.150	59.080
358.85	4.210	59.900
360.15	4.210	59.870
360.25	4.210	59.820
380.166	4.64	66.03
400.166	4.60	65.43

Table 6.2.1-6 (16 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
420.166	4.56	64.89
440.166	4.53	64.39
460.166	4.50	63.93
480.166	4.47	63.50
500.166	4.44	63.11
520.166	4.41	62.73
540.166	4.39	62.38
560.166	4.36	62.04
580.166	4.34	61.72
600.166	4.32	61.41
620.166	4.30	61.12
640.166	4.28	60.83
660.166	4.26	60.55
680.166	4.24	60.28
700.166	4.22	60.03
720.166	4.20	59.77
740.166	4.19	59.53
760.166	4.17	59.29
780.166	4.15	59.06
800.166	4.14	58.84
820.263	4.12	58.62
840.348	4.11	58.41
860.348	4.09	58.20
880.348	4.08	58.00
900.348	4.06	57.81
920.348	4.05	57.62

Table 6.2.1-6 (17 of 22)

Part B. Reactor Vessel Pressure vs. Time
(Decay heat Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
600.0	4.378	62.273
800.0	4.248	60.419
999.0	4.149	59.012
1504.4	3.981	56.621
1997.8	3.876	55.135
4005.0	3.66	52.063
6003.6	3.544	50.41
8004.3	3.471	49.373
9995.6	3.42	48.648
15005.7	3.332	47.387
20011.7	3.252	46.247
40038.3	2.976	42.328
59965.1	2.751	39.127
79991.5	2.594	36.896
100002.3	2.347	33.387
150010.0	2.067	29.403
200018.4	1.936	27.533
400054.2	1.719	24.455
600092.3	1.621	23.059
800133.9	1.566	22.273
1000000.0	1.53	21.764

Table 6.2.1-6 (18 of 22)

Part C. Safety Injection Flow vs. Time (Blowdown Period)

Time (sec)	Safety Injection Tank Flow	
	kg/sec	lbm/sec
0.000	0.00	0.00
0.026	0.00	0.00
11.513	0.00	0.00
12.013	0.00	0.00
12.513	2,164.62	4,772.20
13.013	2,786.54	6,143.30
13.513	3,212.60	7,082.60
14.009	3,589.48	7,913.50
14.507	3,867.31	8,526.00
15.017	4,094.01	9,025.80
15.257	4,166.59	9,185.80
15.503	4,261.98	9,396.10
15.753	4,377.01	9,649.70
16.008	4,487.23	9,892.70
16.257	4,598.95	10,139.00
16.505	4,710.99	10,386.00
16.753	4,823.48	10,634.00
17.007	4,925.99	10,860.00
17.251	5,008.54	11,042.00
17.500	5,074.31	11,187.00
17.750	5,130.56	11,311.00
18.000	5,170.47	11,399.00
18.249	5,196.33	11,456.00

Table 6.2.1-6 (19 of 22)

Part C. Safety Injection Flow vs. Time (Blowdown Period)

Time (sec)	Safety Injection Tank Flow	
	kg/sec	lbm/sec
18.509	5,209.93	11,486.00
18.752	5,210.84	11,488.00
19.002	5,203.58	11,472.00
19.254	5,192.24	11,447.00
19.508	5,176.37	11,412.00
19.752	5,157.32	11,370.00

Table 6.2.1-6 (20 of 22)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
19.752	2,681.58	5,911.91	328.55	724.33
19.852	2,674.22	5,895.68	328.55	724.33
20.852	2,600.14	5,732.36	328.48	724.18
21.852	2,534.94	5,588.61	328.48	724.19
22.852	2,461.80	5,427.38	328.26	723.70
23.852	2,390.82	5,270.89	328.01	723.15
24.852	2,322.43	5,120.10	327.75	722.58
25.852	2,256.38	4,974.49	327.49	721.99
26.852	2,192.52	4,833.71	327.22	721.39
27.852	2,130.98	4,698.04	326.95	720.81
28.052	2,118.95	4,671.50	326.90	720.69
28.152	2,112.96	4,658.30	326.87	720.64
30.152	2,028.39	4,471.86	326.84	720.56
32.152	1,954.64	4,309.26	326.86	720.60
34.152	1,887.04	4,160.23	326.87	720.63
36.152	1,825.19	4,023.89	326.89	720.68
38.152	1,767.99	3,897.78	326.91	720.73
40.152	1,714.78	3,780.47	326.93	720.77
42.152	1,665.10	3,670.93	326.95	720.81
44.152	1,618.54	3,568.28	326.97	720.85
46.152	1,574.76	3,471.78	326.99	720.89
48.152	1,533.49	3,380.78	327.01	720.93
49.152	1,513.71	3,337.18	327.01	720.95
49.252	1,511.76	3,332.89	327.01	720.95
49.352	684.62	1,509.33	327.02	720.95
49.452	684.26	1,508.55	327.02	720.95
64.552	631.76	1,392.80	327.13	721.21
79.652	587.39	1,294.99	327.24	721.44
94.752	549.31	1,211.03	327.34	721.65
109.852	516.17	1,137.97	327.43	721.86
124.952	487.00	1,073.66	327.52	722.06
140.052	461.07	1,016.49	327.60	722.24
155.152	437.80	965.19	327.68	722.42

Table 6.2.1-6 (21 of 22)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
170.252	416.76	918.81	327.76	722.60
185.352	397.61	876.57	327.84	722.76
199.752	380.82	839.56	327.90	722.91
215.252	359.30	792.11	327.91	722.91
230.352	339.44	748.35	327.91	722.92
245.452	320.62	706.84	327.91	722.92
260.552	307.17	677.21	327.96	723.03
275.652	288.52	636.08	327.94	723.00
290.752	270.34	596.00	327.93	722.96
305.852	285.85	630.20	328.24	723.64
320.952	273.03	601.92	328.25	723.68
336.052	264.44	583.00	328.31	723.80
351.152	252.48	556.64	328.33	723.84
360.252	248.68	548.24	328.37	723.93
362.252	256.00	564.38	328.45	724.11
364.252	246.05	542.46	328.37	723.95
366.252	246.46	543.36	328.39	723.99
368.252	246.43	543.29	328.41	724.02
370.252	245.72	541.73	328.42	724.04
371.852	243.99	537.91	328.42	724.03
371.952	244.19	538.36	328.42	724.04
372.052	0.00	0.00	328.42	724.05
372.152	0.00	0.00	328.42	724.05
402.352	0.00	0.00	328.49	724.20
432.552	0.00	0.00	328.51	724.24
462.752	0.00	0.00	328.47	724.16
492.952	0.00	0.00	328.47	724.15
523.152	0.00	0.00	328.45	724.10
553.352	0.00	0.00	328.45	724.11
583.552	0.00	0.00	328.47	724.15
599.852	0.00	0.00	328.47	724.16
599.952	0.00	0.00	328.47	724.16

Table 6.2.1-6 (22 of 22)

Part D. Chronology of Events

Time (sec)	Event	Values
0.0	Break occurs	-
3.76	Containment pressure Hi-Hi setpoint	1.547kg/cm²G (22.0 psig)
12.01	Start safety injection tank (SIT) injection	-
17.71	First peak containment pressure (Blowdown phase)	3.123kg/cm²G (44.42 psig)
19.75	End of blowdown	-
	Start SI pump injection	-
49.35	SIT flow is turned down to low flow by fluidic device in SIT	-
113.76	Start containment spray actuation	-
199.75	End of reflood	-
323.82	Peak containment temperature	134.59 ^{o}C (274.27 ^{o}F)
324.12	Peak containment pressure	3.592kg/cm²G (51.09 psig)
360.25	End of post reflood	-
372.05	Safety injection tank empty	-
52,355.4	Time of depressurization of the containment at 50 % of peak pressure	1.795kg/cm²G (25.54 psig)

Table 6.2.1-7 (1 of 20)

Double-Ended Discharge Leg Slot Break – Minimum SIS Flow
(0.9121 m^2 (9.8175 ft^2) Break Area)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.000	0.00	0.00	0.00	0.00
0.026	35,570.66	78,420.29	309.67	557.44
0.051	36,255.06	79,929.15	309.62	557.34
0.102	52,155.38	114,983.53	310.08	558.17
0.150	54,241.46	119,582.56	310.69	559.27
0.205	53,118.19	117,106.18	311.20	560.19
0.251	53,000.48	116,846.67	311.46	560.66
0.303	52,555.82	115,866.36	311.68	561.06
0.355	51,903.33	114,427.86	311.78	561.23
0.455	51,283.34	113,060.99	311.86	561.38
0.548	50,839.80	112,083.15	311.87	561.40
0.655	50,335.08	110,970.43	311.89	561.44
0.751	49,799.01	109,788.59	311.92	561.50
0.850	49,295.77	108,679.14	311.98	561.60
0.952	48,985.60	107,995.33	312.09	561.80
1.256	45,974.67	101,357.32	312.52	562.57
1.500	44,806.61	98,782.18	313.10	563.62
1.749	42,469.15	93,628.95	313.84	564.95
2.001	40,547.50	89,392.40	314.75	566.58
2.253	39,075.65	86,147.52	315.77	568.41
2.513	37,917.46	83,594.12	316.79	570.25
2.753	37,135.87	81,871.00	317.79	572.06
3.013	35,641.45	78,576.37	318.70	573.69
3.253	34,354.67	75,739.48	319.39	574.94
3.513	33,446.63	73,737.59	320.70	577.29

Table 6.2.1-7 (2 of 20)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
3.753	32,136.20	70,848.55	322.26	580.11
4.013	30,679.12	67,636.23	324.09	583.39
4.513	28,504.55	62,842.10	327.42	589.38
5.013	26,227.90	57,822.93	331.03	595.89
5.513	24,545.92	54,114.76	337.02	606.67
6.013	21,825.68	48,117.64	349.22	628.64
6.513	17,987.35	39,655.52	376.16	677.13
7.013	13,886.23	30,614.05	428.08	770.59
7.505	12,225.23	26,952.15	454.34	817.86
8.014	11,663.92	25,714.69	459.62	827.36
8.513	11,152.79	24,587.83	461.97	831.59
9.013	10,759.50	23,720.77	463.01	833.46
9.513	9,894.04	21,812.74	479.71	863.53
10.013	8,931.05	19,689.70	504.97	908.99
10.513	8,006.74	17,651.93	528.35	951.08
11.013	6,975.26	15,377.90	556.89	1,002.46
11.513	5,926.46	13,065.67	588.71	1,059.75
12.013	5,345.95	11,785.86	593.54	1,068.43
12.513	6,618.02	14,590.32	460.05	828.14
13.013	7,205.45	15,885.38	405.88	730.62
13.513	7,216.60	15,909.95	378.11	680.64
14.009	7,049.69	15,541.99	356.91	642.47
14.507	6,840.23	15,080.21	336.96	606.56
15.017	6,604.21	14,559.86	319.10	574.41
15.257	6,493.95	14,316.78	311.68	561.06
15.503	6,334.92	13,966.18	305.12	549.25
15.753	6,086.67	13,418.88	297.94	536.33
16.008	6,015.11	13,261.12	289.68	521.46

Table 6.2.1-7 (3 of 20)

Part A. Mass and Energy Release Data
(Blowdown Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
16.257	5,794.29	12,774.28	281.39	506.53
16.505	5,416.53	11,941.46	273.92	493.08
16.753	4,955.88	10,925.90	268.62	483.55
17.007	4,447.82	9,805.81	263.22	473.82
17.251	3,984.08	8,783.44	258.14	464.68
17.500	3,606.06	7,950.04	253.32	456.00
17.750	3,263.42	7,194.64	248.40	447.14
18.000	3,088.10	6,808.13	245.86	442.57
18.249	1,743.93	3,844.73	240.28	432.53
18.509	1,671.14	3,684.24	240.44	432.82
18.752	1,508.29	3,325.24	243.71	438.70
19.002	1,297.66	2,860.86	243.27	437.91
19.254	1,091.70	2,406.81	244.26	439.70
19.508	882.79	1,946.23	247.16	444.92
19.752	678.35	1,495.51	254.14	457.48

Integral Mass and Energy Release at End of Blowdown

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
19.752	322,456.13	710,897.80	112.812	447.702

Table 6.2.1-7 (4 of 20)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
19.75	0.00	0.00	0.00	0.00
19.85	50.46	111.24	727.54	1,309.65
21.85	76.60	168.87	727.13	1,308.90
23.85	229.76	506.53	726.02	1,306.92
25.85	328.08	723.29	725.39	1,305.78
27.85	408.58	900.77	724.62	1,304.39
28.55	433.51	955.72	724.34	1,303.89
28.65	436.93	963.28	724.30	1,303.82
28.75	255.41	563.08	724.26	1,303.74
28.85	256.64	565.80	724.24	1,303.70
32.85	254.15	560.31	723.97	1,303.22
36.85	250.94	553.22	723.64	1,302.63
40.85	247.75	546.19	723.30	1,302.02
44.85	244.83	539.75	722.95	1,301.39
48.85	242.08	533.70	722.60	1,300.75
49.15	241.88	533.26	722.57	1,300.70
49.25	241.81	533.11	722.57	1,300.69
49.35	416.74	918.76	722.56	1,300.68
49.45	416.61	918.47	722.55	1,300.66
79.45	385.62	850.16	719.55	1,295.26
109.45	357.04	787.14	716.22	1,289.27
139.45	328.90	725.11	712.79	1,283.09
169.45	300.92	663.41	709.38	1,276.96
199.45	272.98	601.83	706.15	1,271.14
199.95	272.52	600.80	706.10	1,271.06
200.05	272.43	600.60	706.09	1,271.03
200.15	272.33	600.39	706.08	1,271.02
211.85	272.82	601.47	704.49	1,268.15

Table 6.2.1-7 (5 of 20)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
223.55	273.53	603.03	702.81	1,265.13
235.25	274.36	604.86	701.10	1,262.04
246.95	275.52	607.42	699.28	1,258.78
247.05	274.49	605.15	686.09	1,235.04
247.15	283.36	624.71	684.93	1,232.94
247.75	284.27	626.72	678.18	1,220.79
248.25	276.02	608.52	670.85	1,207.60
249.35	270.10	595.48	659.76	1,187.64
253.35	231.38	510.10	653.82	1,176.93
257.35	209.44	461.74	653.81	1,176.92
261.35	197.72	435.89	653.82	1,176.94
262.15	196.06	432.25	653.81	1,176.93
262.25	195.87	431.82	653.81	1,176.93
265.35	191.26	421.65	653.82	1,176.94
269.35	187.01	412.29	653.81	1,176.92
273.35	183.06	403.57	653.81	1,176.93
274.85	182.19	401.66	653.81	1,176.93
274.95	180.99	399.01	653.81	1,176.93
286.65	131.77	290.50	653.81	1,176.93
298.35	116.00	255.74	653.81	1,176.93
310.05	102.25	225.42	653.80	1,176.91
321.75	92.51	203.95	653.82	1,176.94
333.45	84.57	186.45	653.80	1,176.91
345.15	77.90	171.73	653.82	1,176.95
356.85	71.98	158.70	653.82	1,176.95
368.55	92.48	203.88	653.80	1,176.92
374.35	80.39	177.22	653.80	1,176.91
374.45	80.48	177.43	653.80	1,176.91

Table 6.2.1-7 (6 of 20)

Part A. Mass and Energy Release Data
(Reflood and Post-reflood Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
378.95	75.53	166.52	653.81	1,176.93
383.45	71.64	157.95	653.80	1,176.91
387.95	68.51	151.03	653.83	1,176.96
392.45	66.45	146.49	653.82	1,176.94
396.95	65.09	143.50	653.80	1,176.90
401.45	64.25	141.65	653.82	1,176.94
405.85	63.82	140.70	653.82	1,176.95
420.95	64.11	141.33	653.82	1,176.94
436.05	65.64	144.71	653.83	1,176.96
451.15	67.51	148.83	653.82	1,176.95
466.25	69.38	152.95	653.82	1,176.95
481.35	71.13	156.82	653.79	1,176.90
496.45	72.73	160.35	653.80	1,176.90
511.55	74.18	163.53	653.82	1,176.95
527.25	75.52	166.50	653.80	1,176.90
529.25	76.85	169.42	653.83	1,176.96
529.45	74.65	164.57	653.80	1,176.90
532.45	68.85	151.79	653.79	1,176.90
535.45	64.72	142.68	653.79	1,176.90
538.45	61.84	136.33	653.81	1,176.92
541.45	59.72	131.67	653.82	1,176.95
544.45	58.10	128.10	653.80	1,176.90
547.45	56.81	125.25	653.82	1,176.95
549.05	56.22	123.95	653.84	1,176.98
549.15	56.19	123.88	653.80	1,176.91

Table 6.2.1-7 (7 of 20)

Integral Mass and Energy Release at the End of Reflood and Post-reflood

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
200.05	59,016.59	130,110.00	42.263	167.725
549.15	102,624.29	226,249.00	71.416	283.419

Part A. Mass and Energy Release Data (Spillage)

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
End of Blowdown at 19.752	0.00	0.00	0.000	0.000
End of Reflood at 200.05	68,418.02	150,836.71	5.952	23.619
End of Post-reflood at 549.15	147,783.03	325,807.51	13.702	54.378

Table 6.2.1-7 (8 of 20)

Part A. Mass and energy (Steam) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	Kcal/kg	Btu/lbm
600.0	55.35	122.03	654.84	1178.71
800.0	46.77	103.1	654.53	1178.15
999.0	44.74	98.63	654.26	1177.67
1504.8	42.52	93.75	653.79	1176.82
1999.1	40.33	88.91	653.49	1176.28
3996.9	33.7	74.3	652.84	1175.11
5996.1	30.12	66.41	652.46	1174.43
7996.5	27.93	61.56	652.21	1173.98
9998.0	26.38	58.16	652.02	1173.64
15005.8	24.01	52.94	651.69	1173.04
20012.3	22.56	49.73	651.39	1172.49
40038.8	19.56	43.12	650.32	1170.58
59966.9	18.02	39.72	649.42	1168.96
79995.6	17.05	37.6	648.76	1167.78
100001.6	14.47	31.91	647.71	1165.87
150008.6	12.8	28.22	646.35	1163.43
200016.7	11.7	25.78	645.65	1162.17
400050.2	9.2	20.27	644.39	1159.9
600089.4	7.85	17.31	643.77	1158.78
800134.1	6.98	15.38	643.4	1158.12
1000000.0	6.37	14.04	643.16	1157.69

Integral Mass and Energy Release(Steam) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,005	1,891,405	4,169,834	1,236.108	4,349.405
1,000,000	10,019,578	22,089,388	6,478.911	25,710.395

Table 6.2.1-7 (9 of 20)

Part A. Mass and Energy (Spillage) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
600.0	106.14	233.99	119.94	215.89
800.0	105.26	232.05	87.54	157.57
999.0	114.45	252.31	84.04	151.27
1504.8	133.83	295.05	88.24	158.84
1999.1	143.24	315.8	92.7	166.87
3996.9	151.34	333.66	105.03	189.05
5996.1	153.88	339.25	111.96	201.53
7996.5	155.33	342.45	115.94	208.69
9998.0	156.38	344.77	118.21	212.78
15005.8	158.21	348.8	120.22	216.39
20012.3	159.6	351.85	120.0	216.0
40038.8	163.14	359.66	115.4	207.73
59966.9	165.37	364.57	110.6	199.08
79995.6	166.86	367.87	106.87	192.37
100001.6	169.92	374.62	101.81	183.26
150008.6	172.74	380.83	93.0	167.39
200016.7	174.36	384.4	88.32	158.97
400050.2	177.63	391.61	79.32	142.77
600089.4	179.33	395.35	74.37	133.87
800134.1	180.38	397.67	71.27	128.28
1000000.0	181.1	399.26	69.11	124.4

Integral Mass and Energy Release (Spillage) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,005	13,803,866	30,432,316	1,556.366	6,176.160
1,000,000	176,628,783	389,399,810	14,272.280	56,636.983

Table 6.2.1-7 (10 of 20)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
0.000	167.360	2,380.40
0.026	147.360	2,096.00
0.051	131.970	1,877.00
0.102	124.440	1,770.00
0.150	126.550	1,799.90
0.205	123.280	1,753.50
0.251	124.390	1,769.20
0.303	122.240	1,738.60
0.355	121.610	1,729.70
0.455	119.600	1,701.10
0.548	118.700	1,688.30
0.655	117.750	1,674.80
0.751	116.290	1,654.00
0.850	115.400	1,641.40
0.952	114.580	1,629.70
1.256	107.300	1,526.10
1.500	106.660	1,517.00
1.749	101.420	1,442.50
2.001	99.780	1,419.20
2.253	96.330	1,370.10
2.513	95.120	1,352.90
2.753	93.450	1,329.20
3.013	91.670	1,303.90
3.253	90.120	1,281.80
3.513	88.880	1,264.20
3.753	87.480	1,244.20
4.013	86.210	1,226.20

Table 6.2.1-7 (11 of 20)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
4.513	84.160	1,197.00
5.013	82.180	1,168.90
5.513	80.350	1,142.80
6.013	78.810	1,120.90
6.513	76.680	1,090.70
7.013	74.800	1,063.90
7.505	71.970	1,023.70
8.014	70.510	1,002.90
8.513	68.090	968.43
9.013	66.110	940.35
9.513	64.050	910.98
10.013	61.900	880.49
10.513	58.870	837.39
11.013	55.490	789.25
11.513	50.790	722.45
12.013	46.480	661.04
12.513	41.990	597.21
13.013	38.250	544.01
13.513	34.690	493.40
14.009	31.030	441.40
14.507	27.720	394.32
15.017	24.580	349.64
15.257	23.270	330.97
15.503	21.850	310.76
15.753	20.290	288.64
16.008	18.750	266.73
16.257	17.220	244.90

Table 6.2.1-7 (12 of 20)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
16.505	15.700	223.25
16.753	14.160	201.46
17.007	12.680	180.32
17.251	11.370	161.79
17.500	10.200	145.11
17.750	9.100	129.40
18.000	8.150	115.88
18.249	7.340	104.41
18.509	6.610	94.06
18.752	6.050	86.09
19.002	5.560	79.01
19.254	5.120	72.85
19.508	4.730	67.23
19.752	4.410	62.76

Table 6.2.1-7 (13 of 20)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
19.75	4.080	58.000
19.85	4.090	58.160
21.85	4.120	58.600
23.85	4.440	63.150
25.85	4.790	68.100
27.85	5.140	73.070
28.55	5.260	74.750
28.65	5.270	74.990
28.75	5.290	75.230
28.85	5.300	75.360
32.85	5.280	75.030
36.85	5.250	74.620
40.85	5.220	74.220
44.85	5.190	73.860
48.85	5.170	73.520
49.15	5.170	73.500
49.25	5.170	73.490
49.35	5.170	73.470
49.45	5.160	73.460
79.45	5.010	71.280
109.45	4.880	69.380
139.45	4.760	67.640
169.45	4.640	66.050
199.45	4.540	64.600
199.95	4.540	64.580
200.05	4.540	64.580
200.15	4.540	64.570
211.85	4.540	64.550

Table 6.2.1-7 (14 of 20)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
223.55	4.540	64.540
235.25	4.540	64.530
246.95	4.540	64.530
247.05	4.540	64.590
247.15	4.530	64.500
247.75	4.530	64.380
248.25	4.520	64.290
249.35	4.500	64.010
253.35	4.490	63.890
257.35	4.500	63.970
261.35	4.500	64.020
262.15	4.500	64.030
262.25	4.500	64.030
265.35	4.500	64.020
269.35	4.500	63.940
273.35	4.490	63.830
274.85	4.480	63.770
274.95	4.480	63.780
286.65	4.440	63.100
298.35	4.430	62.970
310.05	4.350	61.820
321.75	4.300	61.180
333.45	4.270	60.760
345.15	4.250	60.430
356.85	4.230	60.160
368.55	4.190	59.560

Table 6.2.1-7 (15 of 20)

Part B. Reactor Vessel Pressure vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
374.35	4.160	59.150
374.45	4.160	59.140
378.95	4.150	59.020
383.45	4.140	58.940
387.95	4.140	58.870
392.45	4.140	58.820
396.95	4.130	58.790
401.45	4.130	58.770
405.85	4.130	58.760
420.95	4.130	58.760
436.05	4.130	58.780
451.15	4.130	58.810
466.25	4.140	58.840
481.35	4.140	58.870
496.45	4.140	58.900
511.55	4.140	58.920
527.25	4.140	58.940
529.25	4.150	58.970
529.45	4.150	58.990
532.45	4.140	58.950
535.45	4.140	58.910
538.45	4.140	58.880
541.45	4.140	58.860
544.45	4.140	58.840
547.45	4.140	58.820
549.05	4.130	58.810
549.15	4.130	58.810

Table 6.2.1-7 (16 of 20)

Part B. Reactor Vessel Pressure vs. Time (Decay heat Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^{2}A	psia
600.0	4.469	63.57
800.0	4.342	61.763
999.0	4.236	60.256
1504.8	4.054	57.658
1999.1	3.941	56.058
3996.9	3.71	52.769
5996.1	3.582	50.952
7996.5	3.5	49.785
9998.0	3.441	48.944
15005.8	3.336	47.454
20012.3	3.244	46.137
40038.8	2.941	41.831
59966.9	2.707	38.504
79995.6	2.548	36.239
100001.6	2.311	32.871
150008.6	2.04	29.01
200016.7	1.912	27.189
400050.2	1.7	24.18
600089.4	1.604	22.821
800134.1	1.551	22.053
1000000.0	1.516	21.556

Table 6.2.1-7 (17 of 20)

Part C. Safety Injection Flow vs. Time
(Blowdown Period)

Time (sec)	Safety Injection Tank Flow	
	kg/sec	kg/sec
0.000	0.00	0.00
0.026	0.00	0.00
11.513	0.00	0.00
12.013	0.00	0.00
12.513	2,164.62	4,772.20
13.013	2,786.54	6,143.30
13.513	3,212.60	7,082.60
14.009	3,589.48	7,913.50
14.507	3,867.31	8,526.00
15.017	4,094.01	9,025.80
15.257	4,166.59	9,185.80
15.503	4,261.98	9,396.10
15.753	4,377.01	9,649.70
16.008	4,487.23	9,892.70
16.257	4,598.95	10,139.00
16.505	4,710.99	10,386.00
16.753	4,823.48	10,634.00
17.007	4,925.99	10,860.00
17.251	5,008.54	11,042.00
17.500	5,074.31	11,187.00
17.750	5,130.56	11,311.00
18.000	5,170.47	11,399.00
18.249	5,196.33	11,456.00
18.509	5,209.93	11,486.00
18.752	5,210.84	11,488.00
19.002	5,203.58	11,472.00
19.254	5,192.24	11,447.00
19.508	5,176.37	11,412.00
19.752	5,157.32	11,370.00

Table 6.2.1-7 (18 of 20)

Part C Safety Injection Flow vs. Time
(Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
19.752	2,681.59	5,911.91	193.78	427.22
19.852	2,674.22	5,895.68	193.78	427.22
21.052	2,587.00	5,703.38	193.75	427.14
22.252	2,507.16	5,527.36	193.72	427.07
23.452	2,421.47	5,338.45	193.56	426.74
24.652	2,339.70	5,158.17	193.40	426.38
25.852	2,261.52	4,985.83	193.23	426.00
27.052	2,186.62	4,820.69	193.06	425.63
28.252	2,115.08	4,662.97	192.89	425.26
28.652	2,091.94	4,611.97	192.84	425.14
28.752	2,086.21	4,599.33	192.82	425.11
32.752	1,933.08	4,261.74	192.82	425.10
36.752	1,807.06	3,983.91	192.84	425.15
40.752	1,699.06	3,745.80	192.87	425.20
44.752	1,604.69	3,537.75	192.89	425.25
49.152	1,513.30	3,336.27	192.91	425.29
49.252	1,511.35	3,331.98	192.91	425.30
49.352	684.43	1,508.92	192.91	425.30
49.452	684.07	1,508.12	192.91	425.30
64.552	631.57	1,392.37	192.98	425.44
79.652	587.21	1,294.58	193.04	425.57
94.752	549.13	1,210.63	193.09	425.70
109.852	516.00	1,137.58	193.15	425.81
124.952	486.83	1,073.28	193.20	425.93
140.052	460.90	1,016.12	193.24	426.03
155.152	437.64	964.84	193.29	426.14
170.252	416.61	918.48	193.34	426.24
185.352	397.46	876.26	193.38	426.33
200.052	380.35	838.53	193.42	426.41
215.152	359.39	792.32	193.42	426.42

Table 6.2.1-7 (19 of 20)

Part C. Safety Injection Flow vs. Time (Reflood and Post-reflood Period)

Time (sec)	Safety Injection Tank Flow		Safety Injection Pump Flow	
	kg/sec	lbm/sec	kg/sec	lbm/sec
230.252	339.53	748.53	193.42	426.42
245.352	320.69	706.99	193.42	426.42
260.452	307.12	677.08	193.45	426.48
275.552	292.22	644.23	193.46	426.51
290.652	283.59	625.22	193.51	426.61
305.752	293.28	646.57	193.65	426.94
320.852	276.64	609.88	193.64	426.91
335.952	260.17	573.58	193.63	426.89
351.052	259.70	572.54	193.70	427.05
351.152	256.89	566.36	193.69	427.02
369.452	242.77	535.23	193.70	427.04
369.552	238.51	525.83	193.68	426.99
369.652	0.00	0.00	193.68	427.00
369.752	0.00	0.00	193.70	427.03
384.852	0.00	0.00	193.73	427.11
399.952	0.00	0.00	193.74	427.12
415.052	0.00	0.00	193.74	427.13
430.152	0.00	0.00	193.74	427.13
445.252	0.00	0.00	193.74	427.12
460.352	0.00	0.00	193.74	427.12
475.452	0.00	0.00	193.74	427.11
490.552	0.00	0.00	193.73	427.11
505.652	0.00	0.00	193.73	427.11
520.752	0.00	0.00	193.73	427.11
535.852	0.00	0.00	193.73	427.11
549.152	0.00	0.00	193.74	427.12
564.252	0.00	0.00	193.74	427.13
579.352	0.00	0.00	193.74	427.13
599.852	0.00	0.00	193.74	427.13
599.952	0.00	0.00	193.74	427.13

Table 6.2.1-7 (20 of 20)

Part D. Chronology of Events

Time (sec)	Event	Values
0.0	Break occurs	-
3.76	Containment pressure Hi-Hi setpoint	1.547kg/cm²G (22.0 psig)
12.01	Start safety injection tank (SIT) injection	-
17.71	First peak containment pressure (Blowdown phase)	3.123kg/cm²G (44.42 psig)
19.75	End of blowdown	-
	Start SI pump injection	-
49.35	SIT flow is turned down to low flow by fluidic device in SIT	-
113.76	Start containment spray actuation	-
200.05	End of reflood	-
320.42	Peak containment temperature	134.52 ^{o}C (274.13 ^{o}F)
321.92	Peak containment pressure	3.583kg/cm²G (50.97 psig)
369.65	Safety injection tank empty	-
549.15	End of post reflood	-
49,051.8	Time of depressurization of the containment at 50 % of peak pressure	1.791kg/cm²G (25.47 psig)

Table 6.2.1-8 (1 of 13)

Double-Ended Hot Leg Slot Break (1.7877 m^2 (19.2423 ft^2) Break Area)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.000	0.00	0.00	0.00	0.00
0.025	76,463.94	168,575.00	358.81	645.90
0.051	71,583.69	157,815.84	357.26	643.11
0.100	78,379.65	172,798.45	358.80	645.88
0.151	78,075.82	172,128.63	359.59	647.29
0.199	73,247.67	161,484.31	359.42	646.99
0.257	69,096.98	152,333.56	359.43	647.00
0.301	65,747.36	144,948.88	359.52	647.17
0.353	63,219.10	139,374.98	359.76	647.61
0.504	59,599.23	131,394.50	360.43	648.81
0.652	55,612.68	122,605.60	361.40	650.56
0.799	52,805.95	116,417.80	362.99	653.42
0.962	50,268.79	110,824.29	365.52	657.97
1.207	46,410.82	102,318.88	368.49	663.32
1.407	45,069.94	99,362.73	367.67	661.85
1.609	44,404.87	97,896.49	365.84	658.54
1.801	44,178.17	97,396.70	363.00	653.45
2.001	44,303.25	97,672.45	359.42	646.99
2.201	44,546.16	98,207.98	355.69	640.28
2.401	44,650.70	98,438.45	352.16	633.93
2.601	44,567.73	98,255.53	349.42	628.99
2.801	44,137.88	97,307.87	347.62	625.76
3.001	43,037.65	94,882.27	347.97	626.38
3.201	41,113.16	90,639.48	350.58	631.09
3.401	39,506.41	87,097.19	353.52	636.36
3.601	37,945.09	83,655.05	356.60	641.92

Table 6.2.1-8 (2 of 13)

Part A. Mass and Energy Release Data
(Blowdown Period)

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
3.801	36,414.18	80,279.95	359.80	647.68
4.001	34,945.21	77,041.40	363.09	653.60
4.201	33,502.52	73,860.79	366.44	659.62
4.401	32,343.39	71,305.35	369.61	665.33
4.601	31,165.54	68,708.63	372.35	670.27
4.801	30,087.66	66,332.29	374.66	674.43
5.001	29,021.42	63,981.62	377.05	678.73
5.201	27,888.46	61,483.85	380.01	684.05
5.401	26,727.17	58,923.64	383.79	690.86
5.601	25,533.29	56,291.55	388.42	699.19
5.801	24,260.05	53,484.53	393.87	709.01
6.001	22,940.05	50,574.42	400.19	720.38
6.201	21,641.55	47,711.69	407.47	733.50
6.401	20,399.99	44,974.52	415.69	748.28
6.601	19,210.83	42,352.85	424.88	764.82
6.801	18,114.06	39,934.88	432.47	778.48
7.001	17,563.30	38,720.65	430.48	774.91
7.201	16,242.88	35,809.61	437.89	788.25
7.401	14,396.00	31,737.90	455.32	819.62
7.601	12,483.44	27,521.41	478.78	861.85
7.803	10,519.83	23,192.38	513.73	924.78
8.001	9,057.38	19,968.20	516.31	929.41
8.200	7,756.37	17,099.95	517.49	931.53
8.401	6,774.16	14,934.54	514.89	926.86
8.601	5,921.37	13,054.45	514.69	926.49
8.804	5,272.76	11,624.50	512.13	921.89
9.005	4,728.00	10,423.51	510.89	919.66
9.204	4,450.27	9,811.23	539.71	971.54

Table 6.2.1-8 (3 of 13)

Part A. Mass and Energy Release Data
(Blowdown Period)

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
9.400	4,558.87	10,050.63	548.54	987.43
9.612	4,586.78	10,112.17	561.64	1,011.01
9.803	4,595.26	10,130.86	565.36	1,017.71
10.011	4,721.83	10,409.92	550.48	990.93
10.200	4,458.70	9,829.80	554.50	998.15
10.400	4,287.29	9,451.91	559.17	1,006.56
10.600	4,142.66	9,133.05	563.27	1,013.94
10.801	3,967.56	8,747.02	566.89	1,020.45
11.001	3,801.78	8,381.54	567.80	1,022.10
11.200	3,576.19	7,884.19	571.65	1,029.04
11.400	3,267.58	7,203.82	583.08	1,049.61
11.600	2,999.69	6,613.22	584.05	1,051.36
11.800	2,566.36	5,657.89	583.09	1,049.62
12.000	2,058.34	4,537.88	594.79	1,070.68
12.200	1,698.88	3,745.40	586.91	1,056.50
12.400	1,546.84	3,410.21	592.55	1,066.65
12.601	1,399.98	3,086.44	601.69	1,083.10
12.801	1,205.75	2,658.24	605.21	1,089.44
13.001	1,000.25	2,205.19	605.09	1,089.22
13.201	848.41	1,870.43	606.60	1,091.93
13.401	761.90	1,679.71	601.78	1,083.26

Integral Mass and Energy Release at End of Blowdown

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
13.401	301,079.78	663,770.75	115.563	458.618

Table 6.2.1-8 (4 of 13)

Part A. Mass and Energy (Steam) Release Data (Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
100.0	88.02	194.05	653.21	1175.79
150.0	79.66	175.61	652.8	1175.03
200.0	71.28	157.14	652.5	1174.49
400.0	57.85	127.55	651.89	1173.41
599.9	53.39	117.7	651.61	1172.9
800.0	50.81	112.03	651.43	1172.58
999.0	48.82	107.62	651.3	1172.34
1502.9	44.86	98.89	651.1	1171.97
1996.0	41.77	92.09	650.98	1171.77
4000.6	34.25	75.52	650.82	1171.47
5996.5	30.61	67.48	650.76	1171.38
8004.8	28.46	62.75	650.76	1171.37
9994.5	27.0	59.52	650.78	1171.41
15005.2	24.75	54.57	650.84	1171.52
20010.6	23.36	51.5	650.83	1171.49
40034.6	20.51	45.22	650.45	1170.81
59960.8	19.02	41.94	649.87	1169.76
79987.5	18.08	39.86	649.37	1168.86
100002.4	14.53	32.04	648.05	1166.49
150008.7	12.82	28.25	646.51	1163.72
200017.4	11.71	25.81	645.78	1162.41

Integral Mass and Energy Release(Steam) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
85,095	2,207,211	4,866,067	1,356.127	4,601.320
1,000,000	10,343,406	22,803,307	6,605.165	26,211.413

Table 6.2.1-8 (5 of 13)

Part A. Mass and Energy (Spillage) Release Data
(Decay heat Period)

Time (sec)	Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
100.0	152.41	336.0	52.39	94.31
150.0	153.7	338.86	55.19	99.34
200.0	155.53	342.88	57.44	103.39
400.0	164.58	362.84	63.66	114.59
599.9	173.9	383.39	68.08	122.55
800.0	182.31	401.92	71.59	128.87
999.0	189.19	417.1	74.17	133.51
1502.9	200.74	442.57	79.33	142.8
1996.0	206.6	455.48	83.61	150.5
4000.6	213.52	470.73	96.13	173.04
5996.5	215.7	475.53	103.73	186.72
8004.8	216.67	477.68	108.56	195.4
9994.5	217.37	479.21	111.66	200.99
15005.2	218.52	481.76	115.65	208.17
20010.6	219.47	483.84	117.08	210.75
40034.6	222.13	489.72	116.57	209.83
59960.8	224.11	494.09	113.73	204.72
79987.5	225.55	497.26	111.06	199.9
100002.4	229.89	506.83	105.21	189.38
150008.7	233.41	514.59	95.25	171.44
200017.4	235.27	518.69	90.43	162.78

Integral Mass and Energy Release(Spillage) at 24 hours and End of Analysis

Time (sec)	Integral Mass		Integral Energy	
	kg	kg	kg	Million Btu
85,095	18,992,294	41,870,842	2,135.757	8,475.369
1,000,000	237,904,035	524,488,617	19,713.765	78,230.541

Table 6.2.1-8 (6 of 13)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
0.000	167.36	2,380.40
0.025	157.69	2,242.90
0.051	128.16	1,822.80
0.100	126.19	1,794.90
0.151	126.33	1,796.80
0.199	121.45	1,727.40
0.257	119.94	1,706.00
0.301	117.60	1,672.60
0.353	115.03	1,636.10
0.504	110.53	1,572.10
0.652	106.06	1,508.50
0.799	100.47	1,429.00
0.962	96.25	1,369.00
1.207	89.49	1,272.80
1.407	85.42	1,214.90
1.609	82.23	1,169.60
1.801	79.81	1,135.10
2.001	78.39	1,115.00
2.201	77.66	1,104.60
2.401	77.06	1,096.10
2.601	76.44	1,087.30
2.801	75.50	1,073.90
3.001	74.51	1,059.80

Table 6.2.1-8 (7 of 13)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
3.201	73.27	1,042.10
3.401	72.02	1,024.40
3.601	70.64	1,004.80
3.801	69.17	983.77
4.001	67.77	963.96
4.201	66.44	945.06
4.401	65.12	926.21
4.601	63.76	906.90
4.801	62.38	887.28
5.001	60.97	867.18
5.201	59.55	847.04
5.401	58.14	826.93
5.601	56.70	806.40
5.801	55.25	785.87
6.001	53.82	765.55
6.201	52.40	745.33
6.401	50.96	724.79
6.601	49.52	704.34
6.801	48.05	683.40
7.001	45.37	645.30
7.201	41.69	593.00
7.401	38.67	550.08

Table 6.2.1-8 (8 of 13)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
7.601	35.75	508.47
7.803	32.78	466.21
8.001	30.09	428.04
8.200	26.95	383.33
8.401	23.75	337.83
8.601	20.81	295.97
8.804	18.33	260.76
9.005	17.98	255.67
9.204	18.84	267.94
9.401	19.52	277.67
9.612	19.81	281.76
9.803	19.68	279.86
10.011	19.09	271.49
10.200	18.81	267.47
10.400	18.31	260.39
10.600	17.56	249.70
10.801	16.73	237.92
11.001	15.78	224.49
11.200	14.74	209.70
11.400	13.50	191.99
11.600	11.92	169.59
11.800	10.23	145.44
12.000	8.82	125.49

Table 6.2.1-8 (9 of 13)

Part B. Reactor Vessel Pressure vs. Time
(Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
12.200	7.82	111.16
12.400	6.98	99.29
12.601	6.26	88.97
12.801	5.63	80.01
13.001	5.09	72.37
13.201	4.63	65.89
13.401	7.89	112.17

Table 6.2.1-8 (10 of 13)

Part B. Reactor Vessel Pressure vs. Time
(Decay heat Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
100.0	3.84	54.621
150.0	3.694	52.541
200.0	3.593	51.099
400.0	3.399	48.342
599.9	3.312	47.113
800.0	3.258	46.336
999.0	3.219	45.783
1502.9	3.158	44.923
1996.0	3.125	44.448
4000.6	3.078	43.785
5996.5	3.063	43.568
8004.8	3.063	43.566
9994.5	3.069	43.648
15005.2	3.086	43.887
20010.6	3.081	43.826
40034.6	2.976	42.323
59960.8	2.82	40.111
79987.5	2.693	38.302
100002.4	2.385	33.928
150008.7	2.07	29.44
200017.4	1.935	27.521

Table 6.2.1-8 (11 of 13)

Part C. Safety Injection Flow vs. Time (Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
0.000	0.00	0.00
0.025	0.00	0.00
6.601	0.00	0.00
6.801	0.00	0.00
7.001	1,242.61	2,739.50
7.201	2,386.97	5,262.40
7.401	3,000.72	6,615.50
7.601	3,470.51	7,651.20
7.803	3,860.91	8,511.90
8.001	4,188.27	9,233.60
8.200	4,536.81	10,002.00
8.401	4,857.95	10,710.00
8.601	5,136.45	11,324.00
8.804	5,340.12	11,773.00
9.005	5,259.83	11,596.00
9.204	5,021.24	11,070.00
9.401	4,802.61	10,588.00
9.612	4,643.40	10,237.00
9.803	4,558.58	10,050.00
10.011	4,543.16	10,016.00
10.200	4,476.89	9,869.90
10.400	4,460.51	9,833.80
10.600	4,480.11	9,877.00
10.801	4,517.62	9,959.70
11.001	4,571.73	10,079.00

Table 6.2.1-8 (12 of 13)

Part C. Safety Injection Flow vs. Time (Blowdown Period)

Time (sec)	Reactor Vessel Pressure	
	kg/cm^2A	psia
11.200	4,638.86	10,227.00
11.400	4,736.84	10,443.00
11.600	4,895.14	10,792.00
11.800	5,061.61	11,159.00
12.000	5,183.63	11,428.00
12.200	5,234.88	11,541.00
12.400	5,273.89	11,627.00
12.601	5,301.56	11,688.00
12.801	5,321.06	11,731.00
13.001	5,327.87	11,746.00
13.201	5,325.60	11,741.00
13.401	4,832.55	10,654.00

Table 6.2.1-8 (13 of 13)

Part D. Chronology of Events

Time (sec)	Event	Values
0.0	Break occurs	-
2.51	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
6.80	Start SI pump injection	-
13.01	Peak containment temperature	132.99 °C (271.38 °F)
	Peak containment pressure	3.394 kg/cm²G (48.28 psig)
13.40	End of blowdown	-
73,578.8	Time of depressurization of the containment at 50% of peak pressure	1.697 kg/cm²G (24.14 psig)

Table 6.2.1-9 (1 of 11)

Main Steam Line Break, 102 % Power – Loss of One CSS Train
(0.849 m^2 (9.134 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,380.819	9,658.104	662.20	1,191.94
0.5	4,100.826	9,040.820	663.33	1,193.98
1.0	3,942.108	8,690.905	663.98	1,195.12
1.5	3,807.299	8,393.700	664.49	1,196.05
2.0	3,688.262	8,131.268	664.92	1,196.84
2.5	3,582.742	7,898.635	665.30	1,197.51
3.0	3,488.819	7,691.569	665.61	1,198.09
3.5	3,404.836	7,506.417	665.91	1,198.59
4.0	3,330.012	7,341.458	666.15	1,199.03
4.5	3,262.684	7,193.025	666.35	1,199.41
5.0	3,201.830	7,058.863	666.56	1,199.75
5.5	3,255.371	7,176.902	666.47	1,199.61
6.0	3,382.016	7,456.108	666.17	1,199.08
6.5	3,478.518	7,668.859	665.92	1,198.60
7.0	3,518.521	7,757.052	665.79	1,198.41
7.5	3,520.334	7,761.048	665.79	1,198.41
8.0	3,511.696	7,742.005	665.83	1,198.46
8.5	3,500.770	7,717.916	665.88	1,198.54
9.0	3,489.703	7,693.518	665.90	1,198.61
9.5	3,479.154	7,670.262	665.94	1,198.68
10.0	3,469.440	7,648.845	665.99	1,198.74
10.5	1,034.484	2,280.659	665.74	1,198.34
11.0	1,039.693	2,292.142	665.68	1,198.22
11.5	1,044.702	2,303.185	665.64	1,198.08

Table 6.2.1-9 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
12.0	1,049.481	2,313.722	665.57	1,197.98
13.0	1,058.114	2,332.754	665.43	1,197.77
14.0	1,064.937	2,347.797	665.39	1,197.59
15.0	1,069.148	2,357.081	665.30	1,197.50
16.0	1,074.878	2,369.712	665.19	1,197.36
17.0	1,079.577	2,380.073	665.17	1,197.23
18.0	1,080.204	2,381.455	665.15	1,197.25
19.0	1,077.352	2,375.166	665.15	1,197.31
20.0	1,071.889	2,363.123	665.27	1,197.44
22.0	1,056.994	2,330.285	665.47	1,197.79
24.0	1,042.039	2,297.314	665.62	1,198.14
26.0	1,030.009	2,270.792	665.82	1,198.44
28.0	1,020.191	2,249.148	665.95	1,198.68
30.0	1,010.070	2,226.835	666.09	1,198.88
32.0	997.754	2,199.683	666.20	1,199.17
34.0	983.264	2,167.737	666.35	1,199.45
36.0	968.101	2,134.309	666.56	1,199.78
38.0	953.938	2,103.085	666.71	1,200.09
40.0	941.570	2,075.818	666.86	1,200.35
42.0	930.687	2,051.825	667.03	1,200.54
44.0	920.388	2,029.118	667.11	1,200.77
46.0	909.914	2,006.028	667.21	1,200.98
48.0	899.085	1,982.153	667.35	1,201.17
50.0	888.366	1,958.521	667.41	1,201.37
55.0	864.778	1,906.520	667.69	1,201.82
60.0	843.878	1,860.443	667.87	1,202.19

Table 6.2.1-9 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
65.0	823.084	1,814.599	668.10	1,202.52
70.0	803.478	1,771.374	668.22	1,202.80
75.0	784.252	1,728.988	668.41	1,203.07
80.0	764.009	1,684.360	668.58	1,203.37
85.0	743.674	1,639.528	668.71	1,203.64
100.0	685.560	1,511.410	669.09	1,204.17
120.0	617.790	1,362.002	669.16	1,204.55
140.0	558.533	1,231.360	669.25	1,204.60
160.0	513.215	1,131.452	669.12	1,204.38
180.0	469.931	1,036.025	668.82	1,203.93
200.0	426.794	940.925	668.47	1,203.28
220.0	384.955	848.684	668.13	1,202.45
240.0	344.314	759.087	667.41	1,201.18
260.0	304.390	671.068	666.58	1,199.58
280.0	264.172	582.403	665.48	1,197.62
100.0	685.560	1,511.410	669.09	1,204.17
300.0	223.833	493.470	663.89	1,194.80
320.0	185.433	408.811	662.23	1,191.50
340.0	150.969	332.832	659.74	1,187.39
360.0	124.016	273.410	657.17	1,182.84
380.0	101.559	223.900	654.79	1,177.76
400.0	79.920	176.195	653.15	1,175.40
420.0	70.685	155.835	652.19	1,173.68
440.0	65.631	144.693	652.13	1,172.83
460.0	62.952	138.786	651.29	1,172.31
480.0	61.577	135.754	651.22	1,171.97

Table 6.2.1-9 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
500.0	60.874	134.204	650.52	1,172.10
525.0	60.445	133.259	651.83	1,171.40
550.0	60.238	132.802	650.75	1,171.67
575.0	60.121	132.545	650.36	1,170.92
600.0	60.044	132.375	651.19	1,170.92
625.0	59.988	132.251	650.13	1,171.26
650.0	59.946	132.159	650.59	1,170.56
675.0	59.911	132.081	650.97	1,170.49
700.0	59.879	132.012	649.64	1,170.35
725.0	59.850	131.947	649.96	1,170.17
750.0	59.823	131.887	650.25	1,169.94
775.0	59.797	131.831	650.53	1,170.44
800.0	59.774	131.779	650.78	1,170.14
825.0	59.751	131.729	649.36	1,169.83
850.0	59.729	131.681	649.60	1,169.49
875.0	59.708	131.635	649.83	1,169.90
900.0	59.689	131.592	650.04	1,169.52
925.0	59.671	131.553	650.23	1,169.87
950.0	59.655	131.517	650.41	1,169.43
975.0	59.638	131.481	648.92	1,168.99
1,000.0	59.623	131.446	649.08	1,169.30
1,050.0	59.591	131.376	649.43	1,169.16
1,100.0	59.559	131.306	649.78	1,169.03
1,150.0	59.528	131.238	650.11	1,168.87
1,200.0	59.498	131.172	648.76	1,168.69

Table 6.2.1-9 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,250.0	59.469	131.108	649.08	1,168.50
1,300.0	59.441	131.045	649.38	1,168.30
1,350.0	59.413	130.984	649.69	1,168.08
1,400.0	59.386	130.924	649.98	1,168.62
1,450.0	59.359	130.865	648.60	1,168.38
1,500.0	59.332	130.805	648.89	1,168.15
1,550.0	59.305	130.745	649.19	1,167.92
1,600.0	59.277	130.684	649.49	1,167.70
1,650.0	59.249	130.622	649.80	1,168.26
1,700.0	59.220	130.559	648.43	1,168.05
1,750.0	59.191	130.494	648.75	1,167.87
1,800.0	59.161	130.428	649.08	1,167.69

Integral Mass and Energy Release at 1800 seconds after postulated accident.

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	300,548.80	662,600.00	199.00	789.60

Table 6.2.1-9 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
0.0	71.7	1,020.0	71.7	1,020.0
0.5	71.0	1,010.1	70.4	1,001.0
1.0	69.9	994.3	68.9	980.5
1.5	68.9	979.6	67.6	961.7
2.0	67.9	965.9	66.4	944.4
2.5	67.0	953.0	65.3	928.5
3.0	66.1	940.8	64.2	913.8
3.5	65.3	929.3	63.3	900.1
4.0	64.6	918.4	62.4	887.4
4.5	63.8	908.1	61.6	875.6
5.0	63.2	898.3	60.8	864.5
5.5	62.5	889.0	60.1	854.2
6.0	61.9	880.2	59.4	844.5
6.5	61.3	871.9	58.8	836.8
7.0	60.9	866.0	58.5	832.0
7.5	60.6	862.3	58.3	828.6
8.0	60.4	859.3	58.0	825.6
8.5	60.2	856.5	57.8	822.9
9.0	60.0	853.8	57.7	820.3
9.5	59.8	851.3	57.5	817.9
10.0	59.7	849.1	57.4	815.8
10.5	60.0	852.8	57.3	815.1

Table 6.2.1-9 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
11.0	61.7	877.1	57.6	819.3
11.5	63.3	899.9	57.9	823.3
12.0	64.8	921.5	58.1	827.1
13.0	67.7	962.4	58.6	834.0
14.0	70.3	1,000.3	59.0	839.5
15.0	72.7	1,034.3	59.2	842.8
16.0	74.8	1,063.7	59.6	847.4
17.0	76.5	1,087.7	59.8	851.1
18.0	77.8	1,106.3	59.9	851.6
19.0	78.7	1,120.1	59.7	849.2
20.0	79.4	1,130.0	59.4	844.8
22.0	80.3	1,142.6	58.5	832.8
24.0	80.9	1,151.4	57.7	820.9
26.0	81.6	1,160.5	57.0	811.2
28.0	82.2	1,169.5	56.5	803.4
30.0	82.7	1,176.0	55.9	795.3
32.0	82.8	1,177.9	55.2	785.4
34.0	82.6	1,175.4	54.4	773.7
36.0	82.3	1,170.3	53.5	761.6
38.0	81.9	1,164.5	52.7	750.2
40.0	81.8	1,163.9	52.0	740.3
42.0	81.8	1,163.8	51.4	731.6
44.0	81.8	1,163.7	50.9	723.4

Table 6.2.1-9 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
46.0	81.8	1,163.6	50.3	715.0
48.0	81.8	1,163.4	49.7	706.3
50.0	81.8	1,163.3	49.0	697.6
55.0	81.8	1,162.9	47.6	677.8
60.0	81.7	1,162.6	46.4	660.2
65.0	81.7	1,162.2	45.2	642.7
70.0	81.7	1,161.8	44.0	626.2
75.0	81.6	1,161.4	42.9	610.0
80.0	81.6	1,161.0	41.7	592.9
85.0	81.6	1,160.6	40.5	575.8
90.0	81.6	1,160.2	39.3	559.1
95.0	81.5	1,159.8	38.2	542.7
100.0	81.5	1,159.4	37.0	526.9
120.0	81.4	1,157.9	33.1	471.3
140.0	81.3	1,156.3	29.8	423.8
160.0	81.2	1,154.8	27.2	387.5
180.0	81.1	1,153.3	24.8	352.8
200.0	81.0	1,151.9	22.4	318.3
220.0	80.9	1,150.4	20.0	284.7
240.0	80.8	1,149.1	17.7	252.1
260.0	80.7	1,147.7	15.5	220.1
280.0	80.6	1,146.4	13.3	188.5
300.0	80.5	1,145.2	11.1	157.6
320.0	80.4	1,144.0	9.0	128.2
340.0	80.3	1,142.9	7.2	101.8

Table 6.2.1-9 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
360.0	80.3	1,141.9	5.6	79.4
380.0	80.2	1,141.0	4.2	60.3
400.0	80.1	1,140.0	3.7	52.9
420.0	80.1	1,139.2	3.5	49.5
440.0	80.0	1,138.3	3.3	47.5
460.0	80.0	1,137.5	3.3	46.3
480.0	79.9	1,136.6	3.2	45.4
500.0	79.8	1,135.8	3.1	44.8
525.0	79.8	1,134.8	3.1	44.2
550.0	79.7	1,133.7	3.1	43.7
575.0	79.6	1,132.7	3.0	43.3
600.0	79.6	1,131.6	3.0	42.9
625.0	79.5	1,130.6	3.0	42.5
650.0	79.4	1,129.5	3.0	42.2
675.0	79.3	1,128.4	2.9	41.9
700.0	79.3	1,127.4	2.9	41.6
725.0	79.2	1,126.3	2.9	41.3
750.0	79.1	1,125.2	2.9	41.0
775.0	79.0	1,124.1	2.9	40.8
800.0	78.9	1,123.0	2.8	40.5
825.0	78.9	1,122.0	2.8	40.3
850.0	78.8	1,120.9	2.8	40.1
875.0	78.7	1,119.8	2.8	39.9
900.0	78.6	1,118.6	2.8	39.7
925.0	78.6	1,117.5	2.8	39.5
950.0	78.5	1,116.4	2.8	39.4

Table 6.2.1-9 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
975.0	78.4	1,115.3	2.8	39.2
1,000.0	78.3	1,114.2	2.7	39.0
1,050.0	78.2	1,111.9	2.7	38.7
1,100.0	78.0	1,109.6	2.7	38.5
1,150.0	77.8	1,107.3	2.7	38.2
1,200.0	77.7	1,105.0	2.7	38.0
1,250.0	77.5	1,102.6	2.7	37.8
1,300.0	77.4	1,100.3	2.6	37.6
1,350.0	77.2	1,097.9	2.6	37.4
1,400.0	77.0	1,095.4	2.6	37.2
1,450.0	76.8	1,093.0	2.6	37.1
1,500.0	76.7	1,090.5	2.6	37.0
1,550.0	76.5	1,088.1	2.6	36.8
1,600.0	76.3	1,085.5	2.6	36.7
1,650.0	76.1	1,083.0	2.6	36.6
1,700.0	76.0	1,080.5	2.6	36.5
1,750.0	75.8	1,077.9	2.6	36.4
1,800.0	75.6	1,075.3	2.6	36.3

Table 6.2.1-9 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.89	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
5.20	High containment pressure reactor trip signal	-
5.30	Reactor trip breakers open, turbine admission valves closed	-
10.40	Main steam isolation valves closed	-
15.40	Main feedwater isolation valves closed	-
35.51	Containment pressure hi-hi setpoint	1.547 kg/cm²G (22.0 psig)
125.51	Start containment spray injection	-
	Peak containment temperature	164.85 ^{o}C (328.72 ^{o}F)
345.41	Peak containment pressure	3.140kg/cm²G (44.66 psig)
1,800.0	End of blowdown	-
3,503.2	Time of depressurization of the containment at 50% of peak pressure	1.569kg/cm²G (22.31 psig)

Table 6.2.1-10 (1 of 11)

Main Steam Line Break, 102 % Power – MSIV Failure
(0.849 m^2 (9.134 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,380.819	9,658.104	662.20	1,191.94
0.5	4,100.826	9,040.820	663.33	1,193.98
1.0	3,942.108	8,690.905	663.98	1,195.12
1.5	3,807.299	8,393.700	664.49	1,196.05
2.0	3,688.262	8,131.268	664.92	1,196.84
2.5	3,582.742	7,898.635	665.30	1,197.51
3.0	3,488.819	7,691.569	665.61	1,198.09
3.5	3,404.836	7,506.417	665.91	1,198.59
4.0	3,330.012	7,341.458	666.15	1,199.03
4.5	3,262.684	7,193.025	666.35	1,199.41
5.0	3,201.830	7,058.863	666.56	1,199.75
5.5	3,255.371	7,176.902	666.47	1,199.61
6.0	3,382.016	7,456.108	666.17	1,199.08
6.5	3,478.518	7,668.859	665.92	1,198.60
7.0	3,518.521	7,757.052	665.79	1,198.41
7.5	3,520.334	7,761.048	665.79	1,198.41
8.0	3,511.696	7,742.005	665.83	1,198.46
8.5	3,500.770	7,717.916	665.88	1,198.54
9.0	3,489.703	7,693.518	665.90	1,198.61
9.5	3,479.154	7,670.262	665.94	1,198.68
10.0	3,469.440	7,648.845	665.99	1,198.74
10.5	3,416.701	7,532.575	666.14	1,199.05

Table 6.2.1-10 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
11.0	3,135.401	6,912.412	666.90	1,200.36
11.5	2,887.685	6,366.288	667.35	1,201.17
12.0	2,669.781	5,885.891	667.55	1,201.57
13.0	2,309.841	5,092.355	667.49	1,201.47
14.0	2,031.553	4,478.830	667.08	1,200.67
15.0	1,813.848	3,998.872	666.48	1,199.61
16.0	1,646.239	3,629.355	665.88	1,198.56
17.0	1,516.285	3,342.853	665.38	1,197.66
18.0	1,412.597	3,114.259	665.09	1,197.07
19.0	1,328.749	2,929.405	664.91	1,196.80
20.0	1,260.249	2,778.388	664.87	1,196.74
22.0	1,158.509	2,554.089	665.08	1,197.14
24.0	1,093.226	2,410.163	665.37	1,197.68
26.0	1,054.966	2,325.813	665.71	1,198.16
28.0	1,033.627	2,278.769	665.81	1,198.50
30.0	1,020.453	2,249.726	665.98	1,198.77
32.0	1,008.474	2,223.316	666.16	1,199.02
34.0	995.075	2,193.777	666.28	1,199.30
36.0	980.739	2,162.170	666.44	1,199.63
38.0	966.176	2,130.065	666.65	1,199.92
40.0	952.698	2,100.350	666.74	1,200.18
42.0	940.703	2,073.906	666.95	1,200.39
44.0	929.696	2,049.640	666.99	1,200.60
46.0	919.099	2,026.277	667.18	1,200.82
48.0	908.466	2,002.835	667.28	1,201.00
50.0	897.553	1,978.775	667.37	1,201.20

Table 6.2.1-10 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
55.0	872.904	1,924.433	667.54	1,201.65
60.0	851.072	1,876.302	667.75	1,201.99
65.0	830.343	1,830.602	668.04	1,202.34
70.0	810.466	1,786.781	668.13	1,202.61
75.0	791.342	1,744.619	668.23	1,202.90
80.0	771.367	1,700.583	668.42	1,203.12
85.0	745.866	1,644.362	668.62	1,203.57
90.0	726.037	1,600.647	668.84	1,203.76
95.0	706.553	1,557.691	668.88	1,203.96
100.0	687.735	1,516.204	669.01	1,204.13
120.0	619.720	1,366.255	669.17	1,204.46
140.0	560.355	1,235.377	669.22	1,204.49
160.0	514.500	1,134.284	669.00	1,204.28
180.0	471.571	1,039.642	668.83	1,203.88
200.0	428.356	944.369	668.37	1,203.24
220.0	386.070	851.144	668.01	1,202.38
240.0	343.723	757.784	667.40	1,201.13
260.0	304.725	671.808	666.50	1,199.60
280.0	265.483	585.293	665.20	1,197.35
300.0	225.617	497.403	663.96	1,194.81
320.0	184.837	407.499	662.21	1,191.66
340.0	150.235	331.213	659.63	1,187.45
360.0	125.644	277.000	657.41	1,182.67
380.0	103.845	228.940	654.82	1,178.04
400.0	89.709	197.775	652.11	1,173.56
420.0	78.302	172.627	650.05	1,170.73

Table 6.2.1-10 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
440.0	68.019	149.956	649.82	1,168.34
460.0	62.791	138.431	649.77	1,168.09
480.0	61.622	135.854	649.12	1,167.43
500.0	59.741	131.706	649.47	1,167.75
525.0	49.520	109.173	650.24	1,170.62
550.0	57.493	126.752	650.51	1,171.58
575.0	59.100	130.294	651.44	1,171.20
600.0	59.640	131.485	650.57	1,171.24
625.0	59.812	131.863	650.37	1,170.91
650.0	59.853	131.954	649.93	1,170.86
675.0	59.849	131.946	649.97	1,170.93
700.0	59.832	131.907	650.15	1,170.52
725.0	59.809	131.858	650.40	1,170.96
750.0	59.787	131.808	650.64	1,170.64
775.0	59.765	131.760	650.88	1,170.31
800.0	59.744	131.713	649.44	1,169.97
825.0	59.723	131.668	649.67	1,170.37
850.0	59.704	131.625	649.87	1,169.99
875.0	59.685	131.584	650.08	1,169.60
900.0	59.667	131.544	650.28	1,169.95
925.0	59.649	131.505	650.47	1,169.54
950.0	59.633	131.468	650.65	1,169.87
975.0	59.617	131.433	649.14	1,169.42
1,000.0	59.602	131.401	649.31	1,169.70
1,050.0	59.573	131.337	649.62	1,169.51
1,100.0	59.544	131.272	649.94	1,169.33

Table 6.2.1-10 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,150.0	59.515	131.209	650.26	1,169.13
1,200.0	59.487	131.146	648.88	1,168.93
1,250.0	59.459	131.085	649.19	1,168.71
1,300.0	59.432	131.025	649.48	1,168.48
1,350.0	59.404	130.965	649.79	1,168.25
1,400.0	59.378	130.906	650.07	1,168.78
1,450.0	59.351	130.847	648.68	1,168.54
1,500.0	59.325	130.789	648.97	1,168.29
1,550.0	59.298	130.731	649.26	1,168.05
1,600.0	59.271	130.671	649.56	1,168.58
1,650.0	59.244	130.611	649.85	1,168.35
1,700.0	59.215	130.548	648.48	1,168.15
1,750.0	59.187	130.485	648.79	1,167.95
1,800.0	59.157	130.420	649.12	1,167.77

Integral Mass and Energy Release at 1,800 seconds after postulated accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	310,663.80	684,900.00	205.70	816.30

Table 6.2.1-10 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
0.0	71.7	1,020.0	71.7	1,020.0
0.5	71.0	1,010.1	70.4	1,001.0
1.0	69.9	994.3	68.9	980.5
1.5	68.9	979.6	67.6	961.7
2.0	67.9	965.9	66.4	944.4
2.5	67.0	953.0	65.3	928.5
3.0	66.1	940.8	64.2	913.8
3.5	65.3	929.3	63.3	900.1
4.0	64.6	918.4	62.4	887.4
4.5	63.8	908.1	61.6	875.6
5.0	63.2	898.3	60.8	864.5
5.5	62.5	889.0	60.1	854.2
6.0	61.9	880.2	59.4	844.5
6.5	61.3	871.9	58.8	836.8
7.0	60.9	866.0	58.5	832.0
7.5	60.6	862.3	58.3	828.6
8.0	60.4	859.3	58.0	825.6
8.5	60.2	856.5	57.8	822.9
9.0	60.0	853.8	57.7	820.3
9.5	59.8	851.3	57.5	817.9
10.0	59.7	849.1	57.4	815.8
10.5	60.0	852.8	57.3	815.1
11.0	61.7	877.1	57.6	819.3
11.5	63.3	899.9	57.9	823.3
12.0	64.8	921.5	58.1	827.1
13.0	67.7	962.4	58.6	834.0

Table 6.2.1-10 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
14.0	70.3	1,000.3	59.0	839.5
15.0	72.7	1,034.3	59.2	842.8
16.0	74.8	1,063.7	59.6	847.4
17.0	76.5	1,087.7	59.8	851.1
18.0	77.8	1,106.3	59.9	851.6
19.0	78.7	1,120.1	59.7	849.2
20.0	79.4	1,130.0	59.4	844.8
22.0	80.3	1,142.6	58.5	832.8
24.0	80.9	1,151.4	57.7	820.9
26.0	81.6	1,160.5	57.0	811.2
28.0	82.2	1,169.5	56.5	803.4
30.0	82.7	1,176.0	55.9	795.3
32.0	82.8	1,177.9	55.2	785.4
34.0	82.6	1,175.4	54.4	773.7
36.0	82.3	1,170.3	53.5	761.6
38.0	81.9	1,164.5	52.7	750.2
40.0	81.8	1,163.9	52.0	740.3
42.0	81.8	1,163.8	51.4	731.6
44.0	81.8	1,163.7	50.9	723.4
46.0	81.8	1,163.6	50.3	715.0
48.0	81.8	1,163.4	49.7	706.3
50.0	81.8	1,163.3	49.0	697.6
55.0	81.8	1,162.9	47.6	677.8
60.0	81.7	1,162.6	46.4	660.2
65.0	81.7	1,162.2	45.2	642.7
70.0	81.7	1,161.8	44.0	626.2

Table 6.2.1-10 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
75.0	81.6	1,161.4	42.9	610.0
80.0	81.6	1,161.0	41.7	592.9
85.0	81.6	1,160.6	40.5	575.8
90.0	81.6	1,160.2	39.3	559.1
95.0	81.5	1,159.8	38.2	542.7
100.0	81.5	1,159.4	37.0	526.9
120.0	81.4	1,157.9	33.1	471.3
140.0	81.3	1,156.3	29.8	423.8
160.0	81.2	1,154.8	27.2	387.5
180.0	81.1	1,153.3	24.8	352.8
200.0	81.0	1,151.9	22.4	318.3
220.0	80.9	1,150.4	20.0	284.7
240.0	80.8	1,149.1	17.7	252.1
260.0	80.7	1,147.7	15.5	220.1
280.0	80.6	1,146.4	13.3	188.5
300.0	80.5	1,145.2	11.1	157.6
320.0	80.4	1,144.0	9.0	128.2
340.0	80.3	1,142.9	7.2	101.8
360.0	80.3	1,141.9	5.6	79.4
380.0	80.2	1,141.0	4.3	61.6
400.0	80.1	1,140.0	3.5	49.2
420.0	80.1	1,139.2	2.9	41.6
440.0	80.0	1,138.3	2.6	37.4
460.0	80.0	1,137.4	2.6	36.7
480.0	79.9	1,136.6	2.5	36.1
500.0	79.8	1,135.8	2.5	35.6

Table 6.2.1-10 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
525.0	79.8	1,134.7	3.0	42.1
550.0	79.7	1,133.7	3.1	43.7
575.0	79.6	1,132.7	3.1	43.7
600.0	79.6	1,131.6	3.1	43.5
625.0	79.5	1,130.6	3.0	43.2
650.0	79.4	1,129.5	3.0	42.8
675.0	79.3	1,128.4	3.0	42.5
700.0	79.3	1,127.4	3.0	42.2
725.0	79.2	1,126.3	2.9	41.9
750.0	79.1	1,125.2	2.9	41.6
775.0	79.0	1,124.1	2.9	41.4
800.0	78.9	1,123.0	2.9	41.1
825.0	78.9	1,121.9	2.9	40.9
850.0	78.8	1,120.9	2.9	40.7
875.0	78.7	1,119.8	2.8	40.4
900.0	78.6	1,118.6	2.8	40.2
925.0	78.6	1,117.5	2.8	40.0
950.0	78.5	1,116.4	2.8	39.9
975.0	78.4	1,115.3	2.8	39.7
1,000.0	78.3	1,114.2	2.8	39.5
1,050.0	78.2	1,111.9	2.8	39.2
1,100.0	78.0	1,109.6	2.7	38.9
1,150.0	77.8	1,107.3	2.7	38.6
1,200.0	77.7	1,105.0	2.7	38.4
1,250.0	77.5	1,102.6	2.7	38.1
1,300.0	77.4	1,100.3	2.7	37.9

Table 6.2.1-10 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,350.0	77.2	1,097.9	2.7	37.7
1,400.0	77.0	1,095.4	2.6	37.6
1,450.0	76.8	1,093.0	2.6	37.4
1,500.0	76.7	1,090.5	2.6	37.3
1,550.0	76.5	1,088.1	2.6	37.1
1,600.0	76.3	1,085.5	2.6	37.0
1,650.0	76.1	1,083.0	2.6	36.9
1,700.0	76.0	1,080.5	2.6	36.8
1,750.0	75.8	1,077.9	2.6	36.7
1,800.0	75.6	1,075.3	2.6	36.6

Table 6.2.1-10 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.89	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
5.20	High containment pressure reactor trip signal	-
5.30	Reactor trip breakers open, turbine admission valves closed	-
10.40	Main steam isolation valves closed	-
15.40	Main feedwater isolation valves closed	-
21.71	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
111.71	Start containment spray injection	-
111.71	Peak containment temperature	167.45 ^{o}C (333.41 ^{o}F)
323.52	Peak containment pressure	3.137kg/cm²G (44.62 psig)
1,800.0	End of blowdown	-
2,799.4	Time of depressurization of the containment at 50% of peak pressure	1.568kg/cm²G (22.31 psig)

Table 6.2.1-11 (1 of 11)

Main Steam Line Break, 75 % Power – Loss of One CSS Train
(0.849 m^2 (9.134 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,466.980	9,848.057	661.81	1,191.24
0.5	4,204.450	9,269.273	662.92	1,193.23
1.0	4,064.733	8,961.248	663.51	1,194.30
1.5	3,962.723	8,736.354	663.94	1,195.06
2.0	3,872.062	8,536.480	664.32	1,195.74
2.5	3,788.659	8,352.607	664.64	1,196.35
3.0	3,711.479	8,182.452	664.96	1,196.89
3.5	3,639.779	8,024.381	665.23	1,197.40
4.0	3,573.518	7,878.300	665.48	1,197.85
4.5	3,511.531	7,741.642	665.72	1,198.27
5.0	3,453.515	7,613.738	665.93	1,198.65
5.5	3,528.482	7,779.011	665.73	1,198.29
6.0	3,543.421	7,811.946	665.71	1,198.24
6.5	3,528.414	7,778.862	665.77	1,198.35
7.0	3,506.109	7,729.687	665.84	1,198.50
7.5	3,482.741	7,678.170	665.94	1,198.66
8.0	3,459.830	7,627.659	666.02	1,198.81
8.5	3,437.723	7,578.921	666.11	1,198.94
9.0	3,416.551	7,532.244	666.17	1,199.08
9.5	3,396.438	7,487.902	666.26	1,199.21
10.0	3,377.489	7,446.127	666.32	1,199.33
10.5	1,007.060	2,220.198	666.10	1,198.95

Table 6.2.1-11 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
11.0	1,008.780	2,223.990	666.05	1,198.93
11.5	1,010.443	2,227.657	666.04	1,198.88
12.0	1,012.030	2,231.156	666.09	1,198.84
13.0	1,014.799	2,237.261	666.04	1,198.79
14.0	1,016.621	2,241.277	666.03	1,198.74
15.0	1,016.953	2,242.009	666.01	1,198.75
16.0	1,020.499	2,249.827	665.95	1,198.67
17.0	1,022.556	2,254.362	665.88	1,198.61
18.0	1,021.879	2,252.869	665.93	1,198.60
19.0	1,018.772	2,246.019	666.00	1,198.70
20.0	1,013.744	2,234.934	666.05	1,198.78
22.0	1,000.397	2,205.509	666.24	1,199.09
24.0	986.331	2,174.500	666.31	1,199.40
26.0	973.992	2,147.297	666.54	1,199.69
28.0	963.314	2,123.755	666.66	1,199.90
30.0	952.773	2,100.516	666.79	1,200.13
32.0	941.004	2,074.570	666.84	1,200.35
34.0	927.816	2,045.495	667.05	1,200.64
36.0	914.092	2,015.239	667.22	1,200.90
38.0	900.983	1,986.338	667.27	1,201.16
40.0	889.237	1,960.443	667.43	1,201.36
42.0	879.069	1,938.026	667.52	1,201.53
44.0	869.461	1,916.843	667.66	1,201.72
46.0	859.892	1,895.748	667.76	1,201.90
48.0	850.185	1,874.347	667.85	1,202.07

Table 6.2.1-11 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
50.0	840.512	1,853.022	667.93	1,202.25
55.0	818.181	1,803.790	668.07	1,202.58
60.0	798.316	1,759.995	668.28	1,202.90
65.0	779.005	1,717.422	668.42	1,203.14
70.0	760.823	1,677.337	668.62	1,203.40
75.0	743.752	1,639.702	668.64	1,203.63
80.0	727.189	1,603.185	668.74	1,203.79
85.0	711.337	1,568.237	668.88	1,203.96
90.0	696.127	1,534.706	668.99	1,204.07
95.0	680.636	1,500.554	669.08	1,204.22
100.0	664.693	1,465.405	669.03	1,204.31
120.0	600.210	1,323.243	669.27	1,204.62
140.0	545.062	1,201.662	669.28	1,204.50
160.0	504.372	1,111.956	669.15	1,204.27
180.0	466.377	1,028.190	668.77	1,203.96
200.0	431.481	951.258	668.63	1,203.35
220.0	398.573	878.707	668.13	1,202.79
240.0	365.786	806.425	667.60	1,201.85
260.0	335.164	738.914	667.14	1,200.82
280.0	306.472	675.659	666.62	1,199.72
300.0	279.338	615.839	665.86	1,198.37
320.0	252.427	556.510	665.14	1,196.92
340.0	226.719	499.833	663.82	1,195.20
360.0	201.996	445.328	662.88	1,193.05
380.0	178.378	393.258	661.52	1,190.82

Table 6.2.1-11 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	156.177	344.314	660.15	1,188.16
420.0	136.784	301.558	658.70	1,185.18
440.0	119.760	264.028	657.15	1,182.07
460.0	106.317	234.389	654.65	1,178.38
480.0	86.770	191.297	653.45	1,176.18
500.0	75.790	167.090	653.12	1,174.82
525.0	68.095	150.124	652.03	1,173.70
550.0	64.112	141.343	651.98	1,173.03
575.0	62.044	136.784	651.15	1,172.65
600.0	60.953	134.379	651.32	1,172.06
625.0	60.361	133.075	651.08	1,171.52
650.0	60.029	132.341	651.35	1,171.22
675.0	59.834	131.912	650.13	1,171.24
700.0	59.711	131.641	651.47	1,171.37
725.0	59.626	131.454	650.72	1,170.75
750.0	59.563	131.314	649.73	1,171.24
775.0	59.512	131.202	650.29	1,170.71
800.0	59.468	131.106	650.77	1,170.81
825.0	59.429	131.020	649.51	1,170.81
850.0	59.393	130.939	649.91	1,170.01
875.0	59.358	130.862	650.29	1,169.93
900.0	59.324	130.788	650.66	1,169.83
925.0	59.291	130.716	649.34	1,169.71
950.0	59.259	130.645	649.69	1,169.58
975.0	59.228	130.576	650.03	1,169.43

Table 6.2.1-11 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,000.0	59.197	130.508	650.37	1,170.04
1,050.0	59.136	130.373	649.35	1,169.72
1,100.0	59.077	130.243	650.00	1,169.35
1,150.0	59.018	130.112	648.95	1,168.99
1,200.0	58.958	129.980	649.61	1,169.41
1,250.0	58.897	129.846	650.29	1,169.08
1,300.0	58.835	129.709	649.27	1,168.77
1,350.0	58.771	129.568	649.98	1,168.50
1,400.0	58.705	129.423	649.01	1,168.26
1,450.0	58.637	129.274	649.76	1,168.06
1,500.0	58.567	129.118	648.83	1,168.70
1,550.0	58.496	128.963	649.62	1,168.55
1,600.0	59.537	131.257	648.34	1,168.70
1,650.0	61.789	136.223	648.98	1,168.67
1,700.0	61.474	135.528	649.05	1,168.76
1,750.0	60.686	133.791	649.24	1,168.24
1,800.0	60.072	132.436	649.22	1,168.11

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	311,298.80	686,300.00	206.20	818.30

Table 6.2.1-11 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
0.0	72.6	1,032.8	72.6	1,032.8
0.5	71.8	1,021.7	71.1	1,011.5
1.0	70.6	1,004.1	69.5	989.3
1.5	69.3	986.0	68.1	968.4
2.0	68.1	968.9	66.7	949.0
2.5	67.0	952.9	65.4	930.8
3.0	65.9	937.8	64.2	913.8
3.5	64.9	923.5	63.1	897.9
4.0	64.0	909.9	62.1	882.9
4.5	63.1	897.0	61.1	868.8
5.0	62.2	884.8	60.1	855.5
5.5	61.4	873.4	59.4	844.6
6.0	60.9	865.6	58.8	836.7
6.5	60.4	859.4	58.3	830.0
7.0	60.0	853.7	57.9	823.9
7.5	59.6	848.2	57.5	818.1
8.0	59.3	842.9	57.1	812.7
8.5	58.9	837.7	56.8	807.5
9.0	58.5	832.8	56.4	802.6
9.5	58.2	828.1	56.1	798.0
10.0	57.9	823.7	55.8	793.7
10.5	58.6	833.2	55.7	793.0
11.0	59.9	851.4	55.8	794.4
11.5	61.1	869.3	55.9	795.7
12.0	62.3	886.7	56.0	797.0
13.0	64.6	919.2	56.2	799.2

Table 6.2.1-11 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
14.0	66.7	949.3	56.3	800.6
15.0	68.6	976.4	56.3	800.9
16.0	70.3	1,000.0	56.5	803.8
17.0	71.7	1,019.8	56.6	805.4
18.0	72.8	1,035.7	56.6	804.8
19.0	73.7	1,048.1	56.4	802.3
20.0	74.3	1,057.3	56.1	798.2
22.0	75.2	1,069.7	55.4	787.5
24.0	75.8	1,078.3	54.6	776.2
26.0	76.4	1,086.2	53.9	766.3
28.0	76.9	1,093.7	53.3	757.8
30.0	77.3	1,099.2	52.7	749.3
32.0	77.4	1,101.2	52.0	739.9
34.0	77.3	1,099.8	51.3	729.3
36.0	77.0	1,096.0	50.5	718.3
38.0	76.7	1,091.3	49.8	707.8
40.0	76.6	1,089.2	49.1	698.3
42.0	76.6	1,089.2	48.5	689.8
44.0	76.6	1,089.1	47.9	681.7
46.0	76.6	1,089.0	47.4	673.6
48.0	76.5	1,088.9	46.8	665.5
50.0	76.5	1,088.8	46.2	657.3
55.0	76.5	1,088.5	44.9	638.5
60.0	76.5	1,088.3	43.7	621.8
65.0	76.5	1,088.0	42.6	605.6

Table 6.2.1-11 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
70.0	76.5	1,087.7	41.5	590.3
75.0	76.4	1,087.3	40.5	575.9
80.0	76.4	1,087.0	39.5	562.0
85.0	76.4	1,086.7	38.6	548.6
90.0	76.4	1,086.4	37.7	535.8
95.0	76.3	1,086.0	36.8	522.8
100.0	76.3	1,085.7	35.8	509.4
120.0	76.2	1,084.3	32.1	457.2
140.0	76.1	1,082.9	29.0	413.1
160.0	76.0	1,081.5	26.7	380.4
180.0	75.9	1,080.0	24.6	350.0
200.0	75.8	1,078.6	22.6	322.0
220.0	75.7	1,077.1	20.8	295.6
240.0	75.6	1,075.5	18.9	269.4
260.0	75.5	1,074.0	17.2	244.8
280.0	75.4	1,072.5	15.6	221.8
300.0	75.3	1,070.9	14.1	200.1
320.0	75.2	1,069.4	12.6	179.5
340.0	75.1	1,067.9	11.2	159.8
360.0	75.0	1,066.3	9.9	140.9
380.0	74.9	1,064.8	8.6	122.8
400.0	74.7	1,063.3	7.4	105.8
420.0	74.6	1,061.8	6.3	90.1
440.0	74.5	1,060.3	5.3	75.8
460.0	74.4	1,058.9	4.4	61.9
480.0	74.3	1,057.4	3.9	55.2

Table 6.2.1-11 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
500.0	74.2	1,056.0	3.6	51.3
525.0	74.1	1,054.3	3.4	48.5
550.0	74.0	1,052.5	3.3	46.8
575.0	73.9	1,050.8	3.2	45.7
600.0	73.7	1,049.0	3.2	45.0
625.0	73.6	1,047.3	3.1	44.4
650.0	73.5	1,045.5	3.1	43.9
675.0	73.4	1,043.8	3.1	43.5
700.0	73.3	1,042.0	3.0	43.1
725.0	73.1	1,040.2	3.0	42.7
750.0	73.0	1,038.4	3.0	42.4
775.0	72.9	1,036.6	3.0	42.1
800.0	72.7	1,034.8	2.9	41.8
825.0	72.6	1,033.0	2.9	41.5
850.0	72.5	1,031.2	2.9	41.3
875.0	72.4	1,029.3	2.9	41.0
900.0	72.2	1,027.5	2.9	40.8
925.0	72.1	1,025.6	2.8	40.5
950.0	72.0	1,023.8	2.8	40.3
975.0	71.8	1,021.9	2.8	40.1
1,000.0	71.7	1,020.0	2.8	39.9
1,050.0	71.4	1,016.3	2.8	39.5

Table 6.2.1-11 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,100.0	71.2	1,012.4	2.8	39.2
1,150.0	70.9	1,008.6	2.7	38.9
1,200.0	70.6	1,004.7	2.7	38.6
1,250.0	70.4	1,000.8	2.7	38.3
1,300.0	70.1	996.8	2.7	38.1
1,350.0	69.8	992.8	2.7	37.8
1,400.0	69.5	988.8	2.6	37.6
1,450.0	69.2	984.7	2.6	37.4
1,500.0	68.9	980.6	2.6	37.2
1,550.0	68.6	976.5	2.6	37.1
1,600.0	68.4	972.5	2.6	37.3
1,650.0	68.1	969.0	2.7	37.9
1,700.0	67.9	965.6	2.7	37.7
1,750.0	67.6	962.0	2.6	37.4
1,800.0	67.4	958.3	2.6	37.1

Table 6.2.1-11 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.71	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
5.00	High containment pressure reactor trip signal	-
5.10	Reactor trip breakers open, turbine admission valves closed	-
10.20	Main steam isolation valves closed	-
15.20	Main feedwater isolation valves closed	-
36.31	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
126.31	Start containment spray injection	-
126.31	Peak containment temperature	163.52 ^{o}C (326.34 ^{o}F)
436.91	Peak containment pressure	3.281kg/cm²G (46.67psig)
1,800.0	End of blowdown	-
3,608.4	Time of depressurization of the containment at 50% of peak pressure	1.639kg/cm²G (23.31psig)

Table 6.2.1-12 (1 of 11)

Main Steam Line Break, 75 % Power – MSIV Failure
(0.849 m^2 (9.134 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,466.980	9,848.057	661.81	1,191.24
0.5	4,204.450	9,269.273	662.92	1,193.23
1.0	4,064.733	8,961.248	663.51	1,194.30
1.5	3,962.723	8,736.354	663.94	1,195.06
2.0	3,872.062	8,536.480	664.32	1,195.74
2.5	3,788.659	8,352.607	664.64	1,196.35
3.0	3,711.479	8,182.452	664.96	1,196.89
3.5	3,639.779	8,024.381	665.23	1,197.40
4.0	3,573.518	7,878.300	665.48	1,197.85
4.5	3,511.531	7,741.642	665.72	1,198.27
5.0	3,453.515	7,613.738	665.93	1,198.65
5.5	3,528.482	7,779.011	665.73	1,198.29
6.0	3,543.421	7,811.946	665.71	1,198.24
6.5	3,528.414	7,778.862	665.77	1,198.35
7.0	3,506.109	7,729.687	665.84	1,198.50
7.5	3,482.741	7,678.170	665.94	1,198.66
8.0	3,459.830	7,627.659	666.02	1,198.81
8.5	3,437.723	7,578.921	666.11	1,198.94
9.0	3,416.551	7,532.244	666.17	1,199.08
9.5	3,396.438	7,487.902	666.26	1,199.21
10.0	3,377.489	7,446.127	666.32	1,199.33

Table 6.2.1-12 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
10.5	3,210.108	7,077.113	666.80	1,200.19
11.0	2,947.211	6,497.522	667.38	1,201.24
11.5	2,715.607	5,986.919	667.70	1,201.85
12.0	2,511.762	5,537.517	667.86	1,202.09
13.0	2,174.656	4,794.321	667.69	1,201.84
14.0	1,913.176	4,217.854	667.27	1,201.04
15.0	1,707.969	3,765.446	666.70	1,200.07
16.0	1,551.382	3,420.229	666.18	1,199.10
17.0	1,429.138	3,150.726	665.79	1,198.36
18.0	1,331.911	2,936.377	665.51	1,197.90
19.0	1,253.575	2,763.675	665.46	1,197.72
20.0	1,189.798	2,623.069	665.41	1,197.76
22.0	1,095.270	2,414.670	665.68	1,198.22
24.0	1,034.490	2,280.671	666.03	1,198.86
26.0	999.836	2,204.273	666.31	1,199.35
28.0	978.638	2,157.539	666.54	1,199.70
30.0	964.021	2,125.314	666.69	1,199.96
32.0	951.645	2,098.028	666.74	1,200.17
34.0	938.892	2,069.914	666.96	1,200.44
36.0	925.675	2,040.774	667.08	1,200.67
38.0	912.455	2,011.629	667.21	1,200.92
40.0	899.763	1,983.648	667.29	1,201.17
42.0	888.422	1,958.646	667.48	1,201.34
44.0	878.103	1,935.895	667.58	1,201.56
46.0	868.281	1,914.242	667.64	1,201.73
48.0	858.701	1,893.121	667.75	1,201.88

Table 6.2.1-12 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
50.0	848.906	1,871.528	667.80	1,202.01
55.0	825.889	1,820.783	668.01	1,202.39
60.0	805.089	1,774.926	668.25	1,202.70
65.0	786.033	1,732.916	668.29	1,202.94
70.0	767.417	1,691.873	668.48	1,203.22
75.0	749.882	1,653.215	668.64	1,203.41
80.0	728.663	1,606.436	668.76	1,203.72
85.0	712.704	1,571.252	668.86	1,203.88
90.0	697.694	1,538.160	668.92	1,204.04
95.0	682.204	1,504.011	669.01	1,204.18
100.0	666.445	1,469.268	669.07	1,204.27
120.0	602.104	1,327.418	669.15	1,204.52
140.0	546.183	1,204.133	669.19	1,204.44
160.0	505.479	1,114.396	669.07	1,204.24
180.0	467.574	1,030.829	668.77	1,203.89
200.0	432.017	952.439	668.49	1,203.33
220.0	399.675	881.137	668.04	1,202.65
240.0	367.091	809.302	667.68	1,201.78
260.0	335.910	740.558	667.14	1,200.85
280.0	307.487	677.896	666.37	1,199.59
300.0	278.869	614.804	665.90	1,198.43
320.0	252.518	556.709	664.90	1,196.86
340.0	227.310	501.135	663.85	1,195.09
360.0	203.210	448.003	662.86	1,193.07
380.0	178.614	393.778	661.76	1,190.77

Table 6.2.1-12 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	156.754	345.586	660.27	1,188.13
420.0	135.537	298.810	658.86	1,185.37
440.0	121.378	267.595	656.63	1,182.01
460.0	105.950	233.582	655.03	1,178.60
480.0	94.571	208.495	653.48	1,175.09
500.0	82.888	182.738	651.48	1,172.17
525.0	74.454	164.143	650.07	1,169.10
550.0	65.760	144.976	649.33	1,168.47
575.0	62.640	138.098	648.15	1,168.01
600.0	61.463	135.504	649.17	1,167.49
625.0	59.226	130.571	648.36	1,167.18
650.0	54.574	120.316	650.49	1,171.08
675.0	57.059	125.794	650.20	1,170.96
700.0	58.273	128.471	650.39	1,171.47
725.0	58.869	129.784	650.60	1,171.18
750.0	59.152	130.409	650.87	1,170.93
775.0	59.279	130.688	651.16	1,170.73
800.0	59.327	130.795	650.63	1,170.53
825.0	59.337	130.816	650.52	1,170.35
850.0	59.327	130.794	650.63	1,170.54
875.0	59.307	130.750	650.85	1,170.17
900.0	59.282	130.696	649.44	1,170.66
925.0	59.255	130.636	649.73	1,170.43
950.0	59.227	130.574	650.04	1,170.22
975.0	59.199	130.512	650.35	1,170.01

Table 6.2.1-12 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,000.0	59.170	130.449	650.67	1,169.81
1,050.0	59.112	130.321	649.61	1,169.42
1,100.0	59.052	130.189	650.27	1,169.84
1,150.0	58.995	130.062	649.21	1,169.44
1,200.0	58.937	129.935	649.85	1,169.05
1,250.0	58.878	129.805	648.80	1,169.45
1,300.0	58.818	129.672	649.46	1,169.10
1,350.0	58.756	129.535	650.15	1,168.80
1,400.0	58.691	129.393	649.16	1,168.53
1,450.0	58.624	129.245	649.90	1,168.32
1,500.0	58.555	129.092	648.96	1,168.16
1,550.0	58.484	128.936	649.75	1,168.02
1,600.0	59.449	131.064	649.30	1,168.13
1,650.0	61.805	136.258	648.81	1,169.11
1,700.0	61.521	135.631	648.56	1,168.61
1,750.0	60.726	133.879	648.82	1,168.22
1,800.0	60.100	132.498	648.92	1,168.32

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	321,096.40	707,900.00	212.70	844.20

Table 6.2.1-12 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
0.0	72.6	1,032.8	72.6	1,032.8
0.5	71.8	1,021.7	71.1	1,011.5
1.0	70.6	1,004.1	69.5	989.3
1.5	69.3	986.0	68.1	968.4
2.0	68.1	968.9	66.7	949.0
2.5	67.0	952.9	65.4	930.8
3.0	65.9	937.8	64.2	913.8
3.5	64.9	923.5	63.1	897.9
4.0	64.0	909.9	62.1	882.9
4.5	63.1	897.0	61.1	868.8
5.0	62.2	884.8	60.1	855.5
5.5	61.4	873.4	59.4	844.6
6.0	60.9	865.6	58.8	836.7
6.5	60.4	859.4	58.3	830.0
7.0	60.0	853.7	57.9	823.9
7.5	59.6	848.2	57.5	818.1
8.0	59.3	842.9	57.1	812.7
8.5	58.9	837.7	56.8	807.5
9.0	58.5	832.8	56.4	802.6
9.5	58.2	828.1	56.1	798.0
10.0	57.9	823.7	55.8	793.7
10.5	58.6	833.2	55.7	793.0
11.0	59.9	851.4	55.8	794.4
11.5	61.1	869.3	55.9	795.7
12.0	62.3	886.7	56.0	797.0
13.0	64.6	919.2	56.2	799.2

Table 6.2.1-12 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
14.0	66.7	949.3	56.3	800.6
15.0	68.6	976.4	56.3	800.9
16.0	70.3	1,000.0	56.5	803.8
17.0	71.7	1,019.8	56.6	805.4
18.0	72.8	1,035.7	56.6	804.8
19.0	73.7	1,048.1	56.4	802.3
20.0	74.3	1,057.3	56.1	798.2
22.0	75.2	1,069.7	55.4	787.5
24.0	75.8	1,078.3	54.6	776.2
26.0	76.4	1,086.2	53.9	766.3
28.0	76.9	1,093.7	53.3	757.8
30.0	77.3	1,099.2	52.7	749.3
32.0	77.4	1,101.2	52.0	739.9
34.0	77.3	1,099.8	51.3	729.3
36.0	77.0	1,096.0	50.5	718.3
38.0	76.7	1,091.3	49.8	707.8
40.0	76.6	1,089.2	49.1	698.3
42.0	76.6	1,089.2	48.5	689.8
44.0	76.6	1,089.1	47.9	681.7
46.0	76.6	1,089.0	47.4	673.6
48.0	76.5	1,088.9	46.8	665.5
50.0	76.5	1,088.8	46.2	657.3
55.0	76.5	1,088.5	44.9	638.5
60.0	76.5	1,088.3	43.7	621.8
65.0	76.5	1,088.0	42.6	605.6

Table 6.2.1-12 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
70.0	76.5	1,087.7	41.5	590.3
75.0	76.4	1,087.3	40.5	575.9
80.0	76.4	1,087.0	39.5	562.0
85.0	76.4	1,086.7	38.6	548.6
90.0	76.4	1,086.4	37.7	535.8
95.0	76.3	1,086.0	36.8	522.8
100.0	76.3	1,085.7	35.8	509.4
120.0	76.2	1,084.3	32.1	457.2
140.0	76.1	1,082.9	29.0	413.1
160.0	76.0	1,081.5	26.7	380.4
180.0	75.9	1,080.0	24.6	350.0
200.0	75.8	1,078.6	22.6	322.0
220.0	75.7	1,077.1	20.8	295.6
240.0	75.6	1,075.5	18.9	269.4
260.0	75.5	1,074.0	17.2	244.8
280.0	75.4	1,072.5	15.6	221.8
300.0	75.3	1,070.9	14.1	200.1
320.0	75.2	1,069.4	12.6	179.5
340.0	75.1	1,067.9	11.2	159.8
360.0	75.0	1,066.3	9.9	140.9
380.0	74.9	1,064.8	8.6	122.8
400.0	74.7	1,063.3	7.4	105.8
420.0	74.6	1,061.8	6.3	90.1
440.0	74.5	1,060.3	5.3	75.8
460.0	74.4	1,058.9	4.5	63.5
480.0	74.3	1,057.5	3.8	53.4

Table 6.2.1-12 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
500.0	74.2	1,056.0	3.2	45.6
525.0	74.1	1,054.3	2.7	38.4
550.0	74.0	1,052.5	2.6	36.9
575.0	73.9	1,050.7	2.6	36.3
600.0	73.7	1,049.0	2.5	35.7
625.0	73.6	1,047.2	2.5	35.1
650.0	73.5	1,045.5	3.0	43.1
675.0	73.4	1,043.7	3.1	43.4
700.0	73.3	1,042.0	3.0	43.3
725.0	73.1	1,040.2	3.0	43.1
750.0	73.0	1,038.4	3.0	42.9
775.0	72.9	1,036.6	3.0	42.6
800.0	72.7	1,034.8	3.0	42.3
825.0	72.6	1,033.0	3.0	42.1
850.0	72.5	1,031.1	2.9	41.8
875.0	72.4	1,029.3	2.9	41.5
900.0	72.2	1,027.5	2.9	41.3
925.0	72.1	1,025.6	2.9	41.0
950.0	72.0	1,023.8	2.9	40.8
975.0	71.8	1,021.9	2.9	40.6
1,000.0	71.7	1,020.0	2.8	40.4
1,050.0	71.4	1,016.2	2.8	40.0
1,100.0	71.2	1,012.4	2.8	39.6
1,150.0	70.9	1,008.6	2.8	39.3

Table 6.2.1-12 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,200.0	70.6	1,004.7	2.7	39.0
1,250.0	70.4	1,000.8	2.7	38.7
1,300.0	70.1	996.8	2.7	38.4
1,350.0	69.8	992.8	2.7	38.2
1,400.0	69.5	988.8	2.7	38.0
1,450.0	69.2	984.7	2.7	37.7
1,500.0	68.9	980.6	2.6	37.5
1,550.0	68.6	976.5	2.6	37.4
1,600.0	68.4	972.4	2.6	37.5
1,650.0	68.1	969.0	2.7	38.1
1,700.0	67.9	965.6	2.7	38.0
1,750.0	67.6	962.0	2.6	37.6
1,800.0	67.4	958.3	2.6	37.3

Table 6.2.1-12 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.71	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
5.00	High containment pressure reactor trip signal	-
5.10	Reactor trip breakers open, turbine admission valves closed	-
10.20	Main steam isolation valves closed	-
15.20	Main feedwater isolation valves closed	-
22.21	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
112.21	Start containment spray injection	-
112.21	Peak containment temperature	165.28 ^{o}C (329.51 ^{o}F)
399.31	Peak containment pressure	3.206kg/cm²G (45.60 psig)
1,800.0	End of blowdown	-
2,944.8	Time of depressurization of the containment at 50% of peak pressure	1.598kg/cm²G (22.72 psig)

Table 6.2.1-13 (1 of 11)

Main Steam Line Break, 50 % Power – Loss of One CSS Train
(0.849 m^2 (9.134 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,540.438	10,010.003	661.48	1,190.62
0.5	4,299.519	9,478.866	662.52	1,192.51
1.0	4,170.701	9,194.869	663.08	1,193.52
1.5	4,072.873	8,979.194	663.51	1,194.29
2.0	3,987.720	8,791.463	663.86	1,194.94
2.5	3,909.641	8,619.327	664.20	1,195.55
3.0	3,836.567	8,458.228	664.50	1,196.09
3.5	3,767.610	8,306.201	664.80	1,196.59
4.0	3,702.539	8,162.744	665.06	1,197.05
4.5	3,641.144	8,027.390	665.29	1,197.49
5.0	3,598.854	7,934.156	665.46	1,197.80
5.5	3,606.383	7,950.756	665.46	1,197.80
6.0	3,580.279	7,893.204	665.56	1,197.99
6.5	3,546.265	7,818.216	665.69	1,198.23
7.0	3,511.439	7,741.439	665.82	1,198.46
7.5	3,477.524	7,666.668	665.96	1,198.68
8.0	3,444.901	7,594.747	666.09	1,198.89
8.5	3,413.605	7,525.751	666.19	1,199.10
9.0	3,383.665	7,459.742	666.29	1,199.29
9.5	3,355.084	7,396.732	666.39	1,199.48
10.0	3,327.871	7,336.737	666.49	1,199.63

Table 6.2.1-13 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
10.5	992.498	2,188.094	666.30	1,199.26
11.0	991.875	2,186.721	666.31	1,199.28
11.5	991.255	2,185.354	666.33	1,199.30
12.0	990.625	2,183.965	666.35	1,199.33
13.0	989.224	2,180.877	666.28	1,199.33
14.0	987.366	2,176.780	666.32	1,199.39
15.0	984.686	2,170.872	666.41	1,199.43
16.0	984.545	2,170.562	666.40	1,199.46
17.0	983.085	2,167.343	666.37	1,199.49
18.0	979.912	2,160.347	666.39	1,199.53
19.0	975.188	2,149.933	666.54	1,199.67
20.0	969.211	2,136.756	666.52	1,199.76
22.0	955.024	2,105.479	666.68	1,200.06
24.0	940.258	2,072.925	666.94	1,200.38
26.0	926.648	2,042.919	667.03	1,200.63
28.0	914.303	2,015.703	667.17	1,200.87
30.0	902.302	1,989.246	667.29	1,201.11
32.0	889.800	1,961.684	667.45	1,201.31
34.0	877.102	1,933.690	667.54	1,201.59
36.0	864.193	1,905.230	667.67	1,201.80
38.0	851.819	1,877.949	667.86	1,202.06
40.0	840.432	1,852.846	667.87	1,202.20
42.0	829.996	1,829.837	668.08	1,202.40
44.0	820.136	1,808.099	668.06	1,202.53
46.0	810.464	1,786.777	668.14	1,202.72
48.0	800.829	1,765.536	668.31	1,202.86

Table 6.2.1-13 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
50.0	791.347	1,744.631	668.35	1,203.01
55.0	769.556	1,696.589	668.57	1,203.30
60.0	750.263	1,654.056	668.70	1,203.53
65.0	731.847	1,613.454	668.72	1,203.75
70.0	714.696	1,575.643	668.82	1,203.95
75.0	698.696	1,540.370	668.96	1,204.06
80.0	683.297	1,506.420	668.96	1,204.18
85.0	668.361	1,473.492	669.10	1,204.28
90.0	652.892	1,439.387	669.18	1,204.40
95.0	636.395	1,403.018	669.24	1,204.47
100.0	620.133	1,367.166	669.21	1,204.54
120.0	559.686	1,233.903	669.30	1,204.55
140.0	514.826	1,135.004	669.16	1,204.40
160.0	476.020	1,049.449	668.88	1,204.06
180.0	440.000	970.039	668.64	1,203.56
200.0	407.269	897.879	668.35	1,202.95
220.0	376.301	829.605	667.82	1,202.14
240.0	345.381	761.439	667.38	1,201.28
260.0	316.594	697.975	666.78	1,200.19
280.0	289.810	638.924	665.95	1,198.89
300.0	264.151	582.356	665.15	1,197.55
320.0	239.779	528.626	664.36	1,196.12
340.0	216.861	478.100	663.56	1,194.31
360.0	195.247	430.448	662.75	1,192.48
380.0	174.971	385.746	661.25	1,190.42

Table 6.2.1-13 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	156.123	344.194	660.38	1,188.28
420.0	139.591	307.746	659.07	1,185.72
440.0	124.939	275.444	657.12	1,183.18
460.0	111.934	246.773	655.74	1,180.44
480.0	99.838	220.107	654.06	1,177.15
500.0	85.474	188.438	652.83	1,175.45
525.0	74.588	164.440	652.92	1,174.29
550.0	68.207	150.371	652.43	1,173.10
575.0	64.492	142.181	651.24	1,172.45
600.0	62.325	137.403	651.42	1,171.74
625.0	61.045	134.582	650.34	1,171.78
650.0	60.276	132.886	650.34	1,171.68
675.0	59.802	131.842	650.48	1,171.10
700.0	59.503	131.183	650.39	1,170.88
725.0	59.306	130.749	650.86	1,170.95
750.0	59.169	130.446	650.68	1,170.60
775.0	59.066	130.219	650.12	1,170.34
800.0	58.984	130.038	651.02	1,170.43
825.0	58.915	129.885	650.09	1,170.27
850.0	58.853	129.749	650.77	1,169.95
875.0	58.795	129.622	649.72	1,169.55
900.0	58.740	129.501	650.32	1,169.88
925.0	58.688	129.385	649.20	1,169.38
950.0	58.636	129.271	649.77	1,169.64
975.0	58.589	129.167	650.29	1,169.80

Table 6.2.1-13 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,000.0	58.573	129.133	650.47	1,169.34
1,050.0	60.151	132.612	650.03	1,169.58
1,100.0	61.540	135.674	649.98	1,169.72
1,150.0	61.261	135.059	649.68	1,169.12
1,200.0	60.671	133.757	649.40	1,169.28
1,250.0	60.177	132.668	649.75	1,169.08
1,300.0	59.863	131.975	649.82	1,169.16
1,350.0	59.707	131.633	649.84	1,168.40
1,400.0	59.674	131.559	648.52	1,168.30
1,450.0	59.718	131.656	649.72	1,168.20
1,500.0	59.787	131.809	648.97	1,168.36
1,550.0	59.839	131.923	648.41	1,168.11
1,600.0	59.854	131.956	649.91	1,168.57
1,650.0	59.839	131.924	648.41	1,168.10
1,700.0	59.810	131.859	648.72	1,167.91
1,750.0	59.780	131.792	649.05	1,168.51
1,800.0	59.756	131.740	649.31	1,168.21

Integral Mass and Energy Release at 1,800 seconds after postulated accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	303,179.60	668,400.00	200.80	796.70

Table 6.2.1-13 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
0.0	73.5	1,045.0	73.5	1,045.0
0.5	72.6	1,032.9	72.0	1,023.5
1.0	71.3	1,014.9	70.4	1,001.1
1.5	70.1	996.5	68.9	979.9
2.0	68.8	978.7	67.5	960.3
2.5	67.6	961.5	66.2	941.9
3.0	66.4	945.1	65.0	924.6
3.5	65.3	929.3	63.9	908.4
4.0	64.3	914.2	62.8	893.1
4.5	63.2	899.7	61.8	878.7
5.0	62.3	885.8	60.8	865.1
5.5	61.5	875.1	60.0	853.6
6.0	60.9	866.2	59.3	843.6
6.5	60.3	858.0	58.7	834.5
7.0	59.8	850.0	58.1	825.8
7.5	59.2	842.3	57.5	817.7
8.0	58.7	834.8	56.9	810.0
8.5	58.2	827.6	56.4	802.6
9.0	57.7	820.6	55.9	795.7
9.5	57.2	814.0	55.5	789.0
10.0	56.8	807.6	55.0	782.8
10.5	57.4	817.2	54.9	781.3
11.0	58.4	830.4	54.9	780.8
11.5	59.3	843.4	54.9	780.3
12.0	60.2	856.2	54.8	779.8
13.0	61.9	880.9	54.7	778.6

Table 6.2.1-13 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
14.0	63.6	904.1	54.6	777.1
15.0	65.0	925.1	54.5	775.0
16.0	66.3	943.6	54.5	774.9
17.0	67.5	959.6	54.4	773.7
18.0	68.4	973.0	54.2	771.1
19.0	69.2	984.0	53.9	767.3
20.0	69.8	992.8	53.6	762.5
22.0	70.7	1,005.8	52.8	751.1
24.0	71.4	1,015.4	52.0	739.3
26.0	72.0	1,023.6	51.2	728.4
28.0	72.5	1,030.9	50.5	718.5
30.0	72.8	1,036.2	49.8	708.9
32.0	73.0	1,039.0	49.1	698.8
34.0	73.0	1,039.0	48.4	688.1
36.0	72.9	1,037.0	47.6	677.2
38.0	72.7	1,034.1	46.9	666.8
40.0	72.5	1,030.8	46.2	657.2
42.0	72.3	1,028.0	45.6	648.5
44.0	72.3	1,027.9	45.0	640.2
46.0	72.3	1,027.9	44.4	632.0
48.0	72.3	1,027.8	43.9	623.9
50.0	72.2	1,027.7	43.3	615.9
55.0	72.2	1,027.5	42.0	597.6
60.0	72.2	1,027.4	40.9	581.4
65.0	72.2	1,027.1	39.8	565.9
70.0	72.2	1,026.9	38.8	551.5

Table 6.2.1-13 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
75.0	72.2	1,026.7	37.8	538.0
80.0	72.2	1,026.4	36.9	525.0
85.0	72.1	1,026.2	36.0	512.5
90.0	72.1	1,025.9	35.1	499.5
95.0	72.1	1,025.7	34.2	486.2
100.0	72.1	1,025.4	33.3	473.2
120.0	72.0	1,024.2	29.9	424.8
140.0	71.9	1,023.0	27.3	388.8
160.0	71.8	1,021.7	25.1	357.7
180.0	71.7	1,020.4	23.1	328.8
200.0	71.6	1,019.0	21.3	302.6
220.0	71.5	1,017.5	19.5	277.8
240.0	71.4	1,016.0	17.8	253.0
260.0	71.3	1,014.4	16.2	229.9
280.0	71.2	1,012.8	14.7	208.5
300.0	71.1	1,011.2	13.3	188.5
320.0	71.0	1,009.6	11.9	169.8
340.0	70.9	1,007.9	10.7	152.3
360.0	70.7	1,006.2	9.5	135.7
380.0	70.6	1,004.4	8.5	120.2
400.0	70.5	1,002.7	7.4	105.8
420.0	70.4	1,000.9	6.5	92.5
440.0	70.2	999.2	5.6	80.1
460.0	70.1	997.4	4.9	69.2
480.0	70.0	995.7	4.1	58.6

Table 6.2.1-13 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
500.0	69.9	993.9	3.8	53.6
525.0	69.7	991.7	3.5	49.8
550.0	69.6	989.5	3.3	47.4
575.0	69.4	987.2	3.2	45.8
600.0	69.2	985.0	3.1	44.7
625.0	69.1	982.8	3.1	44.0
650.0	68.9	980.5	3.1	43.4
675.0	68.8	978.2	3.0	42.9
700.0	68.6	975.9	3.0	42.4
725.0	68.5	973.7	3.0	42.1
750.0	68.3	971.3	2.9	41.7
775.0	68.1	969.0	2.9	41.4
800.0	68.0	966.7	2.9	41.1
825.0	67.8	964.3	2.9	40.8
850.0	67.6	962.0	2.9	40.6
875.0	67.5	959.6	2.8	40.3
900.0	67.3	957.2	2.8	40.1
925.0	67.1	954.8	2.8	39.9
950.0	66.9	952.3	2.8	39.7
975.0	66.8	949.9	2.8	39.5
1,000.0	66.6	947.5	2.8	39.3
1,050.0	66.3	942.7	2.8	39.4
1,100.0	66.0	938.3	2.8	39.6
1,150.0	65.7	934.0	2.8	39.2
1,200.0	65.4	929.6	2.7	38.8
1,250.0	65.0	925.1	2.7	38.4

Table 6.2.1-13 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,300.0	64.7	920.7	2.7	38.1
1,350.0	64.4	916.2	2.7	37.9
1,400.0	64.1	911.8	2.7	37.7
1,450.0	63.8	907.4	2.6	37.6
1,500.0	63.5	903.0	2.6	37.4
1,550.0	63.2	898.6	2.6	37.3
1,600.0	62.9	894.3	2.6	37.2
1,650.0	62.6	890.0	2.6	37.1
1,700.0	62.3	885.7	2.6	37.0
1,750.0	62.0	881.4	2.6	36.9
1,800.0	61.7	877.1	2.6	36.8

Table 6.2.1-13 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.61	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
4.90	High containment pressure reactor trip signal	-
5.00	Reactor trip breakers open, turbine admission valves closed	-
10.10	Main steam isolation valves closed	-
15.10	Main feedwater isolation valves closed	-
37.51	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
127.51	Start containment spray injection	-
127.51	Peak containment temperature	161.90 ^{o}C (323.43 ^{o}F)
457.61	Peak containment pressure	3.115kg/cm²G (44.31 psig)
1,800.0	End of blowdown	-
3,629.4	Time of depressurization of the containment at 50% of peak pressure	1.554kg/cm²G (22.10 psig)

Table 6.2.1-14 (1 of 11)

Main Steam Line Break, 50 % Power – MSIV Failure
(0.849 m^2 (9.134 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,540.438	10,010.003	661.48	1,190.62
0.5	4,299.519	9,478.866	662.52	1,192.51
1.0	4,170.701	9,194.869	663.08	1,193.52
1.5	4,072.873	8,979.194	663.51	1,194.29
2.0	3,987.720	8,791.463	663.86	1,194.94
2.5	3,909.641	8,619.327	664.20	1,195.55
3.0	3,836.567	8,458.228	664.50	1,196.09
3.5	3,767.610	8,306.201	664.80	1,196.59
4.0	3,702.539	8,162.744	665.06	1,197.05
4.5	3,641.144	8,027.390	665.29	1,197.49
5.0	3,598.854	7,934.156	665.46	1,197.80
5.5	3,606.383	7,950.756	665.46	1,197.80
6.0	3,580.279	7,893.204	665.56	1,197.99
6.5	3,546.265	7,818.216	665.69	1,198.23
7.0	3,511.439	7,741.439	665.82	1,198.46
7.5	3,477.524	7,666.668	665.96	1,198.68
8.0	3,444.901	7,594.747	666.09	1,198.89
8.5	3,413.605	7,525.751	666.19	1,199.10
9.0	3,383.665	7,459.742	666.29	1,199.29
9.5	3,355.084	7,396.732	666.39	1,199.48
10.0	3,327.871	7,336.737	666.49	1,199.63
10.5	3,108.588	6,853.299	667.09	1,200.71

Table 6.2.1-14 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
11.0	2,854.257	6,292.592	667.60	1,201.65
11.5	2,630.059	5,798.317	667.89	1,202.16
12.0	2,432.569	5,362.925	667.98	1,202.35
13.0	2,105.534	4,641.931	667.81	1,202.04
14.0	1,850.666	4,080.042	667.38	1,201.26
15.0	1,651.074	3,640.015	666.90	1,200.32
16.0	1,497.737	3,301.963	666.41	1,199.47
17.0	1,377.407	3,036.679	666.03	1,198.84
18.0	1,281.752	2,825.794	665.81	1,198.50
19.0	1,204.800	2,656.144	665.75	1,198.35
20.0	1,142.273	2,518.294	665.87	1,198.47
22.0	1,049.575	2,313.929	666.17	1,199.00
24.0	991.315	2,185.486	666.49	1,199.64
26.0	954.869	2,105.137	666.79	1,200.21
28.0	931.687	2,054.029	666.96	1,200.57
30.0	915.328	2,017.964	667.19	1,200.86
32.0	901.361	1,987.172	667.32	1,201.10
34.0	888.445	1,958.697	667.46	1,201.36
36.0	875.405	1,929.948	667.58	1,201.59
38.0	862.673	1,901.878	667.69	1,201.81
40.0	850.611	1,875.286	667.76	1,202.00
42.0	839.371	1,850.507	667.88	1,202.16
44.0	829.125	1,827.917	667.93	1,202.35
46.0	819.283	1,806.220	668.02	1,202.46
48.0	809.526	1,784.708	668.17	1,202.61

Table 6.2.1-14 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
50.0	799.906	1,763.499	668.20	1,202.78
55.0	776.856	1,712.684	668.33	1,203.08
60.0	756.994	1,668.895	668.57	1,203.31
65.0	738.519	1,628.165	668.64	1,203.50
70.0	717.787	1,582.458	668.86	1,203.82
75.0	700.707	1,544.803	668.90	1,203.97
80.0	684.902	1,509.959	669.00	1,204.14
85.0	669.793	1,476.648	669.01	1,204.28
90.0	654.548	1,443.038	669.16	1,204.33
95.0	638.186	1,406.967	669.08	1,204.43
100.0	621.939	1,371.148	669.20	1,204.47
120.0	561.393	1,237.667	669.23	1,204.52
140.0	515.848	1,137.257	669.00	1,204.30
160.0	477.158	1,051.958	668.96	1,203.95
180.0	441.918	974.267	668.68	1,203.37
200.0	406.402	895.968	668.30	1,202.94
220.0	376.282	829.564	667.85	1,202.20
240.0	345.908	762.601	667.23	1,201.15
260.0	317.346	699.632	666.78	1,200.06
280.0	290.787	641.080	666.12	1,198.76
300.0	265.465	585.254	665.25	1,197.43
320.0	239.110	527.150	664.55	1,196.05
340.0	217.024	478.458	663.52	1,194.25
360.0	196.032	432.178	662.65	1,192.33
380.0	176.280	388.632	661.45	1,190.33

Table 6.2.1-14 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	156.242	344.456	659.87	1,188.25
420.0	140.098	308.865	658.82	1,185.63
440.0	123.558	272.400	657.18	1,183.19
460.0	113.418	250.046	655.98	1,180.18
480.0	101.285	223.296	654.59	1,177.36
500.0	91.820	202.429	652.36	1,174.73
525.0	82.829	182.608	650.74	1,171.36
550.0	73.859	162.832	649.89	1,168.69
575.0	67.005	147.722	649.21	1,167.73
600.0	53.088	117.040	649.86	1,171.39
625.0	56.795	125.213	651.47	1,171.60
650.0	57.810	127.449	650.41	1,171.45
675.0	58.355	128.652	651.19	1,171.38
700.0	58.641	129.283	651.42	1,171.07
725.0	58.781	129.591	649.87	1,170.61
750.0	58.839	129.719	650.93	1,170.99
775.0	58.852	129.748	650.79	1,170.73
800.0	58.839	129.719	650.93	1,170.22
825.0	58.812	129.658	649.53	1,170.77
850.0	58.776	129.579	649.93	1,169.94
875.0	58.734	129.488	650.39	1,169.99
900.0	58.690	129.391	650.88	1,170.10
925.0	58.645	129.290	649.67	1,170.24
950.0	58.598	129.188	650.19	1,169.61
975.0	58.555	129.092	650.67	1,169.71

Table 6.2.1-14 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,000.0	58.540	129.060	649.13	1,169.22
1,050.0	60.122	132.546	650.34	1,169.41
1,100.0	61.569	135.737	649.68	1,169.91
1,150.0	61.304	135.153	649.22	1,169.79
1,200.0	60.684	133.786	649.27	1,169.03
1,250.0	60.176	132.666	649.76	1,169.10
1,300.0	59.857	131.963	649.88	1,169.27
1,350.0	59.702	131.621	649.89	1,168.51
1,400.0	59.671	131.552	648.56	1,169.12
1,450.0	59.717	131.654	649.73	1,168.97
1,500.0	59.789	131.812	648.95	1,168.33
1,550.0	59.841	131.927	650.06	1,168.83
1,600.0	59.856	131.961	649.89	1,168.53
1,650.0	59.842	131.929	648.37	1,168.05
1,700.0	59.812	131.864	648.70	1,168.63
1,750.0	59.782	131.797	649.02	1,168.46
1,800.0	59.758	131.745	649.29	1,168.17

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	312,841.00	689,700.00	207.20	822.20

Table 6.2.1-14 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
0.0	73.5	1,045.0	73.5	1,045.0
0.5	72.6	1,032.9	72.0	1,023.5
1.0	71.3	1,014.9	70.4	1,001.1
1.5	70.1	996.5	68.9	979.9
2.0	68.8	978.7	67.5	960.3
2.5	67.6	961.5	66.2	941.9
3.0	66.4	945.1	65.0	924.6
3.5	65.3	929.3	63.9	908.4
4.0	64.3	914.2	62.8	893.1
4.5	63.2	899.7	61.8	878.7
5.0	62.3	885.8	60.8	865.1
5.5	61.5	875.1	60.0	853.6
6.0	60.9	866.2	59.3	843.6
6.5	60.3	858.0	58.7	834.5
7.0	59.8	850.0	58.1	825.8
7.5	59.2	842.3	57.5	817.7
8.0	58.7	834.8	56.9	810.0
8.5	58.2	827.6	56.4	802.6
9.0	57.7	820.6	55.9	795.7
9.5	57.2	814.0	55.5	789.0
10.0	56.8	807.6	55.0	782.8
10.5	57.4	817.2	54.9	781.3
11.0	58.4	830.4	54.9	780.8
11.5	59.3	843.4	54.9	780.3
12.0	60.2	856.2	54.8	779.8
13.0	61.9	880.9	54.7	778.6

Table 6.2.1-14 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
14.0	63.6	904.1	54.6	777.1
15.0	65.0	925.1	54.5	775.0
16.0	66.3	943.6	54.5	774.9
17.0	67.5	959.6	54.4	773.7
18.0	68.4	973.0	54.2	771.1
19.0	69.2	984.0	53.9	767.3
20.0	69.8	992.8	53.6	762.5
22.0	70.7	1,005.8	52.8	751.1
24.0	71.4	1,015.4	52.0	739.3
26.0	72.0	1,023.6	51.2	728.4
28.0	72.5	1,030.9	50.5	718.5
30.0	72.8	1,036.2	49.8	708.9
32.0	73.0	1,039.0	49.1	698.8
34.0	73.0	1,039.0	48.4	688.1
36.0	72.9	1,037.0	47.6	677.2
38.0	72.7	1,034.1	46.9	666.8
40.0	72.5	1,030.8	46.2	657.2
42.0	72.3	1,028.0	45.6	648.5
44.0	72.3	1,027.9	45.0	640.2
46.0	72.3	1,027.9	44.4	632.0
48.0	72.3	1,027.8	43.9	623.9
50.0	72.2	1,027.7	43.3	615.9
55.0	72.2	1,027.5	42.0	597.6
60.0	72.2	1,027.4	40.9	581.4
65.0	72.2	1,027.1	39.8	565.9

Table 6.2.1-14 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
70.0	72.2	1,026.9	38.8	551.5
75.0	72.2	1,026.7	37.8	538.0
80.0	72.2	1,026.4	36.9	525.0
85.0	72.1	1,026.2	36.0	512.5
90.0	72.1	1,025.9	35.1	499.5
95.0	72.1	1,025.7	34.2	486.2
100.0	72.1	1,025.4	33.3	473.2
120.0	72.0	1,024.2	29.9	424.8
140.0	71.9	1,023.0	27.3	388.8
160.0	71.8	1,021.7	25.1	357.7
180.0	71.7	1,020.4	23.1	328.8
200.0	71.6	1,019.0	21.3	302.6
220.0	71.5	1,017.5	19.5	277.8
240.0	71.4	1,016.0	17.8	253.0
260.0	71.3	1,014.4	16.2	229.9
280.0	71.2	1,012.8	14.7	208.5
300.0	71.1	1,011.2	13.3	188.5
320.0	71.0	1,009.6	11.9	169.8
340.0	70.9	1,007.9	10.7	152.3
360.0	70.7	1,006.2	9.5	135.7
380.0	70.6	1,004.4	8.5	120.2
400.0	70.5	1,002.7	7.4	105.8
420.0	70.4	1,000.9	6.5	92.5
440.0	70.2	999.2	5.6	80.1
460.0	70.1	997.4	4.9	69.2
480.0	70.0	995.7	4.2	59.8

Table 6.2.1-14 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
500.0	69.9	993.9	3.6	51.9
525.0	69.7	991.7	3.1	44.1
550.0	69.6	989.4	2.7	38.3
575.0	69.4	987.2	2.5	35.5
600.0	69.2	985.0	3.0	42.9
625.0	69.1	982.7	3.1	43.4
650.0	68.9	980.5	3.0	43.3
675.0	68.8	978.2	3.0	43.1
700.0	68.6	975.9	3.0	42.8
725.0	68.4	973.6	3.0	42.5
750.0	68.3	971.3	3.0	42.2
775.0	68.1	969.0	2.9	41.9
800.0	68.0	966.7	2.9	41.6
825.0	67.8	964.3	2.9	41.3
850.0	67.6	961.9	2.9	41.1
875.0	67.5	959.6	2.9	40.8
900.0	67.3	957.2	2.9	40.6
925.0	67.1	954.8	2.8	40.3
950.0	66.9	952.3	2.8	40.1
975.0	66.8	949.9	2.8	39.9
1,000.0	66.6	947.4	2.8	39.7
1,050.0	66.3	942.7	2.8	39.8
1,100.0	66.0	938.3	2.8	40.0
1,150.0	65.7	933.9	2.8	39.6

Table 6.2.1-14 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,200.0	65.3	929.5	2.8	39.2
1,250.0	65.0	925.1	2.7	38.8
1,300.0	64.7	920.7	2.7	38.5
1,350.0	64.4	916.2	2.7	38.2
1,400.0	64.1	911.8	2.7	38.0
1,450.0	63.8	907.3	2.7	37.8
1,500.0	63.5	903.0	2.7	37.7
1,550.0	63.2	898.6	2.6	37.6
1,600.0	62.9	894.3	2.6	37.5
1,650.0	62.6	889.9	2.6	37.3
1,700.0	62.3	885.6	2.6	37.2
1,750.0	62.0	881.4	2.6	37.1
1,800.0	61.7	877.1	2.6	37.0

Table 6.2.1-14 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.61	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
4.90	High containment pressure reactor trip signal	-
5.00	Reactor trip breakers open, turbine admission valves closed	-
10.10	Main steam isolation valves closed	-
15.10	Main feedwater isolation valves closed	-
22.51	Peak containment temperature	163.77 ^{o}C (326.79 ^{o}F)
22.61	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
112.61	Start containment spray injection	-
414.11	Peak containment pressure	3.036kg/cm²G (43.18 psig)
1,800.0	End of blowdown	-
2,965.3	Time of depressurization of the containment at 50% of peak pressure	1.517kg/cm²G (21.58 psig)

Table 6.2.1-15 (1 of 11)

Main Steam Line Break, 20 % Power – Loss of One CSS Train
(0.818 m^2 (8.80 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,543.075	10,015.818	661.25	1,190.21
0.5	4,342.305	9,573.193	662.16	1,191.86
1.0	4,229.326	9,324.115	662.68	1,192.80
1.5	4,136.894	9,120.337	663.11	1,193.55
2.0	4,052.469	8,934.211	663.47	1,194.23
2.5	3,973.086	8,759.200	663.82	1,194.86
3.0	3,897.642	8,592.874	664.15	1,195.44
3.5	3,825.607	8,434.063	664.44	1,195.98
4.0	3,756.950	8,282.700	664.74	1,196.49
4.5	3,691.561	8,138.542	665.00	1,196.97
5.0	3,637.675	8,019.742	665.23	1,197.37
5.5	3,595.535	7,926.839	665.38	1,197.68
6.0	3,545.131	7,815.717	665.59	1,198.03
6.5	3,494.407	7,703.888	665.78	1,198.38
7.0	3,445.041	7,595.054	665.97	1,198.70
7.5	3,397.352	7,489.917	666.14	1,199.01
8.0	3,351.329	7,388.453	666.30	1,199.32
8.5	3,306.935	7,290.581	666.45	1,199.59
9.0	3,264.116	7,196.181	666.61	1,199.86
9.5	3,222.835	7,105.172	666.74	1,200.10
10.0	3,183.034	7,017.426	666.88	1,200.34
10.5	947.601	2,089.113	666.84	1,200.22

Table 6.2.1-15 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
11.0	941.554	2,075.781	666.88	1,200.37
11.5	935.627	2,062.714	666.93	1,200.46
12.0	929.824	2,049.921	667.01	1,200.58
13.0	918.586	2,025.147	667.11	1,200.80
14.0	907.779	2,001.320	667.23	1,201.01
15.0	897.274	1,978.161	667.35	1,201.22
16.0	891.685	1,965.840	667.39	1,201.32
17.0	886.219	1,953.788	667.44	1,201.41
18.0	880.418	1,941.000	667.52	1,201.49
19.0	874.278	1,927.463	667.64	1,201.63
20.0	867.864	1,913.323	667.62	1,201.73
22.0	854.612	1,884.106	667.79	1,202.00
24.0	841.477	1,855.148	667.87	1,202.22
26.0	828.976	1,827.589	668.05	1,202.40
28.0	817.112	1,801.434	668.08	1,202.60
30.0	805.536	1,775.912	668.25	1,202.76
32.0	793.908	1,750.277	668.34	1,202.95
34.0	782.174	1,724.408	668.39	1,203.14
36.0	770.574	1,698.833	668.46	1,203.30
38.0	759.434	1,674.275	668.52	1,203.45
40.0	748.943	1,651.146	668.68	1,203.53
42.0	739.052	1,629.340	668.69	1,203.68
44.0	729.561	1,608.416	668.76	1,203.79
46.0	720.284	1,587.962	668.90	1,203.87
48.0	711.168	1,567.865	668.90	1,203.99
50.0	702.302	1,548.318	668.94	1,204.02

Table 6.2.1-15 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
55.0	681.917	1,503.378	669.00	1,204.22
60.0	663.695	1,463.205	669.13	1,204.34
65.0	646.371	1,425.011	669.12	1,204.41
70.0	630.247	1,389.465	669.26	1,204.49
75.0	615.446	1,356.833	669.27	1,204.57
80.0	601.543	1,326.183	669.28	1,204.58
85.0	588.656	1,297.770	669.32	1,204.60
90.0	576.496	1,270.962	669.22	1,204.60
95.0	564.256	1,243.978	669.20	1,204.60
100.0	551.631	1,216.145	669.29	1,204.54
120.0	501.347	1,105.287	669.00	1,204.30
140.0	456.469	1,006.346	668.83	1,203.76
160.0	419.076	923.910	668.38	1,203.15
180.0	386.502	852.095	668.04	1,202.45
200.0	357.726	788.654	667.55	1,201.67
220.0	330.120	727.794	667.03	1,200.61
240.0	301.887	665.551	666.47	1,199.46
260.0	275.506	607.391	665.68	1,198.24
280.0	250.599	552.478	664.81	1,196.79
300.0	227.978	502.608	664.10	1,195.17
320.0	207.332	457.091	663.19	1,193.64
340.0	190.296	419.534	662.13	1,192.04
360.0	187.589	413.566	662.09	1,191.83
380.0	184.059	405.782	661.74	1,191.28

Table 6.2.1-15 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	179.361	395.426	661.79	1,190.87
420.0	173.480	382.461	661.17	1,190.19
440.0	166.577	367.242	660.96	1,189.41
460.0	158.987	350.508	660.43	1,188.56
480.0	151.078	333.071	659.92	1,187.43
500.0	143.574	316.528	658.89	1,186.31
525.0	134.567	296.671	658.41	1,184.81
550.0	125.983	277.746	657.23	1,183.46
575.0	117.970	260.080	656.95	1,181.56
600.0	110.594	243.820	655.55	1,179.97
625.0	103.888	229.035	654.55	1,178.42
650.0	99.241	218.789	653.96	1,176.48
675.0	92.851	204.702	652.66	1,175.86
700.0	88.739	195.636	652.48	1,175.14
725.0	84.419	186.113	652.70	1,174.56
750.0	80.218	176.851	651.97	1,173.87
775.0	76.418	168.473	651.68	1,173.48
800.0	73.135	161.236	652.22	1,172.82
825.0	70.393	155.190	650.63	1,172.11
850.0	68.153	150.253	651.48	1,172.02
875.0	66.355	146.288	651.04	1,171.66
900.0	64.931	143.149	651.46	1,171.51
925.0	63.816	140.692	650.31	1,170.64
950.0	62.954	138.791	651.27	1,170.83
975.0	62.294	137.335	650.14	1,170.86

Table 6.2.1-15 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,000.0	61.794	136.233	650.55	1,170.05
1,050.0	61.142	134.795	649.31	1,169.92
1,100.0	60.786	134.011	649.82	1,170.05
1,150.0	60.590	133.578	650.27	1,169.35
1,200.0	60.468	133.309	649.93	1,169.46
1,250.0	60.376	133.107	649.26	1,168.98
1,300.0	60.297	132.933	650.12	1,169.01
1,350.0	60.226	132.777	649.22	1,168.88
1,400.0	60.165	132.641	649.88	1,169.32
1,450.0	60.112	132.525	648.79	1,168.84
1,500.0	60.067	132.426	649.27	1,168.95
1,550.0	60.029	132.341	649.69	1,168.95
1,600.0	59.995	132.266	650.05	1,168.86
1,650.0	59.965	132.201	648.71	1,168.67
1,700.0	59.938	132.142	649.00	1,168.44
1,750.0	59.914	132.088	649.26	1,168.16
1,800.0	59.892	132.039	649.50	1,168.59

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	301,501.30	664,700.00	199.50	791.80

Table 6.2.1-15 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
0.0	74.0	1,053.0	74.0	1,053.0
0.5	73.1	1,040.2	72.4	1,029.9
1.0	71.9	1,022.5	70.8	1,006.5
1.5	70.6	1,004.6	69.2	984.5
2.0	69.4	987.1	67.8	963.9
2.5	68.2	970.1	66.4	944.5
3.0	67.0	953.6	65.1	926.2
3.5	65.9	937.5	63.9	908.9
4.0	64.8	922.0	62.7	892.4
4.5	63.8	906.9	61.6	876.7
5.0	62.7	892.4	60.6	861.7
5.5	61.8	879.2	59.6	848.1
6.0	60.9	866.8	58.7	835.4
6.5	60.1	854.7	57.9	823.2
7.0	59.3	843.0	57.0	811.5
7.5	58.5	831.7	56.3	800.3
8.0	57.7	820.7	55.5	789.6
8.5	56.9	810.0	54.8	779.2
9.0	56.2	799.7	54.1	769.2
9.5	55.5	789.7	53.4	759.6
10.0	54.8	780.1	52.7	750.3
10.5	55.2	785.4	52.4	745.0
11.0	55.7	792.1	52.0	740.2
11.5	56.2	798.8	51.7	735.5
12.0	56.6	805.4	51.4	730.8
13.0	57.5	818.4	50.7	721.8

Table 6.2.1-15 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
14.0	58.4	831.0	50.1	713.2
15.0	59.3	843.0	49.5	704.7
16.0	60.1	854.2	49.2	700.4
17.0	60.8	864.7	48.9	695.8
18.0	61.5	874.2	48.6	690.9
19.0	62.1	882.9	48.2	685.7
20.0	62.6	890.7	47.8	680.3
22.0	63.6	904.3	47.0	669.1
24.0	64.4	915.9	46.3	658.1
26.0	65.1	926.2	45.5	647.6
28.0	65.8	935.4	44.8	637.6
30.0	66.3	943.0	44.1	627.9
32.0	66.7	948.8	43.5	618.1
34.0	67.0	952.8	42.8	608.2
36.0	67.2	955.4	42.1	598.4
38.0	67.3	957.1	41.4	589.1
40.0	67.4	958.1	40.8	580.2
42.0	67.4	958.5	40.2	571.9
44.0	67.4	958.2	39.6	563.9
46.0	67.3	957.0	39.1	556.1
48.0	67.1	955.0	38.6	548.5
50.0	66.9	952.3	38.0	541.0
55.0	66.7	948.5	36.8	523.9
60.0	66.7	948.5	35.7	508.5
65.0	66.7	948.4	34.7	494.2
70.0	66.7	948.4	33.8	481.3

Table 6.2.1-15 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
75.0	66.7	948.3	33.0	469.5
80.0	66.7	948.3	32.2	458.3
85.0	66.7	948.2	31.5	448.0
90.0	66.7	948.1	30.8	438.2
95.0	66.6	948.0	30.1	428.4
100.0	66.6	947.9	29.4	418.3
120.0	66.6	947.4	26.6	378.0
140.0	66.6	946.8	24.0	342.0
160.0	66.5	946.1	21.9	312.1
180.0	66.5	945.3	20.1	286.0
200.0	66.4	944.4	18.5	262.9
220.0	66.3	943.4	16.9	240.8
240.0	66.2	942.3	15.3	218.1
260.0	66.2	941.2	13.9	197.1
280.0	66.1	939.9	12.5	178.1
300.0	66.0	938.6	11.3	160.8
320.0	65.9	937.3	10.2	145.0
340.0	65.8	935.9	9.3	132.0
360.0	65.7	934.4	9.1	129.9
380.0	65.6	932.9	8.9	127.2
400.0	65.5	931.4	8.7	123.6
420.0	65.4	929.8	8.4	119.1
440.0	65.2	928.1	8.0	113.8
460.0	65.1	926.4	7.6	108.0
480.0	65.0	924.7	7.2	102.0
500.0	64.9	922.9	6.7	95.8

Table 6.2.1-15 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
525.0	64.7	920.6	6.2	88.3
550.0	64.6	918.3	5.7	81.0
575.0	64.4	915.9	5.2	74.3
600.0	64.2	913.5	4.8	68.1
625.0	64.0	911.0	4.4	62.4
650.0	63.9	908.5	4.0	56.5
675.0	63.7	906.0	3.8	54.2
700.0	63.5	903.6	3.7	52.6
725.0	63.4	901.2	3.6	51.0
750.0	63.2	898.8	3.5	49.4
775.0	63.0	896.5	3.4	47.9
800.0	62.9	894.1	3.3	46.7
825.0	62.7	891.8	3.2	45.6
850.0	62.5	889.5	3.1	44.6
875.0	62.4	887.2	3.1	43.8
900.0	62.2	884.9	3.0	43.2
925.0	62.0	882.6	3.0	42.6
950.0	61.9	880.3	3.0	42.1
975.0	61.7	878.0	2.9	41.7
1,000.0	61.6	875.7	2.9	41.3
1,050.0	61.2	871.2	2.9	40.7
1,100.0	60.9	866.6	2.8	40.2
1,150.0	60.6	862.1	2.8	39.8
1,200.0	60.3	857.6	2.8	39.5
1,250.0	60.0	853.1	2.8	39.2
1,300.0	59.7	848.7	2.7	38.9

Table 6.2.1-15 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,350.0	59.4	844.3	2.7	38.7
1,400.0	59.0	839.9	2.7	38.4
1,450.0	58.7	835.5	2.7	38.2
1,500.0	58.4	831.1	2.7	38.0
1,550.0	58.1	826.8	2.7	37.8
1,600.0	57.8	822.5	2.7	37.7
1,650.0	57.5	818.2	2.6	37.5
1,700.0	57.2	813.9	2.6	37.4
1,750.0	56.9	809.7	2.6	37.3
1,800.0	56.6	805.5	2.6	37.2

Table 6.2.1-15 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.57	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 k/cm²G (6.0 psig)
5.20	High containment pressure reactor trip signal	-
5.30	Reactor trip breakers open, turbine admission valves closed	-
10.40	Main steam isolation valves closed	-
15.40	Main feedwater isolation valves closed	-
43.31	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
97.81	Peak containment temperature	157.37 ^{o}C (315.27 ^{o}F)
133.31	Start containment spray injection	-
769.04	Peak containment pressure	2.980kg/cm²G (42.38 psig)
1,800.0	End of blowdown	-
3,787.2	Time of depressurization of the containment at 50% of peak pressure	1.486kg/cm²G (21.13 psig)

Table 6.2.1-16 (1 of 11)

Main Steam Line Break, 20 % Power – MSIV Failure
(0.818 m^2 (8.80 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	4,543.075	10,015.818	661.25	1,190.21
0.5	4,342.305	9,573.193	662.16	1,191.86
1.0	4,229.326	9,324.115	662.68	1,192.80
1.5	4,136.894	9,120.337	663.11	1,193.55
2.0	4,052.469	8,934.211	663.47	1,194.23
2.5	3,973.086	8,759.200	663.82	1,194.86
3.0	3,897.642	8,592.874	664.15	1,195.44
3.5	3,825.607	8,434.063	664.44	1,195.98
4.0	3,756.950	8,282.700	664.74	1,196.49
4.5	3,691.561	8,138.542	665.00	1,196.97
5.0	3,637.675	8,019.742	665.23	1,197.37
5.5	3,595.535	7,926.839	665.38	1,197.68
6.0	3,545.131	7,815.717	665.59	1,198.03
6.5	3,494.407	7,703.888	665.78	1,198.38
7.0	3,445.041	7,595.054	665.97	1,198.70
7.5	3,397.352	7,489.917	666.14	1,199.01
8.0	3,351.329	7,388.453	666.30	1,199.32
8.5	3,306.935	7,290.581	666.45	1,199.59
9.0	3,264.116	7,196.181	666.61	1,199.86
9.5	3,222.835	7,105.172	666.74	1,200.10
10.0	3,183.034	7,017.426	666.88	1,200.34
10.5	2,946.582	6,496.135	667.49	1,201.45

Table 6.2.1-16 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
11.0	2,704.145	5,961.651	667.94	1,202.28
11.5	2,489.705	5,488.889	668.23	1,202.76
12.0	2,300.124	5,070.931	668.31	1,202.93
13.0	1,984.437	4,374.958	668.20	1,202.69
14.0	1,735.908	3,827.042	667.78	1,202.02
15.0	1,540.339	3,395.885	667.39	1,201.22
16.0	1,390.022	3,064.489	666.97	1,200.49
17.0	1,271.865	2,803.997	666.66	1,200.00
18.0	1,178.067	2,597.206	666.52	1,199.71
19.0	1,102.876	2,431.439	666.53	1,199.66
20.0	1,042.099	2,297.448	666.64	1,199.81
22.0	954.302	2,103.886	666.98	1,200.45
24.0	897.232	1,978.069	667.27	1,201.17
26.0	860.202	1,896.430	667.63	1,201.73
28.0	836.228	1,843.577	667.88	1,202.17
30.0	819.408	1,806.495	668.04	1,202.44
32.0	805.871	1,776.651	668.10	1,202.66
34.0	793.212	1,748.743	668.30	1,202.81
36.0	781.520	1,722.965	668.31	1,202.98
38.0	769.953	1,697.464	668.35	1,203.09
40.0	758.891	1,673.077	668.48	1,203.23
42.0	748.363	1,649.866	668.53	1,203.37
44.0	738.636	1,628.423	668.66	1,203.50
46.0	729.085	1,607.366	668.65	1,203.58
48.0	719.894	1,587.102	668.71	1,203.64

Table 6.2.1-16 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
50.0	710.560	1,566.524	668.77	1,203.75
55.0	689.388	1,519.849	668.85	1,203.94
60.0	667.616	1,471.848	668.95	1,204.20
65.0	648.734	1,430.222	669.15	1,204.36
70.0	631.894	1,393.095	669.10	1,204.44
75.0	617.401	1,361.144	669.10	1,204.50
80.0	602.769	1,328.885	669.24	1,204.54
85.0	589.730	1,300.139	669.29	1,204.56
90.0	578.594	1,275.588	669.21	1,204.46
95.0	565.514	1,246.751	669.13	1,204.49
100.0	553.054	1,219.281	669.19	1,204.48
120.0	502.806	1,108.504	669.05	1,204.24
140.0	457.763	1,009.201	668.69	1,203.72
160.0	419.864	925.646	668.31	1,203.16
180.0	387.249	853.742	668.05	1,202.35
200.0	358.454	790.259	667.59	1,201.63
220.0	331.377	730.565	666.91	1,200.58
240.0	302.705	667.354	666.33	1,199.36
260.0	276.492	609.564	665.48	1,198.07
280.0	251.709	554.927	664.66	1,196.55
300.0	229.717	506.441	663.86	1,195.01
320.0	209.045	460.867	663.02	1,193.40
340.0	190.806	420.657	662.45	1,191.94
360.0	188.027	414.531	662.14	1,191.71

Table 6.2.1-16 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
380.0	184.681	407.155	661.68	1,191.44
400.0	180.173	397.215	661.59	1,190.79
420.0	174.568	384.859	661.06	1,190.05
440.0	167.863	370.076	660.66	1,189.22
460.0	160.364	353.544	660.37	1,188.25
480.0	152.469	336.138	659.81	1,187.31
500.0	143.399	316.142	659.00	1,186.49
525.0	135.925	299.664	658.45	1,184.66
550.0	127.419	280.913	657.67	1,183.28
575.0	117.394	258.810	656.76	1,181.56
600.0	112.028	246.981	655.19	1,179.85
625.0	103.506	228.192	655.03	1,178.39
650.0	97.604	215.181	653.66	1,176.68
675.0	92.732	204.441	653.50	1,175.89
700.0	88.637	195.413	653.23	1,175.46
725.0	84.377	186.021	653.02	1,174.60
750.0	80.222	176.860	651.94	1,173.81
775.0	76.454	168.552	651.37	1,173.53
800.0	73.193	161.364	651.70	1,173.12
825.0	70.462	155.342	651.41	1,172.25
850.0	68.225	150.412	650.79	1,172.11
875.0	66.427	146.448	650.34	1,171.75
900.0	65.001	143.304	650.76	1,171.64
925.0	63.884	140.841	651.18	1,170.82

Table 6.2.1-16 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
950.0	63.018	138.931	650.61	1,171.08
975.0	62.354	137.467	651.12	1,170.46
1,000.0	61.850	136.357	649.96	1,170.46
1,050.0	61.192	134.906	650.41	1,170.44
1,100.0	60.832	134.112	649.33	1,169.92
1,150.0	60.629	133.665	649.85	1,170.09
1,200.0	60.502	133.385	649.57	1,169.55
1,250.0	60.407	133.176	650.59	1,169.13
1,300.0	60.327	132.998	649.79	1,169.19
1,350.0	60.254	132.839	648.92	1,169.08
1,400.0	60.191	132.700	649.60	1,168.80
1,450.0	60.137	132.581	650.18	1,169.10
1,500.0	60.091	132.479	649.02	1,169.24
1,550.0	60.052	132.392	649.44	1,168.50
1,600.0	60.017	132.315	649.82	1,168.42
1,650.0	59.985	132.246	648.50	1,168.28
1,700.0	59.957	132.183	648.80	1,168.83
1,750.0	59.931	132.127	649.08	1,168.57
1,800.0	59.908	132.075	649.33	1,168.28

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	310,799.90	685,200.00	205.80	816.50

Table 6.2.1-16 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
0.0	74.0	1,053.0	74.0	1,053.0
0.5	73.1	1,040.2	72.4	1,029.9
1.0	71.9	1,022.5	70.8	1,006.5
1.5	70.6	1,004.6	69.2	984.5
2.0	69.4	987.1	67.8	963.9
2.5	68.2	970.1	66.4	944.5
3.0	67.0	953.6	65.1	926.2
3.5	65.9	937.5	63.9	908.9
4.0	64.8	922.0	62.7	892.4
4.5	63.8	906.9	61.6	876.7
5.0	62.7	892.4	60.6	861.7
5.5	61.8	879.2	59.6	848.1
6.0	60.9	866.8	58.7	835.4
6.5	60.1	854.7	57.9	823.2
7.0	59.3	843.0	57.0	811.5
7.5	58.5	831.7	56.3	800.3
8.0	57.7	820.7	55.5	789.6
8.5	56.9	810.0	54.8	779.2
9.0	56.2	799.7	54.1	769.2
9.5	55.5	789.7	53.4	759.6
10.0	54.8	780.1	52.7	750.3
10.5	55.2	785.4	52.4	745.0
11.0	55.7	792.1	52.0	740.2
11.5	56.2	798.8	51.7	735.5

Table 6.2.1-16 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
12.0	56.6	805.4	51.4	730.8
13.0	57.5	818.4	50.7	721.8
14.0	58.4	831.0	50.1	713.2
15.0	59.3	843.0	49.5	704.7
16.0	60.1	854.2	49.2	700.4
17.0	60.8	864.7	48.9	695.8
18.0	61.5	874.2	48.6	690.9
19.0	62.1	882.9	48.2	685.7
20.0	62.6	890.7	47.8	680.3
22.0	63.6	904.3	47.0	669.1
24.0	64.4	915.9	46.3	658.1
26.0	65.1	926.2	45.5	647.6
28.0	65.8	935.4	44.8	637.6
30.0	66.3	943.0	44.1	627.9
32.0	66.7	948.8	43.5	618.1
34.0	67.0	952.8	42.8	608.2
36.0	67.2	955.4	42.1	598.4
38.0	67.3	957.1	41.4	589.1
40.0	67.4	958.1	40.8	580.2
42.0	67.4	958.5	40.2	571.9
44.0	67.4	958.2	39.6	563.9
46.0	67.3	957.0	39.1	556.1
48.0	67.1	955.0	38.6	548.5

Table 6.2.1-16 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
50.0	66.9	952.3	38.0	541.0
55.0	66.7	948.5	36.8	523.9
60.0	66.7	948.5	35.7	508.5
65.0	66.7	948.4	34.7	494.2
70.0	66.7	948.4	33.8	481.3
75.0	66.7	948.3	33.0	469.5
80.0	66.7	948.3	32.2	458.3
85.0	66.7	948.2	31.5	448.0
90.0	66.7	948.1	30.8	438.2
95.0	66.6	948.0	30.1	428.4
100.0	66.6	947.9	29.4	418.3
120.0	66.6	947.4	26.6	378.0
140.0	66.6	946.8	24.0	342.0
160.0	66.5	946.1	21.9	312.1
180.0	66.5	945.3	20.1	286.0
200.0	66.4	944.4	18.5	262.9
220.0	66.3	943.4	16.9	240.8
240.0	66.2	942.3	15.3	218.1
260.0	66.2	941.2	13.9	197.1
280.0	66.1	939.9	12.5	178.1
300.0	66.0	938.6	11.3	160.8
320.0	65.9	937.3	10.2	145.0
340.0	65.8	935.9	9.3	132.0

Table 6.2.1-16 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
360.0	65.7	934.4	9.1	129.9
380.0	65.6	932.9	8.9	127.2
400.0	65.5	931.4	8.7	123.6
420.0	65.4	929.8	8.4	119.1
440.0	65.2	928.1	8.0	113.8
460.0	65.1	926.4	7.6	108.0
480.0	65.0	924.7	7.2	102.0
500.0	64.9	922.9	6.7	95.8
525.0	64.7	920.6	6.2	88.3
550.0	64.6	918.3	5.7	81.0
575.0	64.4	915.9	5.2	74.3
600.0	64.2	913.5	4.8	68.1
625.0	64.0	911.0	4.4	62.4
650.0	63.9	908.5	4.0	57.5
675.0	63.7	906.0	3.8	54.5
700.0	63.5	903.6	3.7	53.0
725.0	63.4	901.2	3.6	51.4
750.0	63.2	898.8	3.5	49.8
775.0	63.0	896.5	3.4	48.4
800.0	62.9	894.1	3.3	47.1
825.0	62.7	891.8	3.2	46.0
850.0	62.5	889.5	3.2	45.0
875.0	62.4	887.2	3.1	44.2

Table 6.2.1-16 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
900.0	62.2	884.9	3.1	43.6
925.0	62.0	882.6	3.0	43.0
950.0	61.9	880.3	3.0	42.5
975.0	61.7	878.0	3.0	42.1
1,000.0	61.6	875.7	2.9	41.7
1,050.0	61.2	871.2	2.9	41.1
1,100.0	60.9	866.6	2.9	40.6
1,150.0	60.6	862.1	2.8	40.2
1,200.0	60.3	857.6	2.8	39.8
1,250.0	60.0	853.1	2.8	39.5
1,300.0	59.7	848.7	2.8	39.2
1,350.0	59.4	844.3	2.7	38.9
1,400.0	59.0	839.9	2.7	38.7
1,450.0	58.7	835.5	2.7	38.5
1,500.0	58.4	831.1	2.7	38.3
1,550.0	58.1	826.8	2.7	38.1
1,600.0	57.8	822.5	2.7	37.9
1,650.0	57.5	818.2	2.7	37.7
1,700.0	57.2	813.9	2.6	37.6
1,750.0	56.9	809.7	2.6	37.5
1,800.0	56.6	805.5	2.6	37.3

Table 6.2.1-16 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
3.57	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
4.85	High containment pressure reactor trip signal	-
4.95	Reactor trip breakers open, turbine admission valves closed	-
10.05	Main steam isolation valves closed	-
15.05	Main feedwater isolation valves closed	-
22.91	Peak containment temperature	162.43 ^{o}C (324.38 ^{o}F)
25.71	Containment pressure Hi-Hi setpoint	1.547kg/cm²G (22.0 psig)
115.71	Start containment spray injection	-
585.71	Peak containment pressure	2.792kg/cm²G (39.71 psig)
1,800.0	End of blowdown	-
3,242.4	Time of depressurization of the containment at 50% of peak pressure	1.393kg/cm²G (19.81 psig)

Table 6.2.1-17 (1 of 11)

Main Steam Line Break, 0 % Power – Loss of One CSS Train
(0.381 m^2 (4.1 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

	Break Mass Flow Rate		Break Enthalpy	
Time (sec)	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	3,498.934	7,713.870	660.20	1,188.34
0.5	3,424.755	7,550.331	660.69	1,189.19
1.0	3,376.118	7,443.104	661.03	1,189.83
1.5	3,329.717	7,340.808	661.35	1,190.41
2.0	3,284.836	7,241.861	661.65	1,190.96
2.5	3,241.811	7,147.007	661.94	1,191.48
3.0	3,200.821	7,056.639	662.21	1,191.96
3.5	3,161.697	6,970.384	662.46	1,192.40
4.0	3,124.350	6,888.048	662.70	1,192.83
4.5	3,088.950	6,810.004	662.91	1,193.23
5.0	3,055.446	6,736.141	663.11	1,193.59
5.5	3,023.807	6,666.387	663.30	1,193.95
6.0	2,993.966	6,600.599	663.50	1,194.27
6.5	2,965.884	6,538.688	663.68	1,194.57
7.0	2,939.450	6,480.412	663.83	1,194.85
7.5	2,914.585	6,425.594	663.97	1,195.11
8.0	2,891.158	6,373.947	664.09	1,195.35
8.5	2,869.052	6,325.210	664.23	1,195.58
9.0	2,848.180	6,279.196	664.35	1,195.81
9.5	2,828.410	6,235.610	664.47	1,196.00
10.0	2,809.485	6,193.886	664.57	1,196.20
10.5	2,791.244	6,153.672	664.69	1,196.38

Table 6.2.1-17 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
11.0	2,773.953	6,115.551	664.76	1,196.56
11.5	1,101.593	2,428.610	664.86	1,196.69
12.0	1,095.747	2,415.722	664.93	1,196.83
13.0	1,084.024	2,389.876	665.11	1,197.13
14.0	1,072.129	2,363.653	665.22	1,197.43
15.0	1,059.877	2,336.642	665.45	1,197.74
16.0	1,047.084	2,308.438	665.56	1,198.04
17.0	1,040.306	2,293.494	665.67	1,198.17
18.0	1,031.964	2,275.103	665.82	1,198.41
19.0	1,022.454	2,254.138	665.95	1,198.60
20.0	1,012.060	2,231.223	666.07	1,198.85
22.0	989.815	2,182.181	666.29	1,199.35
24.0	967.560	2,133.115	666.63	1,199.79
26.0	947.079	2,087.962	666.79	1,200.21
28.0	929.209	2,048.565	667.02	1,200.60
30.0	913.884	2,014.779	667.15	1,200.88
32.0	900.459	1,985.182	667.33	1,201.15
34.0	888.262	1,958.293	667.48	1,201.35
36.0	876.917	1,933.282	667.57	1,201.58
38.0	865.677	1,908.502	667.69	1,201.78
40.0	854.565	1,884.004	667.83	1,201.96
42.0	843.771	1,860.207	667.84	1,202.18
44.0	833.484	1,837.528	668.04	1,202.32
46.0	823.790	1,816.156	668.13	1,202.48
48.0	814.652	1,796.010	668.14	1,202.67

Table 6.2.1-17 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
50.0	805.948	1,776.820	668.28	1,202.77
55.0	785.230	1,731.145	668.34	1,203.08
60.0	765.380	1,687.383	668.56	1,203.34
65.0	746.645	1,646.079	668.72	1,203.59
70.0	729.006	1,607.191	668.72	1,203.78
75.0	712.101	1,569.922	668.87	1,203.95
80.0	695.814	1,534.015	669.00	1,204.10
85.0	680.170	1,499.526	669.10	1,204.25
90.0	665.105	1,466.313	669.07	1,204.31
95.0	650.395	1,433.883	669.13	1,204.42
100.0	635.628	1,401.326	669.26	1,204.50
120.0	579.631	1,277.874	669.22	1,204.58
140.0	530.144	1,168.774	669.25	1,204.51
160.0	487.038	1,073.740	668.94	1,204.11
180.0	448.963	989.800	668.65	1,203.68
200.0	415.054	915.043	668.35	1,203.11
220.0	383.372	845.195	668.02	1,202.33
240.0	354.379	781.277	667.65	1,201.49
260.0	327.601	722.240	666.97	1,200.57
280.0	302.384	666.646	666.37	1,199.59
300.0	277.831	612.515	665.87	1,198.34
320.0	251.871	555.283	665.02	1,196.87
340.0	223.605	492.967	663.67	1,194.81
360.0	190.340	419.630	662.50	1,192.00
380.0	151.255	333.462	659.81	1,187.54

Table 6.2.1-17 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
400.0	116.719	257.323	656.28	1,181.39
420.0	111.311	245.400	655.82	1,180.11
440.0	111.108	244.952	656.12	1,180.23
460.0	110.887	244.465	655.62	1,180.13
480.0	110.659	243.963	656.07	1,180.10
500.0	110.397	243.384	655.81	1,180.03
525.0	110.012	242.536	655.38	1,180.03
550.0	109.549	241.516	655.41	1,179.63
575.0	108.987	240.276	655.12	1,179.48
600.0	108.293	238.746	655.63	1,179.50
625.0	107.422	236.826	655.36	1,179.35
650.0	106.305	234.363	654.72	1,178.94
675.0	104.838	231.130	655.30	1,178.56
700.0	102.914	226.887	654.92	1,178.12
725.0	107.634	237.293	654.07	1,177.45
750.0	122.464	269.989	657.34	1,182.64
775.0	63.617	140.252	663.34	1,194.99
800.0	59.863	131.975	664.85	1,195.68
825.0	59.833	131.910	665.18	1,196.27
850.0	59.813	131.865	665.41	1,195.92
875.0	59.799	131.834	663.89	1,196.20
900.0	59.787	131.809	664.02	1,196.43
925.0	59.778	131.788	664.12	1,195.86
950.0	59.770	131.771	664.21	1,196.01
975.0	59.763	131.756	664.29	1,196.15

Table 6.2.1-17 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,000.0	59.757	131.743	664.36	1,196.27
1,050.0	59.747	131.720	664.47	1,196.48
1,100.0	59.738	131.700	664.57	1,195.90
1,150.0	59.729	131.680	664.67	1,196.08
1,200.0	59.721	131.662	664.76	1,196.24
1,250.0	59.714	131.647	664.84	1,196.38
1,300.0	59.707	131.633	664.91	1,196.51
1,350.0	59.702	131.620	664.97	1,196.63
1,400.0	59.696	131.608	665.04	1,196.74
1,450.0	59.691	131.597	665.09	1,196.84
1,500.0	59.687	131.587	665.14	1,196.93
1,550.0	59.682	131.578	665.19	1,197.01
1,600.0	59.679	131.570	665.23	1,197.08
1,650.0	59.676	131.563	665.26	1,197.15
1,700.0	59.672	131.556	665.30	1,196.45
1,750.0	59.670	131.550	665.33	1,196.50
1,800.0	59.667	131.544	665.36	1,196.56

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	313,158.50	690,400.00	208.20	826.30

Table 6.2.1-17 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
0.0	77.3	1,100.0	77.3	1,100.0
0.5	76.9	1,094.4	76.1	1,082.0
1.0	76.2	1,083.8	74.8	1,064.0
1.5	75.4	1,072.4	73.7	1,047.8
2.0	74.6	1,060.6	72.6	1,033.0
2.5	73.7	1,048.7	71.6	1,019.2
3.0	72.9	1,036.9	70.7	1,006.2
3.5	72.1	1,025.4	69.9	994.0
4.0	71.3	1,014.2	69.1	982.3
4.5	70.5	1,003.5	68.3	971.3
5.0	69.8	993.2	67.6	960.9
5.5	69.1	983.5	66.9	951.1
6.0	68.5	974.2	66.2	941.8
6.5	67.9	965.5	65.6	933.1
7.0	67.3	957.3	65.0	924.9
7.5	66.8	949.6	64.5	917.2
8.0	66.2	942.3	64.0	910.0
8.5	65.8	935.4	63.5	903.1
9.0	65.3	928.8	63.0	896.6
9.5	64.9	922.5	62.6	890.4
10.0	64.4	916.5	62.2	884.5
10.5	64.0	910.6	61.8	878.7
11.0	63.6	904.9	61.4	873.2
11.5	64.2	913.7	61.1	868.5
12.0	64.8	921.5	60.7	863.8
13.0	65.8	935.6	60.1	854.4

Table 6.2.1-17 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^{2}A	psia	kg/cm^{2}A	psia
14.0	66.6	947.8	59.4	844.9
15.0	67.4	958.1	58.7	835.0
16.0	67.9	966.4	58.0	825.0
17.0	68.4	972.6	57.6	819.4
18.0	68.7	976.8	57.1	812.7
19.0	68.8	979.1	56.6	805.1
20.0	68.9	979.7	56.0	796.7
22.0	68.7	977.2	54.8	778.9
24.0	68.3	972.0	53.5	761.1
26.0	67.9	966.0	52.4	744.7
28.0	67.5	960.6	51.3	730.4
30.0	67.2	955.8	50.5	718.1
32.0	66.9	951.3	49.7	707.4
34.0	66.7	948.2	49.0	697.5
36.0	66.7	948.2	48.4	687.9
38.0	66.7	948.2	47.7	678.5
40.0	66.7	948.2	47.0	669.1
42.0	66.7	948.2	46.4	660.1
44.0	66.7	948.2	45.8	651.4
46.0	66.7	948.2	45.2	643.2
48.0	66.7	948.2	44.7	635.6
50.0	66.7	948.2	44.2	628.2
55.0	66.7	948.2	42.9	610.8
60.0	66.7	948.1	41.8	594.1
65.0	66.6	948.0	40.7	578.3
70.0	66.6	948.0	39.6	563.5

Table 6.2.1-17 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
75.0	66.6	947.9	38.6	549.3
80.0	66.6	947.8	37.7	535.6
85.0	66.6	947.7	36.7	522.4
90.0	66.6	947.6	35.8	509.7
95.0	66.6	947.5	35.0	497.5
100.0	66.6	947.3	34.1	485.6
120.0	66.6	946.7	31.0	440.8
140.0	66.5	945.9	28.2	401.1
160.0	66.4	945.0	25.8	366.5
180.0	66.4	943.9	23.6	336.0
200.0	66.3	942.7	21.7	308.9
220.0	66.2	941.4	19.9	283.5
240.0	66.1	939.9	18.3	260.2
260.0	66.0	938.4	16.8	238.8
280.0	65.9	936.8	15.4	218.5
300.0	65.7	935.0	14.0	198.9
320.0	65.6	933.2	12.6	179.1
340.0	65.5	931.3	11.1	157.4
360.0	65.3	929.4	9.3	132.0
380.0	65.2	927.3	7.2	102.1
400.0	65.0	925.3	5.1	73.2
420.0	64.9	923.1	4.8	68.7
440.0	64.7	921.0	4.8	68.5
460.0	64.6	918.8	4.8	68.3

Table 6.2.1-17 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
480.0	64.4	916.6	4.8	68.1
500.0	64.3	914.5	4.8	67.9
525.0	64.1	911.8	4.8	67.6
550.0	63.9	909.2	4.7	67.2
575.0	63.7	906.7	4.7	66.7
600.0	63.6	904.2	4.6	66.1
625.0	63.4	901.6	4.6	65.4
650.0	63.2	899.1	4.5	64.5
675.0	63.0	896.6	4.4	63.2
700.0	62.9	894.1	4.3	61.6
725.0	62.7	891.6	4.2	59.2
750.0	62.5	889.1	5.5	78.0
775.0	62.3	886.6	3.2	45.4
800.0	62.2	884.2	3.1	44.0
825.0	62.0	881.7	3.1	43.6
850.0	61.8	879.3	3.0	43.3
875.0	61.6	876.9	3.0	43.0
900.0	61.5	874.4	3.0	42.7
925.0	61.3	872.0	3.0	42.5
950.0	61.1	869.6	3.0	42.2
975.0	61.0	867.2	3.0	42.0
1,000.0	60.8	864.8	2.9	41.8
1,050.0	60.5	860.0	2.9	41.4

Table 6.2.1-17 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,100.0	60.1	855.3	2.9	41.0
1,150.0	59.8	850.5	2.9	40.7
1,200.0	59.5	845.8	2.8	40.4
1,250.0	59.1	841.2	2.8	40.1
1,300.0	58.8	836.5	2.8	39.8
1,350.0	58.5	831.9	2.8	39.6
1,400.0	58.2	827.4	2.8	39.4
1,450.0	57.8	822.8	2.8	39.2
1,500.0	57.5	818.3	2.7	39.0
1,550.0	57.2	813.8	2.7	38.8
1,600.0	56.9	809.3	2.7	38.7
1,650.0	56.6	804.9	2.7	38.5
1,700.0	56.3	800.5	2.7	38.4
1,750.0	56.0	796.1	2.7	38.3
1,800.0	55.7	791.7	2.7	38.2

Table 6.2.1-17 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
4.53	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
5.20	High containment pressure reactor trip signal	-
5.30	Reactor trip breakers open, turbine admission valves closed	-
10.40	Main steam isolation valves closed	-
15.40	Main feedwater isolation valves closed	-
43.21	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
133.21	Start containment spray injection	-
133.21	Peak containment temperature	161.83 ^{o}C (323.30 ^{o}F)
767.04	Peak containment pressure	3.208kg/cm²G (45.63 psig)
1,800.0	End of blowdown	-
3,829.3	Time of depressurization of the containment at 50% of peak pressure	1.601kg/cm²G (22.77 psig)

Table 6.2.1-18 (1 of 11)

Main Steam Line Break, 0 % Power – MSIV Failure (0.381 m^2 (4.1 ft^2) Total Break Area)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
0.0	3,498.934	7,713.870	660.20	1,188.34
0.5	3,424.734	7,550.285	660.69	1,189.20
1.0	3,376.061	7,442.978	661.04	1,189.83
1.5	3,329.641	7,340.639	661.36	1,190.41
2.0	3,284.717	7,241.598	661.67	1,190.97
2.5	3,241.680	7,146.719	661.94	1,191.47
3.0	3,200.680	7,056.329	662.20	1,191.95
3.5	3,161.562	6,970.087	662.46	1,192.41
4.0	3,124.263	6,887.857	662.68	1,192.82
4.5	3,088.907	6,809.910	662.92	1,193.23
5.0	3,055.462	6,736.175	663.14	1,193.60
5.5	3,023.872	6,666.532	663.32	1,193.95
6.0	2,994.104	6,600.905	663.50	1,194.26
6.5	2,966.093	6,539.149	663.67	1,194.57
7.0	2,939.723	6,481.013	663.80	1,194.84
7.5	2,914.890	6,426.266	663.97	1,195.11
8.0	2,891.487	6,374.671	664.09	1,195.36
8.5	2,869.360	6,325.888	664.22	1,195.58
9.0	2,848.439	6,279.766	664.36	1,195.79
9.5	2,828.582	6,235.989	664.47	1,196.01
10.0	2,809.505	6,193.930	664.57	1,196.20
10.5	2,791.074	6,153.298	664.69	1,196.38
11.0	2,773.536	6,114.633	664.78	1,196.56
11.5	2,628.173	5,794.160	665.37	1,197.62

Table 6.2.1-18 (2 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
12.0	2,487.995	5,485.118	665.84	1,198.50
13.0	2,240.786	4,940.114	666.51	1,199.69
14.0	2,031.794	4,479.363	666.85	1,200.30
15.0	1,851.094	4,080.986	667.01	1,200.54
16.0	1,699.015	3,745.706	667.03	1,200.57
17.0	1,573.597	3,469.206	666.88	1,200.39
18.0	1,468.041	3,236.493	666.81	1,200.22
19.0	1,379.087	3,040.382	666.75	1,200.05
20.0	1,303.917	2,874.660	666.68	1,199.97
22.0	1,186.471	2,615.734	666.68	1,199.93
24.0	1,101.982	2,429.466	666.71	1,200.10
26.0	1,040.701	2,294.364	666.86	1,200.33
28.0	995.862	2,195.512	667.06	1,200.63
30.0	962.504	2,121.969	667.22	1,200.87
32.0	936.996	2,065.734	667.35	1,201.12
34.0	916.862	2,021.346	667.39	1,201.33
36.0	900.151	1,984.503	667.55	1,201.56
38.0	885.821	1,952.911	667.63	1,201.74
40.0	872.616	1,923.798	667.76	1,201.95
42.0	859.954	1,895.884	667.83	1,202.13
44.0	848.096	1,869.741	667.97	1,202.31
46.0	837.583	1,846.564	667.99	1,202.45
48.0	827.036	1,823.312	668.17	1,202.59
50.0	817.753	1,802.846	668.17	1,202.71
55.0	795.607	1,754.022	668.42	1,203.01

Table 6.2.1-18 (3 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
60.0	774.824	1,708.203	668.54	1,203.25
65.0	755.212	1,664.967	668.69	1,203.51
70.0	736.420	1,623.536	668.78	1,203.67
75.0	718.947	1,585.014	668.89	1,203.84
80.0	702.112	1,547.899	668.84	1,204.02
85.0	686.068	1,512.530	669.03	1,204.14
90.0	670.727	1,478.707	668.98	1,204.23
95.0	655.205	1,444.487	669.10	1,204.30
100.0	640.370	1,411.781	669.14	1,204.37
120.0	583.610	1,286.646	669.11	1,204.37
140.0	532.965	1,174.992	669.09	1,204.18
160.0	488.813	1,077.654	668.76	1,203.91
180.0	450.817	993.886	668.56	1,203.36
200.0	416.275	917.735	668.31	1,202.74
220.0	384.712	848.149	667.77	1,201.91
240.0	370.526	816.874	666.89	1,200.19
260.0	326.350	719.482	666.77	1,200.31
280.0	300.940	663.462	666.25	1,199.32
300.0	277.574	611.949	665.77	1,197.98
320.0	253.583	559.057	664.87	1,196.66
340.0	227.973	502.596	663.68	1,195.00
360.0	200.010	440.949	662.47	1,192.43
380.0	166.936	368.032	660.73	1,189.03
400.0	132.092	291.215	657.87	1,184.00
420.0	111.999	246.916	655.36	1,180.16

Table 6.2.1-18 (4 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
440.0	111.798	246.473	655.65	1,180.25
460.0	111.595	246.026	655.94	1,179.96
480.0	111.601	246.039	655.91	1,179.89
500.0	111.247	245.258	655.30	1,179.98
525.0	110.891	244.474	655.60	1,179.68
550.0	110.468	243.542	655.39	1,179.67
575.0	109.957	242.415	655.71	1,179.79
600.0	109.327	241.026	654.92	1,179.54
625.0	108.520	239.247	655.18	1,179.12
650.0	107.153	236.233	655.14	1,178.92
675.0	105.958	233.598	654.98	1,178.95
700.0	104.372	230.101	654.39	1,178.18
725.0	102.346	225.636	654.64	1,177.56
750.0	97.697	215.387	654.06	1,176.95
775.0	115.405	254.426	655.95	1,180.70
800.0	62.346	137.450	664.04	1,196.07
825.0	50.192	110.655	665.44	1,196.51
850.0	59.814	131.867	663.72	1,195.90
875.0	59.820	131.881	665.33	1,195.77
900.0	59.804	131.847	663.84	1,196.08
925.0	59.792	131.820	663.97	1,196.33
950.0	59.783	131.799	664.07	1,195.76
975.0	59.775	131.782	664.16	1,195.91
1,000.0	59.769	131.768	664.22	1,196.04
1,050.0	59.758	131.744	664.35	1,196.26
1,100.0	59.748	131.723	664.46	1,195.69

Table 6.2.1-18 (5 of 11)

Part A. Mass and Energy Release Data

Time (sec)	Break Mass Flow Rate		Break Enthalpy	
	kg/sec	lbm/sec	kcal/kg	Btu/lbm
1,150.0	59.739	131.703	664.56	1,195.87
1,200.0	59.730	131.683	664.66	1,196.05
1,250.0	59.721	131.664	664.76	1,196.23
1,300.0	59.715	131.649	664.82	1,196.36
1,350.0	59.708	131.635	664.90	1,196.49
1,400.0	59.703	131.623	664.96	1,196.60
1,450.0	59.697	131.611	665.03	1,196.71
1,500.0	59.693	131.601	665.07	1,196.80
1,550.0	59.688	131.591	665.13	1,196.89
1,600.0	59.684	131.582	665.17	1,196.97
1,650.0	59.681	131.574	665.20	1,197.05
1,700.0	59.677	131.567	665.25	1,196.35
1,750.0	59.674	131.560	665.28	1,196.41
1,800.0	59.672	131.554	665.30	1,196.47

Integral Mass and Energy Release at 1,800 Seconds after Postulated Accident

Time (sec)	Integral Mass		Integral Energy	
	kg	lbm	Million kcal	Million Btu
1,800.0	325,042.60	716,600.00	216.10	857.60

Table 6.2.1-18 (6 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
0.0	77.3	1,100.0	77.3	1,100.0
0.5	76.9	1,094.4	76.1	1,082.0
1.0	76.2	1,083.8	74.8	1,064.0
1.5	75.4	1,072.4	73.7	1,047.8
2.0	74.6	1,060.6	72.6	1,032.9
2.5	73.7	1,048.7	71.6	1,019.1
3.0	72.9	1,036.9	70.7	1,006.2
3.5	72.1	1,025.4	69.9	993.9
4.0	71.3	1,014.2	69.1	982.3
4.5	70.5	1,003.5	68.3	971.3
5.0	69.8	993.2	67.6	960.9
5.5	69.1	983.5	66.9	951.1
6.0	68.5	974.3	66.2	941.9
6.5	67.9	965.6	65.6	933.2
7.0	67.3	957.5	65.0	925.0
7.5	66.8	949.7	64.5	917.3
8.0	66.3	942.4	64.0	910.1
8.5	65.8	935.5	63.5	903.2
9.0	65.3	928.9	63.0	896.7
9.5	64.9	922.6	62.6	890.5
10.0	64.4	916.5	62.2	884.5
10.5	64.0	910.6	61.8	878.7
11.0	63.6	904.8	61.4	873.0
11.5	64.2	913.4	61.0	868.2
12.0	64.8	921.1	60.7	863.4
13.0	65.7	934.9	60.0	853.7

Table 6.2.1-18 (7 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
14.0	66.5	946.6	59.3	843.8
15.0	67.2	956.4	58.6	833.6
16.0	67.8	964.3	57.9	823.1
17.0	68.2	970.0	57.5	817.3
18.0	68.5	973.8	57.0	810.2
19.0	68.6	975.7	56.4	802.3
20.0	68.6	976.1	55.8	793.8
22.0	68.4	973.4	54.5	775.9
24.0	68.1	968.3	53.3	758.2
26.0	67.7	962.6	52.2	742.0
28.0	67.3	957.4	51.2	728.0
30.0	67.0	952.8	50.3	715.8
32.0	66.7	948.1	49.6	705.0
34.0	66.4	945.1	48.9	695.0
36.0	66.4	945.1	48.2	685.2
38.0	66.4	945.1	47.5	675.5
40.0	66.4	945.1	46.8	666.1
42.0	66.4	945.1	46.2	656.9
44.0	66.4	945.1	45.6	648.3
46.0	66.4	945.1	45.0	640.2
48.0	66.4	945.0	44.5	632.5
50.0	66.4	945.0	43.9	625.1
55.0	66.4	945.0	42.7	607.5
60.0	66.4	944.9	41.5	590.6
65.0	66.4	944.9	40.4	574.8
70.0	66.4	944.8	39.4	559.8

Table 6.2.1-18 (8 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
75.0	66.4	944.7	38.3	545.5
80.0	66.4	944.6	37.4	531.7
85.0	66.4	944.5	36.5	518.5
90.0	66.4	944.4	35.6	505.7
95.0	66.4	944.3	34.7	493.4
100.0	66.4	944.2	33.8	481.5
120.0	66.3	943.5	30.7	436.6
140.0	66.3	942.7	27.9	396.9
160.0	66.2	941.8	25.5	362.3
180.0	66.1	940.7	23.3	331.9
200.0	66.0	939.5	21.4	304.8
220.0	65.9	938.1	19.7	279.7
240.0	65.9	936.7	18.1	256.8
260.0	65.7	935.1	16.6	235.7
280.0	65.6	933.5	15.2	216.0
300.0	65.5	931.7	13.9	197.3
320.0	65.4	929.9	12.6	178.8
340.0	65.2	928.0	11.2	159.4
360.0	65.1	926.0	9.7	137.7
380.0	65.0	923.9	7.9	112.2
400.0	64.8	921.8	5.9	84.3
420.0	64.7	919.7	4.8	68.8
440.0	64.5	917.5	4.8	68.6
460.0	64.3	915.3	4.8	68.4
480.0	64.2	913.2	4.8	68.3

Table 6.2.1-18 (9 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
500.0	64.1	911.1	4.8	68.1
525.0	63.9	908.5	4.8	67.7
550.0	63.7	905.9	4.7	67.4
575.0	63.5	903.4	4.7	66.9
600.0	63.3	900.9	4.7	66.4
625.0	63.2	898.4	4.6	65.8
650.0	63.0	895.9	4.6	64.9
675.0	62.8	893.4	4.5	63.8
700.0	62.6	890.9	4.4	62.4
725.0	62.5	888.4	4.3	60.5
750.0	62.3	885.9	4.1	58.0
775.0	62.1	883.4	5.0	70.7
800.0	61.9	881.0	2.5	35.6
825.0	61.8	878.5	2.9	41.8
850.0	61.6	876.1	3.1	44.2
875.0	61.4	873.6	3.1	43.9
900.0	61.2	871.2	3.1	43.6
925.0	61.1	868.8	3.0	43.3
950.0	60.9	866.4	3.0	43.0
975.0	60.7	864.1	3.0	42.8
1,000.0	60.6	861.7	3.0	42.5
1,050.0	60.2	856.9	3.0	42.1
1,100.0	59.9	852.2	2.9	41.7
1,150.0	59.6	847.5	2.9	41.3
1,200.0	59.2	842.8	2.9	41.0
1,250.0	58.9	838.1	2.9	40.6

Table 6.2.1-18 (10 of 11)

Part B. Steam Generator Pressures

Time (sec)	Unaffected SG Pressure		Affected SG Pressure	
	kg/cm^2A	psia	kg/cm^2A	psia
1,300.0	58.6	833.5	2.8	40.4
1,350.0	58.3	828.9	2.8	40.1
1,400.0	58.0	824.4	2.8	39.9
1,450.0	57.6	819.8	2.8	39.7
1,500.0	57.3	815.3	2.8	39.4
1,550.0	57.0	810.9	2.8	39.3
1,600.0	56.7	806.4	2.7	39.1
1,650.0	56.4	802.0	2.7	38.9
1,700.0	56.1	797.6	2.7	38.8
1,750.0	55.8	793.2	2.7	38.7
1,800.0	55.5	788.9	2.7	38.5

Table 6.2.1-18 (11 of 11)

Part C. Chronology of Events

Time (sec)	Events	Values
0.0	Break occurs	-
4.53	Containment pressure reaches reactor trip analysis setpoint and main steam isolation signal analysis setpoint	0.422 kg/cm²G (6.0 psig)
5.80	High containment pressure reactor trip signal	-
5.90	Reactor trip breakers open, turbine admission valves closed	-
11.00	Main steam isolation valves closed	-
16.00	Main feedwater isolation valves closed	-
29.11	Containment pressure Hi-Hi setpoint	1.547 kg/cm²G (22.0 psig)
119.11	Start containment spray injection	-
119.11	Peak containment temperature	163.22 ^{o}C (325.79 ^{o}F)
381.91	Peak containment pressure	3.051kg/cm²G (43.40 psig)
1,800.0	End of blowdown	-
3,253.5	Time of depressurization of the containment at 50% of peak pressure	1.522kg/cm²G (21.65 psig)

Table 6.2.1-19 (1 of 2)

Summary Results of Postulated Pipe Rupture Analysis

Part A. Containment Peak Pressure and Temperature for LOCAs

Break Location	DESLSB(1)		DEDLSB(2)		DEHLSB(3)
	Maximum SI Flow	Minimum SI Flow	Maximum SI Flow	Minimum SI Flow	Maximum SI Flow
Total Break Area, m² (ft²)	0.9121	0.9121	0.9121	0.9121	1.7877
	(9.813)	(9.813)	(9.813)	(9.813)	(19.234)
Peak Pressure, kgf/cm²A (psia) [psig]	4.546	4.558	**4.626**	4.617	4.428
	(64.66)	(64.82)	**(65.79)**	(65.67)	(62.98)
	[49.96]	[50.12]	**[51.09]**	[50.97]	[48.28]
Time of Peak Pressure (sec)	102.5	104.6	324.1	321.9	13.0
Peak Temperature, °C(°F)	133.84	133.97	134.59	134.52	132.99
	(272.91)	(273.14)	(274.27)	(274.13)	(271.38)
Time of Peak Temperature (sec)	101.9	104.2	323.8	320.4	13.0
Max. Saturated Temperature, °C(°F)	133.83	133.96	**134.59**	134.51	132.99
	(272.89)	(273.12)	**(274.25)**	(274.11)	(271.38)
Pressure Margin (%)	16.7	16.5	14.8	15.1	19.5

(1) DESLSB: Double-Ended Suction Leg Slot Break
(2) DEDLSB: Double-Ended Discharge Leg Slot Break
(3) DEHLSB: Double-Ended Hot Leg Slot Break

Table 6.2.1-19 (2 of 2)

Part B. Peak Containment Temperature and Pressure for MSLBs

Break Location	102% Power CSS Failure	102% Power MSIV Failure	75% Power CSS Failure	75% Power MSIV Failure	50% Power CSS Failure
Total Break Area, m² (ft²)	0.849	0.849	0.849	0.849	0.849
	(9.134)	(9.134)	(9.134)	(9.134)	(9.134)
Peak Pressure, kgf/cm²A (psia) [psig]	4.173	4.171	4.314	4.239	4.149
	(59.36)	(59.32)	(61.37)	(60.30)	(59.01)
	[44.66]	[44.62]	[46.67]	[45.60]	[44.31]
Time of Peak Pressure (sec)	345.4	323.5	436.9	399.3	457.6
Peak Temperature, °C(°F)	164.85	**167.45**	163.52	165.28	161.90
	(328.72)	**(333.41)**	(326.34)	(329.51)	(323.43)
Time of Peak Temperature (sec)	125.5	111.7	126.3	112.2	127.5
Max. Saturated Temperature, °C(°F)	132.03	132.03	133.59	132.79	131.77
	(269.66)	(269.65)	(272.47)	(271.02)	(269.19)
Pressure Margin (%)	25.57	25.63	22.22	24.01	26.15

Break Location	50 % Power MSIV Failure	20 % Power CSS Failure	20 % Power MSIV Failure	0 % Power CSS Failure	0 % Power MSIV Failure
Total Break Area, m² (ft²)	0.849	0.818	0.818	0.381	0.381
	(9.134)	(8.801)	(8.801)	(4.099)	(4.099)
Peak Pressure, kg/cm² (psia) [psig]	4.069	4.013	3.826	4.242	4.085
	(57.88)	(57.08)	(54.41)	(60.33)	(58.10)
	[43.18]	[42.38]	[39.71]	[45.63]	[43.40]
Time to Peak Pressure (sec)	414.1	769.0	585.7	767.0	381.9
Peak Temperature, °C (°F)	163.77	157.37	162.43	161.83	163.22
	(326.79)	(315.27)	(324.38)	(323.30)	(325.79)
Time to Peak Temperature (sec)	22.5	97.8	22.9	133.2	119.1
Max. Saturated Temperature, °C (°F)	130.88	130.22	127.98	132.79	131.05
	(267.58)	(266.40)	(262.36)	(271.03)	(267.90)
Pressure Margin (%)	28.04	29.36	33.81	23.94	27.66

Table 6.2.1-20 (1 of 2)

Initial Conditions for Containment Peak Pressure and Temperature Analysis

Part A. Reactor Coolant Systems (Based on a nominal core power of 3,983 MWt)

Parameter	Value
Reactor Coolant System	
Reactor power level (1), MWt	4,091.86
Average coolant temperature, °C (°F)	312.45 (594.4)
Mass of reactor coolant system liquid, kg (lbm)	304,767.84 (671,898.0)
Mass of reactor coolant system steam, kg (lbm)	3,025.05 (6,669.1)
Energy in Reactor coolant system liquid plus steam (2), 10^6 kcal (10^6 Btu)	103.04 (408.91)
Energy from feedwater nozzle to MSIV per Steam Generator (2), 10^6 kcal (10^6 Btu)	33.047 (131.14)

Table 6.2.1-20 (2 of 2)

Part B. Containment System

Parameter	Value for Conservatism	
	LOCA	MSLB
Containment building		
Pressure, kg/cm²A (psia)	1.133 (3) (16.12)	0.997 (4) (14.18)
Temperature, °C (°F)	48.9 (120.0)	
Relative humidity, %	0.0	0.0
Component cooling water temperature, °C (°F)	43.3 (110.0) (5)	
IRWST water temperature, °C (°F)	48.9 (120.0)	
Outside air temperature, °C (°F)	No Consideration	
Stored Water (As Applicable)		
IRWST water volume, m³ (ft³)	993.2 (35,076.0)	
Safety Injection Tank Volume, m³ (ft³)	218.3 (7,708.0)	

(1) At full power plus 2 % uncertainty plus max. RCP power (3,983 × 1.02 + 29.2 = 4,091.86)

(2) Energy is relative to 0 °C (32 °F)

(3) The maximum initial pressure is determined based on the LCO described in TS 3.6.4 with uncertainty, (14.7 + 1.0 + 0.42) psia.

(4) The MSLB limiting temperature case conservatively uses the minimum initial pressure.

(5) The CCW is not explicitly modeled. A conservatively high component cooling water temperature of 43.3 °C (110.0 °F) is used for the entire transient.

Table 6.2.1-21

ESF System Parameters for Containment Peak Pressure Analysis

System/Item	Full Capacity	Value Used for Containment Analyses
Passive Safety Injection System		
Number of accumulators (safety injection tanks)	4	4
Pressure setpoint, kg/cm^{2}G (psig)	40.1 – 44.4 (570 – 632)	44.4 (632)
Volume per accumulator		
Maximum, m^3 (ft^3)	54.6 (1,927)	54.6 (1,927)
Minimum, m^3 (ft^3)	45.3 (1,600)	
Active Safety Injection System		
Number of divisions	4	3 or 4 (1)
Number of pumps/division	1	1
Flow rate per pump at 0 psig		
Maximum, L/min (gpm)	4,277.5 (1,130)	5,050 (1,334)
Minimum, L/min (gpm)		3,969.4 (1,048.6)
Containment Spray System		
Number of Trains	2	1
Number of pumps	2	1
Number of Headers	1	1
Flow rate per pump, L/min (gpm)	20,535 (5,425)	17,034 (4,500) (2)
Containment Spray Heat Exchanger		
Systems	Containment Spray System	
Type	Shell and U-tube	
Number	2	1
Heat transfer area, m^2/unit (ft^2/unit)	500 (5,382)	500 (5,382)
Overall Heat Transfer Coefficient, kcal/hr-ft^2-°C (Btu/hr-ft^2-°F)	249.95 (551.04)	150.48 (331.76)
Flow rate per Line		
Spray (tube), L/min (gpm)	18,927 (5,000)	17,034 (4,500) (2)
CCW (shell), L/min (gpm)	30,282 (8,000)	27,254 (7,200) (2)
Source of cooling water	Component Cooling	
Flow Begins, seconds	-	Table 6.2.1-22

(1) Three divisions for the minimum SI flow case, four divisions for the maximum SI flow case.

(2) Conservatively, the CS flow and the CCW flow are assumed to 90% of their design values.

Table 6.2.1-22

Containment Spray Pump Activation Characteristics

Description	Maximum Spray Actuation Time (sec)	
	Offsite Power available	Loss of offsite power
Primary system pipe breaks	N/A	110 (2)
Secondary system pipe breaks	90 (1)	N/A

(1) The maximum delay time of 90 seconds is composed of the durations needed for CS pump loading (20 seconds), pump startup (3 seconds), pipe filling (58 seconds), signal delay (2 seconds) and 7 seconds for contingency.

(2) In the event that the offsite power is lost, a delay time of 20 seconds is additionally considered for the time required for EDG start-up.

Table 6.2.1-23 (1 of 7)

Passive Heat Sink Data

Part A. Heat Sink Data for Containment Maximum Pressure and Temperature Analysis

Passive Heat Sink	Material	Thickness		Surface Area (3)		Boundary
		cm	in	m^2	ft^2	Condition
Containment Building						
Cylinder wall (Above EL. 100 ft)	Epoxy paint	0.01271	0.0040	6,696.2	72,077.9	(1)
	Inorg. Zinc paint	0.01271	0.0040	-	-	
	Carbon steel	0.87782	0.3456	-	-	
	Air	0.01515	0.00596	-	-	
	Concrete	135.6	53.3856	-	-	
Dome	Epoxy paint	0.01271	0.0040	3,250.6	34,989.6	(1)
	Inorg. Zinc paint	0.01271	0.0040	-	-	
	Carbon steel	0.78943	0.3108	-	-	
	Air	0.01515	0.00596	-	-	
	Concrete	106.68	42.0	-	-	
Internal Concrete Structures						
Embedment concrete	Epoxy paint	0.01271	0.0040	484.1	5,210.40	(2)
	Inorg. Zinc paint	0.01271	0.0040	-	-	
	Carbon steel	2.63347	1.0368	-	-	
	Air	0.01515	0.00596	-	-	
	Concrete	78.07757	30.7392	-	-	
Unembedment concrete	Epoxy paint	0.06349	0.0202	10,467.8	112,674.6	(2)
	Concrete	77.25397	30.4149	-	-	
Refueling pool	Stainless Steel	0.52426	0.20640	1,009.0	10,860.4	(2)

Table 6.2.1-23 (2 of 7)

Part A. Heat Sink Data for Containment Maximum Pressure and Temperature Analysis (Continued)

Passive Heat Sink	Materil	Thickness		Surface Area (3)		Boundary
		cm	ft	m^2	ft^2	Condition
Lifting Devices						
Polar crane and trolley bridge	Epoxy paint	0.01271	0.0040	7,501.9	80,750.0	(2)
	In. Zinc Paint	0.01271	0.0040	-	-	
	Carbon steel	1.21920	0.480	-	-	
Components						
Safety Injection Tank	Epoxy paint	0.02539	0.0080	476.6	5,130.0	(2)
	Carbon steel	4.87985	1.9212	-	-	
Internal Structural Steel, Supports, Ducts, Trays						
Miscellaneous Steel - Group A	Epoxy paint	0.01271	0j.0040	8,310.9	89,458.0	(2)
	Inorg. Zinc paint	0.01271	0.0040	-	-	
	Carbon steel	1.67125	0.65798	-	-	
Miscellaneous Steel - Group B	Inorg. Zinc paint	0.01271	0.0040	5,778.1	62,194.5	(2)
	Carbon steel	0.41752	0.16437	-	-	
Miscellaneous Steel - Group C	Epoxy paint	0.01271	0.0040	2,305.8	24,819.3	(2)
	Inorg. Zinc paint	0.01271	0.0040	-	-	
	Carbon steel	0.51810	0.20398	-	-	
Miscellaneous Steel - Group D	Inorg. Zinc paint	0.01271	0.0040	3,170.6	34,128.4	(2)
	Carbon steel	0.40002	0.15749	-	-	
Miscellaneous Steel - Group E	Inorg. Zinc paint	0.01271	0.0040	14,726.2	158,512.1	(2)
	Carbon steel	0.16438	0.06471	-	-	

Table 6.2.1-23 (3 of 7)

Part A. Heat Sink Data for Containment Maximum Pressure and Temperature Analysis (Continued)

Passive Heat Sink	Material	Thickness		Surface Area (3)		Boundary Condition
		cm	ft	m^2	ft^2	
Uninsulated Piping						
Miscellaneous Steel - Group F	Epoxy paint	0.01271	0.0040	1,250.7	13,462.4	(2)
	Inorg. Zinc paint	0.01271	0.0040	-	-	
	Carbon steel	0.67285	0.26490	-	-	
Miscellaneous Steel - Group G	Stainless Steel	0.62789	0.24720	1,496.4	16,107.3	(2)
NSSS Items						
Miscellaneous Steel - Group J	Inorg. Zinc paint	0.01271	0.0040	1,510.5	16,258.7	(2)
	Carbon steel	0.92156	0.36282	-	-	
Miscellaneous Steel - Group K	Stainless Steel	7.25576	2.8566	1,162.2	12,509.4	(2)

(1) Left side (inner side): Containment atmosphere / Right side (outer side): Adiabatic

(2) An internal structure that has two-sided surfaces exposed to the containment atmosphere is assumed as a one-sided conductor with an abatic opposite side that has the same surface area with halved thickness.

(3) The minimum surface area with nominal thickness of each passive heat sink is chosen to minimize heat absorption to passive heat sinks.

Table 6.2.1-23 (4 of 7)

Part B. Thermophysical Properties of Materials for Maximum Pressure and Temperature Analysis

Materials	Density		Specific Heat		Thermal Conductivity	
	kg/m^3	lbm/ft^3	J/kg-°C	Btu/lbm-°F	W/m-°C	Btu/hr-ft-°F
Concrete	2,242.6	140	879.2	0.21	1.592	0.8
Carbon steel	7,817.0	488	460.5	0.11	46.383	26.8
Stainless steel	7,817.0	488	460.5	0.11	15.940	9.21
Inorganic zinc paint	5,462.3	341	891.8	0.213	1.004	0.58
Epoxy paint	1,417.6	88.5	1,272.8	0.304	0.277	0.16
Air	0.961	0.06	720.1	0.172	0.030	0.0174

The properties for each material are assumed constant at the specified values based on the accident expected temperatures.

Table 6.2.1-23 (5 of 7)

Part C. Containment Physical Parameters – ECCS Performance Analysis

Net Free Volume	101,516 m^3 (3,585,000 ft^3)
Initiation Time for Spray Flow	0 sec
Containment Initial Conditions:	
Temperature	10 °C (50 °F)
Pressure	1.024 kg/cm^2A (14.56 psia)
Relative Humidity	90 %
Containment Spray Water:	
Temperature	10.0 °C (50 °F)
Flow Rate (4 pumps)	75706 L/min (20,000 gpm)

Heat Sink Physical Data

Heat Sinks	Layer	Material	Thickness		Surface Area	
			ft	m	ft^2	m^2
Containment cylinder	1	E Paint	0.00025	7.62E-05	84,005	7,804.4
	2	Z Paint	0.00025	7.62E-05		
	3	Carbon Steel	0.0288	0.008778		
	4	Concrete	4.4488	1.355994		
Dome	1	E Paint	0.00025	7.62E-05	35,696.4	3,316.3
	2	Z Paint	0.00025	7.62E-05		
	3	Carbon Steel	0.0259	0.007894		
	4	Concrete	3.5	1.0668		
Basemat	1	E Paint	0.002192	0.000668	15,186.3	1,410.9
	2	Concrete	3	0.9144		
	3	Carbon Steel	0.020833	0.00635		
	4	Concrete	12	3.6576		
Embedment Concrete	1	E Paint	0.00025	7.62E-05	7,815.6	726.1
	2	Z Paint	0.00025	7.62E-05		
	3	Carbon Steel	0.0864	0.026335		
	4	Concrete	2.5616	0.780776		

Table 6.2.1-23 (6 of 7)

Heat Sink Physical Data (cont.):

Heat Sinks	Layer	Material	Thickness		Surface Area	
			ft	m	ft^2	m^2
Unembedment Concrete	1	E Paint	0.001275	0.000389	119,702.4	11,120.8
	2	Concrete	2.534579	0.77254		
	2	Concrete	1.5	0.4572		
Lined Fuel Pool	1	Stainless Steel	0.0172	0.005243	12,417.7	1,153.6
IRWST Outside	1	E Paint	0.002192	0.000668	21,714.6	2,017.4
	2	Concrete	1.5	0.4572		
IRWST Inside	1	Stainless Steel	0.0208	0.00634	29,518.8	2,742.4
	2	Concrete	1.5	0.4572		
Polar Crane and Bridge	1	E Paint	0.0005	0.000152	89,250	8,291.6
	2	Z Paint	0.0005	0.000152		
	2	Carbon Steel	0.04	0.012192		
SIT	1	E Paint	0.00833	0.002539	5,670	526.8
	2	Carbon Steel	0.1601	0.048798		
Misc. Steel G-A	1	E Paint	0.00025	7.62E-05	109,922	10,212.1
	2	Z Paint	0.00025	7.62E-05		
	3	Carbon Steel	0.054831	0.016712		
Misc. Steel G-B	1	Z Paint	0.00025	7.62E-05	760,15.5	7,062.1
	3	Carbon Steel	0.013698	0.004175		
Misc. Steel G-C	1	E Paint	0.00025	7.62E-05	54,835.5	5,094.4
	2	Z Paint	0.00025	7.62E-05		
	3	Carbon Steel	0.016127	0.004916		
Misc. Steel G-D	1	Z Paint	0.00025	7.62E-05	39,439.6	3,664.1
	2	Carbon Steel	0.013124	0.004		
Misc. Steel G-E	1	Z Paint	0.00025	7.62E-05	232,041.9	21,557.5
	2	Carbon Steel	0.005393	0.001644		

Table 6.2.1-23 (7 of 7)

Heat Sink Physical Data (cont.):

Heat Sinks	Layer	Material	Thickness		Surface Area	
			ft	m	(ft^2)	m^2
Misc. Steel G-F	1	E Paint	0.00025	7.62E-05	17,091.1	1,587.8
	2	Z Paint	0.00025	7.62E-05		
	3	Carbon Steel	0.021554	0.00657		
Misc. Steel G-G	1	Stainless Steel	0.020998	0.0064	20,716.8	1,924.7
Misc. Steel G-H	1	Stainless Steel	0.002624	0.0008	58,096.1	5,397.3
Misc. Steel G-I	1	Z Paint	0.00025	7.62E-05	4,528.8	420.7
	2	Carbon Steel	0.22706	0.069208		
Misc. Steel G-J	1	Z Paint	0.00025	7.62E-05	18,713.6	1,738.6
	2	Carbon Steel	0.030235	0.009216		
Misc. Steel G-K	1	Stainless Steel	0.23805	0.072558	13,662.7	1,269.3

Thermal Conductivity of:	
Steel	40.6 kcal/m-hr-°C (27.3 Btu/ft-hr-°F)
Concrete	1.49 kcal/m-hr-°C (1.0 Btu/ft-hr-°F)
Paint (epoxy)	0.31 kcal/m-hr-°C (0.21 Btu/ft-hr-°F)
Paint (inorganic zinc)	1.49 kcal/m-hr-°C (1.0 Btu/ft-hr-°F)
Volumetric Heat Capacity of:	
Steel	942 kcal/m-hr-°C (58.80 Btu/ft^3-°F)
Concrete	517 kcal/m-hr-°C (32.3 Btu/ft^3-°F)
Paint (epoxy)	585 kcal/m-hr-°C (36.5 Btu/ft^3-°F)
Paint (inorganic zinc)	1250 kcal/m-hr-°C (78.0 Btu/ft^3-°F)

Table 6.2.1-24

Initial Conditions for Containment Pressure Analysis

Part A. Initial Conditions for Containment External Pressure Analysis

Parameter	Initial Conditions
Containment Initial Conditions Initial Temperature Initial Pressure Relative Humidity	 48.9 °C (120 °F) 0.997 kg/cm²A (14.18 psia) 100 %
Containment Spray Temperature	10 °C (50 °F)

Part B. Initial Conditions for Containment Minimum Pressure Analysis

Parameter	Initial Conditions
Net free volume	101,516 m^3 (3.585×10^6 ft^3)
Initial Time for Spray Flow	0 sec
Containment Initial Conditions Initial Temperature Initial Pressure Relative Humidity	 10 °C (50 °F) 1.024 kg/cm²A (14.56 psia) 90 %
Containment Spray Water Temperature Flow Rate (2 pumps)	 10 °C (50 °F) 37,853 L/min (10,000 gpm)

Table 6.2.1-25 (1 of 2)

Subcompartments and Postulated Pipe Break

Description	Break Location	Break Size		Break Node	Break Type	Pressure [1], kg/cm^{2}A (psia)	Temperature [1], ^{o}C (^{o}F)	Mass/Energy Multiplier
		I.D., m (ft)	Area, m^2 (ft^2)					
Steam generator	Feedwater economizer nozzle	0.3000 (0.9845)	0.07072 (0.7612)	13	DEGB [2]	77.34 (1100)	244.8 (472.6)	1.0
	Feedwater downcomer nozzle	0.1463 (0.4801)	0.01682 (0.1810)	37	DEGB	77.34 (1100)	244.8 (472.6)	1.0
	Steam generator blowdown nozzle	0.1463 (0.4801)	0.01682 (0.1810)	13	DEGB	77.34 (1100)	244.8 (472.6)	1.0
Pressurizer	POSRV nozzle	0.1969 (0.6458)	0.03044 (0.3276)	25	DEGB	163.5 (2325)	347.8 (658.0)	1.0
	Pressurizer spray nozzle	0.0873 (0.287)	0.00599 (0.0645)	24	DEGB	163.5 (2325) [3]	347.5 (657.5) [3]	1.0
						167.84 (2387.2) [4]	295.6 (564.2) [4]	
Pressurizer spray valve	Pressurizer spray line	0.0667 (0.219)	0.003489 (0.03755)	1	DEGB	167.84 (2387.2)	295.6 (564.2)	1.0
Regenerative heat exchanger	CVCS letdown line	0.0430 (0.141)	0.001446 (0.01556)	1	DEGB	162.61 (2312.9)	295.6 (564.0)	1.0

Table 6.2.1-25 (2 of 2)

Description	Break Location	Break Size		Break Node	Break Type	Pressure (1), kg/cm^{2}A (psia)	Temperature (1), ^{o}C (^{o}F)	Mass/Energy Multiplier
		I.D., m (ft)	Area, m^2 (ft^2)					
Letdown heat exchanger	CVCS letdown line	0.0430 (0.141)	0.001446 (0.01556)	1	DEGB	162.61 (2,312.9)	295.6 (564.0)	1.0
Letdown heat exchanger valve	CVCS letdown line	0.0430 (0.141)	0.001446 (0.01556)	1	DEGB	162.61 (2,312.9)	295.6 (564.0)	1.0

(1) Postulated break condition

(2) Double ended guillotine break

(3) Condition of the pressurizer spray nozzle at the pressurizer.

(4) Condition of the pipe.

Table 6.2.1-26 (1 of 18)

Steam Generator Comportment Nodal Description

A. Feedwater Economizer Nozzle Break Case

Break Location Node No.: 13
Break Line: Feedwater Economizer Line
Break Area: 0.07072 m^2 (0.7612 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
1	El. 100 ft to 113 ft(1)	3.96 (13.00)	93.41 (3,298.9)	48.89 (120.0)	1.03 (14.6)	0	0.271 (3.849)	0.422 (6.0)	56
2	El. 100 ft to 113 ft	3.96 (13.00)	88.95 (3,141.3)	48.89 (120.0)	1.03 (14.6)	0	0.262 (3.722)	0.422 (6.0)	61
3	El. 100 ft to 113 ft	3.96 (13.00)	129.58 (4,576.0)	48.89 (120.0)	1.03 (14.6)	0	0.279 (3.966)	0.422 (6.0)	51
4	El. 100 ft to 113 ft	3.96 (13.00)	115.45 (4,077.3)	48.89 (120.0)	1.03 (14.6)	0	0.232 (3.298)	0.352 (5.0)	52
5	El. 100 ft to 113 ft	3.96 (13.00)	48.00 (1,695.0)	48.89 (120.0)	1.03 (14.6)	0	0.235 (3.344)	0.352 (5.0)	50
6	El. 100 ft to 113 ft	3.96 (13.00)	48.01 (1,695.4)	48.89 (120.0)	1.03 (14.6)	0	0.249 (3.544)	0.352 (5.0)	41
7	El. 113 ft to 121 ft 8 in	2.64 (8.67)	69.09 (2,439.7)	48.89 (120.0)	1.03 (14.6)	0	0.347 (4.933)	0.492 (7.0)	42
8	El. 113 ft to 121 ft 8 in	2.64 (8.67)	66.13 (2,335.4)	48.89 (120.0)	1.03 (14.6)	0	0.272 (3.875)	0.422 (6.0)	55

(1) The detailed location for each node is specified in Figure 6.2.1-21.

Table 6.2.1-26 (2 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
9	El. 113 ft to 121 ft 8 in	2.64 (8.67)	75.59 (2,669.6)	48.89 (120.0)	1.03 (14.6)	0	0.298 (4.238)	0.422 (6.0)	42
10	El. 113 ft to 121 ft 8 in	2.64 (8.67)	66.87 (2,361.5)	48.89 (120.0)	1.03 (14.6)	0	0.222 (3.164)	0.352 (5.0)	58
11	El. 113 ft to 121 ft 8 in	2.64 (8.67)	31.60 (1,116.1)	48.89 (120.0)	1.03 (14.6)	0	0.261 (3.711)	0.422 (6.0)	62
12	El. 113 ft to 121 ft 8 in	2.64 (8.67)	31.60 (1,116.0)	48.89 (120.0)	1.03 (14.6)	0	0.286 (4.072)	0.422 (6.0)	47
13	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	54.53 (1,925.8)	48.89 (120.0)	1.03 (14.6)	0	0.653 (9.281)	0.914 (13.0)	40
14	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	51.87 (1,831.9)	48.89 (120.0)	1.03 (14.6)	0	0.284 (4.046)	0.422 (6.0)	48
15	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	77.50 (2,736.9)	48.89 (120.0)	1.03 (14.6)	0	0.262 (3.722)	0.422 (6.0)	61
16	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	68.91 (2,433.5)	48.89 (120.0)	1.03 (14.6)	0	0.223 (3.173)	0.352 (5.0)	58
17	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	25.71 (908.0)	48.89 (120.0)	1.03 (14.6)	0	0.286 (4.066)	0.422 (6.0)	48
18	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	25.71 (908.0)	48.89 (120.0)	1.03 (14.6)	0	0.271 (3.856)	0.422 (6.0)	56
19	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	33.74 (1,191.5)	48.89 (120.0)	1.03 (14.6)	0	0.524 (7.457)	0.773 (11.0)	48

Table 6.2.1-26 (3 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
20	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	32.41 (1,144.4)	48.89 (120.0)	1.03 (14.6)	0	0.256 (3.645)	0.422 (6.0)	65
21	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	14.03 (495.4)	48.89 (120.0)	1.03 (14.6)	0	0.312 (4.439)	0.492 (7.0)	58
22	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	26.27 (927.7)	48.89 (120.0)	1.03 (14.6)	0	0.218 (3.105)	0.352 (5.0)	61
23	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	16.10 (568.6)	48.89 (120.0)	1.03 (14.6)	0	0.260 (3.703)	0.422 (6.0)	62
24	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	16.10 (568.6)	48.89 (120.0)	1.03 (14.6)	0	0.261 (3.714)	0.422 (6.0)	62
25	El. 135 ft to 145 ft 6 in	3.20 (10.50)	70.25 (2,480.7)	48.89 (120.0)	1.03 (14.6)	0	0.278 (3.956)	0.422 (6.0)	52
26	El. 135 ft to 145 ft 6 in	3.20 (10.50)	66.64 (2,353.3)	48.89 (120.0)	1.03 (14.6)	0	0.193 (2.743)	0.281 (4.0)	46
27	El. 135 ft to 145 ft 6 in	3.20 (10.50)	30.57 (1,079.6)	48.89 (120.0)	1.03 (14.6)	0	0.250 (3.550)	0.352 (5.0)	41
28	El. 135 ft to 145 ft 6 in	3.20 (10.50)	89.03 (3,144.2)	48.89 (120.0)	1.03 (14.6)	0	0.168 (2.385)	0.281 (4.0)	68
29	El. 135 ft to 145 ft 6 in	3.20 (10.50)	31.47 (1,111.4)	48.89 (120.0)	1.03 (14.6)	0	0.175 (2.495)	0.281 (4.0)	60
30	El. 135 ft to 145 ft 6 in	3.20 (10.50)	31.47 (1,111.5)	48.89 (120.0)	1.03 (14.6)	0	0.206 (2.929)	0.352 (5.0)	71

Table 6.2.1-26 (4 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
31	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	71.74 (2,533.4)	48.89 (120.0)	1.03 (14.6)	0	0.158 (2.252)	0.281 (4.0)	78
32	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	68.31 (2,412.4)	48.89 (120.0)	1.03 (14.6)	0	0.153 (2.183)	0.281 (4.0)	83
33	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	34.96 (1,234.5)	48.89 (120.0)	1.03 (14.6)	0	0.201 (2.861)	0.352 (5.0)	75
34	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	71.71 (2,532.4)	48.89 (120.0)	1.03 (14.6)	0	0.163 (2.324)	0.281 (4.0)	72
35	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	29.63 (1,046.3)	48.89 (120.0)	1.03 (14.6)	0	0.173 (2.455)	0.281 (4.0)	63
36	El. 155 ft 6 in to 169 ft	3.05 (10.00)	29.64 (1,046.8)	48.89 (120.0)	1.03 (14.6)	0	0.172 (2.444)	0.281 (4.0)	64
37	El. 155 ft 6 in to 169 ft	4.11 (13.50)	87.08 (3,075.1)	48.89 (120.0)	1.03 (14.6)	0	0.109 (1.557)	0.281 (4.0)	157
38	El. 155 ft 6 in to 169 ft	4.11 (13.50)	82.64 (2,918.2)	48.89 (120.0)	1.03 (14.6)	0	0.111 (1.580)	0.211 (3.0)	90
39	El. 155 ft 6 in to 169 ft	4.11 (13.50)	43.02 (1,519.4)	48.89 (120.0)	1.03 (14.6)	0	0.151 (2.153)	0.281 (4.0)	86
40	El. 155 ft 6 in to 169 ft	4.11 (13.50)	51.91 (1,833.3)	48.89 (120.0)	1.03 (14.6)	0	0.105 (1.493)	0.211 (3.0)	101
41	El. 155 ft 6 in to 169 ft	4.11 (13.50)	27.37 (966.7)	48.89 (120.0)	1.03 (14.6)	0	0.142 (2.017)	0.211 (3.0)	49

Table 6.2.1-26 (5 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
42	El. 155 ft 6 in to 169 ft	4.11 (13.50)	27.37 (966.7)	48.89 (120.0)	1.03 (14.6)	0	0.113 (1.613)	0.211 (3.0)	86
43	El. 169 ft to 178 ft	2.74 (9.00)	55.41 (1,956.7)	48.89 (120.0)	1.03 (14.6)	0	0.081 (1.147)	0.211 (3.0)	162
44	El. 169 ft to 178 ft	2.74 (9.00)	52.62 (1,858.4)	48.89 (120.0)	1.03 (14.6)	0	0.067 (0.954)	0.141 (2.0)	110
45	El. 169 ft to 178 ft	2.74 (9.00)	30.25 (1,068.4)	48.89 (120.0)	1.03 (14.6)	0	0.105 (1.498)	0.211 (3.0)	100
46	El. 169 ft to 178 ft	2.74 (9.00)	36.43 (1,286.5)	48.89 (120.0)	1.03 (14.6)	0	0.080 (1.145)	0.141 (2.0)	75
47	El. 169 ft to 178 ft	2.74 (9.00)	21.02 (742.3)	48.89 (120.0)	1.03 (14.6)	0	0.098 (1.388)	0.141 (2.0)	44
48	El. 169 ft to 178 ft	2.74 (9.00)	21.02 (742.3)	48.89 (120.0)	1.03 (14.6)	0	0.072 (1.020)	0.141 (2.0)	96
49	El. 178 ft to 186 ft 11 in	2.72 (8.92)	69.04 (2,438.3)	48.89 (120.0)	1.03 (14.6)	0	0.045 (0.645)	0.070 (1.0)	55
50	El. 178 ft to 186 ft 11 in	2.72 (8.92)	65.97 (2,329.9)	48.89 (120.0)	1.03 (14.6)	0	0.035 (0.493)	0.070 (1.0)	103
51	El. 178 ft to 186 ft 11 in	2.72 (8.92)	29.98 (1,058.7)	48.89 (120.0)	1.03 (14.6)	0	0.061 (0.873)	0.141 (2.0)	129
52	El. 178 ft to 186 ft 11 in	2.72 (8.92)	36.10 (1,274.8)	48.89 (120.0)	1.03 (14.6)	0	0.028 (0.399)	0.070 (1.0)	151

Table 6.2.1-26 (6 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
53	El. 178 ft to 186 ft 11 in	2.72 (8.92)	27.75 (979.9)	48.89 (120.0)	1.03 (14.6)	0	0.048 (0.682)	0.141 (2.0)	193
54	El. 178 ft to 186 ft 11 in	2.72 (8.92)	27.75 (979.9)	48.89 (120.0)	1.03 (14.6)	0	0.033 (0.466)	0.070 (1.0)	115
55	El. 186 ft 11 in to 191 ft	1.24 (4.08)	68.06 (2,403.3)	48.89 (120.0)	1.03 (14.6)	0	0.021 (0.296)	0.070 (1.0)	238
56	El. 186 ft 11 in to 191 ft	1.24 (4.08)	69.45 (2,452.7)	48.89 (120.0)	1.03 (14.6)	0	0.015 (0.214)	0.070 (1.0)	367
57	El. 100 ft to 113 ft	3.96 (13.00)	9.62 (339.7)	48.89 (120.0)	1.03 (14.6)	0	0.068 (0.972)	0.141 (2.0)	106
58	El. 114 ft to 121.17 ft	2.19 (7.17)	5.95 (210.0)	48.89 (120.0)	1.03 (14.6)	0	0.114 (1.624)	0.211 (3.0)	85
59	El. 136 ft 5 in to 143.67 ft	2.19 (7.17)	5.52 (195.1)	48.89 (120.0)	1.03 (14.6)	0	0.121 (1.717)	0.211 (3.0)	75
60	Containment	-	8.43E+4 (2.98E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-26 (7 of 18)

Steam Generator Comportment Nodal Description

B. Feedwater Downcomer Nozzle Break Case
Break Location Node No.: 37
Break Line: Feedwater Downcomer Line
Break Area: 0.01682 m^2 (0.1810 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
1	El. 100 ft to 113 ft(1)	3.96 (13.00)	93.41 (3,298.9)	48.89 (120.0)	1.03 (14.6)	0	0.034 (0.477)	0.422 (6.0)	1,158
2	El. 100 ft to 113 ft	3.96 (13.00)	88.95 (3,141.3)	48.89 (120.0)	1.03 (14.6)	0	0.041 (0.580)	0.422 (6.0)	934
3	El. 100 ft to 113 ft	3.96 (13.00)	129.58 (4,576.0)	48.89 (120.0)	1.03 (14.6)	0	0.052 (0.745)	0.422 (6.0)	705
4	El. 100 ft to 113 ft	3.96 (13.00)	115.45 (4,077.3)	48.89 (120.0)	1.03 (14.6)	0	0.065 (0.923)	0.352 (5.0)	442
5	El. 100 ft to 113 ft	3.96 (13.00)	48.00 (1,695.0)	48.89 (120.0)	1.03 (14.6)	0	0.049 (0.693)	0.352 (5.0)	622
6	El. 100 ft to 113 ft	3.96 (13.00)	48.01 (1,695.4)	48.89 (120.0)	1.03 (14.6)	0	0.063 (0.892)	0.352 (5.0)	461
7	El. 113 ft to 121 ft 8 in	2.64 (8.67)	69.09 (2,439.7)	48.89 (120.0)	1.03 (14.6)	0	0.027 (0.390)	0.492 (7.0)	1,695
8	El. 113 ft to 121 ft 8 in	2.64 (8.67)	66.13 (2,335.4)	48.89 (120.0)	1.03 (14.6)	0	0.033 (0.474)	0.422 (6.0)	1,166

(1) The detailed location for each node is specified in Figure 6.2.1-21.

Table 6.2.1-26 (8 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
9	El. 113 ft to 121 ft 8 in	2.64 (8.67)	75.59 (2,669.6)	48.89 (120.0)	1.03 (14.6)	0	0.042 (0.599)	0.422 (6.0)	902
10	El. 113 ft to 121 ft 8 in	2.64 (8.67)	66.87 (2,361.5)	48.89 (120.0)	1.03 (14.6)	0	0.049 (0.697)	0.352 (5.0)	617
11	El. 113 ft to 121 ft 8 in	2.64 (8.67)	31.60 (1,116.1)	48.89 (120.0)	1.03 (14.6)	0	0.056 (0.795)	0.422 (6.0)	655
12	El. 113 ft to 121 ft 8 in	2.64 (8.67)	31.60 (1,116.0)	48.89 (120.0)	1.03 (14.6)	0	0.046 (0.655)	0.422 (6.0)	816
13	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	54.53 (1,925.8)	48.89 (120.0)	1.03 (14.6)	0	0.037 (0.521)	0.914 (13.0)	2395
14	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	51.87 (1,831.9)	48.89 (120.0)	1.03 (14.6)	0	0.029 (0.406)	0.422 (6.0)	1,378
15	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	77.50 (2,736.9)	48.89 (120.0)	1.03 (14.6)	0	0.045 (0.642)	0.422 (6.0)	835
16	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	68.91 (2,433.5)	48.89 (120.0)	1.03 (14.6)	0	0.041 (0.590)	0.352 (5.0)	747
17	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	25.71 (908.0)	48.89 (120.0)	1.03 (14.6)	0	0.063 (0.903)	0.422 (6.0)	564
18	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	25.71 (908.0)	48.89 (120.0)	1.03 (14.6)	0	0.049 (0.700)	0.422 (6.0)	757
19	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	33.74 (1,191.5)	48.89 (120.0)	1.03 (14.6)	0	0.042 (0.596)	0.773 (11.0)	1,746

Table 6.2.1-26 (9 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
20	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	32.41 (1,144.4)	48.89 (120.0)	1.03 (14.6)	0	0.029 (0.416)	0.422 (6.0)	1342
21	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	14.03 (495.4)	48.89 (120.0)	1.03 (14.6)	0	0.052 (0.733)	0.492 (7.0)	855
22	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	26.27 (927.7)	48.89 (120.0)	1.03 (14.6)	0	0.039 (0.561)	0.352 (5.0)	791
23	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	16.10 (568.6)	48.89 (120.0)	1.03 (14.6)	0	0.053 (0.748)	0.422 (6.0)	702
24	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	16.10 (568.6)	48.89 (120.0)	1.03 (14.6)	0	0.042 (0.592)	0.422 (6.0)	914
25	El. 135 ft to 145 ft 6 in	3.20 (10.50)	70.25 (2,480.7)	48.89 (120.0)	1.03 (14.6)	0	0.054 (0.766)	0.422 (6.0)	683
26	El. 135 ft to 145 ft 6 in	3.20 (10.50)	66.64 (2,353.3)	48.89 (120.0)	1.03 (14.6)	0	0.036 (0.509)	0.281 (4.0)	686
27	El. 135 ft to 145 ft 6 in	3.20 (10.50)	30.57 (1,079.6)	48.89 (120.0)	1.03 (14.6)	0	0.095 (1.350)	0.352 (5.0)	270
28	El. 135 ft to 145 ft 6 in	3.20 (10.50)	89.03 (3,144.2)	48.89 (120.0)	1.03 (14.6)	0	0.045 (0.639)	0.281 (4.0)	526
29	El. 135 ft to 145 ft 6 in	3.20 (10.50)	31.47 (1,111.4)	48.89 (120.0)	1.03 (14.6)	0	0.074 (1.054)	0.281 (4.0)	280
30	El. 135 ft to 145 ft 6 in	3.20 (10.50)	31.47 (1,111.5)	48.89 (120.0)	1.03 (14.6)	0	0.043 (0.608)	0.352 (5.0)	722

Table 6.2.1-26 (10 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
31	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	71.74 (2,533.4)	48.89 (120.0)	1.03 (14.6)	0	0.102 (1.453)	0.281 (4.0)	175
32	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	68.31 (2,412.4)	48.89 (120.0)	1.03 (14.6)	0	0.036 (0.510)	0.281 (4.0)	684
33	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	34.96 (1,234.5)	48.89 (120.0)	1.03 (14.6)	0	0.107 (1.525)	0.352 (5.0)	228
34	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	71.71 (2,532.4)	48.89 (120.0)	1.03 (14.6)	0	0.039 (0.561)	0.281 (4.0)	613
35	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	29.63 (1,046.3)	48.89 (120.0)	1.03 (14.6)	0	0.082 (1.168)	0.281 (4.0)	242
36	El. 155 ft 6 in to 169 ft	3.05 (10.00)	29.64 (1,046.8)	48.89 (120.0)	1.03 (14.6)	0	0.039 (0.554)	0.281 (4.0)	622
37	El. 155 ft 6 in to 169 ft	4.11 (13.50)	87.08 (3,075.1)	48.89 (120.0)	1.03 (14.6)	0	0.165 (2.343)	0.281 (4.0)	71
38	El. 155 ft 6 in to 169 ft	4.11 (13.50)	82.64 (2,918.2)	48.89 (120.0)	1.03 (14.6)	0	0.045 (0.634)	0.211 (3.0)	373
39	El. 155 ft 6 in to 169 ft	4.11 (13.50)	43.02 (1,519.4)	48.89 (120.0)	1.03 (14.6)	0	0.130 (1.849)	0.281 (4.0)	116
40	El. 155 ft 6 in to 169 ft	4.11 (13.50)	51.91 (1,833.3)	48.89 (120.0)	1.03 (14.6)	0	0.037 (0.521)	0.211 (3.0)	476
41	El. 155 ft 6 in to 169 ft	4.11 (13.50)	27.37 (966.7)	48.89 (120.0)	1.03 (14.6)	0	0.122 (1.733)	0.211 (3.0)	73

Table 6.2.1-26 (11 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
42	El. 155 ft 6 in to 169 ft	4.11 (13.50)	27.37 (966.7)	48.89 (120.0)	1.03 (14.6)	0	0.047 (0.669)	0.211 (3.0)	348
43	El. 169 ft to 178 ft	2.74 (9.00)	55.41 (1,956.7)	48.89 (120.0)	1.03 (14.6)	0	0.108 (1.541)	0.211 (3.0)	95
44	El. 169 ft to 178 ft	2.74 (9.00)	52.62 (1,858.4)	48.89 (120.0)	1.03 (14.6)	0	0.029 (0.410)	0.141 (2.0)	388
45	El. 169 ft to 178 ft	2.74 (9.00)	30.25 (1,068.4)	48.89 (120.0)	1.03 (14.6)	0	0.106 (1.509)	0.211 (3.0)	99
46	El. 169 ft to 178 ft	2.74 (9.00)	36.43 (1,286.5)	48.89 (120.0)	1.03 (14.6)	0	0.034 (0.479)	0.141 (2.0)	318
47	El. 169 ft to 178 ft	2.74 (9.00)	21.02 (742.3)	48.89 (120.0)	1.03 (14.6)	0	0.092 (1.305)	0.141 (2.0)	53
48	El. 169 ft to 178 ft	2.74 (9.00)	21.02 (742.3)	48.89 (120.0)	1.03 (14.6)	0	0.029 (0.418)	0.141 (2.0)	378
49	El. 178 ft to 186 ft 11 in	2.72 (8.92)	69.04 (2,438.3)	48.89 (120.0)	1.03 (14.6)	0	0.040 (0.565)	0.070 (1.0)	77
50	El. 178 ft to 186 ft 11 in	2.72 (8.92)	65.97 (2,329.9)	48.89 (120.0)	1.03 (14.6)	0	0.023 (0.329)	0.070 (1.0)	204
51	El. 178 ft to 186 ft 11 in	2.72 (8.92)	29.98 (1,058.7)	48.89 (120.0)	1.03 (14.6)	0	0.082 (1.164)	0.141 (2.0)	72
52	El. 178 ft to 186 ft 11 in	2.72 (8.92)	36.10 (1,274.8)	48.89 (120.0)	1.03 (14.6)	0	0.012 (0.168)	0.070 (1.0)	495

Table 6.2.1-26 (12 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
53	El. 178 ft to 186 ft 11 in	2.72 (8.92)	27.75 (979.9)	48.89 (120.0)	1.03 (14.6)	0	0.063 (0.901)	0.141 (2.0)	122
54	El. 178 ft to 186 ft 11 in	2.72 (8.92)	27.75 (979.9)	48.89 (120.0)	1.03 (14.6)	0	0.018 (0.252)	0.070 (1.0)	297
55	El. 186 ft 11 in to 191 ft	1.24 (4.08)	68.06 (2,403.3)	48.89 (120.0)	1.03 (14.6)	0	0.013 (0.186)	0.070 (1.0)	438
56	El. 186 ft 11 in to 191 ft	1.24 (4.08)	69.45 (2,452.7)	48.89 (120.0)	1.03 (14.6)	0	0.005 (0.076)	0.070 (1.0)	1,216
57	El. 100 ft to 113 ft	3.96 (13.00)	9.62 (339.7)	48.89 (120.0)	1.03 (14.6)	0	0.011 (0.152)	0.141 (2.0)	1,216
58	El. 114 ft to 121.17 ft	2.19 (7.17)	5.95 (210.0)	48.89 (120.0)	1.03 (14.6)	0	0.012 (0.168)	0.211 (3.0)	1,686
59	El. 136 ft 5 in to 143.67 ft	2.19 (7.17)	5.52 (195.1)	48.89 (120.0)	1.03 (14.6)	0	0.013 (0.181)	0.211 (3.0)	1,557
60	Containment	-	8.43E+4 (2.98E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-26 (13 of 18)

Steam Generator Comportment Nodal Description

C. S/G Blowdown Nozzle Break Case

Break Location Node No.: 13
Break Line: S/G Blowdown Line
Break Area: 0.01682 m^2 (0.1810 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
1	El. 100 ft to 113 ft (1)	3.96 (13.00)	93.41 (3,298.9)	48.89 (120.0)	1.03 (14.6)	0	0.092 (1.306)	0.422 (6.0)	359
2	El. 100 ft to 113 ft	3.96 (13.00)	88.95 (3,141.3)	48.89 (120.0)	1.03 (14.6)	0	0.075 (1.068)	0.422 (6.0)	462
3	El. 100 ft to 113 ft	3.96 (13.00)	129.58 (4,576.0)	48.89 (120.0)	1.03 (14.6)	0	0.086 (1.225)	0.422 (6.0)	390
4	El. 100 ft to 113 ft	3.96 (13.00)	115.45 (4,077.3)	48.89 (120.0)	1.03 (14.6)	0	0.057 (0.816)	0.352 (5.0)	513
5	El. 100 ft to 113 ft	3.96 (13.00)	48.00 (1,695.0)	48.89 (120.0)	1.03 (14.6)	0	0.071 (1.013)	0.352 (5.0)	394
6	El. 100 ft to 113 ft	3.96 (13.00)	48.01 (1,695.4)	48.89 (120.0)	1.03 (14.6)	0	0.068 (0.964)	0.352 (5.0)	419
7	El. 113 ft to 121 ft 8 in	2.64 (8.67)	69.09 (2,439.7)	48.89 (120.0)	1.03 (14.6)	0	0.122 (1.735)	0.492 (7.0)	303
8	El. 113 ft to 121 ft 8 in	2.64 (8.67)	66.13 (2,335.4)	48.89 (120.0)	1.03 (14.6)	0	0.075 (1.069)	0.422 (6.0)	461

Table 6.2.1-26 (14 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
9	El. 113 ft to 121 ft 8 in	2.64 (8.67)	75.59 (2,669.6)	48.89 (120.0)	1.03 (14.6)	0	0.078 (1.110)	0.422 (6.0)	441
10	El. 113 ft to 121 ft 8 in	2.64 (8.67)	66.87 (2,361.5)	48.89 (120.0)	1.03 (14.6)	0	0.055 (0.785)	0.352 (5.0)	537
11	El. 113 ft to 121 ft 8 in	2.64 (8.67)	31.60 (1,116.1)	48.89 (120.0)	1.03 (14.6)	0	0.073 (1.033)	0.422 (6.0)	481
12	El. 113 ft to 121 ft 8 in	2.64 (8.67)	31.60 (1,116.0)	48.89 (120.0)	1.03 (14.6)	0	0.083 (1.177)	0.422 (6.0)	410
13	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	54.53 (1,925.8)	48.89 (120.0)	1.03 (14.6)	0	0.185 (2.625)	0.914 (13.0)	395
14	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	51.87 (1,831.9)	48.89 (120.0)	1.03 (14.6)	0	0.075 (1.064)	0.422 (6.0)	464
15	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	77.50 (2,736.9)	48.89 (120.0)	1.03 (14.6)	0	0.061 (0.868)	0.422 (6.0)	591
16	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	68.91 (2,433.5)	48.89 (120.0)	1.03 (14.6)	0	0.053 (0.757)	0.352 (5.0)	561
17	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	25.71 (908.0)	48.89 (120.0)	1.03 (14.6)	0	0.073 (1.033)	0.422 (6.0)	481
18	El. 121 ft 8 in to 129 ft 4.75 in	2.36 (7.73)	25.71 (908.0)	48.89 (120.0)	1.03 (14.6)	0	0.081 (1.145)	0.422 (6.0)	424
19	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	33.74 (1,191.5)	48.89 (120.0)	1.03 (14.6)	0	0.190 (2.700)	0.773 (11.0)	307

Table 6.2.1-26 (15 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
20	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	32.41 (1,144.4)	48.89 (120.0)	1.03 (14.6)	0	0.059 (0.845)	0.422 (6.0)	610
21	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	14.03 (495.4)	48.89 (120.0)	1.03 (14.6)	0	0.080 (1.132)	0.492 (7.0)	518
22	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	26.27 (927.7)	48.89 (120.0)	1.03 (14.6)	0	0.049 (0.701)	0.352 (5.0)	613
23	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	16.10 (568.6)	48.89 (120.0)	1.03 (14.6)	0	0.064 (0.909)	0.422 (6.0)	560
24	El. 129 ft 4.75 in to 135 ft	1.71 (5.60)	16.10 (568.6)	48.89 (120.0)	1.03 (14.6)	0	0.063 (0.896)	0.422 (6.0)	570
25	El. 135 ft to 145 ft 6 in	3.20 (10.50)	70.25 (2,480.7)	48.89 (120.0)	1.03 (14.6)	0	0.071 (1.004)	0.422 (6.0)	498
26	El. 135 ft to 145 ft 6 in	3.20 (10.50)	66.64 (2,353.3)	48.89 (120.0)	1.03 (14.6)	0	0.053 (0.750)	0.281 (4.0)	433
27	El. 135 ft to 145 ft 6 in	3.20 (10.50)	30.57 (1,079.6)	48.89 (120.0)	1.03 (14.6)	0	0.071 (1.009)	0.352 (5.0)	396
28	El. 135 ft to 145 ft 6 in	3.20 (10.50)	89.03 (3,144.2)	48.89 (120.0)	1.03 (14.6)	0	0.041 (0.589)	0.281 (4.0)	579
29	El. 135 ft to 145 ft 6 in	3.20 (10.50)	31.47 (1,111.4)	48.89 (120.0)	1.03 (14.6)	0	0.051 (0.724)	0.281 (4.0)	452
30	El. 135 ft to 145 ft 6 in	3.20 (10.50)	31.47 (1,111.5)	48.89 (120.0)	1.03 (14.6)	0	0.047 (0.665)	0.352 (5.0)	652

Table 6.2.1-26 (16 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
31	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	71.74 (2,533.4)	48.89 (120.0)	1.03 (14.6)	0	0.055 (0.775)	0.281 (4.0)	416
32	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	68.31 (2,412.4)	48.89 (120.0)	1.03 (14.6)	0	0.036 (0.515)	0.281 (4.0)	677
33	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	34.96 (1,234.5)	48.89 (120.0)	1.03 (14.6)	0	0.071 (1.005)	0.352 (5.0)	398
34	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	71.71 (2,532.4)	48.89 (120.0)	1.03 (14.6)	0	0.043 (0.608)	0.281 (4.0)	558
35	El. 145 ft 6 in to 155 ft 6 in	3.05 (10.00)	29.63 (1,046.3)	48.89 (120.0)	1.03 (14.6)	0	0.047 (0.669)	0.281 (4.0)	498
36	El. 155 ft 6 in to 169 ft	3.05 (10.00)	29.64 (1,046.8)	48.89 (120.0)	1.03 (14.6)	0	0.036 (0.512)	0.281 (4.0)	681
37	El. 155 ft 6 in to 169 ft	4.11 (13.50)	87.08 (3,075.1)	48.89 (120.0)	1.03 (14.6)	0	0.042 (0.592)	0.281 (4.0)	576
38	El. 155 ft 6 in to 169 ft	4.11 (13.50)	82.64 (2,918.2)	48.89 (120.0)	1.03 (14.6)	0	0.029 (0.418)	0.211 (3.0)	618
39	El. 155 ft 6 in to 169 ft	4.11 (13.50)	43.02 (1,519.4)	48.89 (120.0)	1.03 (14.6)	0	0.038 (0.543)	0.281 (4.0)	637
40	El. 155 ft 6 in to 169 ft	4.11 (13.50)	51.91 (1,833.3)	48.89 (120.0)	1.03 (14.6)	0	0.029 (0.416)	0.211 (3.0)	621
41	El. 155 ft 6 in to 169 ft	4.11 (13.50)	27.37 (966.7)	48.89 (120.0)	1.03 (14.6)	0	0.041 (0.586)	0.211 (3.0)	412

Table 6.2.1-26 (17 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
42	El. 155 ft 6 in to 169 ft	4.11 (13.50)	27.37 (966.7)	48.89 (120.0)	1.03 (14.6)	0	0.043 (0.605)	0.211 (3.0)	396
43	El. 169 ft to 178 ft	2.74 (9.00)	55.41 (1,956.7)	48.89 (120.0)	1.03 (14.6)	0	0.024 (0.343)	0.211 (3.0)	775
44	El. 169 ft to 178 ft	2.74 (9.00)	52.62 (1,858.4)	48.89 (120.0)	1.03 (14.6)	0	0.018 (0.258)	0.141 (2.0)	675
45	El. 169 ft to 178 ft	2.74 (9.00)	30.25 (1,068.4)	48.89 (120.0)	1.03 (14.6)	0	0.032 (0.457)	0.211 (3.0)	556
46	El. 169 ft to 178 ft	2.74 (9.00)	36.43 (1,286.5)	48.89 (120.0)	1.03 (14.6)	0	0.024 (0.336)	0.141 (2.0)	495
47	El. 169 ft to 178 ft	2.74 (9.00)	21.02 (742.3)	48.89 (120.0)	1.03 (14.6)	0	0.028 (0.397)	0.141 (2.0)	404
48	El. 169 ft to 178 ft	2.74 (9.00)	21.02 (742.3)	48.89 (120.0)	1.03 (14.6)	0	0.020 (0.291)	0.141 (2.0)	587
49	El. 178 ft to 186 ft 11 in	2.72 (8.92)	69.04 (2,438.3)	48.89 (120.0)	1.03 (14.6)	0	0.020 (0.284)	0.070 (1.0)	252
50	El. 178 ft to 186 ft 11 in	2.72 (8.92)	65.97 (2,329.9)	48.89 (120.0)	1.03 (14.6)	0	0.010 (0.141)	0.070 (1.0)	609
51	El. 178 ft to 186 ft 11 in	2.72 (8.92)	29.98 (1,058.7)	48.89 (120.0)	1.03 (14.6)	0	0.026 (0.372)	0.141 (2.0)	438
52	El. 178 ft to 186 ft 11 in	2.72 (8.92)	36.10 (1,274.8)	48.89 (120.0)	1.03 (14.6)	0	0.007 (0.097)	0.070 (1.0)	931

Table 6.2.1-26 (18 of 18)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
53	El. 178 ft to 186 ft 11 in	2.72 (8.92)	27.75 (979.9)	48.89 (120.0)	1.03 (14.6)	0	0.018 (0.258)	0.141 (2.0)	675
54	El. 178 ft to 186 ft 11 in	2.72 (8.92)	27.75 (979.9)	48.89 (120.0)	1.03 (14.6)	0	0.010 (0.142)	0.070 (1.0)	604
55	El. 186 ft 11 in to 191 ft	1.24 (4.08)	68.06 (2,403.3)	48.89 (120.0)	1.03 (14.6)	0	0.004 (0.064)	0.070 (1.0)	1463
56	El. 186 ft 11 in to 191 ft	1.24 (4.08)	69.45 (2,452.7)	48.89 (120.0)	1.03 (14.6)	0	0.003 (0.049)	0.070 (1.0)	1941
57	El. 100 ft to 113 ft	3.96 (13.00)	9.62 (339.7)	48.89 (120.0)	1.03 (14.6)	0	0.017 (0.241)	0.141 (2.0)	730
58	El. 114 ft to 121.17 ft	2.19 (7.17)	5.95 (210.0)	48.89 (120.0)	1.03 (14.6)	0	0.019 (0.264)	0.211 (3.0)	1,036
59	El. 136 ft 5 in to 143.67 ft	2.19 (7.17)	5.52 (195.1)	48.89 (120.0)	1.03 (14.6)	0	0.019 (0.268)	0.211 (3.0)	1,019
60	Containment	-	8.43E+4 (2.98E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-27 (1 of 8)

Pressurizer Subcompartment Nodal Description

A. POSRV Nozzle Break Case

Break Location Node No.: 25

Break Line: POSRV discharge Line

Break Area: 0.03044 m^2 (0.3276 ft^2)

Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
1	El. 136.73 ft to 143.67 ft, 2nd quadrant	2.12 (6.94)	11.75 (415.1)	48.89 (120.0)	1.03 (14.6)	0	0.089 (1.264)	0.141 (2.0)	58
2	El. 136.73 ft to 143.67 ft, 1st quadrant	2.12 (6.94)	8.75 (308.9)	48.89 (120.0)	1.03 (14.6)	0	0.097 (1.382)	0.141 (2.0)	45
3	El. 136.73 ft to 143.67 ft, 3rd quadrant	2.12 (6.94)	9.67 (341.3)	48.89 (120.0)	1.03 (14.6)	0	0.089 (1.272)	0.141 (2.0)	57
4	El. 136.73 ft to 143.67 ft, 4th quadrant	2.12 (6.94)	7.08 (249.9)	48.89 (120.0)	1.03 (14.6)	0	0.102 (1.452)	0.211 (3.0)	107
5	El. 136.73 ft to 143.67 ft, below the PZR skirt	2.12 (6.94)	3.79 (133.7)	48.89 (120.0)	1.03 (14.6)	0	0.003 (0.040)	0.070 (1.0)	2400
6	El. 143.67 ft to 151.0 ft, 2nd quadrant	2.23 (7.33)	12.41 (438.4)	48.89 (120.0)	1.03 (14.6)	0	0.058 (0.820)	0.141 (2.0)	144
7	El. 143.67 ft to 151.0 ft, 1st quadrant	2.23 (7.33)	9.24 (326.3)	48.89 (120.0)	1.03 (14.6)	0	0.068 (0.968)	0.141 (2.0)	107

Table 6.2.1-27 (2 of 8)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
8	El. 143.67 ft to 151.0 ft, 3rd quadrant	2.23 (7.33)	10.21 (360.5)	48.89 (120.0)	1.03 (14.6)	0	0.065 (0.928)	0.141 (2.0)	116
9	El. 143.67 ft to 151.0 ft, 4th quadrant	2.23 (7.33)	7.47 (264.0)	48.89 (120.0)	1.03 (14.6)	0	0.074 (1.047)	0.141 (2.0)	91
10	El. 151.0 ft to 166.67 ft, 2nd quadrant	4.78 (15.67)	26.54 (937.2)	48.89 (120.0)	1.03 (14.6)	0	0.072 (1.025)	0.141 (2.0)	95
11	El. 151.0 ft to 166.67 ft, 1st quadrant	4.78 (15.67)	19.75 (697.5)	48.89 (120.0)	1.03 (14.6)	0	0.089 (1.263)	0.141 (2.0)	58
12	El. 151.0 ft to 166.67 ft, 3rd quadrant	4.78 (15.67)	21.82 (770.7)	48.89 (120.0)	1.03 (14.6)	0	0.074 (1.058)	0.141 (2.0)	89
13	El. 151.0 ft to 166.67 ft, 4th quadrant	4.78 (15.67)	15.98 (564.3)	48.89 (120.0)	1.03 (14.6)	0	0.115 (1.637)	0.211 (3.0)	83
14	El. 166.67 ft to 178.69 ft, 2nd quadrant	3.66 (12.02)	18.62 (657.5)	48.89 (120.0)	1.03 (14.6)	0	0.122 (1.729)	0.211 (3.0)	74
15	El. 166.67 ft to 178.69 ft, 1st quadrant	3.66 (12.02)	14.01 (494.6)	48.89 (120.0)	1.03 (14.6)	0	0.087 (1.233)	0.211 (3.0)	143
16	El. 166.67 ft to 178.69 ft, 3rd quadrant	3.66 (12.02)	15.60 (550.9)	48.89 (120.0)	1.03 (14.6)	0	0.100 (1.417)	0.141 (2.0)	41
17	El. 166.67 ft to 178.69 ft, 4th quadrant	3.66 (12.02)	10.64 (375.6)	48.89 (120.0)	1.03 (14.6)	0	0.132 (1.884)	0.211 (3.0)	59

Table 6.2.1-27 (3 of 8)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
18	El. 178.69 ft to 188.5 ft, 2nd quadrant	2.99 (9.81)	14.13 (499.0)	48.89 (120.0)	1.03 (14.6)	0	0.258 (3.671)	0.422 (6.0)	63
19	El. 178.69 ft to 188.5 ft, 1st quadrant	2.99 (9.81)	10.48 (369.9)	48.89 (120.0)	1.03 (14.6)	0	0.235 (3.344)	0.352 (5.0)	50
20	El. 178.69 ft to 188.5 ft, 3rd quadrant	2.99 (9.81)	11.78 (415.9)	48.89 (120.0)	1.03 (14.6)	0	0.182 (2.584)	0.352 (5.0)	93
21	El. 178.69 ft to 188.5 ft, 4th quadrant	2.99 (9.81)	7.64 (269.8)	48.89 (120.0)	1.03 (14.6)	0	0.333 (4.738)	0.492 (7.0)	48
22	El. 188.5 ft to 195.0 ft, 2nd quadrant	1.98 (6.50)	12.19 (430.4)	48.89 (120.0)	1.03 (14.6)	0	0.192 (2.731)	0.281 (4.0)	46
23	El. 188.5 ft to 195.0 ft, 1st quadrant	1.98 (6.50)	9.70 (342.7)	48.89 (120.0)	1.03 (14.6)	0	0.217 (3.080)	0.352 (5.0)	62
24	El. 188.5 ft to 195.0 ft, 3rd quadrant	1.98 (6.50)	10.46 (369.5)	48.89 (120.0)	1.03 (14.6)	0	0.163 (2.315)	0.633 (9.0)	289
25	El. 188.5 ft to 195.0 ft, 4th quadrant	1.98 (6.50)	8.32 (293.9)	48.89 (120.0)	1.03 (14.6)	0	0.582 (8.284)	0.844 (12.0)	45
26	El. 195.0 ft to 200.0 ft, 2nd quadrant	1.52 (5.00)	10.83 (382.5)	48.89 (120.0)	1.03 (14.6)	0	0.083 (1.179)	0.211 (3.0)	154
27	El. 195.0 ft to 200.0 ft, 1st quadrant	1.52 (5.00)	8.66 (306.0)	48.89 (120.0)	1.03 (14.6)	0	0.118 (1.675)	0.211 (3.0)	79

Table 6.2.1-27 (4 of 8)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
28	El. 195.0 ft to 200.0 ft, 3rd quadrant	1.52 (5.00)	9.33 (329.4)	48.89 (120.0)	1.03 (14.6)	0	0.094 (1.332)	0.281 (4.0)	200
29	El. 195.0 ft to 200.0 ft, 4th quadrant	1.52 (5.00)	7.46 (263.5)	48.89 (120.0)	1.03 (14.6)	0	0.268 (3.807)	0.422 (6.0)	58
30	Containment	-	7.50E+4 (2.65E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-27 (5 of 8)

Pressurizer Subcompartment Nodal Description

B. Pressurizer Spray Nozzle Break Case

Break Location Node No.: 24

Break Line: Pressurizer Spray Line

Break Area: 0.00599 m^2 (0.0645 ft^2)

Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
1	El. 136.73 ft to 143.67 ft, 2nd quadrant	2.12 (6.94)	11.75 (415.1)	48.89 (120.0)	1.03 (14.6)	0	0.049 (0.692)	0.141 (2.0)	189
2	El. 136.73 ft to 143.67 ft, 1st quadrant	2.12 (6.94)	8.75 (308.9)	48.89 (120.0)	1.03 (14.6)	0	0.053 (0.760)	0.141 (2.0)	163
3	El. 136.73 ft to 143.67 ft, 3rd quadrant	2.12 (6.94)	9.67 (341.3)	48.89 (120.0)	1.03 (14.6)	0	0.050 (0.710)	0.141 (2.0)	182
4	El. 136.73 ft to 143.67 ft, 4th quadrant	2.12 (6.94)	7.08 (249.9)	48.89 (120.0)	1.03 (14.6)	0	0.049 (0.693)	0.211 (3.0)	333
5	El. 136.73 ft to 143.67 ft, below the PZR skirt	2.12 (6.94)	9.11 (321.8)	48.89 (120.0)	1.03 (14.6)	0	0.002 (0.027)	0.070 (1.0)	3604
6	El. 143.67 ft to 151.0 ft, 2nd quadrant	2.23 (7.33)	12.41 (438.4)	48.89 (120.0)	1.03 (14.6)	0	0.035 (0.504)	0.141 (2.0)	297
7	El. 143.67 ft to 151.0 ft, 1st quadrant	2.23 (7.33)	9.24 (326.3)	48.89 (120.0)	1.03 (14.6)	0	0.031 (0.444)	0.141 (2.0)	350

Table 6.2.1-27 (6 of 8)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
8	El. 143.67 ft to 151.0 ft, 3rd quadrant	2.23 (7.33)	10.21 (360.5)	48.89 (120.0)	1.03 (14.6)	0	0.038 (0.543)	0.141 (2.0)	268
9	El. 143.67 ft to 151.0 ft, 4th quadrant	2.23 (7.33)	7.47 (264.0)	48.89 (120.0)	1.03 (14.6)	0	0.035 (0.494)	0.141 (2.0)	305
10	El. 151.0 ft to 166.67 ft, 2nd quadrant	4.78 (15.67)	26.54 (937.2)	48.89 (120.0)	1.03 (14.6)	0	0.038 (0.536)	0.141 (2.0)	273
11	El. 151.0 ft to 166.67 ft, 1st quadrant	4.78 (15.67)	19.75 (697.5)	48.89 (120.0)	1.03 (14.6)	0	0.037 (0.524)	0.141 (2.0)	282
12	El. 151.0 ft to 166.67 ft, 3rd quadrant	4.78 (15.67)	21.82 (770.7)	48.89 (120.0)	1.03 (14.6)	0	0.050 (0.706)	0.141 (2.0)	183
13	El. 151.0 ft to 166.67 ft, 4th quadrant	4.78 (15.67)	15.98 (564.3)	48.89 (120.0)	1.03 (14.6)	0	0.032 (0.457)	0.211 (3.0)	556
14	El. 166.67 ft to 178.69 ft, 2nd quadrant	3.66 (12.02)	18.62 (657.5)	48.89 (120.0)	1.03 (14.6)	0	0.041 (0.590)	0.211 (3.0)	408
15	El. 166.67 ft to 178.69 ft, 1st quadrant	3.66 (12.02)	14.01 (494.6)	48.89 (120.0)	1.03 (14.6)	0	0.062 (0.888)	0.211 (3.0)	238
16	El. 166.67 ft to 178.69 ft, 3rd quadrant	3.66 (12.02)	15.60 (550.9)	48.89 (120.0)	1.03 (14.6)	0	0.048 (0.676)	0.141 (2.0)	196
17	El. 166.67 ft to 178.69 ft, 4th quadrant	3.66 (12.02)	10.64 (375.6)	48.89 (120.0)	1.03 (14.6)	0	0.042 (0.596)	0.211 (3.0)	403

Table 6.2.1-27 (7 of 8)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
18	El. 178.69 ft to 188.5 ft, 2nd quadrant	2.99 (9.81)	14.13 (499.0)	48.89 (120.0)	1.03 (14.6)	0	0.104 (1.486)	0.422 (6.0)	304
19	El. 178.69 ft to 188.5 ft, 1st quadrant	2.99 (9.81)	10.48 (369.9)	48.89 (120.0)	1.03 (14.6)	0	0.137 (1.955)	0.352 (5.0)	156
20	El. 178.69 ft to 188.5 ft, 3rd quadrant	2.99 (9.81)	11.78 (415.9)	48.89 (120.0)	1.03 (14.6)	0	0.142 (2.021)	0.352 (5.0)	147
21	El. 178.69 ft to 188.5 ft, 4th quadrant	2.99 (9.81)	7.64 (269.8)	48.89 (120.0)	1.03 (14.6)	0	0.106 (1.508)	0.492 (7.0)	364
22	El. 188.5 ft to 195.0 ft, 2nd quadrant	1.98 (6.50)	12.19 (430.4)	48.89 (120.0)	1.03 (14.6)	0	0.152 (2.159)	0.281 (4.0)	85
23	El. 188.5 ft to 195.0 ft, 1st quadrant	1.98 (6.50)	9.70 (342.7)	48.89 (120.0)	1.03 (14.6)	0	0.165 (2.349)	0.352 (5.0)	113
24	El. 188.5 ft to 195.0 ft, 3rd quadrant	1.98 (6.50)	10.46 (369.5)	48.89 (120.0)	1.03 (14.6)	0	0.316 (4.494)	0.633 (9.0)	100
25	El. 188.5 ft to 195.0 ft, 4th quadrant	1.98 (6.50)	8.32 (293.9)	48.89 (120.0)	1.03 (14.6)	0	0.124 (1.765)	0.844 (12.0)	580
26	El. 195.0 ft to 200.0 ft, 2nd quadrant	1.52 (5.00)	10.83 (382.5)	48.89 (120.0)	1.03 (14.6)	0	0.094 (1.340)	0.211 (3.0)	124
27	El. 195.0 ft to 200.0 ft, 1st quadrant	1.52 (5.00)	8.66 (306.0)	48.89 (120.0)	1.03 (14.6)	0	0.084 (1.201)	0.211 (3.0)	150

Table 6.2.1-27 (8 of 8)

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2D (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
28	El. 195.0 ft to 200.0 ft, 3rd quadrant	1.52 (5.00)	9.33 (329.4)	48.89 (120.0)	1.03 (14.6)	0	0.151 (2.143)	0.281 (4.0)	87
29	El. 195.0 ft to 200.0 ft, 4th quadrant	1.52 (5.00)	7.46 (263.5)	48.89 (120.0)	1.03 (14.6)	0	0.083 (1.182)	0.422 (6.0)	408
30	Containment	-	7.50E+4 (2.65E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-28

Pressurizer Spray Valve Subcompartment Nodal Description

Break Location Node No.: 1
Break Line: Pressurizer Spray Line
Break Area: 0.003489 m^2 (0.03755 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2D (psid)	Design Peak Press. Diff. kg/cm^2 (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2A (psia)	Relative Humid. %			
1	Pressurizer Spray Valve Room (El. 115 ft to El. 123 ft)	2.44 (8.00)	33.24 (1173.8)	48.89 (120.0)	1.03 (14.6)	0	0.730 (10.388)	1.055 (15.0)	44
2	Entrance Labyrinth (El. 115 ft to El. 123 ft)	2.44 (8.00)	8.82 (311.4)	48.89 (120.0)	1.03 (14.6)	0	0.400 (5.694)	0.562 (8.0)	40
3	Containment	-	8.85E+4 (3.13E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-29

Regenerative Heat Exchanger Subcompartment Nodal Description

Break Location Node No.: 1
Break Line: CVCS Letdown Line
Break Area: 0.001446 m^2 (0.01556 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2 (psid)	Design Peak Press. Diff. kg/cm^2 (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2 (psia)	Relative Humid. %			
1	Regenerative Heat Exchanger Room (El. 128 ft to El. 152 ft)	7.32 (24.00)	136.24 (4811.3)	48.89 (120.0)	1.03 (14.6)	0	0.138 (1.964)	0.211 (3.0)	53
2	Corridor below Regenerative Heat Exchanger Room (El. 100 ft to El. 126 ft)	7.92 (26.00)	168.82 (5961.8)	48.89 (120.0)	1.03 (14.6)	0	0.040 (0.571)	0.070 (1.0)	75
3	Containment	-	8.83E+4 (3.12E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-30 (1 of 2)

Letdown Heat Exchanger and Valve Subcompartments Nodal Description

A. Letdown Heat Exchanger Room – CVCS Letdown Line Break Case

Break Location Node No.: 1
Break Line: CVCS Letdown Line
Break Area: 0.001446 m^2 (0.01556 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2 (psid)	Design Peak Press. Diff. kg/cm^2 (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2 (psia)	Relative Humid. %			
1	Letdown Heat Exchanger Room (El. 100 ft to El. 113 ft)	3.96 (13.00)	164.38 (5804.9)	48.89 (120.0)	1.03 (14.6)	0	0.070 (0.999)	0.141 (2.0)	100
2	Entrance Labyrinth (El. 100 ft to El. 113 ft)	3.96 (13.00)	7.77 (274.3)	48.89 (120.0)	1.03 (14.6)	0	0.036 (0.509)	0.070 (1.0)	96
3	Containment	-	8.84E+4 (3.12E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-30 (2 of 2)

B. Letdown Heat Exchanger Valve Room – CVCS Letdown Line Break Case

Break Location Node No.: 1
Break Line: CVCS Letdown Line
Break Area: 0.001446 m^2 (0.01556 ft^2)
Break Type: Double Ended Guillotine Break

Node No.	Description	Height, m (ft)	Net Free Volume, m^3 (ft^3)	Initial Conditions			Calc. Peak Press. Diff. kg/cm^2 (psid)	Design Peak Press. Diff. kg/cm^2 (psid)	Design Margin, %
				Temp. °C (°F)	Press. kg/cm^2 (psia)	Relative Humid. %			
1	Letdown Heat Exchanger Valve Room (El. 115 ft to El. 123 ft)	2.44 (8.00)	45.74 (1615.4)	48.89 (120.0)	1.03 (14.6)	0	0.154 (2.186)	0.281 (4.0)	83
2	Entrance Labyrinth (El. 115 ft to El. 123 ft)	2.44 (8.00)	8.84 (312.1)	48.89 (120.0)	1.03 (14.6)	0	0.099 (1.401)	0.141 (2.0)	43
3	Containment	-	8.85E+4 (3.13E+6)	48.89 (120.0)	1.03 (14.6)	0	-	-	-

Table 6.2.1-31 (1 of 18)

Steam Generator Compartment Vent Path Description

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
1	1	2	-	×	6.33 (68.1)	7.58 (24.9)	2.45 (8.0)	0.020	0.000	0.500	1.000	1.520
	2	1	-	×				0.020	0.000	0.500	1.000	1.520
2	1	3	-	×	14.11 (151.8)	8.08 (26.5)	2.61 (8.6)	0.024	0.000	0.500	1.000	1.524
	3	1	-	×				0.024	0.000	0.500	1.000	1.524
3	1	5	-	×	8.01 (86.2)	4.51 (14.8)	1.73 (5.7)	0.019	0.000	0.500	1.000	1.519
	5	1	-	×				0.019	0.000	0.500	1.000	1.519
4	1	7	-	×	18.36 (197.7)	3.30 (10.8)	4.84 (15.9)	0.092	0.729	0.500	1.000	2.321
	7	1	-	×				0.092	0.729	0.500	1.000	2.321
5	2	4	-	×	12.98 (139.7)	7.65 (25.1)	2.47 (8.1)	0.023	0.000	0.500	1.000	1.523
	4	2	-	×				0.023	0.000	0.500	1.000	1.523
6	2	6	-	×	8.01 (86.2)	4.44 (14.6)	1.73 (5.7)	0.019	0.000	0.500	1.000	1.519
	6	2	-	×				0.019	0.000	0.500	1.000	1.519
7	2	8	-	×	17.35 (186.8)	3.30 (10.8)	4.70 (15.4)	0.092	0.729	0.500	1.000	2.321
	8	2	-	×				0.092	0.729	0.500	1.000	2.321
8	3	5	-	×	7.16 (77.1)	6.69 (22.0)	1.58 (5.2)	0.012	0.000	0.500	1.000	1.512
	5	3	-	×				0.012	0.000	0.500	1.000	1.512

Table 6.2.1-31 (2 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
9	3	9	-	×	19.57 (210.6)	3.30 (10.8)	4.99 (16.4)	0.091	0.729	0.500	1.000	2.320
	9	3	-	×				0.091	0.729	0.500	1.000	2.320
10	3	57	-	×	1.90 (20.4)	6.26 (20.5)	1.29 (4.2)	0.038	1.354	0.500	0.000	1.892
	57	3	-	×				0.038	0.412	0.000	1.000	1.450
11	3	60	-	×	6.18 (66.6)	15.62 (51.2)	2.41 (7.9)	0.144	0.000	0.500	1.000	1.644
	60	3	-	×				0.144	0.000	0.500	1.000	1.644
12	4	6	-	×	7.16 (77.1)	6.39 (21.0)	1.58 (5.2)	0.011	0.000	0.500	1.000	1.511
	6	4	-	×				0.011	0.000	0.500	1.000	1.511
13	4	10	-	×	16.67 (179.5)	3.30 (10.8)	4.61 (15.1)	0.091	0.729	0.500	1.000	2.320
	10	4	-	×				0.091	0.729	0.500	1.000	2.320
14	4	60	-	×	2.05 (22.1)	15.62 (51.2)	1.39 (4.6)	0.236	0.000	0.500	1.000	1.736
	60	4	-	×				0.236	0.000	0.500	1.000	1.736
15	5	6	-	×	5.71 (61.4)	5.29 (17.4)	2.28 (7.5)	0.023	0.000	0.500	1.000	1.523
	6	5	-	×				0.023	0.000	0.500	1.000	1.523
16	5	11	-	×	6.28 (67.6)	3.30 (10.8)	2.83 (9.3)	0.090	0.729	0.500	1.000	2.319
	11	5	-	×				0.090	0.729	0.500	1.000	2.319

Table 6.2.1-31 (3 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
17	6	12	-	×	6.51 (70.0)	3.30 (10.8)	2.88 (9.4)	0.090	0.729	0.500	1.000	2.319
	12	6	-	×				0.090	0.729	0.500	1.000	2.319
18	7	8	-	×	7.66 (82.5)	7.58 (24.9)	3.29 (10.8)	0.030	0.000	0.500	1.000	1.530
	8	7	-	×				0.030	0.000	0.500	1.000	1.530
19	7	9	-	×	9.13 (98.3)	8.08 (26.5)	3.59 (11.8)	0.048	0.000	0.500	1.000	1.548
	9	7	-	×				0.048	0.000	0.500	1.000	1.548
20	7	11	-	×	6.21 (66.9)	4.51 (14.8)	2.96 (9.7)	0.018	0.000	0.500	1.000	1.518
	11	7	-	×				0.018	0.000	0.500	1.000	1.518
21	7	13	-	×	17.97 (193.4)	2.50 (8.2)	4.78 (15.7)	0.090	0.729	0.500	1.000	2.320
	13	7	-	×				0.090	0.729	0.500	1.000	2.320
22	8	10	-	×	8.38 (90.2)	7.65 (25.1)	3.44 (11.3)	0.044	0.000	0.500	1.000	1.544
	10	8	-	×				0.044	0.000	0.500	1.000	1.544
23	8	12	-	×	6.21 (66.9)	4.44 (14.6)	2.96 (9.7)	0.018	0.000	0.500	1.000	1.518
	12	8	-	×				0.018	0.000	0.500	1.000	1.518
24	8	14	-	×	17.39 (187.2)	2.50 (8.2)	4.71 (15.4)	0.091	0.729	0.500	1.000	2.320
	14	8	-	×				0.091	0.729	0.500	1.000	2.320

Table 6.2.1-31 (4 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
25	9	11	-	×	2.59 (27.9)	6.69 (22.0)	1.91 (6.3)	0.023	0.000	0.500	1.000	1.523
	11	9	-	×				0.023	0.000	0.500	1.000	1.523
26	9	15	-	×	29.51 (317.7)	2.50 (8.2)	6.13 (20.1)	0.092	0.729	0.500	1.000	2.321
	15	9	-	×				0.092	0.729	0.500	1.000	2.321
27	10	12	-	×	2.59 (27.9)	6.39 (21.0)	1.91 (6.3)	0.022	0.000	0.500	1.000	1.522
	12	10	-	×				0.022	0.000	0.500	1.000	1.522
28	10	16	-	×	24.72 (266.1)	2.50 (8.2)	5.61 (18.4)	0.092	0.729	0.500	1.000	2.321
	16	10	-	×				0.092	0.729	0.500	1.000	2.321
29	10	58	-	×	1.90 (20.4)	5.77 (18.9)	1.29 (4.2)	0.064	1.354	0.500	0.000	1.917
	58	10	-	×				0.064	1.354	0.000	1.000	2.417
30	11	12	-	×	3.25 (34.9)	5.29 (17.4)	2.14 (7.0)	0.028	0.000	0.500	1.000	1.528
	12	11	-	×				0.028	0.000	0.500	1.000	1.528
31	11	17	-	×	10.49 (112.9)	2.50 (8.2)	3.65 (12.0)	0.096	0.729	0.500	1.000	2.326
	17	11	-	×				0.096	0.729	0.500	1.000	2.326
32	12	18	-	×	10.43 (112.3)	2.50 (8.2)	3.64 (12.0)	0.096	0.729	0.500	1.000	2.325
	18	12	-	×				0.096	0.729	0.500	1.000	2.325

Table 6.2.1-31 (5 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
33	13	14	-	×	4.70 (50.5)	7.58 (24.9)	2.58 (8.5)	0.024	0.000	0.500	1.000	1.524
	14	13	-	×				0.024	0.000	0.500	1.000	1.524
34	13	15	-	×	8.05 (86.6)	8.08 (26.5)	3.37 (11.1)	0.038	0.000	0.500	1.000	1.538
	15	13	-	×				0.038	0.000	0.500	1.000	1.538
35	13	17	-	×	3.30 (35.6)	4.51 (14.8)	2.16 (7.1)	0.018	0.000	0.500	1.000	1.518
	17	13	-	×				0.018	0.000	0.500	1.000	1.518
36	13	19	-	×	22.30 (240.1)	2.03 (6.7)	5.62 (18.4)	0.010	0.000	0.500	1.000	1.510
	19	13	-	×				0.010	0.000	0.500	1.000	1.510
37	14	16	-	×	7.37 (79.4)	7.65 (25.1)	3.23 (10.6)	0.035	0.000	0.500	1.000	1.535
	16	14	-	×				0.035	0.000	0.500	1.000	1.535
38	14	18	-	×	3.30 (35.6)	4.44 (14.6)	2.16 (7.1)	0.018	0.000	0.500	1.000	1.518
	18	14	-	×				0.018	0.000	0.500	1.000	1.518
39	14	20	-	×	21.47 (231.1)	2.03 (6.7)	5.51 (18.1)	0.011	0.000	0.500	1.000	1.511
	20	14	-	×				0.011	0.000	0.500	1.000	1.511
40	15	17	-	×	3.92 (42.1)	6.69 (22.0)	2.35 (7.7)	0.025	0.000	0.500	1.000	1.525
	17	15	-	×				0.025	0.000	0.500	1.000	1.525

Table 6.2.1-31 (6 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
41	15	21	-	×	10.34 (111.3)	2.03 (6.7)	3.82 (12.5)	0.018	0.000	0.500	0.000	0.518
	21	15	-	×				0.018	0.000	0.000	1.000	1.018
42	16	18	-	×	3.92 (42.1)	6.39 (21.0)	2.35 (7.7)	0.025	0.000	0.500	1.000	1.525
	18	16	-	×				0.025	0.000	0.500	1.000	1.525
43	16	22	-	×	17.95 (193.2)	2.03 (6.7)	5.04 (16.5)	0.002	0.000	0.500	0.000	0.502
	22	16	-	×				0.002	0.000	0.000	1.000	1.002
44	17	18	-	×	3.14 (33.8)	5.29 (17.4)	2.11 (6.9)	0.030	0.000	0.500	1.000	1.530
	18	17	-	×				0.030	0.000	0.500	1.000	1.530
45	17	23	-	×	11.26 (121.2)	2.03 (6.7)	3.99 (13.1)	0.014	0.000	0.500	0.000	0.514
	23	17	-	×				0.014	0.000	0.000	1.000	1.014
46	18	24	-	×	11.26 (121.2)	2.03 (6.7)	3.99 (13.1)	0.014	0.000	0.500	0.000	0.514
	24	18	-	×				0.014	0.000	0.000	1.000	1.014
47	19	20	-	×	3.39 (36.4)	7.58 (24.9)	2.19 (7.2)	0.028	0.000	0.500	1.000	1.528
	20	19	-	×				0.028	0.000	0.500	1.000	1.528
48	19	21	-	×	2.52 (27.2)	5.06 (16.6)	1.89 (6.2)	0.026	0.000	0.500	1.000	1.526
	21	19	-	×				0.026	0.000	0.500	1.000	1.526

Table 6.2.1-31 (7 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
49	19	23	-	×	1.49 (16.0)	4.51 (14.8)	1.45 (4.8)	0.022	0.000	0.500	1.000	1.522
	23	19	-	×				0.022	0.000	0.500	1.000	1.522
50	19	25	-	×	16.79 (180.7)	2.45 (8.1)	4.62 (15.2)	0.092	0.729	0.500	1.000	2.321
	25	19	-	×				0.092	0.729	0.500	1.000	2.321
51	20	22	-	×	2.51 (27.0)	5.06 (16.6)	1.88 (6.2)	0.026	0.000	0.500	1.000	1.526
	22	20	-	×				0.026	0.000	0.500	1.000	1.526
52	20	24	-	×	1.49 (16.0)	4.44 (14.6)	1.45 (4.8)	0.022	0.000	0.500	1.000	1.522
	24	20	-	×				0.022	0.000	0.500	1.000	1.522
53	20	26	-	×	16.24 (174.8)	2.45 (8.1)	4.55 (14.9)	0.093	0.729	0.500	1.000	2.322
	26	20	-	×				0.093	0.729	0.500	1.000	2.322
54	21	23	-	×	1.95 (21.0)	3.90 (12.8)	1.66 (5.4)	0.024	0.000	0.500	1.000	1.524
	23	21	-	×				0.024	0.000	0.500	1.000	1.524
55	21	27	-	×	7.53 (81.0)	2.45 (8.1)	3.26 (10.7)	0.018	0.000	0.500	1.000	1.518
	27	21	-	×				0.018	0.000	0.500	1.000	1.518
56	22	24	-	×	1.95 (21.0)	3.90 (12.8)	1.66 (5.4)	0.024	0.000	0.500	1.000	1.524
	24	22	-	×				0.024	0.000	0.500	1.000	1.524

Table 6.2.1-31 (8 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
57	22	28	-	×	15.25 (164.2)	2.45 (8.1)	4.65 (15.2)	0.008	0.000	0.500	1.000	1.508
	28	22	-	×				0.008	0.000	0.500	1.000	1.508
58	23	24	-	×	2.26 (24.4)	5.29 (17.4)	1.79 (5.9)	0.035	0.000	0.500	1.000	1.535
	24	23	-	×				0.035	0.000	0.500	1.000	1.535
59	23	29	-	×	7.17 (77.2)	2.45 (8.1)	3.02 (9.9)	0.098	0.729	0.500	1.000	2.327
	29	23	-	×				0.098	0.729	0.500	1.000	2.327
60	24	30	-	×	7.09 (76.3)	2.45 (8.1)	3.00 (9.9)	0.098	0.729	0.500	1.000	2.327
	30	24	-	×				0.098	0.729	0.500	1.000	2.327
61	25	26	-	×	6.35 (68.3)	7.58 (24.9)	3.00 (9.8)	0.021	0.000	0.500	1.000	1.521
	26	25	-	×				0.021	0.000	0.500	1.000	1.521
62	25	27	-	×	9.47 (101.9)	4.73 (15.5)	3.66 (12.0)	0.021	0.000	0.500	1.000	1.521
	27	25	-	×				0.021	0.000	0.500	1.000	1.521
63	25	29	-	×	3.00 (32.3)	4.51 (14.8)	2.06 (6.8)	0.016	0.000	0.500	1.000	1.516
	29	25	-	×				0.016	0.000	0.500	1.000	1.516
64	25	31	-	×	19.78 (212.9)	3.12 (10.3)	5.02 (16.5)	0.095	0.729	0.500	1.000	2.324
	31	25	-	×				0.095	0.729	0.500	1.000	2.324

Table 6.2.1-31 (9 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
65	26	28	-	×	8.56 (92.1)	7.65 (25.1)	3.48 (11.4)	0.028	0.000	0.500	1.000	1.528
	28	26	-	×				0.028	0.000	0.500	1.000	1.528
66	26	30	-	×	3.00 (32.3)	4.44 (14.6)	2.06 (6.8)	0.016	0.000	0.500	1.000	1.516
	30	26	-	×				0.016	0.000	0.500	1.000	1.516
67	26	32	-	×	18.64 (200.7)	3.12 (10.3)	4.87 (16.0)	0.095	0.729	0.500	1.000	2.324
	32	26	-	×				0.095	0.729	0.500	1.000	2.324
68	27	29	-	×	3.86 (41.5)	4.04 (13.3)	2.34 (7.7)	0.018	0.000	0.500	1.000	1.518
	29	27	-	×				0.018	0.000	0.500	1.000	1.518
69	27	33	-	×	11.14 (119.9)	3.12 (10.3)	3.97 (13.0)	0.023	0.000	0.500	1.000	1.523
	33	27	-	×				0.023	0.000	0.500	1.000	1.523
70	28	30	-	×	3.86 (41.5)	6.39 (21.0)	2.34 (7.7)	0.019	0.000	0.500	1.000	1.519
	30	28	-	×				0.019	0.000	0.500	1.000	1.519
71	28	34	-	×	30.48 (328.1)	3.12 (10.3)	6.57 (21.5)	0.014	0.000	0.500	1.000	1.514
	34	28	-	×				0.014	0.000	0.500	1.000	1.514
72	28	59	-	×	2.30 (24.7)	5.91 (19.4)	1.36 (4.5)	0.064	1.354	0.500	0.000	1.918
	59	28	-	×				0.064	1.495	0.000	1.000	2.559

Table 6.2.1-31 (10 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
73	29	30	-	×	4.24 (45.7)	5.29 (17.4)	2.45 (8.0)	0.025	0.000	0.500	1.000	1.525
	30	29	-	×				0.025	0.000	0.500	1.000	1.525
74	29	35	-	×	9.06 (97.5)	3.12 (10.3)	3.40 (11.1)	0.100	0.729	0.500	1.000	2.330
	35	29	-	×				0.100	0.729	0.500	1.000	2.330
75	30	36	-	×	9.06 (97.6)	3.12 (10.3)	3.40 (11.1)	0.101	0.729	0.500	1.000	2.330
	36	30	-	×				0.101	0.729	0.500	1.000	2.330
76	31	32	-	×	5.73 (61.7)	7.58 (24.9)	2.85 (9.3)	0.020	0.000	0.500	1.000	1.520
	32	31	-	×				0.020	0.000	0.500	1.000	1.520
77	31	33	-	×	13.32 (143.3)	4.73 (15.5)	4.34 (14.2)	0.026	0.000	0.500	1.000	1.526
	33	31	-	×				0.026	0.000	0.500	1.000	1.526
78	31	35	-	×	6.84 (73.7)	4.51 (14.8)	3.11 (10.2)	0.017	0.000	0.500	1.000	1.517
	35	31	-	×				0.017	0.000	0.500	1.000	1.517
79	31	37	-	×	20.07 (216.0)	3.58 (11.8)	5.05 (16.6)	0.097	0.729	0.500	1.000	2.326
	37	31	-	×				0.097	0.729	0.500	1.000	2.326
80	32	34	-	×	12.45 (134.0)	7.65 (25.1)	4.20 (13.8)	0.038	0.000	0.500	1.000	1.538
	34	32	-	×				0.038	0.000	0.500	1.000	1.538

Table 6.2.1-31 (11 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
81	32	36	-	×	6.84 (73.7)	4.44 (14.6)	3.11 (10.2)	0.017	0.000	0.500	1.000	1.517
	36	32	-	×				0.017	0.000	0.500	1.000	1.517
82	32	38	-	×	19.19 (206.6)	3.58 (11.8)	4.94 (16.2)	0.098	0.729	0.500	1.000	2.327
	38	32	-	×				0.098	0.729	0.500	1.000	2.327
83	33	35	-	×	6.91 (74.4)	4.04 (13.3)	3.13 (10.3)	0.024	0.000	0.500	1.000	1.524
	35	33	-	×				0.024	0.000	0.500	1.000	1.524
84	33	39	-	×	9.54 (102.7)	3.58 (11.8)	3.67 (12.1)	0.018	0.000	0.500	1.000	1.518
	39	33	-	×				0.018	0.000	0.500	1.000	1.518
85	34	36	-	×	6.91 (74.4)	6.39 (21.0)	3.13 (10.3)	0.028	0.000	0.500	1.000	1.528
	36	34	-	×				0.028	0.000	0.500	1.000	1.528
86	34	40	-	×	12.06 (129.8)	3.58 (11.8)	4.13 (13.6)	0.015	0.000	0.500	1.000	1.515
	40	34	-	×				0.015	0.000	0.500	1.000	1.515
87	35	36	-	×	2.66 (28.7)	5.29 (17.4)	1.94 (6.4)	0.018	0.000	0.500	1.000	1.518
	36	35	-	×				0.018	0.000	0.500	1.000	1.518
88	35	41	-	×	5.55 (59.7)	3.58 (11.8)	2.80 (9.2)	0.017	0.000	0.500	1.000	1.517
	41	35	-	×				0.017	0.000	0.500	1.000	1.517

Table 6.2.1-31 (12 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
89	36	42	-	×	5.81 (62.5)	3.58 (11.8)	2.87 (9.4)	0.018	0.000	0.500	1.000	1.518
	42	36	-	×				0.018	0.000	0.500	1.000	1.518
90	37	38	-	×	5.33 (57.4)	7.58 (24.9)	4.20 (13.8)	0.015	0.000	0.500	1.000	1.515
	38	37	-	×				0.015	0.000	0.500	1.000	1.515
91	37	39	-	×	18.22 (196.1)	4.73 (15.5)	5.08 (16.7)	0.023	0.000	0.500	1.000	1.523
	39	37	-	×				0.023	0.000	0.500	1.000	1.523
92	37	41	-	×	8.17 (88.0)	4.08 (13.4)	3.40 (11.2)	0.013	0.000	0.500	1.000	1.513
	41	37	-	×				0.013	0.000	0.500	1.000	1.513
93	37	43	-	×	17.07 (183.8)	3.43 (11.3)	4.91 (16.1)	0.012	0.000	0.500	1.000	1.512
	43	37	-	×				0.012	0.000	0.500	1.000	1.512
94	38	40	-	×	17.04 (183.5)	5.00 (16.4)	4.91 (16.1)	0.023	0.000	0.500	1.000	1.523
	40	38	-	×				0.023	0.000	0.500	1.000	1.523
95	38	42	-	×	8.17 (88.0)	4.01 (13.2)	3.40 (11.2)	0.013	0.000	0.500	1.000	1.513
	42	38	-	×				0.013	0.000	0.500	1.000	1.513
96	38	44	-	×	16.09 (173.2)	3.43 (11.3)	4.77 (15.7)	0.012	0.000	0.500	1.000	1.512
	44	38	-	×				0.012	0.000	0.500	1.000	1.512

Table 6.2.1-31 (13 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
97	39	41	-	×	8.02 (86.3)	4.04 (13.3)	3.37 (11.1)	0.022	0.000	0.500	1.000	1.522
	41	39	-	×				0.022	0.000	0.500	1.000	1.522
98	39	45	-	×	10.99 (118.3)	3.43 (11.3)	3.94 (12.9)	0.023	0.000	0.000	1.000	1.023
	45	39	-	×				0.023	0.000	0.500	0.000	0.523
99	40	42	-	×	8.02 (86.3)	4.27 (14.0)	3.37 (11.1)	0.023	0.000	0.500	1.000	1.523
	42	40	-	×				0.023	0.000	0.500	1.000	1.523
100	40	46	-	×	13.27 (142.8)	3.43 (11.3)	4.33 (14.2)	0.021	0.000	0.000	1.000	1.021
	46	40	-	×				0.021	0.000	0.500	0.000	0.521
101	41	42	-	×	0.74 (8.0)	5.29 (17.4)	1.02 (3.4)	0.031	0.000	0.500	1.000	1.531
	42	41	-	×				0.031	0.000	0.500	1.000	1.531
102	41	47	-	×	6.52 (70.2)	3.43 (11.3)	3.04 (10.0)	0.024	0.000	0.500	1.000	1.524
	47	41	-	×				0.024	0.000	0.500	1.000	1.524
103	42	48	-	×	6.52 (70.2)	3.43 (11.3)	3.04 (10.0)	0.024	0.000	0.500	1.000	1.524
	48	42	-	×				0.024	0.000	0.500	1.000	1.524
104	43	44	-	×	2.70 (29.0)	7.58 (24.9)	1.95 (6.4)	0.017	0.000	0.500	1.000	1.517
	44	43	-	×				0.017	0.000	0.500	1.000	1.517

Table 6.2.1-31 (14 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
105	43	45	-	×	12.15 (130.7)	4.73 (15.5)	4.15 (13.6)	0.028	0.000	0.500	1.000	1.528
	45	43	-	×				0.028	0.000	0.500	1.000	1.528
106	43	47	-	×	5.45 (58.7)	4.22 (13.8)	2.78 (9.1)	0.016	0.000	0.500	1.000	1.516
	47	43	-	×				0.016	0.000	0.500	1.000	1.516
107	43	49	-	×	18.85 (202.9)	2.73 (9.0)	5.16 (16.9)	0.009	0.000	0.500	1.000	1.509
	49	43	-	×				0.009	0.000	0.500	1.000	1.509
108	44	46	-	×	11.36 (122.3)	5.00 (16.4)	4.01 (13.2)	0.028	0.000	0.500	1.000	1.528
	46	44	-	×				0.028	0.000	0.500	1.000	1.528
109	44	48	-	×	5.45 (58.7)	4.15 (13.6)	2.78 (9.1)	0.016	0.000	0.500	1.000	1.516
	48	44	-	×				0.016	0.000	0.500	1.000	1.516
110	44	50	-	×	18.85 (202.9)	2.73 (9.0)	5.16 (16.9)	0.011	0.000	0.500	1.000	1.511
	50	44	-	×				0.011	0.000	0.500	1.000	1.511
111	45	47	-	×	5.91 (63.6)	4.04 (13.3)	2.89 (9.5)	0.026	0.000	0.500	1.000	1.526
	47	45	-	×				0.026	0.000	0.500	1.000	1.526
112	45	51	-	×	11.49 (123.7)	2.73 (9.0)	4.03 (13.2)	0.018	0.000	0.000	0.000	0.018
	51	45	-	×				0.018	0.000	0.000	0.000	0.018

Table 6.2.1-31 (15 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
113	46	48	-	×	5.91 (63.6)	4.27 (14.0)	2.89 (9.5)	0.027	0.000	0.500	1.000	1.527
	48	46	-	×				0.027	0.000	0.500	1.000	1.527
114	46	52	-	×	13.88 (149.4)	2.73 (9.0)	4.43 (14.5)	0.017	0.000	0.000	0.000	0.017
	52	46	-	×				0.017	0.000	0.000	0.000	0.017
115	47	48	-	×	1.06 (11.4)	5.29 (17.4)	1.22 (4.0)	0.030	0.000	0.500	1.000	1.530
	48	47	-	×				0.030	0.000	0.500	1.000	1.530
116	47	53	-	×	6.68 (71.9)	2.73 (9.0)	2.92 (9.6)	0.098	0.729	0.500	1.000	2.327
	53	47	-	×				0.098	0.729	0.500	1.000	2.327
117	48	54	-	×	6.68 (71.9)	2.73 (9.0)	2.92 (9.6)	0.098	0.729	0.500	1.000	2.327
	54	48	-	×				0.098	0.729	0.500	1.000	2.327
118	49	50	-	×	6.52 (70.1)	7.58 (24.9)	3.04 (10.0)	0.025	0.000	0.500	1.000	1.525
	50	49	-	×				0.025	0.000	0.500	1.000	1.525
119	49	51	-	×	12.04 (129.6)	4.73 (15.5)	4.13 (13.5)	0.028	0.000	0.500	1.000	1.528
	51	49	-	×				0.028	0.000	0.500	1.000	1.528
120	49	53	-	×	7.66 (82.5)	4.22 (13.8)	3.29 (10.8)	0.018	0.000	0.500	1.000	1.518
	53	49	-	×				0.018	0.000	0.500	1.000	1.518

Table 6.2.1-31 (16 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
121	49	55	-	×	24.73 (266.1)	1.98 (6.5)	6.71 (22.0)	0.005	0.000	0.500	1.000	1.505
	55	49	-	×				0.005	0.000	0.500	1.000	1.505
122	50	52	-	×	11.26 (121.2)	5.00 (16.4)	3.99 (13.1)	0.028	0.000	0.500	1.000	1.528
	52	50	-	×				0.028	0.000	0.500	1.000	1.528
123	50	54	-	×	7.66 (82.5)	4.15 (13.6)	3.29 (10.8)	0.017	0.000	0.500	1.000	1.517
	54	50	-	×				0.017	0.000	0.500	1.000	1.517
124	50	56	-	×	23.80 (256.1)	1.98 (6.5)	6.58 (21.6)	0.005	0.000	0.500	1.000	1.505
	56	50	-	×				0.005	0.000	0.500	1.000	1.505
125	51	53	-	×	5.85 (63.0)	4.04 (13.3)	2.88 (9.4)	0.027	0.000	0.500	1.000	1.527
	53	51	-	×				0.027	0.000	0.500	1.000	1.527
126	51	55	-	×	9.08 (97.8)	1.98 (6.5)	4.06 (13.3)	0.006	0.000	0.500	1.000	1.506
	55	51	-	×				0.006	0.000	0.500	1.000	1.506
127	52	54	-	×	5.85 (63.0)	4.27 (14.0)	2.88 (9.4)	0.027	0.000	0.500	1.000	1.527
	54	52	-	×				0.027	0.000	0.500	1.000	1.527
128	52	56	-	×	10.94 (117.7)	1.98 (6.5)	4.46 (14.6)	0.005	0.000	0.500	1.000	1.505
	56	52	-	×				0.005	0.000	0.500	1.000	1.505

Table 6.2.1-31 (17 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
129	53	54	-	×	3.31 (35.6)	5.29 (17.4)	2.16 (7.1)	0.031	0.000	0.500	1.000	1.531
	54	53	-	×				0.031	0.000	0.500	1.000	1.531
130	53	55	-	×	11.22 (120.8)	1.98 (6.5)	4.52 (14.8)	0.009	0.000	0.500	1.000	1.509
	55	53	-	×				0.009	0.000	0.500	1.000	1.509
131	54	56	-	×	11.22 (120.8)	1.98 (6.5)	4.52 (14.8)	0.009	0.000	0.500	1.000	1.509
	56	54	-	×				0.009	0.000	0.500	1.000	1.509
132	55	56	-	×	7.52 (80.9)	8.31 (27.3)	3.70 (12.1)	0.042	0.000	0.500	1.000	1.542
	56	55	-	×				0.042	0.000	0.500	1.000	1.542
133	55	60	-	×	45.03 (484.7)	0.62 (2.0)	9.05 (29.7)	0.001	0.000	0.500	1.000	1.501
	60	55	-	×				0.001	0.000	0.500	1.000	1.501
134	56	60	-	×	45.95 (494.7)	0.62 (2.0)	9.14 (30.0)	0.001	0.000	0.500	1.000	1.501
	60	56	-	×				0.001	0.000	0.500	1.000	1.501
135	57	60	-	×	2.36 (25.4)	1.30 (4.3)	2.15 (7.0)	0.009	0.000	0.500	1.000	1.509
	60	57	-	×				0.009	0.000	0.500	1.000	1.509
136	58	60	-	×	1.63 (17.6)	1.37 (4.5)	1.79 (5.9)	0.014	0.000	0.500	1.000	1.514
	60	58	-	×				0.014	0.000	0.500	1.000	1.514

Table 6.2.1-31 (18 of 18)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
137	59	60	-	×	1.43 (15.4)	1.41 (4.6)	1.67 (5.5)	0.009	0.000	0.500	1.000	1.509
	60	59	-	×				0.009	0.000	0.500	1.000	1.509
138	9	60	-	×	4.12 (44.4)	15.62 (51.2)	2.09 (6.9)	0.171	0.000	0.500	1.000	1.671
	60	9	-	×				0.171	0.000	0.500	1.000	1.671
139	15	60	-	×	3.68 (39.6)	15.62 (51.2)	2.00 (6.6)	0.175	0.000	0.500	1.000	1.675
	60	15	-	×				0.175	0.000	0.500	1.000	1.675
140	52	60	-	×	24.90 (268.0)	2.54 (8.3)	5.21 (17.1)	0.017	0.000	0.500	1.000	1.517
	60	52	-	×				0.017	0.000	0.500	1.000	1.517

Table 6.2.1-32 (1 of 9)

Pressurizer Subcompartment Vent Path Description

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
1	1	2	-	×	2.32 (25.0)	2.74 (9.0)	1.55 (5.1)	0.047	0.191	0.000	0.000	0.238
	2	1	-	×				0.182	0.490	0.000	0.000	0.672
2	1	3	-	×	2.90 (31.2)	2.55 (8.4)	1.77 (5.8)	0.131	0.444	0.000	0.000	0.575
	3	1	-	×				0.361	0.910	0.000	0.000	1.272
3	1	5	-	×	0.05 (0.5)	2.43 (8.0)	0.15 (0.5)	0.063	1.263	0.500	1.000	2.826
	5	1	-	×				0.063	1.263	0.500	1.000	2.826
4	1	6	-	×	5.88 (63.3)	2.17 (7.1)	2.39 (7.9)	0.026	0.000	0.000	0.000	0.026
	6	1	-	×				0.026	0.000	0.000	0.000	0.026
5	2	4	-	×	1.74 (18.7)	2.55 (8.4)	1.28 (4.2)	0.047	0.160	0.000	0.000	0.207
	4	2	-	×				0.130	0.328	0.000	0.000	0.458
6	2	5	-	×	0.05 (0.5)	2.12 (7.0)	0.15 (0.5)	0.060	1.263	0.500	1.000	2.823
	5	2	-	×				0.060	1.263	0.500	1.000	2.823
7	2	7	-	×	4.38 (47.1)	2.17 (7.1)	2.00 (6.6)	0.031	0.000	0.000	0.000	0.031
	7	2	-	×				0.031	0.000	0.000	0.000	0.031
8	3	4	-	×	1.60 (17.2)	2.74 (9.0)	1.20 (3.9)	0.022	0.090	0.000	0.000	0.112
	4	3	-	×				0.086	0.231	0.000	0.000	0.318

Table 6.2.1-32 (2 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
9	3	5	-	×	0.05 (0.5)	2.05 (6.7)	0.15 (0.5)	0.059	1.263	0.500	1.000	2.822
	5	3	-	×				0.059	1.263	0.500	1.000	2.822
10	3	30	-	×	1.26 (13.5)	4.88 (16.0)	1.28 (4.2)	0.024	0.634	0.500	1.000	2.158
	30	3	-	×				0.024	0.594	0.500	1.000	2.119
11	3	8	-	×	4.84 (52.1)	2.17 (7.1)	2.12 (6.9)	0.029	0.000	0.000	0.000	0.029
	8	3	-	×				0.029	0.000	0.000	0.000	0.029
12	4	5	-	×	0.05 (0.5)	2.05 (6.7)	0.15 (0.5)	0.059	1.263	0.500	1.000	2.822
	5	4	-	×				0.059	1.263	0.500	1.000	2.822
13	4	9	-	×	3.54 (38.1)	2.17 (7.1)	1.76 (5.8)	0.035	0.000	0.000	0.000	0.035
	9	4	-	×				0.035	0.000	0.000	0.000	0.035
14	5	30	-	×	4.50 (48.4)	0.30 (1.0)	2.32 (7.6)	0.005	0.000	0.500	1.000	1.505
	30	5	-	×				0.005	0.000	0.500	1.000	1.505
15	6	7	-	×	2.45 (26.4)	2.74 (9.0)	1.58 (5.2)	0.047	0.188	0.000	0.000	0.235
	7	6	-	×				0.182	0.490	0.000	0.000	0.672
16	6	8	-	×	3.06 (33.0)	2.55 (8.4)	1.81 (5.9)	0.131	0.439	0.000	0.000	0.570
	8	6	-	×				0.361	0.910	0.000	0.000	1.272

Table 6.2.1-32 (3 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
17	6	10	-	×	5.88 (63.3)	3.54 (11.6)	0.04 (0.1)	0.126	0.729	0.000	0.000	0.856
	10	6	-	×				0.126	0.729	0.000	0.000	0.856
18	7	9	-	×	1.84 (19.8)	2.55 (8.4)	1.30 (4.3)	0.047	0.158	0.000	0.000	0.205
	9	7	-	×				0.130	0.328	0.000	0.000	0.458
19	7	11	-	×	4.38 (47.1)	3.54 (11.6)	0.04 (0.1)	0.135	0.729	0.000	0.000	0.864
	11	7	-	×				0.135	0.729	0.000	0.000	0.864
20	8	9	-	×	1.69 (18.1)	2.74 (9.0)	1.22 (4.0)	0.022	0.089	0.000	0.000	0.111
	9	8	-	×				0.086	0.231	0.000	0.000	0.318
21	8	12	-	×	4.84 (52.1)	3.54 (11.6)	0.04 (0.1)	0.132	0.729	0.000	0.000	0.861
	12	8	-	×				0.132	0.729	0.000	0.000	0.861
22	9	13	-	×	3.54 (38.1)	3.54 (11.6)	0.04 (0.1)	0.141	0.729	0.000	0.000	0.871
	13	9	-	×				0.141	0.729	0.000	0.000	0.871
23	10	11	-	×	5.24 (56.4)	2.74 (9.0)	1.94 (6.4)	0.047	0.178	0.000	0.000	0.224
	11	10	-	×				0.182	0.551	0.000	0.000	0.733
24	10	12	-	×	6.55 (70.5)	2.55 (8.4)	2.31 (7.6)	0.131	0.454	0.000	0.000	0.585
	12	10	-	×				0.361	1.040	0.000	0.000	1.401

Table 6.2.1-32 (4 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
25	10	14	-	×	5.88 (63.3)	4.26 (14.0)	0.04 (0.1)	0.135	0.729	0.000	0.000	0.864
	14	10	-	×				0.135	0.729	0.000	0.000	0.864
26	11	13	-	×	3.93 (42.3)	2.55 (8.4)	1.53 (5.0)	0.047	0.163	0.000	0.000	0.211
	13	11	-	×				0.130	0.374	0.000	0.000	0.504
27	11	15	-	×	4.38 (47.1)	4.26 (14.0)	0.04 (0.1)	0.145	0.729	0.000	0.000	0.874
	15	11	-	×				0.145	0.729	0.000	0.000	0.874
28	12	13	-	×	3.60 (38.8)	2.74 (9.0)	1.43 (4.7)	0.022	0.084	0.000	0.000	0.106
	13	12	-	×				0.086	0.260	0.000	0.000	0.347
29	12	16	-	×	4.84 (52.1)	4.26 (14.0)	0.04 (0.1)	0.142	0.729	0.000	0.000	0.871
	16	12	-	×				0.142	0.729	0.000	0.000	0.871
30	13	17	-	×	3.54 (38.1)	4.26 (14.0)	0.04 (0.1)	0.153	0.729	0.000	0.000	0.882
	17	13	-	×				0.153	0.729	0.000	0.000	0.882
31	14	15	-	×	3.87 (41.6)	2.74 (9.0)	1.57 (5.1)	0.043	0.163	0.500	1.000	1.706
	15	14	-	×				0.169	0.480	0.500	1.000	2.148
32	14	16	-	×	4.87 (52.4)	2.55 (8.4)	1.87 (6.1)	0.123	0.404	0.500	1.000	2.028
	16	14	-	×				0.339	0.937	0.500	1.000	2.776

Table 6.2.1-32 (5 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
33	14	18	-	×	1.91 (20.6)	3.33 (10.9)	0.52 (1.7)	0.182	0.000	0.500	1.000	1.682
	18	14	-	×				0.182	0.000	0.500	1.000	1.682
34	15	17	-	×	2.57 (27.7)	2.55 (8.4)	1.02 (3.3)	0.034	0.113	0.500	1.000	1.647
	17	15	-	×				0.095	0.262	0.500	1.000	1.856
35	15	19	-	×	1.81 (19.5)	3.33 (10.9)	0.75 (2.5)	0.125	0.000	0.500	1.000	1.625
	19	15	-	×				0.125	0.000	0.500	1.000	1.625
36	16	17	-	×	2.37 (25.5)	2.74 (9.0)	0.96 (3.1)	0.016	0.061	0.500	1.000	1.577
	17	16	-	×				0.063	0.180	0.500	1.000	1.743
37	16	20	-	×	2.27 (24.5)	3.33 (10.9)	0.90 (2.9)	0.105	0.000	0.500	1.000	1.605
	20	16	-	×				0.105	0.000	0.500	1.000	1.605
38	17	21	-	×	0.95 (10.2)	3.33 (10.9)	0.69 (2.2)	0.138	0.000	0.500	1.000	1.638
	21	17	-	×				0.138	0.000	0.500	1.000	1.638
39	18	19	-	×	3.13 (33.7)	2.74 (9.0)	1.45 (4.7)	0.042	0.161	0.500	1.000	1.703
	19	18	-	×				0.166	0.452	0.500	1.000	2.117
40	18	20	-	×	4.06 (43.7)	2.55 (8.4)	1.72 (5.6)	0.122	0.399	0.500	1.000	2.020
	20	18	-	×				0.335	0.871	0.500	1.000	2.706

Table 6.2.1-32 (6 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
41	18	22	-	×	6.64 (71.5)	2.52 (8.3)	0.04 (0.1)	0.611	0.729	0.500	1.000	2.840
	22	18	-	×				0.611	0.729	0.500	1.000	2.840
42	19	21	-	×	2.02 (21.7)	2.55 (8.4)	0.91 (3.0)	0.431	0.101	0.500	1.000	2.032
	21	19	-	×				0.352	0.235	0.500	1.000	2.088
43	19	23	-	×	5.14 (55.3)	2.52 (8.3)	0.04 (0.1)	0.615	0.729	0.500	1.000	2.844
	23	19	-	×				0.615	0.729	0.500	1.000	2.844
44	20	21	-	×	1.86 (20.0)	2.74 (9.0)	0.86 (2.8)	0.458	0.057	0.500	1.000	2.015
	21	20	-	×				0.399	0.160	0.500	1.000	2.059
45	20	24	-	×	5.60 (60.3)	2.52 (8.3)	0.04 (0.1)	0.614	0.729	0.500	1.000	2.843
	24	20	-	×				0.614	0.729	0.500	1.000	2.843
46	21	25	-	×	4.30 (46.3)	2.52 (8.3)	0.04 (0.1)	0.618	0.729	0.500	1.000	2.847
	25	21	-	×				0.618	0.729	0.500	1.000	2.847
47	22	23	-	×	4.60 (49.5)	2.74 (9.0)	2.23 (7.3)	0.035	0.000	0.000	0.000	0.035
	23	22	-	×				0.035	0.000	0.000	0.000	0.035
48	22	24	-	×	5.14 (55.4)	2.55 (8.4)	2.34 (7.7)	0.031	0.000	0.000	0.000	0.031
	24	22	-	×				0.031	0.000	0.000	0.000	0.031

Table 6.2.1-32 (7 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
49	22	26	-	×	6.69 (72.0)	1.75 (5.8)	2.89 (9.5)	0.014	0.000	0.000	0.000	0.014
	26	22	-	×				0.014	0.000	0.000	0.000	0.014
50	23	25	-	×	4.06 (43.7)	2.55 (8.4)	2.10 (6.9)	0.034	0.000	0.000	0.000	0.034
	25	23	-	×				0.034	0.000	0.000	0.000	0.034
51	23	27	-	×	5.35 (57.6)	1.75 (5.8)	2.58 (8.5)	0.015	0.000	0.000	0.000	0.015
	27	23	-	×				0.015	0.000	0.000	0.000	0.015
52	24	25	-	×	3.92 (42.2)	2.74 (9.0)	2.07 (6.8)	0.038	0.000	0.000	0.000	0.038
	25	24	-	×				0.038	0.000	0.000	0.000	0.038
53	24	28	-	×	5.76 (62.0)	1.75 (5.8)	2.66 (8.7)	0.015	0.000	0.000	0.000	0.015
	28	24	-	×				0.015	0.000	0.000	0.000	0.015
54	25	29	-	×	4.61 (49.6)	1.75 (5.8)	2.40 (7.9)	0.016	0.000	0.000	0.000	0.016
	29	25	-	×				0.016	0.000	0.000	0.000	0.016
55	26	27	-	×	3.76 (40.5)	2.74 (9.0)	1.96 (6.4)	0.040	0.000	0.000	0.000	0.040
	27	26	-	×				0.040	0.000	0.000	0.000	0.040
56	26	28	-	×	4.18 (45.0)	2.55 (8.4)	2.03 (6.7)	0.036	0.000	0.000	0.000	0.036
	28	26	-	×				0.036	0.000	0.000	0.000	0.036

Table 6.2.1-32 (8 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
57	26	30	-	×	7.53 (81.0)	0.76 (2.5)	2.89 (9.5)	0.007	0.000	0.000	1.000	1.007
	30	26	-	×				0.507	0.000	0.500	0.000	1.007
58	27	29	-	×	3.34 (36.0)	2.55 (8.4)	1.88 (6.2)	0.039	0.000	0.000	0.000	0.039
	29	27	-	×				0.039	0.000	0.000	0.000	0.039
59	27	30	-	×	6.02 (64.8)	0.76 (2.5)	2.58 (8.5)	0.008	0.000	0.000	1.000	1.008
	30	27	-	×				0.508	0.000	0.500	0.000	1.008
60	28	29	-	×	3.24 (34.9)	2.74 (9.0)	1.85 (6.1)	0.042	0.000	0.000	0.000	0.042
	29	28	-	×				0.042	0.000	0.000	0.000	0.042
61	28	30	-	×	6.48 (69.8)	0.76 (2.5)	2.66 (8.7)	0.008	0.000	0.000	1.000	1.008
	30	28	-	×				0.008	0.000	0.500	0.000	0.508
62	29	30	-	×	5.18 (55.8)	0.76 (2.5)	2.40 (7.9)	0.009	0.000	0.000	1.000	1.009
	30	29	-	×				0.009	0.000	0.500	0.000	0.509
63	22	30	-	×	3.76 (40.5)	2.36 (7.8)	1.96 (6.4)	0.026	0.000	0.000	1.000	1.026
	30	22	-	×				0.026	0.000	0.500	0.000	0.526
64	23	30	-	×	1.00 (10.8)	2.21 (7.3)	1.05 (3.4)	0.065	0.000	0.000	1.000	1.065
	30	23	-	×				0.046	0.000	0.500	0.000	0.546

Table 6.2.1-32 (9 of 9)

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contra ction	Expansion	Total
65	24	30	-	×	3.24 (34.9)	2.36 (7.8)	1.85 (6.1)	0.028	0.000	0.000	1.000	1.028
	30	24	-	×				0.028	0.000	0.500	0.000	0.528
66	26	30	-	×	3.76 (40.5)	2.36 (7.8)	1.96 (6.4)	0.037	0.000	0.000	1.000	1.037
	30	26	-	×				0.037	0.000	0.500	0.000	0.537
67	27	30	-	×	1.25 (13.5)	2.21 (7.3)	1.14 (3.8)	0.046	0.000	0.000	1.000	1.046
	30	27	-	×				0.046	0.000	0.500	0.000	0.546
68	28	30	-	×	3.24 (34.9)	2.36 (7.8)	1.85 (6.1)	0.039	0.000	0.000	1.000	1.039
	30	28	-	×				0.039	0.000	0.500	0.000	0.539

Table 6.2.1-33

Pressurizer Spray Valve Subcompartment Vent Path Description

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning	Contraction	Expansion	Total
1	1	2	-	×	1.88 (20.3)	5.06 (16.6)	1.31 (4.3)	0.056	1.215	0.500	1.000	2.771
	2	1	-	×				0.056	1.068	0.500	1.000	2.624
2	2	3	-	×	1.39 (15.0)	2.21 (7.3)	1.31 (4.3)	0.023	0.000	0.500	1.000	1.523
	3	2	-	×				0.023	0.000	0.500	1.000	1.523
3	1	3	-	×	0.17 (1.8)	2.51 (8.3)	0.41 (1.3)	0.043	0.000	0.500	1.000	1.543
	3	1	-	×				0.043	0.000	0.500	1.000	1.543

Table 6.2.1-34

Regenerative Heat Exchanger Subcompartment Vent Path Description

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning/ Grating	Contraction	Expansion	Total
1	1	2	-	×	4.99 (53.7)	8.23 (27.0)	2.35 (7.7)	0.090	0.729	0.500	1.000	2.319
	2	1	-	×				0.090	0.729	0.500	1.000	2.319
2	2	3	-	×	12.39 (133.4)	5.72 (18.8)	2.85 (9.4)	0.031	0.226	0.500	1.000	1.757
	3	2	-	×				0.031	0.804	0.500	1.000	2.335
3	2	3	-	×	12.39 (133.4)	5.72 (18.8)	2.85 (9.4)	0.031	0.226	0.500	1.000	1.757
	3	2	-	×				0.031	0.804	0.500	1.000	2.335
4	1	3	-	×	0.33 (3.6)	5.72 (18.8)	0.61 (2.0)	0.087	0.000	0.500	1.000	1.587
	3	1	-	×				0.087	0.000	0.500	1.000	1.587

Table 6.2.1-35 (1 of 2)

Letdown Heat Exchanger and Valve Subcompartments Vent Path Description

A. Letdown Heat Exchanger Room

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning	Contraction	Expansion	Total
1	1	2	-	×	2.36 (25.4)	8.19 (26.9)	1.49 (4.9)	0.014	0.507	0.500	1.000	2.021
	2	1	-	×				0.014	0.634	0.500	1.000	2.147
2	2	3	-	×	3.18 (34.2)	1.20 (4.0)	1.48 (4.9)	0.022	0.000	0.500	1.000	1.522
	3	2	-	×				0.022	0.000	0.500	1.000	1.522
3	1	3	-	×	0.33 (3.6)	2.51 (8.3)	0.61 (2.0)	0.028	0.000	0.500	1.000	1.528
	3	1	-	×				0.028	0.000	0.500	1.000	1.528

Table 6.2.1-35 (2 of 2)

B. Letdown Heat Exchanger Valve Room

Junction No.	Volume Node No.		Description of Vent Path Flow		Area, m^2 (ft^2)	Length, m (ft)	Hydraulic Diameter, m (ft)	Head Loss, K				
	From	To	Choked	Unchoked				Friction, ft/d	Turning	Contraction	Expansion	Total
1	1	2	-	×	1.88 (20.3)	5.90 (19.4)	1.31 (4.3)	0.056	1.215	0.500	1.000	2.771
	2	1	-	×				0.056	1.068	0.500	1.000	2.624
2	2	3	-	×	1.39 (15.0)	2.21 (7.3)	1.31 (4.3)	0.023	0.000	0.500	1.000	1.523
	3	2	-	×				0.023	0.000	0.500	1.000	1.523
3	1	3	-	×	0.17 (1.8)	2.51 (8.3)	0.41 (1.3)	0.043	0.000	0.500	1.000	1.543
	3	1	-	×				0.043	0.000	0.500	1.000	1.543

Table 6.2.1-36 (1 of 5)

Mass and Energy Release Data

S/G Compartment

A. Feedwater Economizer Nozzle Break (Same Values for Forward and Reverse)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	5,792.1 (12,769.5)	6,143,466.6 (5,822,882.0)	1,061 (456.0)
1.0	5,792.1 (12,769.5)	6,143, 466.6 (5,822,882.0)	1,061 (456.0)

B. Feedwater Downcomer Nozzle Break (Same Values for Forward and Reverse)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	1,377.3 (3,036.4)	1,460,808.4 (1,384,579.0)	1,061 (456.0)
1.0	1,377.3 (3,036.4)	1,460, 808.4 (1,384,579.0)	1,061 (456.0)

C. S/G Blowdown Nozzle Break (Same Values for Forward and Reverse)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	1,377.3 (3,036.4)	1,460,808.4 (1,384,579.0)	1,061 (456.0)
1.0	1,377.3 (3,036.4)	1,460,808.4 (1,384,579.0)	1,061 (456.0)

Table 6.2.1-36 (2 of 5)

Pressurizer Compartment

A. POSRV Nozzle Break

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	830.8 (1,831.7)	2,146,829.0 (2,034,801.0)	2,584.0 (1,110.9)
0.5	1,924.7 (4,243.2)	3,185,717.3 (3,019,477.0)	1,655.3 (711.63)
1.0	1,924.7 (4,243.2)	3,185,717.3 (3,019,477.0)	1,655.3 (711.63)

B-1. Pressurizer Spray Nozzle Break (Forward)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	696.3 (1535.0)	914,477.2 (866,757.0)	1,313.4 (564.65)
1.0	696.3 (1535.0)	914,477.2 (866,757.0)	1,313.4 (564.65)

B-2. Pressurizer Spray Nozzle Break (Reverse)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	378.9 (835.4)	627,243.5 (594,512.0)	1,655.3 (711.63)
1.0	378.9 (835.4)	627,243.5 (594,512.0)	1,655.3 (711.63)

Table 6.2.1-36 (3 of 5)

Pressurizer Spray Valve Room

A-1. Pressurizer Spray Valve Break (Forward)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	405.4 (893.65)	532,381.3 (504,600.0)	1,313.4 (564.65)
1.5	405.4 (893.65)	532,381.3 (504,600.0)	1,313.4 (564.65)

A-2. Pressurizer Spray Valve Break (Reverse)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	405.4 (893.65)	532,381.3 (504,600.0)	1,313.4 (564.65)
0.04833	0.0	0.0	-

Table 6.2.1-36 (4 of 5)

Regenerative Heat Exchanger Room

A-1. Letdown Line Break in the Regenerative Heat Exchanger Room (Forward)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)
1.5	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)

A-2. Letdown Line Break in the Regenerative Heat Exchanger Room (Reverse)

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)
0.3	0.0	0.0	-

Table 6.2.1-36 (5 of 5)

Letdown Heat Exchanger and Valve Rooms

A. Letdown Line Break in Letdown Heat Exchanger Room

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)
1.5	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)

B. Letdown Line Break in Letdown Heat Exchanger Valve Room

Time, s	Mass Rate, kg/s (lbm/s)	Energy Rate, kJ/s (Btu/s)	Average Enthalpy, kJ/kg (Btu/lbm)
0.0	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)
1.5	163.3 (359.94)	214,427.5 (203,238.0)	1,313.4 (564.65)

Table 6.2.1-37 (1 of 30)

Stored Energy Sources

Part A. Loss-of-Coolant Accident
Case: Double-Ended Suction Leg Slot Break with Maximum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At Peak Pressure After EOB	At End of Reflood	At End of Post-Reflood	At 1 Day
1. Reactor coolant system water internal energy	103.036 (408.906)	5.639 (22.378)	5.639 (22.378)	10.642 (42.234)	10.72 (42.541)	10.503 (41.681)	6.98 (27.69)
2. Safety injection tank water internal energy	10.53 (41.788)	9.657 (38.325)	9.657 (38.325)	4.917 (19.514)	4.779 (18.964)	4.346 (17.247)	0.0 (0.0)
3. Energy stored in core	7.65 (30.361)	3.615 (14.346)	3.615 (14.346)	1.153 (4.577)	1.151 (4.567)	0.964 (3.827)	55.40 (2) (219.83)
4. Energy stored in RV internals	10.584 (42.003)	8.941 (35.482)	8.941 (35.482)	7.243 (28.744)	7.178 (28.485)	6.961 (27.626)	
5. Energy stored in RV metal	22.625 (89.789)	22.049 (87.501)	22.049 (87.501)	21.637 (85.869)	21.611 (85.767)	21.529 (85.439)	
6. Energy Stored in PZR, Primary Pipes, Valves and Pumps	39.834 (158.082)	35.358 (140.319)	35.358 (140.319)	33.904 (134.552)	33.829 (134.252)	33.6 (133.344)	
7. Energy stored in SG secondary tubes	10.688 (42.416)	9.738 (38.647)	9.738 (38.647)	6.829 (27.102)	6.779 (26.904)	6.639 (26.348)	0.0 (0.0)
8. Energy stored in SG secondary walls	37.688 (149.569)	37.777 (149.919)	37.777 (149.919)	34.948 (138.692)	34.845 (138.284)	34.554 (137.13)	
9. Secondary Coolant Internal Energy in SG 1(Affected)	34.395 (136.5)	35.788 (142.028)	35.788 (142.028)	20.843 (82.718)	20.623 (81.844)	19.891 (78.939)	0.0 (0.0)
10. Secondary Coolant Internal Energy in SG 2 (Unaffected)	34.395 (136.5)	37.935 (150.548)	37.935 (150.548)	31.214 (123.874)	31.02 (123.105)	30.602 (121.447)	
11. Secondary Coolant Internal Energy in Steam Line	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	
12. Total NSSS Stored Energy	320.502 (1271.934)	215.572 (855.513)	215.572 (855.513)	182.408 (723.897)	181.61 (720.732)	178.666 (709.048)	62.37 (247.52)

Table 6.2.1-37 (2 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Suction Leg Slot Break with Maximum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At Peak Pressure After EOB	At End of Reflood	At End of Post-Reflood	At 1 Day
13. Feedwater to SG 1 (Affected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
14. Feedwater to SG 2 (Unaffected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
15. Steam flow to turbine	0.0 (0.0)	0.02 (0.078)	0.02 (0.078)	0.02 (0.078)	0.02 (0.078)	0.02 (0.078)	0.0 (0.0)
16. Energy from decay heat after shutdown	0.0 (0.0)	2.108 (8.367)	2.108 (8.367)	6.061 (24.053)	6.255 (24.823)	6.842 (27.153)	762.91 (3027.49)
17. Steam energy release through break	0.0 (0.0)	110.483 (438.46)	110.483 (438.46)	138.521 (549.732)	139.289 (552.777)	141.374 (561.053)	1358.12 (5389.44)
18. Liquid energy release by spillage	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	10.396 (41.256)	10.694 (42.439)	12.367 (49.079)	2185.61 (8673.21)
19. Total energy release	0.0 (0.0)	110.483 (438.46)	110.483 (438.46)	148.917 (590.988)	149.983 (595.216)	153.741 (610.132)	3543.73 (14062.7)
20. Energy Content of RCB Atmosphere	66.56 (264.15)	156.30 (620.27)	156.30 (620.27)	168.15 (667.28)	168.06 (666.90)	167.51 (664.74)	110.34 (437.88)
21. Energy Content of RCB Internal Structures (3)	0.00 (0.00)	5.98 (23.73)	5.98 (23.73)	25.26 (100.23)	26.29 (104.32)	28.26 (112.13)	186.96 (741.93)
22. Energy Content of IRWST Water	48.01 (190.51)	49.52 (196.50)	49.52 (196.50)	64.96 (257.77)	66.02 (261.99)	68.48 (271.76)	146.95 (583.14)
23. Energy Removed by CSHXs	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.09)	746.77 (2963.43)

(1) The provided energy data is based on the temperature: 0 °C (32 °F), if not specified.

(2) All the RCS metal components are incorporated into a heat structure to model metal sensible energy release after EOPR.

(3) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (3 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Suction Leg Slot Break with Minimum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At Peak Pressure After EOB	At End of Reflood	At End of Post-Reflood	At 1 Day
1. Reactor Coolant System Water Internal Energy	103.036 (408.906)	5.639 (22.378)	5.639 (22.378)	10.613 (42.119)	10.77 (42.741)	10.716 (42.527)	6.52 (25.86)
2. Safety Injection Tank Water Internal Energy	10.53 (41.788)	9.657 (38.325)	9.657 (38.325)	4.88 (19.365)	4.602 (18.264)	4.305 (17.085)	0.0 (0.0)
3. Energy Stored in Core	7.65 (30.361)	3.615 (14.346)	3.615 (14.346)	1.24 (4.921)	1.24 (4.921)	1.093 (4.338)	55.38 (2) (219.78)
4. Energy Stored in RV Internals	10.584 (42.003)	8.941 (35.482)	8.941 (35.482)	7.291 (28.937)	7.181 (28.499)	7.048 (27.972)	
5. Energy Stored in RV Metal	22.625 (89.789)	22.049 (87.501)	22.049 (87.501)	21.635 (85.862)	21.586 (85.664)	21.531 (85.445)	
6. Energy Stored in PZR, Primary Pipes, Valves and Pumps	39.834 (158.082)	35.358 (140.319)	35.358 (140.319)	33.901 (134.539)	33.755 (133.961)	33.606 (133.367)	
7. Energy Stored in SG Secondary Tubes	10.688 (42.416)	9.738 (38.647)	9.738 (38.647)	6.825 (27.087)	6.736 (26.731)	6.652 (26.399)	0.0 (0.0)
8. Energy Stored in SG Secondary Walls	37.688 (149.569)	37.777 (149.919)	37.777 (149.919)	34.929 (138.618)	34.73 (137.829)	34.543 (137.086)	
9. Secondary Coolant Internal Energy in SG 1(Affected)	34.395 (136.5)	35.788 (142.028)	35.788 (142.028)	20.719 (82.224)	20.311 (80.607)	19.921 (79.059)	0.0 (0.0)
10. Secondary Coolant Internal Energy in SG 2 (Unaffected)	34.395 (136.5)	37.935 (150.548)	37.935 (150.548)	31.309 (124.253)	30.961 (122.872)	30.683 (121.767)	
11. Secondary Coolant Internal Energy in Steam Line	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	
12. Total NSSS Stored Energy	320.502 (1271.934)	215.572 (855.513)	215.572 (855.513)	182.42 (723.945)	180.949 (718.109)	179.174 (711.066)	61.90 (245.64)

Table 6.2.1-37 (4 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Suction Leg Slot Break with Minimum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At Peak Pressure After EOB	At End of Reflood	At End of Post-Reflood	At 1 Day
13. Feedwater to SG 1 (Affected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
14. Feedwater to SG 2 (Unaffected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
15. Steam Flow to Turbine	0.0 (0.0)	0.02 (0.078)	0.02 (0.078)	0.02 (0.078)	0.02 (0.078)	0.02 (0.078)	0.0 (0.0)
16. Energy from Decay Heat after Shutdown	0.0 (0.0)	2.108 (8.367)	2.108 (8.367)	6.138 (24.359)	6.531 (25.917)	6.944 (27.556)	762.93 (3027.55)
17. Steam Energy Release through Break	0.0 (0.0)	110.483 (438.46)	110.483 (438.46)	138.925 (551.335)	140.383 (557.119)	141.687 (562.295)	1357.18 (5385.73)
18. Liquid Energy Release by Spillage	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	9.526 (37.803)	10.018 (39.759)	10.994 (43.632)	1574.79 (6249.27)
19. Total Energy Release	0.0 (0.0)	110.483 (438.46)	110.483 (438.46)	148.451 (589.138)	150.401 (596.878)	152.682 (605.927)	2931.97 (11635.0)
20. Energy Content of RCB Atmosphere	66.56 (264.15)	156.30 (620.27)	156.30 (620.27)	168.50 (668.68)	168.18 (667.40)	167.58 (665.02)	109.29 (433.68)
21. Energy Content of RCB Internal Structures (3)	0.00 (0.00)	5.98 (23.73)	5.98 (23.73)	25.60 (101.61)	27.28 (108.25)	28.61 (113.55)	184.93 (733.85)
22. Energy Content of IRWST Water	48.01 (190.51)	49.52 (196.50)	49.52 (196.50)	64.12 (254.45)	65.72 (260.80)	67.20 (266.66)	144.02 (571.53)
23. Energy Removed by CSHXs	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.02)	0.03 (0.11)	734.26 (2913.77)

(1) The provided energy data is based on the temperature: 0 °C (32 °F), if not specified.

(2) All the RCS metal components are incorporated into a heat structure to model metal sensible energy release after EOPR.

(3) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (5 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Discharge Leg Slot Break with Maximum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At End of Reflood	At Peak Pressure After EOR	At End of Post-Reflood	At 1 Day
1. Reactor coolant system water internal energy	103.036 (408.906)	3.127 (12.41)	3.262 (12.944)	10.159 (40.316)	9.16 (36.353)	8.235 (32.682)	4.01 (15.90)
2. Safety injection tank water internal energy	10.53 (41.788)	9.405 (37.323)	8.962 (35.565)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
3. Energy stored in core	7.65 (30.361)	3.376 (13.398)	3.448 (13.683)	1.518 (6.023)	0.969 (3.846)	1.164 (4.62)	50.12 (2) (198.90)
4. Energy stored in RV internals	10.584 (42.003)	8.75 (34.724)	8.66 (34.369)	6.775 (26.887)	6.075 (24.108)	5.876 (23.32)	
5. Energy stored in RV metal	22.625 (89.789)	22.063 (87.558)	21.959 (87.145)	21.165 (83.994)	20.619 (81.83)	20.449 (81.152)	
6. Energy Stored in PZR, Primary Pipes, Valves, and Pumps	39.834 (158.082)	35.918 (142.544)	35.828 (142.186)	32.979 (130.881)	31.322 (124.303)	30.962 (122.873)	
7. Energy stored in SG secondary tubes	10.688 (42.416)	9.863 (39.143)	9.878 (39.2)	6.551 (25.998)	5.438 (21.582)	5.314 (21.091)	0.0 (0.0)
8. Energy stored in SG secondary walls	37.688 (149.569)	37.871 (150.294)	37.824 (150.109)	34.305 (136.143)	32.334 (128.319)	31.948 (126.789)	
9. Secondary coolant internal energy in SG 1 (Affected)	34.395 (136.5)	36.967 (146.708)	36.983 (146.768)	22.816 (90.547)	19.525 (77.487)	19.408 (77.023)	0.0 (0.0)
10. Secondary Coolant Internal Energy in SG 2 (Unaffected)	34.395 (136.5)	37.839 (150.168)	37.834 (150.148)	27.195 (107.924)	22.316 (88.562)	21.515 (85.384)	
11. Secondary Coolant Internal Energy in Steam Line	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	
12. Total NSSS Stored Energy	320.502 (1271.934)	214.256 (850.29)	213.714 (848.137)	172.539 (684.733)	156.835 (622.411)	153.948 (610.953)	54.13 (214.80)

Table 6.2.1-37 (6 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Discharge Leg Slot Break with Maximum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At End of Reflood	At Peak Pressure After EOR	At End of Post-Reflood	At 1 Day
13. Feedwater to SG 1 (Affected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
14. Feedwater to SG 2 (Unaffected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
15. Steam flow to turbine	0.0 (0.0)	0.075 (0.299)	0.073 (0.289)	0.073 (0.289)	0.073 (0.289)	0.073 (0.289)	0.0 (0.0)
16. Energy from decay heat after shutdown	0.0 (0.0)	1.702 (6.753)	1.804 (7.159)	9.283 (36.84)	13.449 (53.373)	14.601 (57.945)	763.68 (3030.54)
17. Steam energy release through break	0.0 (0.0)	112.156 (445.1)	112.811 (447.7)	154.968 (615.003)	173.309 (687.788)	175.685 (697.219)	1367.16 (5425.32)
18. Liquid energy release by spillage	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	9.303 (36.919)	12.684 (50.336)	14.869 (59.008)	2192.47 (8700.43)
19. Total energy release	0.0 (0.0)	112.156 (445.1)	112.811 (447.7)	164.271 (651.922)	185.993 (738.124)	190.554 (756.228)	3559.63 (14125.7)
20. Energy Content of RCB Atmosphere	66.56 (264.15)	156.18 (619.79)	155.66 (617.69)	164.37 (652.26)	170.21 (675.43)	169.80 (673.81)	109.36 (433.97)
21. Energy Content of RCB Internal Structures (3)	0.00 (0.00)	5.73 (22.72)	6.55 (25.99)	33.90 (134.52)	41.76 (165.73)	43.35 (172.02)	186.94 (741.83)
22. Energy Content of IRWST Water	48.01 (190.51)	49.46 (196.28)	49.81 (197.67)	75.61 (300.06)	88.15 (349.80)	92.75 (368.07)	155.03 (615.20)
23. Energy Removed by CSHXs	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.19 (0.75)	0.52 (2.08)	0.64 (2.54)	753.46 (2989.97)

(1) The provided energy data is based on the temperature: 0 °C (32 °F), if not specified.

(2) All the RCS metal components are incorporated into a heat structure to model metal sensible energy release after EOPR.

(3) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (7 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Discharge Leg Slot Break with Minimum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At End of Reflood	At Peak Pressure After EOR	At End of Post-Reflood	At 1 Day
1. Reactor Coolant System Water Internal Energy	103.036 (408.906)	3.127 (12.41)	3.262 (12.944)	10.142 (40.249)	9.463 (37.556)	10.495 (41.649)	5.63 (22.34)
2. Safety Injection Tank Water Internal Energy	10.53 (41.788)	9.405 (37.323)	8.962 (35.565)	2.106 (8.356)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
3. Energy Stored in Core	7.65 (30.361)	3.376 (13.398)	3.448 (13.683)	1.518 (6.023)	1.205 (4.781)	1.471 (5.839)	47.90 (2) (190.06)
4. Energy Stored in RV Internals	10.584 (42.003)	8.75 (34.724)	8.66 (34.369)	6.774 (26.882)	6.136 (24.351)	5.784 (22.953)	
5. Energy Stored in RV Metal	22.625 (89.789)	22.063 (87.558)	21.959 (87.145)	21.164 (83.989)	20.644 (81.926)	19.792 (78.545)	
6. Energy Stored in PZR, Primary Pipes, Valves, and Pumps	39.834 (158.082)	35.918 (142.544)	35.828 (142.186)	32.978 (130.874)	31.375 (124.512)	29.766 (118.13)	
7. Energy Stored in SG Secondary Tubes	10.688 (42.416)	9.863 (39.143)	9.878 (39.2)	6.548 (25.988)	5.474 (21.724)	5.013 (19.895)	0.0 (0.0)
8. Energy Stored in SG Secondary Walls	37.688 (149.569)	37.871 (150.294)	37.824 (150.109)	34.303 (136.135)	32.396 (128.564)	30.472 (120.93)	
9. Secondary Coolant Internal Energy in SG 1(Affected)	34.395 (136.5)	36.967 (146.708)	36.983 (146.768)	22.806 (90.506)	19.473 (77.281)	19.33 (76.711)	0.0 (0.0)
10. Secondary Coolant Internal Energy in SG 2 (Unaffected)	34.395 (136.5)	37.839 (150.168)	37.834 (150.148)	27.187 (107.895)	22.615 (89.748)	19.433 (77.123)	
11. Secondary Coolant Internal Energy in Steam Line	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	
12. Total NSSS Stored Energy	320.502 (1271.934)	214.256 (850.29)	213.714 (848.137)	174.601 (692.918)	157.856 (626.464)	150.632 (597.794)	53.52 (212.40)

Table 6.2.1-37 (8 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Discharge Leg Slot Break with Minimum ECCS Flow
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure Prior to EOB	At EOB	At End of Reflood	At Peak Pressure After EOR	At End of Post-Reflood	At 1 Day
13. Feedwater to SG 1 (Affected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
14. Feedwater to SG 2 (Unaffected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
15. Steam Flow to Turbine	0.0 (0.0)	0.075 (0.299)	0.073 (0.289)	0.073 (0.289)	0.073 (0.289)	0.073 (0.289)	0.0 (0.0)
16. Energy from Decay Heat after Shutdown	0.0 (0.0)	1.702 (6.753)	1.804 (7.159)	9.293 (36.882)	13.311 (52.826)	20.24 (80.324)	764.41 (3033.40)
17. Steam Energy Release through Break	0.0 (0.0)	112.156 (445.1)	112.811 (447.7)	155.075 (615.425)	172.783 (685.701)	184.227 (731.119)	1363.41 (5410.44)
18. Liquid Energy Release by Spillage	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.952 (23.619)	9.996 (39.668)	13.702 (54.378)	1580.06 (6270.20)
19. Total Energy Release	0.0 (0.0)	112.156 (445.1)	112.811 (447.7)	161.026 (639.045)	182.779 (725.369)	197.93 (785.497)	2943.47 (11680.6)
20. Energy Content of RCB Atmosphere	66.56 (264.15)	156.18 (619.79)	155.66 (617.69)	164.48 (652.71)	170.01 (674.67)	166.63 (661.23)	108.00 (428.56)
21. Energy Content of RCB Internal Structures (3)	0.00 (0.00)	5.73 (22.72)	6.55 (25.99)	33.95 (134.73)	41.51 (164.74)	48.81 (193.69)	184.63 (732.67)
22. Energy Content of IRWST Water	48.01 (190.51)	49.46 (196.28)	49.81 (197.67)	74.29 (294.80)	84.99 (337.25)	102.52 (406.84)	152.30 (604.37)
23. Energy Removed by CSHXs	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.19 (0.76)	0.51 (2.02)	1.34 (5.33)	742.38 (2945.99)

(1) The provided energy data is based on the temperature: 0 °C (32 °F), if not specified.

(2) All the RCS metal components are incorporated into a heat structure to model metal sensible energy release after EOPR.

(3) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (9 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Hot Leg Slot Break
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure at EOB	At EOB	At 1 Day
1. Reactor coolant system water internal energy	103.036 (408.906)	5.591 (22.19)	5.591 (22.19)	3.49 (13.87)
2. Safety injection tank water internal energy	10.53 (41.788)	9.086 (36.058)	9.086 (36.058)	0.0 (0.0)
3. Energy stored in core	7.65 (30.361)	3.551 (14.091)	3.551 (14.091)	62.29 (2) (247.19)
4. Energy stored in RV internals	10.584 (42.003)	8.485 (33.675)	8.485 (33.675)	
5. Energy stored in RV metal	22.625 (89.789)	21.957 (87.138)	21.957 (87.138)	
6. Energy stored in PZR, primary piping, valves, and pumps	39.834 (158.082)	35.076 (139.201)	35.076 (139.201)	
7. Energy stored in SG secondary tubes	10.688 (42.416)	9.421 (37.389)	9.421 (37.389)	0.0 (0.0)
8. Energy stored in SG secondary walls	37.688 (149.569)	37.107 (147.263)	37.107 (147.263)	
9. Secondary coolant internal energy in SG 1 (Affected)	34.395 (136.5)	34.455 (136.738)	34.455 (136.738)	0.0 (0.0)
10. Secondary coolant internal energy in SG 2 (Unaffected)	34.395 (136.5)	36.753 (145.858)	36.753 (145.858)	
11. Secondary coolant internal energy in steam line	9.076 (36.02)	9.076 (36.02)	9.076 (36.02)	
12. Total NSSS stored energy	320.502 (1271.934)	210.56 (835.621)	210.56 (835.621)	65.78 (261.06)

Table 6.2.1-37 (10 of 30)

Part A. Loss-of-Coolant Accident
Case: Double-Ended Hot Leg Slot Break
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Description of Stored Energy	Prior to LOCA	At Peak Pressure at EOB	At EOB	At 1 Day
13. Feedwater to SG 1 (Affected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
14. Feedwater to SG 2 (Unaffected)	0.0 (0.0)	3.316 (13.158)	3.316 (13.158)	0.0 (0.0)
15. Steam flow to turbine	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
16. Energy generated from decay heat after shutdown	0.0 (0.0)	1.978 (7.848)	1.978 (7.848)	762.37 (3025.34)
17. Steam energy release through break	0.0 (0.0)	115.563 (458.62)	115.563 (458.62)	1370.47 (5438.44)
18. Liquid energy release by spillage	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2152.03 (8539.93)
19. Total energy release	0.0 (0.0)	115.563 (458.62)	115.563 (458.62)	3522.49 (13978.4)
20. Energy content of RCB atmosphere	66.56 (264.15)	164.18 (651.53)	164.08 (651.13)	112.52 (446.53)
21. Energy content of RCB internal structures (3)	0.00 (0.00)	4.92 (19.52)	5.11 (20.27)	188.20 (746.86)
22. Energy content of IRWST water	48.01 (190.51)	48.97 (194.33)	49.03 (194.57)	147.18 (584.06)
23. Energy removed by CSHXs	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	737.55 (2926.82)

(1) The provided energy data is based on the temperature: 0 °C (32 °F), if not specified.

(2) All the RCS metal components are incorporated into a heat structure to model metal sensible energy release after EOPR.

(3) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (11 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 102 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	101.996 (404.777)	68.753 (272.852)	60.080 (238.43)
2. Energy stored in core	8.525 (33.831)	2.788 (11.064)	2.475 (9.822)
3. Energy stored in pressurizer, primary piping, valves, and pumps	59.117 (234.611)	43.958 (174.449)	39.776 (157.853)
4. Energy stored in SG tubes	10.340 (41.036)	7.553 (29.973)	6.752 (26.794)
5. Energy stored in SG secondary walls	41.159 (163.341)	37.368 (148.298)	36.924 (146.534)
6. Secondary coolant internal energy in Steam Generator	34.546 (137.1)	23.448 (93.055)	21.258 (84.364)
7. Secondary coolant internal energy in Steam Generator 2	34.546 (137.1)	1.371 (5.442)	0.430 (1.706)
8. Secondary coolant internal energy in steamline	9.105 (36.132)	7.251 (28.775)	7.251 (28.775)
9. Total NSSS Stored Energy	299.334 (1,187.929)	192.490 (763.909)	174.944 (694.278)
10. Feedwater To Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater To Steam Generator 2	0.000 (0.000)	18.696 (74.198)	23.181 (91.997)
12. Steam Flow To Turbine	0.000 (0.000)	6.425 (25.500)	6.425 (25.500)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	21.576 (85.624)	58.285 (231.309)
14. Break Flow	0.000 (0.000)	140.378 (557.100)	198.938 (789.5)

Table 6.2.1-37 (12 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 102 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	153.13 (607.68)	144.80 (574.62)	61.97 (245.90)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	39.85 (158.12)	63.53 (252.12)	32.09 (127.34)
17. Energy content of IRWST water	48.00 (190.50)	0.00 (237.97)	96.54 (383.12)	57.48 (228.10)
18. Energy removed by CSHXs	0.00 (0.00)	0.30 (1.19)	5.79 (22.99)	156.22 (619.94)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (13 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 102 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	101.996 (404.777)	69.270 (274.903)	60.086 (238.456)
2. Energy stored in core	8.525 (33.831)	2.807 (11.141)	2.475 (9.823)
3. Energy stored in pressurizer, primary piping, valves, and pumps	59.117 (234.611)	44.204 (175.426)	39.779 (157.866)
4. Energy stored in SG tubes	10.340 (41.036)	7.597 (30.149)	6.752 (26.797)
5. Energy stored in SG secondary walls	41.159 (163.341)	37.420 (148.503)	36.923 (146.53)
6. Secondary coolant internal energy in Steam Generator	34.546 (137.1)	23.602 (93.668)	21.259 (84.37)
7. Secondary coolant internal energy in Steam Generator 2	34.546 (137.1)	1.955 (7.757)	0.433 (1.718)
8. Secondary coolant internal energy in steamline	9.105 (36.132)	0.594 (2.358)	0.512 (2.033)
9. Total NSSS Stored Energy	299.334 (1,187.929)	187.449 (743.905)	168.220 (667.592)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	18.573 (73.709)	23.183 (92.002)
12. Steam Flow to Turbine	0.000 (0.000)	6.425 (25.500)	6.425 (25.500)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	20.854 (82.760)	58.285 (231.309)
14. Break Flow	0.000 (0.000)	144.662 (574.100)	205.666 (816.200)

Table 6.2.1-37 (14 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 102 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	153.25 (608.13)	131.58 (522.17)	62.12 (246.51)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	39.32 (156.03)	60.80 (241.28)	30.83 (122.35)
17. Energy content of IRWST water	48.00 (190.50)	63.97 (253.87)	114.52 (454.47)	58.24 (231.12)
18. Energy removed by CSHXs	0.00 (0.00)	0.38 (1.52)	9.13 (36.23)	173.53 (688.64)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (15 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 75 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	100.913 (400.480)	63.604 (252.417)	55.498 (220.247)
2. Energy stored in core	7.141 (28.342)	2.536 (10.063)	2.349 (9.324)
3. Energy stored in pressurizer, primary piping, valves, and pumps	58.598 (232.552)	41.223 (163.597)	37.316 (148.092)
4. Energy stored in SG tubes	10.282 (40.804)	7.026 (27.883)	6.278 (24.915)
5. Energy stored in SG secondary walls	41.281 (163.826)	36.120 (143.346)	35.615 (141.34)
6. Secondary coolant internal energy in Steam Generator	37.732 (149.74)	24.168 (95.913)	21.651 (85.924)
7. Secondary coolant internal energy in Steam Generator 2	37.732 (149.74)	1.277 (5.067)	0.550 (2.183)
8. Secondary coolant internal energy in steamline	9.314 (36.962)	7.059 (28.014)	7.059 (28.014)
9. Total NSSS stored energy	302.992 (1,202.446)	183.013 (726.300)	166.316 (660.038)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	18.842 (74.777)	23.016 (91.341)
12. Steam Flow to Turbine	0.000 (0.000)	4.770 (18.93)	4.770 (18.93)
13. Energy Generated during Shutdown From Decay Heat	0.000 (0.000)	17.818 (70.711)	51.595 (204.759)
14. Break Flow	0.000 (0.000)	151.591 (601.600)	206.170 (818.2)

Table 6.2.1-37 (16 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 75 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	157.35 (624.42)	150.18 (595.96)	61.98 (245.94)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	43.92 (174.30)	65.28 (259.07)	33.52 (133.03)
17. Energy content of IRWST water	48.00 (190.50)	63.23 (250.91)	97.84 (388.25)	58.06 (230.39)
18. Energy removed by CSHXs	0.00 (0.00)	0.47 (1.88)	5.89 (23.36)	162.35 (644.25)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (17 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 75 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	100.913 (400.48)	64.621 (256.454)	55.499 (220.251)
2. Energy stored in core	7.141 (28.342)	2.570 (10.199)	2.350 (9.326)
3. Energy stored in pressurizer, primary piping, valves, and pumps	58.598 (232.552)	41.710 (165.530)	37.317 (148.093)
4. Energy stored in SG tubes	10.282 (40.804)	7.117 (28.243)	6.278 (24.916)
5. Energy stored in SG secondary walls	41.281 (163.826)	36.220 (143.741)	35.613 (141.332)
6. Secondary coolant internal energy in Steam Generator	37.732 (149.74)	24.487 (97.177)	21.651 (85.924)
7. Secondary coolant internal energy in Steam Generator 2	37.732 (149.74)	2.086 (8.277)	0.554 (2.198)
8. Secondary coolant internal energy in steamline	9.314 (36.962)	0.585 (2.320)	0.511 (2.028)
9. Total NSSS Stored Energy	302.992 (1,202.446)	179.395 (711.940)	159.773 (634.068)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	18.659 (74.051)	23.018 (91.349)
12. Steam Flow to Turbine	0.000 (0.000)	4.770 (18.93)	4.770 (18.93)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	16.863 (66.920)	51.579 (204.693)
14. Break Flow	0.000 (0.000)	154.136 (611.700)	212.696 (844.1)

Table 6.2.1-37 (18 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 75 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	155.29 (616.23)	135.97 (539.59)	62.07 (246.31)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	42.51 (168.71)	62.36 (247.46)	32.11 (127.42)
17. Energy content of IRWST water	48.00 (190.50)	68.22 (270.71)	116.37 (461.77)	58.79 (233.28)
18. Energy removed by CSHXs	0.00 (0.00)	0.59 (2.34)	9.29 (36.86)	179.43 (712.02)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (19 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 50 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	100.044 (397.031)	66.464 (263.766)	57.907 (229.808)
2. Energy stored in core	5.859 (23.252)	2.540 (10.080)	2.378 (9.437)
3. Energy stored in pressurizer, primary piping, valves, and pumps	58.094 (230.549)	42.306 (167.894)	38.184 (151.537)
4. Energy stored in SG tubes	10.221 (40.563)	7.227 (28.682)	6.446 (25.58)
5. Energy stored in SG secondary walls	41.397 (164.287)	35.946 (142.655)	35.184 (139.63)
6. Secondary coolant internal energy in Steam Generator	40.766 (161.781)	26.976 (107.055)	23.758 (94.285)
7. Secondary coolant internal energy in Steam Generator 2	40.766 (161.781)	3.726 (14.787)	0.581 (2.307)
8. Secondary coolant internal energy in steamline	9.489 (37.658)	6.963 (27.632)	6.963 (27.632)
9. Total NSSS Stored Energy	306.635 (1,216.902)	192.148 (762.552)	171.401 (680.216)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	13.844 (54.942)	18.421 (73.106)
12. Steam Flow to Turbine	0.000 (0.000)	3.177 (12.61)	3.177 (12.61)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	10.380 (41.192)	50.537 (200.561)
14. Break Flow	0.000 (0.000)	135.439 (537.500)	200.702 (796.5)

Table 6.2.1-37 (20 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 50 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	152.51 (605.21)	146.96 (583.20)	61.97 (245.91)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	43.54 (172.78)	64.04 (254.12)	32.59 (129.31)
17. Energy content of IRWST water	48.00 (190.50)	63.50 (251.97)	96.76 (383.97)	57.65 (228.79)
18. Energy removed by CSHXs	0.00 (0.00)	0.51 (2.02)	5.77 (22.91)	158.26 (628.04)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (21 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 50 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	100.044 (397.031)	64.500 (255.973)	57.907 (229.808)
2. Energy stored in core	5.859 (23.252)	2.477 (9.831)	2.378 (9.437)
3. Energy stored in pressurizer, primary piping, valves, and pumps	58.094 (230.549)	41.363 (164.152)	38.184 (151.537)
4. Energy stored in SG tubes	10.221 (40.563)	7.050 (27.978)	6.446 (25.58)
5. Energy stored in SG secondary walls	41.397 (164.287)	35.732 (141.805)	35.182 (139.622)
6. Secondary coolant internal energy in Steam Generator	40.766 (161.781)	26.311 (104.418)	23.758 (94.285)
7. Secondary coolant internal energy in Steam Generator 2	40.766 (161.781)	2.214 (8.785)	0.585 (2.321)
8. Secondary coolant internal energy in steamline	9.489 (37.658)	0.569 (2.258)	0.512 (2.033)
9. Total NSSS Stored Energy	306.635 (1,216.902)	180.216 (715.201)	164.952 (654.622)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	14.098 (55.948)	18.423 (73.113)
12. Steam Flow to Turbine	0.000 (0.000)	3.177 (12.61)	3.177 (12.61)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	11.225 (44.546)	50.527 (200.521)
14. Break Flow	0.000 (0.000)	148.391 (588.900)	207.153 (822.1)

Table 6.2.1-37 (22 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 50 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	150.30 (596.43)	133.17 (528.45)	62.12 (246.50)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	41.84 (166.04)	61.11 (242.49)	31.20 (123.81)
17. Energy content of IRWST water	48.00 (190.50)	68.28 (270.97)	114.87 (455.84)	58.36 (231.60)
18. Energy removed by CSHXs	0.00 (0.00)	0.62 (2.45)	9.11 (36.15)	175.17 (695.13)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (23 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 20 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	98.468 (390.776)	60.071 (238.395)	60.175 (238.807)
2. Energy stored in core	4.317 (17.134)	2.511 (9.964)	2.396 (9.51)
3. Energy stored in pressurizer, primary piping, valves, and pumps	57.458 (228.027)	39.035 (154.913)	39.103 (155.184)
4. Energy stored in SG tubes	10.141 (40.244)	6.610 (26.232)	6.623 (26.283)
5. Energy stored in SG secondary walls	41.473 (164.587)	33.969 (134.810)	33.974 (134.829)
6. Secondary coolant internal energy in Steam Generator	46.168 (183.222)	27.922 (110.809)	27.689 (109.884)
7. Secondary coolant internal energy in Steam Generator 2	46.168 (183.222)	1.232 (4.889)	0.836 (3.316)
8. Secondary coolant internal energy in steamline	9.606 (38.121)	6.744 (26.765)	6.744 (26.765)
9. Total NSSS Stored Energy	313.799 (1,245.332)	178.093 (706.776)	177.540 (704.578)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	8.447 (33.523)	11.593 (46.006)
12. Steam Flow to Turbine	0.000 (0.000)	1.123 (4.457)	1.123 (4.457)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	15.343 (60.889)	53.033 (210.464)
14. Break Flow	0.000 (0.000)	158.168 (627.700)	199.493 (791.7)

Table 6.2.1-37 (24 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 20 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	148.54 (589.45)	147.60 (585.74)	61.97 (245.90)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	49.69 (197.18)	63.63 (252.52)	32.50 (128.99)
17. Energy content of IRWST water	48.00 (190.50)	71.79 (284.90)	96.03 (381.06)	57.58 (228.48)
18. Energy removed by CSHXs	0.00 (0.00)	1.27 (5.03)	5.63 (22.33)	157.74 (625.95)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (25 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 20 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	98.468 (390.776)	60.927 (241.794)	60.175 (238.807)
2. Energy stored in core	4.317 (17.134)	2.274 (9.023)	2.396 (9.51)
3. Energy stored in pressurizer, primary piping, valves, and pumps	57.458 (228.027)	39.478 (156.669)	39.103 (155.184)
4. Energy stored in SG tubes	10.141 (40.244)	6.688 (26.541)	6.623 (26.283)
5. Energy stored in SG secondary walls	41.473 (164.587)	34.207 (135.751)	33.975 (134.832)
6. Secondary coolant internal energy in Steam Generator	46.168 (183.222)	28.626 (113.606)	27.689 (109.884)
7. Secondary coolant internal energy in Steam Generator 2	46.168 (183.222)	2.815 (11.170)	0.840 (3.333)
8. Secondary coolant internal energy in steamline	9.606 (38.121)	0.531 (2.106)	0.512 (2.034)
9. Total NSSS Stored Energy	313.799 (1,245.332)	175.545 (696.661)	171.313 (679.867)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	7.592 (30.128)	11.592 (46.005)
12. Steam Flow to Turbine	0.000 (0.000)	1.123 (4.457)	1.123 (4.457)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	5.268 (20.907)	53.031 (210.456)
14. Break Flow	0.000 (0.000)	149.827 (594.600)	205.716 (816.4)

Table 6.2.1-37 (26 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 20 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	143.13 (568.00)	133.75 (530.76)	62.10 (246.41)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	44.82 (177.88)	60.48 (240.00)	31.08 (123.32)
17. Energy content of IRWST water	48.00 (190.50)	75.62 (300.09)	114.20 (453.17)	58.28 (231.27)
18. Energy removed by CSHXs	0.00 (0.00)	1.20 (4.77)	8.93 (35.43)	174.45 (692.29)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (27 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 0 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	98.364 (390.366)	62.225 (246.945)	62.455 (247.856)
2. Energy stored in core	3.289 (13.054)	2.501 (9.923)	2.422 (9.611)
3. Energy stored in pressurizer, primary piping, valves, and pumps	61.107 (242.509)	42.204 (167.491)	42.349 (168.066)
4. Energy stored in SG tubes	10.082 (40.012)	6.705 (26.608)	6.723 (26.682)
5. Energy stored in SG secondary walls	41.907 (166.312)	34.756 (137.932)	34.769 (137.985)
6. Secondary coolant internal energy in Steam Generator	49.521 (196.526)	30.304 (120.264)	30.069 (119.332)
7. Secondary coolant internal energy in Steam Generator 2	49.521 (196.526)	0.471 (1.870)	0.321 (1.272)
8. Secondary coolant internal energy in steamline	10.084 (40.019)	8.007 (31.777)	8.007 (31.777)
9. Total NSSS Stored Energy	323.876 (1,285.323)	187.174 (742.811)	187.116 (742.581)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	7.573 (30.054)	10.697 (42.451)
12. Steam Flow to Turbine	0.000 (0.000)	0.002 (0.007)	0.002 (0.007)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	23.131 (91.798)	64.154 (254.598)
14. Break Flow	0.000 (0.000)	167.189 (663.500)	208.186 (826.2)

Table 6.2.1-37 (28 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 0 % Power – Loss of One CSS Train
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	155.19 (615.83)	153.76 (610.18)	61.98 (245.95)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	51.50 (204.37)	65.67 (260.62)	34.18 (135.65)
17. Energy content of IRWST water	48.00 (190.50)	73.01 (289.73)	97.52 (387.00)	58.19 (230.93)
18. Energy removed by CSHXs	0.00 (0.00)	1.32 (5.24)	5.81 (23.04)	164.86 (654.20)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-37 (29 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 0 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown
1. Reactor coolant system water internal energy	98.364 (390.366)	61.677 (244.768)	62.455 (247.856)
2. Energy stored in core	3.289 (13.054)	2.207 (8.759)	2.422 (9.611)
3. Energy stored in pressurizer, primary piping, valves, and pumps	57.017 (226.277)	39.267 (155.835)	39.627 (157.263)
4. Energy stored in SG tubes	10.082 (40.012)	6.646 (26.373)	6.723 (26.682)
5. Energy stored in SG secondary walls	41.907 (166.312)	34.724 (137.803)	34.716 (137.772)
6. Secondary coolant internal energy in Steam Generator	49.521 (196.526)	30.436 (120.786)	30.059 (119.291)
7. Secondary coolant internal energy in Steam Generator 2	49.521 (196.526)	1.411 (5.600)	0.324 (1.284)
8. Secondary coolant internal energy in steamline	10.084 (40.019)	0.656 (2.605)	0.522 (2.072)
9. Total NSSS Stored Energy	319.786 (1,269.092)	177.023 (702.530)	176.848 (701.832)
10. Feedwater to Steam Generator 1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
11. Feedwater to Steam Generator 2	0.000 (0.000)	3.368 (13.367)	9.377 (37.212)
12. Steam Flow to Turbine	0.000 (0.000)	0.002 (0.007)	0.002 (0.007)
13. Energy Generated During Shutdown From Decay Heat	0.000 (0.000)	0.006 (0.025)	66.378 (263.425)
14. Break Flow	0.000 (0.000)	146.048 (579.600)	216.073 (857.5)

Table 6.2.1-37 (30 of 30)

Part B. Main Steam Line Break
Conditions: Main Steam Line Break, 0 % Power – MSIV Failure
Unit of Energy:(1) 10^6 kcal (10^6 Btu)

Energy Description (Time)	Prior to MSLB	At Peak Pressure	End of Blowdown	At 1 Day
15. Energy content of RCB atmosphere	58.56 (232.37)	150.73 (598.13)	139.79 (554.71)	62.13 (246.55)
16. Energy content of RCB internal structures (2)	0.00 (0.00)	40.70 (161.51)	62.76 (249.05)	32.86 (130.39)
17. Energy content of IRWST water	48.00 (190.50)	66.46 (263.75)	116.63 (462.84)	58.97 (234.03)
18. Energy removed by CSHXs	0.00 (0.00)	0.52 (2.05)	9.22 (36.58)	182.59 (724.58)

(1) The provided energy contents is based on the temperature: 0 °C (32 °F), if not specified.

(2) The initial energy content in RCB internal structures is assumed to zero (0) Btu.

Table 6.2.1-38

Primary Side Resistance Factors Used in FLOOD3 Code

Path	Resistance Factor, R′ SI unit(1) (British unit)(2)
Core	
Lower core	1.90468 (0.34795)
Upper core	1.72879 (0.31582)
Upper plenum to steam generator, broken side	
Upper plenum to tubes	9.62163 (1.75768)
Tubes to steam generator outlet	8.21834 (1.50133)
Steam generator outlet in broken side of annulus	
Forward flow	65.50043 (11.96563)
Reverse flow	370.96195 (67.76737)
Annulus to break	
Suction leg break	345.23735 (63.06799)
Discharge leg	6.09321 (1.11311)
Steam generator outlet in broken side to break	
Suction leg break	12.05189 (2.20164)
Discharge leg break	59.49286 (10.86816)
Upper plenum to annulus, intact side	
Upper plenum to tubes	9.62163 (1.75768)
Tubes to annulus	24.59345 (4.49273)
Break resistances	
1.0 break	24.50463 (4.47651)

(1) SI units of R′ are $\frac{\frac{\mathrm{kg}}{\mathrm{cm}^2}}{\frac{\mathrm{kg}^2}{\mathrm{sec}^2}\frac{\mathrm{m}^3}{\mathrm{kg}}} \times 10^6$

(2) British units of R are $\frac{\mathrm{psi}}{\frac{\mathrm{lbm}^2}{\mathrm{sec}^2}\frac{\mathrm{ft}^3}{\mathrm{sec}}} \times 10^6$

Table 6.2.1-39 (1 of 4)

Blowdown and Reflood Mass and Energy Release for the Minimum Containment Pressure Analysis

Time (sec)	Mass Flow		Energy Release		Integral of Mass Flow		Integral of Energy Release	
	(kg/sec)	(lbm/sec)	(kcal/sec)	(Btu/sec)	(kg)	(lbm)	(kcal)	(Btu)
0.0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.5	4.0478E+04	8.9239E+04	3.0496E+02	5.4892E+02	1.9390E+04	4.2747E+04	3.0489E+02	5.4881E+02
1.0	3.8352E+04	8.4551E+04	3.0536E+02	5.4966E+02	3.9243E+04	8.6517E+04	3.0502E+02	5.4904E+02
1.5	3.5484E+04	7.8229E+04	3.0614E+02	5.5104E+02	5.7629E+04	1.2705E+05	3.0525E+02	5.4943E+02
2.0	3.3342E+04	7.3507E+04	3.0736E+02	5.5324E+02	7.4844E+04	1.6500E+05	3.0557E+02	5.5004E+02
2.5	3.0077E+04	6.6308E+04	3.0904E+02	5.5628E+02	9.0762E+04	2.0010E+05	3.0603E+02	5.5082E+02
3.0	2.6917E+04	5.9342E+04	3.1092E+02	5.5965E+02	1.0495E+05	2.3138E+05	3.0657E+02	5.5182E+02
3.5	2.4673E+04	5.4394E+04	3.1330E+02	5.6394E+02	1.1780E+05	2.5970E+05	3.0716E+02	5.5291E+02
4.0	2.3000E+04	5.0706E+04	3.1553E+02	5.6796E+02	1.2972E+05	2.8599E+05	3.0785E+02	5.5411E+02
4.5	2.1681E+04	4.7798E+04	3.1769E+02	5.7186E+02	1.4088E+05	3.1059E+05	3.0853E+02	5.5536E+02
5.0	2.0762E+04	4.5773E+04	3.1906E+02	5.7429E+02	1.5148E+05	3.3395E+05	3.0921E+02	5.5658E+02
5.5	1.9331E+04	4.2616E+04	3.2273E+02	5.8093E+02	1.6150E+05	3.5605E+05	3.0993E+02	5.5787E+02
6.0	1.8100E+04	3.9903E+04	3.2677E+02	5.8820E+02	1.7084E+05	3.7665E+05	3.1075E+02	5.5933E+02
6.5	1.6981E+04	3.7436E+04	3.3031E+02	5.9456E+02	1.7961E+05	3.9598E+05	3.1162E+02	5.6091E+02
7.0	1.6005E+04	3.5284E+04	3.3358E+02	6.0047E+02	1.8785E+05	4.1414E+05	3.1251E+02	5.6252E+02
7.5	1.5184E+04	3.3475E+04	3.3654E+02	6.0577E+02	1.9564E+05	4.3132E+05	3.1341E+02	5.6413E+02
8.0	1.4343E+04	3.1621E+04	3.4015E+02	6.1228E+02	2.0302E+05	4.4759E+05	3.1431E+02	5.6576E+02
8.5	1.3768E+04	3.0354E+04	3.4188E+02	6.1537E+02	2.1003E+05	4.6303E+05	3.1519E+02	5.6735E+02

Table 6.2.1-39 (2 of 4)

Time (sec)	Mass Flow		Energy Release		Integral of Mass Flow		Integral of Energy Release	
	(kg/sec)	(lbm/sec)	(kcal/sec)	(Btu/sec)	(kg)	(lbm)	(kcal)	(Btu)
9.0	1.2562E+04	2.7694E+04	3.5097E+02	6.3176E+02	2.1666E+05	4.7765E+05	3.1609E+02	5.6897E+02
9.5	1.1544E+04	2.5449E+04	3.6493E+02	6.5688E+02	2.2272E+05	4.9102E+05	3.1721E+02	5.7097E+02
10.0	1.0776E+04	2.3757E+04	3.7671E+02	6.7807E+02	2.2830E+05	5.0331E+05	3.1852E+02	5.7334E+02
11.0	9.2543E+03	2.0402E+04	4.0238E+02	7.2429E+02	2.3830E+05	5.2535E+05	3.2147E+02	5.7866E+02
12.0	7.9242E+03	1.7470E+04	4.3098E+02	7.7579E+02	2.4689E+05	5.4430E+05	3.2476E+02	5.8457E+02
13.0	6.5127E+03	1.4358E+04	4.6772E+02	8.4190E+02	2.5411E+05	5.6022E+05	3.2824E+02	5.9084E+02
14.0	5.2411E+03	1.1555E+04	5.0596E+02	9.1069E+02	2.5998E+05	5.7316E+05	3.3179E+02	5.9723E+02
15.0	4.6682E+03	1.0292E+04	4.8775E+02	8.7792E+02	2.6481E+05	5.8380E+05	3.3504E+02	6.0308E+02
16.0	4.1764E+03	9.2074E+03	4.5039E+02	8.1068E+02	2.6921E+05	5.9352E+05	3.3728E+02	6.0709E+02
17.0	3.8009E+03	8.3795E+03	4.0661E+02	7.3191E+02	2.7319E+05	6.0228E+05	3.3863E+02	6.0955E+02
18.0	3.9936E+03	8.8044E+03	3.1929E+02	5.7472E+02	2.7715E+05	6.1102E+05	3.3886E+02	6.0993E+02
19.0	4.3933E+03	9.6855E+03	2.6231E+02	4.7215E+02	2.8125E+05	6.2004E+05	3.3818E+02	6.0873E+02
20.0	4.7481E+03	1.0468E+04	2.4456E+02	4.4020E+02	2.8625E+05	6.3107E+05	3.3656E+02	6.0580E+02
21.0	4.1141E+03	9.0701E+03	2.2618E+02	4.0713E+02	2.9071E+05	6.4091E+05	3.3499E+02	6.0297E+02
22.0	3.3562E+03	7.3991E+03	2.1431E+02	3.8576E+02	2.9440E+05	6.4904E+05	3.3358E+02	6.0044E+02
23.0	2.7299E+03	6.0185E+03	2.0023E+02	3.6041E+02	2.9739E+05	6.5564E+05	3.3234E+02	5.9821E+02
24.0	2.5565E+03	5.6361E+03	1.6748E+02	3.0147E+02	3.0008E+05	6.6157E+05	3.3098E+02	5.9576E+02
25.0	2.2504E+03	4.9613E+03	1.4686E+02	2.6435E+02	3.0253E+05	6.6697E+05	3.2956E+02	5.9321E+02
26.0	2.1186E+03	4.6708E+03	1.3026E+02	2.3446E+02	3.0478E+05	6.7191E+05	3.2814E+02	5.9066E+02
27.0	1.4850E+03	3.2739E+03	1.1722E+02	2.1099E+02	3.0648E+05	6.7568E+05	3.2704E+02	5.8864E+02

Table 6.2.1-39 (3 of 4)

Time (sec)	Mass Flow		Energy Release		Integral of Mass Flow		Integral of Energy Release	
	(kg/sec)	(lbm/sec)	(kcal/sec)	(Btu/sec)	(kg)	(lbm)	(kcal)	(Btu)
28.0	9.7126E+02	2.1413E+03	1.0656E+02	1.9181E+02	3.0783E+05	6.7866E+05	3.2606E+02	5.8691E+02
29.0	2.3777E+02	5.2418E+02	1.3044E+02	2.3480E+02	3.0845E+05	6.8001E+05	3.2563E+02	5.8614E+02
30.0	-2.7861E+01	-6.1424E+01	3.0927E+02	5.5667E+02	3.0849E+05	6.8011E+05	3.2562E+02	5.8608E+02
35.0	6.9793E+02	1.5387E+03	7.9865E+01	1.4375E+02	3.0897E+05	6.8117E+05	3.2540E+02	5.8571E+02
40.0	8.8990E+02	1.9619E+03	8.8169E+01	1.5870E+02	3.1048E+05	6.8450E+05	3.2437E+02	5.8387E+02
45.0	1.3250E+03	2.9211E+03	8.3381E+01	1.5009E+02	3.1447E+05	6.9328E+05	3.2137E+02	5.7848E+02
50.0	1.5416E+03	3.3986E+03	8.2278E+01	1.4811E+02	3.2109E+05	7.0788E+05	3.1645E+02	5.6962E+02
55.0	1.9205E+03	4.2340E+03	7.9000E+01	1.4220E+02	3.2996E+05	7.2744E+05	3.1010E+02	5.5818E+02
60.0	2.7710E+02	6.1091E+02	1.5380E+02	2.7683E+02	3.3467E+05	7.3783E+05	3.0708E+02	5.5276E+02
65.0	6.6563E+02	1.4675E+03	1.1439E+02	2.0590E+02	3.3853E+05	7.4633E+05	3.0482E+02	5.4867E+02
70.0	1.3201E+03	2.9104E+03	1.0186E+02	1.8334E+02	3.4253E+05	7.5514E+05	3.0251E+02	5.4456E+02
75.0	7.1960E+02	1.5864E+03	1.2308E+02	2.2155E+02	3.5108E+05	7.7399E+05	2.9760E+02	5.3568E+02
80.0	5.7749E+02	1.2732E+03	1.3700E+02	2.4659E+02	3.5385E+05	7.8010E+05	2.9631E+02	5.3335E+02
85.0	7.0170E+02	1.5470E+03	1.2683E+02	2.2829E+02	3.5678E+05	7.8656E+05	2.9500E+02	5.3098E+02
90.0	6.8902E+02	1.5190E+03	1.2712E+02	2.2883E+02	3.6023E+05	7.9418E+05	2.9340E+02	5.2808E+02
95.0	7.1538E+02	1.5771E+03	1.2854E+02	2.3137E+02	3.6377E+05	8.0198E+05	2.9178E+02	5.2520E+02
100.0	6.4224E+02	1.4159E+03	1.3226E+02	2.3807E+02	3.6713E+05	8.0938E+05	2.9033E+02	5.2259E+02
110.0	7.8987E+02	1.7414E+03	1.2860E+02	2.3147E+02	3.7479E+05	8.2626E+05	2.8699E+02	5.1658E+02
120.0	7.5700E+02	1.6689E+03	1.3782E+02	2.4809E+02	3.8276E+05	8.4384E+05	2.8378E+02	5.1082E+02
130.0	7.9850E+02	1.7604E+03	1.4100E+02	2.5380E+02	3.8957E+05	8.5885E+05	2.8144E+02	5.0661E+02

Table 6.2.1-39 (4 of 4)

Time (sec)	Mass Flow		Energy Release		Integral of Mass Flow		Integral of Energy Release	
	(kg/sec)	(lbm/sec)	(kcal/sec)	(Btu/sec)	kg	(kg/sec)	(lbm/sec)	(kcal/sec)
140.0	9.5967E+02	2.1157E+03	1.3145E+02	2.3660E+02	3.9830E+05	8.7811E+05	2.7828E+02	5.0088E+02+0
150.0	2.9828E+03	6.5760E+03	1.0014E+02	1.8025E+02	4.1133E+05	9.0683E+05	2.7316E+02	4.9170E+02
160.0	7.1382E+02	1.5737E+03	1.3534E+02	2.4361E+02	4.2243E+05	9.3130E+05	2.6916E+02	4.8449E+02
170.0	5.1086E+02	1.1262E+03	1.3636E+02	2.4546E+02	4.2852E+05	9.4473E+05	2.6727E+02	4.8108E+02
180.0	4.6529E+02	1.0258E+03	1.3828E+02	2.4889E+02	4.3343E+05	9.5556E+05	2.6576E+02	4.7837E+02
190.0	2.5487E+02	5.6189E+02	1.6409E+02	2.9536E+02	4.3804E+05	9.6570E+05	2.6429E+02	4.7573E+02
200.0	5.8582E+02	1.2915E+03	1.1404E+02	2.0528E+02	4.4215E+05	9.7477E+05	2.6308E+02	4.7355E+02
210.0	8.6572E+02	1.9086E+03	1.1693E+02	2.1047E+02	4.4943E+05	9.9082E+05	2.6075E+02	4.6937E+02
220.0	5.7720E+02	1.2725E+03	1.9409E+02	3.4936E+02	4.5694E+05	1.0074E+06	2.5885E+02	4.6592E+02
230.0	6.1350E+02	1.3525E+03	1.9972E+02	3.5952E+02	4.6446E+05	1.0239E+06	2.5740E+02	4.6334E+02
240.0	4.9210E+02	1.0849E+03	2.2733E+02	4.0920E+02	4.7021E+05	1.0366E+06	2.5678E+02	4.6221E+02
250.0	5.1957E+02	1.1455E+03	1.9743E+02	3.5537E+02	4.7567E+05	1.0487E+06	2.5610E+02	4.6097E+02
260.0	3.0596E+02	6.7452E+02	2.5417E+02	4.5750E+02	4.7992E+05	1.0580E+06	2.5575E+02	4.6036E+02
270.0	1.7236E+02	3.7999E+02	3.2615E+02	5.8707E+02	4.8231E+05	1.0633E+06	2.5587E+02	4.6057E+02
280.0	1.2492E+02	2.7540E+02	3.2722E+02	5.8900E+02	4.8358E+05	1.0661E+06	2.5619E+02	4.6115E+02
290.0	1.2775E+02	2.8164E+02	3.1618E+02	5.6913E+02	4.8490E+05	1.0690E+06	2.5634E+02	4.6143E+02
300.0	1.1250E+02	2.4803E+02	3.5827E+02	6.4484E+02	4.8607E+05	1.0716E+06	2.5655E+02	4.6178E+02

Table 6.2.2-1

Input Values Used in CSS Evaluation Calculations

CSP NPSH Evaluation	
$h_{static\ head}$	9.19 m (30.16 ft)
$h_{line\ loss}$	2.34 m (7.67 ft)
$h_{IRWST\ sump\ strainer}$	≤ 0.61 m (2.00 ft) (1)
$NPSH_{available}$	6.25 m (20.50 ft)
$NPSH_{required}$	5.33 m (17.50 ft)
$NPSH_{margin}$	0.91 (3.00 ft)
SI Pump NPSH Evaluation	
$h_{static\ head}$	9.14 m (30.0 ft)
$h_{line\ loss}$	1.30 m (4.28 ft)
$h_{IRWST\ sump\ strainer}$	≤ 0.61 m (2.00 ft)(1)
$NPSH_{available}$	7.23 m (23.73 ft)
$NPSH_{required}$	6.71 m (22.00 ft)
$NPSH_{margin}$	0.53 m (1.73 ft)

(1) Contains head loss due to debris clogging and chemical effect.

Table 6.2.2-2 (1 of 2)

Containment Spray System Design Parameters

Containment Spray Pump Data	
Quantity	2
Type	Centrifugal, vertical single stage
Safety class	2
Code	ASME Section III, Class 2
Design pressure, kg/cm^2 (psig)	63.28 (900)
Design temperature, °C (°F)	204.4 (400)
Design flow rate, m3/lpm (gpm)	20,535.86 (5,425) (1)
Design head, m (ft)	140.2 (460)
Material	Austenite stainless steel
Seals	Mechanical
Containment Spray Heat Exchanger Data	
Quantity	2
Type	Shell and tube, horizontal U-tube
Overall heat transfer coefficient and the effective heat transfer area, UA, W-°C (Btu/hr-°F)	0.906×10^6 (1.718×10^6)
Tube Side	
Fluid	Reactor coolant
Design pressure, kg/cm^2 (psig)	63.28 (900)
Design temperature, °C (°F)	204.4 (400)
Material	Austenitic stainless steel
Code	ASME Section III, Class 2
Fouling resistance, m^2-°C/W (hr-ft^2 -°F/Btu)	0.000088 (0.0005)
Shellside	
Fluid	Component cooling water
Design pressure, kg/cm^2 (psig)	14.06 (200)
Design temperature, °C (°F)	93.33 (200)
Material	Carbon steel

Table 6.2.2-2 (2 of 2)

Containment Spray Heat Exchanger Data (cont.)	
Code	ASME Section III, Class 3
Fouling resistance, m^2-°C/W (hr-ft^2 -°F/Btu)	0.000088 (0.0005)
Design capacity	
Tube side	
Flow, m^3/min (gpm)	18.927 (5,000)
Inlet temperature, °C (°F)	98.89 (210)
Outlet temperature, °C (°F)	74.17 (165.5)
Shell Side	
Flow, m^3/min (gpm)	30.283 (8,000)
Inlet temperature, °C (°F)	43.33 (110)
Outlet temperature, °C (°F)	58.50 (137.3)
Heat load, Btu/hr	31.65×10^6 (108×10^6)
Spray Nozzle Data	
Number (total for two spray headers) (main/auxiliary)	614/222
Type	Non-clogging, hollow cone
Flow rate per nozzle (main/auxiliary)	57.5/11.4 L/min at 2.81 kg/cm^2 (15.2/3.0 gpm at 40 psid)
Material	Stainless steel

(1) Including bypass flow 1.609 m^3/min (425 gpm)

Table 6.2.2-3 (1 of 5)

Containment Spray System Failure Modes and Effects Analysis

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
1	CSP suction isolation valves SI-0347, SI-0348	a) Fails closed	• Corrosion • Mechanical binding • Operator error	Effective loss of one CSP	• Low flow indication F-338C, F-348D • Periodic testing	Parallel redundant containment spray path	Valves normally locked open
		b) Fails open	Corrosion	No effect during CSS operation	Periodic testing	None required	-
2	Containment spray pump 1, 2	a) Fails to pump on CSAS	• Mechanical failure • Electrical failure	Loss of one train containment spray	• Low flow indication F-338C, F-348D • Periodic testing	Parallel redundant containment spray path	-
3	CSP discharge isolation valve CS-1003, CS-1004	a) Fails closed	• Corrosion • Mechanical binding • Operator error	Effective loss of one containment spray path	• Low pressure indication P-071, P-081 • Valve position indicator • Periodic testing	Parallel redundant containment spray path	Valves normally locked open
		b) Fails open	Same as 3a)	No effect on safety operation	Periodic testing	None required	-
4	CSP pump flow indication F-338C, F-348D	a) False indication	Electrical malfunction	Possible isolation of affected CSS train	Comparison with redundant indicator with all other process instrumentation and valve position indications consistent	Redundant train	-

Table 6.2.2-3 (2 of 5)

No	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
5	Containment spray heat exchanger 1, 2	a) Loss of cooling	• Insufficient component cooling water flow • Excessive fouling	Diminished ability of subsystem to provide temperature and pressure suppression within the containment during recirculation mode of operation	High temperature indication from T-071C, T-072D	Parallel redundant containment spray path	-
6	Containment spray header block valve CS-0001, CS-0002	a) Fails closed	• Corrosion • Mechanical binding • Operator error • Electrical failure	Effective loss of one containment spray path	• Valve position indicator • Periodic testing	Parallel redundant containment spray path	Valves normally locked open
		b) Fails open	Mechanical failure	No effect during CSS operation	Periodic testing	None required	-
7	Containment spray header isolation valve CS-0003, CS-0004	a) Fails closed	• Corrosion • Mechanical binding • Electrical failure	Effective loss of one containment spray path	• Valve position indicator • Periodic testing	Parallel redundant containment spray path	-
		b) Fails open	• Mechanical failure • Electrical failure	No effect during CSS operation	• Valve position indicator • Periodic testing	None required	Valve normally locked closed

Table 6.2.2-3 (3 of 5)

No	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
8	Containment spray nozzles	a) Nozzle blockage	• Foreign objects in containment spray lines • Corrosion	No containment spray flow to affected nozzle	• Low flow indication F-338C, F-348D • Periodic testing	Parallel redundant CSS train	The main and auxiliary spray nozzles have 1.31 cm (0.516 in) and 0.559 cm (0.220) in orifices, respectively, and are not subject to clogging by particles less than 0.299 cm (0.09 in) maximum dimension. Solution is completely stable and soluble at all temperatures of interest in the containment and therefore does not precipitate or otherwise interfere with nozzle performance.

Table 6.2.2-3 (4 of 5)

No	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
9	Containment spray mini-flow heat exchanger 1, 2	a) Loss of cooling	• Insufficient component cooling water flow • Excessive fouling	Possibly damage to one CSP	Periodic testing	Parallel redundant containment spray train	
10	Containment spray IRWST return line flow control valves CS-0005, CS-0006	a) Fails open	• Corrosion • Mechanical binding • Operator error • Electrical failure	Diversion of flow from containment spray header	• Valve position indicator • Periodic testing	Parallel redundant containment spray train, series isolation valve	Valves normally locked closed
		b) Fails closed	• Corrosion • Mechanical binding	No effect during CSS operation	Periodic testing	None required	
11	IRWST isolation valves SI-308, SI-309	a) Fails closed	• Corrosion • Mechanical binding • Operator error • Electrical failure	Effective loss of one CSP	• Low flow indication F-338C, F-348D • Periodic testing	Parallel redundant containment spray path	Valves normally locked open
		b) Fails open	Corrosion	No effect on CSS operation	Periodic testing	None required	

Table 6.2.2-3 (5 of 5)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects Including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
12	CSP/SCP suction cross-connect valves SI-340, SI-342	a) Fails open	• Corrosion • Mechanical binding • Operator error • Electrical failure	Effective loss of one CSP	• Low flow indication F-338C, F-348D • High CS pump suction pressure indication P-051, P-061 • Periodic testing • Valve position indicator	Shutdown cooling system normally isolated	Valves normally locked closed
		b) Fails closed	• Corrosion • Mechanical binding • Electrical failure	No effect on CSS System operation	• Periodic testing • Valve position indicator	None required	
13	CSP/SCP discharge cross-connect valves SI-341, SI-343	a) Fails open	• Corrosion • Mechanical binding • Operator error • Electrical failure	Effective loss of one CSP	• High flow indication F-338C, F-348D • Periodic testing • Valve position indicator	Shutdown cooling system normally isolated	Valves are normally locked closed
		b) Fails closed	• Corrosion • Mechanical binding • Electrical failure	No effect on CSS system operation	• Periodic testing • Valve position indicator	None required	
14	Spent fuel pool cooling and Cleanup system isolation valves CS-1011, CS-1012	a) Fails open	Mechanical binding	None	Periodic testing	Blind flange provides isolation	Valves normally locked closed
		b) Fails closed	Mechanical binding	None	Periodic testing		

Table 6.2.2-4

Containment Spray System Display Instrumentation

Parameter	Identification No.		Type of Readout	Indicator Location
	Train C	Train D		
CSP discharge pressure	P-071	P-081	Indicator/alarm	MCR/RSR
CSP suction pressure (1)	P-051	P-061	Indicator/alarm	MCR/RSR
CSP flow (2)	F-338	F-348	Indicator	MCR/RSR
Spray header isolation valve position	CS-003	CS-004	Open/closed status	MCR/RSR
Spray header block valve position	CS-001	CS-002	Open/closed status	MCR/RSR
IRWST return line flow control valve position	CS-005	CS-006	Open/closed status 0 – 100 % position indication	MCR/RSR MCR/RSR
CSP discharge manual isolation valve position	CS-1003	CS-1004	Open/closed status	MCR/RSR
CSP status (2)	CSP 1	CSP 2	Indicating lights	MCR/RSR
CSP motor current	I-017C	I-018D	Indicator/alarm	MCR/RSR
CSHX outlet temperature	T-071C	T-072D	Indicator	MCR/RSR

(1) Specified function provided when CSP is used for shutdown cooling

(2) Required for post-accident monitoring

Table 6.2.2-5

Mass Mean Diameter

Nozzle Type	Differential Pressure across the Nozzle (psi)	Mass Mean Diameter (microns)
Main Nozzle	20	371
	30	350
	40	294
	50	291
Auxiliary Nozzle	20	254
	30	180
	40	146
	50	137

Table 6.2.4-1 (1 of 15)

List of Containment Penetrations and System Isolation Positions

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3] Nor-mal	Fail Safe	Shut-down	Acci-dent	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
1	Main steam line #1 from SG #1[8]	3	MS-091	15	10.3.2-1	Globe	Steam	-	Outside	Out	3	O	C	C	C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		30.9	MS-012	5		Gate		75	Outside		(57)	O	C	C	C	EH	MSIS	A,R,M				Nonessential
		6	MS-1302	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		6	MS-1304	-		Safety		-	Outside			C	-	C	C	-	setpoint	-				Nonessential
		6	MS-1306	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		6	MS-1308	-		Safety		-	Outside			C	-	C	C	-	setpoint	-				Nonessential
		6	MS-1310	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		16	MS-102	-		Angle		-	Outside			C	C	C	C	EH	setpoint	R,M				Nonessential
		1	MS-1257	-		Globe		-	Outside			LC	-	LC	-	HW	SV	M				
		4	MS-016	10		Gate		-	Outside			C	C	C	C	EH	setpoint	R,M				Nonessential
																	SV					
																	setpoint					
																	-					
																	-					
																	MSIS					
2	Main steam line #2 from SG #1[8]	3	MS-090	15	10.3.2-1	Globe	Steam	-	Outside	Out	1	O	C	C	C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		30.9	MS-011	5		Gate		69	Outside		(57)	O	C	C	C	EH	MSIS	A,R,M				Nonessential
		6	MS-1301	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		6	MS-1303	-		Safety		-	Outside			C	-	C	C	-	setpoint	-				Nonessential
		6	MS-1305	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		6	MS-1307	-		Safety		-	Outside			C	-	C	C	-	setpoint	-				Nonessential
		6	MS-1309	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		16	MS-101	-		Angle		-	Outside			C	C	C	C	EH	setpoint	R,M				Nonessential
		8	MS-0110	5		Globe		-	Outside			C	O	C	O	P	SV	A,R,M				Essential
		1	MS-1030	-		Globe		-	Outside			LC	-	LC	LC	HW	setpoint	M				
		4	MS-015	10		Gate		-	Outside			C	C	C	C	EH	SV	A,R,M				Nonessential
		1	MS-0112	15		Globe		-	Outside			O	O	O	O	P	setpoint	A,R,M				Essential
																	-					
																	AFAS					
																	-					
																	MSIS					
																	-					

Table 6.2.4-1 (2 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3]				Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
3	Main steam line #1 from SG #2 [8]	3	MS-093	15	10.3.2-1	Globe	Steam	-	Outside	Out	1	O	C	C	C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		30.9	MS-014	5		Gate		69	Outside		(57)	O	C	C	C	EH	MSIS	A,R,M				Nonessential
		6	MS-1312	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		6	MS-1314	-		Safety		-	Outside			C	-	C	C	-	setpoint	-				Nonessential
		6	MS-1316	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		6	MS-1318	-		Safety		-	Outside			C	-	C	C	-	setpoint	-				Nonessential
		6	MS-1320	-		Safety		-	Outside			C	-	C	C	-	SV	-				Nonessential
		16	MS-104	-		Angle		-	Outside			C	C	C	C	EH	setpoint	R,M				Nonessential
		8	MS-109	5		Globe		-	Outside			C	O	C	O	P	SV	A,R,M				Essential
		1	MS-111	15		Globe		-	Outside			O	O	O	O	P	setpoint	A,R,M				Essential
		4	MS-018	10		Gate		-	Outside			C	C	C	C	EH	SV	A,R,M				Nonessential
		1	MS-1051	-		Globe		-	Outside			LC	-	LC	LC	HW	setpoint	M				
																	-					
																	AFAS					
																	-					
																	MSIS					
																	-					

Table 6.2.4-1 (3 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3] Nor-mal	Fail Safe	Shut-down	Acci-dent	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
4	Main steam line #2 from SG #2 [8]	30.9	MS-013	5	10.3.2-1	Gate	Steam	75	Outside	Out	3	O	C	C	C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		6	MS-1311	-		Safety		-	Outside		(57)	C	-	C	C	-	SV setpoint	-				Nonessential
		6	MS-1313	-		Safety		-	Outside			C	-	C	C	-	SV setpoint	-				Nonessential
		6	MS-1315	-		Safety		-	Outside			C	-	C	C	-	SV setpoint	-				Nonessential
		6	MS-1317	-		Safety		-	Outside			C	-	C	C	-	SV setpoint	-				Nonessential
		6	MS-1319	-		Safety		-	Outside			C	-	C	C	-	SV setpoint	-				Nonessential
		16	MS-103	-		Angle		-	Outside			C	C	C	C	EH	-	R,M				Nonessential
		1	MS-1073	-		Globe		-	Outside			LC	-	LC	LC	HW	-	M				Nonessential
		4	MS-017	10		Gate		-	Outside			C	C	C	C	EH	MSIS	R,M				Nonessential
		3	MS-092	15		Globe		-	Outside			O	C	C	C	EH	MSIS	A,R,M				Nonessential
5	Main feedwater to downcomer nozzle SG #1	10	FW-131	5	10.4.7-1	Gate	Water	-	Outside	In	10	O	C	C	O/C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		10	FW-132	5		Gate		15	Outside		(57)	O	C	C	O/C	EH	MSIS	A,R,M				Nonessential
6	Main feedwater to downcomer nozzle SG #2	10	FW-133	5	10.4.7-1	Gate	Water	-	Outside	In	10	O	C	C	O/C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		10	FW-134	5		Gate		15	Outside		(57)	O	C	C	O/C	EH	MSIS	A,R,M				Nonessential
7	Main feedwater to economizer nozzles for SG #1	24	FW-121	5	10.4.7-1	Gate	Water	-	Outside	In	34	O	C	C	O/C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		24	FW-122	5		Gate		17	Outside		(57)	O	C	C	O/C	EH	MSIS	A,R,M				Nonessential
8	Main feedwater to economizer nozzles for SG #2	24	FW-123	5	10.4.7-1	Gate	Water	-	Outside	In	34	O	C	C	O/C	EH	MSIS	A,R,M	A	No	[9]	Nonessential
		24	FW-124	5		Gate		17	Outside		(57)	O	C	C	O/C	EH	MSIS	A,R,M				Nonessential
9	Chemical injection	1	FW-138	15	10.4.7-1	Globe	Mixed chemical (15 wt% ethanlo amine and 2 wt% hydrazine)	-	Outside	In	10	C	C	C	C	P	MSIS	A,R,M	A	No	-	Nonessential
		1	FW-139	15		Globe		-	Outside		(57)	C	C	C	C	P	MSIS	A,R,M				Nonessential

Table 6.2.4-1 (4 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)(15)	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)(2)	Valve Position(3) Nor-mal	Fail Safe	Shut-down	Acci-dent	Actuator Type(4)	Actuation Signal(5)	Type(6)	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line(7)
10	Motor-driven AFW pump PP02A discharge	6 6	AF-0043 AF-1007A	14 -	10.4.9-1	Gate Check	Demi. Water	8 -	Outside Inside	In	4 (56)	O C	AI -	O C	O/C O/C	E -	AFAS/AAFAS -	A,R,M -	A	No	(9)	Essential
11	Motor-driven AFW pump PP02B discharge	6 6	AF-0046 AF-1007B	14 -	10.4.9-1	Gate Check	Demi. Water	6 -	Outside Inside	In	4 (56)	O C	AI -	O C	O/C O/C	E -	AFAS/AAFAS -	A,R,M -	A	No	(9)	Essential
12	Turbine-driven AFW pump PP01A discharge	6 6	AF-0044 AF-1008A	14 -	10.4.9-1	Gate Check	Demi. Water	7 -	Outside Inside	In	4 (56)	O C	AI -	O C	O/C O/C	E -	AFAS/AAFAS -	A,R,M -	A	No	(9)	Essential
13	Turbine-driven AFW pump PP01B discharge	6 6	AF-0045 AF-1008B	14 -	10.4.9-1	Gate Check	Demi. Water	7 -	Outside Inside	In	4 (56)	O C	AI -	O C	O/C O/C	E -	AFAS/ AAFAS -	A,R,M -	A	No	(9)	Essential
14	Safety injection pump #4 Discharge	4 4	SI-616 SI-113	10 -	6.3.2-1	Globe Check	Borated Water	57 -	Outside Inside	In	18 (55)	C C	AI -	C C	O O	E -	SIAS -	A,R,M -	A	No	-	Essential
15	Safety injection pump #2 discharge	10 1 4 12	SI-600 SI-602 SI-626 SI-123	10 10 10 -	6.3.2-1	Globe Globe Globe Check	Borated Water	22 - - -	Outside Outside Outside Inside	In	8 (55)	C C C C	AI AI AI -	C C C O	O/C O O O	E E E -	- - SIAS -	R,M R,M A,R,M -	A	No	-	Essential
16	Safety injection pump #3 discharge	4 4	SI-636 SI-133	10 -	6.3.2-1	Globe Check	Borated Water	73 -	Outside Inside	In	18 (55)	C C	AI -	C C	O O	E -	SIAS	A,R,M -	A	No	-	Essential
17	Safety injection pump #1 discharge	10 1 4 12	SI-601 SI-603 SI-646 SI-143	10 10 10 -	6.3.2-1	Globe Globe Globe Check	Borated Water	26 - - -	Outside Outside Outside Inside	In	8 (55)	C C C C	AI AI AI -	C C C O	O/C O O O	E E E -	- - SIAS -	R,M R,M A,R,M -	A	No	-	Essential
18	SCS pump #2 suction	16 8 16	SI-654 SI-189 SI-656	160- - 80	6.3.2-1	Gate Relief Gate	Borated Water	- - 15	Inside Inside Outside	Out	7 (55)	LC C LC	AI - AI	O C O	O/C C O/C	E - E	- RV setpoint -	R,M - R,M	A	No	(10)	Essential
19	SCS pump #1 suction	16 8 16	SI-653 SI-179 SI-655	160 - 80	6.3.2-1	Gate Relief Gate	Borated Water	- - 15	Inside Inside Outside	Out	7 (55)	LC C LC	AI - AI	O C O	O/C C O/C	E - E	- RV setpoint -	R,M - R,M	A	No	(10)	Essential

Table 6.2.4-1 (5 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3]				Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
												Nor-mal	Fail Safe	Shut-down	Acci-dent							
20	Hot leg injection loop #2	4 4	SI-331 SI-533	10 -	6.3.2-1	Globe Check	Borated Water	32 -	Outside Inside	In	18 (55)	LC C	AI -	LC C	O/C O/C	E -	- -	R,M -	A	No	-	Essential
21	Hot leg injection loop #1	4 4	SI-321 SI-523	10 -	6.3.2-1	Globe Check	Borated Water	23 -	Outside Inside	In	18 (55)	LC C	AI -	LC C	O/C O/C	E -	- -	R,M -	A	No	-	Essential
22	Containment spray pump #2 discharge	14 14	CS-004 CS-1008	15 -	6.2.2-1	Gate Check	Borated Water	13 -	Outside Inside	In	4 (56)	LC C	AI -	LC C	O/C O/C	E -	CSAS -	A,R,M -	C	Yes	-	Essential
23	Containment spray pump #1 discharge	14 14	CS-003 CS-1007	15 -	6.2.2-1	Gate Check	Borated Water	16 -	Outside Inside	In	4 (56)	LC C	AI -	LC C	O/C O/C	E -	CSAS -	A,R,M -	C	Yes	-	Essential
24	Safety injection pump #1 suction	20	SI-304	60	6.3.2-1	Gate	Borated Water	39	Outside	Out	15 (56)	LO	AI	LO	LO	E	-	R,M	A	No	(11)	Essential
25	Safety injection pump #2 suction	20	SI-305	60	6.3.2-1	Gate	Borated Water	39	Outside	Out	15 (56)	LO	AI	LO	LO	E	-	R,M	A	No	(11)	Essential
26	Safety injection pump #3 and containment spray pump #1 suction	20	SI-308	60	6.3.2-1	Gate	Borated Water	30	Outside	Out	15 (56)	LO	AI	LO	LO	E	-	R,M	A	No	(11)	Essential
27	Safety injection pump #4 and containment spray pump #2 suction	20	SI-309	60	6.3.2-1	Gate	Borated Water	28	Outside	Out	15 (56)	LO	AI	LO	LO	E	-	R,M	A	No	(11)	Essential
28	SIS division 1 miniflow return to IRWST	10 10 4	SI-300 SI-100 SI-302	50 - 20	6.3.2-1	Gate Check Gate	Borated Water	21 - -	Outside Inside Outside	In	12 (56)	C C LO	AI - AI	C C LO	C O LO	E - E	- - -	R,M - R,M	C	Yes	-	Essential

Table 6.2.4-1 (6 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)(15)	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC) (2)	Valve Position(3)				Actuator Type(4)	Actuation Signal(5)	Type(6)	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line(7)
												Nor-mal	Fail Safe	Shut-down	Acci-dent							
29	SIS division 2 miniflow return to IRWST	10 10 4	SI-301 SI-101 SI-303	50 - 20	6.3.2-1	Gate Check Globe	Borated Water	22 - -	Outside Inside Outside	In	12 (56)	C C LO	AI - AI	C C LO	C O LO	E - E	- - -	R,M - R,M	C	Yes	-	Essential
30	Return header from SI tanks	2 2 3/4	SI-682 SI-293 SI-474	5 - -	6.3.2-1	Globe Globe Relief	Borated Water	- - -	Inside Outside Inside	In	11 (55)	C LC C	C - -	O/C O/C C	C LC C	P HW -	SIAS - RV setpoint	A,R,M M -	C	Yes	-	Nonessential
31	CCW supply to letdown heat exchanger	8 8 3/4	CC-0296 CC-0297 CC-1685	40 40 -	9.2.2-1	Butterfly Butterfly Check	Deminer-alized water with corrosion inhibitors	13 - -	Outside Inside Inside	In	19 (56)	O O O	AI AI -	O O O	C C C	E E -	CIAS CIAS -	A,R,M A,R,M -	C	Yes	-	Nonessential
32	CCW return from letdown heat exchanger	8 8 3/4	CC-0301 CC-0302 CC-1686	40 40 -	9.2.2-1	Butterfly Butterfly Check	Deminer-alized water with corrosion inhibitors	- 14 -	Inside Outside Inside	Out	16 (56)	O O C	AI AI -	O O C	C C C	E E -	CIAS CIAS -	A,R,M A,R,M -	C	Yes	-	Nonessential
33	CCW supply to RCP coolers 1A, 1B, 2A, and 2B	10 10	CC-231 CC-1099	50 -	9.2.2-1	Butterfly Check	Deminer-alized water with corrosion inhibitors	38 -	Outside Inside	In	5 (56)	O O	AI -	O O	C C	E -	CCWSTLLAS -	A,R,M -	C	Yes	-	Nonessential
34	CCW return from RCP coolers 1A, 1B, 2A, and 2B	10 10 3/4	CC-0250 CC-0249 CC-1100	50 50 -	9.2.2-1	Butterfly Butterfly Check	Deminer-alized water with corrosion inhibitors	25 - -	Outside Inside Inside	Out	16 (56)	O O C	AI AI -	O O C	C C C	E E -	CCWSTLLAS CCWSTLLAS -	A,R,M A,R,M -	C	Yes	-	Nonessential
35	CVCS IRWST boron recovery return	3 3	CV-509 CV-189	5 -	9.3.4-1	Gate Check	Borated Water	3 -	Outside Inside	In	4 (56)	O/C O/C	AI -	O/C O/C	C C	E -	CIAS -	A,R,M -	C	Yes	-	Nonessential
36	Shutdown purification line to letdown heat exchanger	2 2	CV-362 CV-363	- -	9.3.4-1	Gate Check	Primary Coolant	- -	Outside Inside	In	9 (55)	LC C	- -	O/C O/C	LC C	HW -	- -	M -	C	Yes	-	Nonessential

Table 6.2.4-1 (7 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3] Nor-mal	Fail Safe	Shut-down	Acci-dent	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
37	Letdown to purification system	2 2	CV-523 CV-522	5 5	9.3.4-1	Globe[1] Globe[1]	Primary Coolant	- -	Outside Inside	Out	14 (55)	O O	C C	C C	C C	P P	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Essential
38	CVCS charging line	3 3	CV-524 CV-747	5 -	9.3.4-1	Globe Check	Primary Coolant	7 -	Outside Inside	In	5 (55)	O O	AI -	C C	O O	E -	- -	R,M -	C	Yes	-	Essential
39	RCP seal injection	2 2	CV-255 CV-835	5 -	9.3.4-1	Globe Check	Primary Coolant	- -	Outside Inside	In	5 (55)	O O	AI -	O O	O O	E -	- -	R,M -	C	Yes	-	Essential
40	RCP seal return flow	1 1	CV-505 CV-506	5 5	9.3.4-1	Globe Globe	Primary Coolant	- -	Outside Inside	Out	14 (55)	O O	C C	C C	C C	P P	CSAS CSAS	A,R,M A,R,M	C	Yes	-	Nonessential
41	RDT flow to RDPs	3 3	CV-561 CV-560	5 5	9.3.4-1	Globe[1] Globe[1]	Primary Coolant	1 -	Outside Inside	Out	17 (56)	O/C O/C	C C	O/C O/C	C C	P P	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
42	Resin sluice supply to reactor Drain Tank	1½ 1½	CV-580 CV-494	5 -	9.3.4-1	Gate[1] Check	Demi. Water	- -	Outside Inside	In	6 (56)	C C	C -	C C	C C	P -	CIAS -	A,R,M -	C	Yes	-	Nonessential
43	Service air supply	3 3	SA-001 SA-1401	15 -	9.3.1-2	Globe Check	Compressed Air	10 -	Outside Inside	In	6 (56)	C C	C -	O O	C C	P -	CIAS -	A,R,M -	C	Yes	-	Nonessential
44	Instrument air supply	2 2½	IA-020 IA-1601	15 -	9.3.1-1	Globe Check	Compresse d Air	12 -	Outside Inside	In	28 (56)	O O/C	C -	O O/C	C C	P -	CSAS -	A,R,M -	C	Yes	-	Nonessential
45	Refueling pool cleanup suction line	6 6	FC-1143 FC-1142	- -	9.1.3-1	Gate Gate	Borated Water	2 -	Outside Inside	Out	21 (56)	LC LC	- -	O/C O/C	LC LC	HW HW	- -	M M	C	Yes	-	Nonessential
46	Refueling pool cleanup return header	10 10	FC-1144 FC-1145	- -	9.1.3-1	Gate Check	Borated Water	16 -	Outside Inside	In	9 (56)	LC -	- -	O/C -	LC -	HW -	- -	M -	C	Yes	-	Nonessential
47	SIT sample line	3/4 3/4	PX-020 PX-021	15 15	9.3.2-1	Globe Globe	Borated Water	- -	Outside Inside	Out	20 (55)	C C	C C	C C	C C	S S	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
48	Pressurizer liquid sample line	3/4 3/4	PX-0003 PX-0004	15 15	9.3.2-1	Globe Globe	Primary coolant	- -	Outside Inside	Out	20 (55)	O/C O/C	C C	C C	C C	S S	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
49	Pressurizer steam space sample line	3/4 3/4	PX-0005 PX-0006	15 15	9.3.2-1	Globe Globe	Primary coolant	- -	Outside Inside	Out	20 (55)	O/C O/C	C C	C C	C C	S S	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential

Table 6.2.4-1 (8 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3]				Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
												Nor-mal	Fail Safe	Shut-down	Acci-dent							
50	Hot leg sample line	3/4 3/4	PX-0001 PX-0002	15 15	9.3.2-1	Globe Globe	Primary coolant	- -	Outside Inside	Out	20 (55)	O/C O/C	C C	C C	O/C O/C	S S	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
51	SG #1 blowdown cold leg sample	3/4	PS-0035	15	-	Gate[12]	Secondary Coolant	-	Outside	Out	26 (57)	O/C	C	C	C	P	CIAS/MSIS AFAS/HRAS	A,R,M	A	No	[9]	Nonessential
52	SG#1 blowdown hot leg sample	3/4 3/4	PS-0031 PS-0257	15 15	- -	Gate[12] Gate[12]	Secondary Coolant	- -	Outside Outside	Out	36 (57)	O O/C	C C	C C	C C	P P	CIAS/MSIS AFAS/HRAS CIAS/MSIS AFAS	A,R,M	A	No	[9]	Nonessential
53	SG #1 downcomer Sample	3/4	PS-0033	15	-	Gate[12]	Secondary Coolant	-	Outside	Out	26 (57)	O	C	C	C	P	CIAS/MSIS AFAS/HRAS	A,R,M	A	No	[9]	Nonessential
54	SG #2 blowdown cold leg sample	3/4	PS-0036	15	-	Gate[12]	Secondary Coolant	-	Outside	Out	26 (57)	O/C	C	C	C	P	CIAS/MSIS AFAS/HRAS	A,R,M	A	No	[9]	Nonessential
55	SG #2 blowdown hot leg sample	3/43 /4	PS-0032 PS-0258	1515	-	Gate[12] Gate[12]	Secondary Coolant	-	Outside Outside	Out	36 (57)	OO/ C	CC	CC	CC	PP	CIAS/MSIS AFAS/HRAS CIAS/MSIS AFAS	A,R,M	A	No	[9]	Nonessential
56	SG #2 downcomer sample	3/4	PS-0034	15	-	Gate[12]	Secondary Coolant	- -	Outside	Out	26 (57)	O	C	C	C	P	CIAS/MSIS AFAS/HRAS	A,R,M	A	No	[9]	Nonessential
57	Contain-ment high volume purge supply system	48 48	VQ-0011 VQ-0012	5 5	9.4.6-2	Butterfly[12] Butterfly[12]	Outside Air	3 -	Outside Inside	In	23 (56)	C C	C C	C C	C C	EH E	CIAS/CPIAS CIAS/CPIAS	A,R,M A,R,M	C	Yes	-	Nonessential
58	Contain-ment high volume purge exhaust system	48 48	VQ-0013 VQ-0014	5 5	9.4.6-2	Butterfly[12] Butterfly[12]	Containment Atmosphere	- 3	Inside Outside	Out	23 (56)	C C	C C	C C	C C	E EH	CIAS/CPIAS CIAS/CPIAS	A,R,M A,R,M	C	Yes	-	Nonessential
59	Contain-ment low volume purge supply system	8 8	VQ-0031 VQ-0032	5 5	9.4.6-2	Butterfly[13] Butterfly[13]	Outside Air / Containment Atmosphere	- -	Outside Inside	in	2 (56)	C C	C C	C C	C C	P P	CIAS/CPIAS CIAS/CPIAS	A,R,M A,R,M	C	Yes	-	Nonessential

Table 6.2.4-1 (9 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3] Nor-mal	Fail Safe	Shut-down	Acci-dent	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
60	Contain-ment low volume purge supply system	8 8	VQ-0033 VQ-0034	5 5	9.4.6-2	Butterfly[13] Butterfly[13]	Containment Atmosphere	- 3	Inside Outside	out	17 (56)	C C	C C	C C	C C	P P	CIAS/CPIAS CIAS/CPIAS	A,R,M A,R,M	C	Yes	-	Nonessential
61	SG #1 blowdown to blowdown flash tank	8 8	SD-0005 SD-0007	40 40	10.4.8-1	Gate Gate	Secondary Coolant	8 -	Outside Outside	Out	29 (57)	O O	C C	O O	C C	P E	MSIS/CIAS/ DPS-AFAS/ AFAS MSIS/CIAS/ DPS-AFAS /AFAS HRAS/ BFTHHLAS	A,R,M A,R,M	A	No	[9]	Nonessential
62	SG #2 blowdown to blowdown flash Tank	8 8	SD-0006 SD-0008	40 40	10.4.8-1	Gate Gate	Secondary Coolant	8 -	Outside Outside	Out	29 (57)	O O	C C	O O	C C	P E	MSIS/CIAS/ DPS-AFAS /AFAS MSIS/CIAS/ DPS-AFAS /AFAS HRAS/ BFTHHLAS	A,R,M A,R,M	A	No	[9]	Nonessential
63	SG wet layup recirculatio n return to SG #1	4 4	SD-1113 SD-1115	- -	10.4.8-1	Gate Check	Secondary Coolant	14 -	Outside Inside	In	9 (57)	LC C	- -	O/C O/C	LC C	HW -	- -	M -	C	Yes	[9]	Nonessential
64	SG wet layup recirculatio n return to SG #2	4 4	SD-1114 SD-1116	- -	10.4.8-1	Gate Check	Secondary Coolant	8 -	Outside Inside	In	9 (57)	L/C O	- -	O/C O/C	LC C	HW -	- -	M -	C	Yes	[9]	Nonessential
65	Fire Protection water supply to containment Line #2	6 6	FP-0030 FP–1440	30 -	9.5.1-1	Globe[12] Check	Fresh water	- -		In	28 (56)	O O	C -	C C	C C	P -	CIAS -	A,R,M -	C	Yes	[14]	Nonessential
67	PCW supply to containment ventilation units	12 12	WI-0013 WI-1043	50 -	9.2-7-2	Gate[12] Check	Chilled water	6 -	Outside Inside	In	28 (56)	O O	C -	O O	C C	P -	CIAS -	A,R,M -	C	Yes	[14]	Nonessential

Table 6.2.4-1 (10 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3] Nor-mal	Fail Saf e	Shut-down	Acci-dent	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
68	PCW return from containment ventilation units	12 12 -	WI-0012 WI-0015 WI-0014	50 50 -	9.2.7-2	Gate[12] Gate[12] Relief	Chilled water	4 - -	Outside Inside Inside	Out	33 (56)	O O C	C AI -	O O C	C C C	P E -	CIAS CIAS RV setpoint	A,R,M A,R,M -	C	Yes	[14]	Nonessential
69	Containment radiation monitor (inlet)	3/4 3/4	PR-432 PR-431	15 15	-	Gate[12] Gate[12]	Containment Atmosphere	- -	Outside Inside	Out	24 (56)	O O	AI AI	O O	C C	E E	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
70	Containment radiation monitor (outlet)	3/4 3/4	PR-434 PR-1433	15 -	-	Gate[12] Check	Containment Atmosphere	- -	Outside Inside	In	5 (56)	O O	AI -	O O	C C	E -	CIAS -	A,R,M -	C	Yes	-	Nonessential
71	Containment pressure sensing line	3/4 3/4 3/4 3/4 3/4 3/4	CM-17 CM-18 CM-19 CM-20 CM-21 CM-22	OPEN OPEN OPEN OPEN OPEN OPEN	-	Globe Globe Globe Globe Globe Globe	Containment Atmosphere	- - - - - -	Outside Outside Outside Outside Outside Outside	Out Out Out Out Out Out	13 (56)	O O O O O O	O O O O O O	O O O O O O	O O O O O O	S S S S S S	- - - -	R,M R,M R,M R,M R,M R,M	C	Yes	-	Essential
72	Demi. water	2 2	WM-1751 WM-1752	- -	9.2.3-1	Globe Check	Demi. water	- -	Outside Inside	In	9 (56)	C C	- -	C C	C C	HW -	- -	M -	C	Yes	-	Nonessential
73	Nitrogen supply to safety injection tanks and RDT	1 1	NT-0004 NT-1016	15 -	-	Globe[)] Check	Nitrogen Gas	- -	Outside Inside	In	28 (55)	O O/C	C -	O O/C	C C	P -	CIAS -	A,R,M -	C	Yes	-	Nonessential
74	Containment air sample	1/2 1/2	PX-0041 PX-0042	15 15	9.3.2-1	Gate Gate	Containment Atmosphere	- -	Inside Outside	Out	22 (56)	C C	A1 A1	C C	O/C O/C	E E	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
75	Containment drain sump pump discharge line	4 4	DE-0006 DE-0005	20 20	9.3.3-1	Globe Globe	Primary Coolant	- -	Outside Inside	Out	27 (56)	O O	C AI	O O	C C	P E	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential
76	Containment air sample	1/2 1/2	PX-0043 PX-1020	15 -	9.3.2-1	Gate Check	Containment Atmosphere	- -	Outside Inside	In	4 (56)	C C	A1 -	C C	O/C O/C	E -	CIAS -	A,R,M -	C	Yes	-	Nonessential
77	Reactor drain tank gas space to GWMS	1 1	GW-0002 GW-0001	15 15	11.3-1	Globe Globe	Gas	- -	Outside Inside	In/Out	30 (56)	O O	C AI	O O	C C	S E	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Nonessential

Table 6.2.4-1 (11 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Containment	Flow Direction Relative to Containment	Valve Arrangement (GDC)[2]	Valve Position[3] Normal	Fail Safe	Shutdown	Accident	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justification for Not Testing	Essential/ Nonessential Line[7]
78	Sample return to containment	3/4 3/4	PX-0053 PX-1005	15 -	9.3.2-1	Globe Check	Borated Water	- -	Outside Inside	In	25 (56)	C C	C -	C -	O/C O/C	S -	CIAS -	A,R,M -	C	Yes	-	Nonessential
79	Non-condensible gas exhaust to containment	6 6	CA-0013 CA-1023	30 -	10.4.2-1	Gate Check	Inleakage Air	19 -	Outside Inside	In	4 (56)	C C	AI -	C C	O/C O/C	E -	CIAS -	A,R,M	C	Yes	-	Nonessential
80	Channel A containment monitor suction from Containment	1/2 1/2 1/2	CM-001 CM-003 CM-023	15 15 15	-	Globe Globe Globe	Containment Atmosphere (Combustible Gas)	- - -	Inside Outside Inside	Out	35 (56)	C C C	C C C	C C C	O/C O/C O/C	S S S	CIAS CIAS CIAS	A,R,M A,R,M A,R,M	C C C	Yes Yes Yes	-	Essential
81	Channel A containment monitor discharge to containment	1/2 1/2	CM-009 CM-1013	15 -	-	Globe Check	Containment Atmosphere (Combustible Gas)	- -	Outside Inside	In	25 (56)	C C	C -	C C	O/C O/C	S -	CIAS -	A,R,M -	C	Yes	-	Essential
82	Channel B containment monitor suction from containment	1/2 1/2 1/2	CM-002 CM-004 CM-024	15 15 15	-	Globe Globe Globe	Containment Atmosphere (Combustible Gas)	- - -	Inside Outside Inside	Out	35 (56)	C C C	C C C	C C C	O/C O/C O/C	S S S	CIAS CIAS CIAS	A,R,M A,R,M A,R,M	C C C	Yes Yes Yes	-	Essential
84	Channel A IRWST monitor Suction from IRWST	1/2 1/2	CM-011 CM-013	15 15	-	Globe Globe	Containment Atmosphere (Combustible Gas)	- -	Inside Outside	Out	20 (56)	C C	C C	C C	O/C O/C	S S	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Essential
85	Channel B IRWST monitor suction IRWST	1/2 1/2	CM-012 CM-014	15 15	-	Globe Globe	Containment Atmosphere (Combustible Gas)	- -	Inside Outside	Out	20 (56)	C C	C C	C C	O/C O/C	S S	CIAS CIAS	A,R,M A,R,M	C	Yes	-	Essential
86	IRWST to boric acid makeup pump	4 4	IW-005 IW-006	20 20	6.8-3	Gate Gate	Borated Water	19 -	Outside Outside	Out	31 (56)	O/C	A1	O/C	O/C	E	CIAS CIAS	A,R,M A,R,M	A	No	[11]	Nonessential
87	Auxiliary steam supply	2 ½ 2 ½	AS-1016 AS-1017	N/A N/A	-	Globe Globe	Steam	8 -	Outside Inside	In	21 (56)	C C	C C	C C	C C	HW HW	-	M M	C	Yes	-	Nonessential
88	ECSBS supply line	6 6	CS-1013 CS-1014	- -	6.2.2-1	Gate Check	Air	14 -	Outside Inside	In	9 (56)	LC C	- -	LC C	O/C O/C	- -	- -	M -	C	Yes	-	Nonessential

Table 6.2.4-1 (12 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Containment	Flow Direction Relative to Containment	Valve Arrangement (GDC)[2]	Valve Position[3] Normal	Fail Safe	Shutdown	Accident	Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justification for Not Testing	Essential/ Nonessential Line[7]
89	IRWST level instrument upper tap isolation	1 1 1 1	IW-010 IW-022 IW-024 IW-026	15 15 15 15	6.8-3	Globe Globe Globe Globe	Borated Water	- - - -	Outside Outside Outside Outside	Out	13 (56)	O O O O	O O O O	O O O O	O O O O	S S S S	- - - -	R,M R,M R,M R,M	C	Yes	-	Essential
90	IRWST level instrument lower tap isolation	1 1 1 1	IW-011 IW-023 IW-025 IW-027	15 15 15 15	6.8-3	Globe Globe Globe Globe	Borated Water	- - - -	Outside Outside Outside Outside	Out	13 (56)	O O O O	O O O O	O O O O	O O O O	S S S S	- - - -	R,M R,M R,M R,M	C	No	Note 11	Essential
91	HVT Level Instrument isolation	1 1 1 1 1 1 1 1 1 1	IW-012 IW-013 IW-014 IW-015 IW-016 IW-017 IW-028 IW-029 IW-030 IW-031	15 15 15 15 15 15 15 15 15 15	6.8-3	Globe Globe Globe Globe Globe Globe Globe Globe Globe Globe	Borated Water	- - - - - - - - - -	Outside Outside Outside Outside Outside Outside Outside Outside Outside Outside	Out	13 (56)	O O O O O O O O O O	O O O O O O O O O O	O O O O O O O O O O	O O O O O O O O O O	S S S S S S S S S S	- - - - - - - - - -	R,M R,M R,M R,M R,M R,M R,M R,M R,M R,M	C	Yes	-	Essential
92	Reactor cavity instrument isolation	1 1 1 1 1 1 1 1 1	IW-018 IW-019 IW-020 IW-021 IW-032 IW-033 IW-034 IW-035	15 15 15 15 15 15 15 15	6.8-3	Globe Globe Globe Globe Globe Globe Globe Globe	Borated Water	- - - - - - - -	Outside Outside Outside Outside Outside Outside Outside Outside	Out	13 (56)	O O O O O O O O	O O O O O O O O	O O O O O O O O	O O O O O O O O	S S S S S S S S	- - - - - - - -	R,M R,M R,M R,M R,M R,M R,M R,M	C	Yes	-	Essential
93	Fuel Transfer Tube	-	-	-	-	Flange	-	-	-	-	37(-)	C	-	C	C	-	-	M	B	No	-	-
94	Personnel airlock	-	-	-	-	-	-	-	-	-	38(-)	-	-	-	-	-	-	-	B	No	-	-
95	Equip. Hatch	-	-	-	-	-	-	-	-	-	39(-)	-	-	-	-	-	-	-	B	No	-	-
96	(Electric)	_	EC3-001	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
97	(Electric)	_	EC3-002	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
98	(Electric)	_	EC3-003	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
99	(Electric)	_	EC3-004	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
100	(Electric)	_	EC3-005	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
101	(Electric)	_	EC3-006	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_

Table 6.2.4-1 (13 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3]				Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
												Nor-mal	Fail Safe	Shut-down	Acci-dent							
102	(Electric)	_	EC3-007	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
103	(Electric)	_	EC3-008	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
104	(Electric)	_	EC3-009	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
105	(Electric)	_	EC3-010	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
106	(Electric)	_	EC3-011	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
107	(Electric)	_	EC3-012	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
108	(Electric)	_	EC3-013	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
109	(Electric)	_	EC3-014	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
110	(Electric)	_	EC3-015	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
111	(Electric)	_	EC3-016	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
112	(Electric)	_	EC3-017	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
113	(Electric)	_	EC3-018	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
114	(Electric)	_	EC3-019	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
115	(Electric)	_	EC3-020	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
116	(Electric)	_	EC3-021	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
117	(Electric)	_	EC3-022	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
118	(Electric)	_	EC4-001	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
119	(Electric)	_	EC4-002	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
120	(Electric)	_	EC4-003	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
121	(Electric)	_	EC4-004	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
122	(Electric)	_	EC4-005	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
123	(Electric)	_	EC4-006	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
124	(Electric)	_	EC4-007	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
125	(Electric)	_	EC4-008	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
126	(Electric)	_	EC4-009	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
127	(Electric)	_	EC4-010	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
128	(Electric)	_	EC4-011	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
129	(Electric)	_	EC4-012	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
130	(Electric)	_	EC4-013	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
131	(Electric)	_	EC4-014	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
132	(Electric)	_	EC4-015	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
133	(Electric)	_	EC4-016	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_

Table 6.2.4-1 (14 of 15)

Item No.	Service	Line Size (in)	Valve No.	Closure Time (sec)	Figure No.	Valve Type	Fluid	Length of Pipe(ft)[15]	Location Relative to Contain-ment	Flow Direction Relative to Contain-ment	Valve Arrange-ment (GDC)[2]	Valve Position[3]				Actuator Type[4]	Actuation Signal[5]	Type[6]	Type Test	Type-C Test	Justifi-cation for Not Testing	Essential/ Nonessential Line[7]
												Nor-mal	Fail Safe	Shut-down	Acci-dent							
134	(Electric)	_	EC4-017	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
135	(Electric)	_	EC4-018	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
136	(Electric)	_	EC4-019	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
137	(Electric)	_	EC4-020	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
138	(Electric)	_	EC4-021	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
139	(Electric)	_	EC4-022	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
140	(Electric)	_	EC4-023	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
141	(Electric)	_	EC4-024	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
142	(Electric)	_	EC4-025	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
143	(Electric)	_	EC4-026	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
144	(Electric)	_	EC4-027	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
145	(Electric)	_	EC4-028	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
146	(Electric)	_	EC4-029	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
147	(Electric)	_	EC4-030	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
148	(Electric)	_	EC4-031	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
149	(Electric)	_	EC4-032	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
150	(Electric)	_	EC4-033	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
151	(Electric)	_	EC4-034	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
152	(Electric)	_	EC4-035	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
153	(Electric)	_	EC4-036	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
154	(Electric)	_	EC4-037	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
155	(Electric)	_	EC4-038	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
156	(Electric)	_	EC4-039	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
157	(Electric)	_	EC4-040	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
158	(Electric)	_	EC4-041	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
159	(Electric)	_	EC4-042	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
160	(Electric)	_	EC4-043	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_
161	(Electric)	_	EC4-044	_	_	_	_	_	_	_	40(-)	_	_	_	_	_	_	_	B	No	_	_

Table 6.2.4-1 (15 of 15)

(1) Valve closure time is established based on system considerations, but all valves stroke to their designated position upon actuation as soon as practicable. An upper limit of 60 seconds as shown in the table is used in stroke time determination except for the low volume purge system supply and exhaust valves, which are required to close in 30 seconds per Subsection 15.6.5.2. Valve closure time is shown for these valves, which receive a CIAS. CIAS signal generation time is not included in the valve closure times shown in this table.

(2) Valve arrangements are shown in Figure 6.2.4-1.

(3) Valve position abbreviations

O – Open C - Closed

O/C – Open or Closed LO - Locked Open#

LC – Locked Closed# AI - Fails-As-Is

If other than handwheel-operated manual valve, valve actuator operability is controlled by administrative means(e.g., removing actuator power, air supply, using key-controlled switch).

(4) Actuator type abbreviations

E – motor operated (electric powered)

P – pneumatically operated (compressed air powered), except as qualified by Note 13

HW – manual handwheel operated

S – solenoid operator

EH – electro hydraulic operated

(5) Definition of actuation signals

CIAS – containment isolation actuation signal

DPS AFAS – diverse protection system auxiliary feedwater actuation signal

HRAS – high radiation actuation signal

HHAS – high humidity actuation signal

SIAS – safety injection actuation signal

CSAS – containment spray actuation signal

MSIS – main steam isolation signal

BFTHHLAS – blowdown flash tank high-high level actuation signal

CCWSTLLAS – component cooling water surge tank low low level actuation signal

CPIAS – containment purge isolation actuation signal

All of above signals are engineered safety feature (ESF) signals and classified as ESF valves except HRAS, HHAS, CCWLLSTAS, BFTHHLAS, and DPS AFAS.

(6) Abbreviations for actuation signal types

A – automatically initiated

R – remotely initiated

M – manually initiated

(7) Essential lines are lines that are required for safe shut down of the reactor or to mitigate the consequences of an accident. Nonessential lines are either be locked closed through manual valves or automatically isolated upon a CIAS or approved automatic signal unless the line is provided with a regulatory exemption.

(8) Main steam isolation valves are piston-operated, using process fluid.

(9) The main steam, main feedwater, auxiliary feedwater, sample and blowdown lines are all connected to the secondary side of the steam generator, which is kept at a higher pressure than the primary side soon after a LOCA occurs. Any leakage between the primary and secondary sides of the steam generators is directed inward to the containment. Refer to Table 3.9-15 for qualitative in-service leakage testing to periodically access valve degradation.

(10) The shutdown cooling system (SCS), which functions to remove reactor decay heat during shutdown, are operated during Type-A tests to maintain the unit in a safe condition.

(11) An effective fluid seal on these penetrations is provided by the IRWST (in-containment refueling water storage tank).

(12) Maximum valve closure time on CIAS is 60 sec.

(13) Maximum valve closure time on CIAS is 30 sec.

(14) The fire protection system (FP) and plant chilled water system (WI) are operated during Type-A tests to supply chilled water for containment fan cooler (RCFC) and fire protection.

(15) The value is the length of pipe from containment to outermost isolation valve (or the maximum length that is not exceeded in further design).

Table 6.2.5-1 (1 of 2)

Location of PARs and HIs

HMS No.	Location	Type	Elevation	Azimuth Angle (°)	Radius	
					m	ft
P1	IRWST vent stack area	Middle	97 ft 0 in	345.7	18.75	61 ft 6 in
P2	IRWST vent stack area	Middle	97 ft 0 in	227.3	19.66	64 ft 6 in
P3	IRWST vent stack area	Middle	97 ft 0 in	53.7	18.72	61 ft 5 in
P4	IRWST vent stack area	Middle	97 ft 0 in	162	18.44	60 ft 6 in
P5	In-core instrument tube chase	Small	120 ft 0 in	62.5	7.11	23 ft 4 in
P6	Cavity upper chamber room	Small	95 ft 0 in	94.9	7.95	26 ft 1 in
P7	Regenerative heat exchanger room	Small	146 ft 0 in	97.5	14.45	47 ft 5 in
P8	Pressurizer compartment	Small	194 ft 6 in	116.1	14.40	47 ft 3 in
P9	Pathway between annular and lower compartments (El. 100 ft)	Middle	102 ft 0 in	36	18.62	61 ft 1 in
P10	Pathway between annular and lower compartments (El. 100 ft)	Middle	102 ft 0 in	210	16.61	54 ft 6 in
P11	Pathway between annular and lower compartments (El. 114 ft)	Middle	116 ft 0 in	9.9	16.61	54 ft 6 in
P12	Pathway between annular and lower compartments (El. 114 ft)	Middle	116 ft 0 in	197.5	16.61	54 ft 6 in
P13	Pathway between annular and lower compartments (El. 136.5 ft)	Middle	138 ft 6 in	100	16.61	54 ft 6 in
P14	Pathway between annular and lower compartments (El. 136.5 ft)	Middle	138 ft 6 in	282.2	16.25	53 ft 4 in
P15	Steam generator room (El. 136.5 ft)	Large	147 ft 0 in	347.5	14.45	47 ft 5 in
P16	Steam generator room (El. 136.5 ft)	Large	147 ft 0 in	170	14.45	47 ft 5 in
P17	Steam generator room (El. 188.0 ft)	Large	182 ft 0 in	24.6	14.45	47 ft 4 in

Table 6.2.5-1 (2 of 2)

HMS No.	Location	Type	Elevation (ft)	Azimuth Angle (°)	Radius	
					m	ft
P18	Steam generator room (El. 188.0 ft)	Large	182 ft 0 in	155.4	14.45	47 ft 4 in
P19	Upper compartment	Large	185 ft 3 in	314	22.38	73 ft 5 in
P20	Upper compartment	Large	185 ft 3 in	46	22.38	73 ft 5 in
P21	Upper compartment	Large	185 ft 3 in	134	22.38	73 ft 5 in
P22	Upper compartment	Large	185 ft 3 in	217	22.38	73 ft 5 in
P23	Containment dome area	Large	270 ft 5 in	0.	22.07	72 ft 5 in
P24	Containment dome area	Large	270 ft 5 in	45	22.07	72 ft 5 in
P25	Containment dome area	Large	270 ft 5 in	90	22.07	72 ft 5 in
P26	Containment dome area	Large	270 ft 5 in	135	22.07	72 ft 5 in
P27	Containment dome area	Large	270 ft 5 in	180	22.07	72 ft 5 in
P28	Containment dome area	Large	270 ft 5 in	225	22.07	72 ft 5 in
P29	Containment dome area	Large	270 ft 5 in	270	22.07	72 ft 5 in
P30	Containment dome area	Large	270 ft 5 in	315	22.07	72 ft 5 in
I1	Cavity access area	Glow plug	100 ft 0 in	94	13.00	42 ft 8 in
I2	Steam generator room (El. 156 ft)	Glow plug	163 ft 6 in	345.5	14.94	49 ft
I3	Steam generator room (El. 156 ft)	Glow plug	163 ft 6 in	12.5	14.94	49 ft
I4	Steam generator room (El. 156 ft)	Glow plug	163 ft 6 in	167.5	14.94	49 ft
I5	Steam generator room (El. 156 ft)	Glow plug	163 ft 6 in	194.5	14.94	49 ft
I6	Compartment below regenerative heat exchanger room	Glow plug	119 ft 0 in	104.2	14.94	49 ft 0 in
I7	Pressurizer compartment	Glow plug	153 ft 0 in	137.8	14.65	48 ft 1 in
I8	Pressurizer compartment	Glow plug	153 ft 0 in	116.7	12.88	42 ft 3 in

Table 6.2.5-2 (1 of 6)

Hydrogen Monitoring System Failure Modes and Effects Analysis

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
1. Channel A containment monitor suction from containment CM-001 CM-003 CM-0023	a) Fails to open on demand	Detection of hydrogen in containment building	• No safety-related impact on plant • Isolation is achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-002, 004, 024).	• Normally closed • Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line is formed in the closed loop.		H_2 monitoring line is formed in the closed loop.	

Table 6.2.5-2 (2 of 6)

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
2. Channel A containment monitor suction from containment CM-011 CM-013	a) Fails to open on demand	Detection of hydrogen in IRWST	No safety-related impact on plant Isolation achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-012, 014).	• Normally closed • Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line formed in the closed loop		H_2 monitoring line is formed in the closed loop.	

Table 6.2.5-2 (3 of 6)

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
3. Channel A containment monitor discharge to containment CM-009	a) Fails to open on demand	Detection of hydrogen in containment building	• No safety-related impact on plant • Isolation is achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-010)	Normally closed Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line is formed in the closed loop		H_2 monitoring line is formed in the closed loop	

Table 6.2.5-2 (4 of 6)

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
4. Channel B containment monitor suction from containment CM-002 CM-004 CM-0024	a) Fails to open on demand	Detection of hydrogen in containment building	• No safety-related impact on plant • Isolation is achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-001, 003, 023)	• Normally closed • Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line is formed in the closed loop		H_2 monitoring line is formed in the closed loop	

Table 6.2.5-2 (5 of 6)

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
5. Channel B containment monitor suction from containment CM-012 CM-014	a) Fails to open on demand	Detection of hydrogen in IRWST	• No safety-related impact on plant • Isolation is achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-011, 013)	• Normally closed • Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line is formed in the closed loop		H_2 monitoring line is formed in the closed loop.	

Table 6.2.5-2 (6 of 6)

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
6. Channel B containment monitor discharge to containment CM-010	a) Fails to open on demand	Detection of hydrogen in containment building	• No safety-related impact on plant • Isolation is achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-009)	• Normally closed • Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line is formed in the closed loop		H_2 monitoring line is formed in the closed loop	

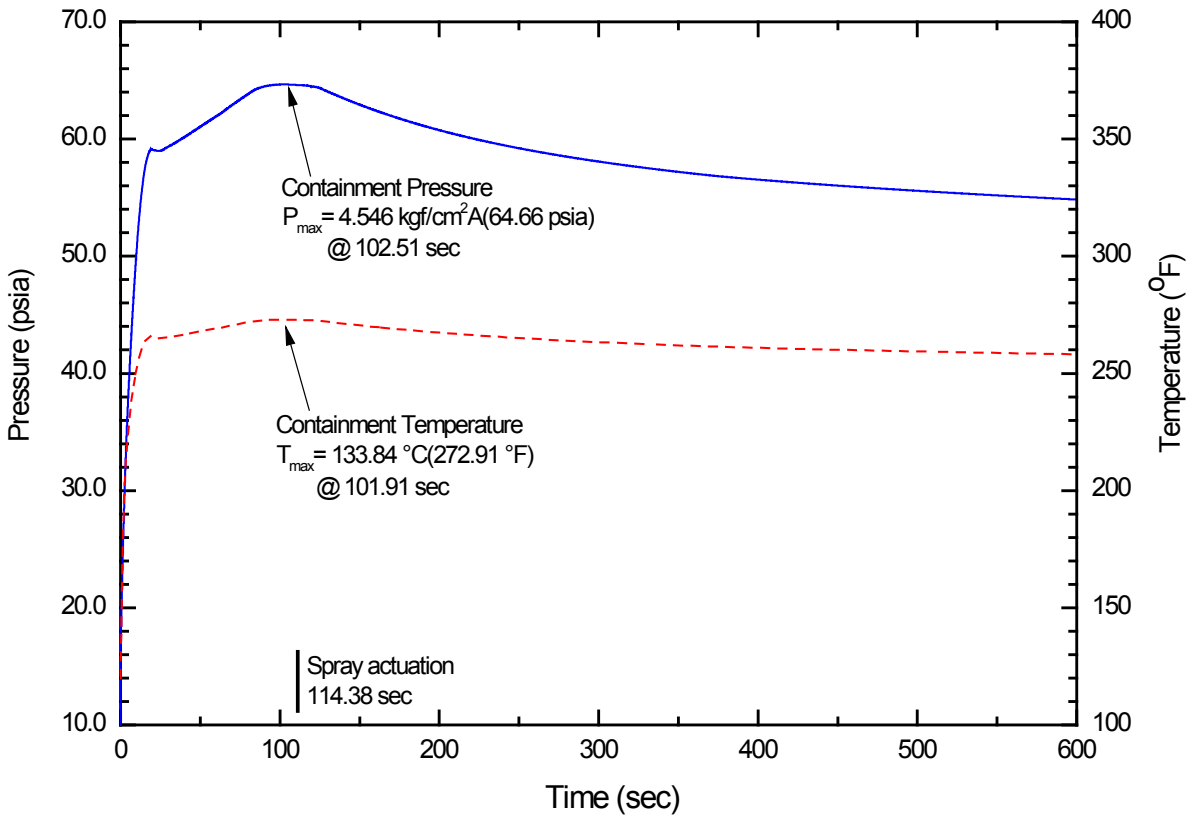


Figure 6.2.1-1 Containment Pressure and Temperature vs. Time; LOCA – DESLSB with Maximum SI Flow (1 of 2)

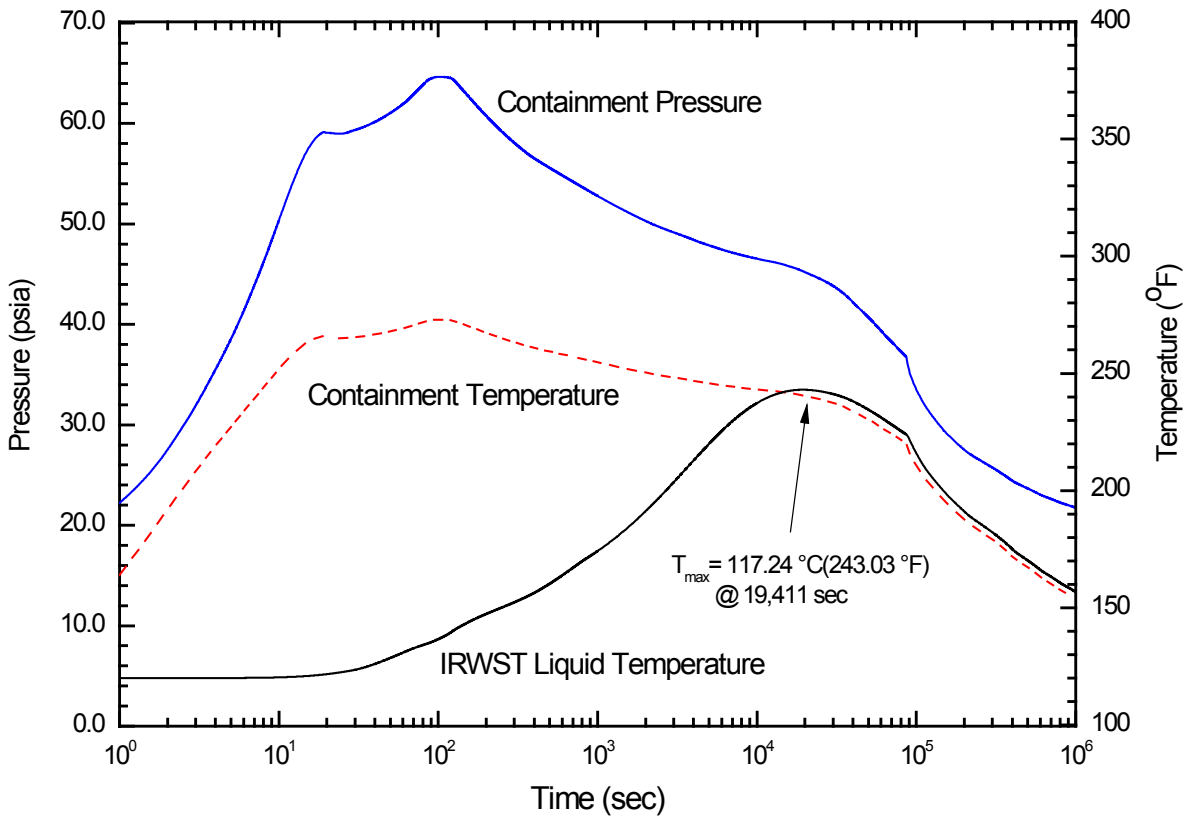


Figure 6.2.1-1 Containment Pressure and Temperature vs. Time; LOCA – DESLSB with Maximum SI Flow (Long term) (2 of 2)

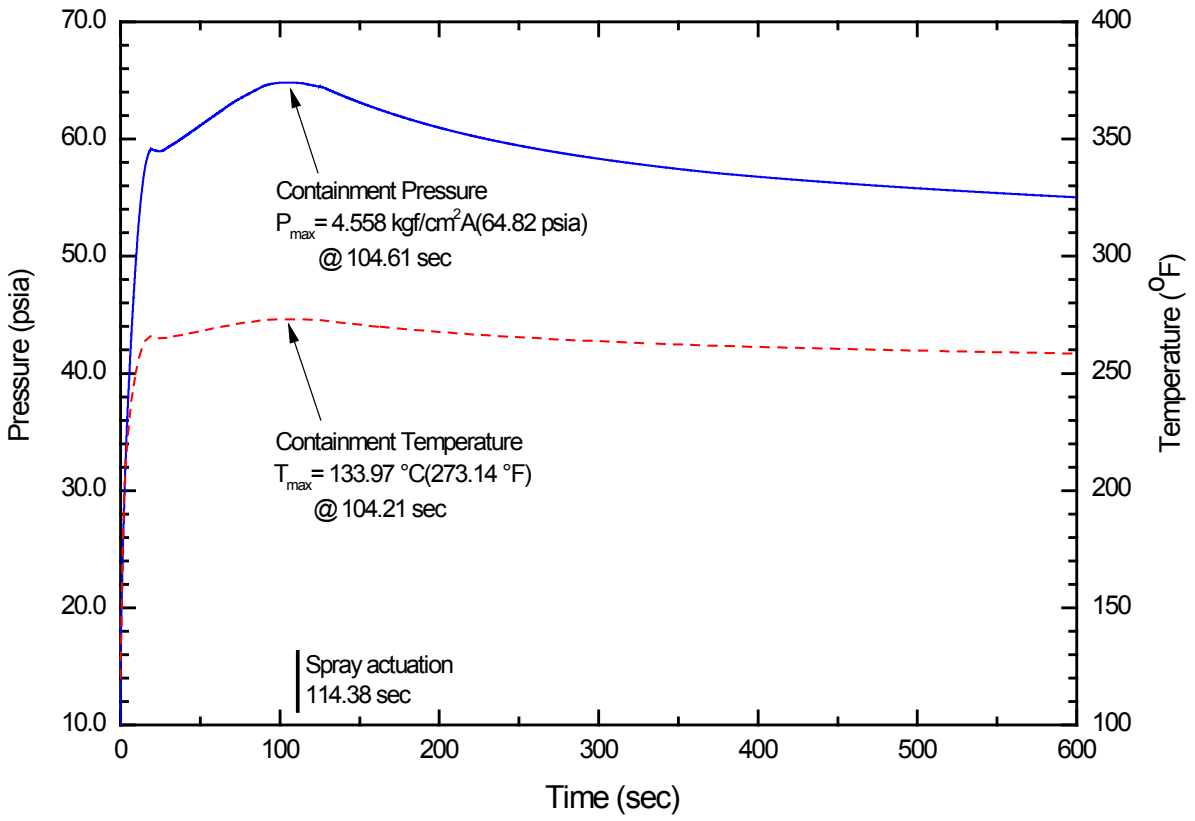


Figure 6.2.1-2 Containment Pressure and Temperature vs. Time; LOCA – DESLSB with Minimum SI Flow (1 of 2)

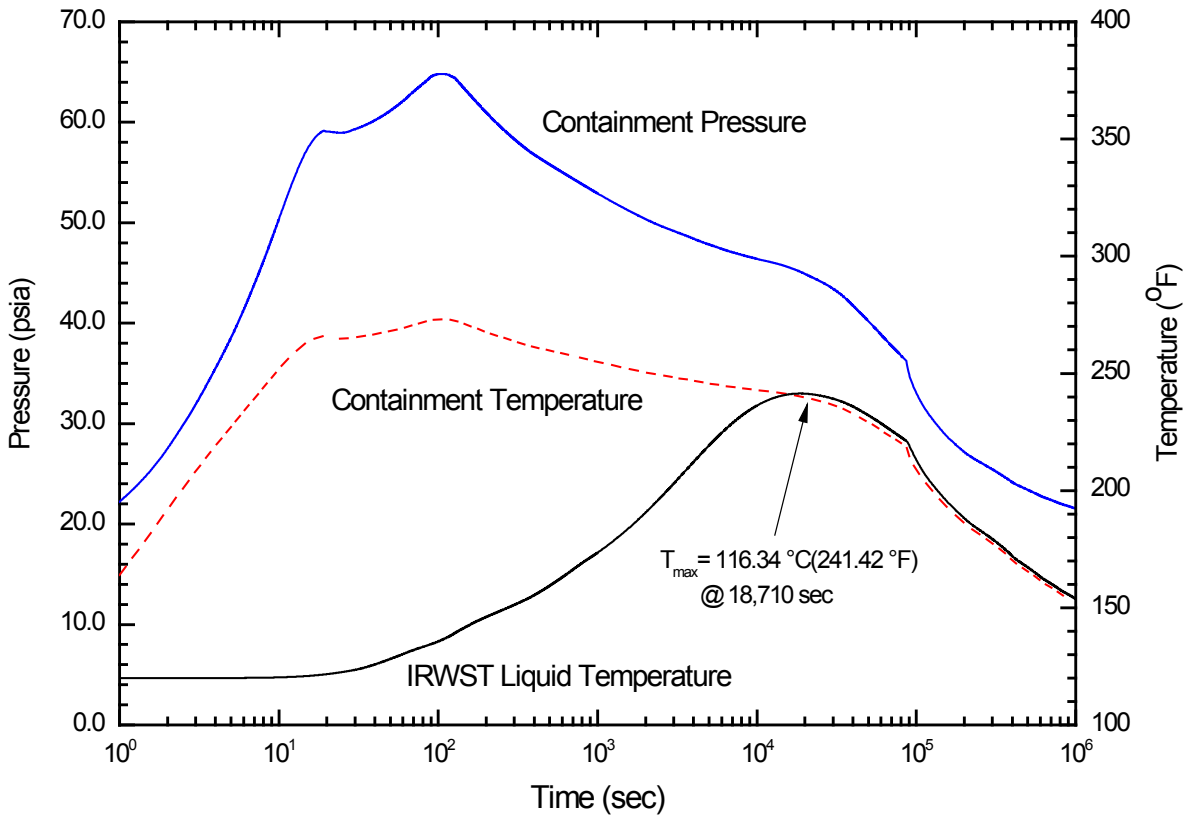


Figure 6.2.1-2 Containment Pressure and Temperature vs. Time; LOCA – DESLSB with Minimum SI Flow (Long term) (2 of 2)

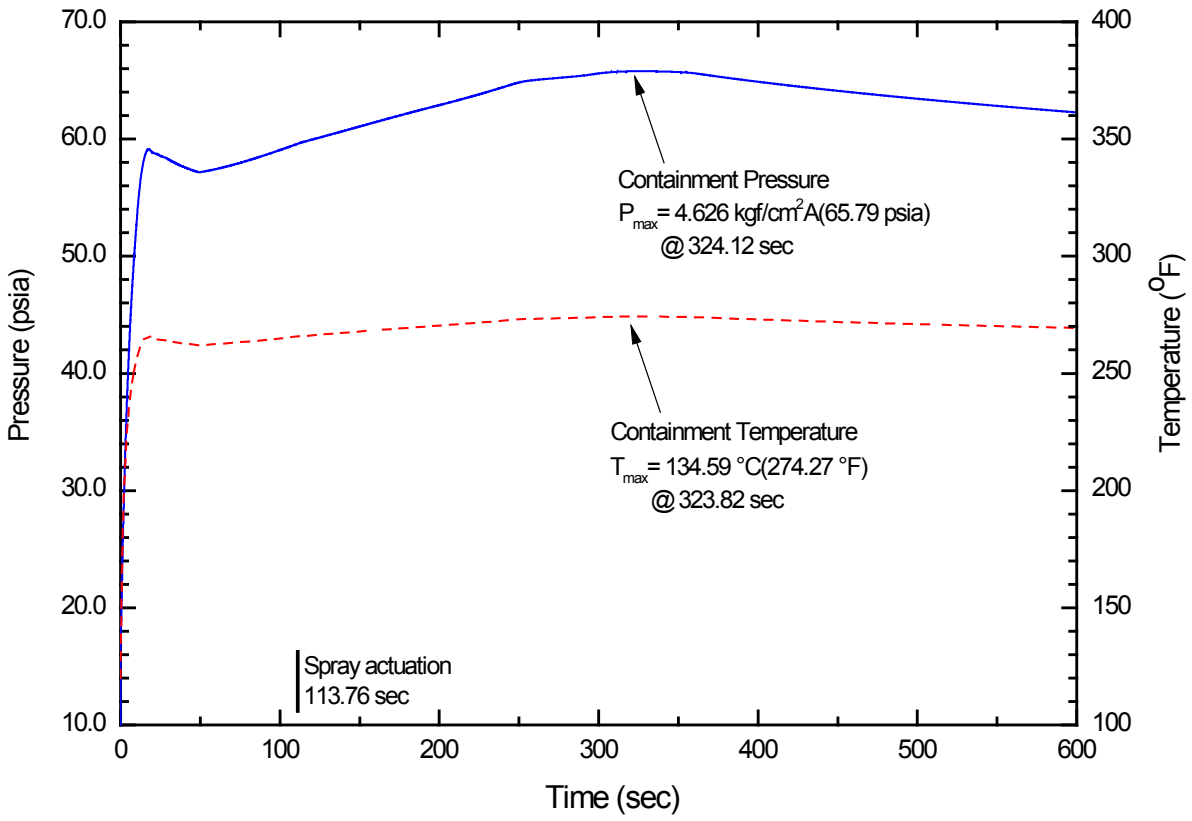


Figure 6.2.1-3 Containment Pressure and Temperature vs. Time; LOCA – DEDLSB with Maximum SI Flow (1 of 2)

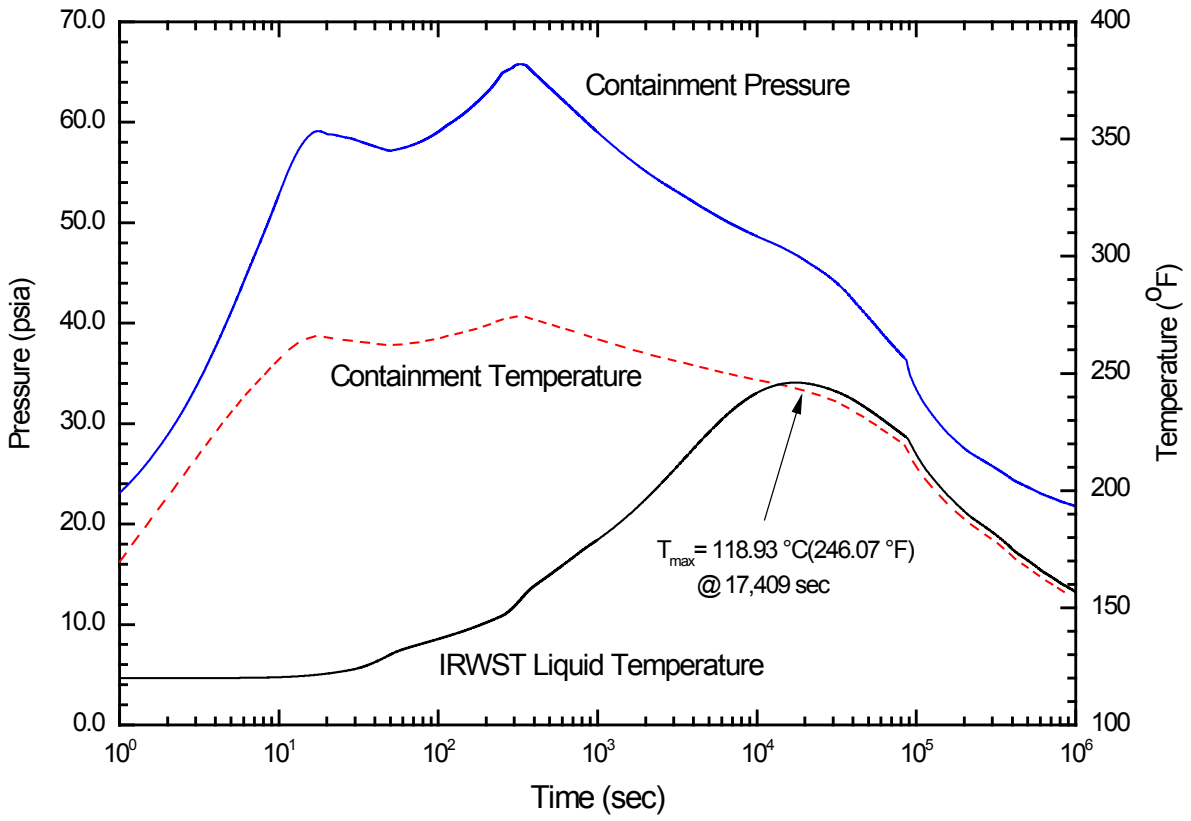


Figure 6.2.1-3 Containment Pressure and Temperature vs. Time; LOCA – DEDLSB with Maximum SI Flow (Long term) (2 of 2)

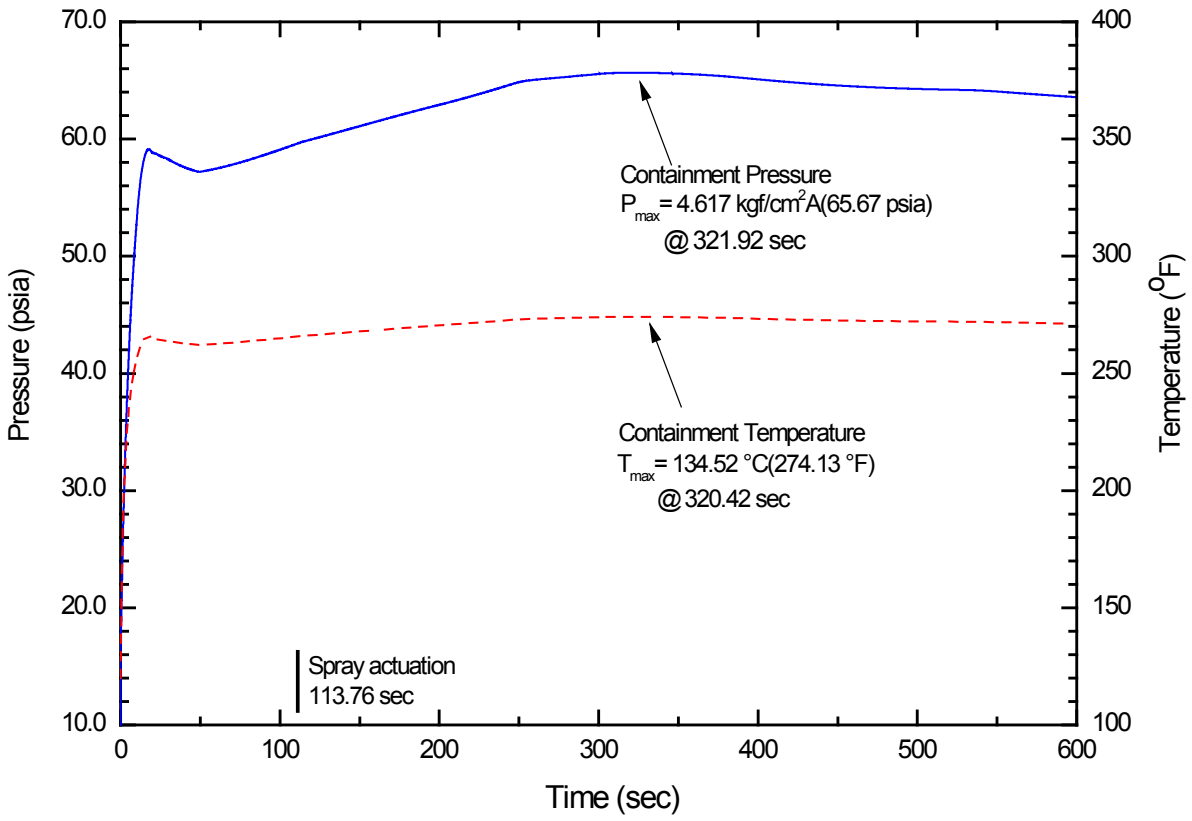


Figure 6.2.1-4 Containment Pressure and Temperature vs. Time; LOCA – DEDLSB with Minimum SI Flow (1 of 2)

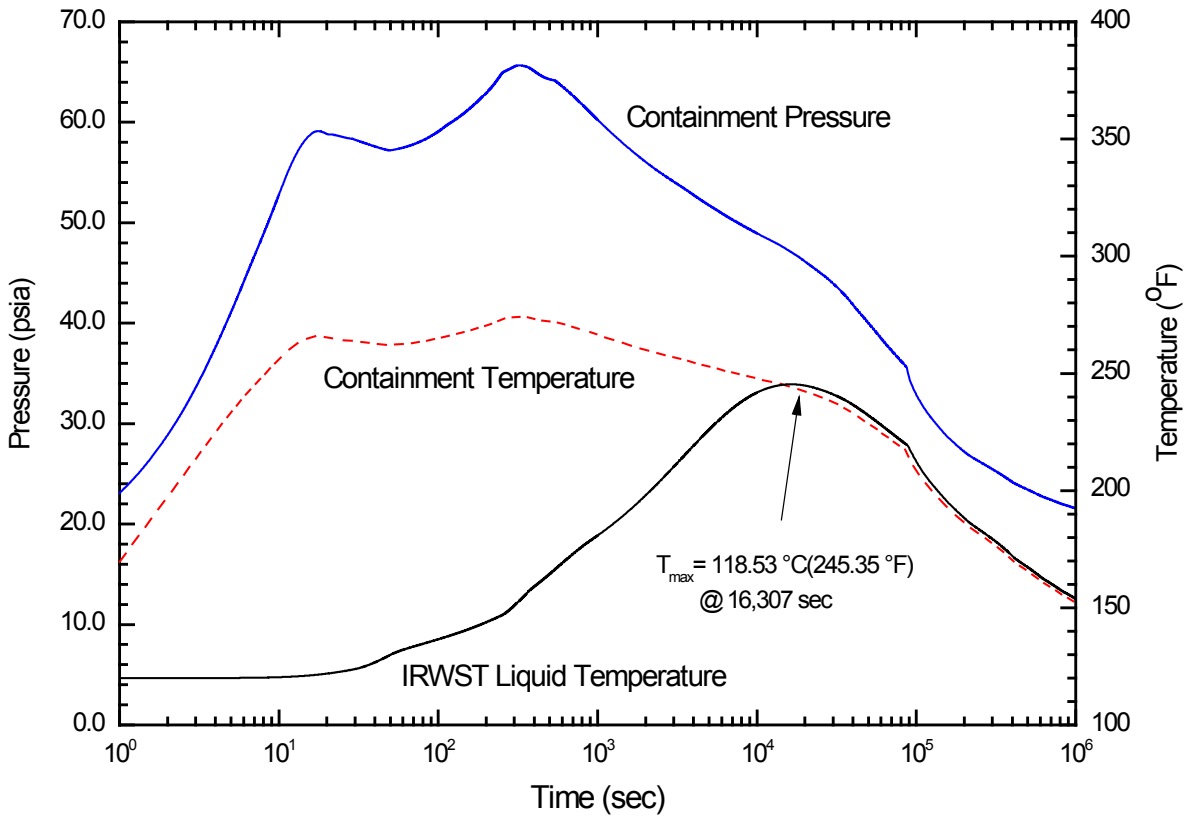


Figure 6.2.1-4 Containment Pressure and Temperature vs. Time; LOCA – DEDLSB with Minimum SI Flow (Long term) (2 of 2)

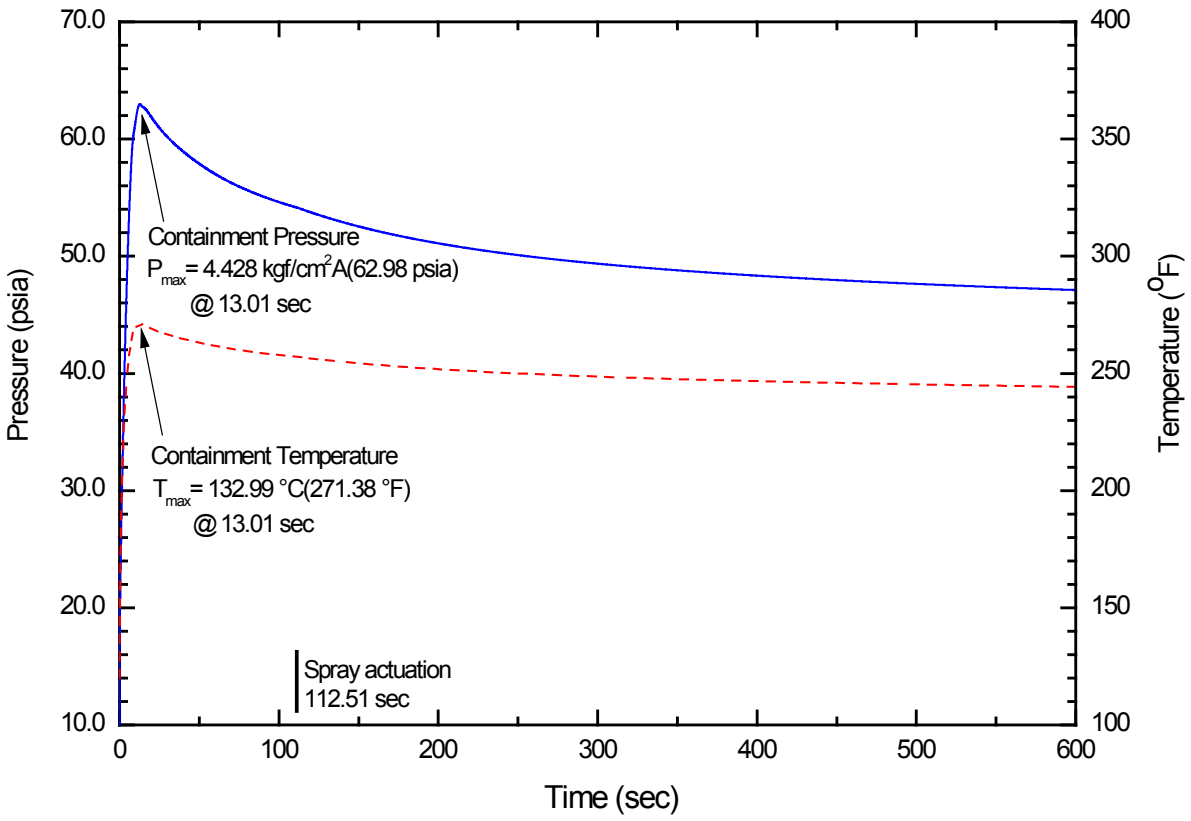


Figure 6.2.1-5 Containment Pressure and Temperature vs. Time; LOCA – DEHLSB (1 of 2)

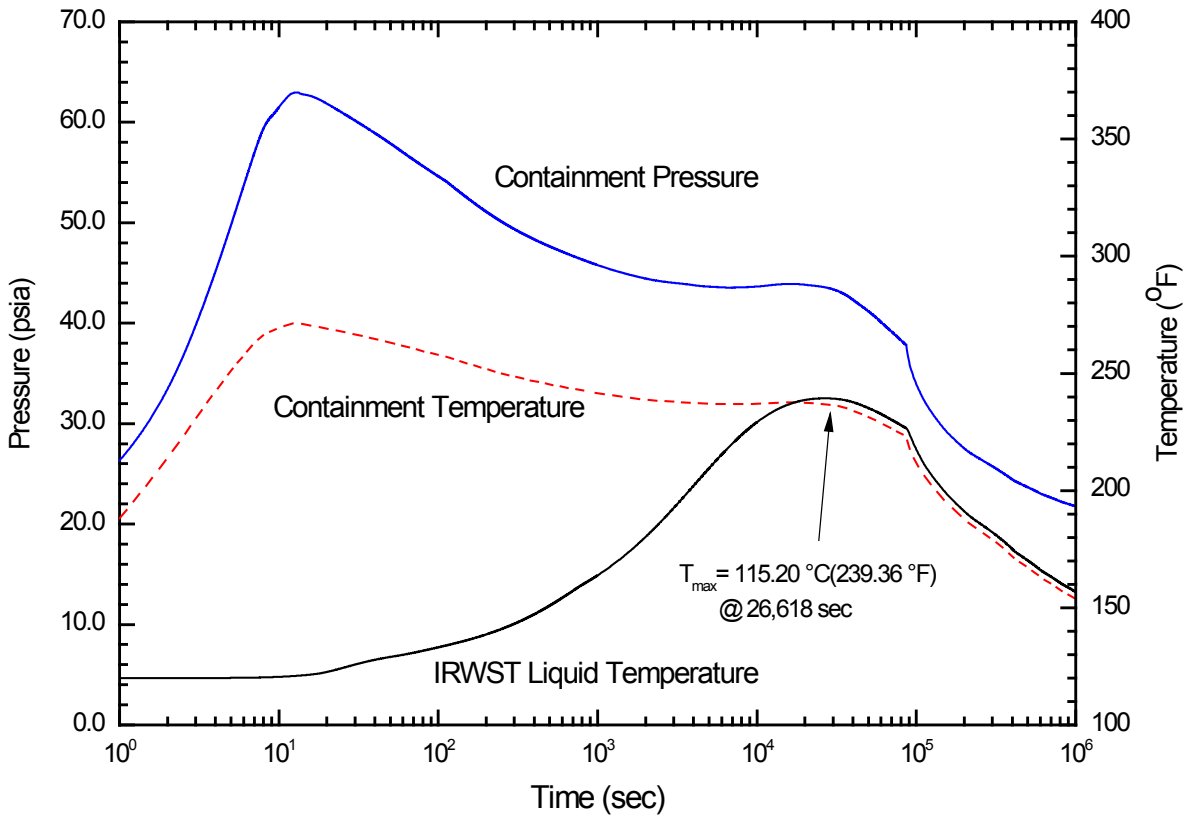


Figure 6.2.1-5 Containment Pressure and Temperature vs. Time; LOCA – DEHLSB (Long term) (2 of 2)

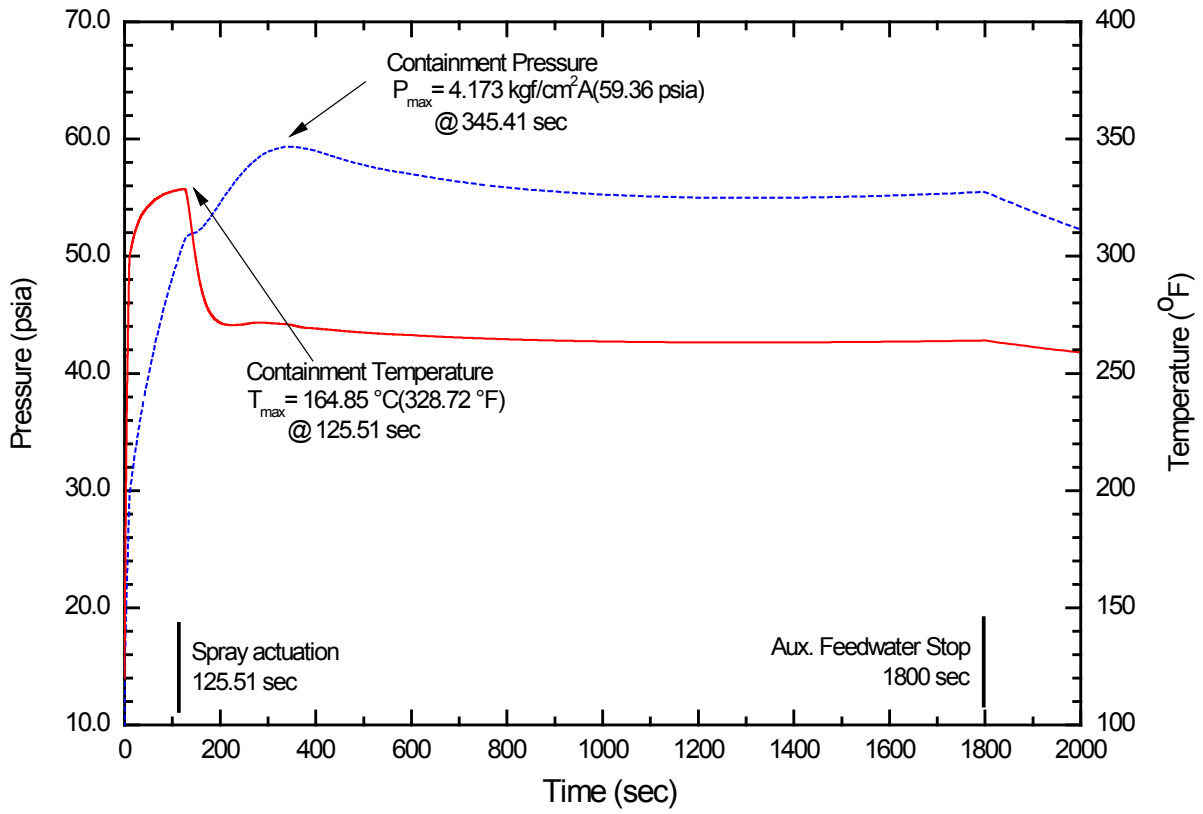


Figure 6.2.1-6 Containment Pressure and Temperature vs. Time; MSLB – 102 % Power with Loss of a CSS Train (1 of 2)

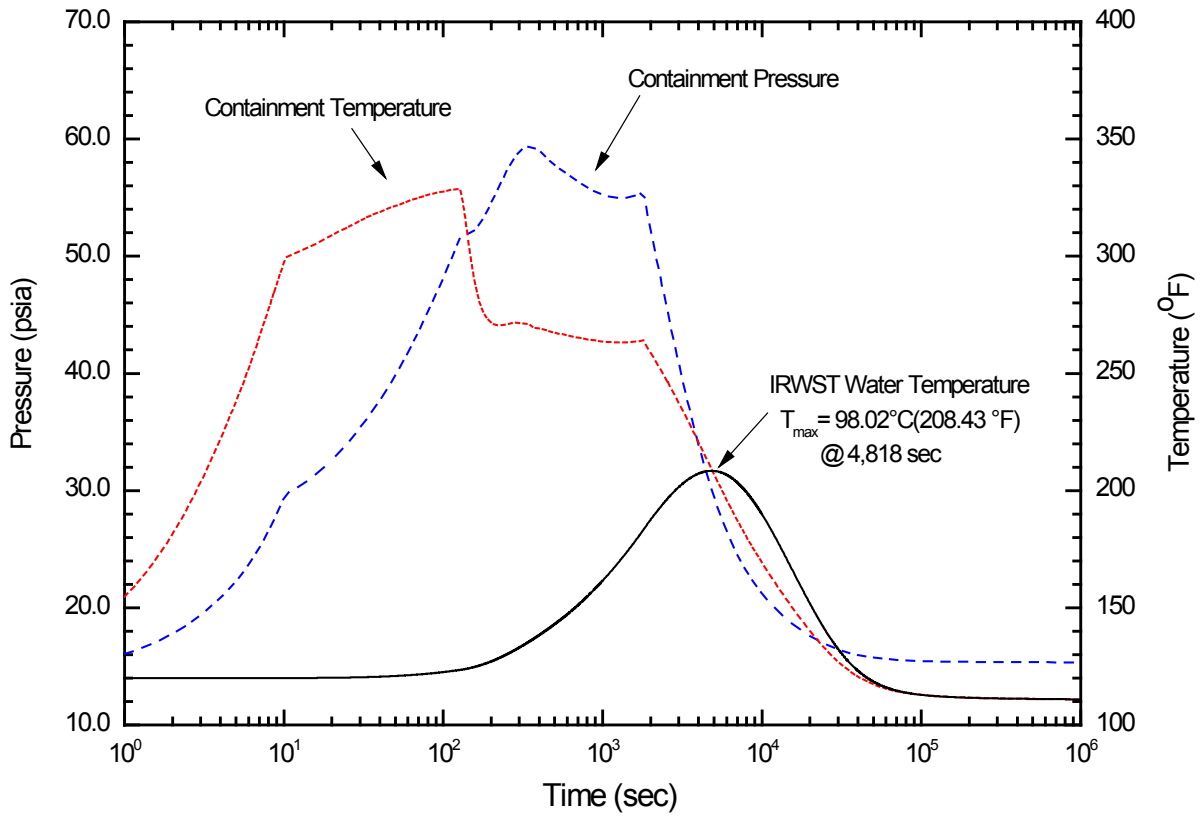


Figure 6.2.1-6 Containment Pressure and Temperature vs. Time; MSLB – 102 % Power with Loss of a CSS Train (Long term) (2 of 2)

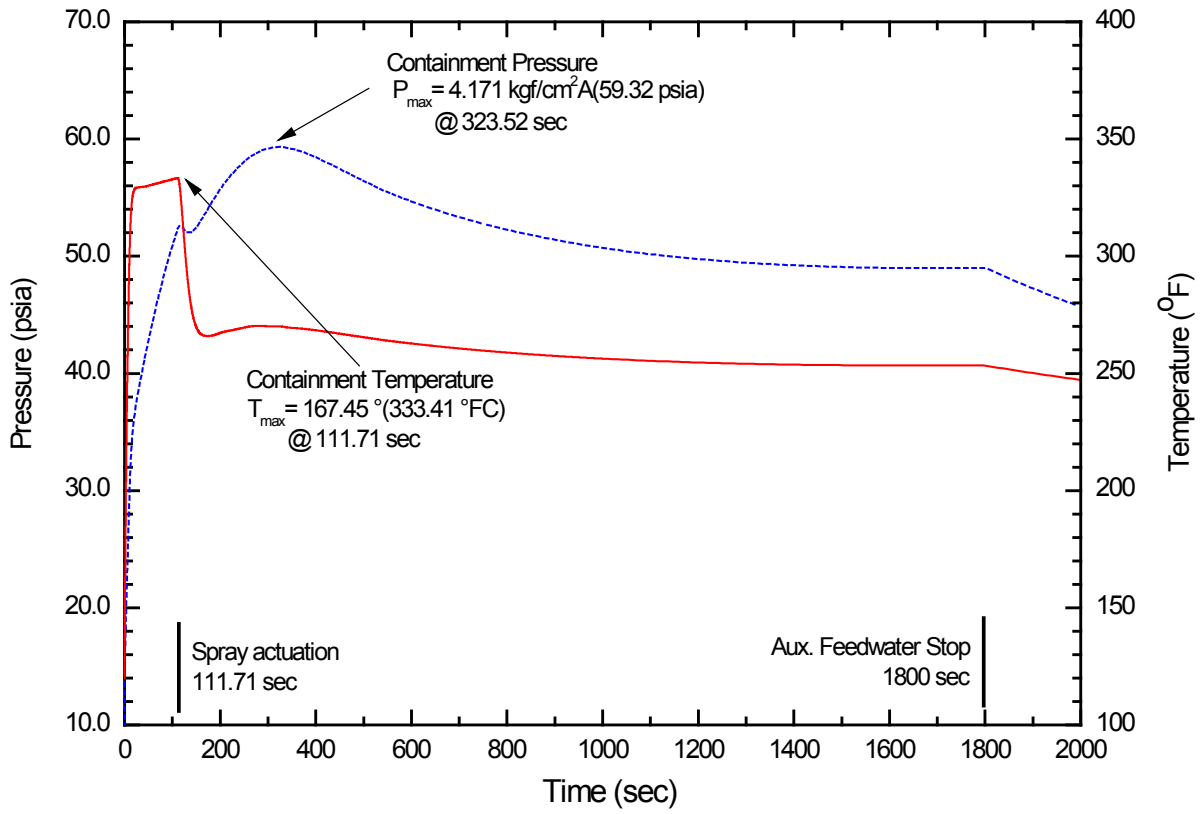


Figure 6.2.1-7 Containment Pressure and Temperature vs. Time; MSLB – 102 % Power with an MSIV Single Failure (1 of 2)

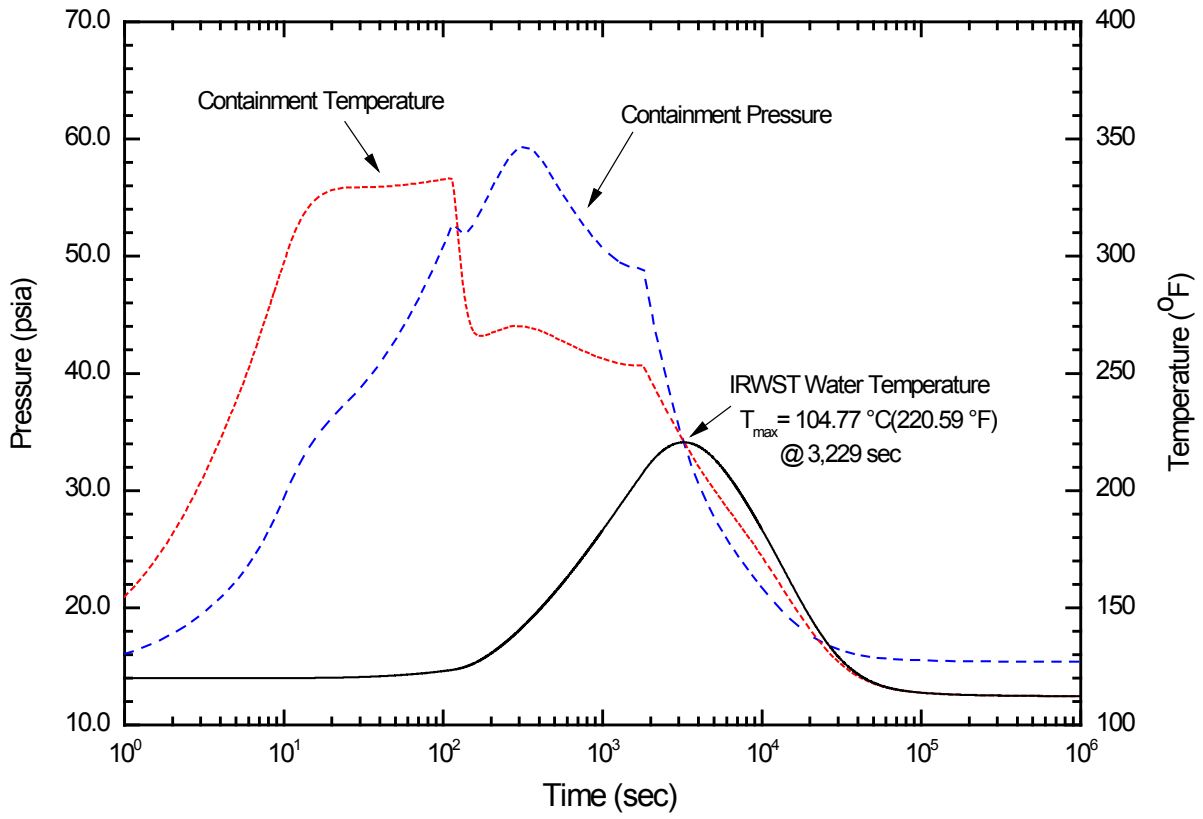


Figure 6.2.1-7 Containment Pressure and Temperature vs. Time; MSLB – 102 % Power with an MSIV Single Failure (Long Term) (2 of 2)

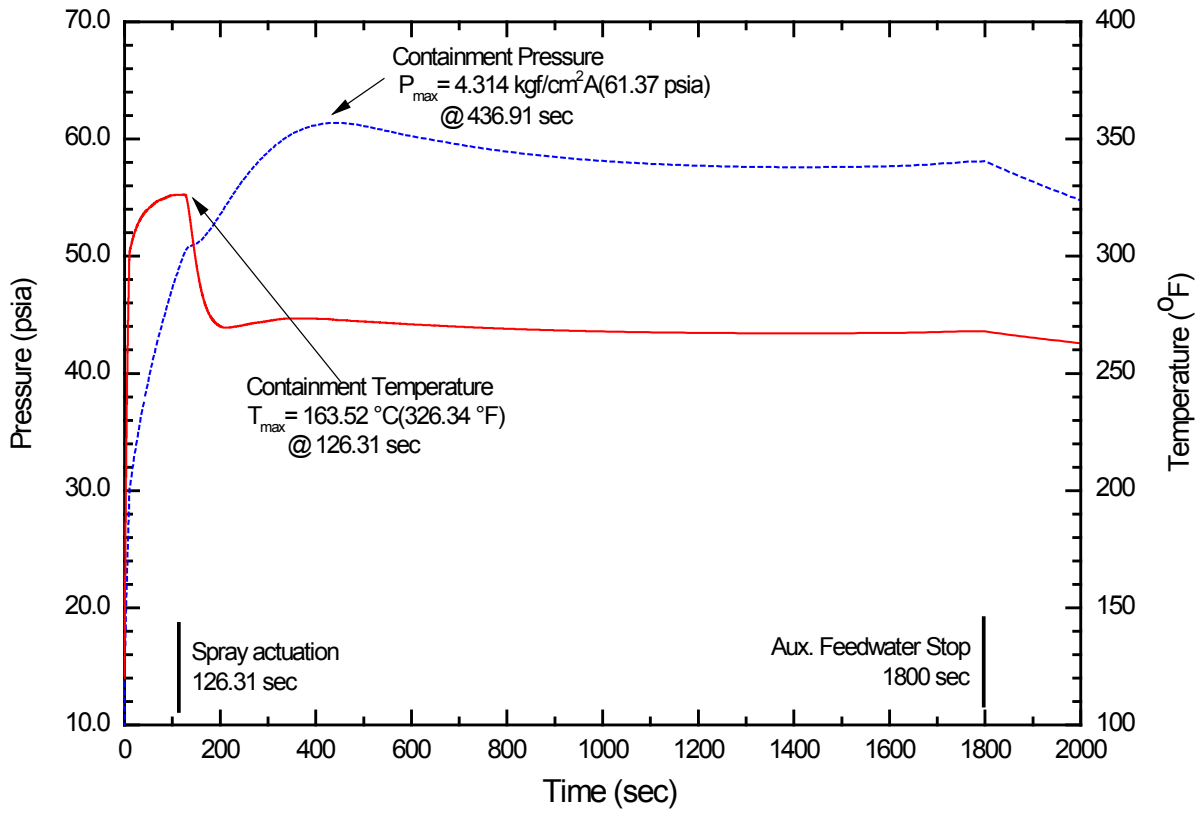


Figure 6.2.1-8 Containment Pressure and Temperature vs. Time; MSLB – 75 % Power with Loss of a CSS Train (1 of 2)

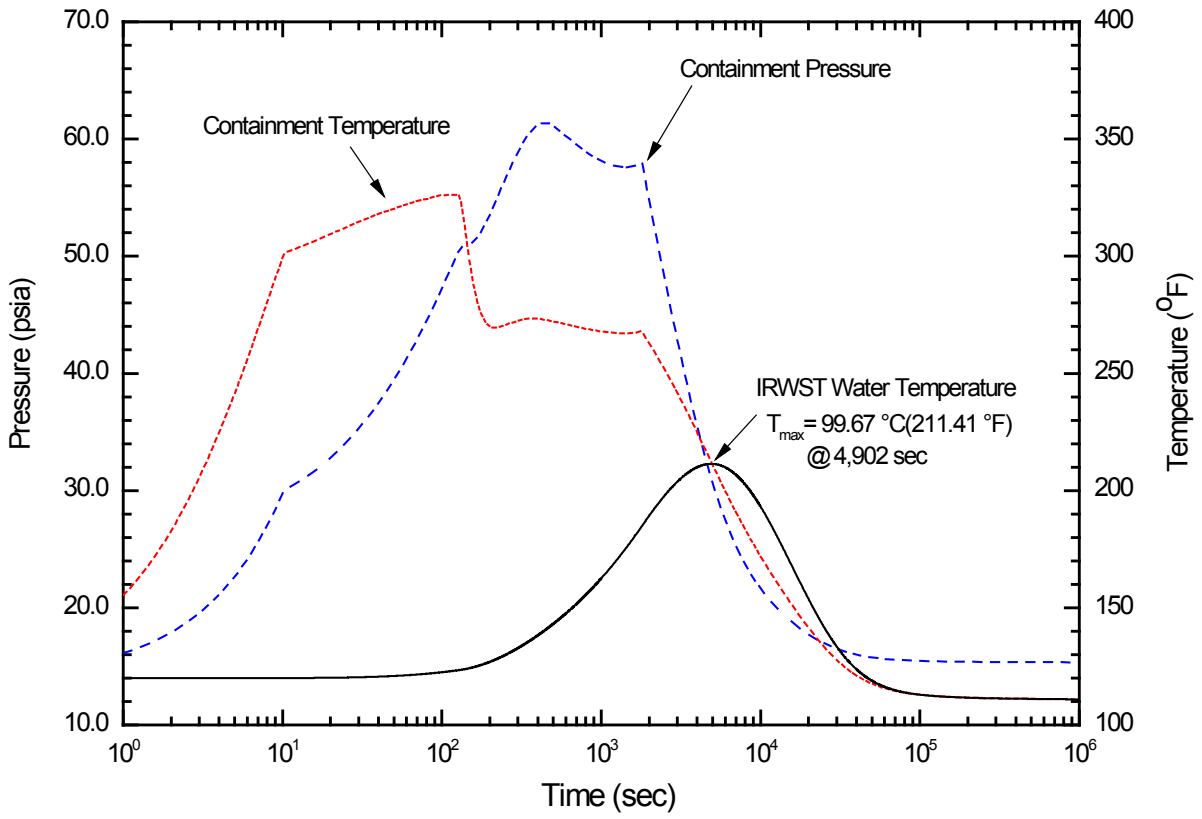


Figure 6.2.1-8 Containment Pressure and Temperature vs. Time; MSLB – 75 % Power with Loss of a CSS Train (Long term) (2 of 2)

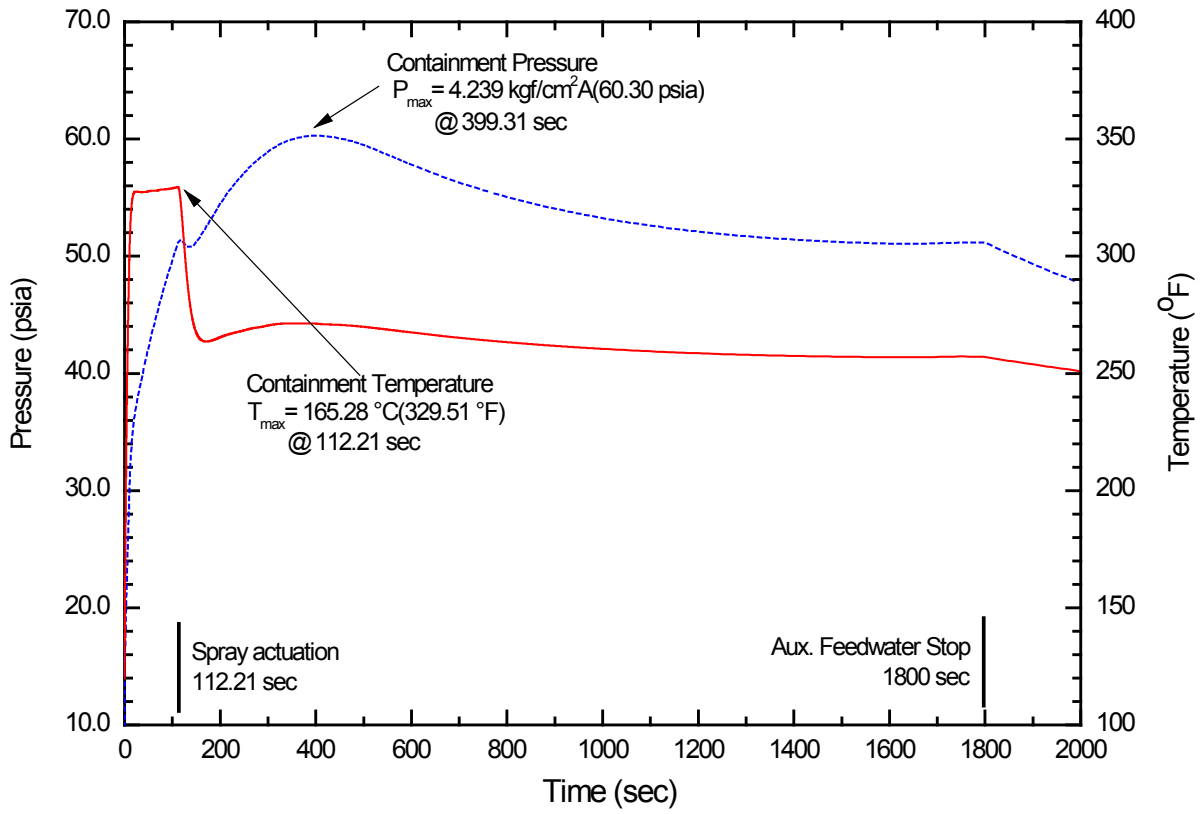


Figure 6.2.1-9 Containment Pressure and Temperature vs. Time; MSLB – 75 % Power with an MSIV Single-failure (1 of 2)

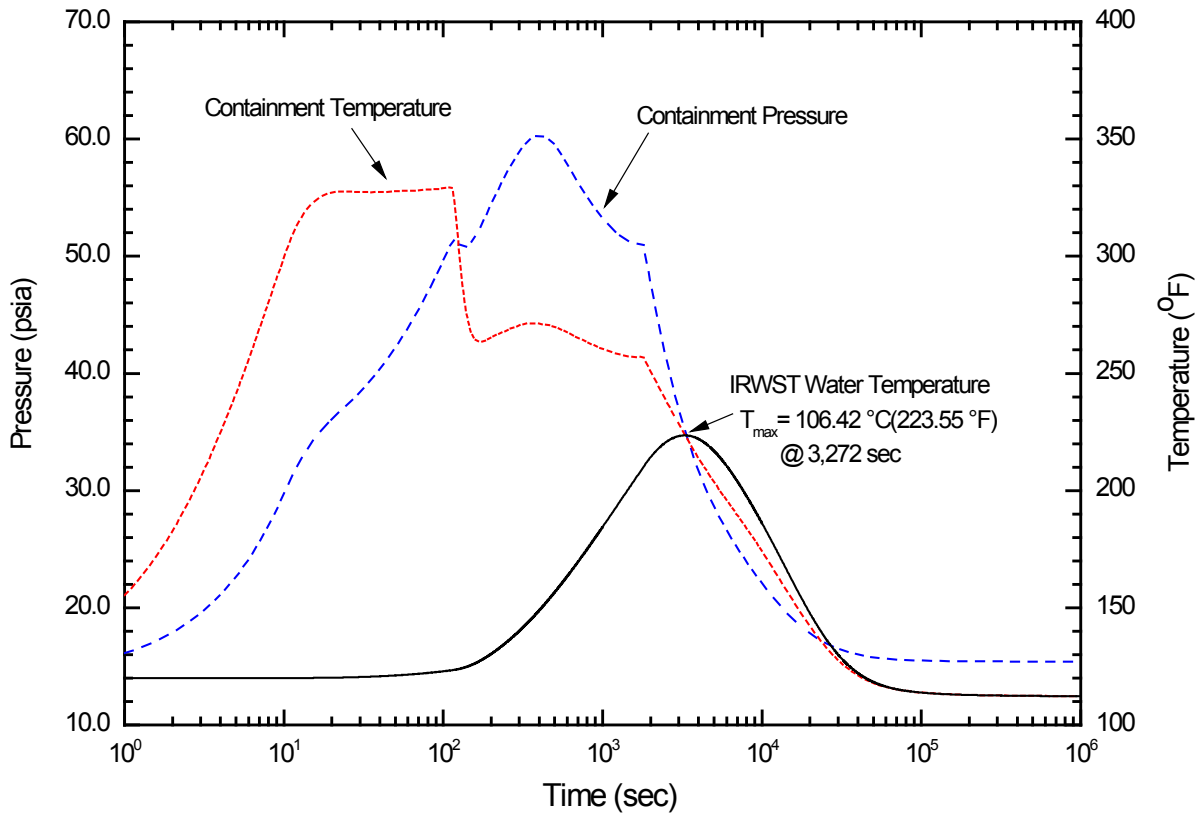


Figure 6.2.1-9 Containment Pressure and Temperature vs. Time; MSLB – 75 % Power with an MSIV Single-failure (Long term) (2 of 2)

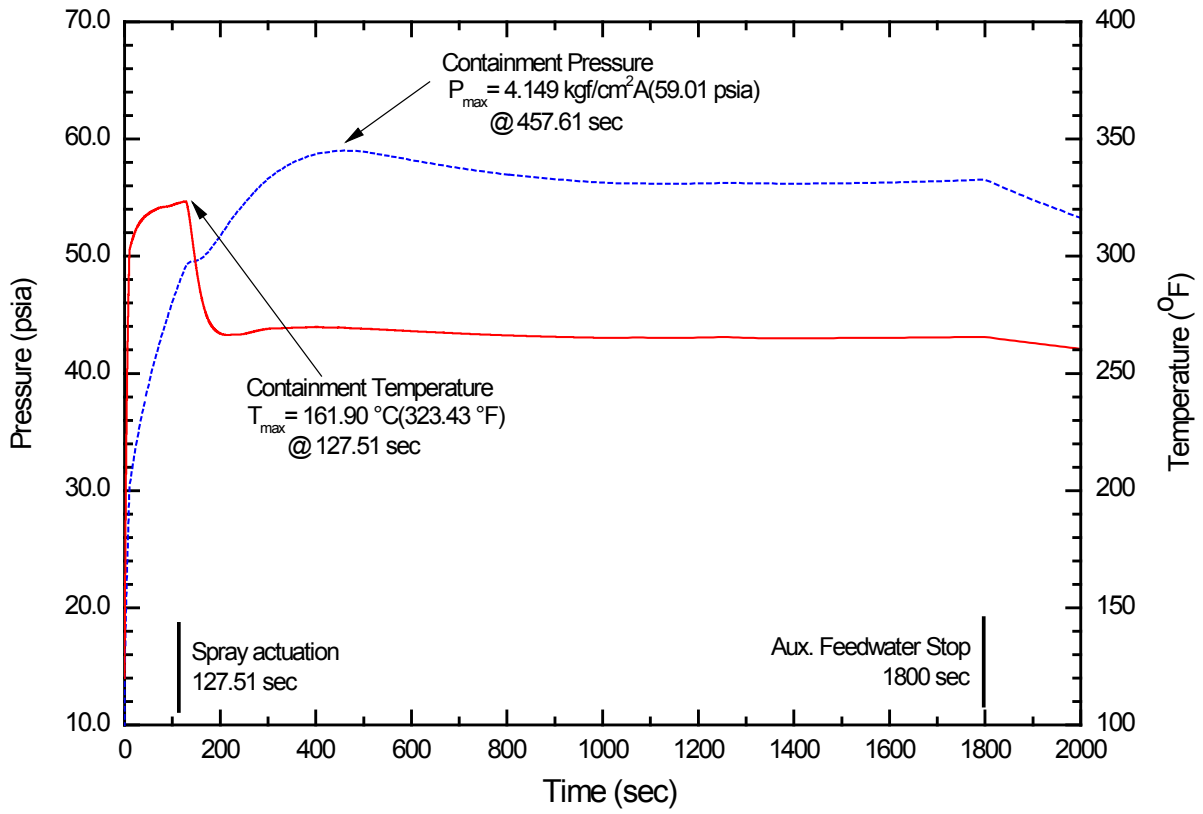


Figure 6.2.1-10 Containment Pressure and Temperature vs. Time; MSLB – 50 % Power with Loss of a CSS Train (1 of 2)

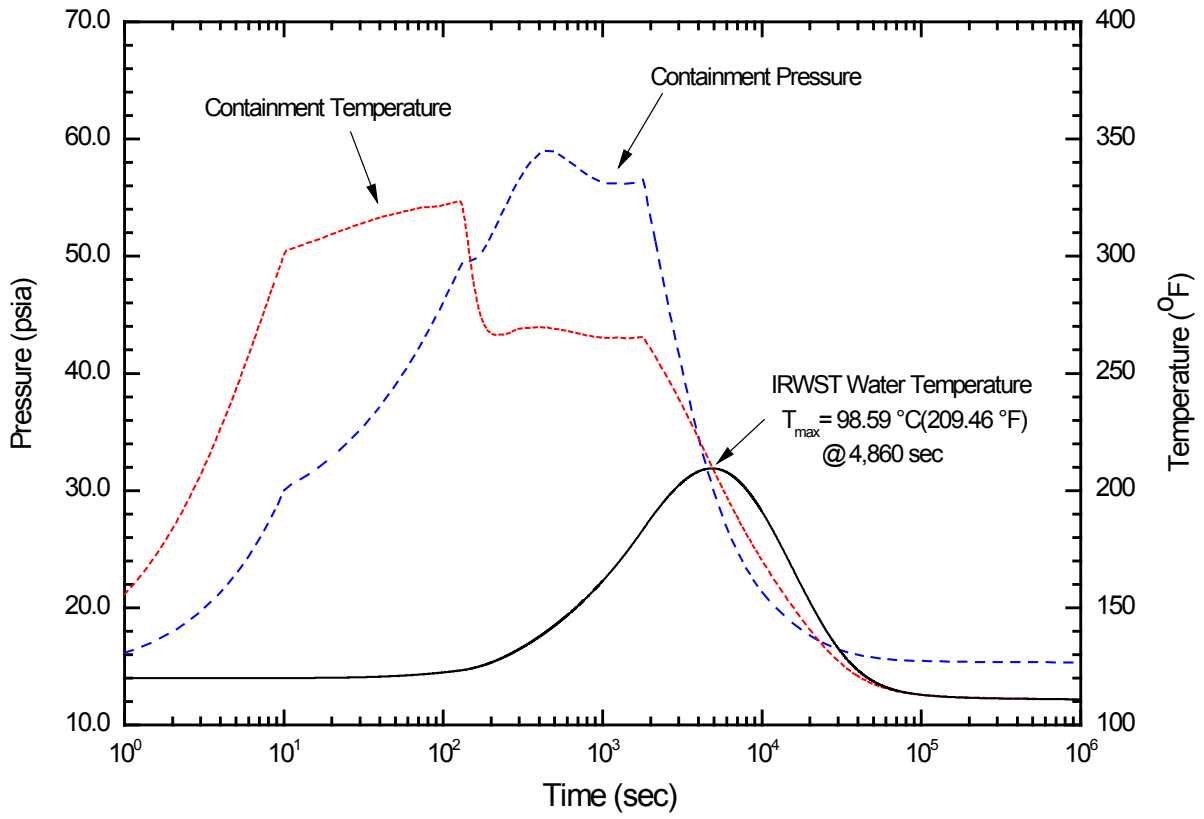


Figure 6.2.1-10 Containment Pressure and Temperature vs. Time; MSLB – 50 % Power with Loss of a CSS Train (Long term) (2 of 2)

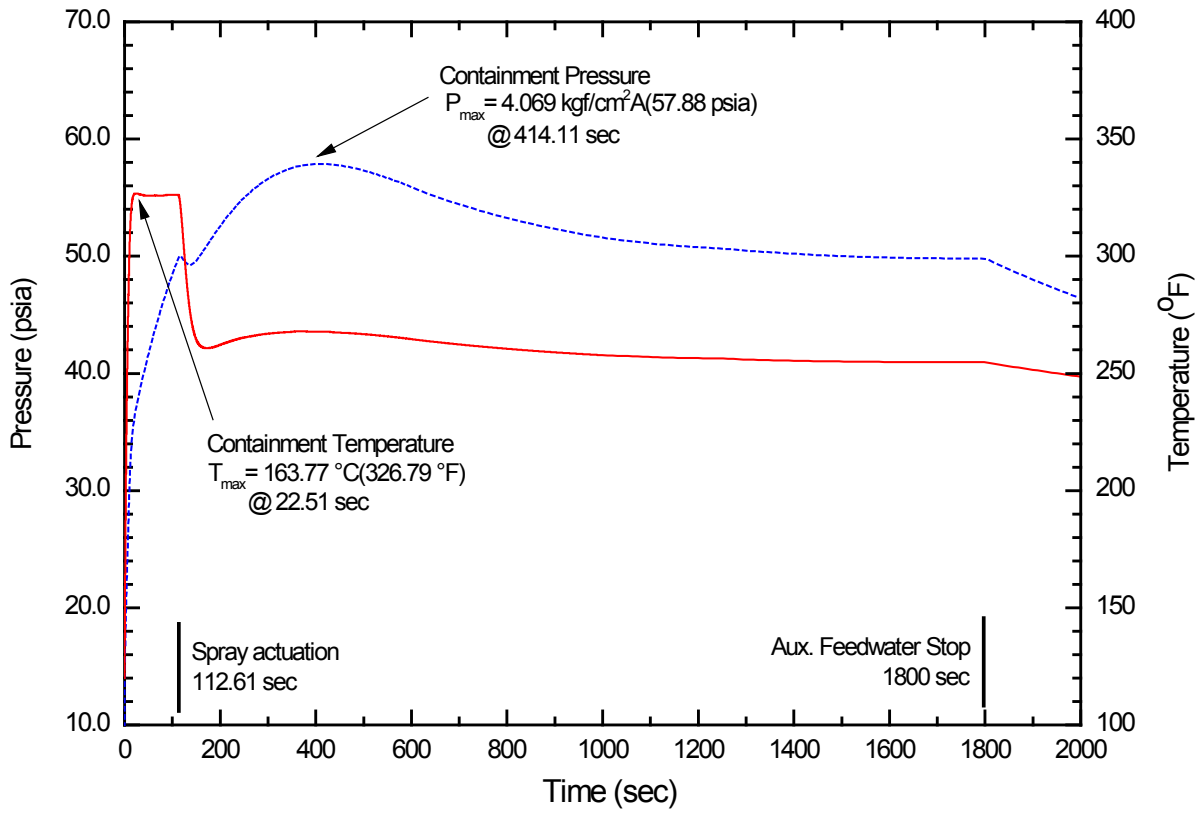


Figure 6.2.1-11 Containment Pressure and Temperature vs. Time; MSLB – 50 % Power with an MSIV Single Failure (1 of 2)

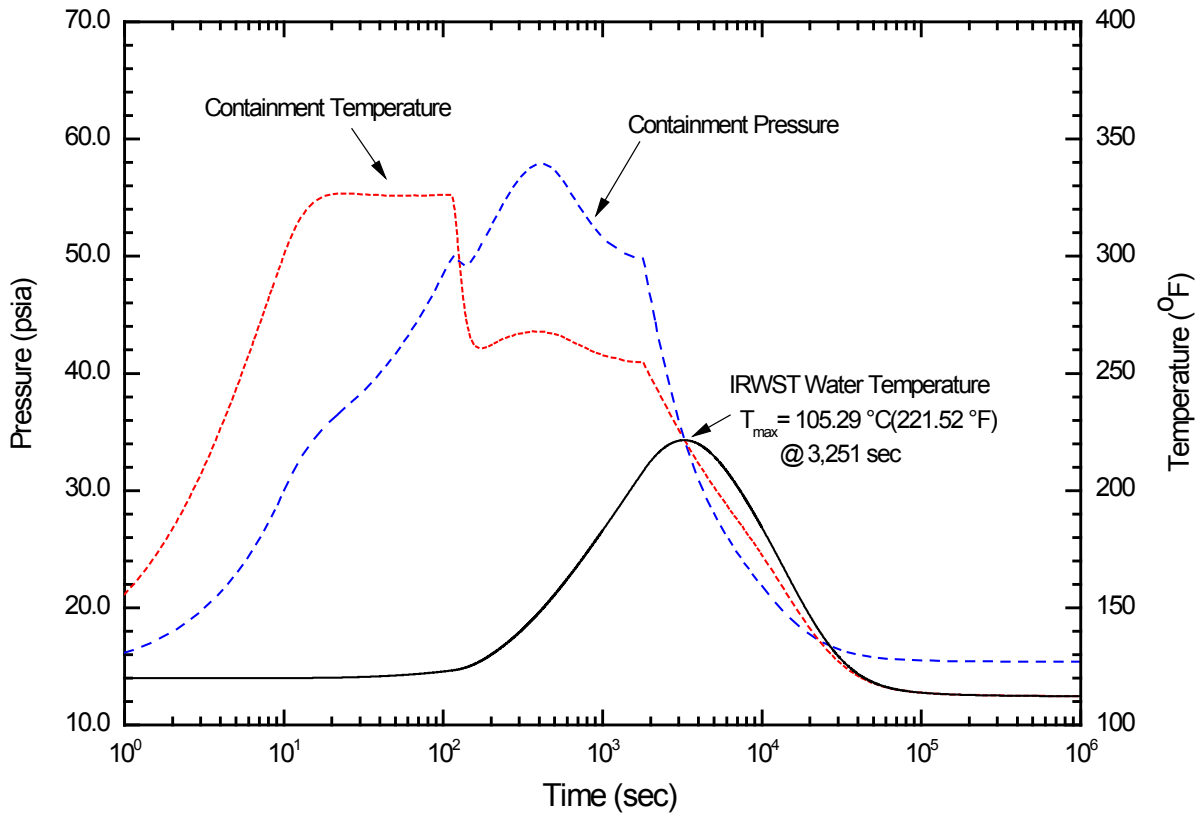


Figure 6.2.1-11 Containment Pressure and Temperature vs. Time; MSLB – 50 % Power with an MSIV Single-failure (Long term) (2 of 2)

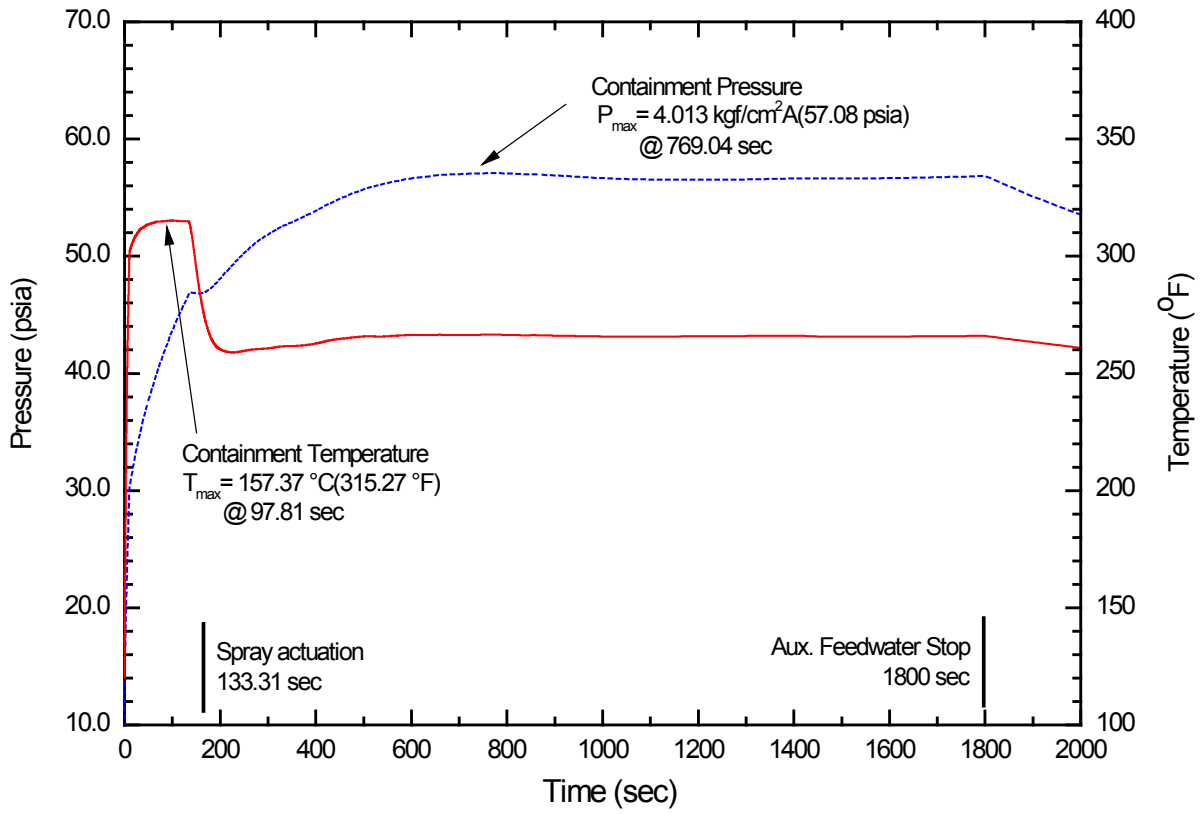


Figure 6.2.1-12 Containment Pressure and Temperature vs. Time; MSLB – 20 % Power with Loss of a CSS Train (1 of 2)

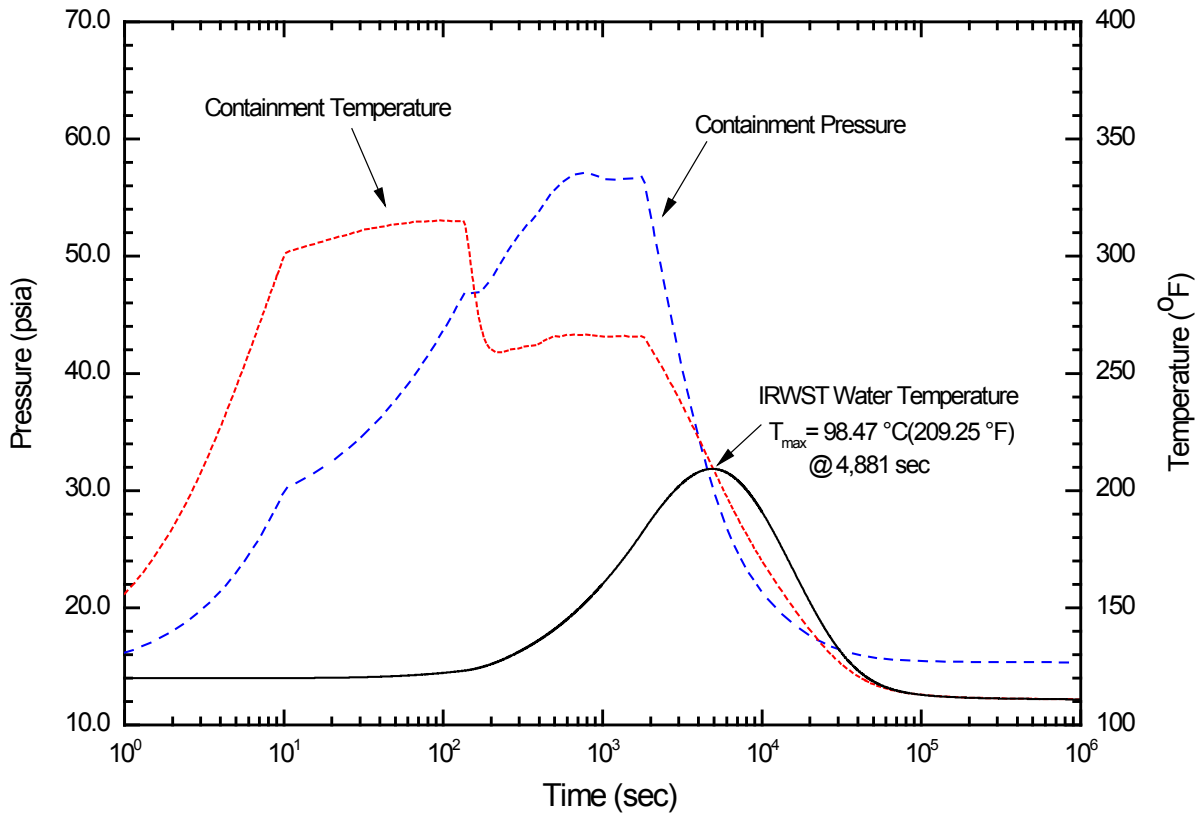


Figure 6.2.1-12 Containment Pressure and Temperature vs. Time; MSLB – 20 % Power with Loss of a CSS Train (Long term) (2 of 2)

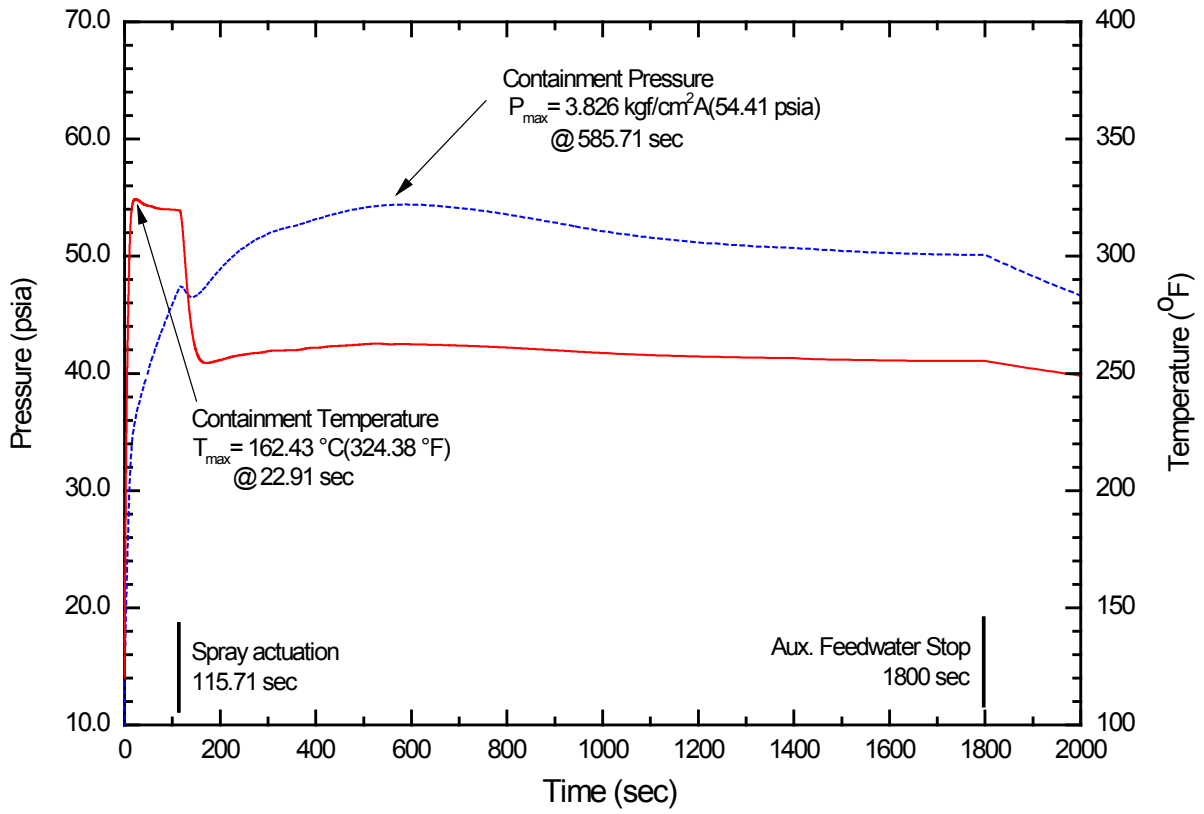


Figure 6.2.1-13 Containment Pressure and Temperature vs. Time; MSLB – 20 % Power with an MSIV Single-Failure (1 of 2)

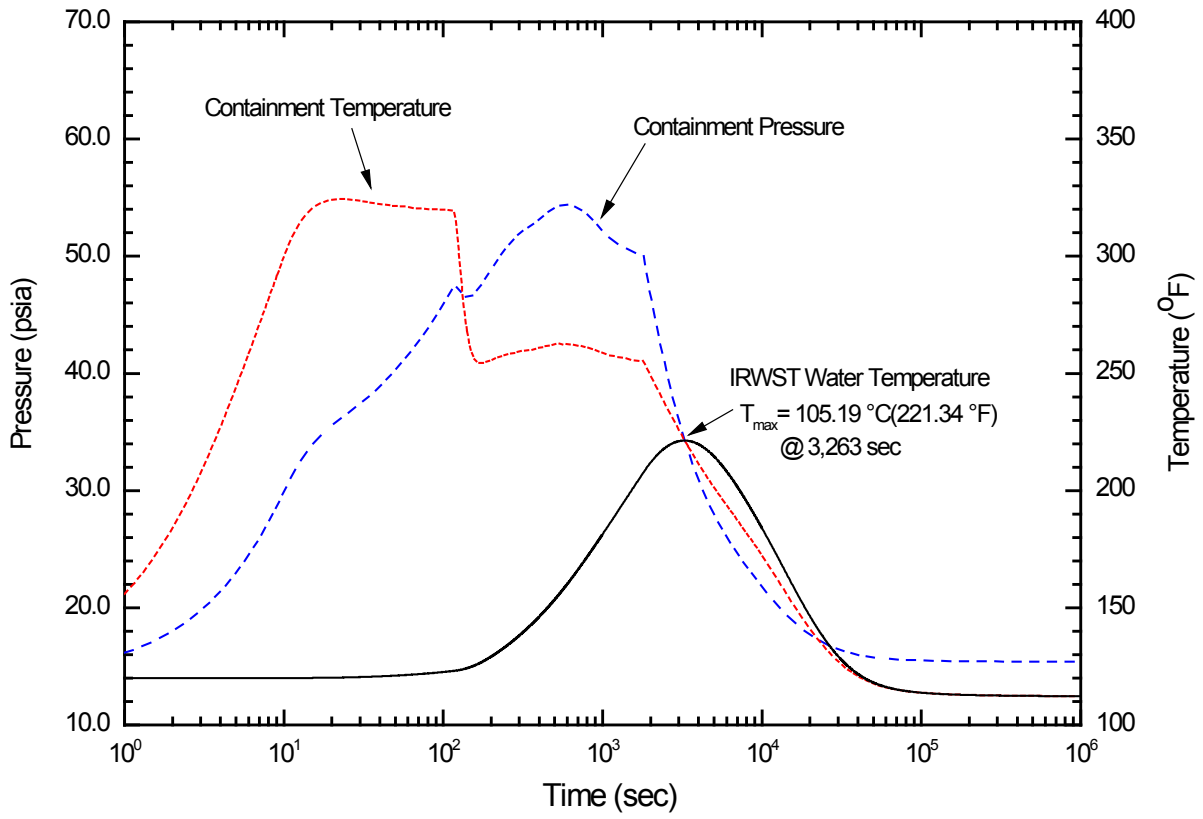


Figure 6.2.1-13 Containment Pressure and Temperature vs. Time; MSLB – 20 % Power with an MSIV Single-Failure (Long term) (2 of 2)

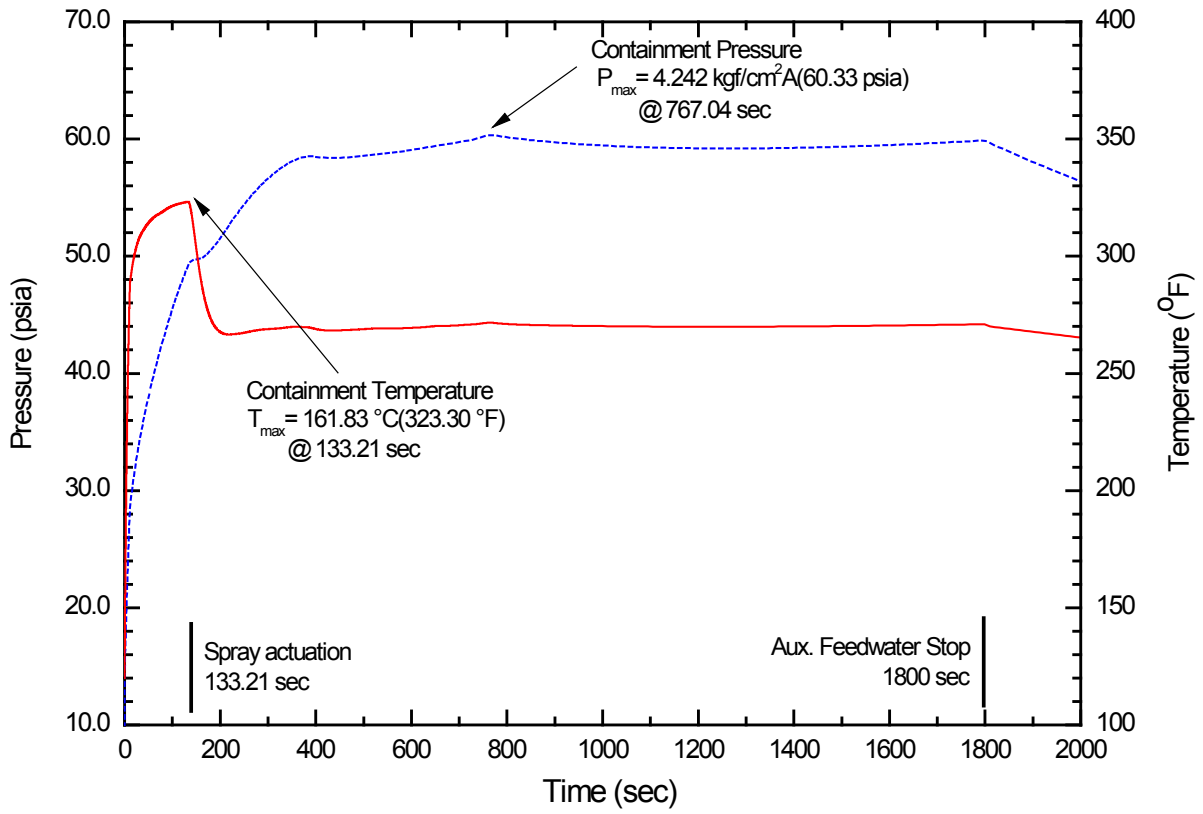


Figure 6.2.1-14 Containment Pressure and Temperature vs. Time; MSLB – 0 % Power with Loss of a CSS Train (1 of 2)

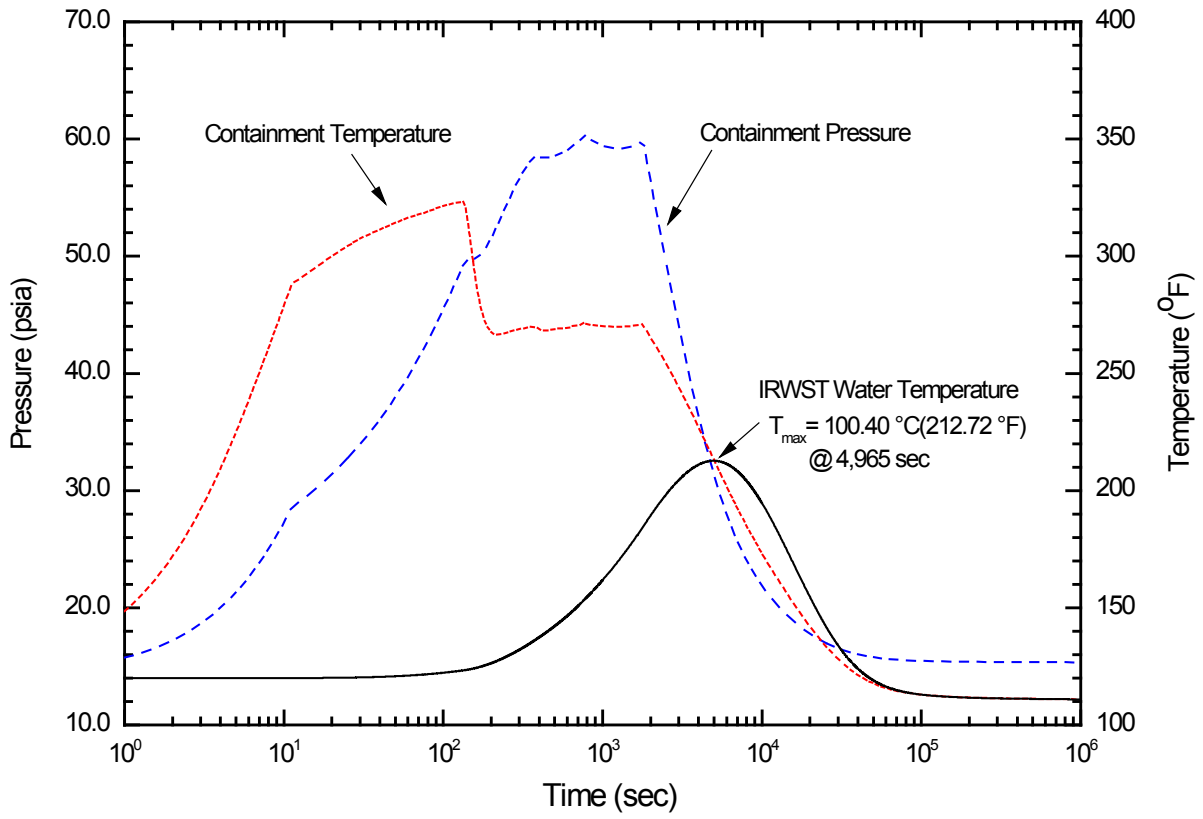


Figure 6.2.1-14 Containment Pressure and Temperature vs. Time; MSLB – 0 % Power with Loss of a CSS Train (Long term) (2 of 2)

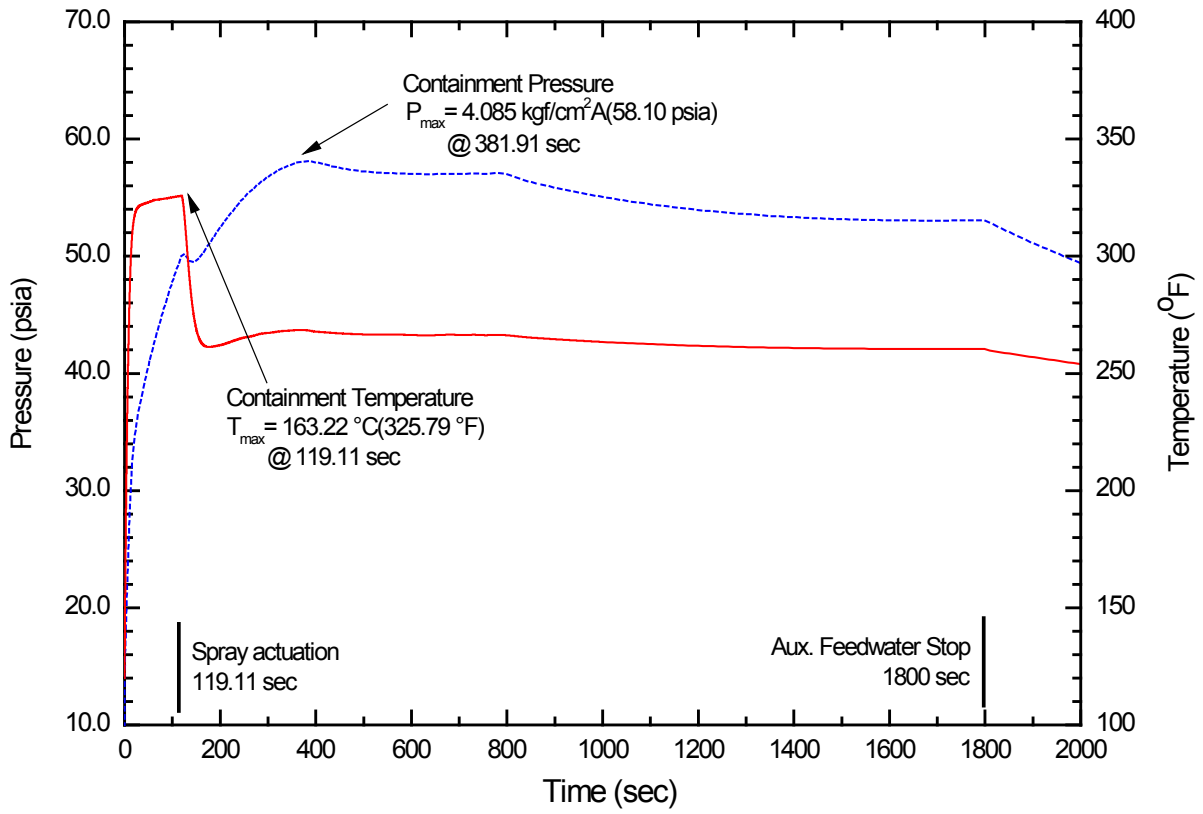


Figure 6.2.1-15 Containment Pressure and Temperature vs. Time; MSLB – 0 % Power with an MSIV Single Failure (1 of 2)

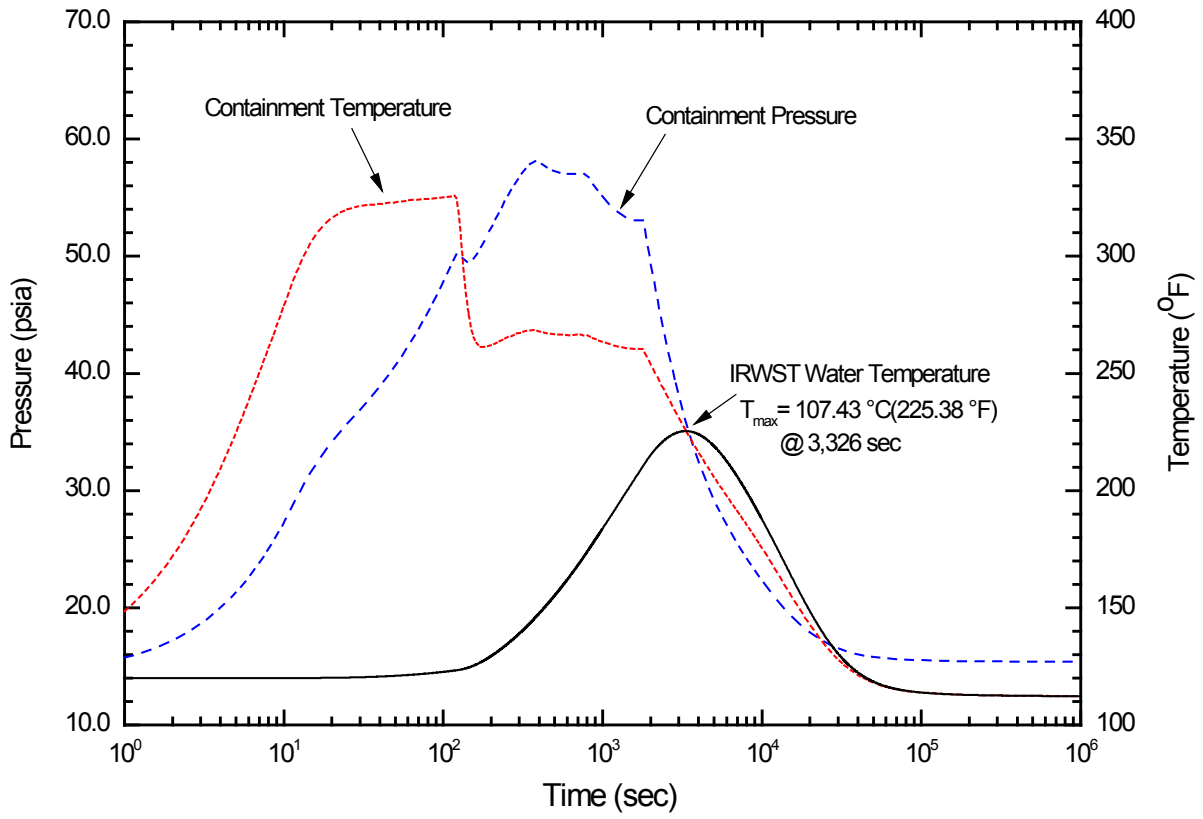


Figure 6.2.1-15 Containment Pressure and Temperature vs. Time; MSLB – 0 % Power with an MSIV Single Failure (Long Term) (2 of 2)

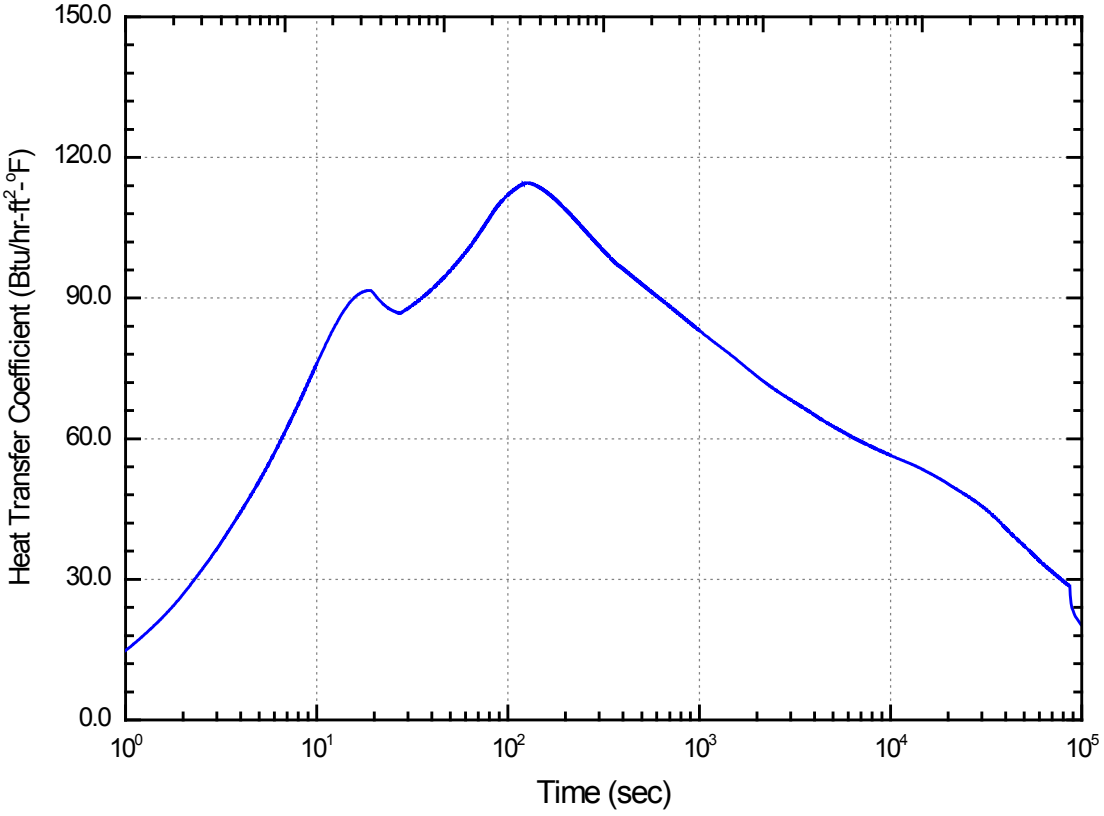


Figure 6.2.1-16 Condensing Heat Transfer Coefficient vs. Time; LOCA – DESLSB with Maximum SI Flow

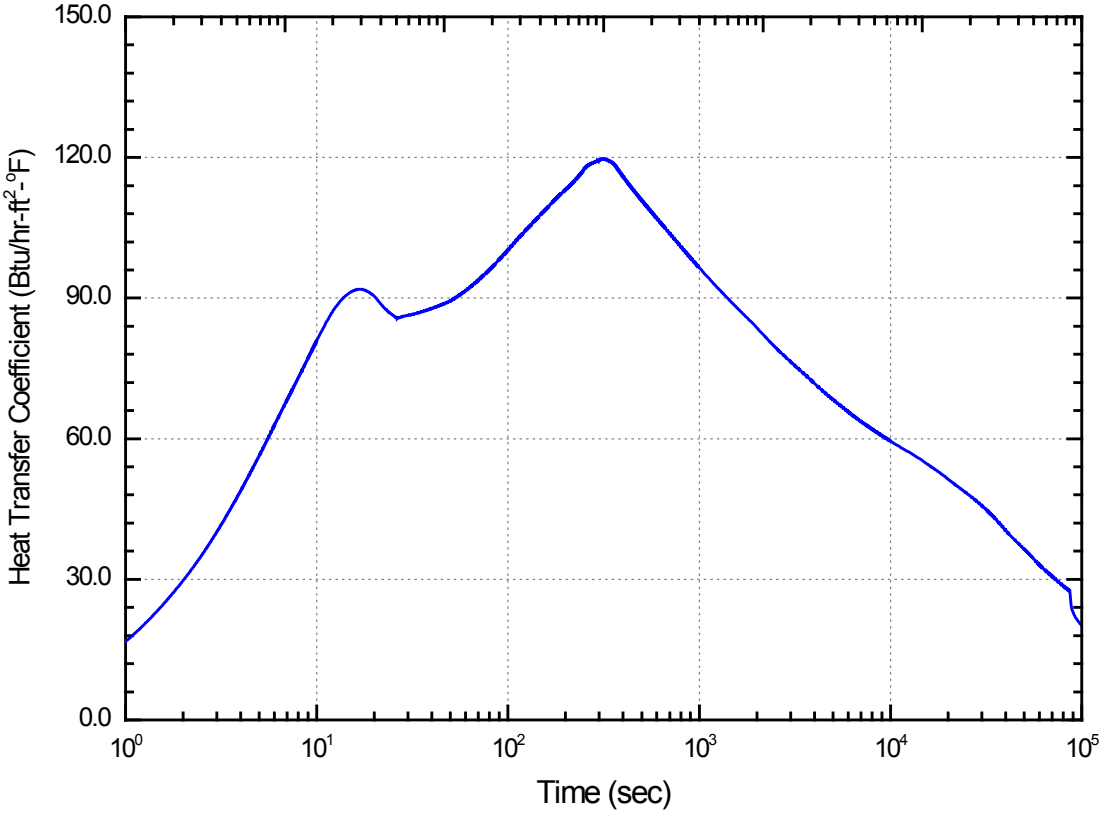


Figure 6.2.1-17 Condensing Heat Transfer Coefficient vs. Time; LOCA – DEDLSB with Maximum SI Flow

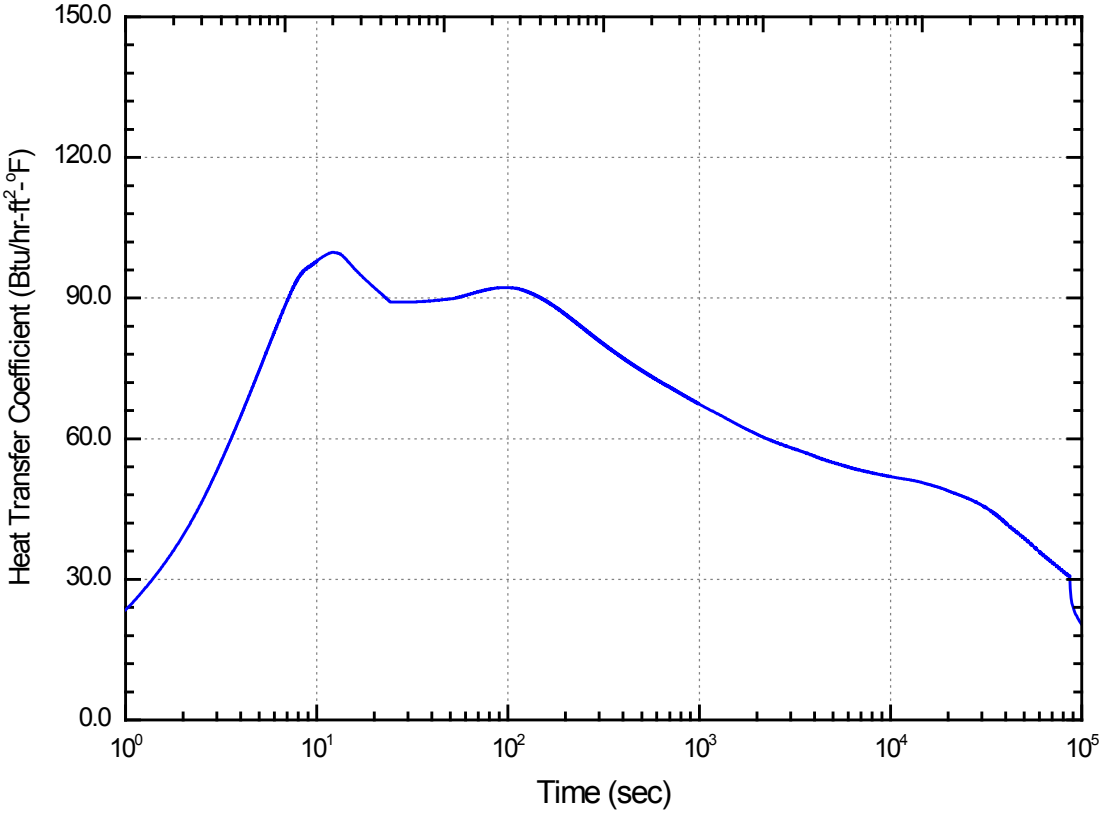


Figure 6.2.1-18 Condensing Heat Transfer Coefficient vs. Time; LOCA – DEHLSB

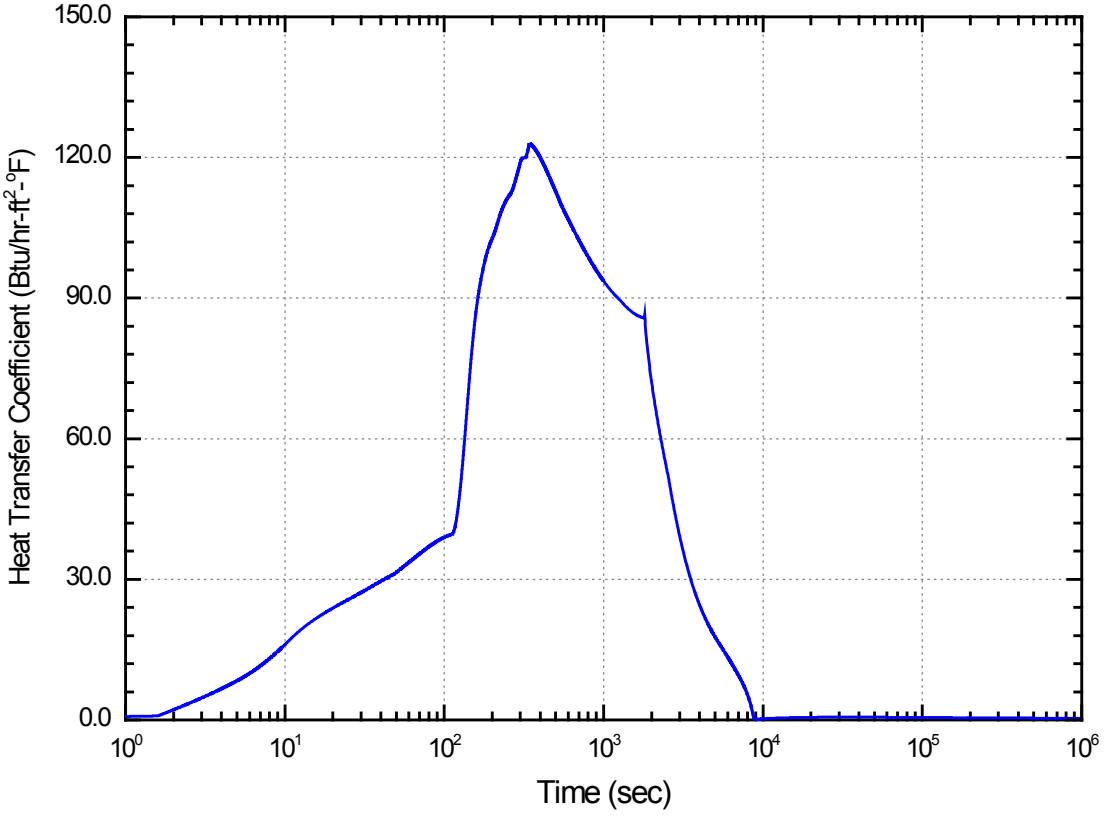


Figure 6.2.1-19 Condensing Heat Transfer Coefficient vs. Time; MSLB – 102 % Power with an MSIV Single-Failure

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-20 Schematic of Potential Water Traps in Containment

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-21 Horizontal Section View and Nodal Model of the steam generator Subcompartment (1 of 6)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-21 Horizontal Section View and Nodal Model of the Steam Generator Subcompartment (2 of 6)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-21 Horizontal Section View and Nodal Model of the Steam Generator Subcompartment (3 of 6)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-21 Horizontal Section View and Nodal Model of the Steam Generator Subcompartment (4 of 6)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-21 Horizontal Section View and Nodal Model of the Steam Generator Subcompartment (5 of 6)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-21 Horizontal Section View and Nodal Model of the Steam Generator Subcompartment (6 of 6)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-22 Horizontal Section View and Nodal Model of the Pressurizer Subcompartment (1 of 3)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-22 Horizontal Section View and Nodal Model of the Pressurizer Subcompartment (2 of 3)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-22 Horizontal Section View and Nodal Model of the Pressurizer Subcompartment (3 of 3)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-23 Plan View and Nodal Model of the Pressurizer Spray Valve Subcompartment

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-24 Sectional View and Nodal Model of the Regenerative Heat Exchanger Subcompartment

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-25 Plan Views and Nodal Models of the Letdown Heat Exchanger and Valve Subcompartments (1 of 2)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.1-25 Plan Views and Nodal Models of the Letdown Heat Exchanger and Valve Subcompartments (2 of 2)

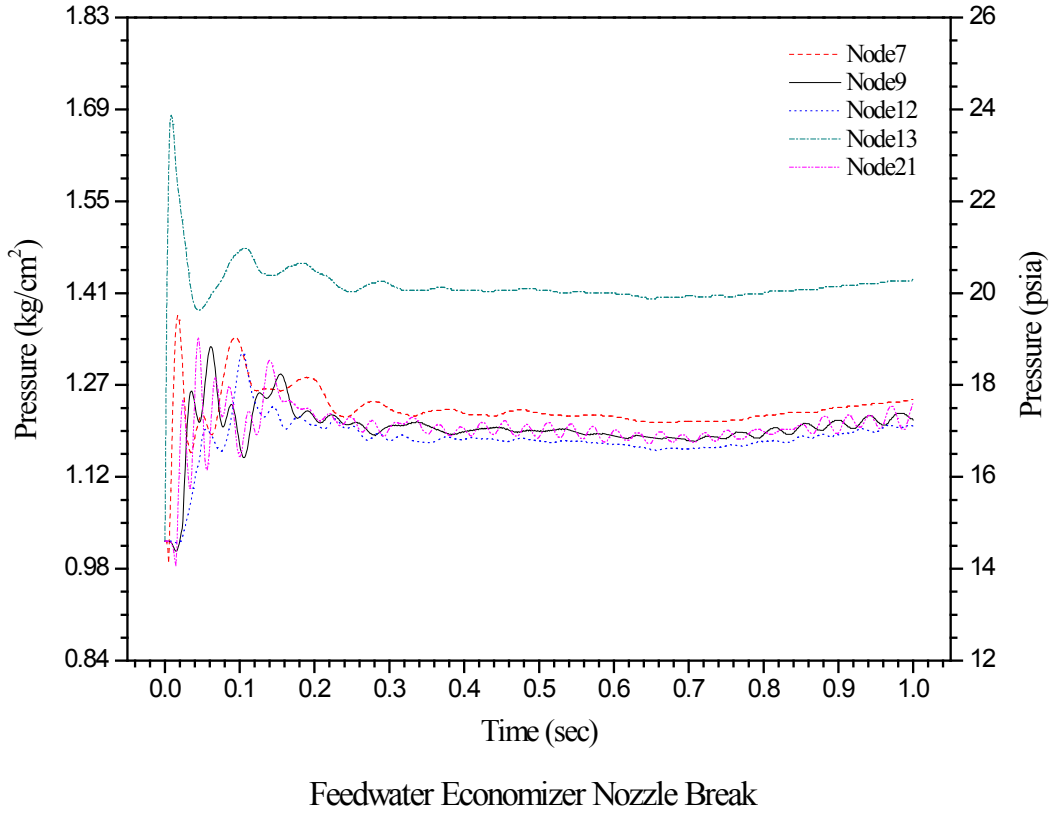


Figure 6.2.1-26 Steam Generator Subcompartment Pressure Response (1 of 3)

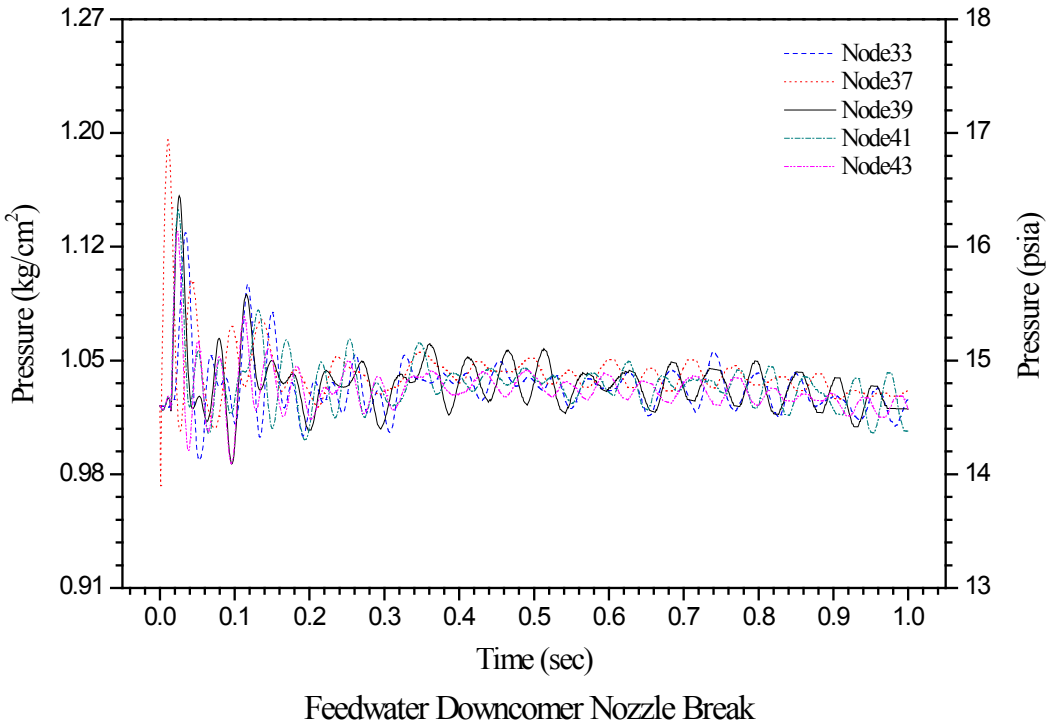


Figure 6.2.1-26 Steam Generator Subcompartment Pressure Response (2 of 3)

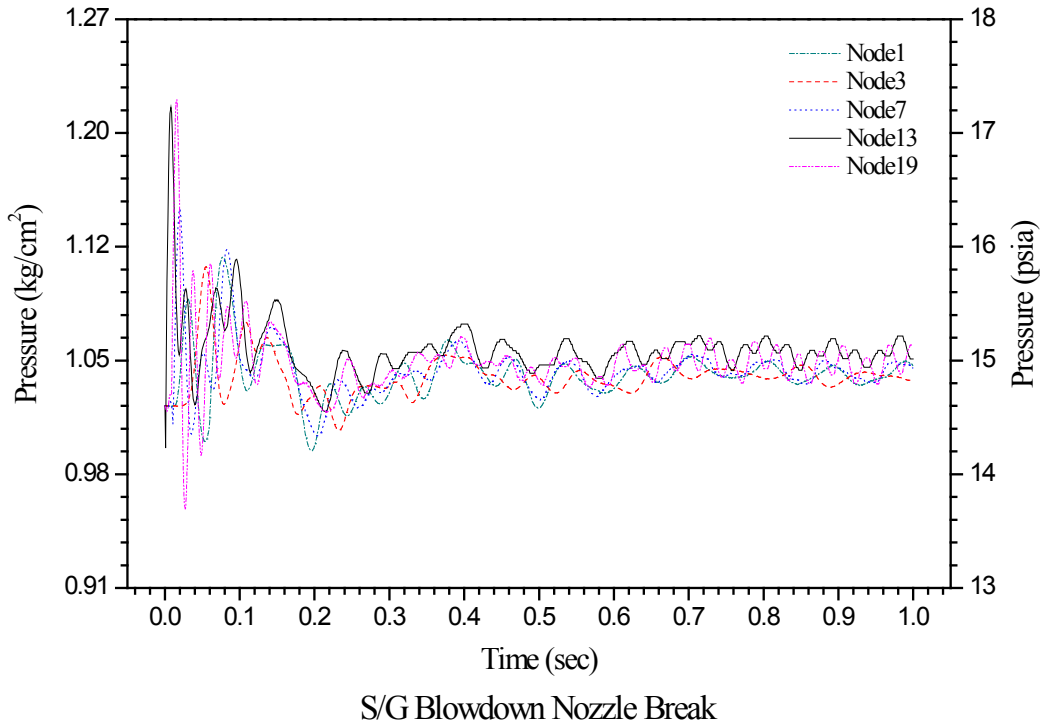


Figure 6.2.1-26 Steam Generator Subcompartment Pressure Response (3 of 3)

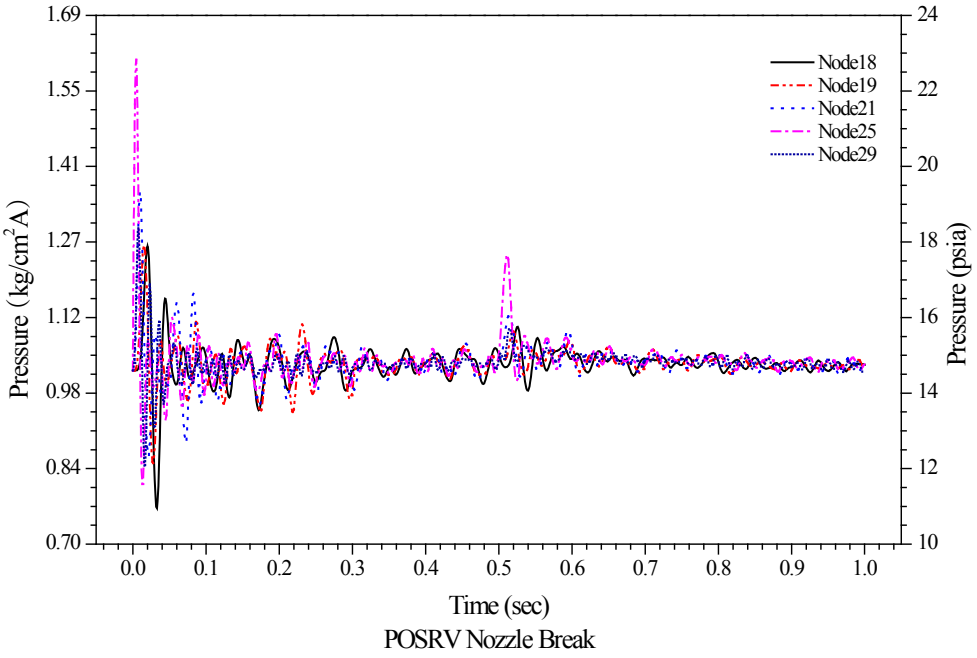


Figure 6.2.1-27 Pressurizer Subcompartment Pressure Response (1 of 2)

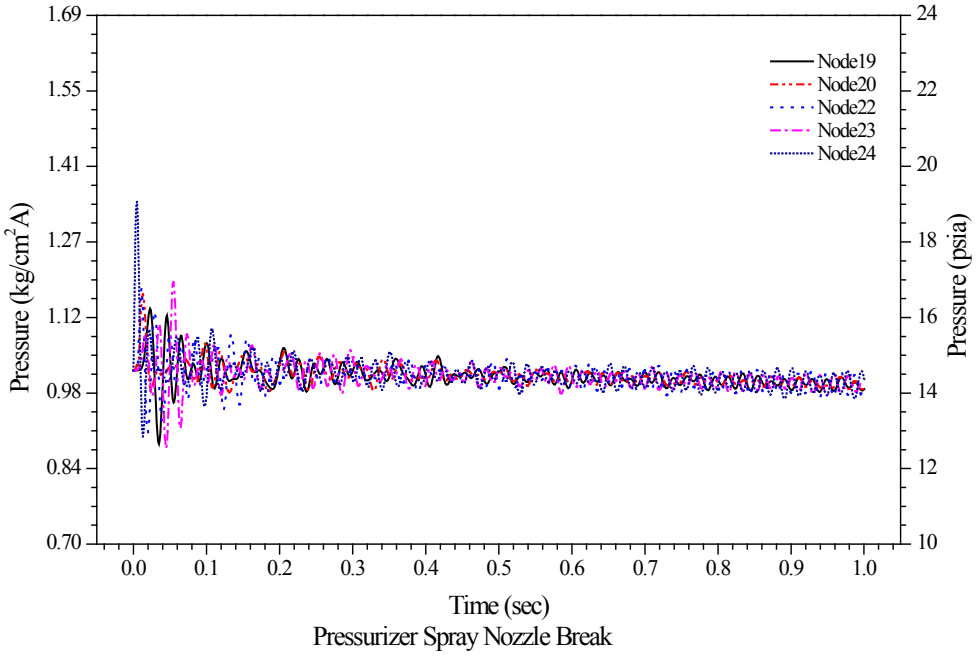


Figure 6.2.1-27 Pressurizer Subcompartment Pressure Response (2 of 2)

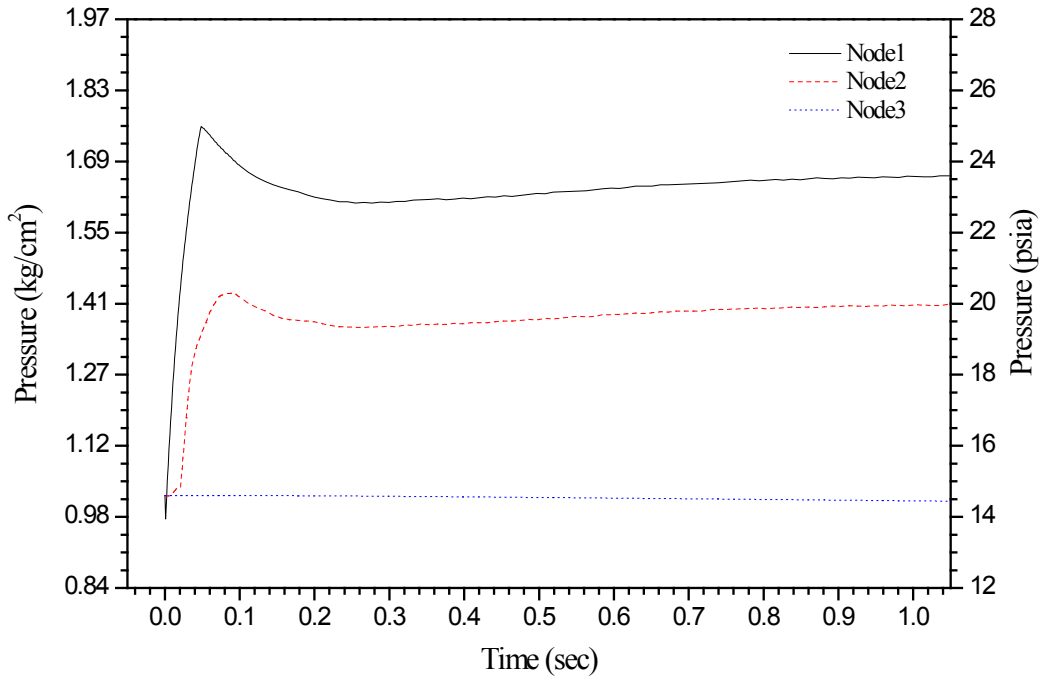


Figure 6.2.1-28 Pressurizer Spray Valve Subcompartment Pressure Response

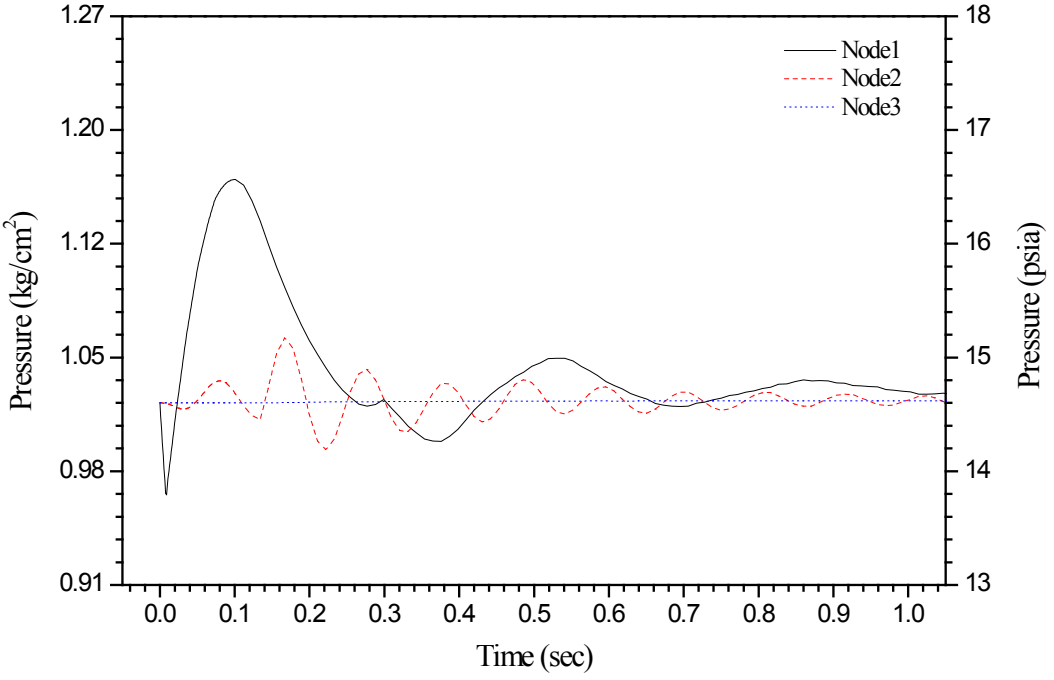


Figure 6.2.1-29 Regenerative Heat Exchanger Subcompartment Pressure Response

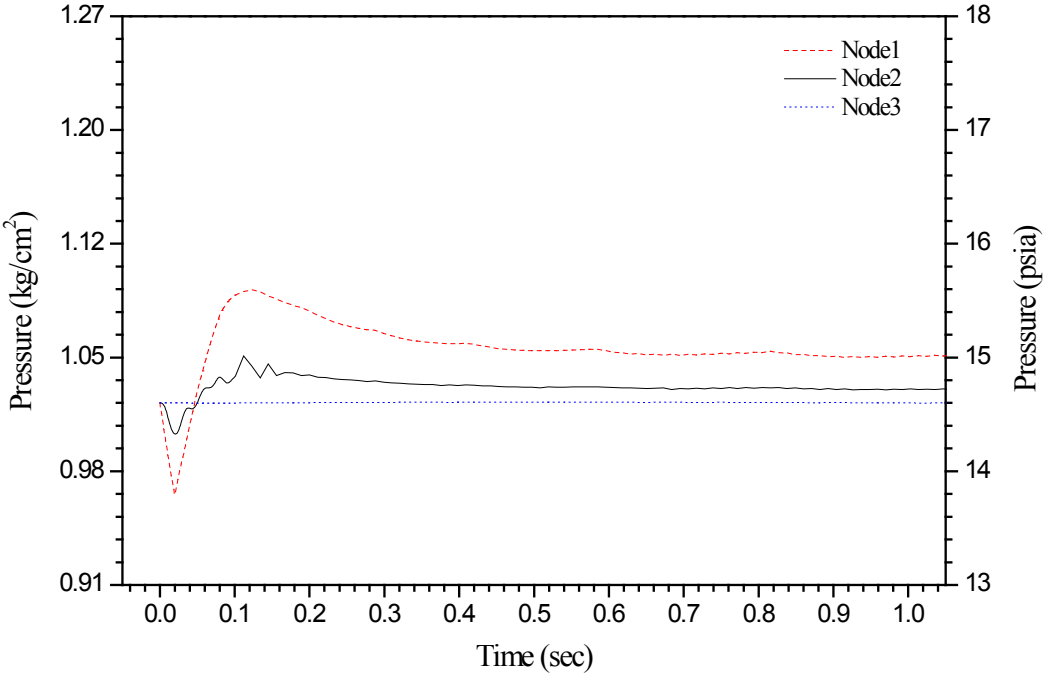


Figure 6.2.1-30 Letdown Heat Exchanger Subcompartment Pressure Response

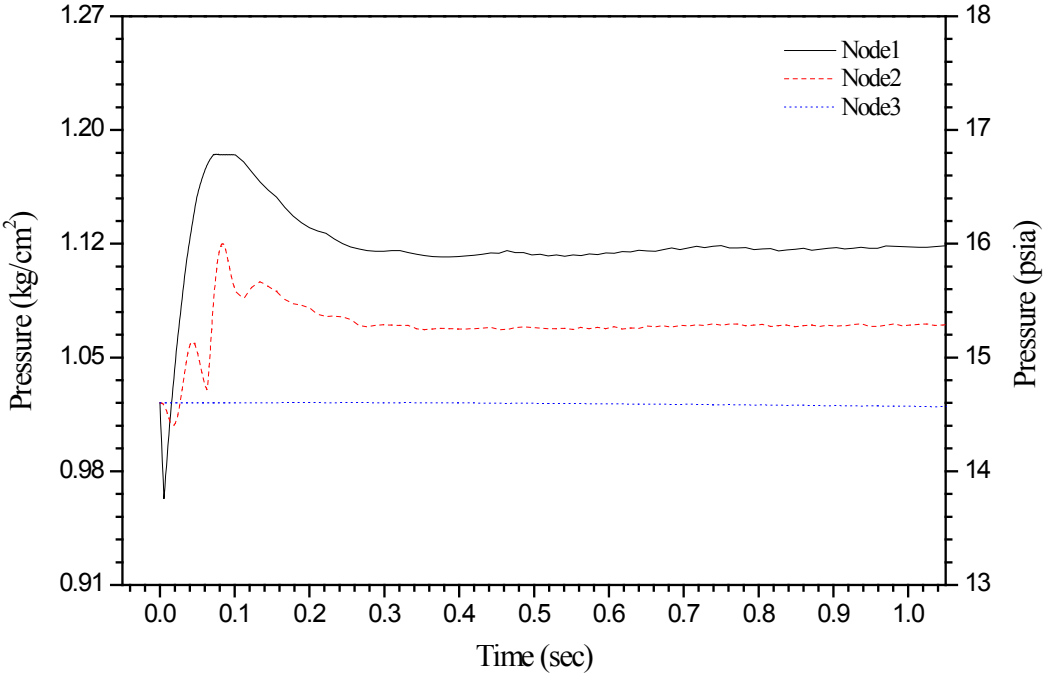


Figure 6.2.1-31 Letdown Heat Exchanger Valve Subcompartment Pressure Response

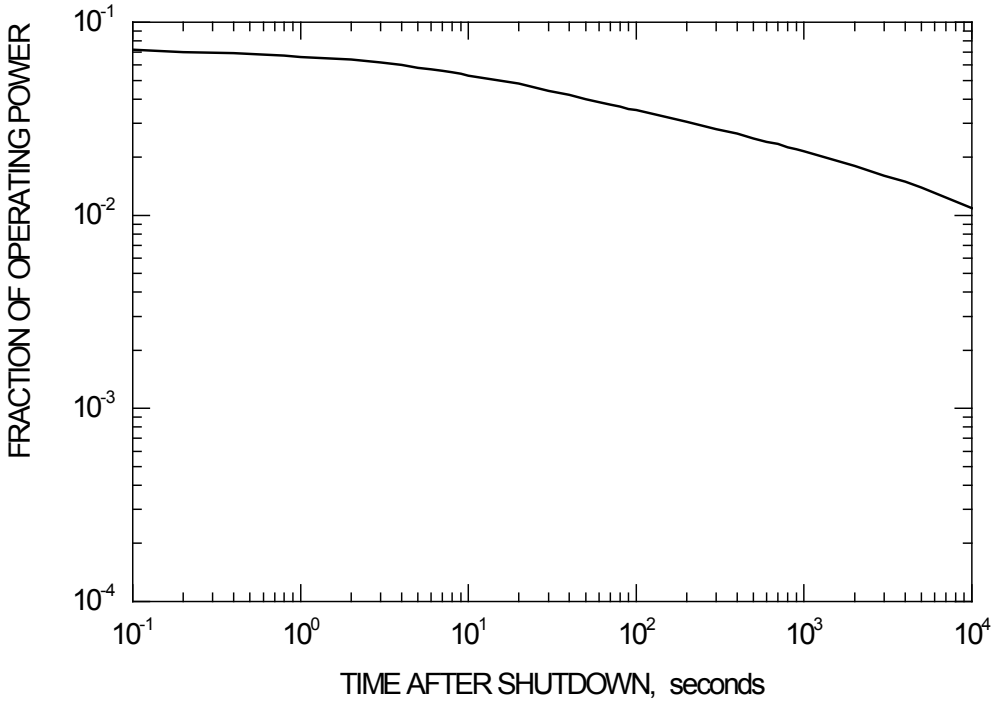


Figure 6.2.1-32 Normalized Decay Heat Curve (Early Period) (1 of 2)

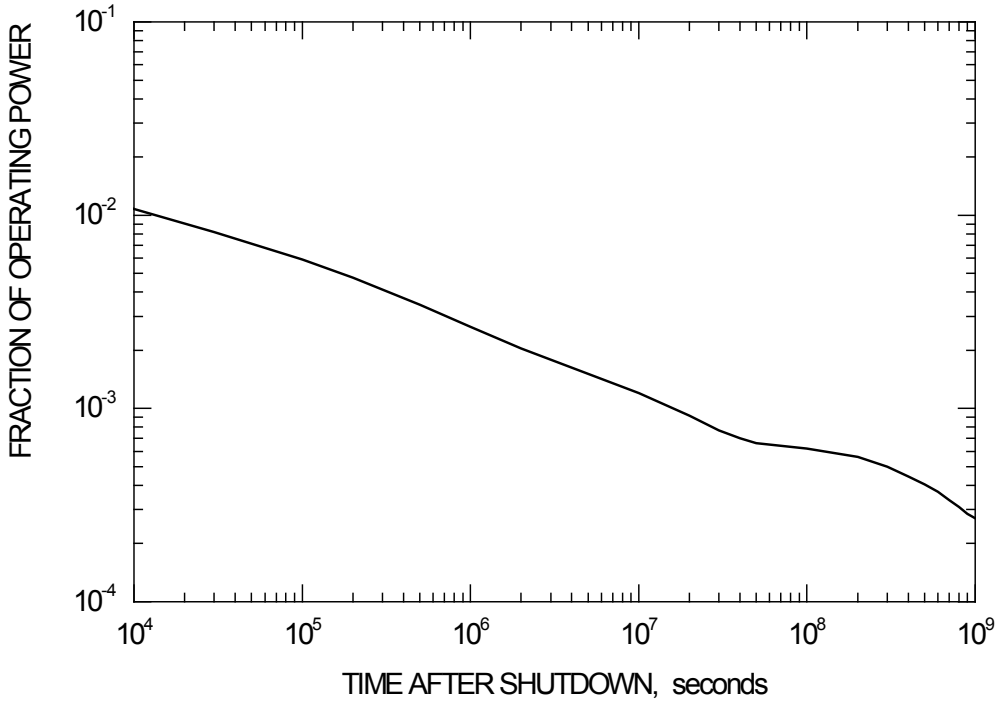


Figure 6.2.1-32 Normalized Decay Heat Curve (Latter Period) (2 of 2)

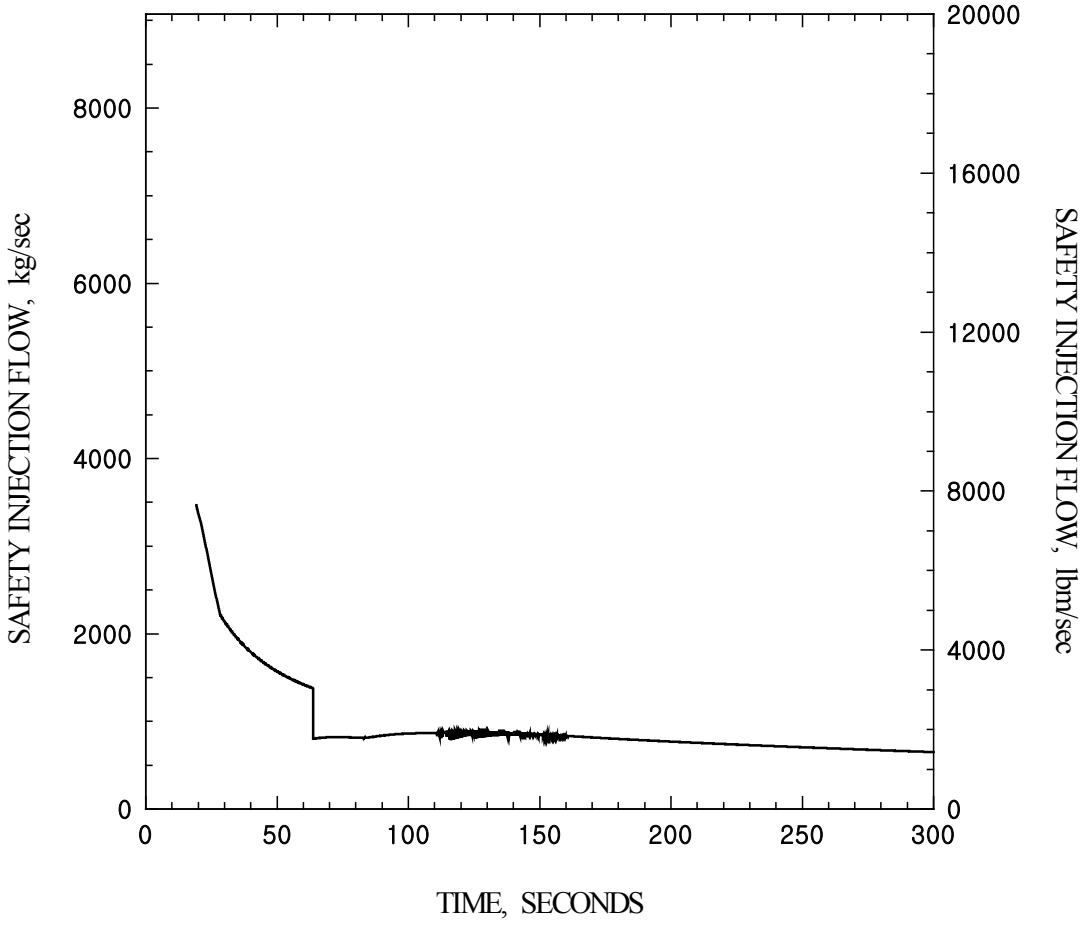


Figure 6.2.1-33 Double-Ended Suction Leg Slot Break; Maximum SI Pump Flow vs. Time

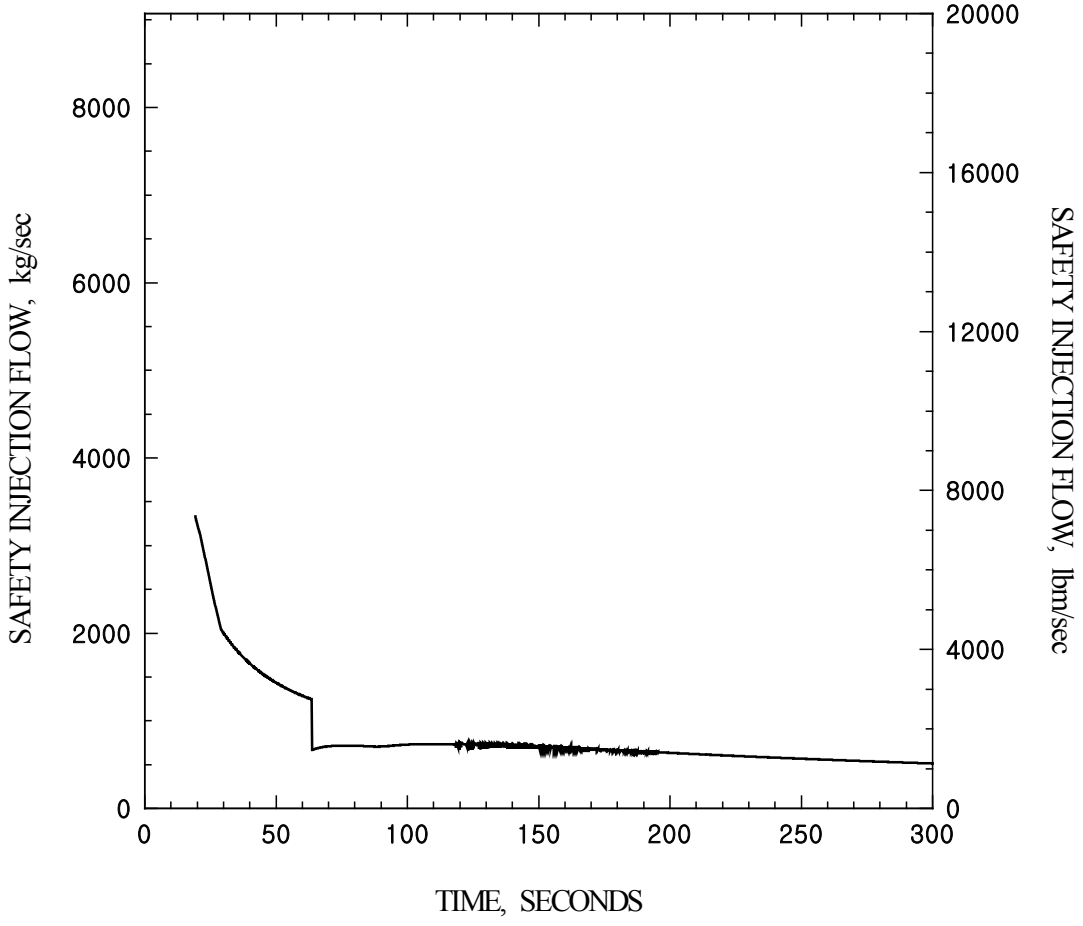


Figure 6.2.1-34 Double-Ended Suction Leg Slot Break; Minimum SI Pump Flow vs. Time

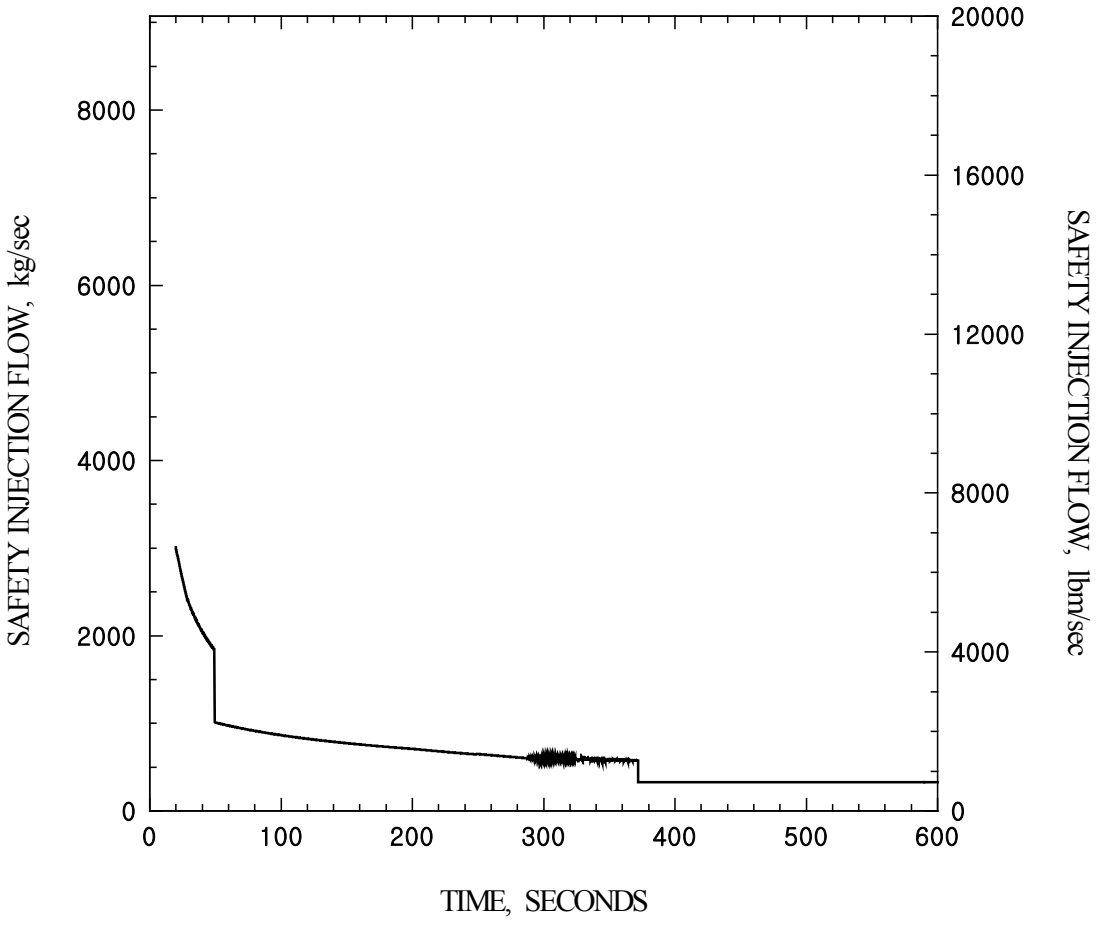


Figure 6.2.1-35 Double-Ended Discharge Leg Slot Break; Maximum SI Pump Flow vs. Time

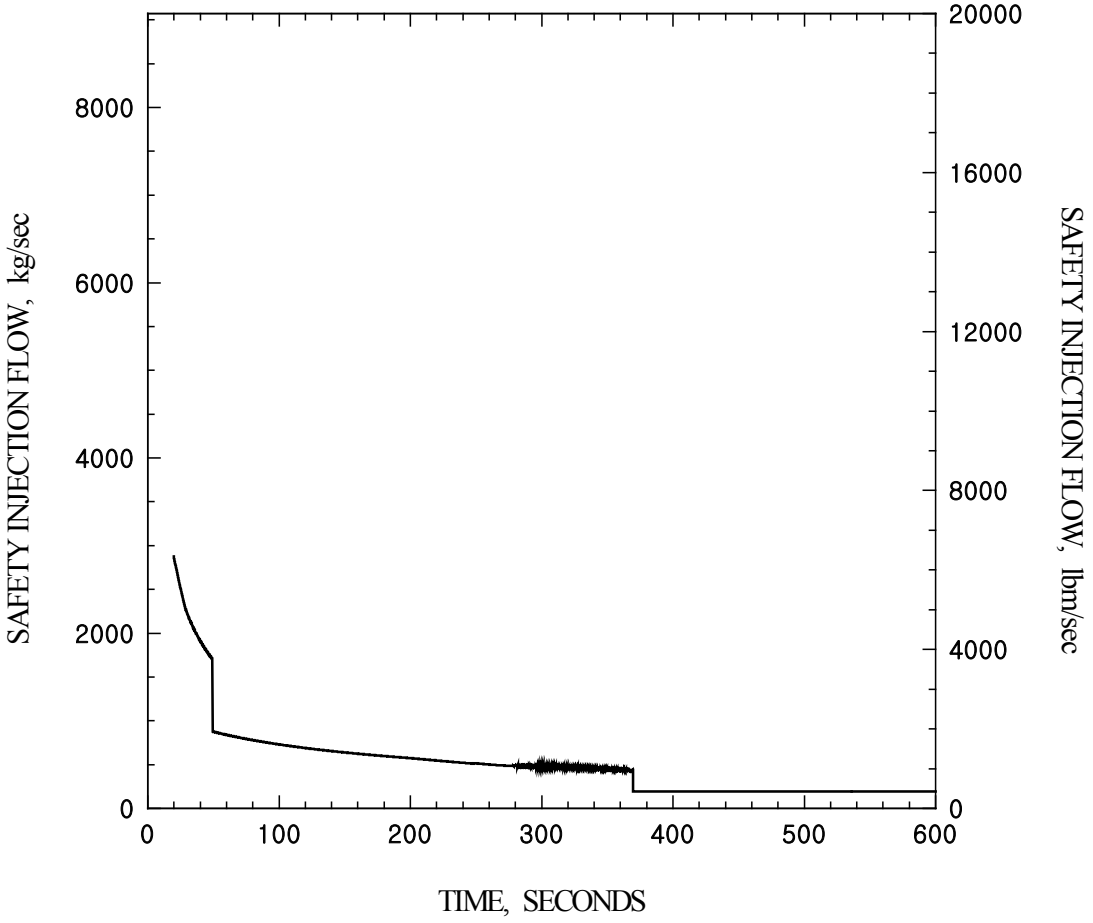


Figure 6.2.1-36 Double-Ended Discharge Leg Slot Break; Minimum SI Pump Flow vs. Time

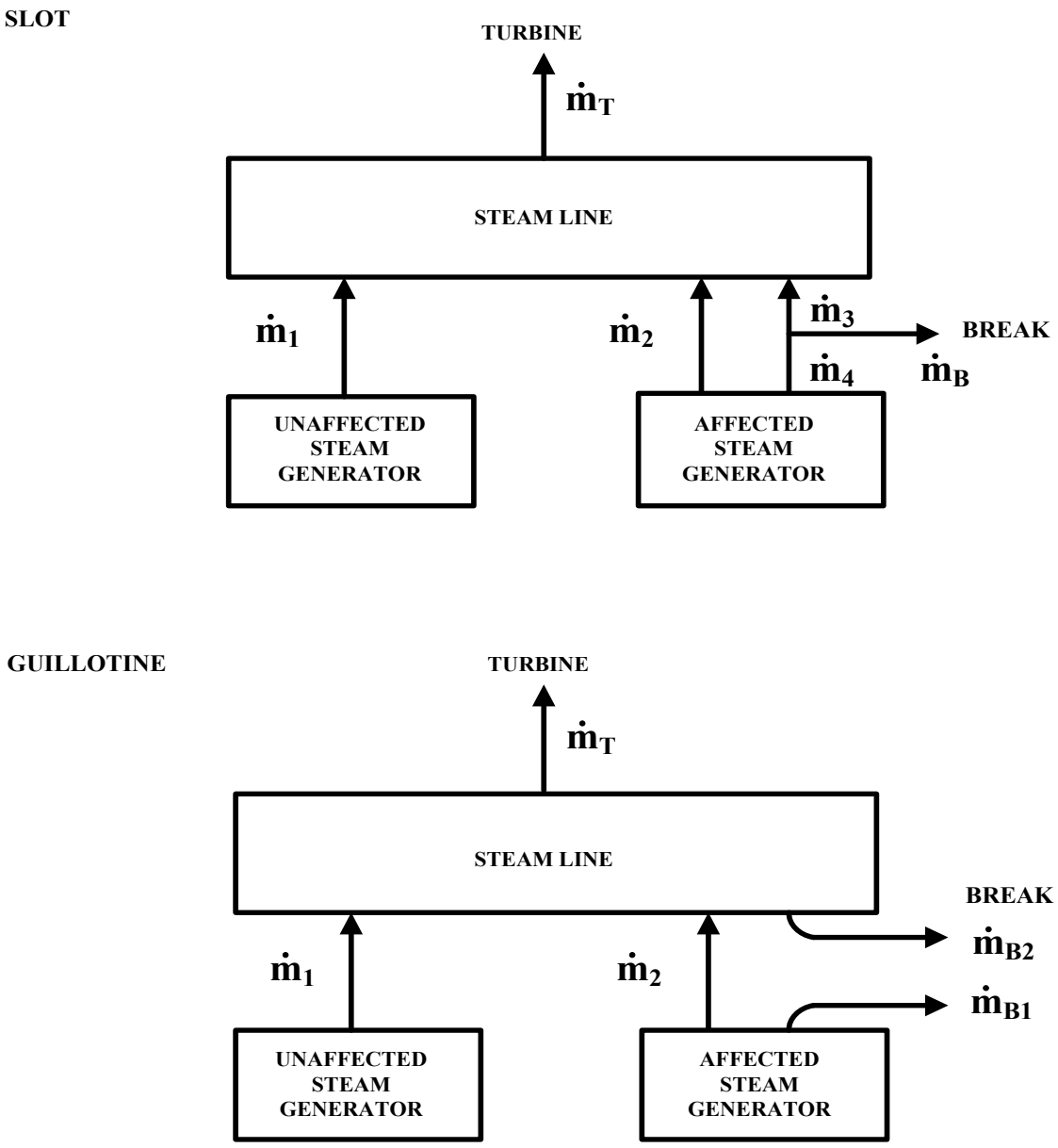


Figure 6.2.1-37 Main Steam Line Break Model

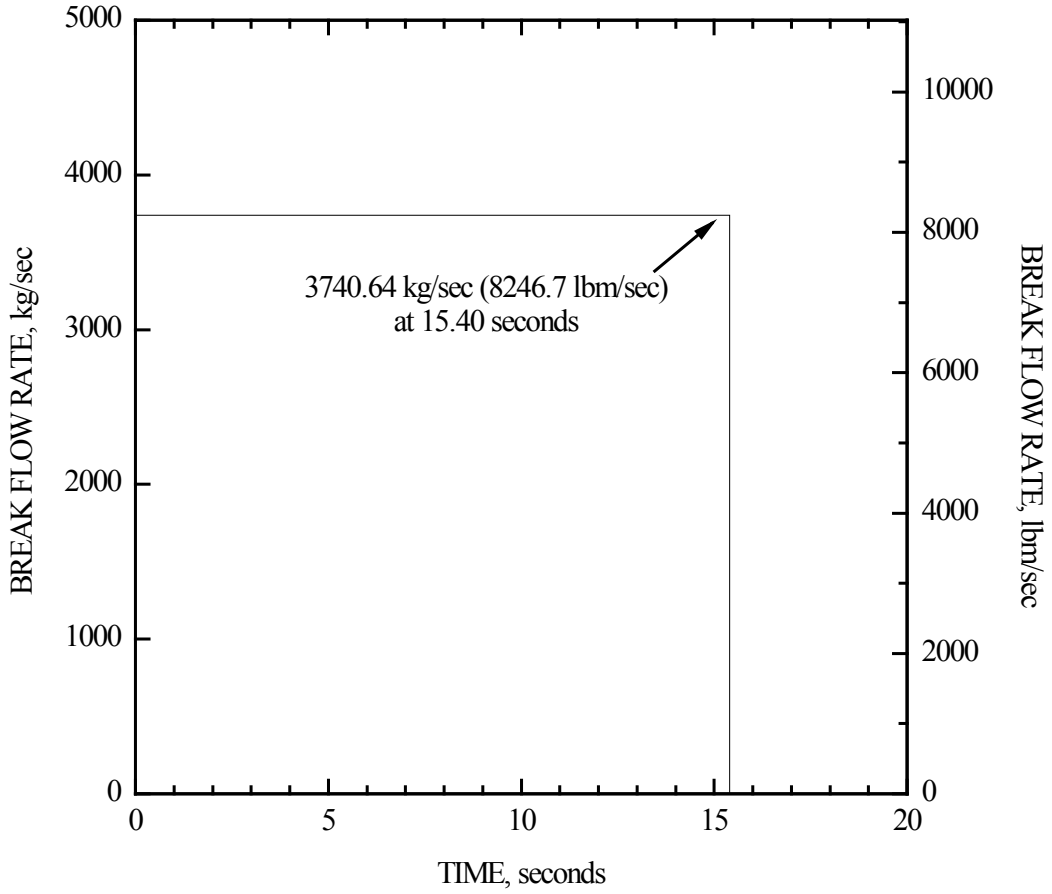


Figure 6.2.1-38 Main Steam Line Break, 102 % Power – Loss of One CSS Train Feedwater Addition vs. Time (1 of 2)

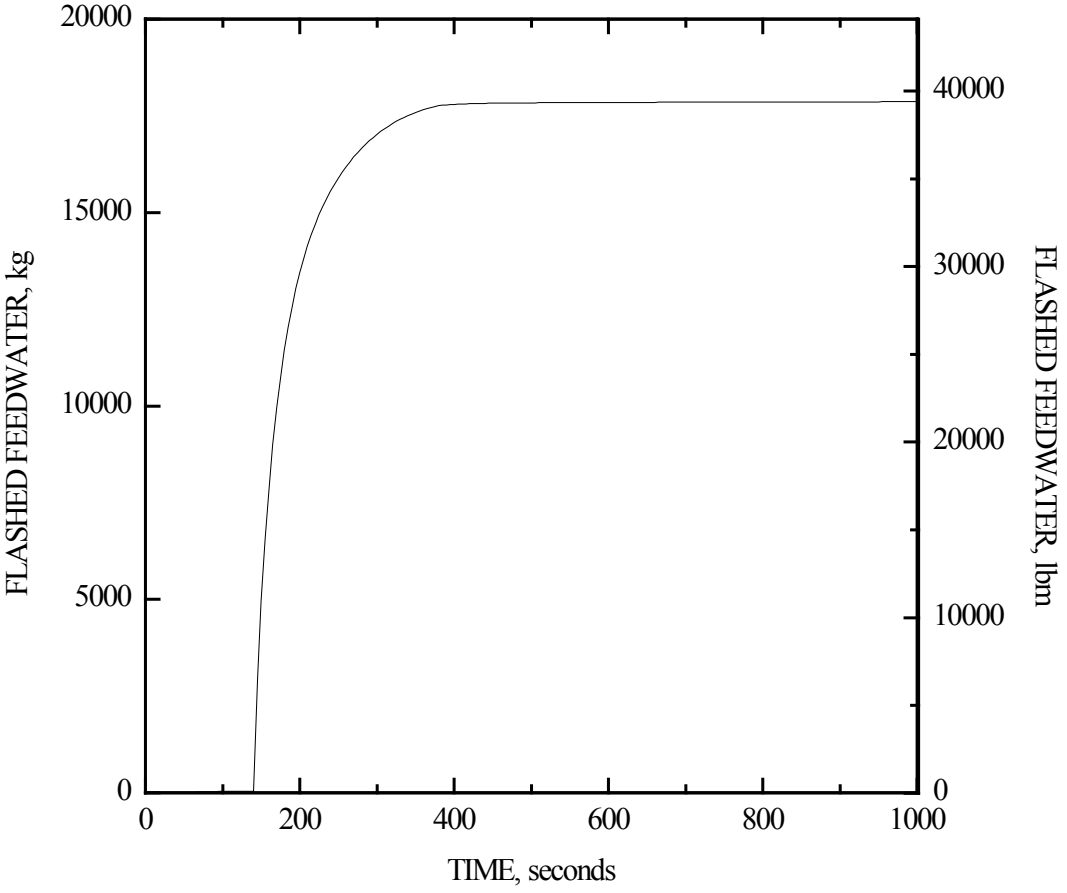


Figure 6.2.1-38 Main Steam Line Break, 102 % Power – Loss of One CSS Train Feedwater Addition vs. Time (2 of 2)

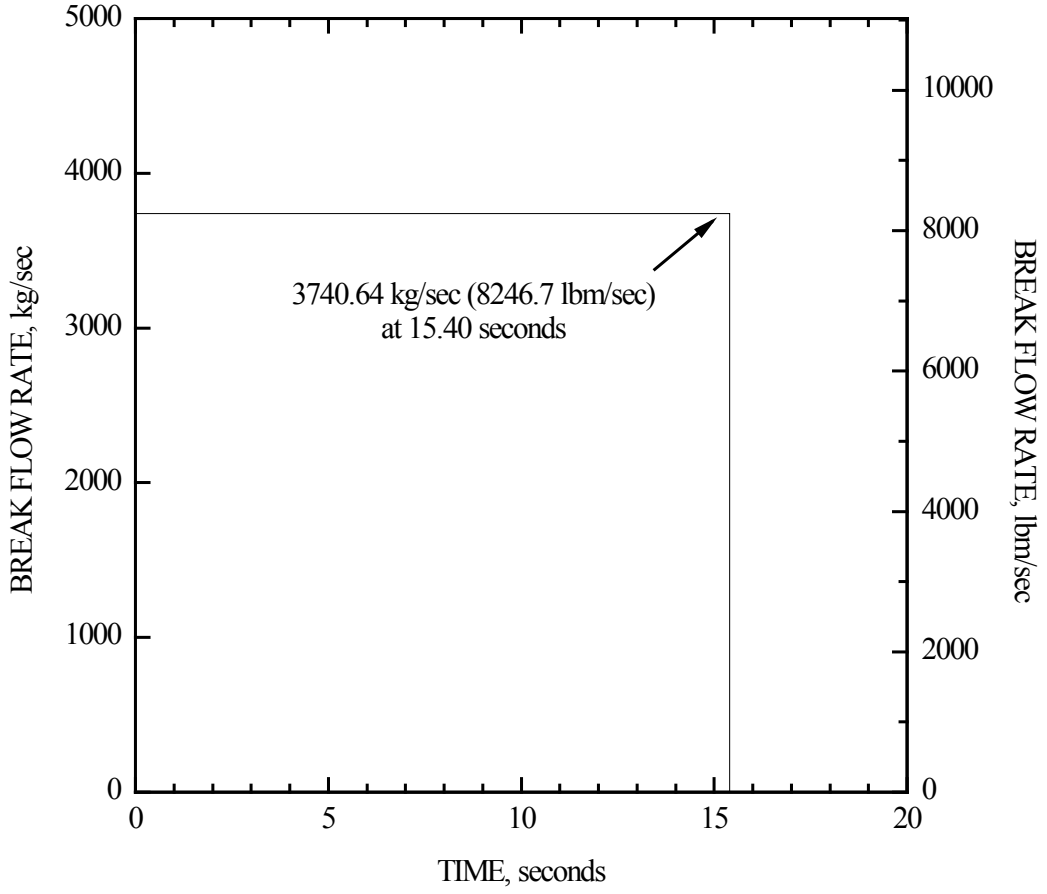


Figure 6.2.1-39 Main Steam Line Break, 102 % Power MSIV Failure Feedwater Addition vs. Time (1 of 2)

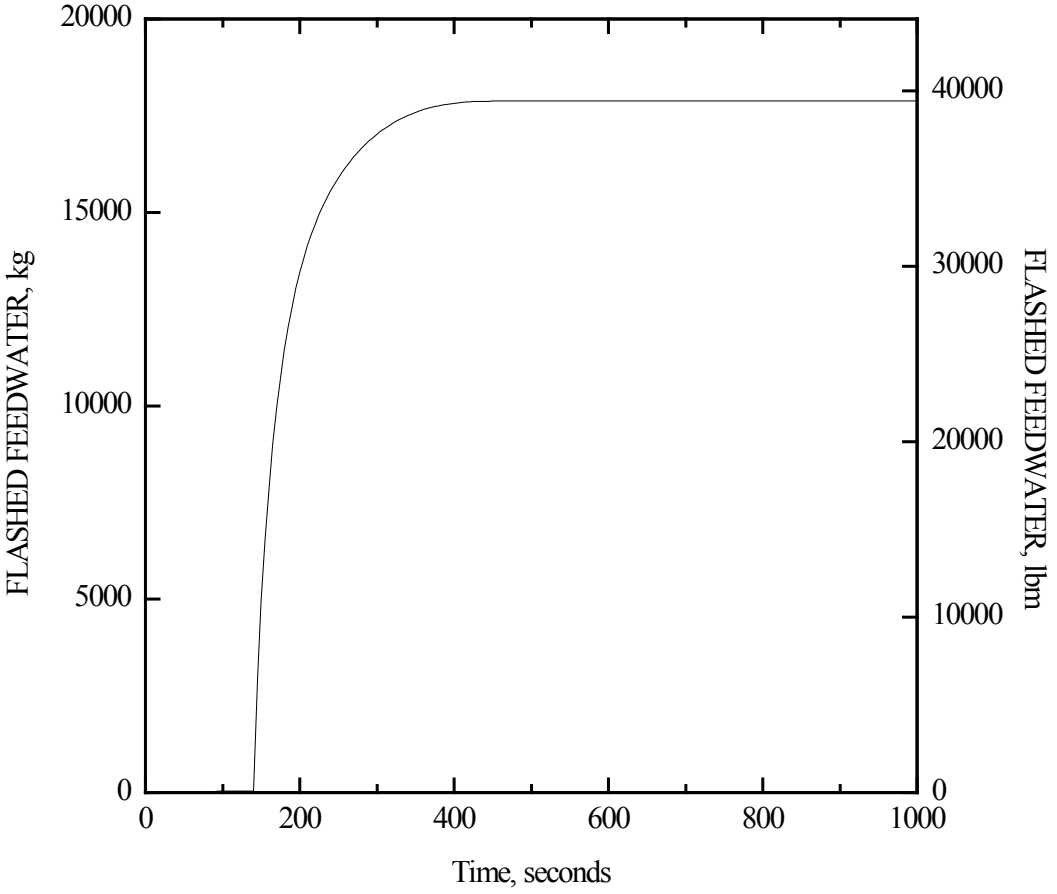


Figure 6.2.1-39 Main Steam Line Break, 102 % Power MSIV Failure Feedwater Addition vs. Time (2 of 2)

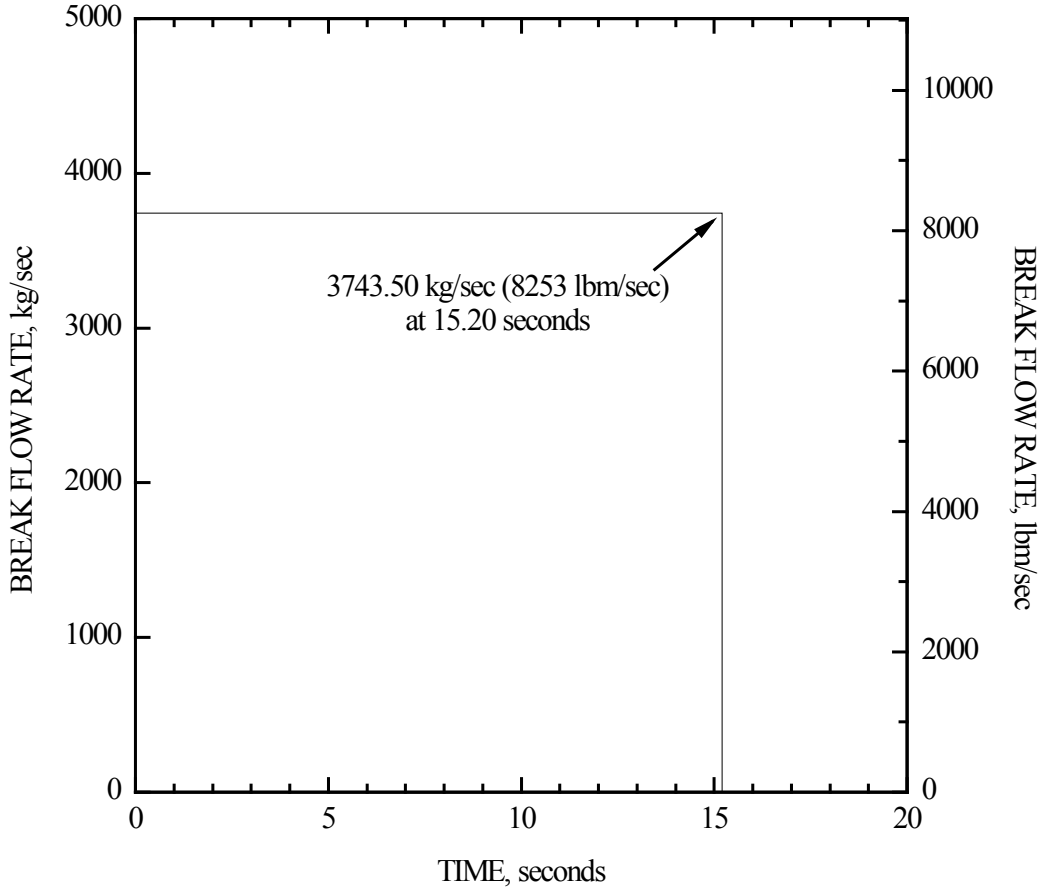


Figure 6.2.1-40 Main Steam Line Break, 75 % Power – Loss of One CSS Train Feedwater Addition vs. Time (1 of 2)

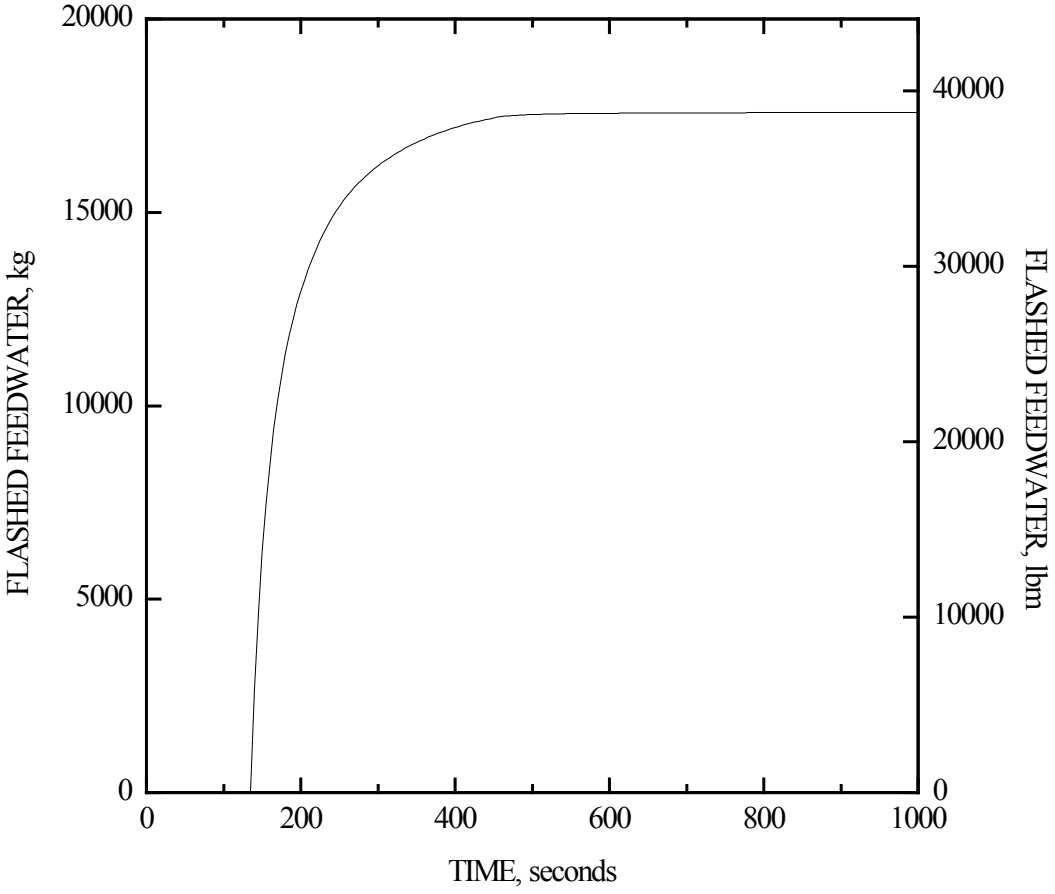


Figure 6.2.1-40 Main Steam Line Break, 75 % Power – Loss of One CSS Train Feedwater Addition vs. Time (2 of 2)

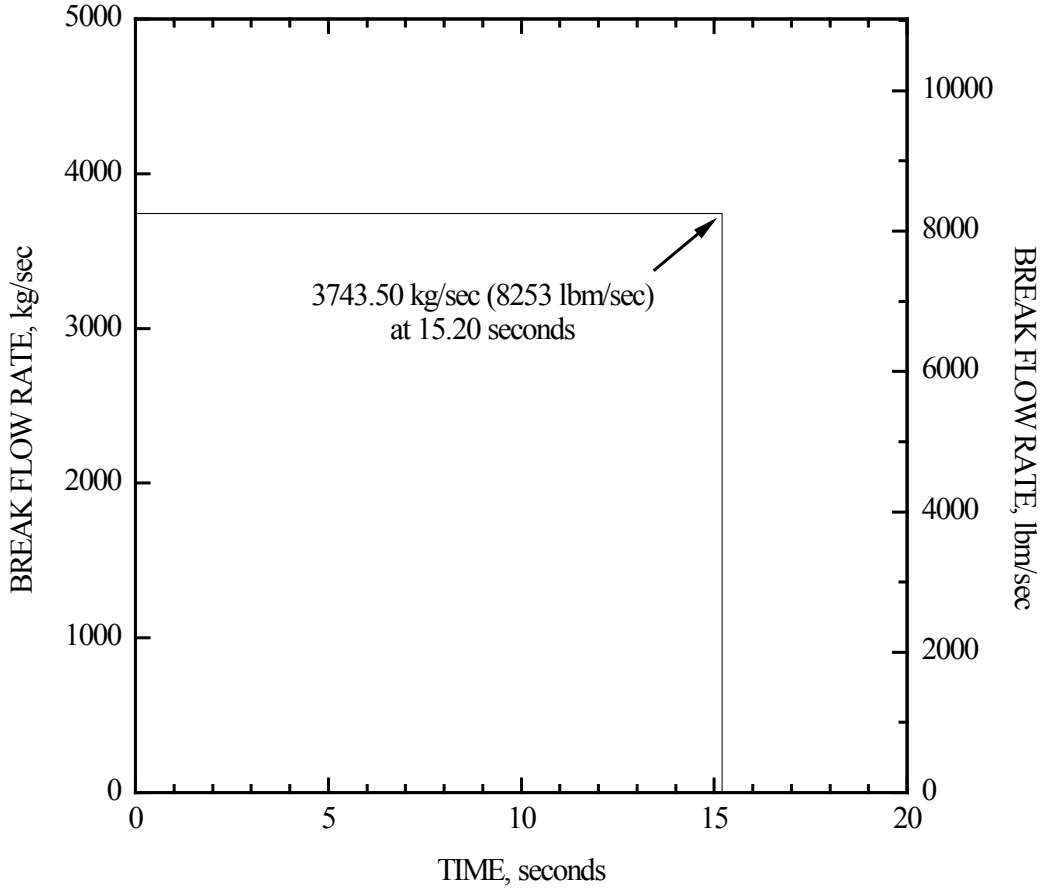


Figure 6.2.1-41 Main Steam Line Break, 75 % Power MSIV Failure Feedwater Addition vs. Time (1 of 2)

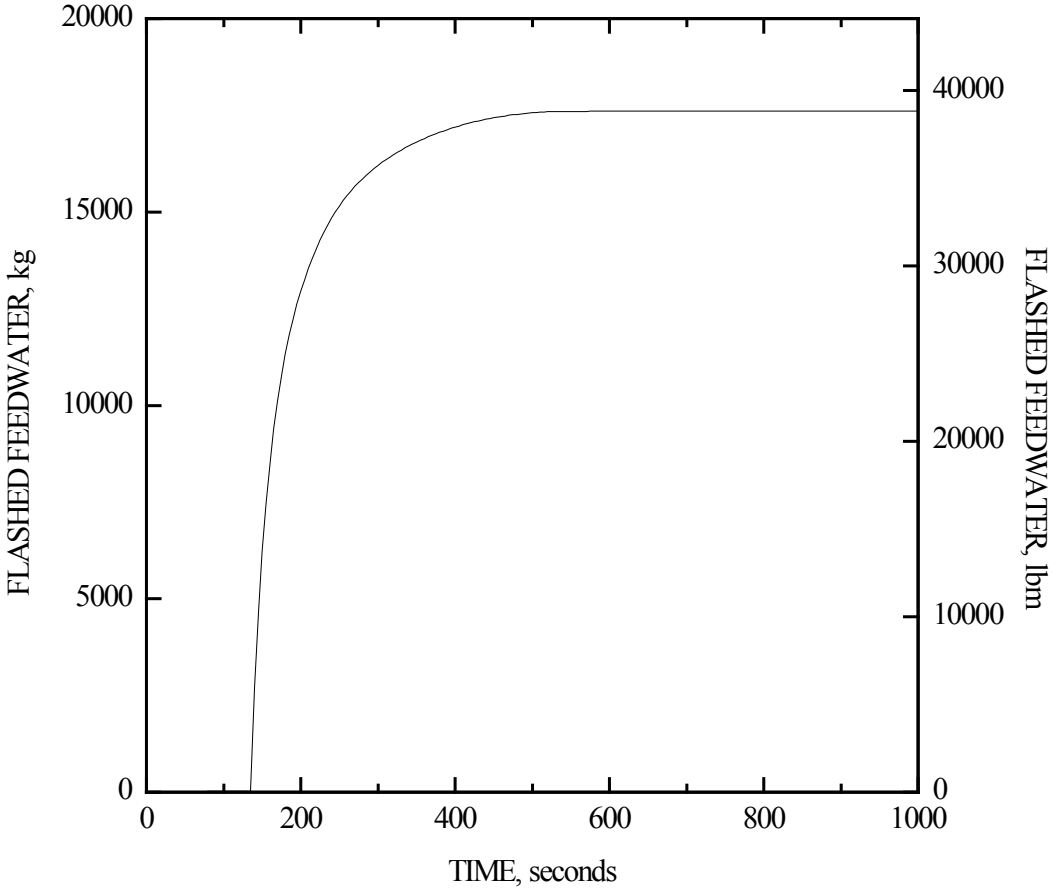


Figure 6.2.1-41 Main Steam Line Break, 75 % Power MSIV Failure Feedwater Addition vs. Time (2 of 2)

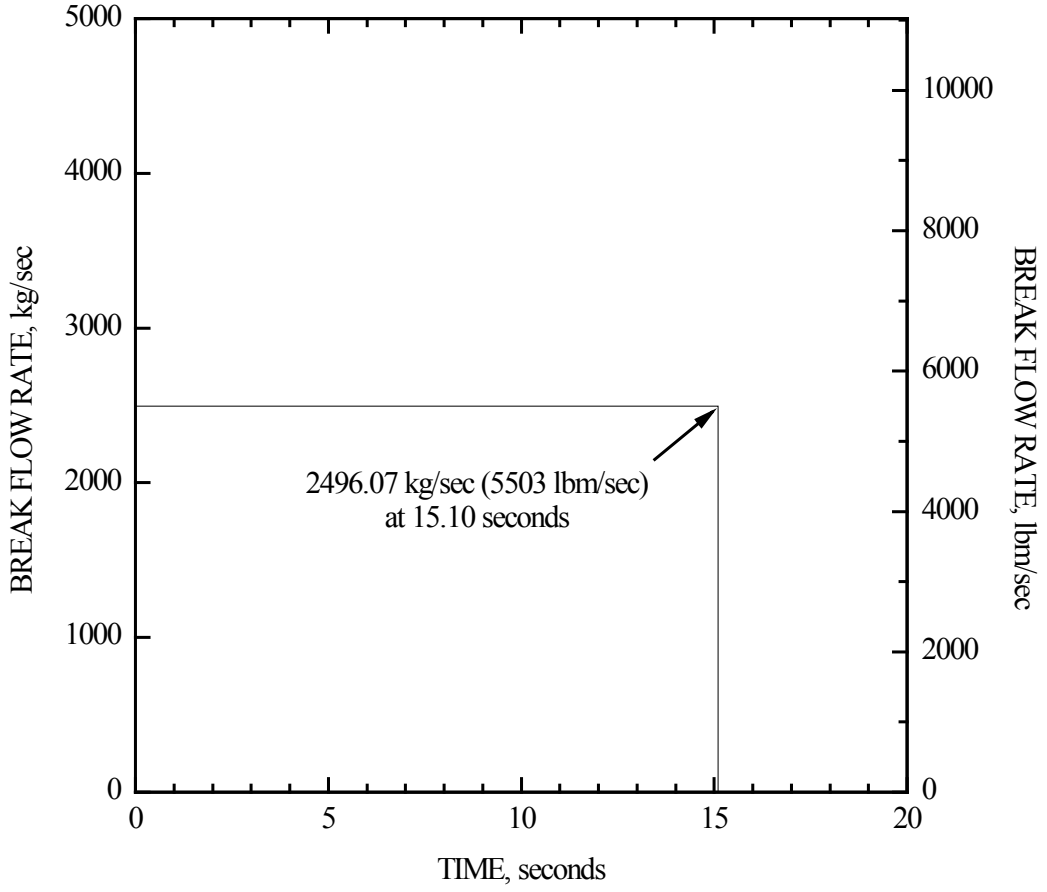


Figure 6.2.1-42 Main Steam Line Break, 50 % Power – Loss of One CSS Train Feedwater Addition vs. Time (1 of 2)

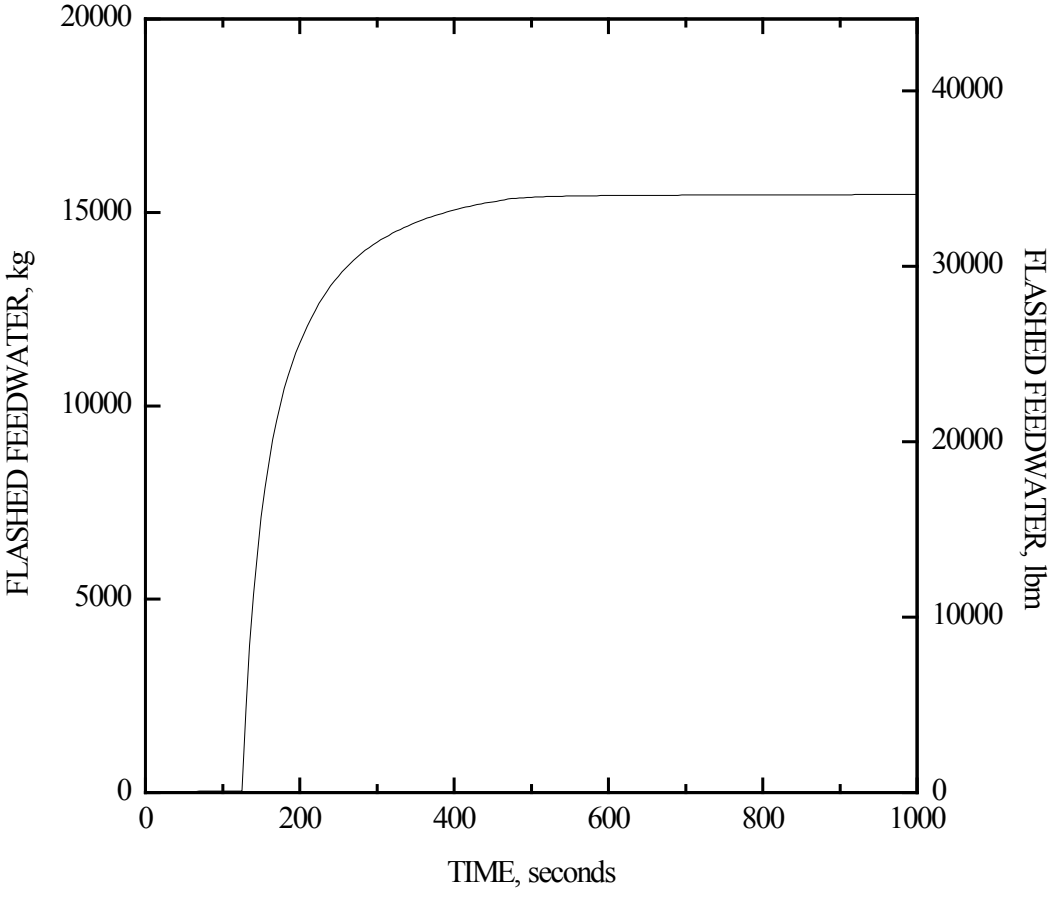


Figure 6.2.1-42 Main Steam Line Break, 50 % Power – Loss of One CSS Train Feedwater Addition vs. Time (2 of 2)

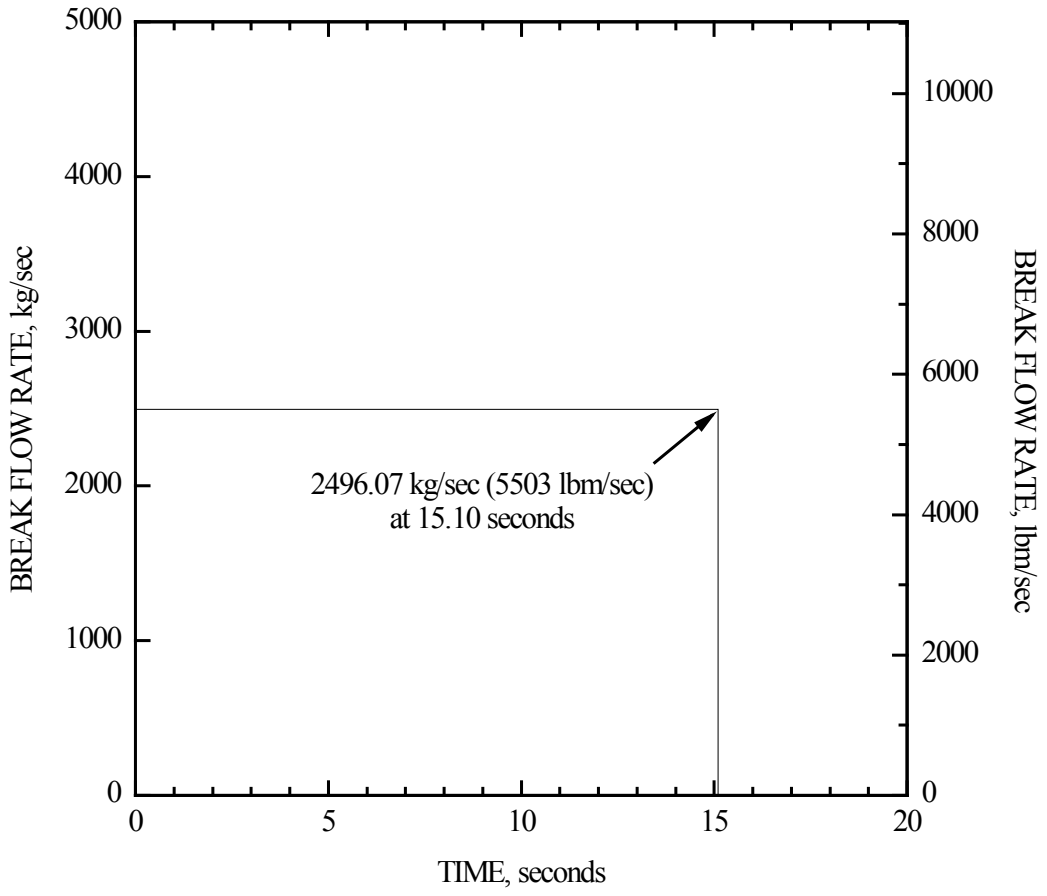


Figure 6.2.1-43 Main Steam Line Break, 50 % Power – MSIV Failure Feedwater Addition vs. Time (1 of 2)

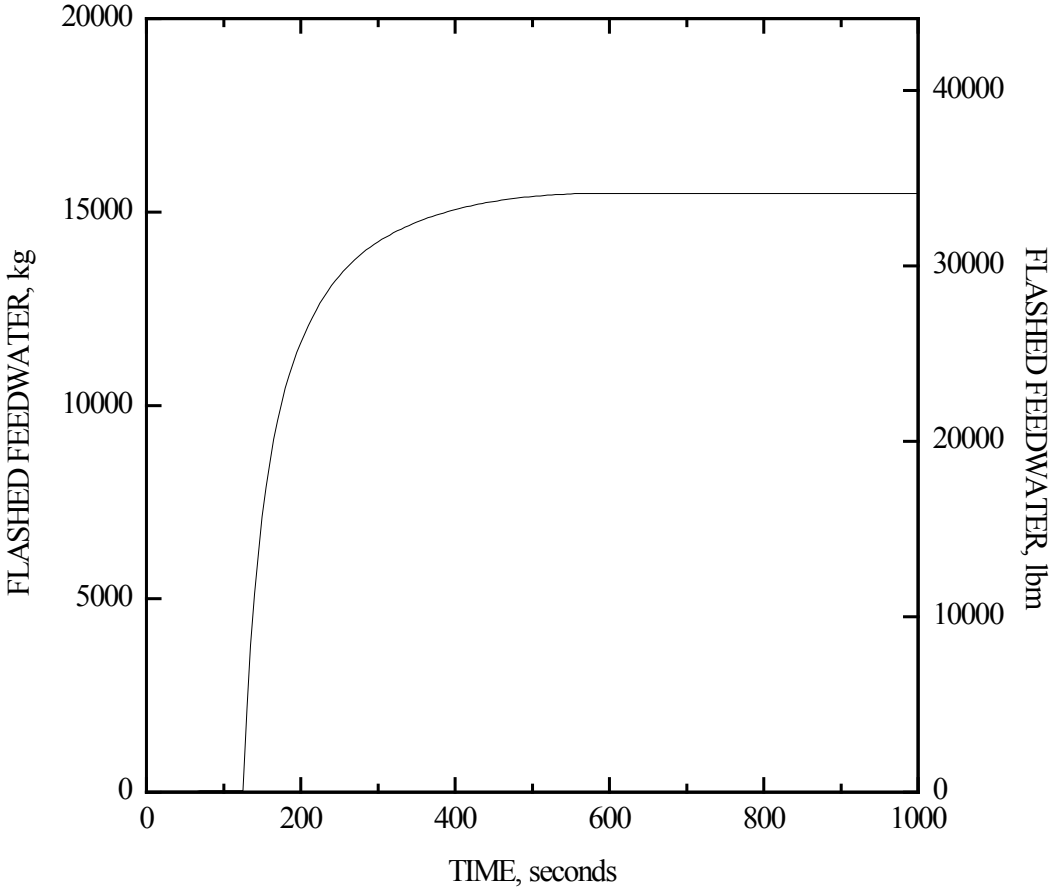


Figure 6.2.1-43 Main Steam Line Break, 50 % Power – MSIV Failure Feedwater Addition vs. Time (2 of 2)

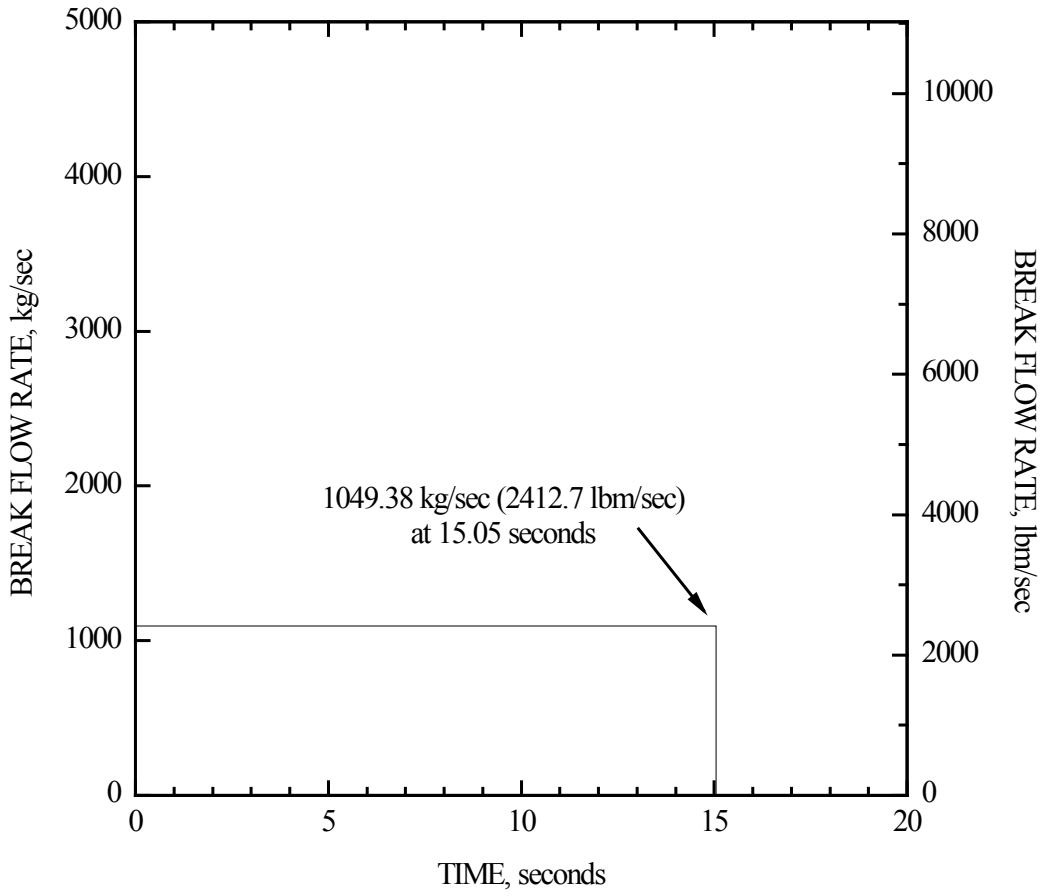


Figure 6.2.1-44 Main Steam Line Break, 20 % Power – Loss of One CSS Train Feedwater Addition vs. Time (1 of 2)

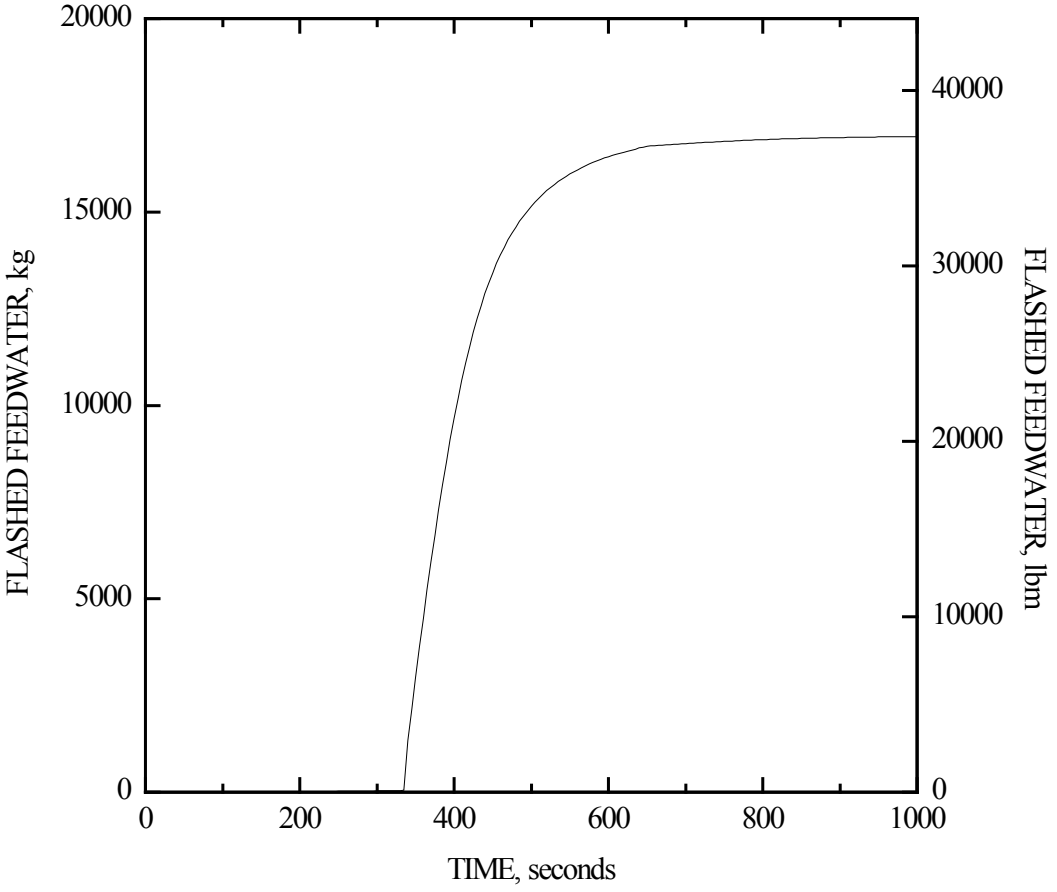


Figure 6.2.1-44 Main Steam Line Break, 20 % Power – Loss of One CSS Train Feedwater Addition vs. Time (2 of 2)

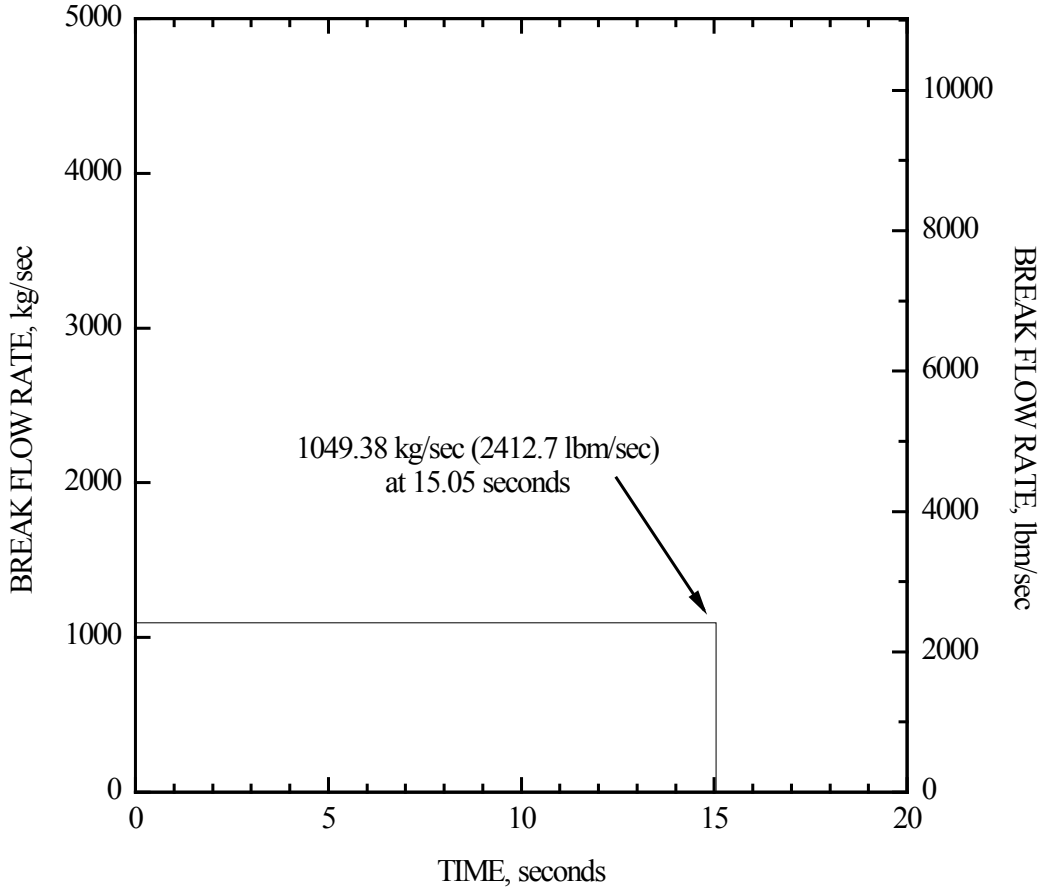


Figure 6.2.1-45 Main Steam Line Break, 20 % Power – MSIV Failure Feedwater Addition vs. Time (1 of 2)

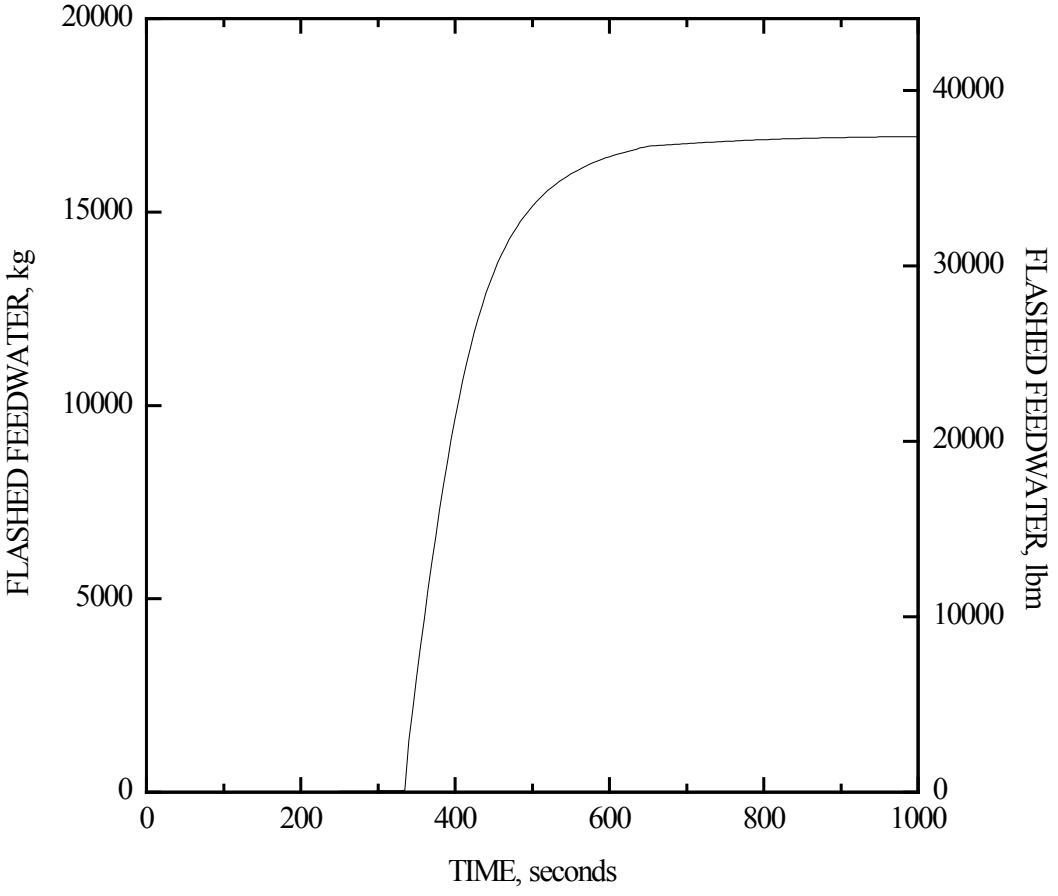


Figure 6.2.1-45 Main Steam Line Break, 20 % Power – MSIV Failure Feedwater Addition vs. Time (2 of 2)

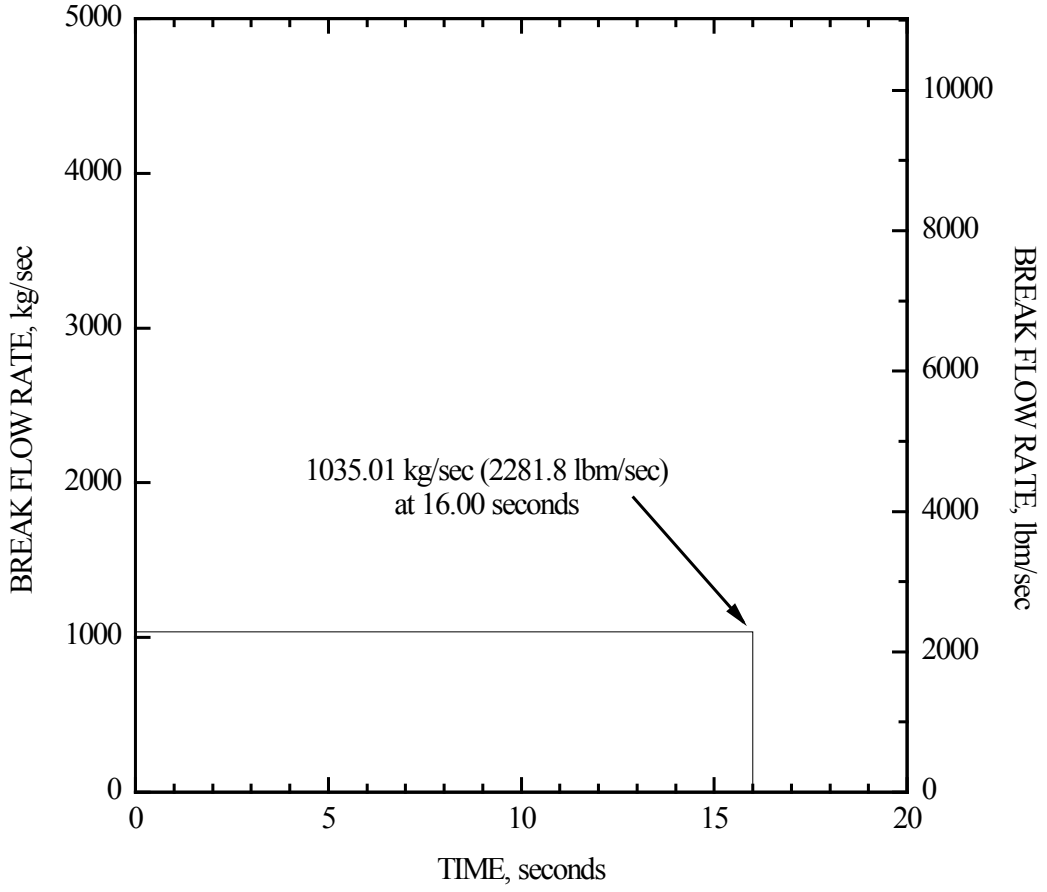


Figure 6.2.1-46 Main Steam Line Break, 0 % Power – Loss of One CSS Train Feedwater Addition vs. Time (1 of 2)

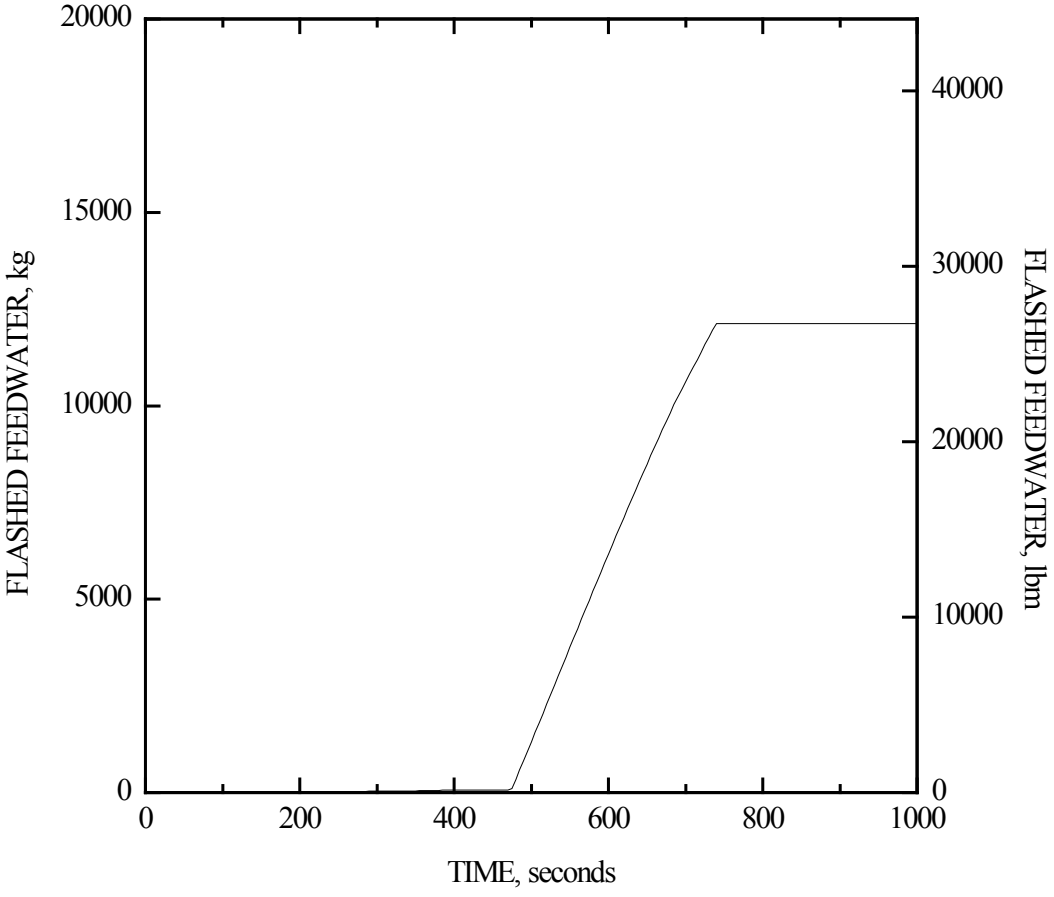


Figure 6.2.1-46 Main Steam Line Break, 0 % Power – Loss of One CSS Train Feedwater Addition vs. Time (2 of 2)

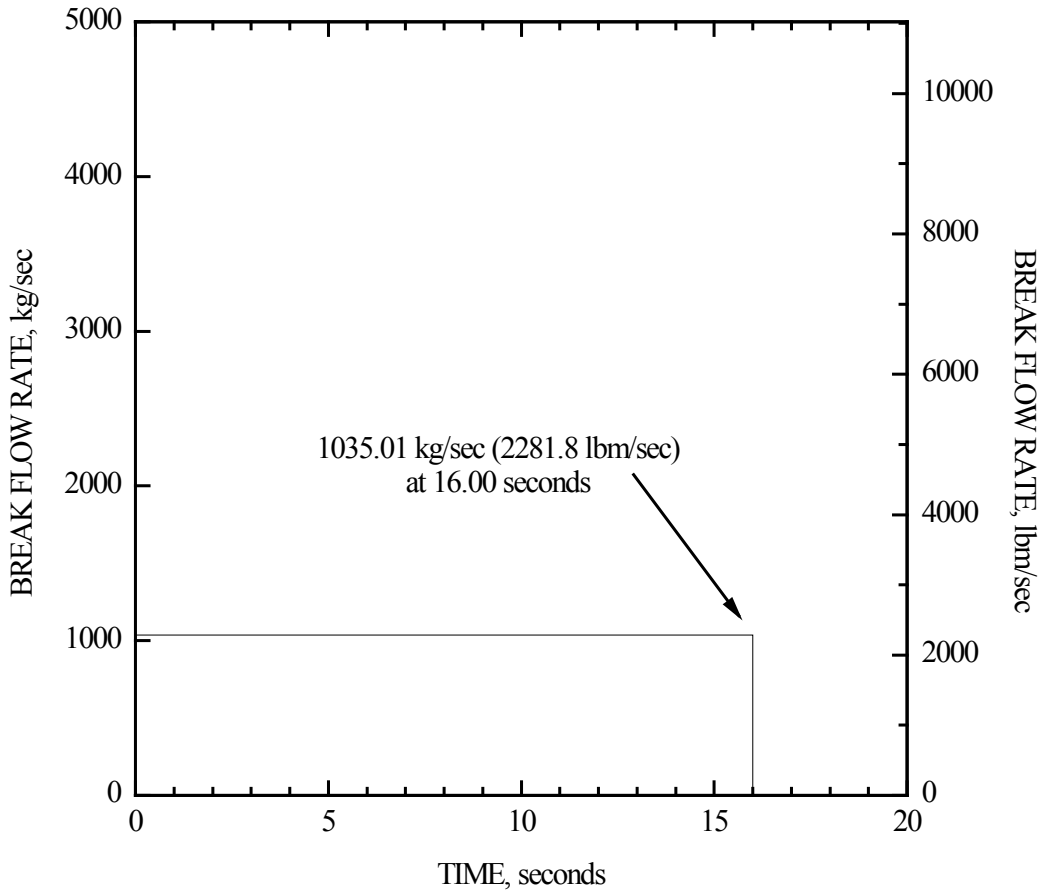


Figure 6.2.1-47 Main Steam Line Break, 0 % Power – MSIV Failure Feedwater Addition vs. Time (1 of 2)

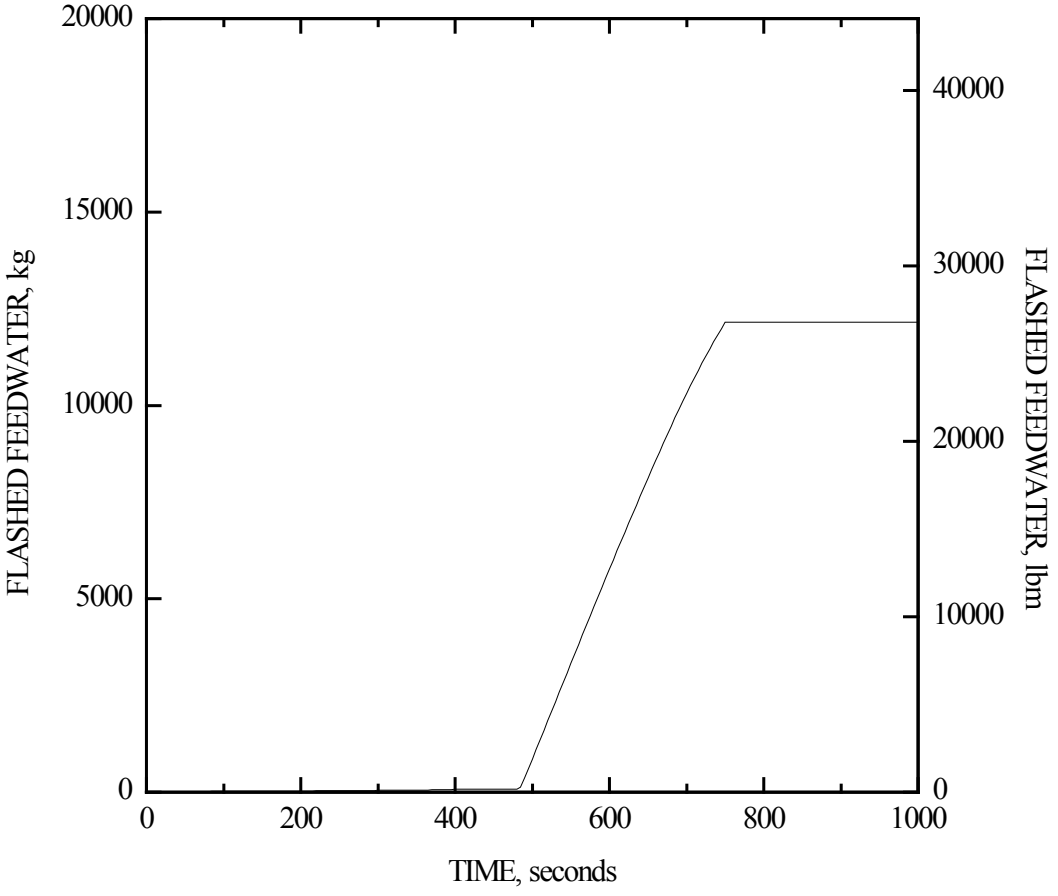


Figure 6.2.1-47 Main Steam Line Break, 0 % Power – MSIV Failure Feedwater Addition vs. Time (2 of 2)

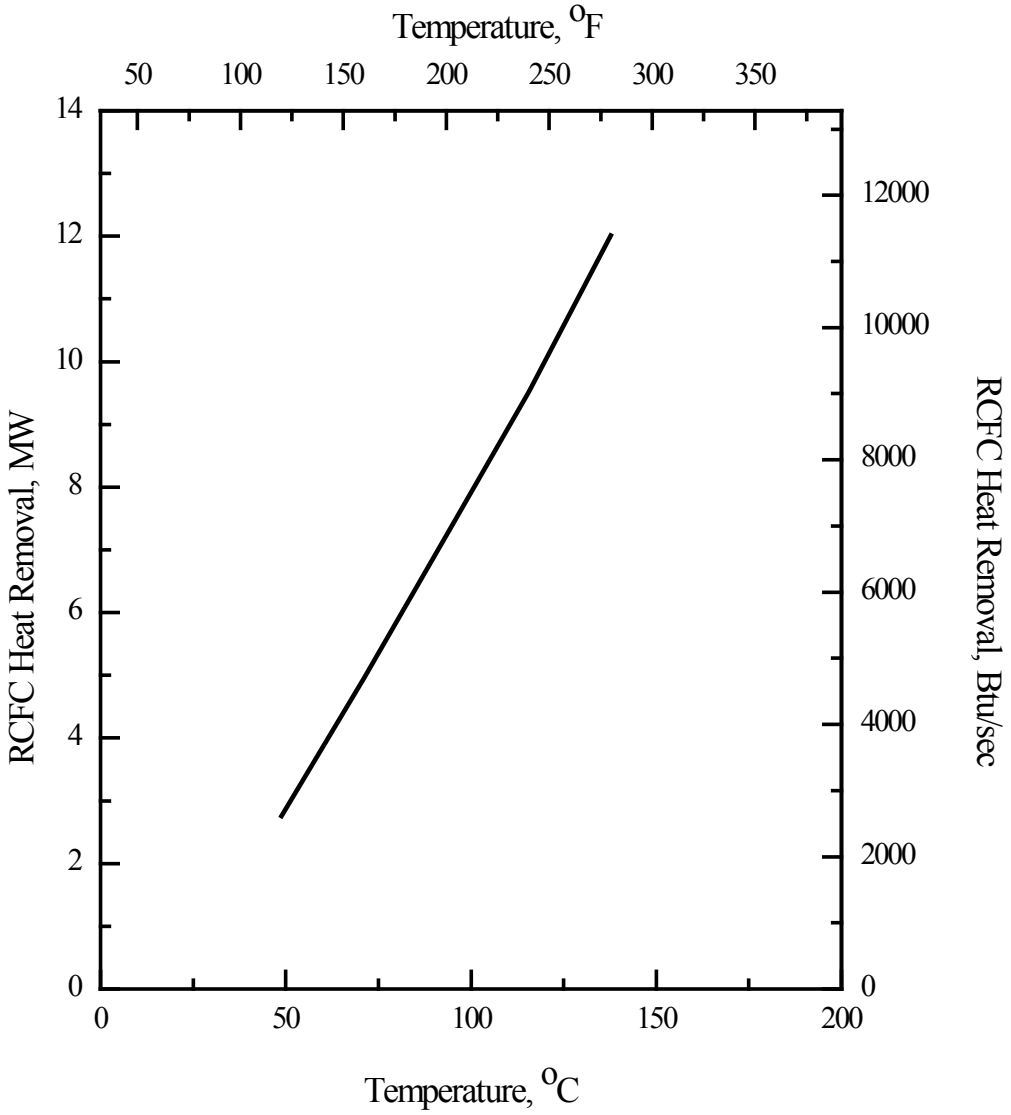


Figure 6.2.1-48 ECCS Performance Analysis (Cooling Fan Heat Removal Capacity)

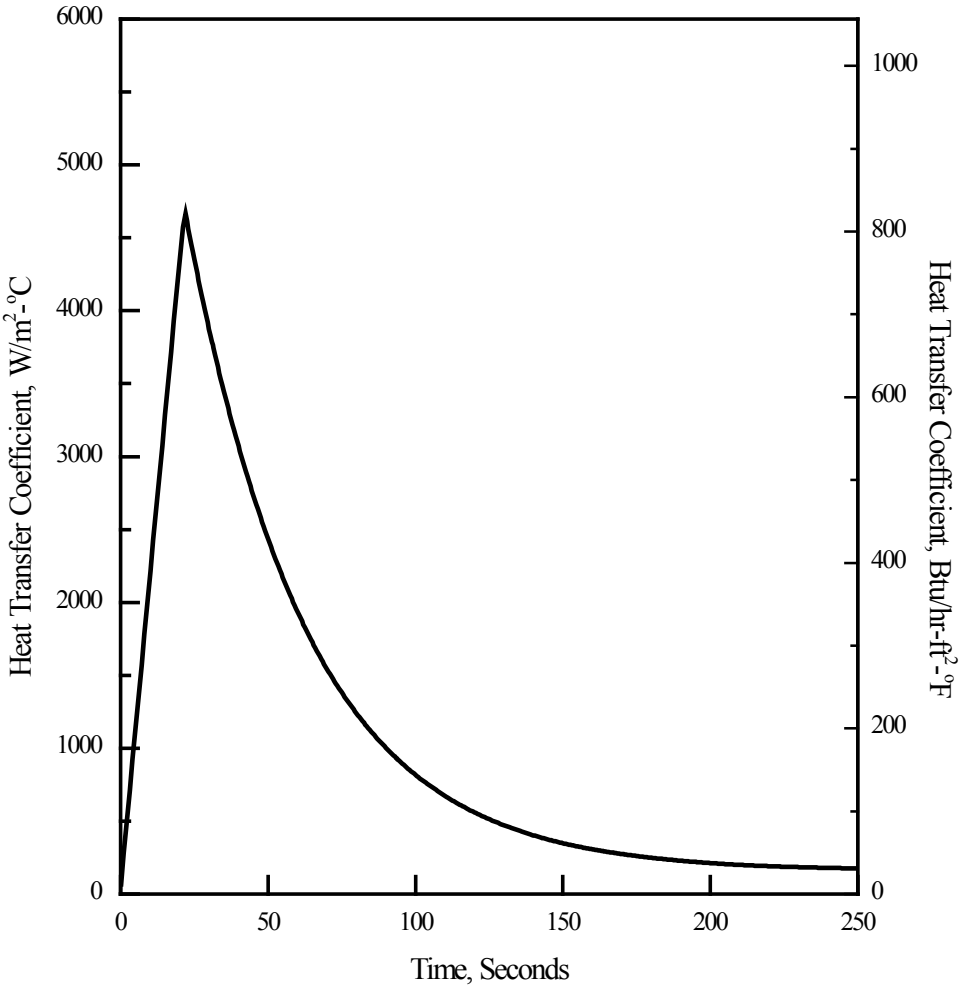


Figure 6.2.1-49 ECCS Performance Analysis
(Condensation Heat Transfer Coefficient for Passive Heat Removal Source)

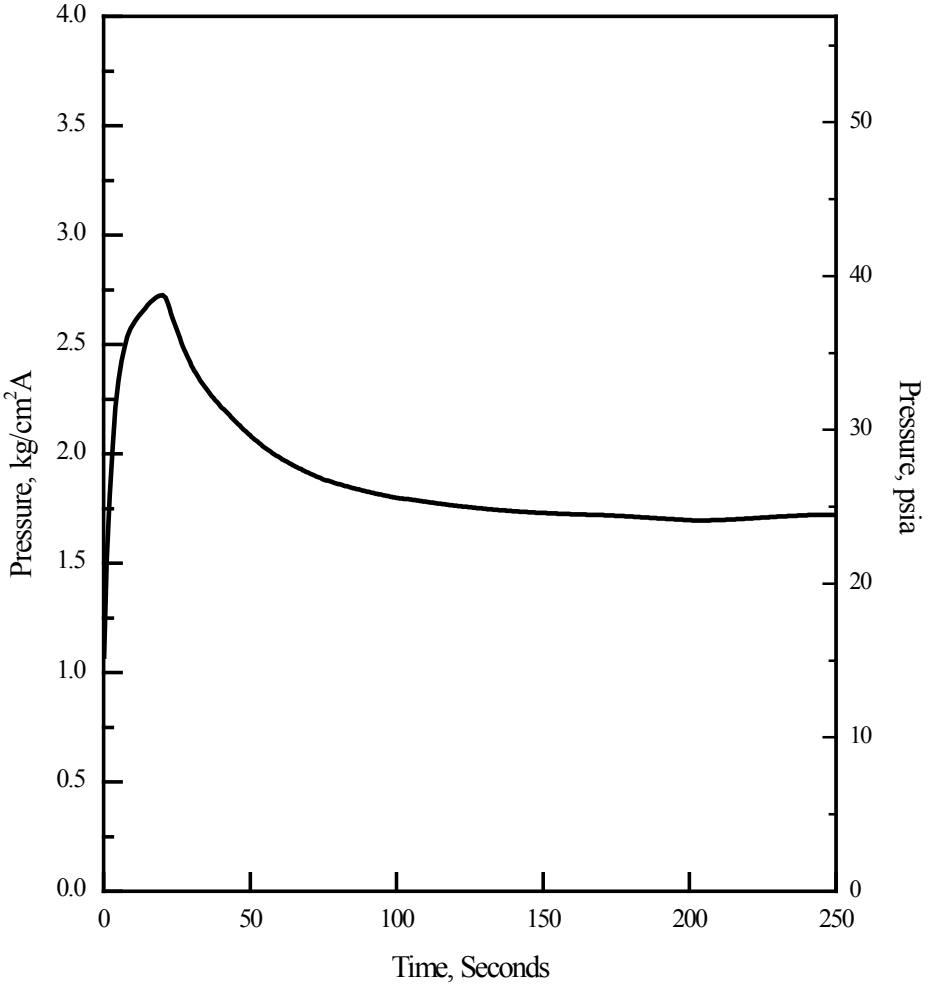


Figure 6.2.1-50 1.0 x Double-Ended Guillotine Break in Pump Discharge Leg (Min. Containment Pressure for ECCS Performance Analysis)

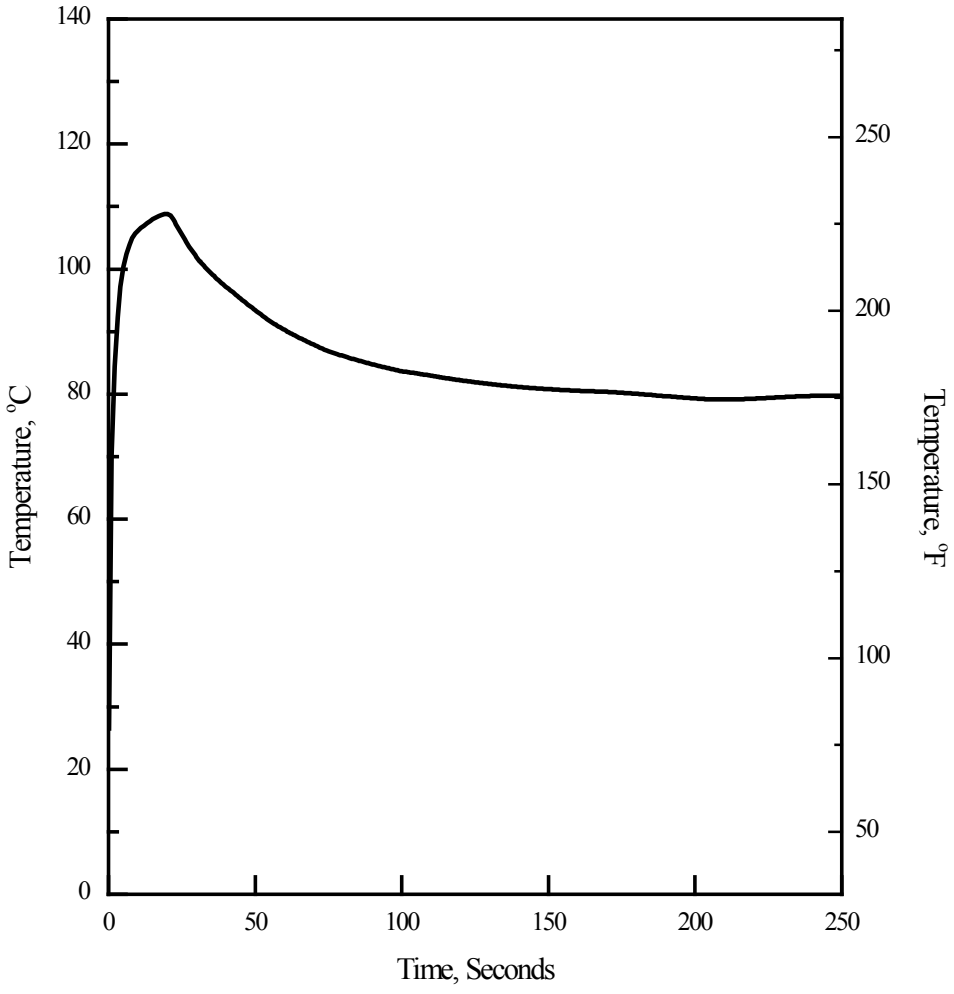


Figure 6.2.1-51 1.0 x Double-Ended Guillotine Break in Pump Discharge Leg (Containment Atmosphere Temperature)

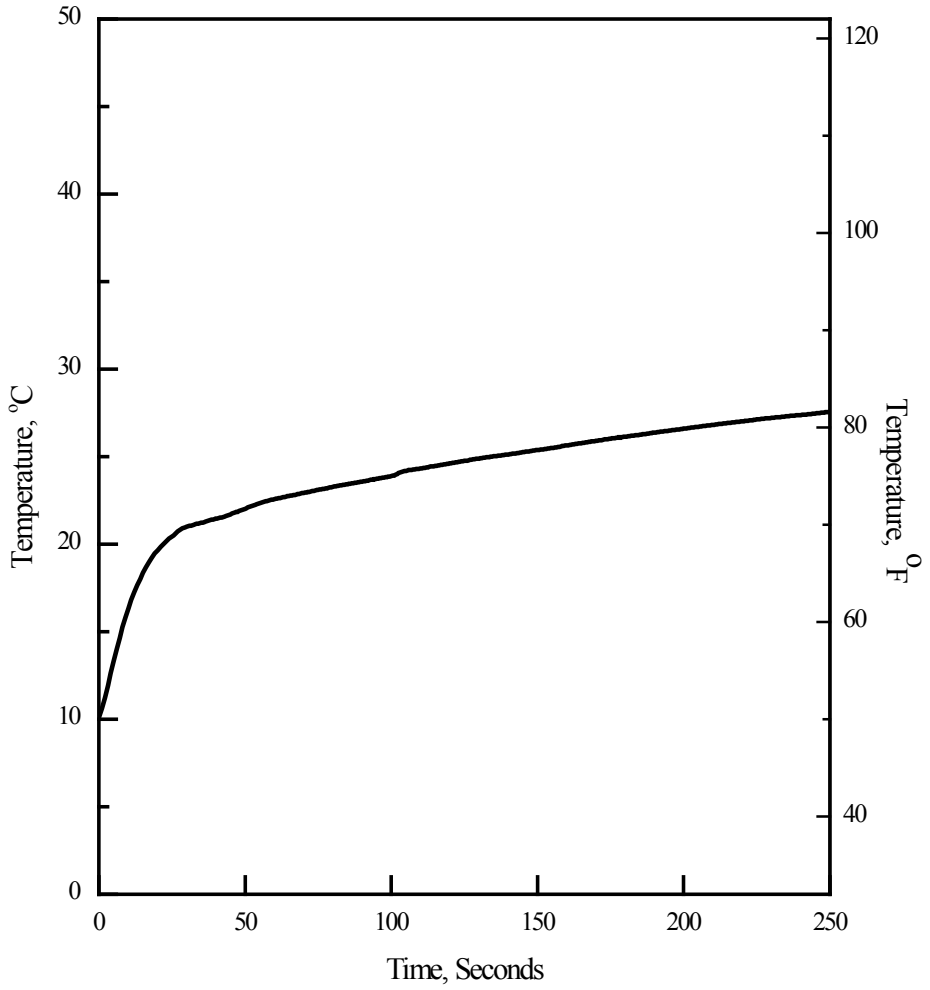


Figure 6.2.1-52 1.0 x Double-Ended Guillotine Break In Pump Discharge Leg (In-containment Refueling Water Storage Tank)

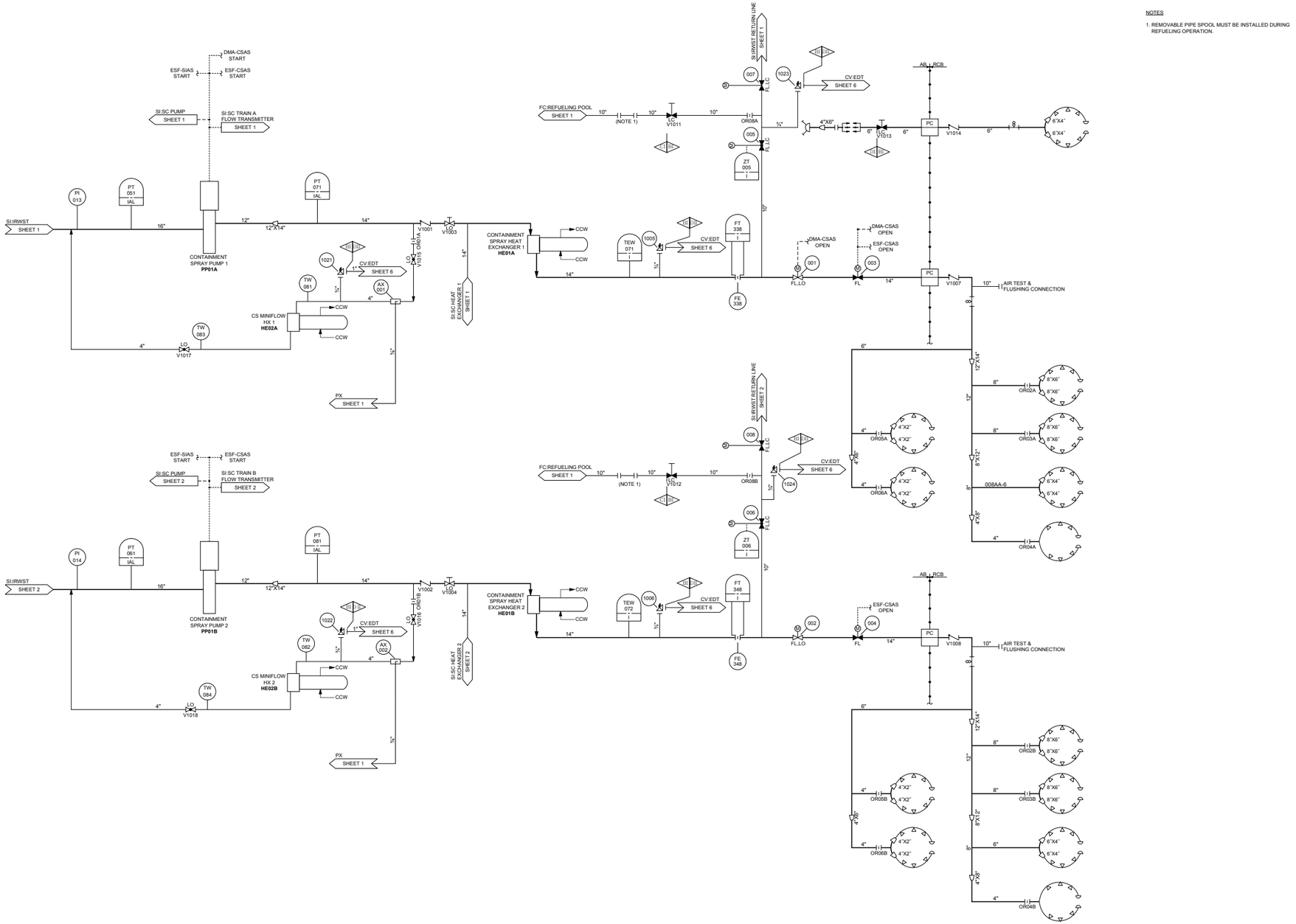


Figure 6.2.2-1 Containment Spray System Flow Diagram

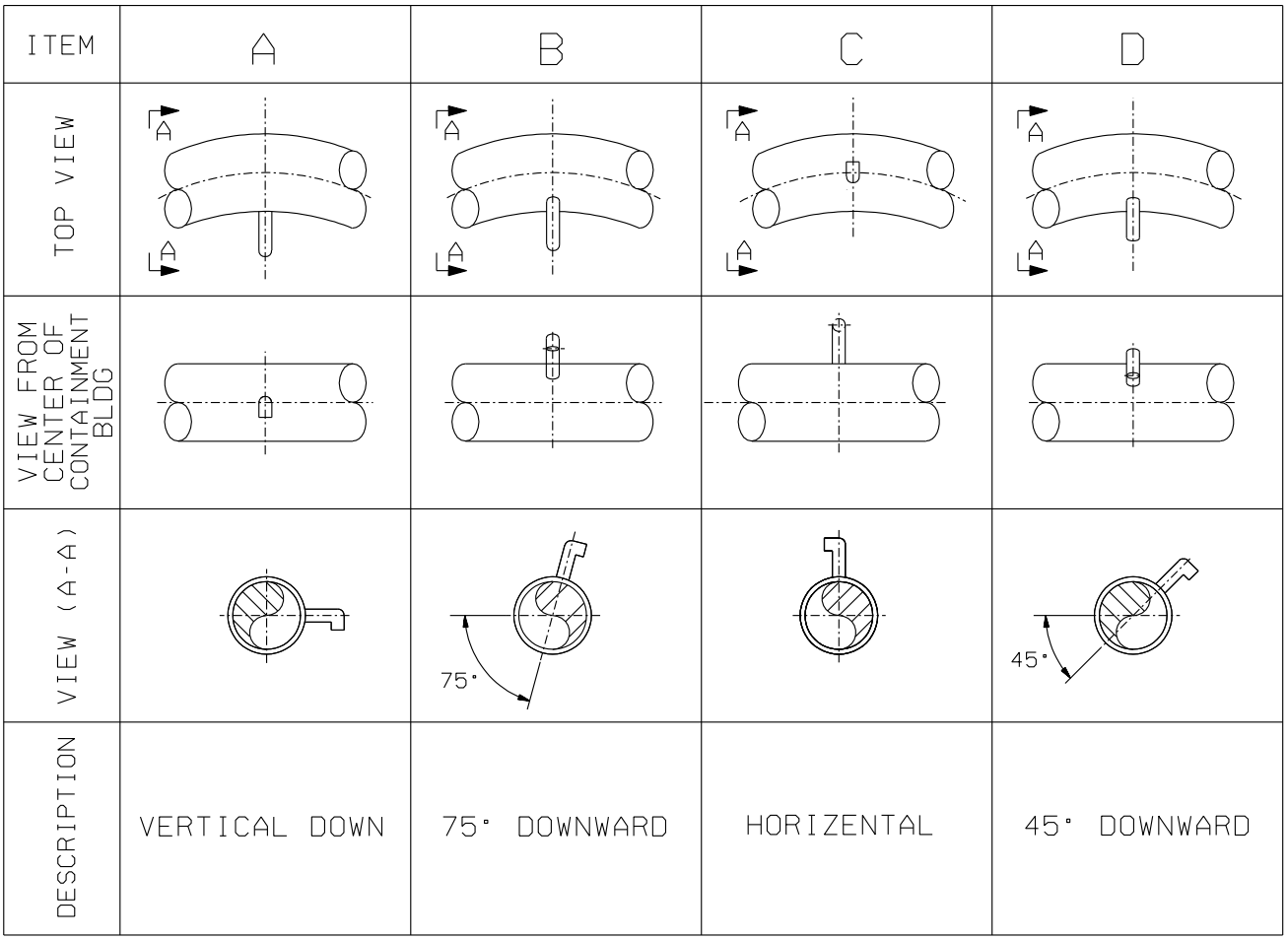


Figure 6.2.2-2 Containment Spray Nozzle Orientation

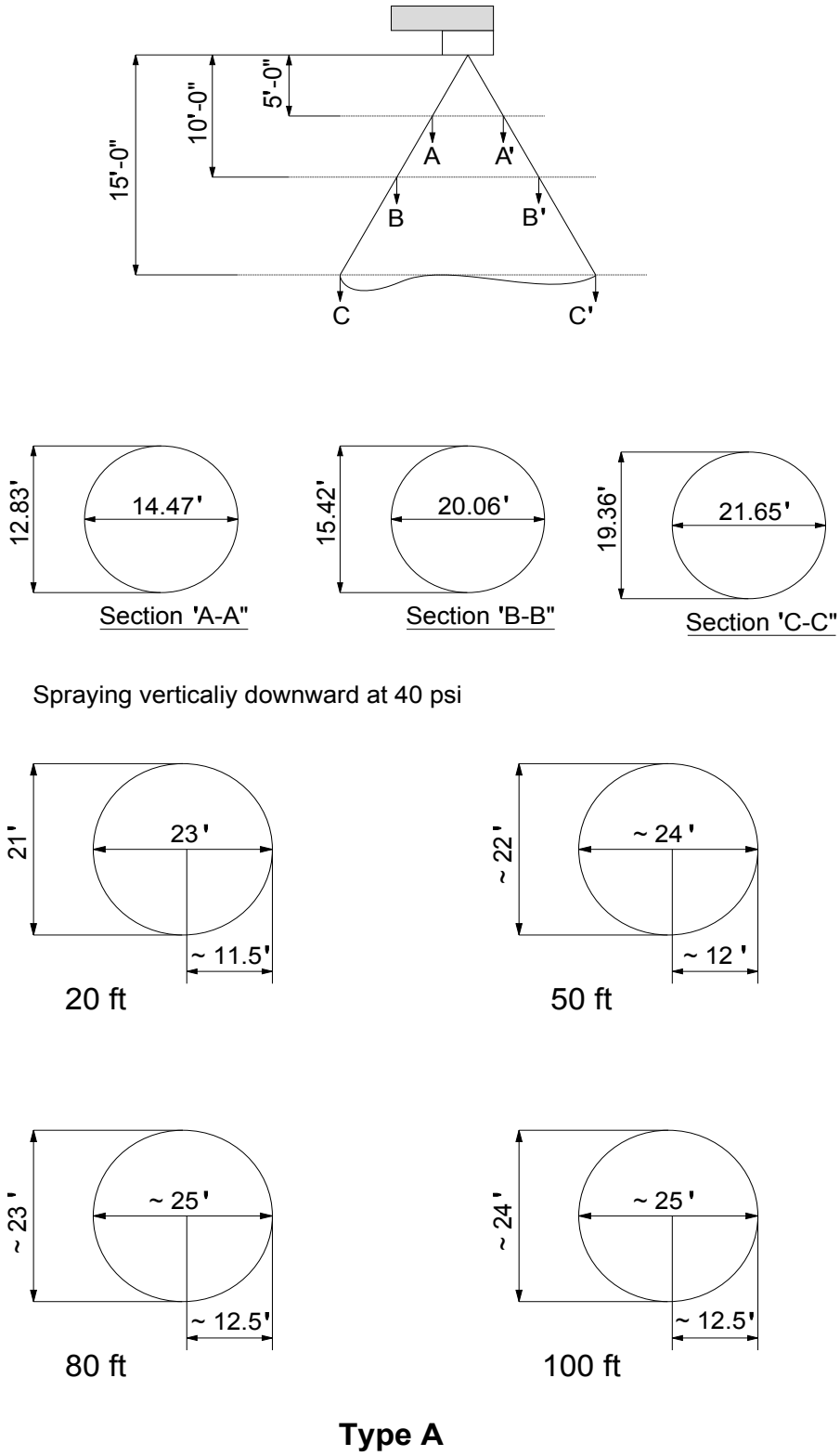
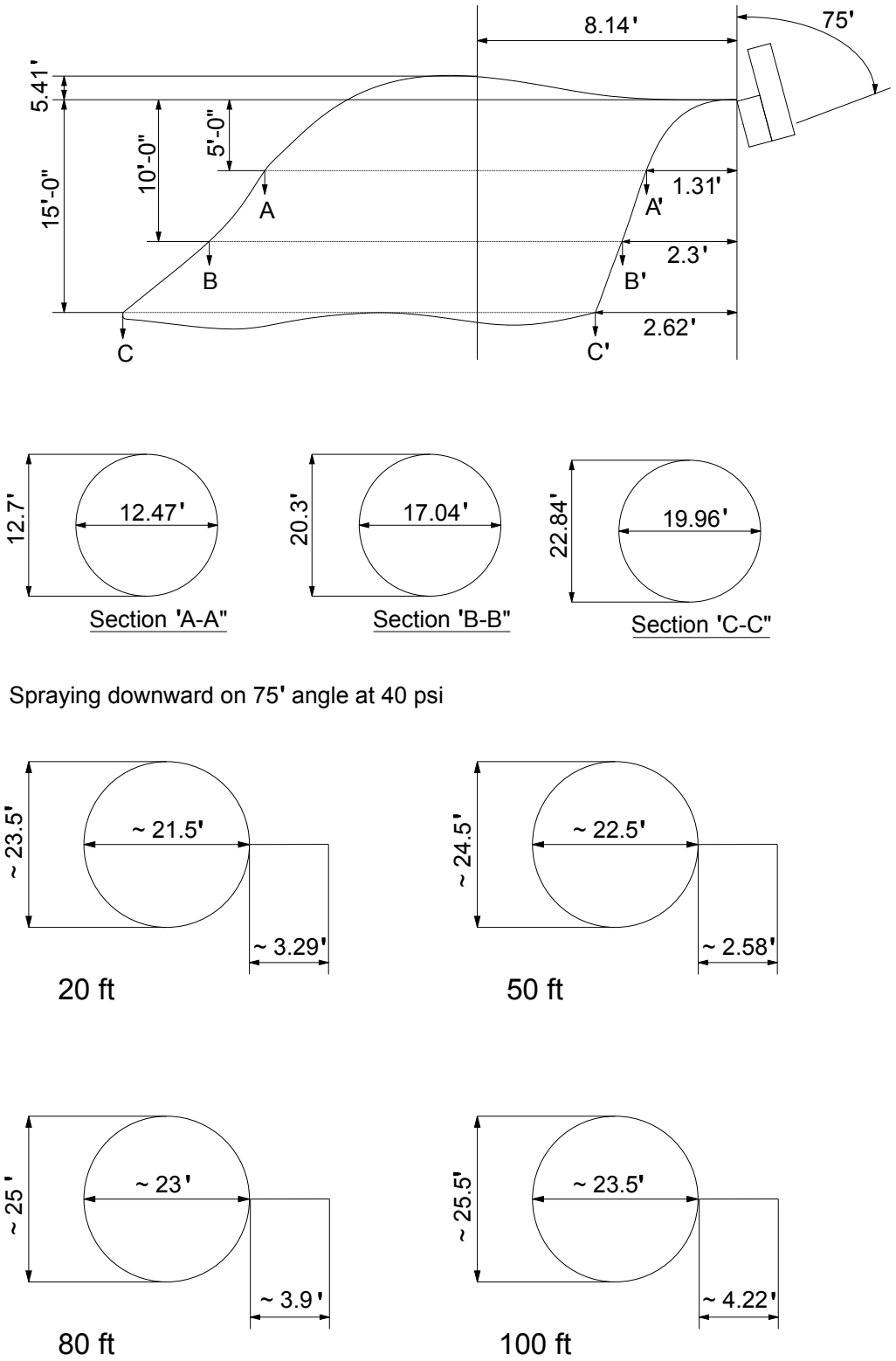


Figure 6.2.2-3 Main Spray Nozzle Spray Profiles (1 of 4)



Type B

Figure 6.2.2-3 Main Spray Nozzle Spray Profiles (2 of 4)

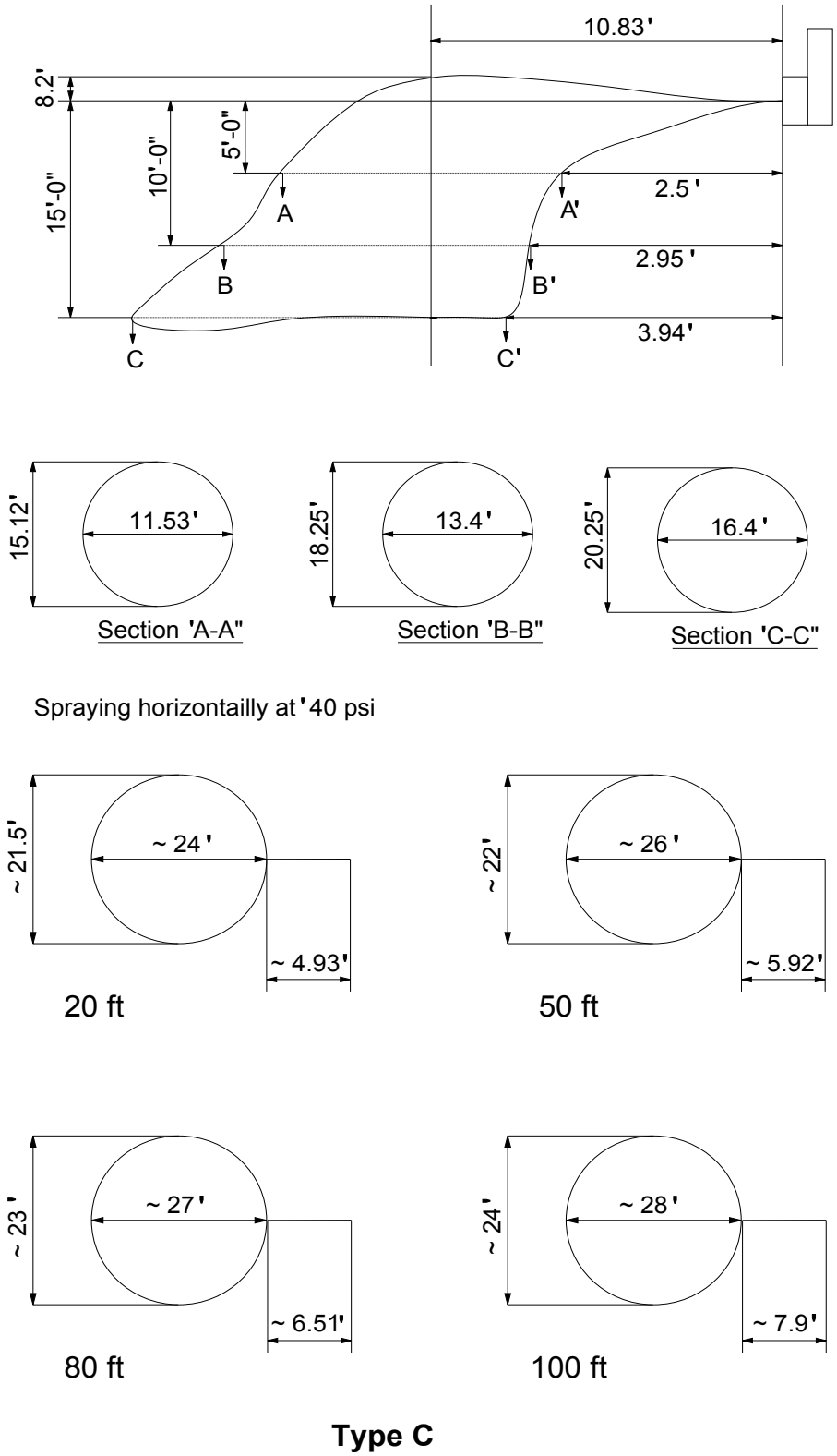
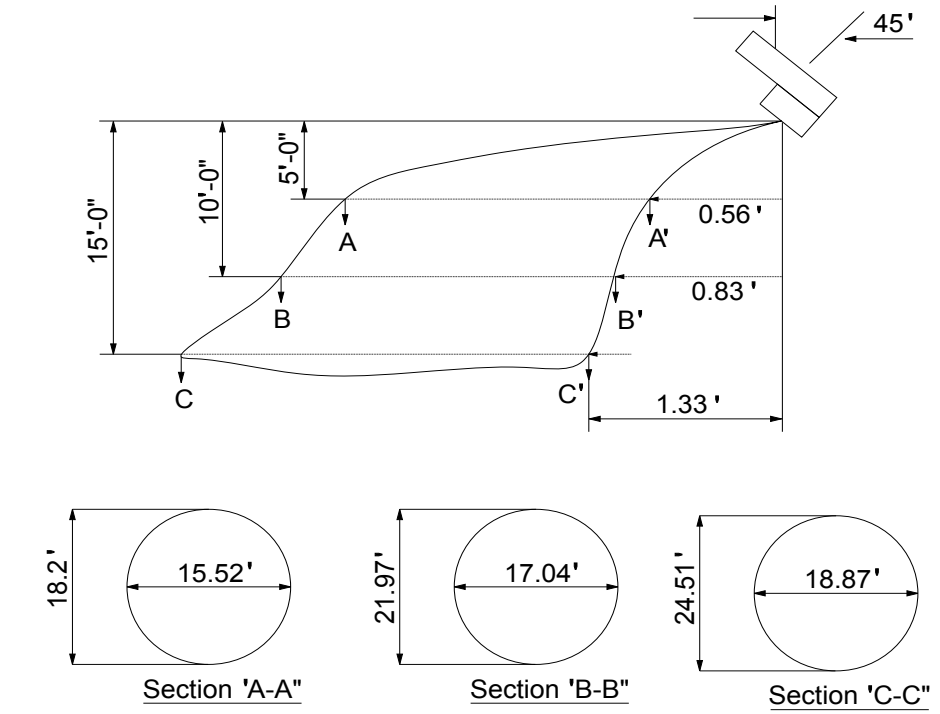
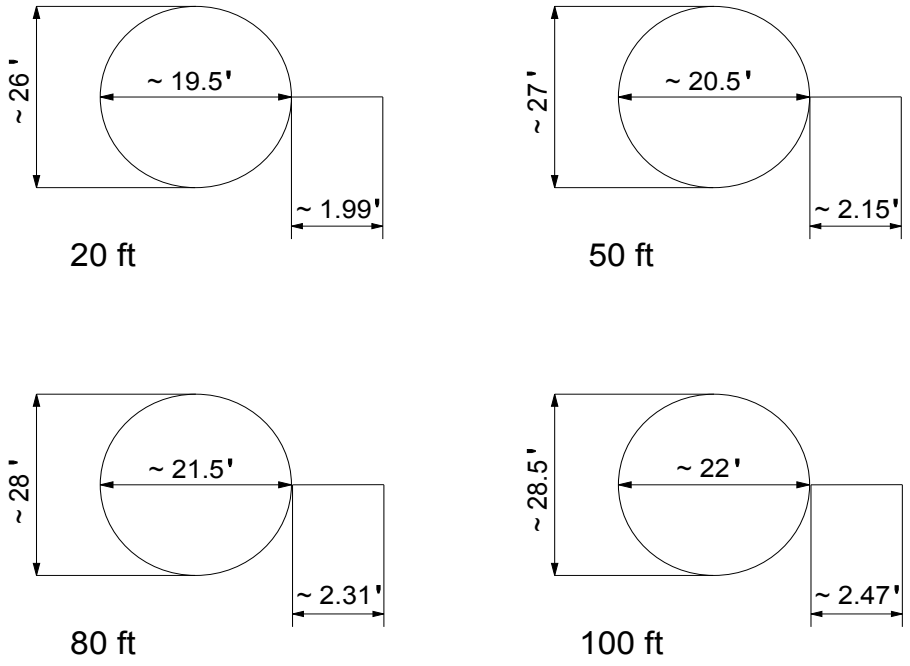


Figure 6.2.2-3 Main Spray Nozzle Spray Profiles (3 of 4)



Spraying downward on 45' angle at 40 psi

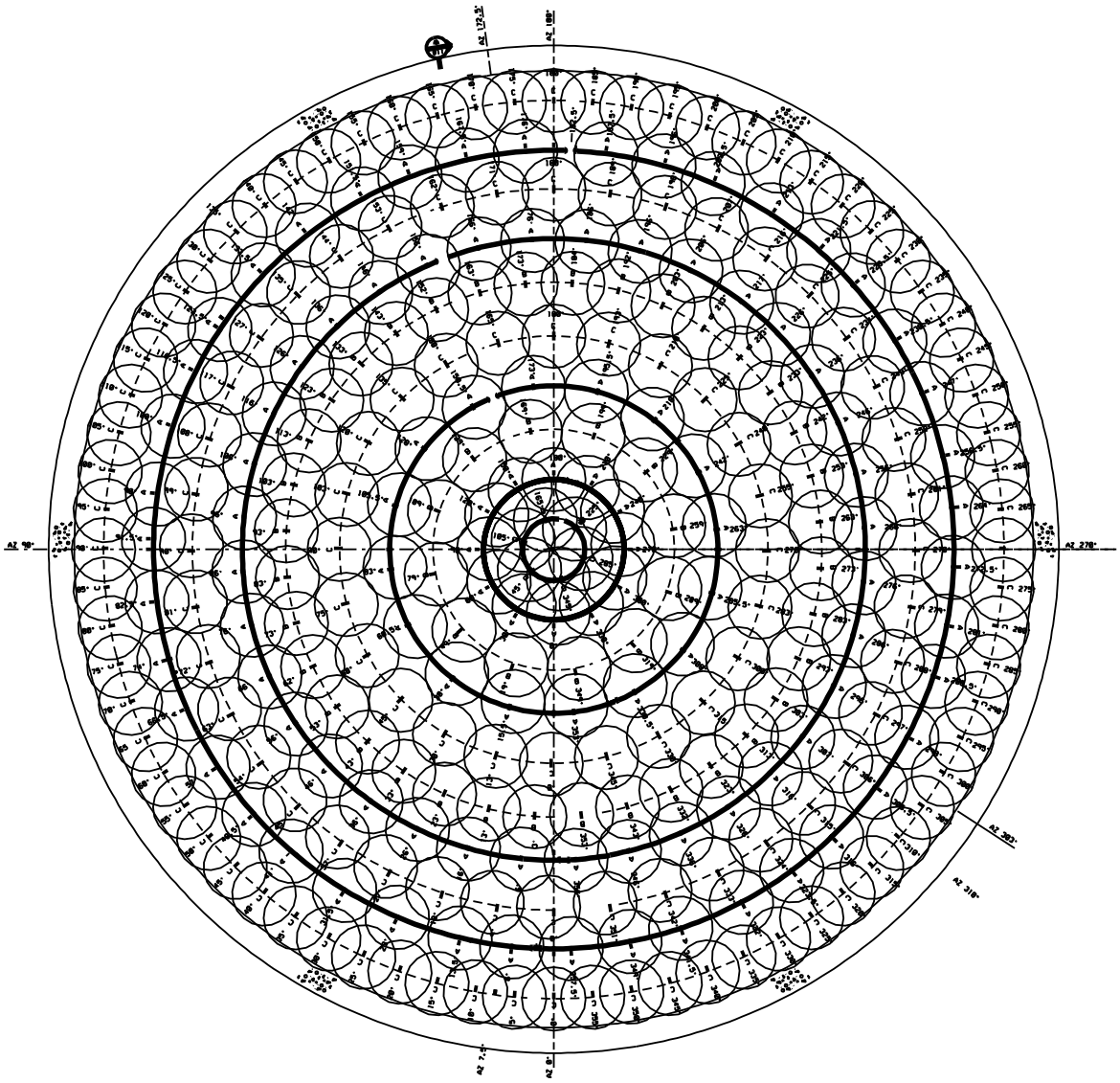


Type D

Figure 6.2.2-3 Main Spray Nozzle Spray Profiles (4 of 4)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.2.2-4 Spray Nozzle Header Elevations

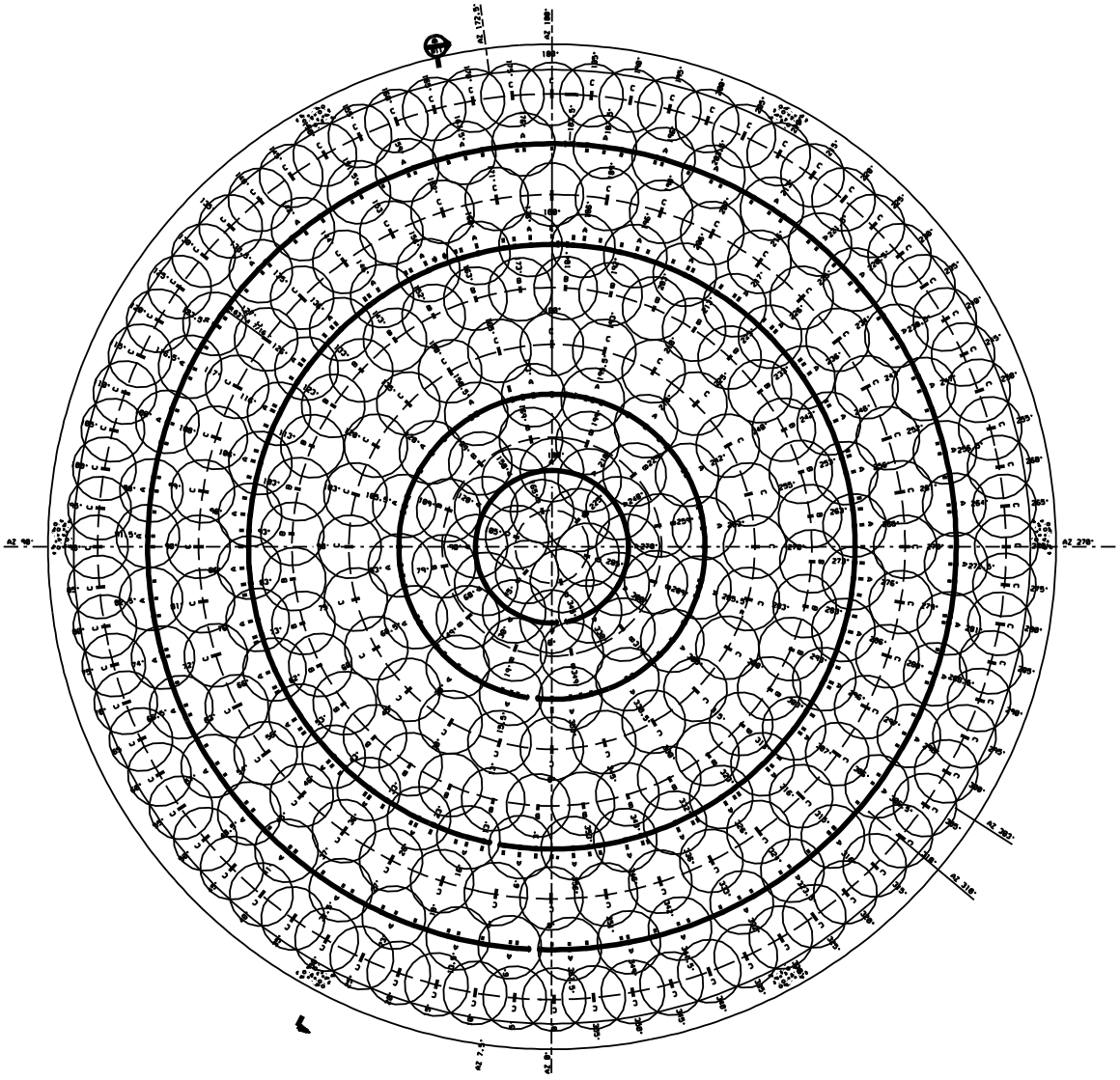


Train A

Nozzle \ Ring	First Ring	Second Ring	Third Ring	Fourth Ring
Vertical	42	36	16	12
75 Degrees	0	36	12	0
Horizontal	72	40	24	0
45 Degrees	0	0	0	6
Total	114	112	52	18

Total of Spray Nozzle : 296

Figure 6.2.2-5 Sprayed Regions (1 of 2)

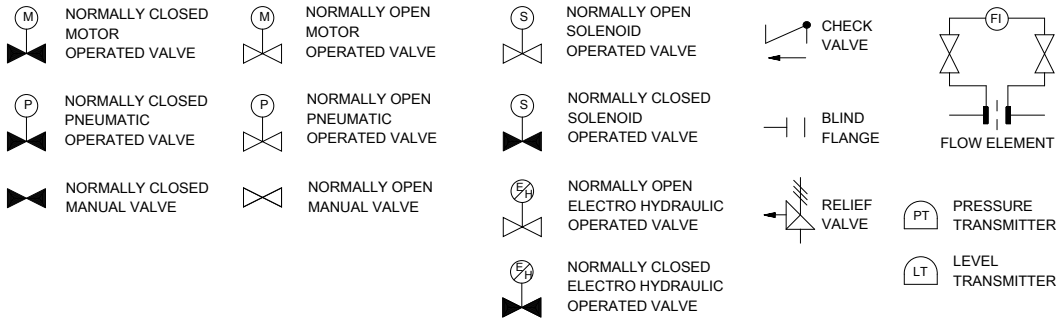


Train B

Nozzle \ Ring	First Ring	Second Ring	Third Ring	Fourth Ring
Vertical	42	36	16	12
75 Degrees	0	36	12	0
Horizontal	72	40	24	0
45 Degrees	0	0	0	6
Total	114	112	52	18

Total of Spray Nozzle : 296

Figure 6.2.2-5 Sprayed Regions (2 of 2)



VALVE ARRANGEMENT NO. (GDC)	INSIDE CONTAINMENT	OUTSIDE CONTAINMENT	ITEM NO.
1 (57)		NT, AFWS, DRAIN	1,4
2 (56)	P	P	59
3 (57)		NT, DRAIN	2,3

Figure 6.2.4-1 Containment Isolation Valve Arrangement (1 of 13)

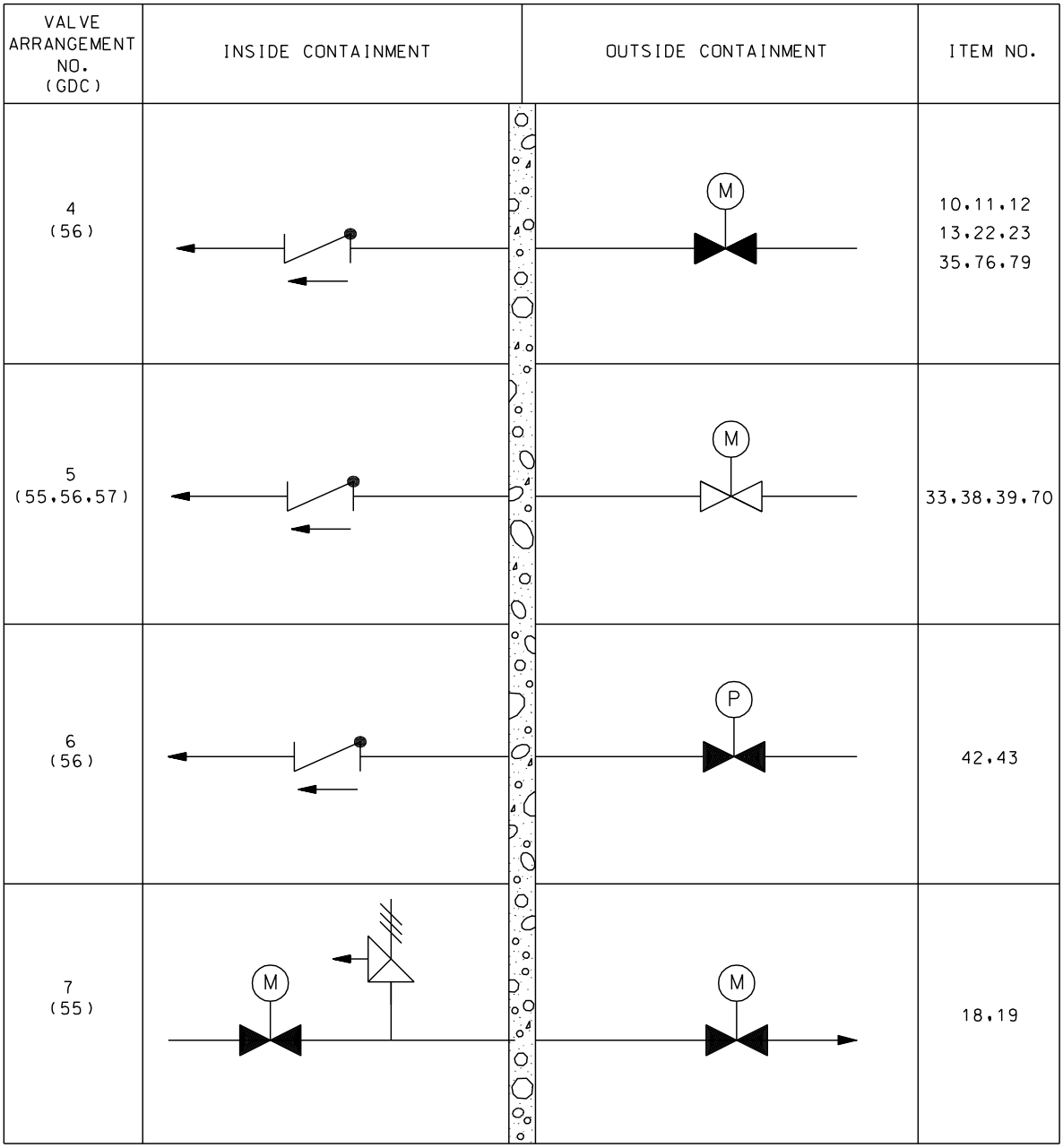


Figure 6.2.4-1 Containment Isolation Valve Arrangement (2 of 13)

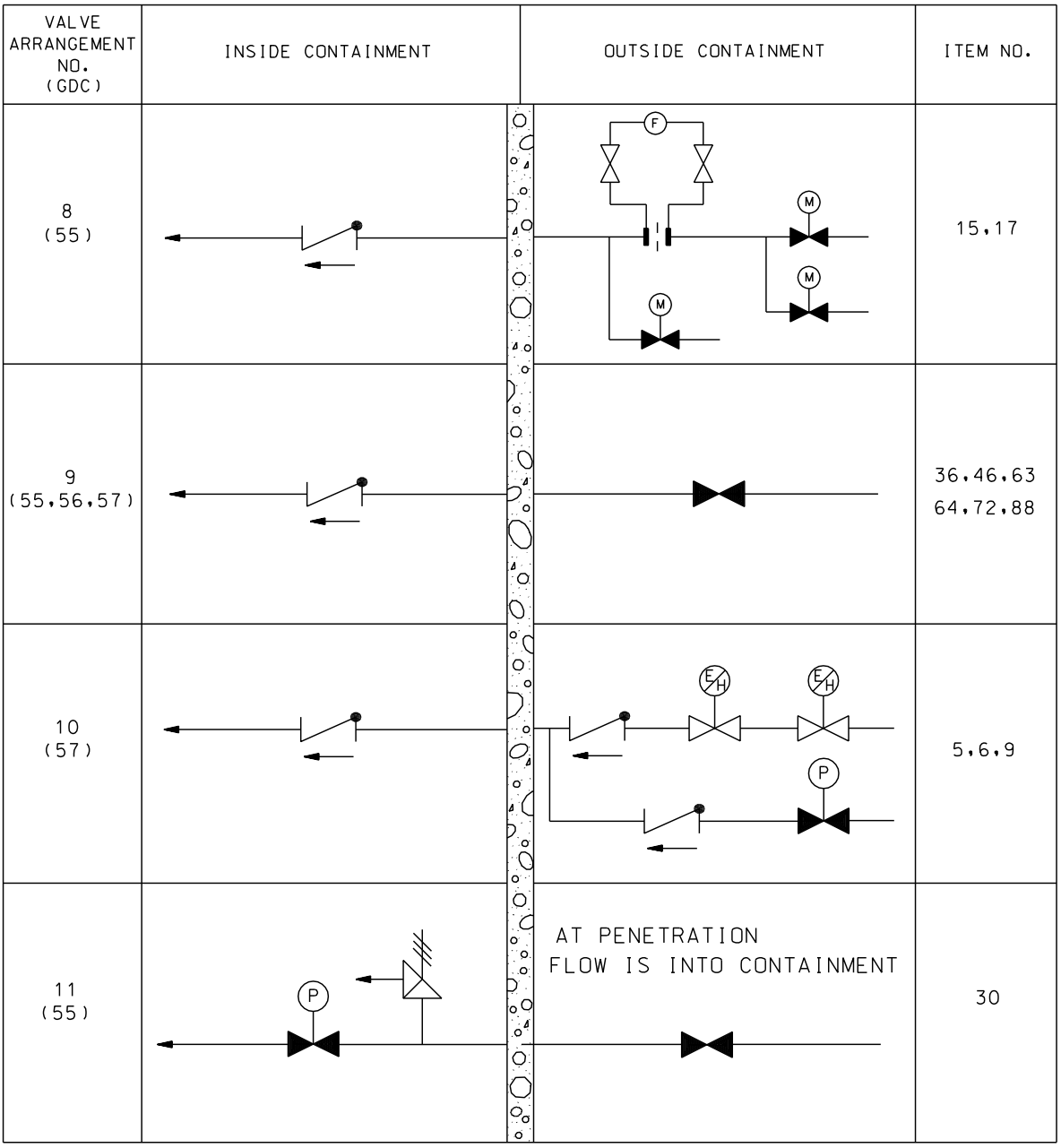


Figure 6.2.4-1 Containment Isolation Valve Arrangement (3 of 13)

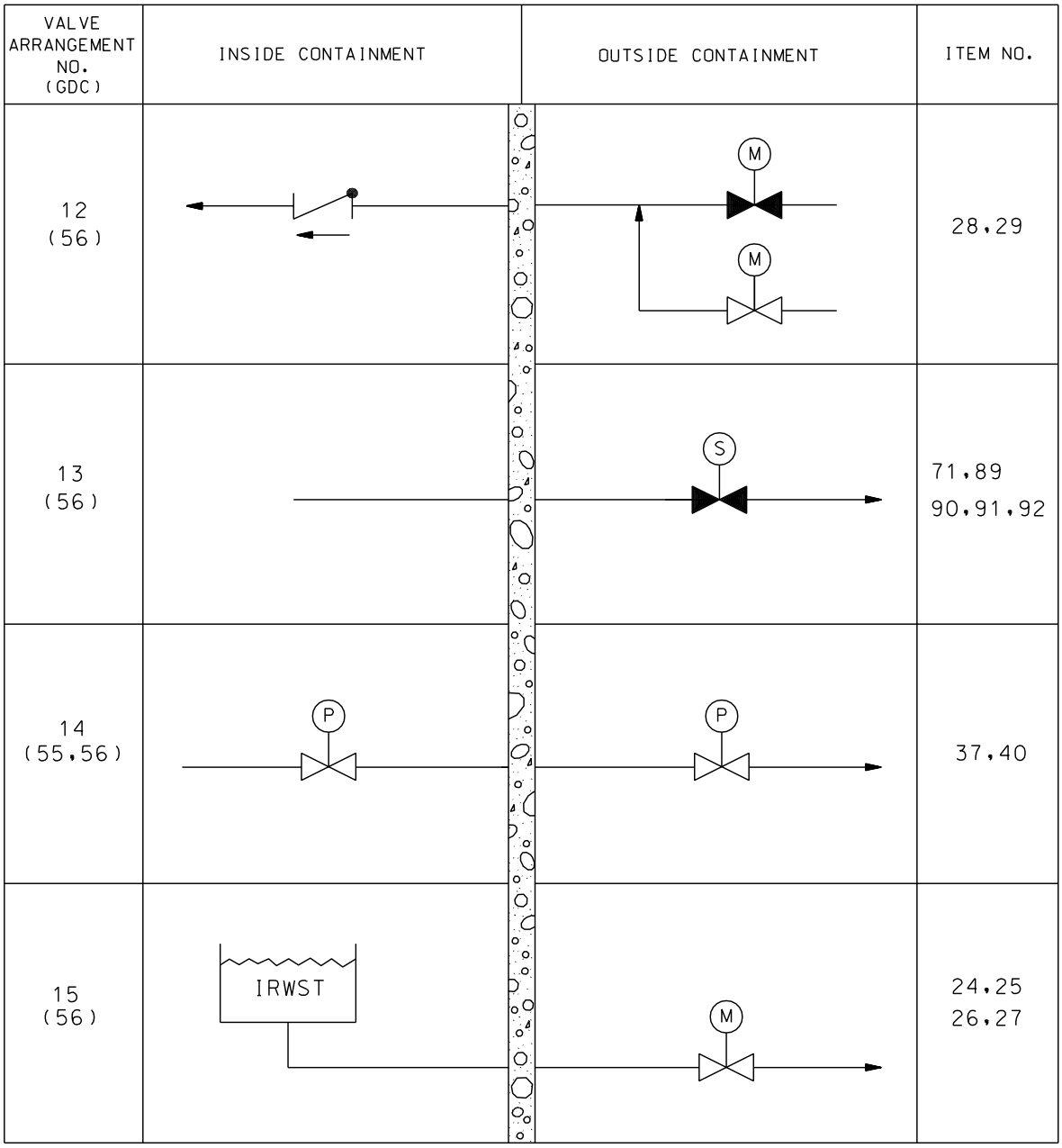


Figure 6.2.4-1 Containment Isolation Valve Arrangement (4 of 13)

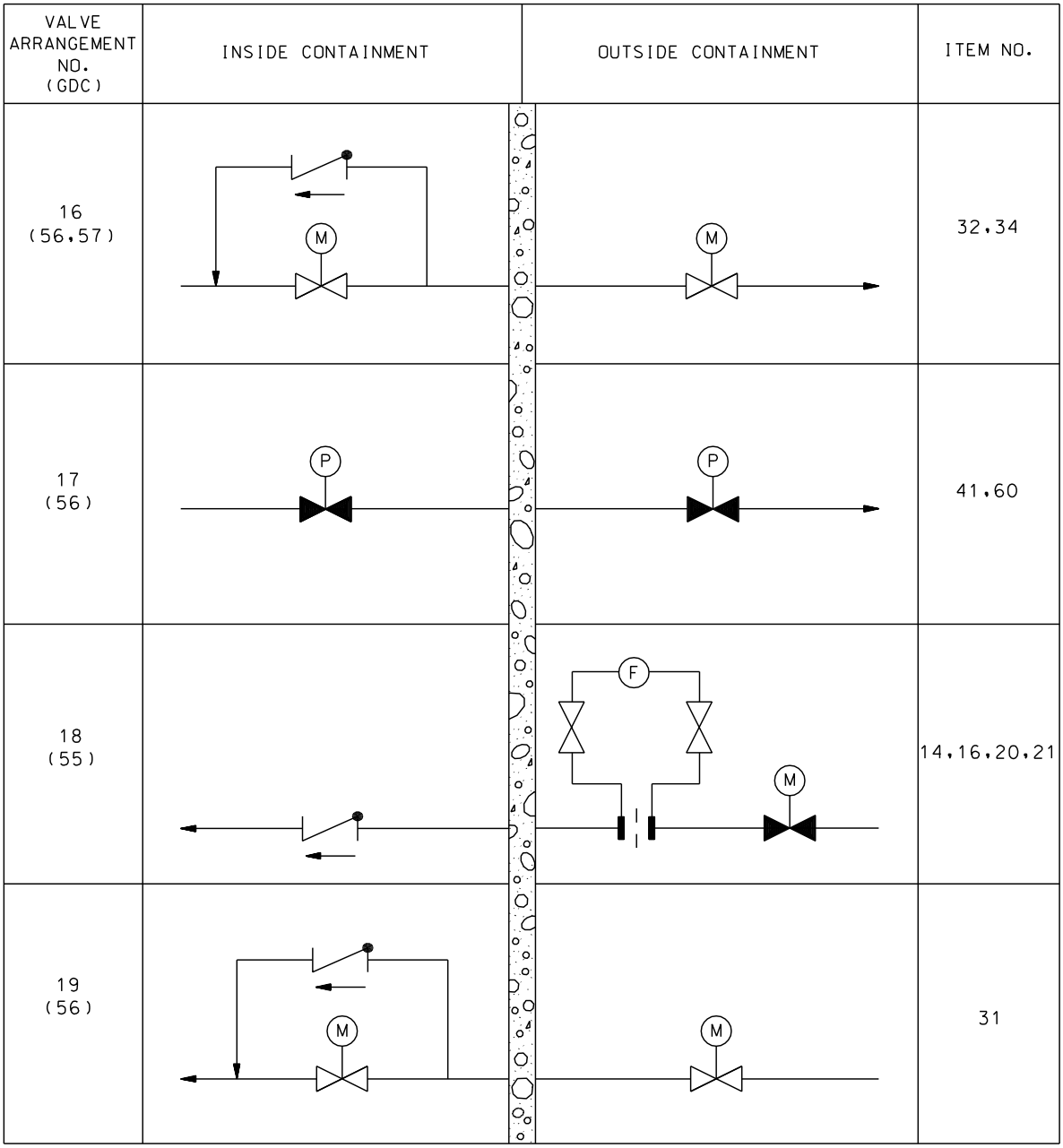


Figure 6.2.4-1 Containment Isolation Valve Arrangement (5 of 13)

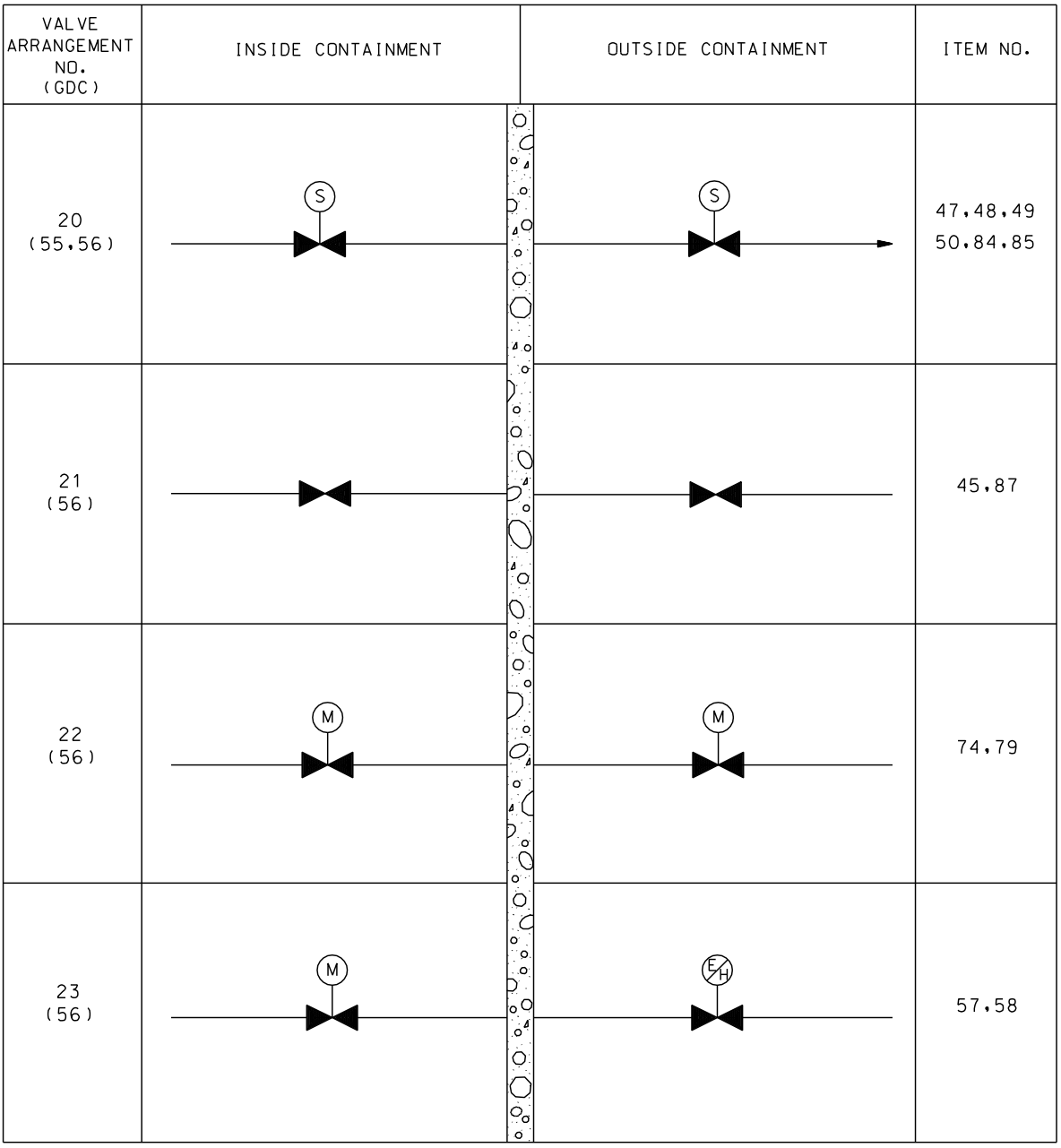


Figure 6.2.4-1 Containment Isolation Valve Arrangement (6 of 13)

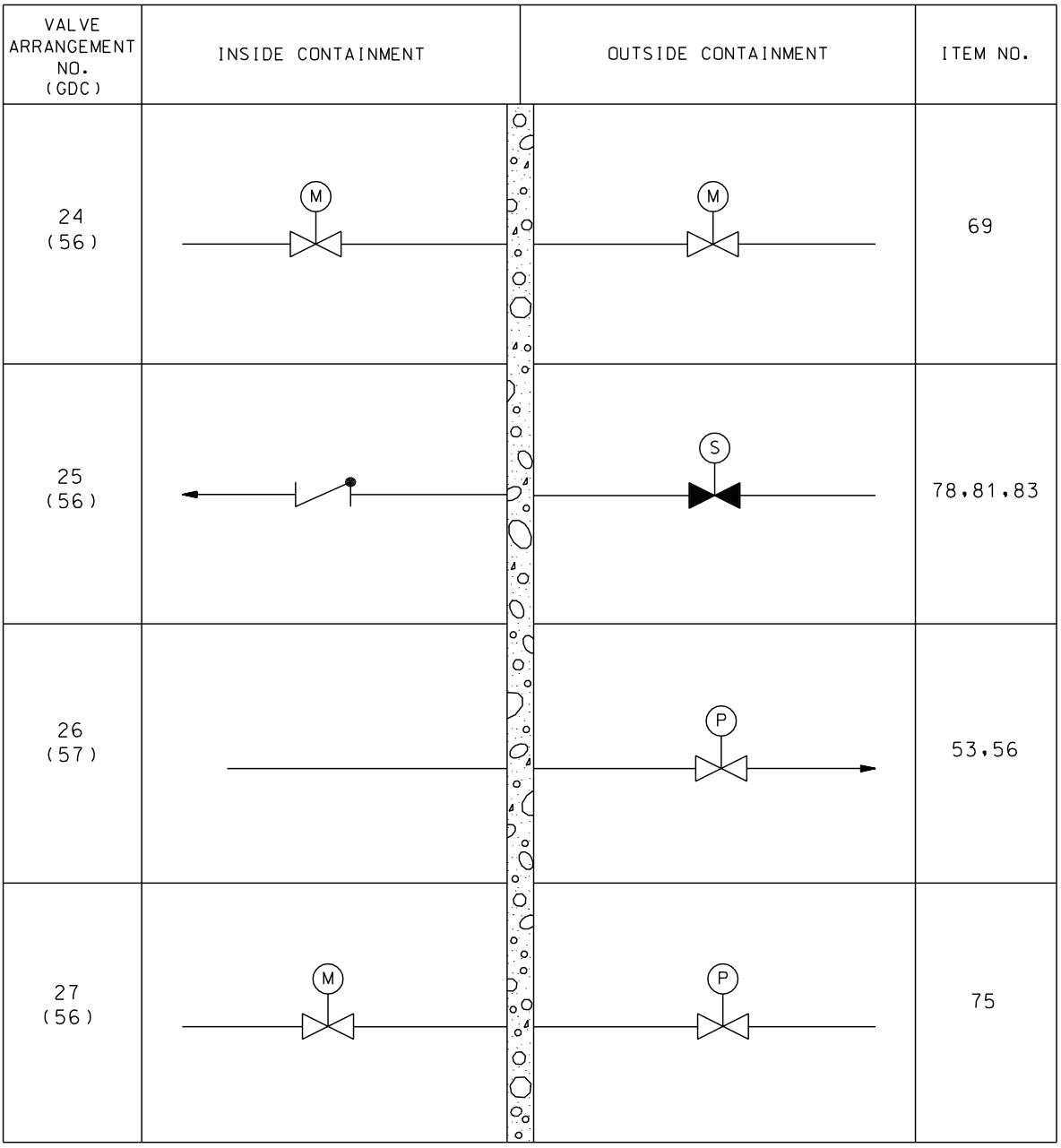


Figure 6.2.4-1 Containment Isolation Valve Arrangement (7 of 13)

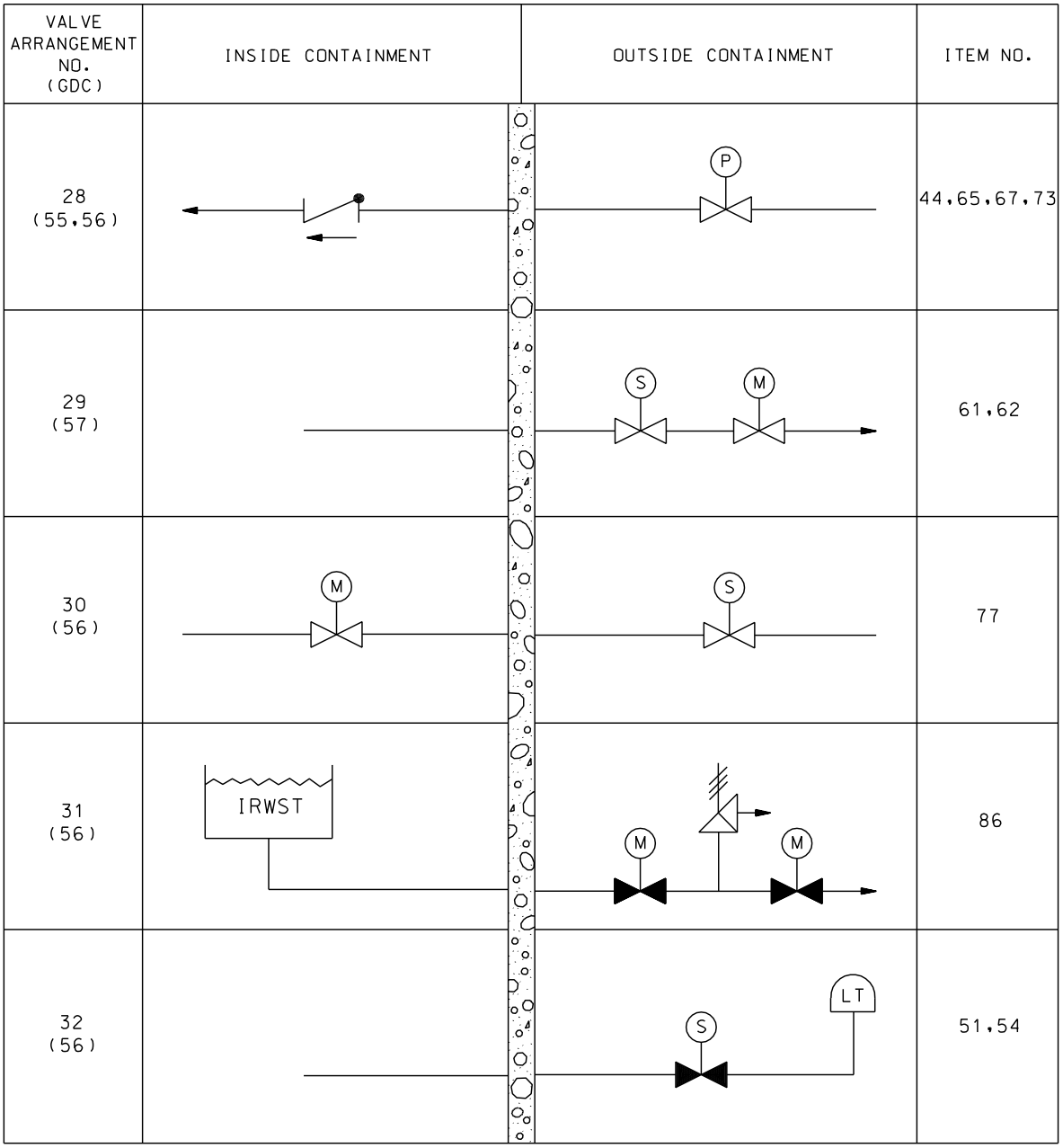


Figure 6.2.4-1 Containment Isolation Valve Arrangement (8 of 13)

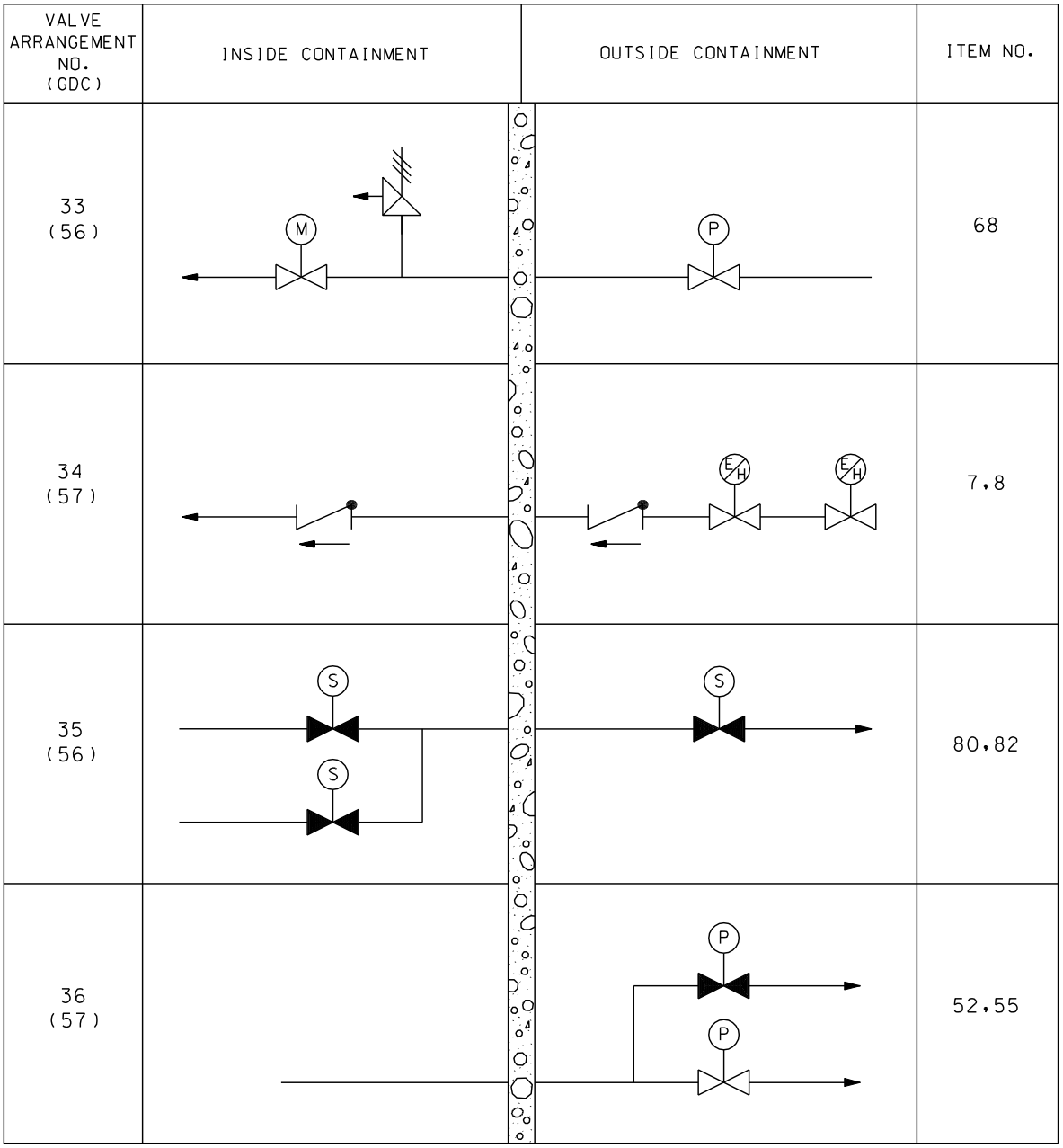


Figure 6.2.4-1 Containment Isolation Valve Arrangement (9 of 13)

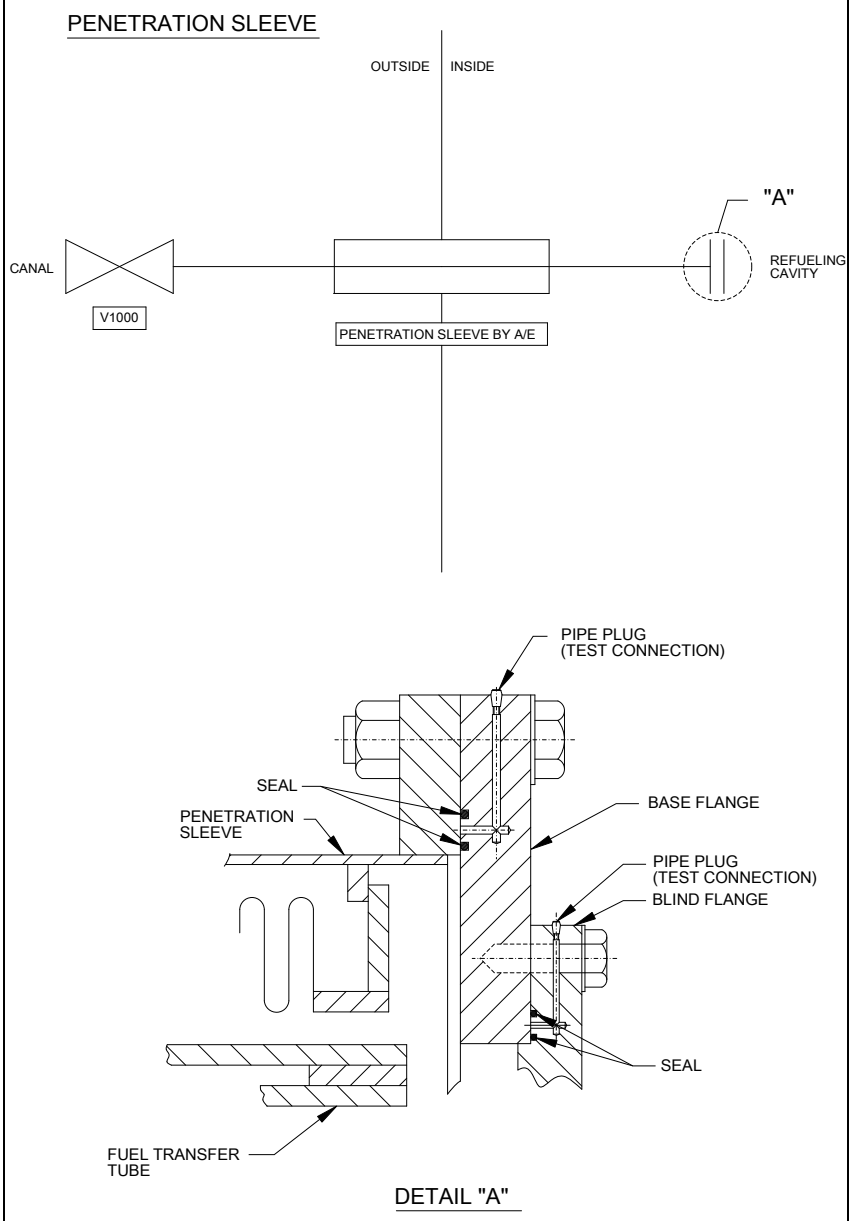
VALVE ARRANGEMENT NO (GDC)	Fuel Transfer Tube	ITEM NO.
37 (-)		93

Figure 6.2.4-1 Containment Isolation Valve Arrangement (10 of 13)

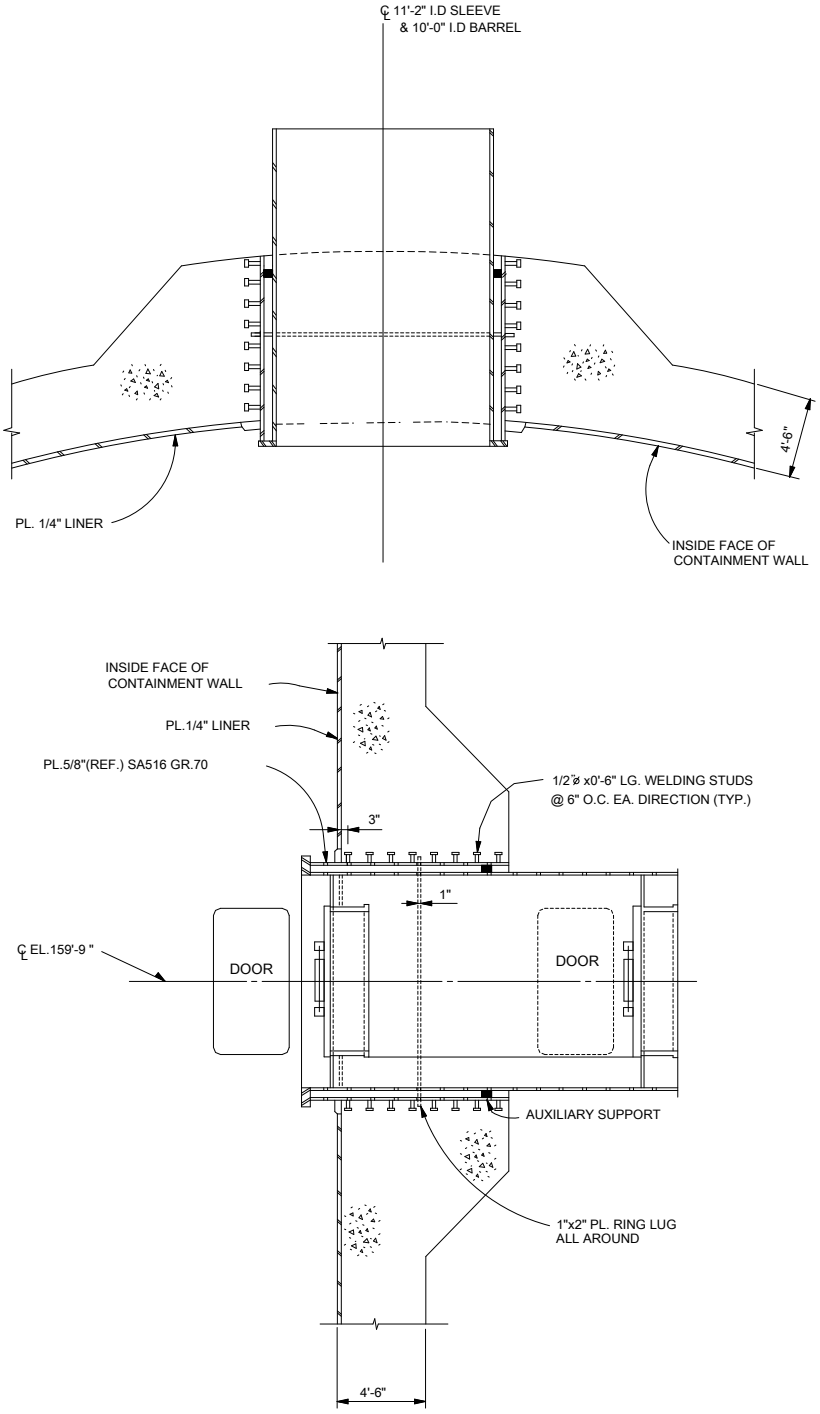
VALVE ARRANGEMENT NO (GDC)	Personnel Airlock	ITEM NO.
38 (-)		94

Figure 6.2.4-1 Containment Isolation Valve Arrangement (11 of 13)

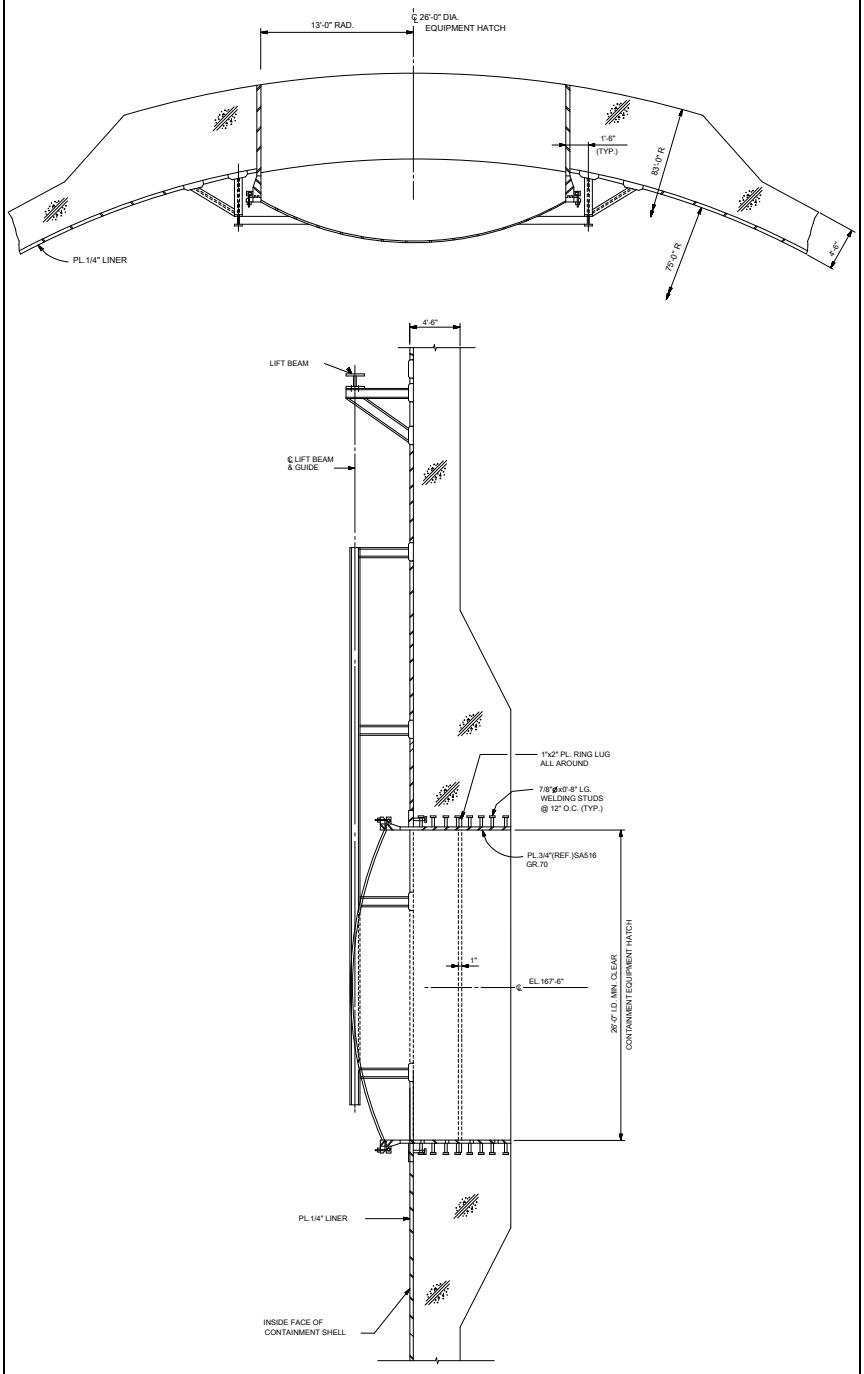
VALVE ARRANGEMENT NO (GDC)	Equipment Hatch	ITEM NO.
39 (-)		95

Figure 6.2.4-1 Containment Isolation Valve Arrangement (12 of 13)

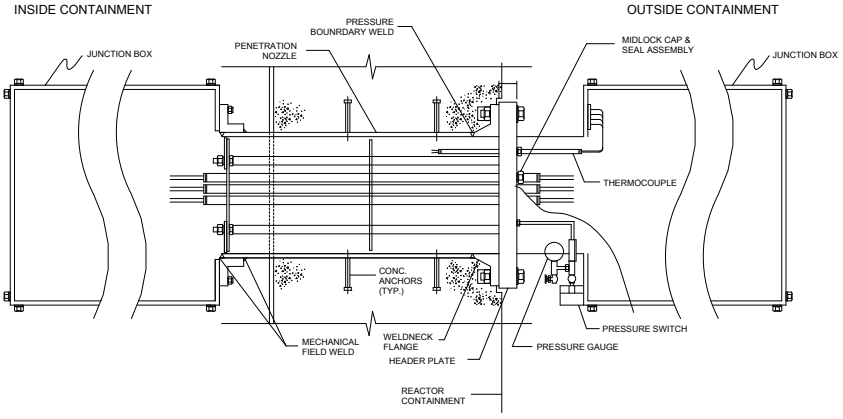
VALVE ARRANGEMENT NO (GDC)	Typical Electrical Penetration Assembly	ITEM NO.
40 (-)		96~161

Figure 6.2.4-1 Containment Isolation Valve Arrangement (13 of 13)

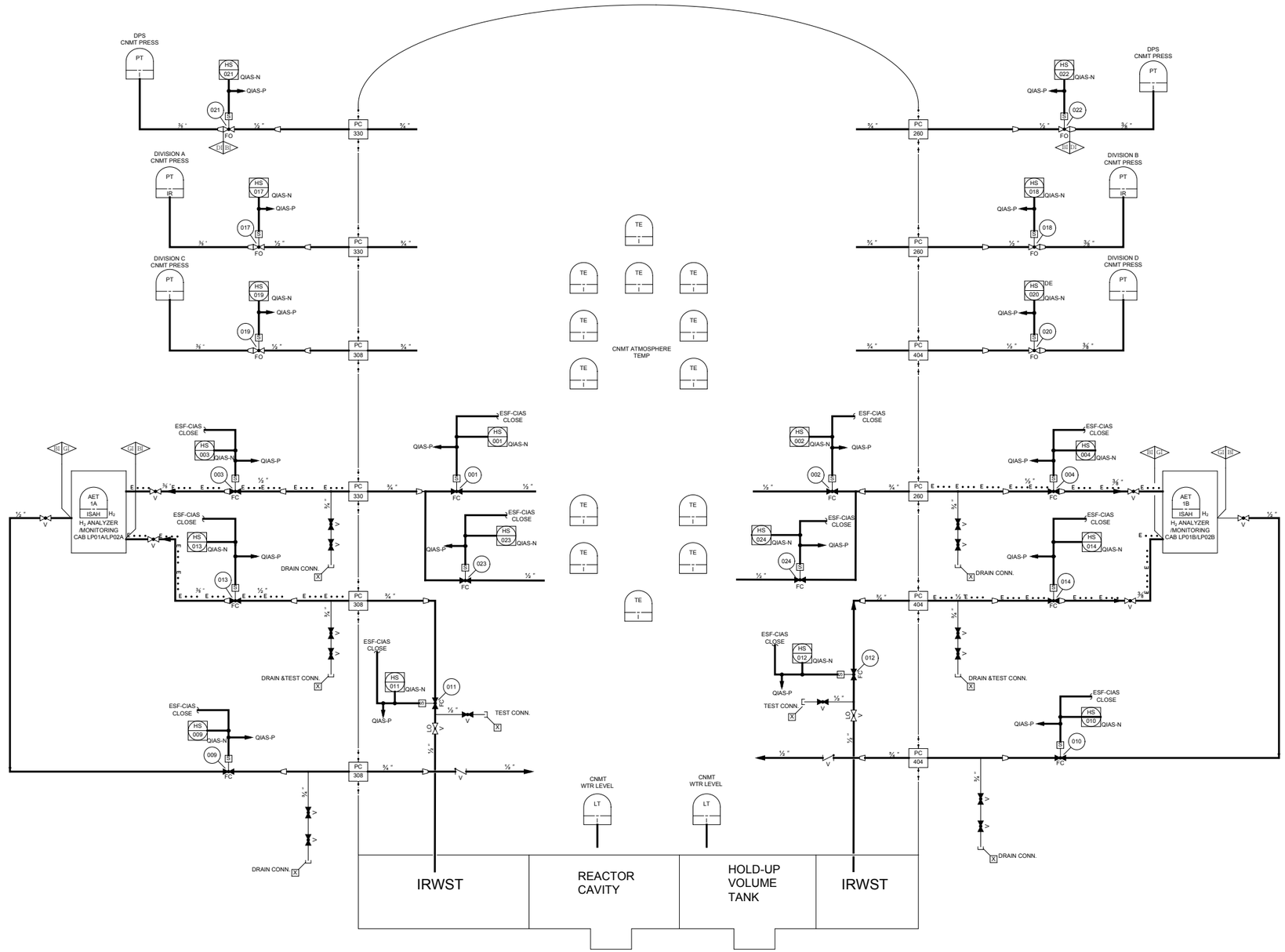
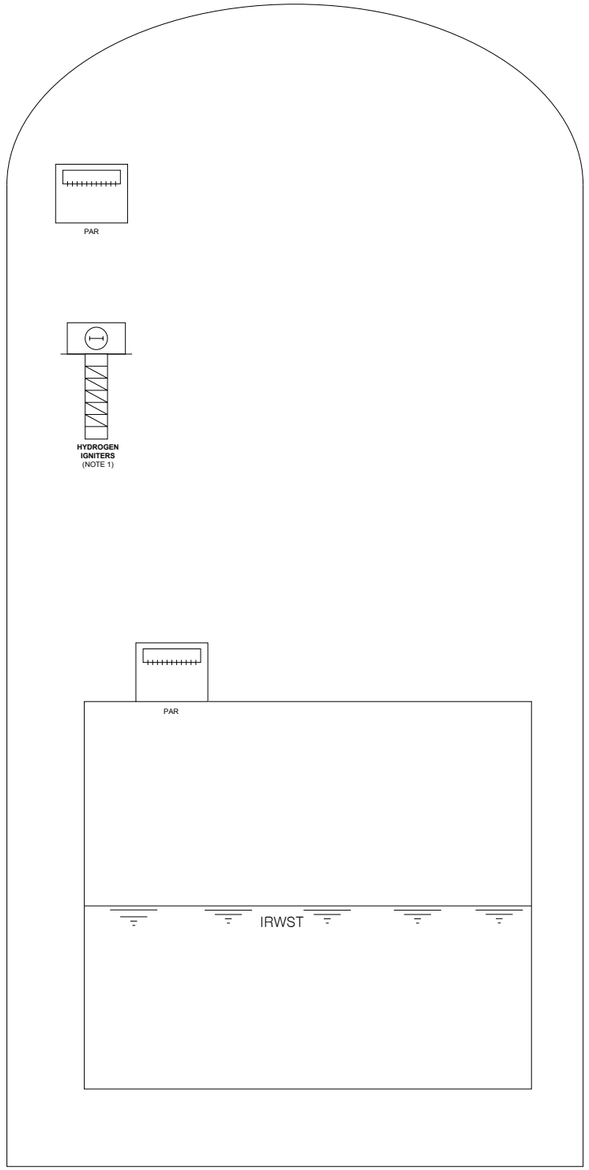


Figure 6.2.4-2 Containment Monitoring System Diagram



NOTES:

1. ALL HYDROGEN IGNITERS ARE CONTROLLED BY ONE (1)CONTROL HANDSWICH.
   THE HYDROGEN IGNITERS FOR SEVERE ACCIDENT HYDROGEN CONTROL ARE POWERED FROM AN ELECTRICALLY ISOLATED DIVISION Ⅱ CLASS 1E POWER BUS.
   IN THE EVENT OF A LOSS OF DIVISION Ⅱ CLASS 1E POWER BUS, THE HYDROGEN IGNITERS WILL BE POWERED FROM AN ELECTRICALLY ISOLATED DIVISION Ⅰ CLASS 1E POWER BUS.
   IN THE EVENT OF A LOSS OF OFFSITE POWER, THE HYDROGEN IGNITERS WILL BE POWERED FROM THE EMERGENCY DIESEL GENERATOR.
   ON LOSS OF OFFSITE POWER AND FAILURE OF THE EMERGENCY DIESEL GENERATOR TO START OF RUN (STATION BLACKOUT), THE IGNITERS WILL BE POWERED FROM THE AAC DIESEL GENERATOR. DURING THE COMPLETE LOSS OF AC POWER INCLUDING AAC DIESEL GENERATOR, THE HYDROGEN IGNITERS WILL BE POWERED FROM THE DC BATTERY.

Figure 6.2.5-1 Containment Hydrogen Control System

6.3 Safety Injection System

6.3.1 Design Bases

The safety injection system (SIS) consists of active and passive injection systems. The active portion of the SIS consists of four mechanically separated trains, each consisting of a safety injection (SI) pump and associated valves. Each SI pump is provided with its own suction line from the in-containment refueling water storage tank (IRWST) and its own discharge line to a direct vessel injection (DVI) nozzle on the reactor vessel. The passive portion consists of four identical pressurized safety injection tanks (SITs).

The SIS design was developed based on Combustion Engineering's System 80+ plant (Reference 1), which was designed in the United States except for the fluidic device in the SIT. The SIS design and the System 80+ plant are compared in Section 1.3. The fluidic device is described in Subsection 6.3.2.2.2.

The SIS is designed to achieve the two major functions:

a. Safety injection

b. Safe shutdown

The containment pH control is described in Subsections 6.5.2.3.2 and 6.8.2.2.1.

6.3.1.1 Safety Injection

The SIS is designed to provide core cooling in the unlikely event of a loss-of-coolant accident (LOCA). The SIS limits fuel damage to maintain a coolable core geometry, limits the cladding metal-water reaction, and removes the energy generated in the core. The SIS maintains the core subcritical during the extended period after a LOCA. The SIS provides reasonable assurance that the criteria of 10 CFR 50.46 (Reference 2) are met.

The SIS schematic flow diagram is provided in Figure 6.3.1-1. The SIS is capable of injecting borated water into the reactor vessel to mitigate accidents other than a LOCA. Safety injection is initiated in the event of a steam generator tube rupture (SGTR), steam

line break (SLB), or control elements assembly (CEA) ejection incident. The borated water injected by the SIS provides inventory and reactivity control for these events.

6.3.1.2 Safe Shutdown

The SIS provides sufficient boron to maintain the reactor subcritical during safe cold shutdown assuming that the most reactive control rod remains out of the core.

The SI pumps are used to inject borated water into the reactor coolant system (RCS) and restore the RCS water inventory when the RCS pressure decrease rapidly by opening pressurizer pilot operated safety relief valves (POSRVs) during beyond design basis event of a total loss of feedwater to steam generators.

6.3.1.3 Compliance with Regulatory Requirements

The SIS is designed to the following regulatory requirements:

a. GDC 2, "Design Bases for Protection against Natural Phenomena"

b. GDC 4, "Environmental and Dynamic Effects Design Bases"

c. GDC 5, "Sharing of Structures, Systems, and Components"

d. GDC 17, "Electric Power Systems"

e. GDC 27, "Combined Reactivity Control Systems Capability"

f. GDC 35, "Emergency Core Cooling"

g. GDC 36, "Inspection of Emergency Core Cooling System"

h. GDC 37, "Testing of Emergency Core Cooling System"

i. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors"

Conformance with the GDC is addressed in Section 3.1, and 10 CFR 50.46 is addressed in Subsection 6.3.1.1.

Conformance with the relevant items of the Three Mile Island Action Plan is addressed in Table 6.3.1-1 and Subsection 1.9.3.

The SIS design incorporates the resolution of the relevant unresolved safety issues and medium-priority and high-priority generic safety issues that are specified in NUREG-0933, as described in Table 6.3.1-2 and Section 1.9.3.

Conformance with the generic safety issue (GSI)-191 and NRC RG 1.82 is described in Subsection 6.8.4.5.

The SIS design incorporates operating experience insights from generic letters and bulletins, as described in Table 6.3.1-3 and Subsection 1.9.4.

6.3.1.4 Functional Design Bases

The SIS is designed to inject the borated water into the RCS through DVI nozzle. The discharge of each SI pump and tank is piped directly to a DVI nozzle. The flow is directed into the reactor vessel downcomer region through the DVI nozzle.

The SIS is designed so that for breaks larger than 0.0462 m^2 (0.5 ft^2), two diagonal SI pumps, in conjunction with the SITs, provide 100 percent of the minimum injection flow rate required to satisfy the LOCA performance requirements in Subsection 6.3.1.1. For breaks equal to or smaller than 0.0462 m^2 (0.5 ft^2), each SI pump, in conjunction with the SITs, has 100 percent of the capacity to satisfy the LOCA performance requirements.

The shutoff head and flow rate of the SI pumps are selected to provide reasonable assurance that adequate flow is delivered to the reactor vessel to accomplish the functional requirements in Subsections 6.3.1.1 and 6.3.1.2. Table 6.3.2-4 presents the minimum and maximum flow delivery.

Storage of water for the SIS is accomplished by the IRWST, which contains a sufficient amount of borated water to accomplish the requirements in Subsections 6.3.1.1 and 6.3.1.2.

SI pump capacity is sufficient to satisfy the functional requirements for decay heat removal through feed and bleed operations.

The SIS is designed to have a combined capability, in conjunction with the injection of borated water, of reliably controlling reactivity changes to provide reasonable assurance that under postulated accident conditions and with appropriate margin for stuck rods, the capability to cool the core is maintained.

The SIS is designed to allow the SI pumps to be tested at design flow with the reactor operating at power. All SIS ASME Section III components are arranged to provide adequate clearances to permit in-service inspection.

6.3.1.5 Reliability Design Bases

The safety function defined in Subsections 6.3.1.1 and 6.3.1.2 is a licensing requirement and can be accomplished assuming the failure of a single active component during a short-term mode of operation or assuming a single active or limited leakage passive failure of a component during a long-term (hot leg/DVI nozzle simultaneous injection) post-accident operation.

For failure analysis, all necessary supporting systems, including the onsite electrical power system, are considered as part of the SIS. A failure modes and effects analysis (FMEA) is presented in Table 6.3.2-2.

Adequate physical separation is provided between the redundant piping paths and containment penetrations of the SIS so that the SIS meets its functional requirements even with the failure of a single active component during the short-term injection mode or with a single active failure or a limited leakage passive failure during the long-term, post-accident mode.

The SIS system and component arrangement satisfies system head loss requirements to provide reasonable assurance that adequate safety injection flow is provided to the RCS. The system head loss requirements for the safety injection mode are specified in Table 6.3.2-3.

The SI pumps are located in the auxiliary building as close as practicable to the containment structure.

The SIS check valves upstream of the DVI nozzles are located as close to the DVI nozzles as practicable. The SIS check valves used for containment isolation are located as close as practicable to the containment penetrations.

Each SIT is located in the region of ring shape inside the containment and as close as possible to the reactor DVI nozzle into which it injects.

The SI pumps and motor-operated and solenoid-operated valves are capable of being powered from the plant turbine generator (onsite power source), plant startup power source (offsite power), and emergency diesel generators (emergency power). Power connections are through four independent electrical trains with each train providing power to each bus. In the event of a LOCA, in conjunction with a single failure in the electrical supply, the flow from at least three SI pumps is available for core protection.

Each emergency diesel generator and the automatic sequencers necessary for generator loading are designed so that flow is delivered to the reactor vessel within a maximum of 40 seconds after an safety injection actuation signal (SIAS) setpoint is reached. The emergency generator design requirements are described in Subsection 8.3.1.

Process instrumentation is available to the operator in the main control room (MCR) to assist in assessing post-LOCA conditions. SIS instrumentation is described in Subsection 6.3.5. The type of instrument, parameter measured, and instrument range are listed in Table 7.5-1. Each SIS safeguards train is provided with an independent I&C system that is powered by the same emergency power associated with that train so that the safety-related equipment in each train operates within the design limits specified in Section 3.11.

The cabling that is associated with redundant channels of vital Class 1E circuits for the SIS is physically separated to preserve redundancy and prevent a single failure from causing multiple channel malfunctions or interactions between channels. Associated circuit cabling from redundant channels is separated, provided with isolation devices, or analyzed or tested to demonstrate that no credible single failure could adversely affect redundant channels of Class 1E circuits.

In the routing of SIS Class 1E circuits and the location of equipment served by these Class 1E circuits, consideration is given to their exposure to potential hazards such as postulated ruptures of piping, flammable material, flooding, and nonflame-retardant wiring. Adequate separation or protective measures are provided.

Physical identification of safety-related SIS equipment and cabling is provided to allow recognition of safety status by plant personnel.

Failures of non-safety grade systems do not compromise the redundancy of the SIS.

Protection for components is provided from internally generated flooding that could prevent the performance of safety-related functions.

6.3.1.6 Protection Design Bases

Design provisions are made to provide reasonable assurance that SIS components are capable of functioning in the event of a maximum probable flood or other natural phenomenon, as defined in GDC 2 of Appendix A of 10 CFR Part 50.

The SIS is designed to seismic Category I requirements except safety injection filling tank (SIFT), piping, and valves in the SIS fill line.

The maximum expected leakage from a moderate energy pipe rupture postulated during normal plant conditions in the SIS is defined by the methods described in Section 3.6. Isolation valves used to contain leakage are protected from the adverse effects of a high or moderate energy pipe rupture to provide reasonable assurance of their operation when required.

Provisions are made for the detection, containment, and isolation of the maximum expected leakage from a moderate energy pipe rupture.

No limited leakage passive failure or the effects (e.g., flooding, spray impingement, steam, temperature, pressure, radiation, loss of net positive suction head (NPSH), loss of recirculation water inventory) in the SIS during the long-term post-accident mode precludes the availability of minimum acceptable safety injection capability.

The SIS is protected from the effects of pipe rupture and pipe whip. In addition, the SIS is protected from missiles.

The SIS components are supported so that pipe stresses and support reactions are within allowable limits.

The loadings imposed by the SIS piping on the DVI nozzles or the connecting system piping on SIS nozzles are described in Section 3.12.

6.3.1.7 Environmental Design Bases

Components of the SIS and instrumentation that operate following a LOCA are designed to operate in the environmental conditions described in Section 3.11.

6.3.2 System Design

6.3.2.1 System Schematic

The SIS flow diagram is shown in Figure 6.3.2-1. The major components of the SIS are four identical SI pumps, an IRWST, four identical SITs, two identical SIFTs, and associated valves. The major components are described in Subsection 6.3.2.2.

6.3.2.1.1 Safety Injection Tank System

Four SITs are provided. SIT data are summarized in Table 6.3.2-1. The SITs that contain borated water pressurized by a nitrogen cover, constitute the passive injection system because no operator action or electrical signal is required for operation. Each tank is connected to its associated reactor vessel nozzle for DVI by a separate line containing two check valves that isolate the tank from the RCS during normal operation. When the RCS pressure falls below the tank pressure, the check valves open, discharging the contents of the tank into the reactor vessel.

Four SITs initially provide a means of rapid reflooding of the core following a large break LOCA (LBLOCA), and keeping it covered until the flow from the SI pumps becomes available. Each SIT contains borated water to a maximum of 2.5 weight boric acid and is

pressurized with nitrogen. The SITs are provided with connections for filling, draining, pressurizing, venting, relieving, and sampling. In addition, pressure and level instrumentations with appropriate alarms are provided to assure that technical specifications are met during normal power operation.

A fluidic device (Reference 3, Figure 6.3.2-2), which is installed in each of the SITs, provides two operational stages of a safety water injection into primary coolant system and results in more effective use of borated water in the SITs in the event of a LOCA.

SIT water is delivered into the vortex chamber through both the supply and control nozzles at the early stage of LBLOCA when the SIT starts to operate and the standpipe is covered with water. The SIT provides a large injection flow rate of SIT water, which is required during the refill phase of an LBLOCA. When the SIT water level is lowered to below the top of the standpipe, the flow path through the supply nozzle is absent and all SIT water is delivered only through the control nozzle. As a result, the injection flow rate of the SIT water is decreased, but is still sufficient to remove decay heat during the reflood phase, extending the total duration of the SIT water injection.

The fluidic device consists of a vortex chamber, supply port, control ports, and standpipe. The device has a supply port at the center and four control ports around the supply port with an equal circumferential angle of 90 degrees at the surface top. The supply port is connected to a standpipe that extends vertically. The vortex chamber is a flat slice of cylinder and is installed horizontally, with its axis overlapping with the centerline of the SIT.

A motor-operated isolation valve provided in each SIT discharge line is administratively controlled to open in the MCR to provide reasonable assurance of the tank's availability during normal operation. Power to the motor operator of each valve is removed to prevent inadvertent closure. To provide further reasonable assurance of SIT availability, each SIT isolation valve receives an automatic open signal if an SIAS occurs due to low pressurizer pressure or high containment pressure. During startup and shut down operations, a variable low pressurizer pressure SIAS setpoint is used, as described in Subsection 7.3.1.9.

Each motor-operated SIT isolation valve is also provided with an "auto-open" and "permissive close" interlock based on pressurizer pressure. During startup, the interlock automatically opens the valves when RCS pressure is increased above 42.2 kg/cm^2A

(600 psia). During plant cooldown, the interlock prevents the valves from being closed until RCS pressure is reduced to 33.4 kg/cm^{2}A (475 psia).

The SITs are normally pressurized to a nominal operating pressure of 42.9 kg/cm^2 (610 psig) for normal operation. During startup, the operator pressurizes the SITs when pressurizer pressure reaches 45.0 kg/cm^{2}A (640 psia). Failure to do so results in an alarm when pressurizer pressure reaches 50.3 kg/cm^{2}A (715 psia).

During plant cooldown, SIT pressure is reduced to 28.1 kg/cm^2 (400 psig) before RCS pressure reaches 45.0 kg/cm^{2}A (640 psia). Inadvertent repressurization of the SITs during this mode of operation from a leaky nitrogen supply valve or by accidental tripping of a nitrogen supply valve switch is prevented by having two fail-closed valves in series with separate hand switches on each SIT nitrogen supply line. The air supply actuating the nitrogen supply valves is controlled by solenoid valves. The two nitrogen supply valve solenoids on each SIT are connected to separate electrical buses through redundant and physically separated electrical trains. The solenoids provide reasonable assurance that a fault in one of the trains does not cause a spurious opening of both nitrogen supply valves.

Redundant level and pressure instrumentation described in Subsection 6.3.5.3 and Table 7.5-1 are provided to monitor the condition of the tanks. Sufficient visual and audible indications are made available to the operator so that maintaining the SITs within the required technical specifications during various modes of plant operation. Provisions are made for sampling, filling, draining, and correcting boron concentration. Atmospheric vent valves are provided for tank venting. The valves are locked closed, and the power to each valve is removed during normal operation to prevent inadvertent SIT venting.

The SIT relief valve set at 49.2 kg/cm^2 (700 psig) is installed in the SIT to prevent the overpressure. The two check valves installed in SIT discharge line are held by pressure differential between the RCS and SIT operating pressure.

The nitrogen supply system is designed such that all four SITs can be pressurized to 44.29 kg/cm^2 (630 psig) from 0 kg/cm^2 (0 psig) within approximately 8 hours assuming minimum fluid level in the tank. The two nitrogen system isolation valves (SI-642, 649, SI-632, 639, SI-622, 629, and SI-612, 619) are provided and maximum gas volume in the tank is 17.2 m^3 (610 ft^3) each SIT. The capacity of SIT relief valve (SI-211, 221, 231, and 241) is 169.9 m^3 (6,000 ft^3) per minute.

6.3.2.1.2 Safety Injection System

The SIS consists of four mechanically separated trains. Each train contains one SI pump and associated suction and discharge paths. The SI pumps take suction from the IRWST, which is located in the containment, and inject borated water into the RCS through DVI nozzle to flood and cool the core following a LOCA. The SIS is initiated automatically upon an SIAS or manually. The SIAS is produced by a two-out-of-four low pressurizer pressure or high containment pressure signal.

The primary function of the SI pumps is to inject borated water into the RCS if a break occurs in the RCPB. For small break LOCA, the RCS pressure remains high for a long period following the accident, and the SI pumps provide reasonable assurance that the injected flow is sufficient to meet the criteria given in Section 6.3.1. If necessary, SI pump flow is throttled to reduce RCS pressure to conditions that allow the initiation of shutdown cooling system operation for long-term mode. During shutdown cooling operations following a small break, the SI pumps continue injecting into the reactor vessel downcomer to provide makeup for spillage out the break.

Long-term mode for LBLOCA is accomplished by manually realigning the SIS for simultaneous hot leg and DVI nozzle injections. The alignment of SI pumps 1 and 2 is maintained to inject to the DVI nozzles; the discharge of SI pumps 3 and 4 is realigned to discharge to the RCS hot legs. This provides flushing flow and the ultimate subcooling of the core for those LBLOCA that shutdown cooling cannot be used.

The SIS is designed such that two diagonal SI pumps (i.e., SI pumps 1,3 or 2,4) in conjunction with the SITs provide 100 percent of the required minimum injection flow rate to the core to meet the system functions that are described in Section 6.3.1.1.

The SI pumps are also sized so that, after consideration of spillage directly out through the break, one SI pump, in conjunction with the SITs, supplies adequate water to the core to match decay heat boil-off rates soon enough to minimize core uncovery and allow small break LOCAs to meet the performance criteria in Subsection 6.3.1.1. A SI pump characteristic curve is shown in Figure 6.3.2-3. The effectiveness of the SI pump during a SLB is also analyzed to provide reasonable assurance that the pumps are adequately sized.

Figure 6.3.2-4 is the elevation drawing of SIS. The SIS piping from the IRWST to the DVI nozzle is verified monthly to be sufficiently filled with water.

The SI pumps are normally in a standby, non-operating condition. As such, flow path piping has the potential to develop voids and pockets of entrained gases. The SIS is designed to minimize the air accumulation in the pipe. The provision is made to check the air accumulation in the line of the SIS periodically, and the SIFTs provide the way to fill the line of the SIS by gravity to prevent a water hammer and air ingestion into the SI pump. Maintaining the SIS piping sufficiently filled with borated water provides reasonable assurance that the system will perform properly. This also prevents water hammer, pump cavitation, and pumping of non-condensable gas (e.g., air, nitrogen, hydrogen) into the reactor vessel following an SIAS or during shutdown cooling. The provision is made to perform gravity filling every month in Technical Specifications (Chapter 16).

The arrangement of the SI pump mini-flow recirculation lines precludes pump deadheaded operation from the type of parallel pump interaction described in NRC Bulletin No. 88-04. The only cross connections in the SIS arrangement tie together the two SI pumps at a junction downstream of an orifice and a check valve installed in the mini-flow line of each pump. The mini-flow line is then routed to the IRWST, which is vented to the containment atmosphere. There is no plausible operating configuration in which the operation of one SI pump would cause the other pump to operate at less than the required mini-flow.

The SI pumps can be used to achieve safe shutdown by providing makeup for volume contraction and by providing sufficient boron to achieve and maintain necessary shutdown margins.

The SI pumps can also be used to provide injection flow during feed and bleed operations when pressurizer POSRV is used for decay heat removal; the POSRV is described in Subsection 5.4.14.

The SI pump delivery lag time is described in Chapter 15.

6.3.2.2 Component Description

A summary of design parameters and codes for the major components is given in Table 6.3.2-1. Subsection 15.6.5 specifies the components used to provide core protection for the complete spectrum of RCS pipe breaks.

6.3.2.2.1 In-containment Refueling Water Storage Tank

The IRWST is described in Section 6.8.

6.3.2.2.2 Safety Injection Tanks

The SITs are made of carbon steel and stainless steel. The design pressure of SIT is 49.2 kg/cm^2A (700 psig), consistent with the setpoint of SIT relief valves and operating pressure is 42.9 kg/cm^2A (610 psig). The design temperature of SIT is 93.3 °C (200 °F) and operating temperature is 48.9 °C (120 °F).

Figure 6.3.2-5 shows the schematic characteristics during the SIT blowdown. Figure 6.3.2-2 is a simplified view of SIT. Table 6.3.2-1 provides the SIT design parameters.

The discharge piping of each SIT is routed to a DVI nozzle on the reactor vessel. The SITs automatically discharge their contents of borated water into the RCS if RCS pressure drops below SIT pressure as a result of a LOCA. The fluidic device located in the tank regulates the flow rate with changing level.

The SITs contain borated water at a maximum concentration of 2.5 weight boric acid (4,400 ppm). The tank gas fractions, water fractions, gas pressure, and outlet pipe size are selected to allow three of the four tanks to flood and cover the core before significant fuel damage and a significant zirconium-water reaction can occur following a LOCA. The volume of water in the tanks is conservatively calculated assuming that all water injected before the end of the RCS blowdown is lost.

The SITs inject a large flow for a limited duration, in order to refill the reactor vessel lower plenum and downcomer, as rapidly as possible following the blowdown period. The SITs

also inject a relatively small flow to establish the core reflooding condition by maintaining the downcomer water level after refilling the reactor vessel lower plenum and downcomer.

The detailed design requirements and design specifications of the SIT with fluidic device are provided in APR1400-Z-M-TR-12003-P (Reference 3).

6.3.2.2.3 Safety Injection Pumps

The SI pumps are horizontal, centrifugal, or multistage. The design flow of an SI pump is 3,085 L/min (815 gpm) at 868.7 m (2,850 ft) design head. The design temperature of the SI pump is 176.7 °C (350 °F). The design pressure of the SI pump is 144.1 kg/cm^2 (2,050 psig). The SI pump design parameters are described in Table 6.3.2-1. The IRWST is the water source of SI pumps and located in containment.

The SI pumps are provided with minimum flow protection (mini-flow recirculation lines) to prevent damage resulting from operation against a closed discharge isolation valve or RCS pressure conditions that are higher than SI pump shutoff head. In addition, individual SI pump ultrasonic flow meters provide a low flow alarm in the event that an SI pump is operating at a flow rate that is less than the required mini-flow.

SI pump mini-flow is specified to be limited within the range of 321.8 to 397.5 L/min (85 to 105 gpm) at the pump shutoff head. The results indicate that a mini-flow rate of 321.8 to 397.5 L/min (85 to 105 gpm) provides adequate protection for the SI pumps at low flow conditions. Limiting the maximum mini-flow to 397.5 L/min (105 gpm) prevents a reduction in the capability of the SI pumps to deliver flow to the RCS. Testing that is performed to demonstrate acceptable SI pump operation while operating at mini-flow is described in Subsection 6.3.4.1.

Maximum SI pump flow is limited to an acceptable value when the system is set up during preoperational testing with the RCS at atmospheric pressure not to exceed the SI pump runout flow.

The Table 6.3.2-4 presents maximum and minimum SIS flow delivery to the RCS. The maximum and minimum flow delivery is used for safety analysis. The LOCA analysis is described in Subsection 15.6.5.

Mechanical shaft seals are used and provided with leakoff that collect any leakage past the seals. The seals are designed for operation with a pumped fluid temperature of 176.7 °C (350 °F).

The SI pump motors are specified to have the capability of starting and accelerating the driven equipment, under load, to a design point running speed within 5 seconds. This is based on an initial voltage of 75 percent of rated voltage at the motor terminals, increasing linearly with time to 90 percent voltage in the first 3 seconds and to 100 percent voltage in the next 2 seconds.

The SI pumps are provided with drain and flushing connections to permit a reduction of radioactive contamination before maintenance. The pressure-containing parts of the pump are stainless steel with internals selected for compatibility with boric acid solutions. The materials selected are analyzed to provide reasonable assurance that differential expansion during design transients can be accommodated.

The design temperature of the SI pumps is based on the saturation temperature of the reactor coolant at the containment design pressure plus a design tolerance. The design pressure for the SI pumps is based on the shutoff head plus maximum containment pressure plus a design tolerance. The pump data are provided in Table 6.3.2-1.

The SI pumps are specified to limit the maximum required NPSH to 6.1 m (20 ft) at pump runout flow. The SI pump NPSH requirements are described in Table 6.3.2-1. Pump vendor tests are conducted to provide reasonable assurance that the actual required NPSH does not exceed the specified limit. Available NPSH is calculated in accordance with NRC RG 1.1 (Reference 4). The difference between required NPSH and available NPSH provides reasonable assurance that NPSH requirements are satisfied.

The strainer is designed to protect the pump inlet and prevent ingestion of debris that can cause a loss of NPSH, in accordance with NRC RG 1.82 (Reference 5), for long-term recirculation cooling following a LOCA.

6.3.2.2.4 Piping

Piping is designed to deliver borated water from the SITs and the IRWST through the SI pumps to the reactor vessel nozzles.

Each DVI nozzle has an internal diameter no greater than 21.6 cm (8.5 in) and a flow area no greater than 366.1 cm^2 (56.75 in^2). The DVI line piping connected to each nozzle has a nominal diameter of 30.5 cm (12 in). The DVI nozzles restrict flow out of the reactor vessel in the event of a DVI line break.

The SIS piping is fabricated of austenitic stainless steel and is designed to ASME Section III. Flexibility and seismic loading analyses are performed to confirm the structural adequacy of the system piping.

6.3.2.2.5 Valves

The relative location, type, type of operator, position (during the normal operating mode of the plant), and failure position of the SIS valves are shown in Figure 6.3.2-1.

a. Relief valves

Protection against over pressurization of components within the SIS is provided by the conservative design of the system piping, maximum use of welded connections, appropriate valves between high-pressure sources and low-pressure piping and by the relief valves. All lines from the RCS up to and including the outermost containment isolation valves are designed for full RCS pressure. Relief valves are provided as required by applicable codes. All relief valves are totally enclosed and pressure tight with suitable provisions for gagging to allow testing.

A tabulation of SIS relief valves is provided below.

1) SI-211, 221, 231, and 241, SIT relief valves

The relief valves on the SITs are sized to protect the tanks against the maximum fill rate of liquid or gas into the SITs. They discharge into the

containment. The set pressure is 42.9 kg/cm^2 (700 psig) with a capacity of 169,900 slpm (6,000 scfm) of gas or 870.6 L/min (230 gpm) of liquid.

2) SI-473, SIT fill line thermal relief

A relief valve is provided on the check valve leakage return line. This relief valve is sized to protect against overpressure of the line when relieving injection line pressure due to leakage past the check valves located at the SIS connections to the RCS. It discharges into the reactor drain tank (RDT). The set pressure is 144.1 kg/cm^2 (2,050 psig) with a capacity of 132.5 L/min (35 gpm).

3) SI-474 and SI-292, SIT fill line relief valves

Relief valves are located on the SIT fill line to protect against overpressure due to a temperature increase. SI-474 discharges to the RDT and SI-292 discharges to the equipment drain tank (EDT). They are set at 144.1 kg/cm^2 (2,050 psig) with a capacity of 37.9 L/min (10 gpm).

4) SI-166, 409, 417, 439, 449, and 468, SI relief valves

These valves are sized to protect the isolated high-pressure injection lines against the pressure due to a temperature increase. They discharge into the EDT. The valves are set at 144.1 kg/cm^2 (2,050 psig) with a capacity of 37.9 L/min (10 gpm).

5) SI-285 and SI-286, SI relief valves

These valves are sized to protect the SI pump bypass flow lines against pressure due to a temperature increase. They discharge to the EDT. The set pressure is 144.1 kg/cm^2 (2,050 psig) with a capacity of 37.9 L/min (10 gpm).

b. Actuator-operated throttling and stop valves

The failure position of each valve on loss of actuating signal or power supply is selected to provide reasonable assurance of safe operation. System redundancy is considered when defining the failure position of any given valve. Valve position indication is provided at the MCR as indicated in Figure 6.3.2-1. A momentary push button with appropriate status control in the MCR and/or manual override handwheel is provided where necessary for efficient and safe plant operation. All actuator-operated valves have stem leakage controlled by double packing with a lantern ring leakoff connection.

Valves SI-616, 626, 636, and 646 are not used to adjust the SIS flow. During preoperational testing, orifices are added to each SI line to prevent excessive pump run out flow. The valves automatically open upon receiving an SIAS. During post-LOCA operation, these valves, which have a nominal size of 10.2 cm (4 in), can be used to throttle the SI pump flow to assist in controlling RCS pressure before and during shutdown cooling.

Motor-operated valves SI-602 and SI-603 are provided in parallel to SI-626 and SI-646, respectively. The valves are normally closed and do not receive an SIAS to open. The valves have a nominal size of 2.54 cm (1 in) and are used for controlling post-accident SI pump 1 and SI pump 2 flow at low flow rates.

Motor-operated throttling valves SI-321 and SI-331 are provided in the hot leg injection path of SI pumps 3 and 4, respectively. During post-accident, SI hot leg injection line isolation valves SI-321 and SI-331 are opened (in conjunction with SI hot leg injection line valves SI-604 and SI-609) while SI-636 and SI-616 are closed to provide SI pump flow to the RCS hot legs.

c. Check valves

All check valves are the totally enclosed type. The swing check valves are installed in the pump suction lines.

6.3.2.2.6 Safety Injection Filling Tanks

Two SIFTs are provided. SIFT data are summarized in Table 6.3.2-1. Gravity filling of SIS piping from IRWST cannot be performed because the elevation of IRWST is lower than the top of the SIS piping. Thus, the SIFTs are installed on the level of the auxiliary building at an elevation of 156 ft to fill the SIS piping by gravity. Two SIFTs provide a means of removing gas that may have accumulated at the top of the SIS piping. Maintaining the SIS piping sufficiently filled with borated water provides reasonable assurance that the system will perform properly, injecting the full capacity of SI pump into the RCS. This prevents water hammer, pump cavitation, and pumping of non-condensable gas (e.g., air, nitrogen, hydrogen).

Therefore, the provision is made to perform gravity filling every month in accordance with technical specifications surveillance requirements. Each SIFT is connected to two SIS trains and one SCS train. The boric acid storage tank (BAST) supplies borated water (4,400 ppm) to the SIFTs using the boric acid makeup pump (BAMP). The SIFTs are provided with a level indicator, temperature indicator, and vent to the gaseous waste management system (GWMS).

6.3.2.3 Applicable Codes and Classification

The codes and classification are described in Subsection 6.3.2.2 and Table 6.3.2-1.

6.3.2.4 Materials Specifications and Compatibility

The materials used in the construction of the SIS components are presented along with the component parameters in Table 6.3.2-1. All materials in contact with the reactor coolant are austenitic stainless steel. The materials of construction used in both the active and passive components are described in Section 6.1.

6.3.2.5 System Reliability

6.3.2.5.1 Safety Injection Tanks

The performance evaluation in Subsection 15.6.5 demonstrates the adequacy of the quantity of coolant supplied. In order to prevent accidental discharge from the SCS suction relief valves (SI-179 and SI-189), SIT pressure is decreased to an acceptable value before reactor coolant pressure is below 45.0 kg/cm^{2}A (640 psia) and subsequently, the isolation valves on the tanks are closed. An interlock with pressurizer pressure prevents these valves from being closed if pressurizer pressure is greater than 33.4 kg/cm^{2}A (475 psia).

Inadvertent repressurization of the SITs during shutdown cooling due to a leaky nitrogen supply valve or the accidental tripping of a valve switch is prevented by having two fail-closed supply valves in series with separate hand switches. The air supply actuating the nitrogen supply valves is controlled by solenoid valves. The nitrogen supply line inside the containment is not normally pressurized.

The two nitrogen supply valve solenoids on each SIT are connected to separate electrical buses through redundant and physically separated electrical trains in order to provide reasonable assurance that a fault in one of the trains will not cause a spurious opening of both nitrogen supply valves.

The motor-operated isolation valves on the SIT discharge are interlocked with pressurizer pressure to open the valves automatically as system pressure is increased to 42.2 kg/cm^{2}A (600 psia). When RCS pressure increases to 45.0 kg/cm^{2}A (640 psia), the operator repressurizes the SITs. Failure to do so results in an alarm at a pressurizer pressure of 50.3 kg/cm^{2}A (715 psia). Further details of valve control are provided in Section 7.6.

The atmospheric vents on the SIT are locked closed, fail closed, and power to their solenoid valve is interrupted during operation when the RCS pressure is greater than 50.3 kg/cm^{2}A (715 psia). This procedure provides reasonable assurance that the tank is not vented during RCS power operation.

6.3.2.5.2 Safety Injection Pumps

Each of the four SI pumps is provided with a separate suction line from the IRWST and a separate discharge line to one of four DVI nozzles. One SI pump and the associated injection valves operate from one emergency power supply, the other SI pumps and injection valves from each independent emergency power supply. This provides the automatic operation of three trains of SI pumps in the unlikely event of a concurrent loss of offsite power and the failure of an active component, including a standby generator.

With the exception of check valves, the open or closed position of all valves in the injection paths not receiving an SIAS is administratively controlled.

Prevention of flow blockage in small diameter pipes, including the above piping, is accomplished by control of particle size and specific weight in the injection water through IRWST design.

The IRWST is designed to prevent the loss of NPSH in the SI pump due to the LOCA-generated debris during the long-term cooling mode. The hold-up volume tank (HVT) and the strainers in the IRWST are used to filter the debris. The design of the IRWST is described in Section 6.8.

The piping between the IRWST and the SI pump is designed to conform with the BTP 6-5 to confirm the availability of an adequate source of water for the SIS.

The SIS is designed to minimize the air accumulation in the pipe. The provision is made to check the air accumulation in the line of the SIS periodically, and the SIFTs provide the way to fill the line of the SIS by gravity to prevent the water hammer phenomenon and the air ingestion into the SI pump.

A hot leg injection path is provided from the discharge of SI pumps 3 and 4 to allow hot leg injection through the nozzle connections on each shutdown cooling suction line to prevent the boron precipitation during the long-term cooling mode.

6.3.2.5.3 Power Sources

Independent electrical trains supply power to the SIS equipment. Each train can receive power from the following:

a. Onsite power

b. Offsite power

c. Emergency power

The safeguards initiation sensors, electrical controls, and electrical indication equipment normally receive power from four 120-volt ac buses. Four 125-volt station batteries with inverters are provided as a backup upon loss of all other sources of power.

System reliability is achieved with the following:

a. Four electrical trains, with each train supplying power to each bus. Each bus powers the pump, valves, and associated support systems of each SI train.

b. Two sources of power, normal and standby to each train, with automatic backup from the emergency generators.

c. Four emergency generators, each capable of supplying power for the minimum safeguards loads.

d. No spuriously initiated unnecessary injection flow or prevention of the initiation of required injection flow from a single electrical failure.

e. Alternate ac source of power.

Each remotely actuated valve in the SI hot leg injection lines (SI-321, 604, and SI-331, 609, respectively) is powered from a separate bus in other electrical trains. This prevents an inadvertent opening of a hot leg injection path in the event of a fault in a single bus.

6.3.2.5.4 Capacity to Maintain Cooling Following a Single Failure

The SIS is designed to meet its functional requirements even with the failure of a single active component during the short-term mode of operation or with the single active or limited leakage passive failure of a component during the long-term mode of operation. By providing the proper redundancy of equipment, even with the single failure noted above, the minimum required SIS equipment is available.

The SIS is designed using a philosophy of total physical separation of redundant trains so that the system can carry out its safety function assuming a single active failure during both normal and short-term post-accident modes and a single active or limited leakage passive failure during long-term, post-accident modes after event initiation. Total separation of mechanical trains provides reasonable assurance that a single failure in one train cannot preclude the other trains from accomplishing their safety functions. An FMEA for the SIS is presented in Table 6.3.2-2. An FMEA for the ESFAS is discussed in Subsection 7.3.3.

Minimum operability requirements for components of the SIS are as delineated in the Technical Specifications. Consistent with these operability requirements and system failure modes, the minimum SIS equipment that operates during postulated accidents is described in Subsection 15.6.5. The equipment is required to mitigate the consequences of a LOCA that is initiated when the reactor is in any condition from hot shutdown to full power operation. Reasonable assurance of conservative results are provided for other incidents in which the SIS is required.

The following design features are provided in the system in order to meet the single failure criterion.

a. Three redundant SI trains

b. Separate suction piping and valves from the IRWST to each SI pump

c. Separate discharge piping and valves from each SI pump to its respective DVI nozzle into the reactor vessel downcomer

d. Redundant SI pump injection paths from one SI pump in other trains to the RCS hot legs

e. Separation of the SIS trains. No limited leakage passive failure, as defined in Subsection 3.1.31, or effects (e.g., flooding, spray impingement, steam, temperature, pressure, radiation, loss of NPSH) preclude the SIS from accomplishing its safety functions. A limited leakage passive failure is defined as the failure of a pump seal or valve packing, whichever is greater. The maximum leakage is expected to be from a failed SI pump seal.

   Leakage to the pump compartment drains to the room sump. From there, it is pumped to the waste management system. The sump pumps in each room handle the expected amounts of leakage. If leakages exceed the sump pump capacity, the affected SIS train will be isolated.

6.3.2.6 Protection Provisions

The SIS is provided with protection from damage that could result from a LOCA by (1) the design of components to withstand the DBA environment including coolant chemistry, radiation, temperature, and pressure resulting from the accident, (2) a seismic design that withstands the stress imposed by a safe shutdown earthquake (SSE) occurring simultaneously with a LOCA, and (3) protection from missiles in accordance with Section 3.5.

6.3.2.6.1 Capability to Withstand the Design Bases Environment

Components located in the containment, such as remote-operated valves and I&C equipment, that are required for the initiation of safety injection are designed to withstand the LOCA conditions of temperature, pressure, humidity, chemistry, and radiation for the required extended period described in Section 3.11. The valves include those associated with fill, drainage, and pressure control of the SITs, which receive an SIAS or are required to operate following an accident. The instrumentation includes the wide range level and pressure instrumentation associated with the SITs.

To the extent that is practicable, SIS components required to maintain a functional status are located outside the containment to eliminate exposure of this equipment to post-LOCA conditions. The equipment outside the containment is designed in consideration of the chemical and radiation effects associated with operation following a LOCA. Figure 6.3.2-1 indicates the location of equipment inside or outside the containment.

Design pressures and temperatures are in excess of the maximum pressures and temperatures seen by the respective component during the worst normal operating and design bases conditions. Pump construction materials are compatible with the expected water chemistry under normal and LOCA conditions. A radiation resistance requirement is placed on the pumps consistent with Section 3.11.

Piping that cannot be isolated for the SIS connected to the RCS that could be subjected to temperature distributions that would result in unacceptable thermal stress is identified in Subsection 3.12.5.9.

6.3.2.6.2 Missile Protection

Protection from possible RCS-generated missiles is provided by locating all components outside the containment except for the IRWST and SITs. In addition, the piping and valves installed in the containment are protected from RCS-generated missiles by protective measures such as adequate separation, isolation, and pipe whip restraints. The SITs are located outside the biological shield to provide protection from possible RCS-generated missiles.

6.3.2.6.3 Seismic Design

The SIS is designed to seismic Category I requirements. The general design basis for Category I equipment is that it must be able to withstand the appropriate seismic loads plus other applicable loads without loss of the design functions that are required to protect the public.

For the SIS, the components must be able to withstand the stresses resulting from emergency operation following a LOCA, simultaneous with the stresses resulting from an SSE without loss of function.

The detailed description of seismic classification and design is described in Subsection 3.2.1 and Section 3.7.

6.3.2.6.4 Water Hammer

The SIS design addresses system dynamic loads such as those that may result from water hammer. Plant operating and maintenance procedures are prepared in accordance with guidelines to minimize the potential for water hammer. Design features, such as vents and drains, are provided in SIS piping and used in conjunction with these procedures to provide reasonable assurance that these lines are maintained (restored in the case of maintenance or repair) in a water-filled condition. Maintaining the SIS in a water-filled condition minimizes the potential for water hammer during system startup.

6.3.2.7 Provisions for Performance Testing and Inspection

The SIS is designed to allow for periodic in-service inspection and functional testing. The design provides the capability of periodically demonstrating that the system operates properly when an accident signal is received. The provision is made to conduct the full flow test using the return line during power operation. The SITs are designed to have the sampling line to inspect the boron concentration. The SIS design incorporates provisions to allow for testing of motor-operated valve (MOV) under differential pressure. Performance testing is described in Subsection 6.3.4.

6.3.2.8 Manual Actions

The short-term injection mode of operation is automatically initiated by an SIAS.

The long-term mode is manually initiated at approximately 3 hours post-LOCA at which time the hot leg injection valves in the discharge piping of SI pumps 3 and 4 are opened and the corresponding DVI flow path cold side valves are closed. The DVI nozzle flow paths of SI pumps 1 and 2 remain open. The configuration with SI pumps 3 and 4 injecting into the hot legs and SI pumps 1 and 2 injecting into their respective DVI nozzles provides circulation flow through the core. For small pipe breaks, the SI pumps provide makeup for spillage while the RCS is cooled down and depressurized to shutdown cooling initiation conditions using the steam generator atmospheric dump valves and auxiliary feedwater

system. For small LOCAs, the SITs are vented and/or isolated to allow RCS depressurization. This is followed by a manual shutdown cooling operation.

6.3.3 Performance Evaluation

The safety analyses to evaluate the SIS performance are described in Subsection 15.6.5.

6.3.4 Tests and Inspections

During fabrication of the SIS components, tests and inspections are performed and documented in accordance with code requirements to provide reasonable assurance of high-quality construction. As necessary, performance tests of components are performed in the vendor facilities. The SIS is designed and installed to permit in-service inspections and tests in accordance with the ASME Section XI and ASME Operation and Maintenance (OM), respectively.

6.3.4.1 SIS Performance Tests

Prior to the initial plant startup, a comprehensive series of system flow tests, as detailed in Section 14.2, are performed to verify that the design performance of the system and individual components is attained.

Preoperational tests are performed to confirm that the as-built SIS meets operability requirements and provides a level of performance that meets the safety analyses. Preoperational tests of the SIS are conducted in accordance with NRC RG 1.79 (Reference 6), as described in Chapter 14. The pre-operational test for SIS is described in following subsections:

a. 14.2.12.1.21 – Safety Injection System Test

b. 14.2.12.1.22 – Safety Injection Tank Subsystem Test

c. 14.2.12.1.23 – Engineered Safety Features – Component Control System Test

d. 14.2.12.1.59 – Pre-core Safety Injection Check Valve Test

Each installed SI train is tested to measure the SI pump developed differential pressure at mini-flow and runout flow through the DVI lines and for SI pumps 3 and 4, measure runout flow through the hot leg injection lines. Runout flow testing is conducted with the RCS at atmospheric pressure conditions. Test results are used to confirm SI pump performance characteristics over the operating range of the pump and to confirm system resistance characteristics. Test conditions, including fluid temperature, suction and discharge side fluid elevations, and potential instrument uncertainties are taken into account in the analysis. To simulate the SI injection in hot operating conditions, the small amounts of water injected into the RCS during hot operating condition.

Testing is performed to confirm that the SI pump mini-flow rate in the installed system meets the pump minimum flow requirements. Testing is performed to confirm that the SI pump return line to the IRWST allows each SI pump to be operated at a rated flow during in-service testing.

A test is conducted to demonstrate that the SITs can be depressurized by venting for entry into shutdown cooling. During the test, each SIT is pressurized and its isolation valve closed. The test confirms that each SIT vent valve can be opened from the MCR and SIT pressure decreases while the SIT is being vented.

Each SIT is tested to measure changes in SIT pressure and level during SIT blowdown. The test results are used to demonstrate that the as-built resistance coefficients of the fluidic device of each tank and discharge line are within the limits used to perform safety analyses in Chapter 15.

The leak test of check valves in SI lines is performed using the local vent line in the hot condition of reactor.

The testing under maximum startup loading conditions is performed in Subsection 14.2.12.1.39.

The opening the valves under maximum differential pressure at the ambient RCS pressure is described in Subsection 14.2.7.3.

6.3.4.2 Reliability Tests and Inspections

After the plant is brought into operation, periodic tests and inspections of the SIS components and trains are performed to provide reasonable assurance of proper operation in the event of an accident. The scheduled tests and inspections are necessary to verify system operability.

The tests permit a complete checkout at the trains and component level during normal plant operation. Satisfactory operability of the complete system can be verified during normally scheduled refueling shutdown. The complete schedule of SIS tests and inspections is provided in Chapter 16, technical specifications, in accordance with 10 CFR 50.55a(f) (Reference 7).

All the valves of SIS are confirmed to operate in the design flow and differential pressure during the preoperational test in accordance with NRC RG 1.68 (Reference 8).

During the normal power operation, the SI pump can be tested at minimum and rated flow using the bypass line of mini flow line, periodically.

The leak test of check valves in SI lines is performed using the local vent and drain lines.

Actuation of the ESF signal and interlock is described in Section 7.3.

The in-service test of SI valves and pumps is described in Subsection 3.9.6.

The fabrication and layout of SIS consider the in-service test and inspection of components in accordance with Section 6.6.

6.3.5 Instrumentation Requirements

6.3.5.1 Design Criteria

The I&C for the SIS are designed in accordance with the applicable portions of the Institute of Electrical and Electronics Engineers (IEEE) standards as delineated in Subsection 7.1.2.

The controls automatically provide the sequence of operations required to initiate an SIS operation. The I&C design that actuates and controls the SIS is based on the following:

a. Redundant instruments are provided for the initiation of SIS actions. Four sensors are used for each critical parameter. A trip from any two of the four sensors initiates the appropriate SIS action.

b. Electric power required for SIS controls and instruments is supplied through four preferred ac buses. Emergency generators provide an alternate source of power.

Where required to provide reasonable assurance of proper system alignment, the open/closed position of remotely actuated valves is administratively controlled in the MCR. Required valve positions are indicated on Figure 6.3.2-1.

All valves except check valves that are not required to operate on the initiation of SI in the SI flow path are controlled to provide reasonable assurance that the valves are maintained in the appropriate SI position during operation.

The instrumentation and associated analog and logic channels used for SI initiation are described further in Section 7.3.

6.3.5.2 System Actuation Signals

Operation of the SIS is controlled by the SIAS, which is initiated in the event of low pressurizer pressure or high containment pressure. Both of these parameters provide an indication of a LOCA, which requires operation of the SIS. An SIAS can also be initiated manually from the MCR.

Initiation of SI is derived from four independent pressurizer pressure sensors and four independent containment pressure sensors. Coincidental trip signals from two out of the four sensors for either parameter automatically initiates SI. Automatic SIAS operation is actuated at a low pressurizer pressure or a high containment pressure.

During startup and shut down operations, a variable setpoint on low pressurizer pressure is used. The further description of the SIAS is in Section 7.3.

6.3.5.3 Instrumentation during Operation

The instrumentation provided for monitoring SIS components during SIS operation is described in this section. The instrument readout location is described in Figure 6.3.2-1.

6.3.5.3.1 Pressure

a. SIT pressure

Pressure transmitters mounted on each SIT provide indication of the pressure in each SIT. Wide range pressure channels P-311D, 321B, 331C, and 341A provide pressure indication in the MCR and remote shutdown room. Narrow range pressure channels P-312, 322, 332, 342, 313, 323, 333, and 343 provide pressure indication in the MCR. Alarms are provided in the MCR to alert the operator to high or low SIT pressure conditions.

b. SI pump discharge pressure

Pressure channels P-306, 307, 308, and 309 provide an indication of SI pump discharge pressure in the MCR. The operator uses the pressure channels to monitor SI pump operation.

6.3.5.3.2 Valve Position

a. SIT isolation valve position

Redundant valve position indication is provided in the MCR and RSR for valves SI-614, 624, 634, and 644. The position indication verifies the fully open or fully closed position with an alarm if the valve is not fully open.

b. Hot leg injection isolation valve position

Open/closed valve position indication is provided in the MCR for valves SI-604 and 609.

c. Hot leg injection flow control valve position

Open/closed and full range (0 to 100 percent) position indication is provided in the MCR for valves SI-321 and 331. Full range position indication is used to monitor intermediate valve positions when the valves are used for throttling SI pump flow to the RCS hot legs.

d. SI line isolation valve position

Open/closed and full range (0 to 100 percent) position indication is provided in the MCR for valves SI-616 and 636 and in the MCR and RSR for valves SI-626 and 646. Full range position indication is used to monitor intermediate valve positions when the valves are used to throttle SI pump flow to the DVI nozzles.

e. SI line low flow control valve position

Open/closed and full range (0 to 100 percent) position indication is provided in the MCR and RSR for valves SI-602 and 603. Full range position indication is used to monitor intermediate valve positions when the valves are used to throttle SI pump flow to the DVI nozzles.

f. IRWST isolation valve position

Open/closed position indication is provided in the MCR for valves SI-304 and 305 and in the MCR and RSR for valves SI-308 and 309.

g. SI pump IRWST recirculation line valve position

Open/closed and full range (0 to 100 percent) position indication is provided in the MCR for valves SI-302 and 303. Full range position indication is used to monitor intermediate valve positions when the valves are used to throttle the SIT fill line for SI-303.

h. SIT vent valve position

Open/closed position indication is provided in the MCR and RSR for valves SI-605, 606, 607, 608, 613, 623, 633, and 643.

i. SI pump manual isolation valve position

Open/closed position indication is provided in the MCR for SI-130, 131, 402, 435, 447, 470, 476, and 478. An alarm is provided to alert the operator when a valve is not fully open.

6.3.5.3.3 Level

Water level for each SIT is indicated in the MCR. Channels L-311D, 321B, 331C, and 341A provide a wide-range level indication. Channels L-312, 322, 332, and 342 and L-313, 323, 333, and 343 provide narrow range indication. Alarms are provided in the MCR to alert the operator to high or low and high-high or low-low level conditions.

6.3.5.3.4 Flow

a. DVI nozzle injection line flow

A flow measurement channel is provided to indicate the DVI nozzle injection line flow rate. Channels F-311D, 321B, 331C, and 341A provide flow indication in the MCR for each SI pump.

b. SI pump hot leg injection flow

Channels F-390C and 391D provide indication of SI pumps 3 and 4 flow rates to the RCS hot legs in the MCR.

c. SI pump ultrasonic flow measurement channels

Ultrasonic flow measurement channels F-306, 307, 308, and 309 provide local indication of SI pump suction flow, including mini-flow recirculation flow back to the IRWST. An alarm is provided in the MCR to alert the operator when pump flow is less than the minimum recirculation flow required for pump protection.

6.3.5.3.5 SI Pump Motor Current

Motor currents for each SI pump are indicated in MCR to monitor the SI pump operation.

6.3.5.4 Accident Monitoring Instrumentation

The accident monitoring instrumentation is described in Subsection 7.5.1.1.

6.3.6 Design Features for Minimization of Contamination

The APR1400 is designed with specific features to meet the requirements of 10 CFR 20.1406 (Reference 9) and NRC RG 4.21 (Reference 10). The basic principles of NRC RG 4.21, and the methods of control suggested in the regulations, are specifically delineated in four design objectives and two operational objectives as discussed in Subsection 12.4.2. The following evaluation summarizes the primary features to address the design and operational objectives for the SIS.

The SIS has been evaluated for leakage identification from the SSCs that contain radioactive or potentially radioactive materials, the areas and pathways where probable leakage may occur, and the methods of leakage control incorporated in the design of the system. The leak identification evaluation indicated that the SIS is designed to facilitate early leak detection and the prompt assessment and response to manage collected fluids. Thus, unintended contamination of the facility and the environment is minimized or prevented by the SSC design, supplemented by operational procedures and programs for inspection and maintenance activities.

Prevention/Minimization of Unintended Contamination

a. The SIS components are located inside the reactor containment building and the auxiliary building. The cubicle floors where the components are located are sloped, coated with epoxy, and provided with drains that are routed to the local drain hubs and sumps. This design approach prevents unintended contamination of the facility and the environment.

b. The system tanks and pumps are fabricated from stainless steel material and are of welded construction for life-cycle planning, thus minimizing leakage and unintended contamination of the facility and the environment.

Adequate and Early Leak Detection

a. The SI tanks are equipped with level instruments to monitor liquid levels. The level instruments provide alarm signals in the event that leakage occurs.

b. The SIS is not used during normal power operation. Any leakage is drained to the floor and is collected in the local sump which is equipped with a liquid level switch. If leakage exceeds a predetermined liquid level within the sump, the level switch initiates an alarm in the MCR for operator actions to investigate the source of leakage.

Reduction of Cross-Contamination, Decontamination, and Waste Generation

The SSCs are designed with life-cycle planning using nuclear industry-proven materials compatible with the chemical, physical, and radiological environment, thus minimizing waste generation. The pump shaft seals are of the mechanical type and constructed of materials compatible with the SI fluid. This design approach minimizes contamination of the facility and the environment. The SIS is designed to be isolated from the RCS during normal power operation to minimize cross-contamination of systems.

Decommissioning Planning

The SSCs are designed for extended service life and are fabricated as individual assemblies for easy removal. The SSCs are designed with decontamination capabilities. Design features, such as welding techniques used and surface finishes are intented to minimize the need for decontamination and the resultant waste generation. The SIS is designed with a minimal amount of embedded piping for contaminated or potentially contaminated fluid to facilitate decommissioning.

Operations and Documentation

a. The COL applicant is to prepare operational procedures and maintenance programs as related to leak detection and contamination control (COL 6.3(1)). Procedures and maintenance programs are to be completed before fuel is loaded for commissioning.

b. The COL applicant is to maintain complete documentation of system design, construction, design modifications, field changes, and operations (COL 6.3(2)).

Site Radiological Environmental Monitoring

The SIS is on standby mode during normal power operation and is designed to have low levels of contamination. Through monitoring, inservice inspection, and lessons learned from industry experiences, the integrity of the SIS is well maintained, resulting in a very low potential for contamination of the facility. Because of its location, the potential for environmental contamination of soil and groundwater from liquid leakage is minimal. Hence, the SIS is not required to be part of the site radiological environmental monitoring program.

6.3.7 Combined License Information

COL 6.3(1) The COL applicant is to prepare operational procedures and maintenance programs as related to leak detection and contamination control.

COL 6.3(2) The COL applicant is to maintain complete documentation of system design, construction, design modifications, field changes, and operations.

6.3.8 References

1. 10 CFR Part 52, Appendix B, "Design Certification Rule for the System 80+ Design," U.S. Nuclear Regulatory Commission.

2. 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," U.S. Nuclear Regulatory Commission.

3. APR1400-Z-M-TR-12003-P (Proprietary) & NP (Non-Proprietary), "Fluidic Device Design for the APR1400," Rev. 0, KHNP, December 2012.

4. Regulatory Guide 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System," Rev. 0, U.S. Nuclear Regulatory Commission, November 1970.

5. Regulatory Guide 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," Rev. 4, U.S. Nuclear Regulatory Commission, March 2012.

6. Regulatory Guide 1.79, "Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors," Rev. 1, U.S. Nuclear Regulatory Commission, September 1975.

7. 10 CFR 50.55a(f), "Inservice testing requirements," U.S. Nuclear Regulatory Commission.

8. Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants," Rev. 4, U.S. Nuclear Regulatory Commission, June 2013.

9. 10 CFR 20.1406, "Minimization of Contamination", U.S. Nuclear Regulatory Commission.

10. Regulatory Guide 4.21, "Minimization of Contamination and Radioactive Waste Generation-Life Cycle Planning," Rev. 0, U.S. Nuclear Regulatory Commission, June 2008.

Table 6.3.1-1

Responses of APR1400 to TMI Action Plan

No.	Title	APR1400 Design
III.D.1.1	Integrity of Systems Outside Containment Likely to Contain Radioactive Material for Pressurized-water Reactors and Boling-Water Reactors	Radiation monitoring equipment is provided to detect primary-to-secondary system leakage and leakage from the primary system to the containment atmosphere. These monitoring systems are designed to be consistent with the recommendations of NRC RG 1.45 for detection of primary system leakage. The more detail descriptions such as leakage detection methods, instrumentation, relevant systems, sensitivity, response time, testing and calibration are in Subsection 5.2.5.

Table 6.3.1-2

Responses of APR1400 to Generic Safety Issues

No.	Title	APR1400 Design
191	Assessment of Debris Accumulation on PWR Sump Performance	The APR1400 is designed in accordance with NRC RG 1.82, Revision 4, and the methodology of NEI 04-07 and NRC's Safety Evaluation Report (SER) for NEI 04-07. Four redundant passive type strainers are installed within the IRWST, which has a broad footprint to obtain sufficient surface area. Insulation and coatings debris are estimated by the NEI 04-07 methodology, and 200 pounds of latent debris is assumed to reach strainers. Trisodium phosphate (TSP) is selected as the agent for pH control in the recirculation water inside the HVT, to mitigate the chemical effect that might be caused during long term cooling. The more detail descriptions are described in Subsection 6.3.2.2.3 and Section 6.8.

Table 6.3.1-3

Responses of APR1400 to Generic Letters

No.	Title	APR1400 Design
GL 2008-01	Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems.	The SIFTs are installed on the level of the auxiliary building to fill the SIS piping by gravity. Two SIFTs provide a means of removing gas that may have accumulated at the top of the SIS piping. Maintaining the SIS piping sufficiently filled with borated water provides reasonable assurance that the system will perform properly. This prevents water hammer, pump cavitation, and pumping of non-condensable gas. The more detail descriptions are in Subsection 6.3.2.1.2.

Table 6.3.2-1 (1 of 3)

SIS Component Parameters

Safety Injection Pumps

Quantity	4
Type	Multistage, horizontal, centrifugal
Safety classification	2
Seismic Category	I
Code	ASME Section III, Class 2
Design pressure	144.1 kg/cm^{2}G (2,050 psig)
Maximum operating suction pressure	7.0 kg/cm^{2}G (100 psig)
Design temperature	176.7 °C (350 °F)
Design flow rate	3,085 L/min (815 gpm)(1)
Design head	868.7 m (2,850 ft)
Materials	Stainless steel, type 304, 316 or approved alternate
Shaft seal	Mechanical
Brake horsepower	746 kW (1,000 hp)

Safety Injection Pump NPSH

	Flow/Pump L/min (gpm)	Maximum NPSH required m (ft)	Minimum NPSH available m (ft)
Long-Term Cooling Mode	4,675(1,235) (2)	6.1 (20) (3)	6.7 (22) (3)

(1) Does not include minimum bypass flow.

(2) Including minimum bypass flow.

(3) Calculation is based on the NRC RGs 1.1 and 1.82. SI pumps take suction from the IRWST at runout flows.

Table 6.3.2-1 (2 of 3)

Safety Injection Tanks

Quantity	4	
Safety classification	2	
Seismic Category	I	
Code	ASME Section III, Class 2	
Design pressure, internal/external	49.2 kg/cm^{2}G / 7.0 kg/cm^{2}G (700 psig / 100 psig)	
Design temperature	93.3 °C (200 °F)	
Operating temperature	48.9 °C (120 °F) 10.0 °C (50 °F)	
Normal operating pressure	42.9 kg/cm^{2}G (610 psig)	
Nominal internal volume	68.1 m^3 (2,406 ft^3)	
Normal liquid volume	52.6 m^3 (1,858 ft^3)	
Fluid	Borated water	4,400 ppm (maximum) 2,300 ppm (minimum)
Material	Clad	Stainless steel, type 304, 316, or approved alternate
	Body	Carbon steel, type SA-516 Gr. 70, or approved alternate
In-containment Refueling Water Storage Tank	Refer to Section 6.8	
Piping		
Internal volume from first RCS check valve to direct vessel injection nozzle, each line, maximum	0.35 m^3 (12.4 ft^3)	
Resistance coefficient K from SIT discharge to the reactor vessel, based on a cross sectional area of 0.05195 m^2 (0.5592 ft^2), each line, range	6 – 10	

Table 6.3.2-1 (3 of 3)

Safety Injection Filling Tanks

Quantity	2
Safety classification	NNS
Code	ASME Section VIII
Design pressure, internal/external	0.105 kg/cm^{2}G / 0.105 kg/cm^{2}g (1.5 psig / 1.5 psig)
Design temperature	93.3 °C (200 °F)
Operating temperature	10 ~ 48.9 °C (50 ~120 °F)
Normal operating pressure	Atmosphere
Nominal internal volume	5.68 m^3 (200.52 ft^3)
Normal liquid volume	3.79 m^3 (133.68 ft^3)
Fluid	Borated water: 4,400 ppm (maximum)
Material	Austenitic stainless steel

Table 6.3.2-2 (1 of 14)

Safety Injection System Failure Modes and Effects Analysis

Part A. Injection Mode (Short-Term Injection)

When pressurizer pressure drops below 127.3 kg/cm^{2}A (1,810 psia) or containment pressure rises above 0.13 kg/cm^2 (1.9 psig) during plant operation, an SIAS is generated and the SIS automatically goes into operation. For feed and bleed operation, same line-up as injection mode is used.

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
1	IRWST isolation valve SI-304 SI-305 SI-308 SI-309	a) Fails closed	• Mechanical binding • Electrical malfunction • Corrosion	Loss of one of SI lines	• Periodic testing • Operator • Loss of associated SI pump	Redundant SI train	Valve normally locked open in the control room
		b) Fails open	• Mechanical binding • Electrical malfunction • Corrosion	None	None	None	
2	SI Pump suction isolation valve SI-470 SI-402 SI-130 SI-131	a) Fails closed	• Mech. binding • Corrosion	Loss of one of SI lines	• Periodic testing • Operator • Loss of associated SI pump	Redundant SI train	Valve is normally locked open at the valve
		b) Fails open	• Mech. binding • Corrosion	None	None	None	

Table 6.3.2-2 (2 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
3	CS Pump suction isolation valve SI-347 SI-348	a) Fails closed	• Mech. binding • Corrosion	Loss of one of the CS lines	• Periodic testing • Operator • Loss of associated CS pump	Redundant CS train	
		b) Fails open	• Mech. binding • Corrosion	None	None	None	
4	Safety Injection Pump No. 1 No. 2 No. 3 No. 4	a) Fails to start on SIAS	Electrical malfunction	Reduce SI injection flow to associated DVI line	• Low pressure indication for P-308, P-309, P-306 or P-307 pump “run” light; • Periodic testing	Other three SI pumps provide system-required flow continuously	
5	SI Pump discharge isolation valve SI-476 SI-478 SI-435 SI-447	a) Fails closed	• Mech. binding • Corrosion	Loss of one of the SI injection lines	• Periodic testing • Pressure indication for P-308, P-309, P-306, or P-307	Redundant SI train	Valve is normally locked open at the valve
		b) Fails open	• Mech. binding • Corrosion	None	None	None	

Table 6.3.2-2 (3 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
6	SI Pump Orifice Bypass valve SI-218 SI-219 SI-254 SI-255	a) Fails closed	• Mech. binding • Corrosion	Cannot provide an adequate condition for SIT refilling flow path (SI-219, 255 only) or SI pump testing	Operator	Orifice is available to provide an alternate flow path	
		b) Fails open	• Mech. binding • Corrosion	Reduce flow to RCS	None	Redundant train	Valve is normally locked closed at the valve
7	SI Pump Mini-flow isolation valve SI-410 SI-411 SI-412 SI-413	a) Fails closed	• Mech. binding • Corrosion	• Potential pump damage and loss of the SI train. • Loss of SIT filling flow path (SI-411, 413 only) or SI pump testing	Periodic testing; None, unless pump overheats and fails	Redundant SI pump	Valve is normally locked open
		b) Fails open	• Mech. binding • Corrosion	None	Flow indicator (F-341A, F-331C F-321B, F-311D)	None	
8	SI Pump Mini-flow sampling system isolation valve SI-465 SI-427	a) Fails open	• Mech. binding • Corrosion	None	None	None	
		b) Fails closed	• Mech. binding • Corrosion	Unable to sample at this location	Operator	Other sample location	

Table 6.3.2-2 (4 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
9	SI combined mini-flow line isolation valve SI-302 SI-303	a) Fails open	• Mech. binding • Elect. malfunction • Corrosion	Effective loss of SIT fill operation (SI-303 only)	• Operator • Periodic testing; • Valve position indication in the control room	None	Valve is normally locked open in the control room
		b) Fails closed	• Mech. binding • Elect. malfunction • Corrosion	• Cannot provide an adequate condition for SI pump testing. • Potential damage of associated SI pump	Operator	None	
10	IRWST return line isolation valve SI-395 SI-959	a) Fails open	• Mech. binding • Elect. malfunction • Corrosion	Loss of ERVC flow path (SI-395 only)	Operator	None	
		b) Fails closed	• Mech. binding • Elect. malfunction • Corrosion	• Cannot provide an adequate condition for SI pump testing. • Loss of one IRWST cooling flow path	Operator	None	Valve is normally locked open in the control room
11	SI line isolation valve SI-616 SI-626 SI-636 SI-646	a) Fails closed	• Mech. binding • Elect. malfunction • Corrosion	Decrease in ability to inject safety injection water in RCS	• Valve position indication in control room • Periodic testing	Other three redundant DVI injection lines	
		b) Fails to open on SIAS	Same as 11a	Same as 11a	Same as 11a	Same as 11a	
		c) Fails open	Same as 11a	None	Same as 11a	None required	

Table 6.3.2-2 (5 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
12	SI (line) low flow control valve SI-603 SI-602	a) Fails closed	• Mech. binding • Corrosion	Cannot provide an low flow control	• Operator • Valve position indication in control room • Periodic testing includes other	• Alternate flow path through SI line isolation valve (SI-616, 626, 636, 646) • Redundant train	Fail as is reset after loss of elec. power is not required, but the design includes similar feature (i.e., one-shot)
		b) Fails open	Same as 12a)	Slightly increase flow to RCS in case SI injection	Same as 12a	Same as 12a)	
13	Check valve leakage isolation Valve SI-618 SI-628 SI-638 SI-648	a) Fails closed	• Mech. binding • Air line separates from valve operator	None	• Valve position indication in control room • Periodic testing; SIT level indicator	None	Valve is normally closed
		b) Fails to close on SIAS	• Electrical malfunction • Seat leakage • Contamination	None	Same as 13a	Redundant isolation valves in series prevent SI DVI line being drained	Valve is designed to fail closed and is normally closed
		c) Fails open	• Seat leakage • Contamination	None	Same as 13a	Same as 13b	Same as 13b

Table 6.3.2-2 (6 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
13	Check valve leakage isolation Valve SI-618 SI-628 SI-638 SI-648	d) Initially open, re-opens due to lack of LOP reset fails open	• Electrical malfunction • Seat leakage	None	• Valve position indicator in the control room • SIT level indicator	Operator can close redundant series isolation valve (SI-661 or SI-670) to prevent affected SIT from being drained	Valve is designed to fail closed following the interruption of power to the valve
		e) Initially open, re-opens due to lack of LOP reset fails closed	Air line separates from valve operator	Cannot drain leakage line to determine the rate of back leakage of affected SI DVI line check valve when required	Same as 13a	None	
14	SIT discharge isolation Valve SI-614 SI-624 SI-634 SI-644	a) Fails closed	• Mech. binding • Electrical malfunction • Corrosion	Loss of flow from SIT to one of affected DVI line	• Valve position indication in the control room • Periodic testing	Redundant SIT flow to DVI lines	Valve is normally locked open in the control room
		b) Fails open	Same as 14a	Cannot isolate affected SIT when required	Same as 14a	None; inline check valves prevent reverse flow	
		c) Fails to open on SIAS	Same as 14a	Same as 14a	Same as 14a	Same as 14a	Same as 14a

Table 6.3.2-2 (7 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
15	SIT fill and drain (line) isolation Valve SI-611 SI-621 SI-631 SI-641	a) Fails closed	• Mech. binding • Air line separates from valve operator	Cannot adjust the SIT water level when required	• Valve position indication in control room • Periodic testing; SIT level indicator	None	Plant shutdown can occur if SIT level is outside the Tech. Spec. limits
		b) Fails to close on SIAS	• Electrical malfunction • Seat leakage • Contamination	None	Same as 15a except SIT level indicator	Redundant isolation valves in series (SI-322, 332, 661, 670) prevent being drained	Valve is designed to fail closed and is normally closed
		c) Fails open	Same as 15a	None	Same as 15a	Same as 15a	Valve is designed to fail closed
		d) Initially open, re-opens due to lack of LOP reset fails open	• Electrical malfunction • Seat leakage	Potential for draining one SIT during SIT fill operation	• Valve position indicator in control room • SIT level indicator	Operator can close redundant series isolation valve (SI-661 or SI-670) to prevent affected SIT from being drained	Valve is normally closed except during SIT fill/drain operation
		e) Initially open, re-opens due to lack of LOP reset fails closed	• Electrical malfunction • Air line separates from valve operator	Cannot adjust the water of the affected SIT when required	Same as 15a	None	Plant shutdown can occur if SIT level is outside the Tech. Spec. limits

Table 6.3.2-2 (8 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
16	SIT nitrogen (N_2) supply isolation Valve SI-619, 612 SI-629, 622 SI-639, 632 SI-649, 642	a) Fails closed	• Mech. binding • Air line separates from valve operator	Cannot repressurize the SIT when required	• Valve position indication in control room • Periodic testing		Plant shutdown
		b) Fails open	• Mech. binding • Seat leakage • Electrical malfunction	None	Same as 16a	Series isolation valves (SI-619/629/639/649, SI-612/622/632/642) are closed	Valve is designed to fail closed
		c) Initially open, re-opens due to lack of LOP reset fails open	• Seat leakage • Electrical malfunction	Loss of redundant isolation capability for nitrogen supply line to affected SIT	Same as 16a	Redundant series isol. valve is unaffected	
		d) Initially open, re-opens due to lack of LOP reset fails closed	• Mech. binding • Air line separates from valve operator	Same as 16a	Same as 16a	None	Same as 16a

Table 6.3.2-2 (9 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
17	SIT atmos. Vent isolation Valves SI-613, 605 SI-623, 606 SI-633, 607 SI-643, 608	a) Fails closed	• Mech. binding, • Electrical malfunction	Degradation of redundancy to vent the SIT for refill or relieve pressure	• Valve position indication in control room • Periodic testing • No change in tank pressure when valve is opened	Redundant parallel vent line	
		b) Fails open	• Mech. binding • Electrical malfunction	None	• Valve position indication in control room • Periodic testing • Low SIT pressure	Series isolation valves (SI-112/122/132/142, SI-118/128/138/148) are closed	Power removed from valve during normal operation until tanks are required to be vented
18	SIT sampling isolation valves SI-214 SI-224 SI-234 SI-244	a) Fails closed	Mech. binding	No impact on normal operation, unable to sample SIT contents	Operator	None	
		b) Fails open	• Mech. binding • Seat leakage	Minor loss of tank contents	• Local leak detectors • Radiation monitors	None	Isolation valves shall be located downstream of the valve and locked closed

Table 6.3.2-2 (10 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
19	RDT isolation valve SI-661	a) Fails open	• Electrical malfunction • Seat leakage	Potential for partially draining one SIT during SIT draining operation	• Valve position indication in control room • SIT level indicator	Operator can close redundant isolation valves (SI-611/621/631/641) to prevent affected SIT from being drained	Valve is opened to drain SIT or relieve pressure from check valve leakage to CVCS RDT
		b) Fails closed	Air line separates from valve operator	Cannot drain line to CVCS RDT to determine the rate of back leakage of affected SI DVI line check valve nor drain SIT to RDT when required	Same as 19a	Alternative line to drain line using SI-670	Same as 19a
20	SIT fill line isolation valve SI-682	a) Fails open	• Electrical malfunction • Seat leakage	Potential for draining one SIT during SIT fill/drain operation	• Valve position indication in control room • SIT level indicator	Operator can close redundant series isolation valves to prevent the affected SIT from being drained	Valve is opened to adjust SIT level
		b) Fails closed	• Electrical malfunction • Air line separates from valve operator	Cannot adjust the water level of the affected SIT when required	Same as 20a	None	Plant shutdown can occur if SIT level is outside Tech. Spec. limits

Table 6.3.2-2 (11 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
21	SIT drain line isolation valve SI-670	a) Fails open	• Electrical malfunction • Seat leakage	Potential for draining one SIT during SIT fill/drain operation	Valve position indication in control room SIT level indicator	Operator can close redundant series isolation valves to prevent the affected SIT from being drained	Valve is opened to adjust SIT level
		b) Fails closed	• Electrical malfunction • Air line separates from valve operator	Cannot adjust the water level of the affected SIT when required	Same as 21a	None	Plant shutdown can occur if SIT level is outside Tech. Spec. limits
22	SIT atmos. Vent isolation Valve SI-112, 118 SI-122, 128 SI-132, 138 SI-142, 148	a) Fails closed	• Mech. binding • Corrosion	Degradation of redundancy to vent the SIT for refill or relieve pressure	None	Redundant parallel vent line	Valve is normally locked open
		b) Fails open	• Mech. binding • Corrosion	None	None	Series isolation valves (SI-605/606/607 /608, SI-613/ 623/633/643)	

Table 6.3.2-2 (12 of 14)

Part B. Injection Mode (Long-Term Injection)

At 1 hour after the LOCA, the operator initiates cooldown with the steam generators (SGs). Steam is relieved through the turbine bypass system if ac power is available or through the atmospheric dump system if power is unavailable. If shutdown cooling entry condition can be achieved within 3 hours, the SCS is placed in operation. If it appears that SCS cannot be achieved within 3 hours, then at 2-3 hours after the LOCA, the SI pump discharge lines are realigned so that the total injection flow is divided equally between the DVI lines and hot legs. This is the same line-up as the short-term injection mode above, with the following changes and additions.

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
1	SI (line) hot leg (injection) isolation valve SI-604 SI-609	a) Fails open	• Mech. binding • Electrical malfunction • Corrosion	None	• Periodic testing • Valve position indication in control room	Si hot leg injection line isolation valves (SI-321/331) are closed	Valve is normally locked closed during short-term injection mode of operation
		b) Fails closed	Same as 1a	Loss of one hot leg injection flow path	Same as 1a	Redundant SI train	
2	SI line (DVI injection isolation Valve SI-636 SI-616	a) Fails closed	• Mech. binding • Electrical malfunction • Corrosion	None	• Valve position indication in control room • Periodic testing	Parallel redundant DVI injection lines	
		b) Fails open	Same as 2a	Injection flow is not divided equally between the DVI lines and hot legs	Same as 2a	None	

Table 6.3.2-2 (13 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
3	SI Hot leg injection line isolation Valve SI-321 SI-331	a) Fails closed	• Mech. Binding • Electrical malfunction	Loss of one hot leg injection flow path	• Valve position indication in control room • Periodic testing	Redundant SI train	
		b) Fails open	• Same as 3a • Seat leakage	None	Same as 3a	None	Valve is normally locked close in control room
4	SCS suction line isolation Valve SI-651 SI-652	a) Fails open	• Mech. binding • Electrical malfunction • Seat leakage	None	• Periodic testing • Valve position indication in control room	Redundant series isolation valves (SI-653/654) are closed	Valve is normally locked closed in control room
		b) Fails closed	• Mech. binding • Electrical malfunction	None	Same as 4a	None required	

Table 6.3.2-2 (14 of 14)

No.	Name	Failure Mode	Cause	Symptoms and Local Effects including Dependent Failures	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
5	Hot leg check valve leakage line isolation. valve SI-322 SI-332	a) Fails to close on SIAS	• Electrical. malfunction. • Seat leakage • Contamination	None	• Valve position indication in control room • Periodic testing	SIT drain line isolation valves, SI-670 prevent hot leg injection from being drained	Valve is designed to fail closed
		b) Fails closed	• Mech. binding • Air line separates from • Valve operator	Cannot perform test on the hot leg injection line check valve	Same as 5a		
		c) Fails open	• Seat leakage • Contamination	None	Same as 5a	Same as 5a	Valve is normally closed and fails closed
		d) Initially open, re-opens due to lack of LOP reset, fails open	• Electrical. malfunction • Seat leakage	None	Same as 5a	SIT drain line isolation valves, SI-670 prevent hot leg injection from being drained	Valve is opened to drain hot leg leakage
		e) Initially open, re-opens due to lack of LOP reset, fails closed	• Mech. binding • Air line separates from valve operator	Same as 5b	Same as 5a	None	Same as 5d

Table 6.3.2-3

Safety Injection System Head Loss Requirements

	Flow/Pump,(1) L/min (gpm)	Required System Resistance, m (ft)
Safety injection pumps	4,278 (1,130)	583.7 (1,915) (2)

(1) Value does not include bypass flow rate.

(2) Friction and elevation losses between the water level in the IRWST at the start of long-term and the outlet of the reactor vessel nozzle.

Table 6.3.2-4

Safety Injection System Flow Delivery to RCS (1)

Maximum Pump Flow to DVI Nozzle per SI Pump			
RCS Pressure		Flow	
kg/cm^{2}G	psig	L/min	gpm
0	0	4,278	1,130
4	50	4,209	1,112
7	100	4,145	1,095
11	150	4,081	1,078
14	200	4,013	1,060
18	250	3,944	1,042
21	300	3,876	1,024
25	350	3,804	1,005
28	400	3,736	987
32	450	3,664	968
35	500	3,592	949
42	600	3,441	909
49	700	3,290	869
56	800	3,131	827
63	900	2,968	784
70	1,000	2,797	739
77	1,100	2,620	692
84	1,200	2,434	643
91	1,300	2,237	591
98	1,400	2,029	536
105	1,500	1,809	478
112	1,600	1,567	414
120	1,700	1,306	345
127	1,800	1,007	266
134	1,900	655	173
141	2,000	182	48
143	2,027	0	0

Minimum Pump Flow to DVI Nozzle per SI Pump			
RCS Pressure		Flow	
kg/cm^{2}G	psig	L/min	gpm
0	0	3,835	1,013
4	50	3,774	997
7	100	3,713	981
11	150	3,653	965
14	200	3,592	949
18	250	3,528	932
21	300	3,464	915
25	350	3,399	898
28	400	3,331	880
32	450	3,263	862
35	500	3,195	844
42	600	3,047	805
49	700	2,896	765
56	800	2,733	722
63	900	2,559	676
70	1,000	2,370	626
77	1,100	2,165	572
84	1,200	1,938	512
91	1,300	1,673	442
98	1,400	1,359	359
105	1,500	939	248
112	1,595	0	0

(1) Assume no failure in the respective safety injection line.

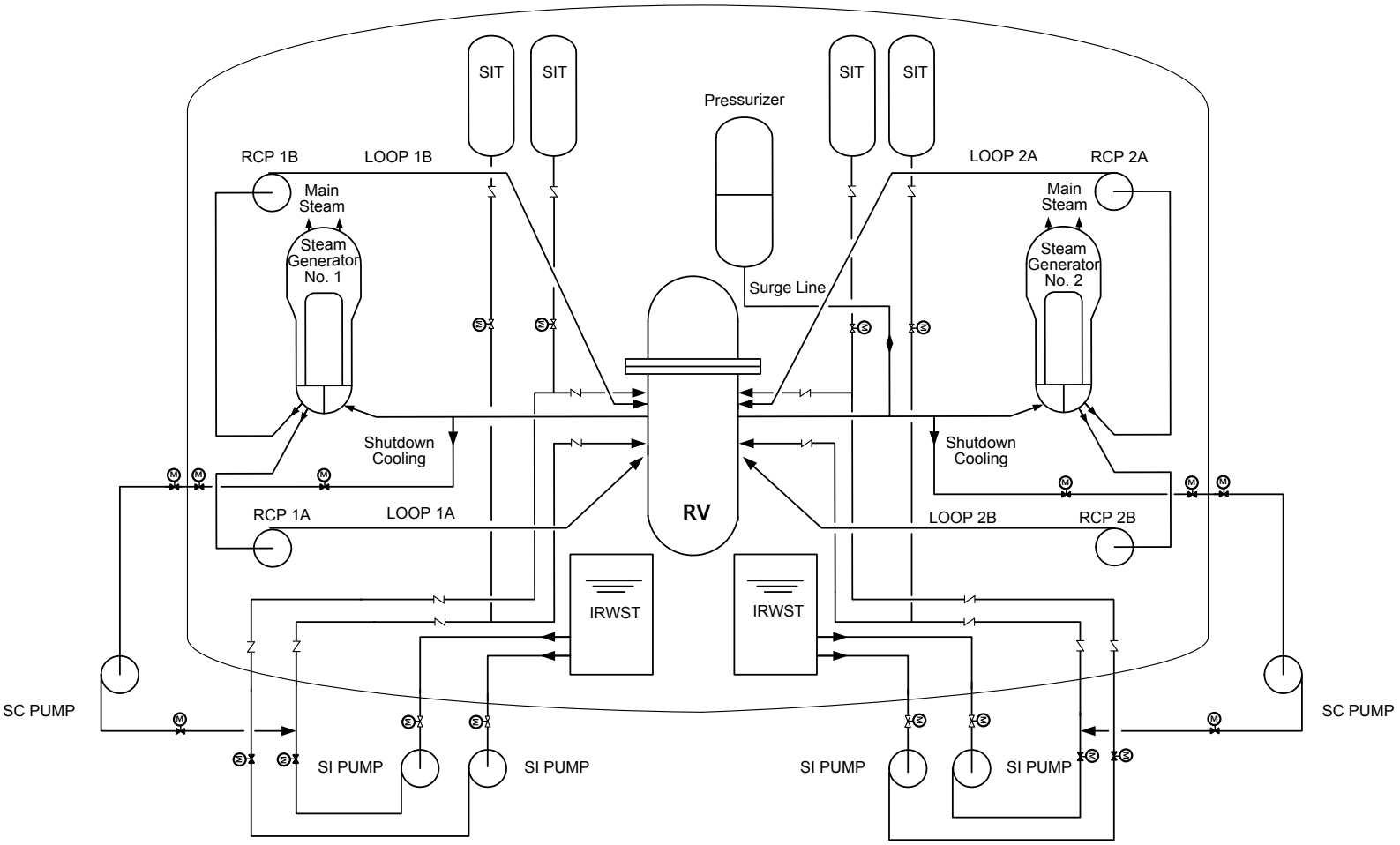


Figure 6.3.1-1 Safety Injection System Schematic Flow Diagram

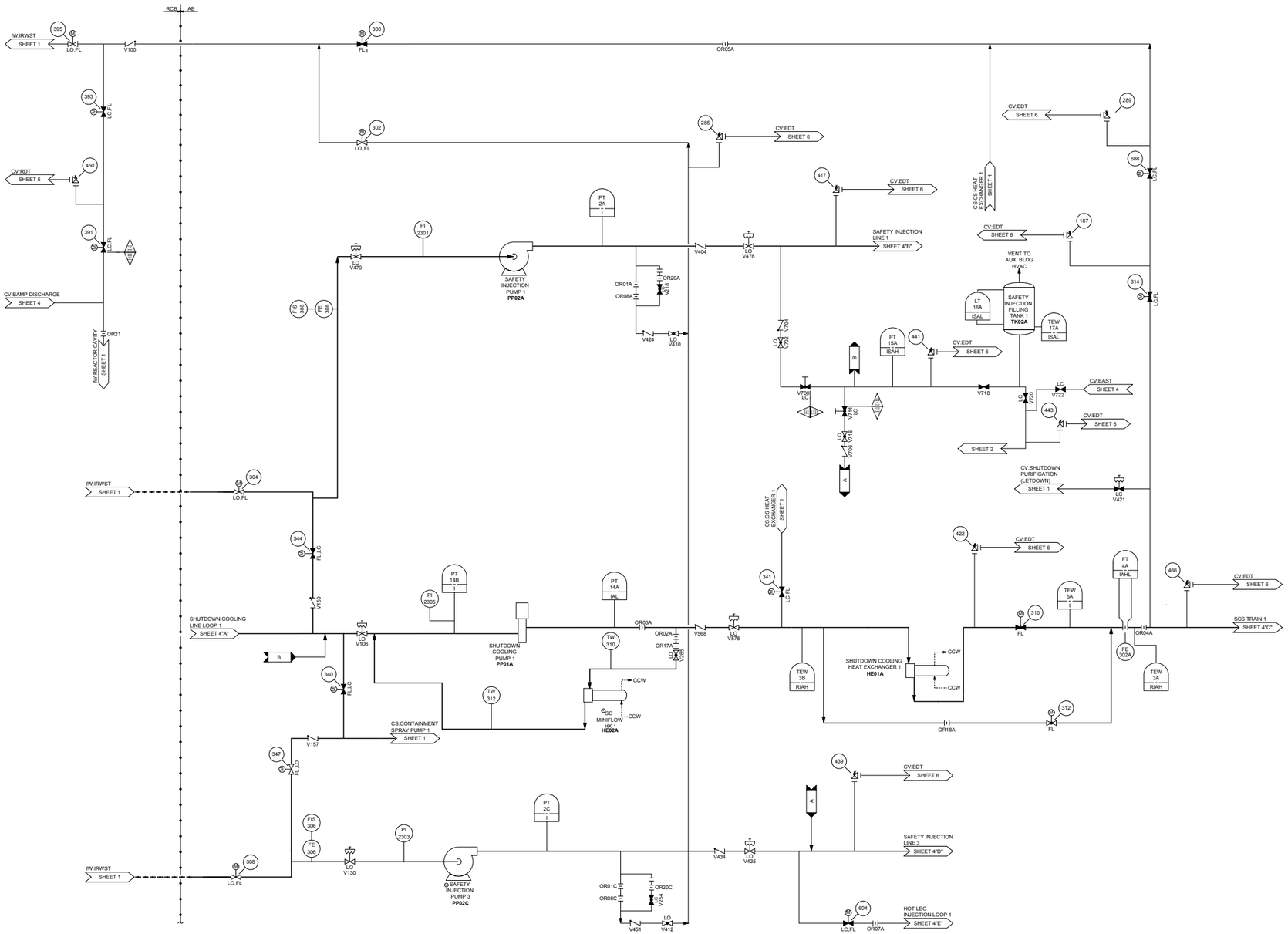


Figure 6.3.2-1 Safety Injection / Shutdown Cooling System Flow Diagram (1 of 4)

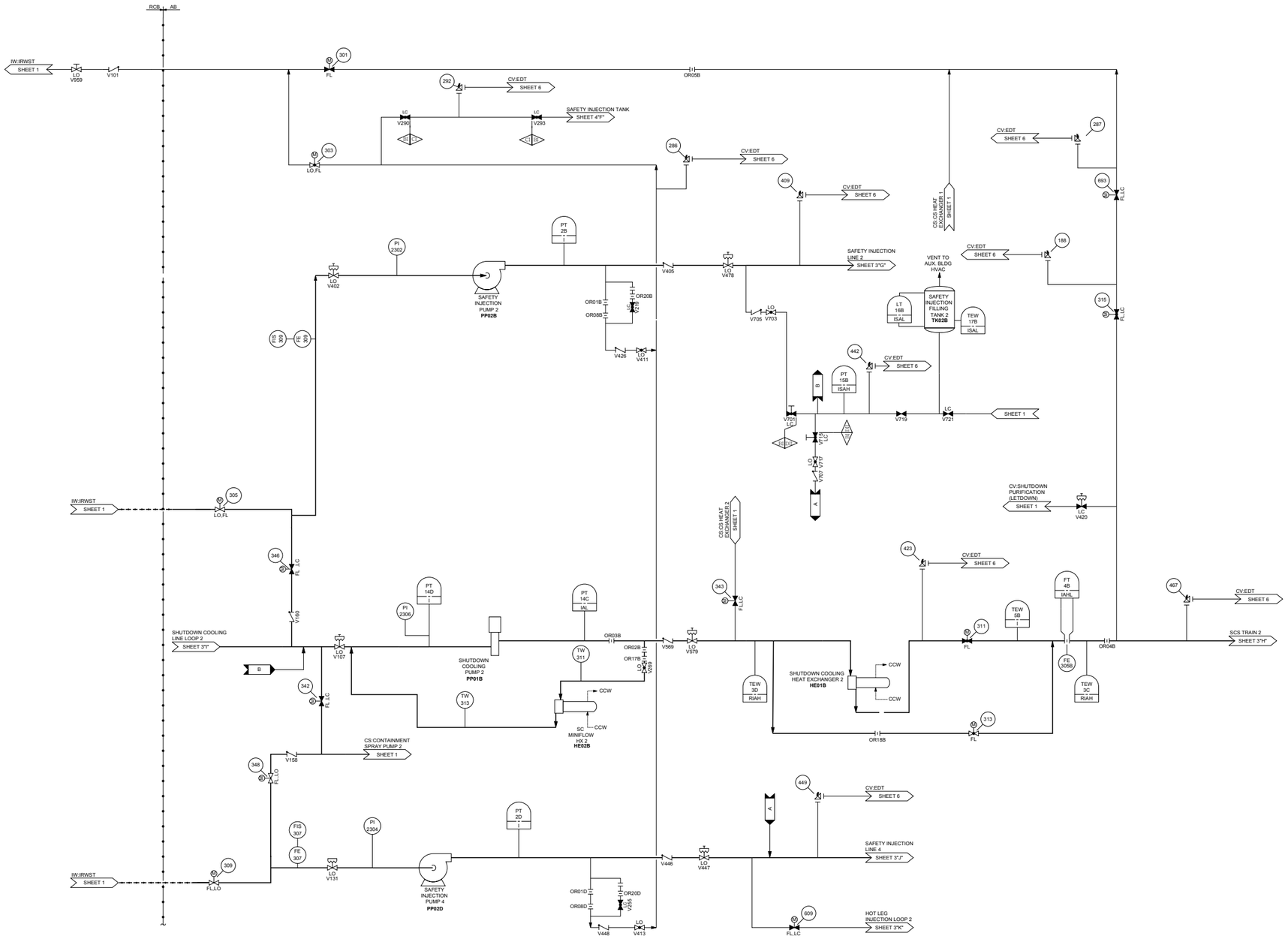


Figure 6.3.2-1 Safety Injection / Shutdown Cooling System Flow Diagram (2 of 4)

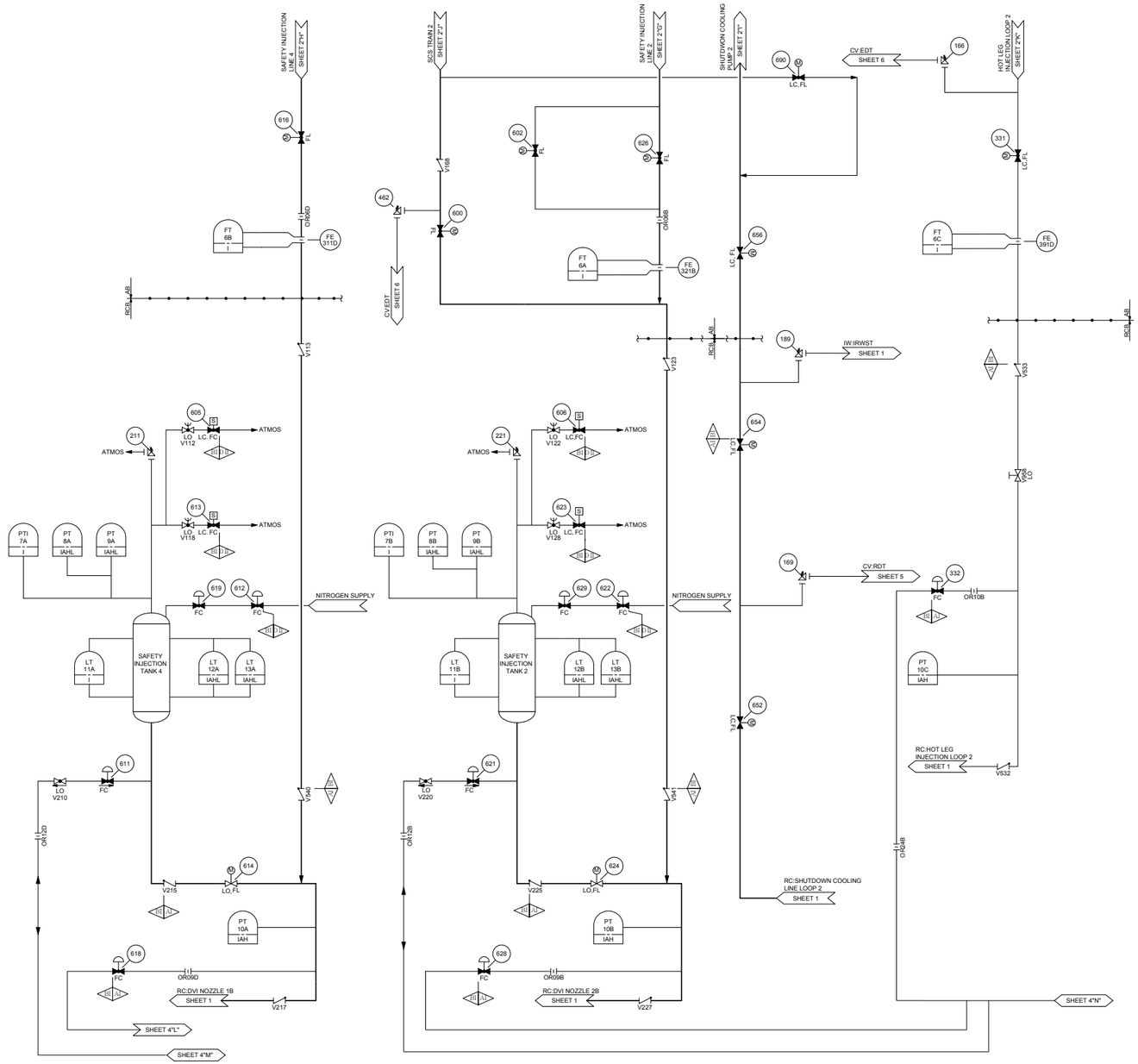


Figure 6.3.2-1 Safety Injection / Shutdown Cooling System Flow Diagram (3 of 4)

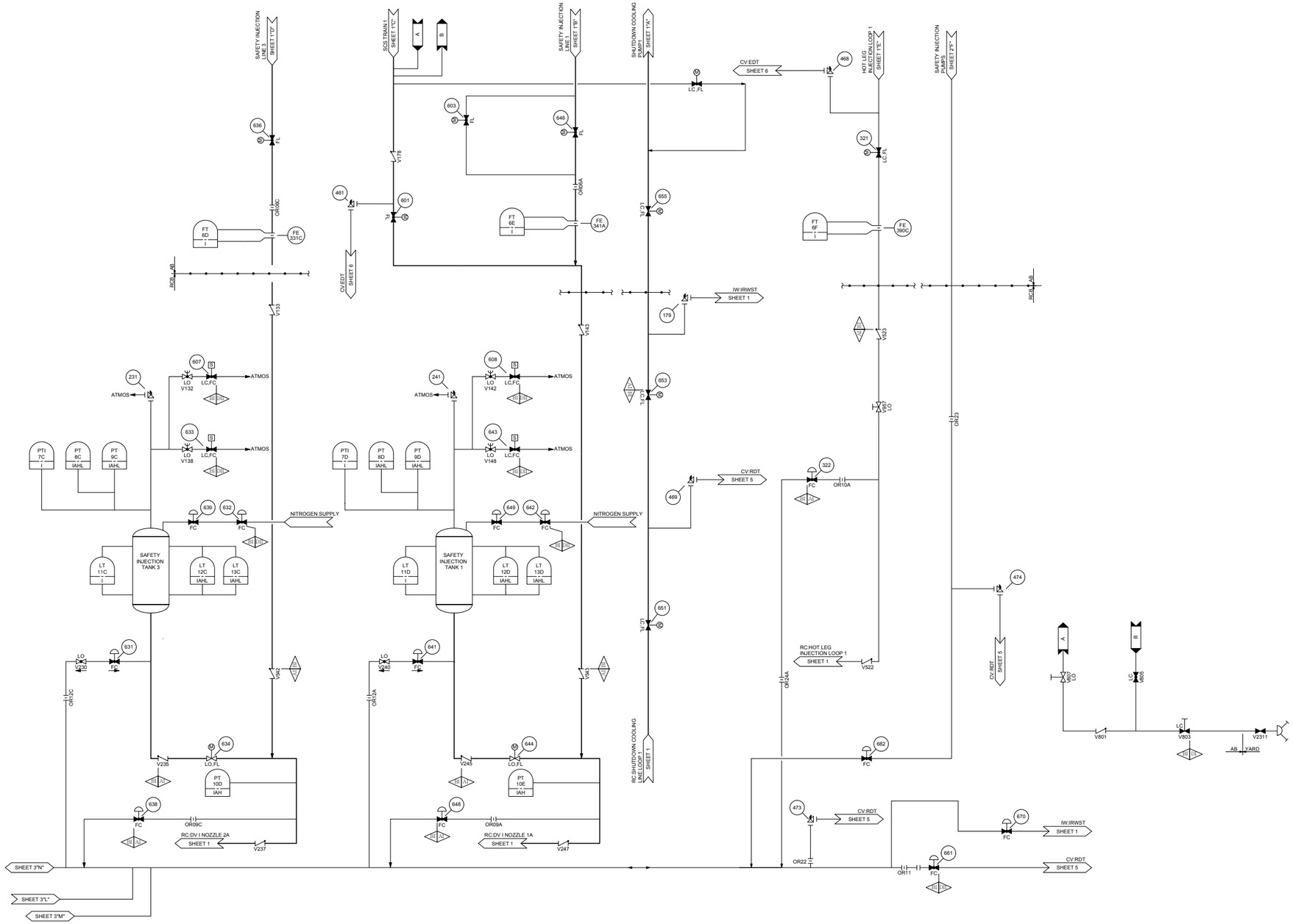


Figure 6.3.2-1 Safety Injection / Shutdown Cooling System Flow Diagram (4 of 4)

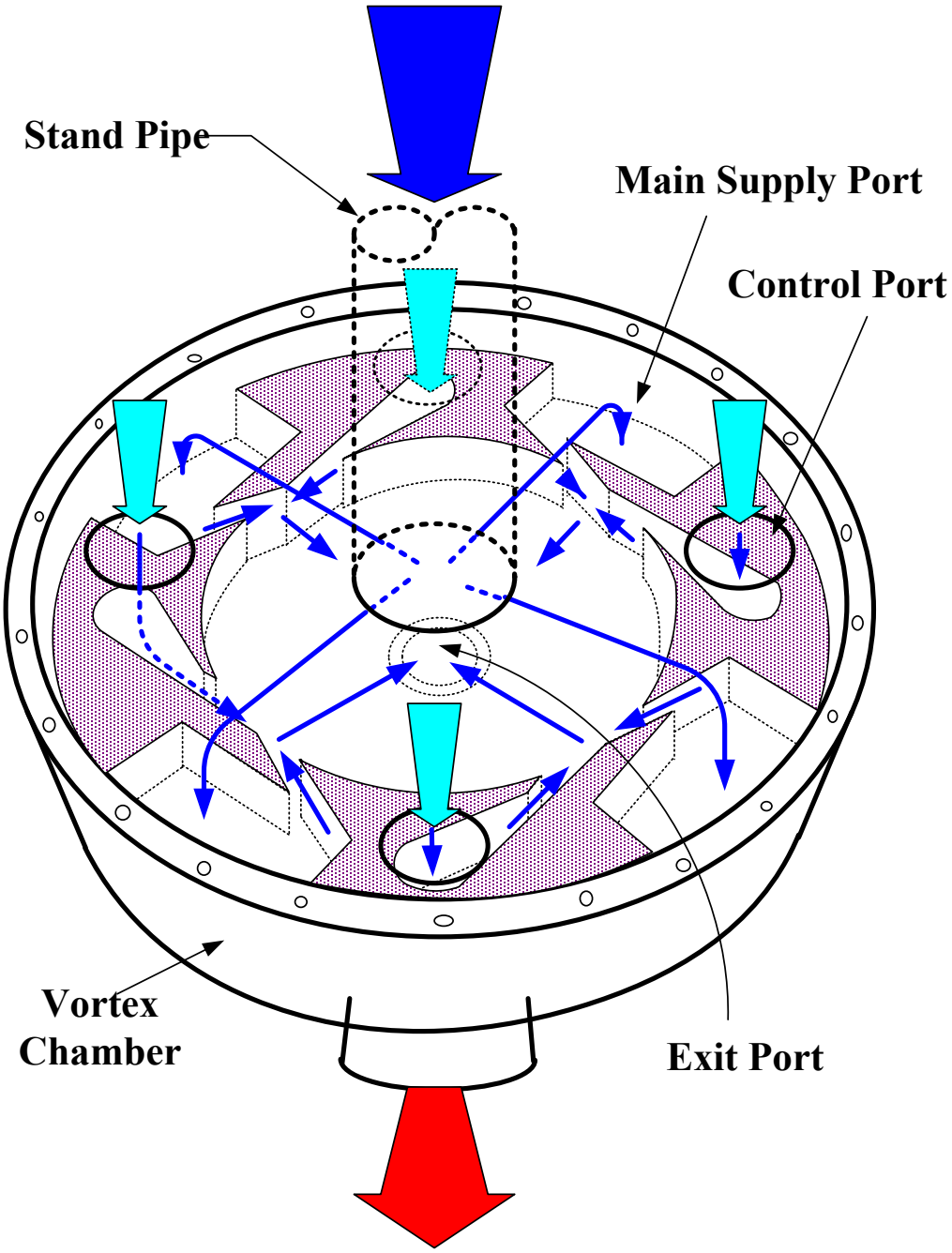


Figure 6.3.2-2 Schematic Diagram of Fluidic Device

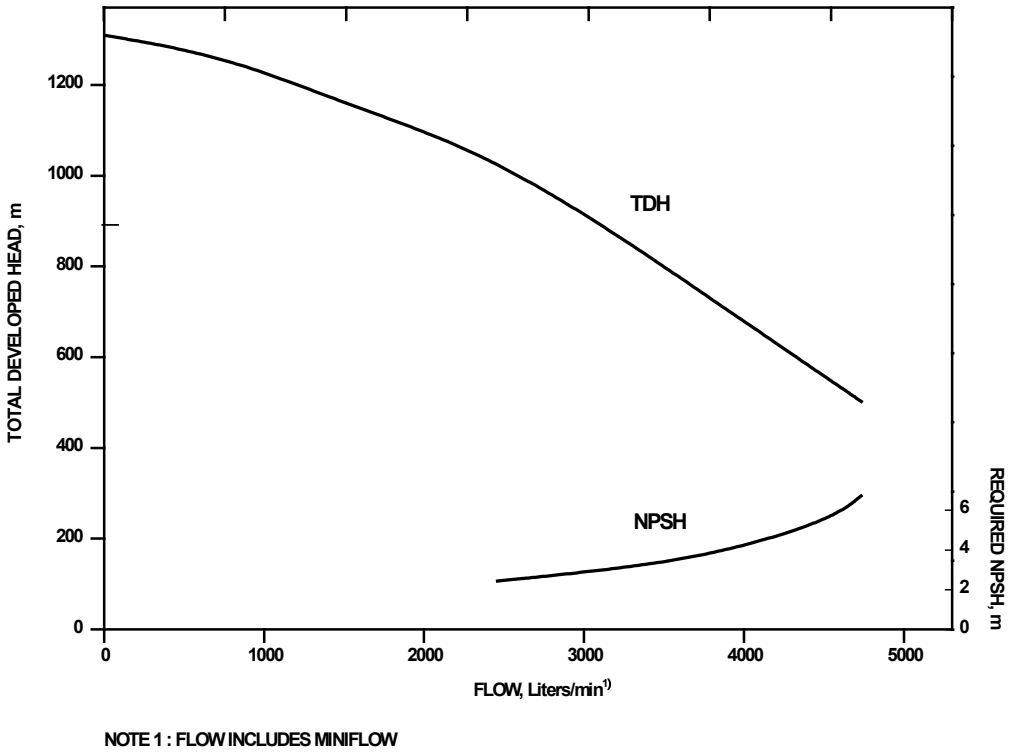


Figure 6.3.2-3 Safety Injection Pump Head and NPSH Curves (Typical)

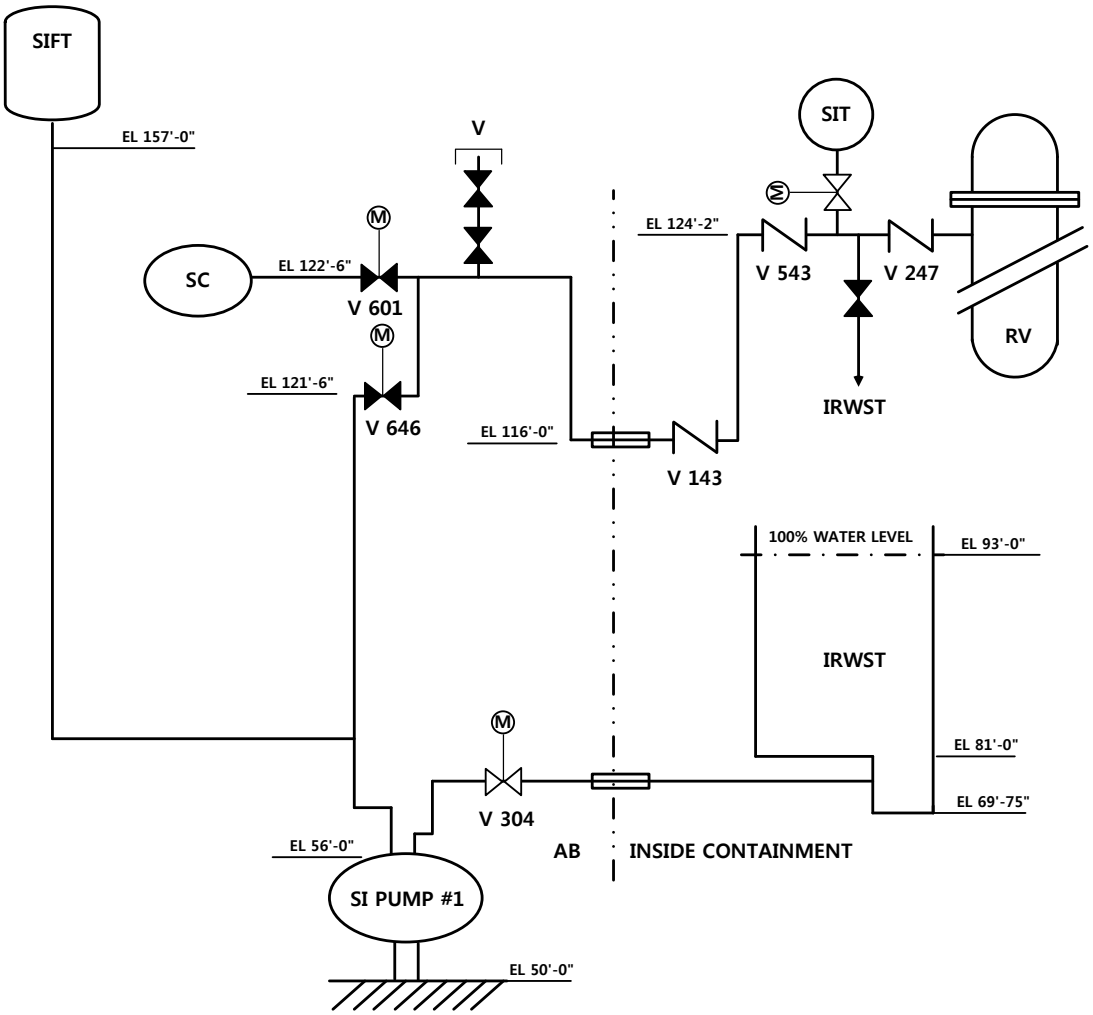


Figure 6.3.2-4 SIS Elevation Diagram

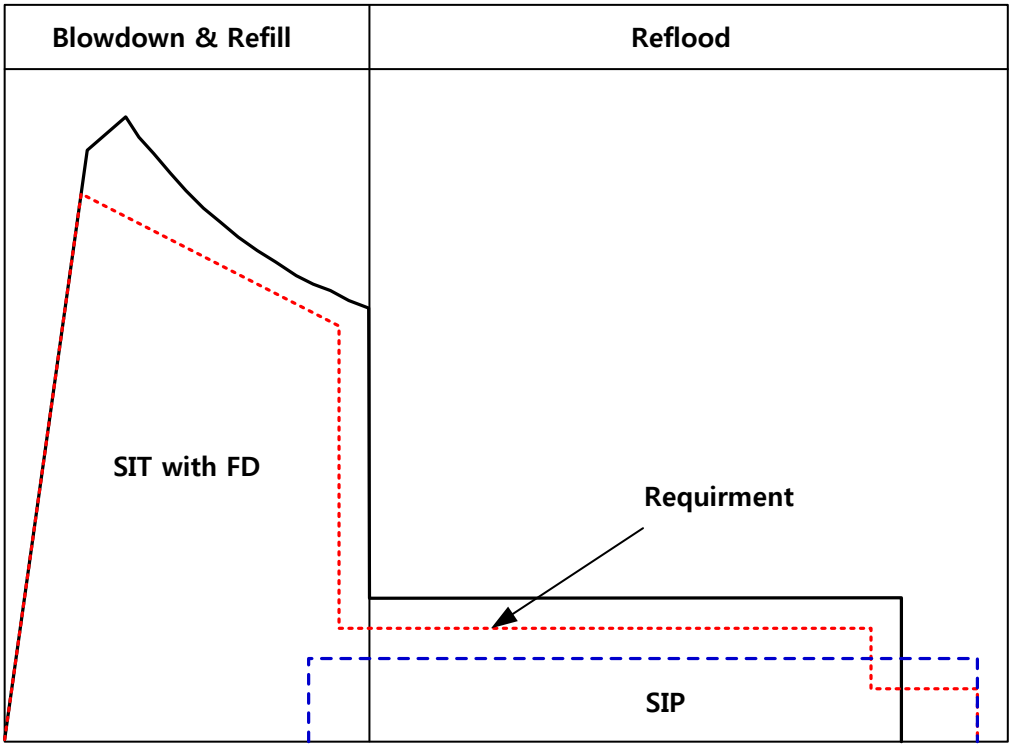


Figure 6.3.2-5 SIT-FD Flow Schematic Characteristics

6.4 Habitability Systems

Habitability systems are designed to allow control room operators to remain in the control room envelope (CRE) and take actions to operate the plant safely under normal conditions, and maintain it in a safe condition under abnormal conditions, including a loss-of coolant accident (LOCA), as required by General Design Criterion (GDC) 19 (Reference 1).

The personnel support items and equipment for habitability systems are addressed in Subsections 6.4.1 and 6.4.2.2. The emergency planning is described in Section 13.3.

The habitability systems include the heating, ventilation, and air conditioning (HVAC) system for the CRE, which includes the main control room (MCR) and the safety-related systems are design to:

a. Maintain conditions that are comfortable for plant personnel and provide reasonable assurance that the MCR equipment continues to function properly

b. Protect plant personnel in the CRE from the potential exposure to airborne radioactivity in the outside atmosphere

c. Protect plant personnel from exposure to potentially toxic chemicals that are postulated to be released near the plant site

d. Protect plant personnel from the effects of high-energy line breaks in the surrounding plant areas

e. Protect plant personnel in the CRE from smoke from an onsite fire

The CRE is described in Subsection 6.4.2.1, as defined in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.196 (Reference 2) and NRC RG 1.197 (References 3). The CRE is serviced by the control room HVAC system, which maintains CRE habitability for normal and abnormal conditions.

Information on the MCR and associated habitability systems are referred to Subsections 6.5.1, 9.4.1, and 15.6.5.5.

In addition, habitability systems for the CRE include radiation shielding (Section 12.3), the radiation monitoring system (Section 11.5), the emergency lighting system (Subsection 9.5.3), and fire protection system (Subsection 9.5.1).

6.4.1 Design Bases

The design bases are as follows:

a. The CRE is designed in accordance with the requirements of the Standard Review Plan Section 6.4 (Reference 4), and NRC RGs 1.78 (Reference 5), 1.196, and 1.197.

b. The CRE volume except for HVAC equipment rooms is approximately 5,663 m^3 (2000,000 ft^3). The air inside the CRE can support five persons for at least six days. Thus, CO_2 buildup in an isolated CRE is not considered a limiting problem.

c. The habitability systems are designed to support a minimum of five people in the CRE during all normal conditions and at least 30 days of accident-operating conditions.

d. A minimum of eight hours of emergency food supplies are provided for the MCR staff with additional onsite food supplies if needed in the CRE. Unlimited water supply and onsite first aid are available.

e. Sanitary facilities are provided for the MCR operating personnel in the CRE.

f. The radiation exposure of MCR staff in accident conditions as described in Chapter 15 does not exceed the occupational dose limit in GDC 19 (Reference 1).

g. Adequate self-contained breathing apparatus are available inside the CRE. Face mask respirators and 6-hour bottled air supplies are provided for emergency staff.

h. The control room HVAC system is provided with two 100 percent capacity emergency makeup air cleaning units (ACUs) to allow access to and occupancy of the control room under accident conditions.

i. The control room HVAC system is capable of maintaining the CRE at a positive pressure with respect to the surrounding areas to provide habitability and to prevent uncontrolled incoming air leakage during normal and emergency modes of operation.

j. The control room HVAC system is capable of isolating the outside air intake, upon detection of high radiation by the MCR supply air intake radiation monitors.

k. The control room HVAC system is classified and designed to the requirements of safety Class 3 and seismic Category I, as described in Section 3.2.

6.4.2 System Design

6.4.2.1 Definition of Control Room Envelope

The CRE is located at elevation 47.55 m (156 ft) and 53.00 m (174 ft) in auxiliary building. The CRE in an emergency can be isolated from other plant areas and the environment external to the CRE.

The CRE consists of the following areas as shown on Figure 6.4-1:

a. MCR

b. Atomic energy bureau (AEB) room, meeting room, service room

c. Instrument maintenance shop, corridors, HVAC areas, and HVAC equipment rooms

d. Technical support center (TSC) and TSC record storage room

e. Computer room, computer room office, and computer room package air conditioning unit (PACU) room

f. Kitchen and dining room, locker room, shower room, and toilets

The CRE layout, doors, corridors, shield walls, and the arrangement of equipment are shown in Figure 6.4-1.

6.4.2.2 Ventilation System Design

The control room HVAC system consists of two redundant divisions. Each division has an outside air intake equipped with redundant radiation monitors and a smoke detector, dampers, an ACU, two air handling units (AHUs), ductwork, and instrumentation and controls. The control room HVAC system is provided with a kitchen and toilet exhaust fan and a control room smoke removal fan.

During normal operation, return air from the CRE is mixed with makeup air from the missile protected outside air intakes, and the air is filtered and conditioned in the AHU and delivered to the CRE to maintain a minimum 3.175 mm (0.125 in) of water gauge of positive pressure with respect to the surrounding areas. The toilets, the kitchen and dining room, the locker room and shower room are exhausted to the atmosphere by a kitchen and toilet exhaust fan. Two isolation dampers in the exhaust duct of the kitchen and toilet exhaust fan are opened. Humidification equipment provides final adjustments to the CRE humidity for maintaining normal comfort conditions.

Figure 6.4-2 shows the airflow path in the normal mode.

The CRE maintains the habitability in the normal mode as follows:

a. The outside air intake isolation dampers open.

b. One of the four supply AHUs operates, and its associated AHU inlet isolation dampers are opened.

c. The other AHUs are kept in standby and their associated AHU inlet isolation dampers are closed.

d. The kitchen and toilet exhaust fan operates continuously, and the associated isolation dampers are opened.

e. The two isolation dampers for the smoke removal fan remain closed.

On receipt of engineered safety feature actuation system – safety injection actuation signal (ESFAS-SIAS) or engineered safety feature actuation system-control room emergency ventilation actuation signal (ESFAS-CREVAS), the normal makeup air path for the AHU inlet is isolated, and the emergency makeup ACU starts automatically to filter the outside makeup air and part of the recirculated air from the CRE. Upon failure of the designated ACU, the standby AHU and ACU of redundant division automatically start. The ACU filters the particulates and potential radioactive iodine from the outside makeup air and a portion of the return air from the CRE and delivers the filtered air to the inlet of the AHU along with the balance of the return air from the CRE.

Two isolation dampers in the exhaust duct of the kitchen and toilet exhaust fan are closed automatically, and the kitchen and toilet exhaust fan stops. Two isolation dampers in the exhaust duct of the smoke removal fan remain closed or are automatically closed to maintain CRE boundary integrity.

Figure 6.4-3 shows the air flow path in the emergency mode.

The CRE maintains the habitability in the emergency mode as follows:

a. The outside air intake having the lower radioactive contamination level is automatically selected, and the associated outside air intake isolation dampers are opened.

b. The operating supply AHU continues to run, and all AHU inlet isolation dampers are automatically closed on receipt of ESFAS-SIAS or ESFAS-CREVAS.

c. The designated emergency makeup ACU automatically starts on receipt of ESFAS-SIAS or ESFAS-CREVAS, and the associated ACU inlet isolation dampers are automatically opened. The ACU fans are interlocked with the associated ACU inlet isolation dampers.

d. The two isolation dampers for the kitchen and toilet exhaust fan are automatically closed on receipt of ESFAS-SIAS or ESFAS-CREVAS, and the exhaust fan stops.

e. The two isolation dampers for the smoke removal fan remain closed, or are automatically closed on receipt of ESFAS-SIAS or ESFAS-CREVAS.

Smoke detectors are provided in the outside air intakes and the supply and return air ducts for the control room HVAC system. Upon detection of smoke in the outside air intake, the smoke damper in the outside air intake duct is closed automatically. Smoke detection is annunciated in the MCR and remote shutdown room (RSR). In case that smoke is detected at both of outside air intakes, the smoke dampers in the outside air intakes are closed automatically, and the operator manually places the system into recirculation mode without outside makeup air.

Figure 6.4-4 shows the air flow path in the recirculation mode.

The recirculation mode is as follows:

a. All outside air intake isolation dampers are closed.

b. The operating supply AHU continues to run.

c. The two isolation dampers for the kitchen and toilet exhaust fan are closed and the exhaust fan stops.

d. The two isolation dampers for the smoke removal fan remain closed.

In case of a fire within the MCR, the supply and return ducts are isolated by fusible link fire dampers, and the monitoring and control of the plant is performed in the RSR. The RSR is located in a different fire area and is at a different elevation from the MCR. The RSR is not contained within the CRE. The RSR is described in Subsection 7.4.1.

Following the suppression of a fire, smoke in the CRE is removed by the manual start of the smoke removal fan.

Major component descriptions are as follows:

Control Room Supply AHU

The AHUs consist of a prefilter, a chilled water cooling coil, an electric heating coil, and a fan. Chilled water is supplied from the essential chilled water system (ECWS). The AHUs are each powered from a separate Class 1E power source.

The AHUs are safety Class 3 and seismic Category I components. The drain lines of the AHUs are designed as non-safety-related and seismic Category II to prevent an adverse interaction with the safety-related AHUs, and the drain lines have a water-filled loop seal to preclude infiltration of unfiltered contaminated air into the CRE.

The AHUs are located on the elevation 174 ft in the auxiliary building as shown on Figure 6.4-1. The major design parameters of the AHUs are described in Tables 9.4.1-1 and 9.4.1-3.

Emergency Makeup ACU

The ACUs are designed to meet the requirement of ASME AG-1-2009, ASME N509-2002 (Reference 7), and NRC RG 1.52 (Reference 8). The ACUs are safety Class 3 and seismic Category I components.

The ACUs consist of a prefilter, two electric heating coils, a HEPA filter, a carbon adsorber, a post-filter, and two fans, along with ducts, dampers, and related instrumentation. The heating coils and fans of ACU are fed from each separated Class 1E power.

The ACUs are located on the elevation 174 ft in the auxiliary building as shown on Figure 6.4-1. The major design parameters of the ACUs are described in Subsection 6.5.1, Tables 9.4.1-1 and 9.4.1-3.

Isolation Dampers

The design and construction of isolation dampers are in accordance with ASME N509-2002 and ASME AG-1-2009. The isolation dampers are pneumatic or electro-hydraulic-actuated type. All isolation dampers used to isolate the CRE from the outside are leaktight and the leakage class of these dampers is zero leakage in accordance with Appendix DA-I

of ASME AG-1. The isolation damper components are safety Class 3 and seismic Category I.

a. Outside air intake isolation dampers

Two electro-hydraulic actuated spring return (ESR) type leaktight isolation dampers are installed in series in each outside air intake. These dampers are used to isolate the outside intake air to prevent infiltration of higher radioactive contamination level air to the CRE from the outside in the emergency mode.

b. AHU inlet isolation dampers

Two pneumatic actuated spring return (PSR) type leaktight isolation dampers are installed in series for each of four AHUs in the outside air normal makeup duct. Four sets of these dampers are arranged in parallel for the AHU inlets and each set is powered from a separate Class 1E power source. These dampers are used to isolate the normal makeup air path from the outside contaminated air in the emergency mode. By the time a postulated radiation activity reaches these dampers, these dampers would have already been closed and switched to the emergency mode. The location and closure time of these dampers are designed so that they are closed before the airborne radioactive material reaches the first of the two isolation dampers. The closure time of these dampers is less than or equal to 8.4 seconds after receiving an actuation signal.

c. ACU inlet isolation dampers

Two ESR-type leaktight isolation dampers are installed in parallel for each of two ACUs in the outside air emergency makeup duct. Each damper is powered from a separate Class 1E power source. Each damper is interlocked with associated emergency makeup ACU fan. The dampers direct the outside makeup airflow to the ACU in the emergency mode.

d. ACU return air isolation dampers

Two ESR-type isolation dampers are installed in parallel for each of two ACUs in the ACU return air duct, and each damper is powered from a separate Class 1E power source. Each damper is interlocked with associated emergency makeup ACU fan. These dampers direct the return airflow to the ACU in the emergency mode.

e. Kitchen and toilet exhaust isolation dampers

Two PSR-type leaktight isolation dampers are installed in series in the exhaust duct of kitchen and toilet exhaust fan. The closure time of these dampers is less than or equal to 8.4 seconds after receiving an actuation signal. The dampers are used to isolate the CRE from the outside contaminated air in the emergency mode.

f. Smoke removal isolation dampers

Two PSR-type leaktight isolation dampers are installed in series in the exhaust duct of the smoke removal fan. The dampers are normally closed to isolate the CRE from the outside except for smoke removal within the CRE.

6.4.2.3 Leaktightness

The CRE boundary is designed to minimize the unfiltered in-leakage. Air sealing components have adequate leaktightness to provide operator habitability within the CRE boundary under normal and abnormal plant conditions.

The provisions to maintain the CRE boundary integrity by providing leaktightness of components penetrating the CRE are as follows:

a. The piping, conduits, and cable trays that penetrate the CRE boundary are sealed with materials that are compatible with materials of the piping, conduits, and cable trays. The sealing materials are designed to withstand the air pressure across the CRE boundary and are fire resistant and can be used in fire-rated barriers. The penetrations are tested for air leakage periodically.

b. Doors that provide access the CRE area are sealed to keep the CRE area air tight to maintain pressurization of the CRE area. Two double doors are arranged in series to form an air lock vestibule to minimize unfiltered in-leakage from surrounding areas while operational personnel are opening the door.

c. All building joints located in the CRE boundary are sealed.

The system maintains a positive pressure of 3.175 mm (0.125 in) water gauge as a minimum within the CRE boundary, which limits unfiltered in-leakage through walls, ceiling, doors, pipes, ducts, and cable penetrations.

The total system in-leakage in the emergency mode is equal to or less than 510 cmh (300 cfm), including 17 cmh (10 cfm) for egress and ingress. The total system out-leakage in the emergency mode is equal to or less than 3,060 cmh (1,800 cfm). The makeup airflow rate during the normal and emergency modes is 6,286 cmh (3,700 cfm). Exfiltration, required to maintain the positive pressure across the CRE boundary, is to be less than the amount of makeup air and occur at the potential leak paths described above.

The leakage tests are performed in accordance with ASTM E741-00 (Reference 9) to calculate the exfiltration and infiltration rates and confirm the CRE flow balance to maintain the design positive pressure in the CRE with respect to the surrounding areas. The ASTM E741-00 tests verify the in-leakage value into the CRE (~493 cmh [~290 cfm]) with makeup flow rate by an emergency makeup ACU (~6,290 cmh [~3,700 cfm]) in the emergency mode.

6.4.2.4 Interaction with Other Zones and Pressure-Containing Equipment

The control room HVAC system is an independent HVAC system, and there is no interaction between the control room HVAC system and other zones and pressure-containing equipment. The control room HVAC system maintains positive pressure in the CRE to direct the air flow from the CRE to adjacent areas. The auxiliary building clean area HVAC system services the access corridors to the CRE. The control room HVAC system and the auxiliary building clean area HVAC system are designed to balance the CRE air flow to preclude air flow into the CRE from adjacent areas.

Two isolation dampers for the kitchen and toilet exhaust fan and two isolation dampers for the smoke removal fan are provided to isolate the CRE from the outside CRE in emergency and recirculation modes. In addition, there are no pressure-containing tanks, equipment, or piping through which hazardous or radioactive material could be transferred into the CRE.

Potential leak paths are addressed in Subsection 6.4.2.3.

The access doors to the CRE are administratively controlled to prevent them from being opened in the emergency mode.

6.4.2.5 Shielding Design

The radiological consequence analysis for a LOCA is performed to determine the post-LOCA doses at the exclusion area boundary (EAB), low population zone (LPZ), MCR, and technical support center (TSC) in Subsection 15.6.5.5. In this analysis, the following radiation sources, which may result in exposure to control room personnel, are considered based on the NRC RG 1.183 (Reference 10, Section 4.2.1):

a. Radioactive material in the MCR that enters through filtered and unfiltered inflow from outside of MCR (I)

b. External radioactive plume released from the facility (II)

c. Radioactive material in the reactor containment (III)

d. Radioactive material in systems and components inside or external to the control room envelope (e.g., radioactive material buildup in CR intake, recirculation filters) (IV)

Details of the radioactive sources (e.g., origin, strength, geometry, radiation type, energy) and the parameters used for shielding calculations (e.g., shield thickness, separation distances, decay considerations, dose conversion factors) are described in Table 6.4-1 and Figure 6.4-6. The radioactivity transport model for LOCA is shown in Figure 15A-7. The general shielding design criteria are described in Subsection 12.3.2.

6.4.3 System Operational Procedures

In the normal mode, the control room HVAC system maintains the proper environment in the MCR and other areas in the CRE. The normal mode is described in Subsections 6.4.2 and 9.4.1.

Upon receipt of ESFAS-CREVAS or ESFAS-SIAS, the system is automatically switched to the emergency mode by directing makeup air flow and recirculation flow to the designated emergency makeup ACU. The emergency mode is described in Subsections 6.4.2 and 9.4.1.

On detection of smoke in the outside air intake, the smoke damper in the outside air intake duct is automatically closed to prevent the spread of smoke throughout the CRE. In case that smoke is detected at both of outside air intakes, the smoke dampers are automatically closed in the outside air intakes and the system is manually switched to the recirculation mode by the operator. The recirculation mode is described in Subsection 6.4.2 and 9.4.1. On detection of smoke at the supply and return air ducts to the MCR, the associated smoke damper in the ducts automatically closes to maintain MCR habitability.

The COL applicant is to provide the automatic and manual operating procedures for the control room HVAC system, which are required in the event of postulated toxic gas release (COL 6.4(1)).

6.4.4 Design Evaluations

Evaluations are conducted of the systems required to be operational to provide reasonable assurance of the MCR habitability following a postulated DBA. The parameters associated with the MCR habitability evaluations are provided in the Chapter 15. The MCR shielding design, based on the most limiting design-basis LOCA fission product release, is addressed in Chapter 12.

6.4.4.1 Radiological Protection

In accordance with GDC 19, the dose to an individual in the MCR is not exceeded for any postulated DBA described in Chapter 15. As shown in Table 6.4-2, radiation exposures to

MCR personnel resulting from DBAs do not exceed the occupational dose limit of 50 mSv TEDE specified in GDC 19.

6.4.4.2 Toxic Gas Protection

The habitability system for the CRE protects operators against accidents involving toxic gas release. The sources of onsite chemicals are listed in Table 6.4-3 and their locations are shown in Figure 6.4-5. An analysis of the severity of postulated accidents involving toxic gas release is performed in accordance with NRC RG 1.78 and the methodology in NUREG-0570 (Reference 11). The results of the analysis of toxic hazards in postulated accidents involving toxic gas release show that the toxic gases do not affect MCR habitability. The habitability in the MCR from mobile and offsite toxic gas releases is discussed in Section 2.2.

Adequate self-contained breathing apparatus are available inside the CRE to prepare for emergency situations due to toxic gases. Face mask respirators and 6-hour bottled air supplies are provided for the emergency operators. The MCR emergency habitability system components are discussed in Subsection 6.4.1.

The COL applicant is to provide the details of specific toxic chemicals of mobile and stationary sources and evaluate the MCR habitability based on the recommendations in NRC RG 1.78 to meet the requirements of TMI Action Plan Item III.D.3.4 and GDC 19 (COL 6.4(2)).

6.4.5 Testing and Inspection

Test and inspection requirements of the control room HVAC system are given in Subsection 9.4.1. A preoperational test is performed as described in Subsection 14.2.12.1 to provide reasonable assurance that system and component capabilities are achieved and maintained.

In-service test and test interval requirements including the unfiltered in-leakage test are described in Subsections 3.7.11, 5.5.11, and 5.5.18 of Chapter 16, Technical Specifications.

Periodic testing to confirm the CRE integrity is performed using test methods and at testing frequencies in accordance with NRC RG 1.197. The air in-leakage test of the CRE boundary is performed in accordance with ASTM E741-00.

6.4.6 Instrumentation Requirement

Instrumentation is provided for the control room HVAC system to control and indicate the temperature and to indicate radioactivity levels.

Two redundant radiation monitors are installed in the two outside air intakes to annunciate high radiation alarms and to initiate control room emergency ventilation actuation signals (CREVAS). The monitors are powered from a Class 1E, battery backed, and vital instrument power sources.

Instrumentation for the emergency makeup ACUs is designed to meet the requirements of ASME AG-1 and NRC RG 1.52. More detailed instrumentation requirements for MCR habitability are described on Subsection 9.4.1.5. The actuated systems and ESF functional logic for control room HVAC system are described in Section 7.3.

The COL applicant is to identify and develop toxic gas detection requirements to protect operators and assure the MCR habitability as described on Subsection 6.4.4.2. The number, locations, sensitivity, range, type, and design of the toxic gas detectors are to be developed by the COL applicant (COL 6.4(3)).

6.4.7 Combined License Information

COL 6.4(1) The COL applicant is to provide automatic and manual operating procedures for the control room HVAC system, which are required in the event of a postulated toxic gas release.

COL 6.4(2) The COL applicant is to provide the details of specific toxic chemicals of mobile and stationary sources and evaluate the MCR habitability based on the recommendations in NRC RG 1.78 to meet the requirements of TMI Action Plan Item III.D.3.4 and GDC 19.

COL 6.4(3) The COL applicant is to identify and develop toxic gas detection requirements to protect the operators and provide reasonable assurance of the MCR habitability. The number, locations, sensitivity, range, type, and design of the toxic gas detectors are to be developed by the COL applicant.

6.4.8 References

1. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room," U.S. Nuclear Regulatory Commission.

2. Regulatory Guide 1.196, "Control Room Habitability at Light Water Nuclear Power Reactors," Rev. 1, U.S. Nuclear Regulatory Commission, September 2007.

3. Regulatory Guide 1.197, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," U.S. Nuclear Regulatory Commission, May 2003.

4. NUREG-0800, Standard Review Plan, Section 6.4, "Control Room Habitability System," Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

5. Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Rev. 1, U.S. Nuclear Regulatory Commission, December 2001.

6. ASME AG-1-2009, "Code on Nuclear Air and Gas Treatment," The American Society of Mechanical Engineers, 2009.

7. ASME N509-2002, "Nuclear Power Plant Air-Cleaning Units and Components," The American Society of Mechanical Engineers, 2002.

8. Regulatory Guide 1.52, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," Rev. 4, U.S. Nuclear Regulatory Commission, September 2012.

9. ASTM E741-00, "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution," American Society for Testing and Materials, 2000.

10. Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” U.S. Nuclear Regulatory Commission, July 2000.

11. NUREG-0570, “Toxic Vapor Concentration in the Control Room Following a Postulated Accidental Release,“ U.S. Nuclear Regulatory Commission, June 1979.

Table 6.4-1

The Accident Radiation Source Description and Radiation Shielding Design for MCR and TSC

Type	Source No.			
	I	II	III	IV
Origin	MCR	Radioactive Plume	Containment	MCR Filter
Strength	Table 15.6.5-13 and Figure 15A-7			
Geometry	Finite Cloud	Semi-infinite	Cylinder	Rectangular
Radiation Type	Gamma and Beta	Gamma	Gamma	Gamma
Energy	N/A		25 energy groups of Gamma	
DCF	FGR 11 and 12	FGR 12	ICRP 51	
Shielding Thickness	N/A	0.46 m (1.5 ft)	3.05 m (10.0 ft) (includes wall between source and MCR)	0.46 m (1.5 ft)
Distances Source to MCR	N/A			2.01 m (6.6 ft)
Decay Consideration	Decays of radioactive nuclides are considered			
Radiation Streaming	The MCR is located at El. 156 ft in the auxiliary building. The closest penetration areas from the MCR are the two main steam valve rooms that have main steam pipes penetrated through the containment building wall. The MCR and main steam valve rooms are surrounded by 0.91 m (3 ft) and 1.22 m (4 ft) concrete walls, respectively, and there is another 0.91 m (3 ft) shielding wall between them. Because of the three shielding walls, the exposure to the operator in the MCR due to the radiation streaming is minimized during LOCA conditions.			
Isometric Drawing	Figure 6.4-6			

Table 6.4-2

MCR and TSC Doses from Design Basis Accidents

Design Basis Accident		TEDE (mSv)(1)
Steam system piping failure	1 % Fuel Failure	3.26E+01
	Pre-accident spike	7.82E+00
	Event-generated spike	1.29E+01
Feedwater system pipe break		5.91E+00
RCP rotor seizure		1.93E+01
Control element assembly ejection	Containment leakage	1.84E+01
	Steam system release case	3.41E+01
Failure of small lines carrying primary coolant outside containment		6.41E+00
Steam generator tube rupture	Pre-accident spike	1.00E+01
	Event-generated spike	7.94E+00
Loss of coolant accident		3.88E+01
Fuel handing accident		1.19E+01

(1) TEDE: Total effective dose equivalent

Table 6.4-3 (1 of 2)

Amounts of Hazardous Chemicals Stored Onsite

Chemicals	Location (1)	Distance to MCR Air Intake	Quantity	Concentration	Pressure	Temperature	Container Type	Boiling Point
H_2SO_4	1 / 2	118.9 m (390.1ft) 119.9 m (393.4 ft)	1: 56.8m^3 (15,000 gal) 2 :30.3 m^3 (8,000 gal)	95 %	Atmospheric Pressure	Ambient Temperature	Tank	337 °C (638°F)
NaOH	1 / 2	118.9 m (390.1 ft) /119.9 m (393.4 ft)	1:56.8 m^3 (15,000 gal) 2 :30.3 m^3 (8,000 gal)	45~50 %	Atmospheric Pressure	Ambient Temperature	Tank	1,390 °C (2,534°F)
C_2H_7NO	1	118.9 m (390.1 ft)	18.9 m^3 (5,000 gal)	40 %	Atmospheric Pressure	Ambient Temperature	Tank	170 °C (338°F)
N_2H_4	1	118.9 m (390.1 ft)	18.9 m^3 (5,000 gal)	40 %	Atmospheric Pressure	Ambient Temperature	Tank	114 °C (237°F) - anhydrous 119 °C (236°F) - hydrate
NaOCl (2)	3	198.6 m (651.4 ft)	1.9 m^3 (500 gal)	12 %	Atmospheric Pressure	Ambient Temperature	Tank (Pretreatment Related Facility of the Cooling Tower)	1,413 °C (2,575°F) (NaCl)

Table 6.4-3 (2 of 2)

Chemicals	Location (1)	Distance to MCR Air Intake	Quantity	Concentration	Pressure	Temperature	Container Type	Boiling Point
N_2	1	118.9 m (390.1ft)	14.4 m^3 (3,800 gal) 254.9 m^3 (9,000 SCF)	100 % 100 %	1.7 Mpa (250 psig) 17.9 Mpa (2,610 psig)	-158.9°C (-254°F) -40~93.3°C (-40~200 °F)	Tank High Pressure Vessel	-252.7 °C (-422°F)
H_2	1	118.9 m (390.1 ft)	652.4 m^3 (23,040 SCF)	100 %	13.8 Mpa (2,000 psig)	-18.8~38.6°C (-1.9~101.5°F)	Cylinder	-195.8 °C (-320°F)

(1) Location number of 1, 2 and 3 are identified in Figure 6.4-5.
(2) Assumed value by engineering experience.
(3) SCF (Standard Cubic Feet): a measure of quantity of gas, equal to a cubic feet of volume at 15.6 °C (60 °F) and 101.6 kPa (14.73 psi).

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.4-1 Control Room Envelope Flow Diagram (1 of 2)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.4-1 Control Room Envelope Flow Diagram (2 of 2)

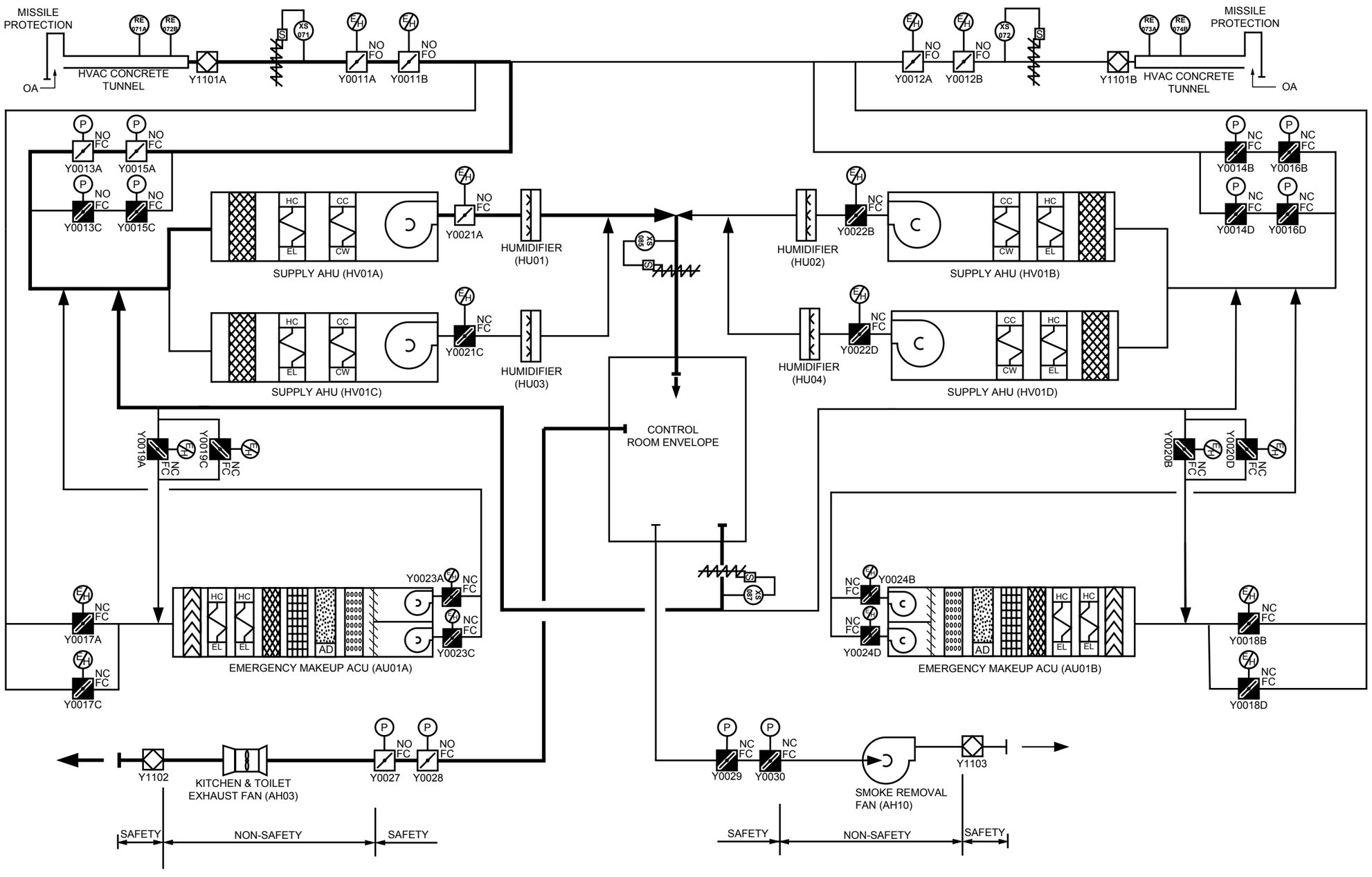


Figure 6.4-2 Control Room HVAC System Flow Diagram (Normal Mode)

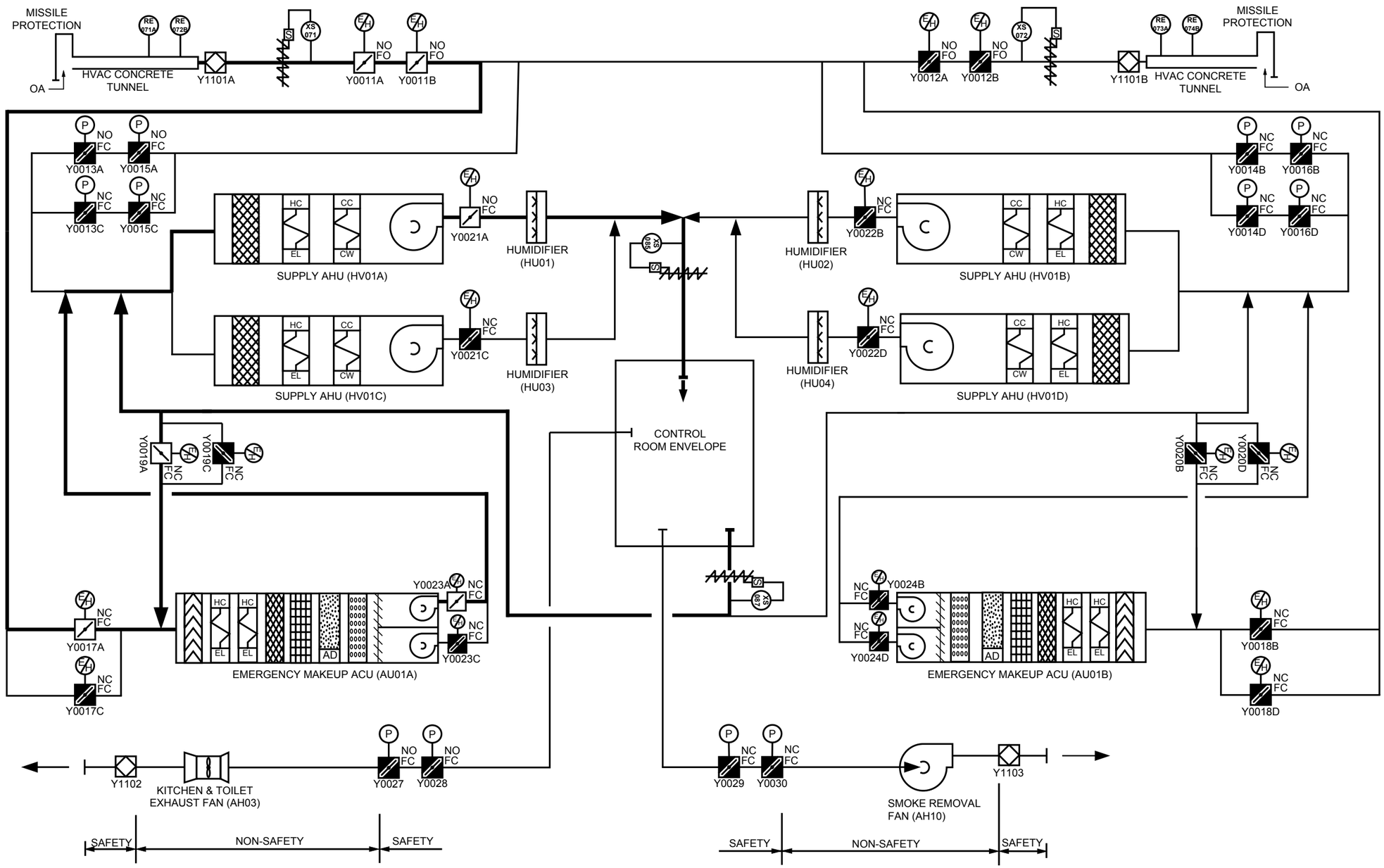


Figure 6.4-3 Control Room HVAC System Flow Diagram (Emergency Mode)

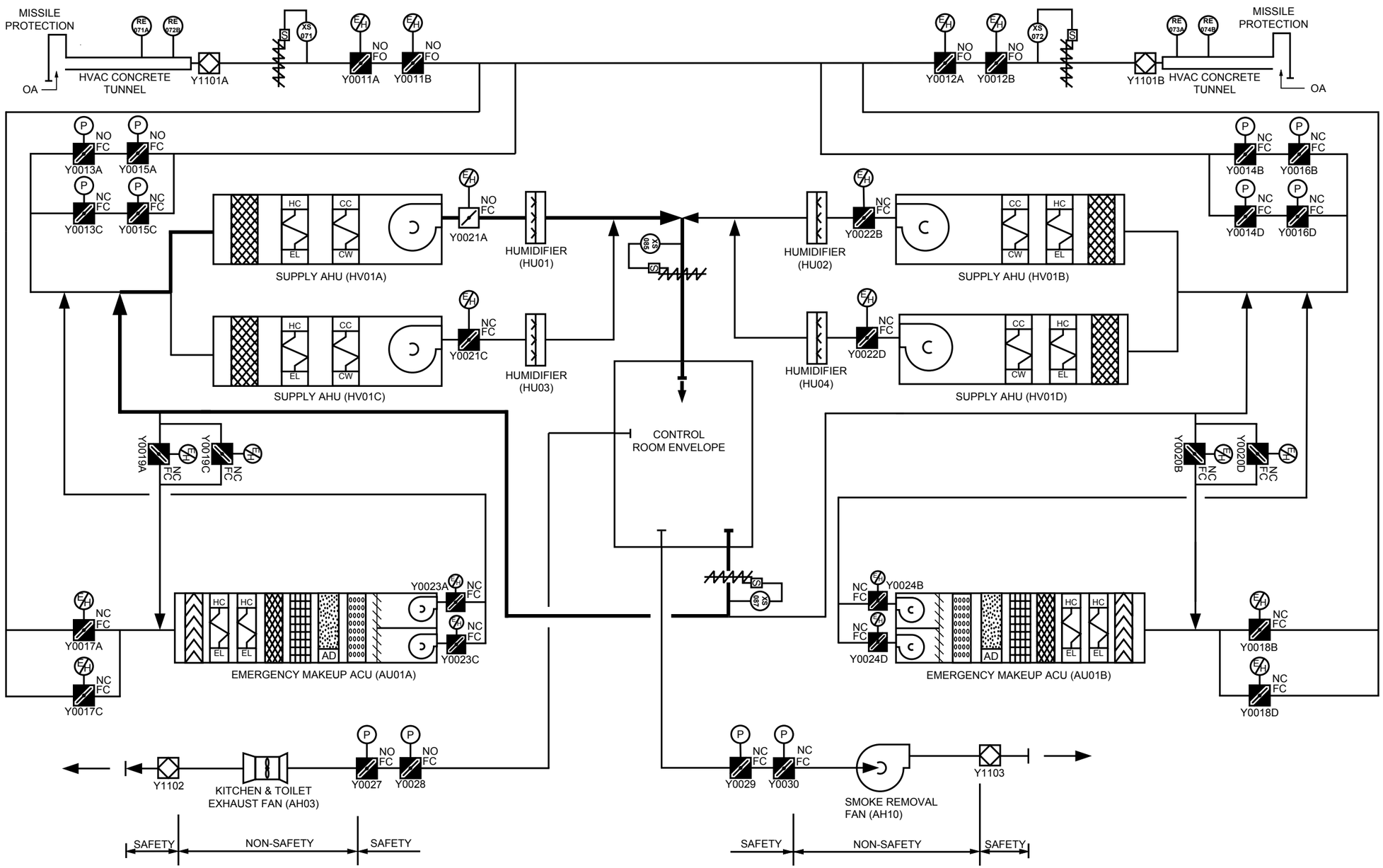


Figure 6.4-4 Control Room HVAC System Flow Diagram (Recirculation Mode)

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.4-5 Onsite Toxic Chemical Location in Site Plot Plan Drawing

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.4-6 Schematic View of MCR Shielding Design

6.5 Fission Product Removal and Control Systems

The fission product removal and control systems that are credited in the APR1400 design are as follows:

a. ESF filter systems

b. Containment spray system

c. Containment

This section describes the design features of the above systems including the evaluation of the performance to mitigate the accidental release of fission products.

6.5.1 Engineered Safety Feature Filter Systems

The three engineered safety feature (ESF) filter systems that perform safety-related functions following a design basis accident (DBA) are as follows:

a. Control room emergency makeup air cleaning system (CREACS) – Part of the control room heating, ventilation and air conditioning (HVAC) system

   The CREACS filters the outside makeup air, which has potential to carry radioactive iodine and particulates after a DBA to the control room HVAC system. The control room HVAC system that includes CREACS is described in Section 6.4 and Subsection 9.4.1.

b. Auxiliary building controlled area emergency exhaust system (ABCAEES) – Part of the auxiliary building controlled area HVAC system

   The ABCAEES filters the radioactive iodine and particulates in the exhaust air from the mechanical penetration rooms and the safety-related mechanical equipment rooms, which are cooled by safety-related cubicle coolers after a DBA. The auxiliary building controlled area HVAC system that includes ABCAEES is described in Subsection 9.4.5.

c. Fuel handling area emergency exhaust system (FHAEES) – Part of the fuel handling area HVAC system

The FHAEES filters the radioactive iodine and particulates in the exhaust air from the fuel handling area after a fuel handling accident in the auxiliary building. The fuel handling area HVAC system that includes FHAEES is described in Subsection 9.4.2.

6.5.1.1 Design Bases

The ESF filter systems mitigate the consequences of the postulated accidents by filtering radioactive particulates and iodine from the air. The ESF filter systems are safety-related systems and designed to meet seismic Category I requirements. Each ESF filter system consists of two safety-related redundant divisions. The redundant divisions are physically separated and powered from separate Class 1E power sources. The component specification of each ESF filter system is shown in Table 6.5-1.

Each ESF filter system is designed to meet the requirements of NRC RG 1.52 (Reference 1), ASME N509 (Reference 2), and ASME AG-1 (Reference 6).

6.5.1.1.1 Control Room Emergency Makeup Air Cleaning System

a. The control room emergency makeup air cleaning system (CREACS) is designed to provide filtered outside makeup air to the control room. The CREACS consists of two redundant divisions and each division includes an emergency makeup air cleaning unit (ACU).

b. The CREACS is designed in accordance with the requirements of 10 CFR Part 50 Appendix A, GDC 2, 4, 19, and 60.

c. The capacity of the emergency makeup ACU is based on the required air quantity to meet the following:

1) To maintain the control room envelope (CRE) at approximately 3.175 mm (0.125 in) water gauge positive pressure with respect to the adjacent areas

2) To limit the dose received by MCR personnel to less than 50 mSv total effective dose equivalent (TEDE) for the duration of the accident in accordance with GDC 19 (Reference 4)

d. Each ACU has a removal efficiency of no less than 99 percent of radioactive iodine and all particulates that are 0.3 μm and larger in size.

6.5.1.1.2 Auxiliary Building Controlled Area Emergency Exhaust System

a. The auxiliary building controlled area emergency exhaust system (ABCAEES) is designed to maintain a minimum 6.35 mm (0.25 inch) water gauge of negative pressure in the mechanical penetration rooms and the safety-related mechanical equipment rooms with respect to the adjacent areas. The ABCAEES filters potential particulate and iodine concentrations in the exhaust air from the mechanical penetration rooms and the safety-related mechanical equipment rooms and is based on the postulated leakages from the mechanical penetration rooms and the safety-related mechanical equipment rooms. The ABCAEES consists of two redundant divisions, and each division includes two emergency exhaust ACUs.

b. The ABCAEES is designed in accordance with the requirements of 10 CFR Part 50 Appendix A, GDC 2, 4, and 60.

c. The capacity of the emergency exhaust ACU is based on the required air quantity to maintain the mechanical penetration rooms and the safety-related mechanical equipment rooms at a minimum 6.35 mm (0.25 inch) water gauge of negative pressure with respect to the adjacent areas.

d. Each ACU has a removal efficiency of no less than 99 percent of the radioactive iodine and all particulates that are 0.3 μm and larger in size.

6.5.1.1.3 Fuel Handling Area Emergency Exhaust System

a. The fuel handling area emergency exhaust system (FHAEES) is designed to treat the exhaust air from the fuel handling area after a fuel handling accident. The system is designed to maintain a slightly negative pressure in the fuel handling

area with respect to the surrounding areas. The FHAEES consists of two redundant divisions and each division includes one emergency exhaust ACU.

b. The FHAEES is designed in accordance with the requirements of 10 CFR Part 50 Appendix A, GDC 2, 60, and 61.

c. The capacity of the emergency exhaust ACU is based on the required air quantity to maintain the fuel handling area at a slightly negative pressure with respect to the adjacent areas.

d. Each ACU has a removal efficiency of no less than 99 percent of radioactive iodine and of all particulates that are 0.3 μm and larger in size.

6.5.1.2 System Design

6.5.1.2.1 General System Description

The design feature and the fission product removal capability of the ESF filter systems in accordance with the guidance in NRC RG 1.52 are shown in Table 6.5-2.

6.5.1.2.1.1 Control Room Emergency Makeup Air Cleaning System

a. The CREACS is not normally running, and the emergency makeup ACU in each division starts automatically in response to any one of the following signals:

1) Engineered safety feature actuation system – safety injection actuation signal (ESFAS-SIAS)

2) Engineered safety feature actuation system – control room emergency ventilation actuation signal (ESFAS-CREVAS)

3) Remote manual actuation from the MCR or RSR

b. The isolation dampers on the inlet and outlet of the emergency makeup ACU open upon receipt of the corresponding emergency makeup ACU starting signal.

6.5.1.2.1.2 Auxiliary Building Controlled Area Emergency Exhaust System

a. The ABCAEES is not normally running, and the emergency exhaust ACUs in each division start automatically in response to any one of the following signals:

   1) ESFAS-SIAS

   2) Remote manual actuation from the MCR or RSR

b. The isolation dampers on the inlet and outlet of the emergency exhaust ACU open upon receipt of corresponding emergency exhaust ACU starting signal.

6.5.1.2.1.3 Fuel Handling Area Emergency Exhaust System

a. The FHAEES is not normally running, and the emergency exhaust ACU in each division starts automatically in response to any one of the following signals:

   1) High radiation signal from the radiation monitor located in the common discharge duct of the fuel handling area exhaust ACUs

   2) ESFAS – fuel handling area emergency ventilation actuation signal (FHEVAS)

   3) Remote manual actuation from the MCR or RSR

b. The isolation dampers on the inlet and outlet of the emergency exhaust ACU open upon receipt of the corresponding emergency exhaust ACU starting signal.

6.5.1.2.2 Component Description

Each ACU in the ABCAEES and FHAEES consists of a moisture separator, electric heating coil, prefilter, high efficiency particulate air (HEPA) filter, carbon adsorber, postfilter, and a fan. Each ACU in the CREACS consists of a moisture separator, two electric heating coils, a prefilter, HEPA filter, carbon adsorber, postfilter, and two fans. Water drains are provided for the moisture separators, and the carbon absorber sections.

a. The moisture separator is designed to remove any entrained water droplets and moisture to minimize water loading of the filters. The moisture separator is located upstream of the electric heating coil and the prefilter. The moisture removal efficiency for 10 micron particles is not less than 99 percent.

b. The electric heating coil is installed and sized to reduce the humidity of the air stream to at least 70 percent relative humidity for the worst inlet conditions to provide a reasonable assurance of a high iodine removal capability of the carbon adsorber.

c. The prefilter is located upstream of the HEPA filter to protect the HEPA filter by removing large particles. The prefilter exhibits 90 to 95 percent efficiency based on America Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 52.2 (Reference 5).

d. The HEPA filter is located upstream of the carbon adsorber to protect the carbon adsorber from particulate loading. The HEPA filter is capable of a minimum removal efficiency of 99 percent of particulates that are 0.3 μm and larger in size. HEPA filters are designed, constructed, qualified, and factory tested in accordance with ASME AG-1 (Reference 6).

e. The carbon adsorber is provided to remove airborne radioactivity. The carbon adsorber is a rechargeable Type III adsorber cell and the quantity of the carbon adsorber is based on a retention of 2.5 mg iodine/g carbon. The bed dimensions are designed so that the air has at least a 0.25 seconds residence time in charcoal per 50.8 mm (2 in) of bed.

f. The postfilter is located downstream of the carbon adsorber to trap charcoal fines that may be entrained by the airstream. The postfilter is a medium-efficiency filter of minimum efficiency reporting value 15.

g. The fan is provided to draw and exhaust air from the corresponding area. The fan total pressure is based on the worst pressure condition when the filters are operating at design pressure drop for dirty filter conditions.

h. The design parameters of ESF filter system components are given in Tables 9.4.1-1, 9.4.2-1, and 9.4.5-3.

6.5.1.3 Design Evaluation

According to the radiological consequences analyses for the DBA including loss of coolant accident (LOCA) in Chapter 15, the filter capabilities of the MCR emergency makeup air cleaning system are taken into account. Due to the filter effects, the radioactive materials that enter by unfiltered inflow from outside the MCR are minimized. As shown in Table 6.4-2, the resultant TEDE doses to the MCR and TSC operators meet the guideline of GDC 19.

The auxiliary building controlled area emergency exhaust system is designed to mitigate the radioactive releases due to potential leakage from the ESF systems after a DBA. The radiological consequence analysis in Subsection 15.6.5.5 take credit of filtering efficiency of the auxiliary building controlled area emergency exhaust ACU and the resultant TEDE meet the dose limits in 10 CFR 50.34(a)(1) and GDC 19.

The fuel handling area emergency exhaust system is utilized to mitigate the consequence of the fuel handling accident in the spent fuel pool area. As described in Subsection 15.7.4, the radiological doses at the offsite locations and the MCR meet the allowable dose limits even without taking credit for this safety-related filtering system. However, this system provides additional mitigation of exposures in the case of a fuel handling accident in the fuel handling area of the auxiliary building.

6.5.1.4 Tests and Inspections

The ESF filter systems and their components are tested in accordance with the following test programs:

a. Pre-operational testing

b. In-service surveillance

6.5.1.4.1 Pre-Operational Testing

The ACUs in ESF filter systems are tested in accordance with NRC RG 1.52 guidance, ASME AG-1 requirements.

a. The prefilters and postfilters are tested in accordance with Section FB of ASME AG-1.

b. The HEPA filters are tested using dioctyl phthalate (DOP) or an alternative agent (e.g., poly-alpha-olefin (PAO)) that meets the guidance of NRC RG 1.52 and have a minimum efficiency of 99 percent. The field acceptance test is performed in accordance with Section TA of ASME AG-1. The HEPA filters are tested in accordance with Section FC of ASME AG-1 after installation.

c. The carbon adsorbers are tested in accordance with Section FE (for Type III adsorber cells) of ASME AG-1.

d. The isolation dampers are tested in accordance with Section DA of ASME AG-1.

e. The ACU fan and associated mounting is tested in accordance with Section BA of ASME AG-1.

f. The ESF filter system ductwork is tested in accordance with Section SA of ASME AG-1.

6.5.1.4.2 In-service Surveillance

Testing and inspection of ESF filter systems are performed periodically under the ventilation filter testing program (VFTP) described in Subsection 5.5.11 of Chapter 16, Technical Specifications. In-place testing is performed in accordance with ASME N511 and NRC RG 1.52 as follows:

a. The visual inspection of ACU is performed in accordance with Section 5 of ASME N511.

b. The HEPA filter in-place leak test is performed in accordance with Section 5 of N511.

c. The carbon adsorbers in-place leak test is performed in accordance with Section 5 of N511.

d. The laboratory test for carbon adsorbers are performed in accordance with NRC RG 1.52. Test canisters are used to sample and analyze the activated carbon adsorber material.

6.5.1.5 Instrumentation Requirements

ESF actuation signals such as SIAS, CREVAS, and FHEVAS, as well as the high radiation signal from the radiation monitor in the common discharge duct of the fuel handling area exhaust ACUs actuate emergency ACUs. ESFAS signals are described in Subsection 7.3.1. Flow rate, pressure drop, and status indication of the ACUs are provided based on ASME AG-1 and Table 1 of NRC RG 1.52. The relevant readout or alarms are monitored in the MCR and RSR.

6.5.1.5.1 Radiation Monitors

The radiation monitors for the airborne radioactivity detection and alarm of the ESF filter systems are described in Subsection 11.5.3.

6.5.1.5.2 Flow Rate

Each volumetric air flow rate of emergency ACUs in the ESF filter systems is indicated in the MCR and RSR. The airflow rate high and low alarms are provided in the MCR and RSR.

6.5.1.5.3 Pressure

Differential pressure across the filters in the ACU is indicated locally and alarmed in the MCR and RSR.

6.5.1.6 Materials

ESF filter system materials are chosen considering the environmental conditions where the materials are located. ESF filter system materials meet the requirements in NRC RG 1.52 and ASME AG-1.

6.5.2 Containment Spray Systems

The containment spray system (CSS) is an automatically actuated ESF system. The heat removal function of the CSS is described in Subsection 6.2.2, and the fission product removal function of the CSS is described in this subsection. The system components and capacity are described in Subsection 6.2.2. The CSS mitigates the radiological consequences following the DBAs that release fission products inside the containment.

6.5.2.1 Design Bases

The CSS is a safety-grade system designed to reduce containment pressure and temperature from an MSLB or a LOCA and remove fission products from the containment atmosphere following a DBA. Fission products are removed to reduce activity at the site boundary due to radioactive iodine. The CSS satisfies the relevant requirement of 10 CFR Part 50 Appendix A, GDC 41, 42, and 43. Compliance with these GDC is addressed in Section 3.1.

The CSS uses the IRWST and has two independent divisions including two containment spray (CS) pumps, two CS heat exchangers, two CS mini-flow heat exchangers, two independent spray headers, associated piping, valves, and instrumentation. The system is shown on Figure 6.2.2-1. Post-accident pH control of the sprayed fluid is provided using trisodium phosphate (TSP), which is stored in the holdup volume tank (HVT). The pH of the IRWST water during the post-accident is maintained above 7.0 so that radioactive iodine dissolved into IRWST water does not re-evaporate into the containment atmosphere.

The CSS provides sprays of borated water to the containment atmosphere from the upper regions of the containment. The spray flow is provided by the CSPs, which take suction from the IRWST. The CSPs start on the receipt of a safety injection actuation signal (SIAS) or containment spray actuation signal (CSAS). The CS pumps discharge through the CSHXs and the spray header isolation valves to their respective spray nozzle headers

and then into the containment atmosphere. Spray flow to the CS nozzle headers is not provided until a CSAS automatically opens the containment spray header isolation valves. The main spray nozzle headers are located in the upper part of the containment building to provide the falling spray droplets to approach thermal equilibrium with the steam-air atmosphere. Condensation of the steam by the falling spray reduces the containment pressure and temperature.

By reducing the containment pressure, the CSS diminishes the pressure differential between the containment atmosphere and the external environment atmosphere, thus reducing the leakage of fission products to the external environment.

Performance requirements are set to conform with the dose limit specified in 10 CFR 50.34.

Following a LOCA or an MSLB, the containment pressure is reduced to near atmospheric pressure. When the containment pressure is reduced sufficiently, the CSS is not required for iodine removal. The operator determines that containment spray is no longer required, and the operator terminates the CSS operation. When the containment temperature and pressure do not stabilize or continue reducing, the operator restarts the CSS manually.

The CSPs are designed to be functionally interchangeable with the shutdown cooling pumps (SCPs) when not required to perform their requisite design basis function, assuming a loss of offsite power and single failure. The CSPs can be used as a backup to the SCPs to provide residual heat removal, and the CSPs and the CSHXs can be used as a backup to the SCPs and the shutdown cooling heat exchangers (SCHXs) to provide cooling of the IRWST.

6.5.2.2 System Design (for Fission Product Removal)

The IRWST contains 2,457 m^3 (649,000 gal) of borated water to at least 4,000 ppm concentration. TSP is stored in baskets at the HVT. The TSP is fully dissolved in the return flow from the sprayed water or break flow.

As discussed in Subsection 6.2.2, there are 296 containment main spray nozzles for each division, arranged in four spray nozzle headers at high locations in the containment. Figure 6.2.2-4 shows the sectional view of the containment providing the main spray nozzle

header elevations. Figure 6.2.2-5 shows the plan view of the locations and types of nozzles on each spray nozzle header. Figure 6.2.2-5 also shows the spray coverage on the operating floor of the containment.

The mass mean drop size produced at the nozzle design condition of 2.81 kg/cm^{2}D (40 psid) is assumed to be 295 microns for the main spray nozzles.

Table 6.5-3 presents a tabulation of the sprayed and unsprayed volumes in the containment. Containment spray coverage is approximately 75 percent of the containment net free volume. Unsprayed volume includes covered regions such as pressurizer and steam generator compartments.

There is no safety grade forced ventilation inside the containment. Air mixing is accomplished by flows due to the density difference between the regions resulting from the effect of the spray.

Operation of the CSS to remove fission products from the containment is described in Subsection 15.6.5.5.1.1. The time of spray initiation is also shown in Subsection 15.6.5.5.1.1.

CSS components including pumps, piping, and valves are described in Subsection 6.2.2.

6.5.2.2.1 Design Features for Minimization of Contamination

The CSS is designed with specific features to meet the requirements of 10 CFR 20.1406 (Reference 8) and NRC RG 4.21 (Reference 9). The basic principles of NRC RG 4.21 and the methods of control suggested in the regulations are specifically delineated into four design objectives and two operational objectives discussed in Subsection 12.4.2. The following evaluation summarizes the primary features to address the design and operational objectives for the CSS.

The CSS has been evaluated for leakage identification from the SSCs that contain radioactive or potentially radioactive materials, the areas and pathways where probable leakage may occur, and the methods of leakage control incorporated in the design of the system. The leak identification evaluation indicated that the CSS is designed to facilitate

early leak detection and the prompt assessment and response to manage collected fluids. Thus, unintended contamination to the facility and the environment is minimized and/or prevented by the SSC design, supplemented by operational procedures and programs, inspection, and maintenance activities.

Prevention/Minimization of Unintended Contamination

a. The CSS components are located in individual cubicles inside the auxiliary building. The cubicle floors are sloped, coated with epoxy, and provided with drains that are routed to the local drain hubs. This design approach prevents unintended contamination of the facility and the environment.

b. The system heat exchangers and pumps are fabricated with stainless steel material and are of welded construction for life-cycle planning, thus minimizing leakage and unintended contamination of the facility and the environment.

c. The pump shaft seal is the mechanical type and is constructed of materials compatible with the spray fluids. A flow restrictor is provided to minimize the loss of fluid in the event of a seal failure. This design approach minimizes contamination to the facility and the environment.

Adequate and Early Leak Detection

a. The CSS is not used during normal power operation. Any leakage is drained to the floor and is collected in the local sump, which is equipped with a liquid level switch. If leakage exceeds a predetermined liquid level within the sump, the level switch initiates an alarm in the MCR for operator actions to investigate the source of leakage.

Reduction of Cross-Contamination, Decontamination, and Waste Generation

a. The SSCs are designed with life-cycle planning through the use of nuclear industry-proven materials compatible with the chemical, physical, and radiological environment, thus minimizing waste generation.

b. Shell and tube type heat exchangers are used to transfer heat from the CSS side to the component cooling water system side. The heat exchangers are designed with stainless steel tubes to minimize the potential for cross-contamination between containment spray and component cooling water. The leakage from the heat exchangers is collected in the local floor drain and sumps.

c. Process sampling connections are provided to determine levels of contamination and determine treatment requirements.

Decommissioning Planning

a. The SSCs are designed for the full service life and fabricated as individual assemblies for easy removal.

b. The SSCs are designed with decontamination capabilities. Design features (e.g., utilized welding technique, surface finishes) are included to minimize the need for decontamination and the resultant waste generation.

c. The CSS is designed without any embedded or buried piping for contaminated or potentially contaminated fluid, which minimizes the potential for unintended contamination of the environment.

Operations and documentation

a. The COL applicant is to provide the operational procedures and maintenance program as related to leak detection and contamination control (COL 6.5(1)).

b. The COL applicant is to maintain the complete documentation of system design, construction, design modifications, field changes, and operations (COL 6.5(2)).

Site Radiological Environmental Monitoring

The CSS is on standby mode during normal power operation and designed to have only low levels of contamination. Through monitoring, in-service inspection, and lessons learned from industry experiences, the integrity of the CSS is well maintained, resulting in a very

low level of contamination of the facility. Because of its location, the potential for environmental contamination of the soil and the groundwater from liquid leakage is minimal. Hence, the CSS is not required to be part of the Site Radiological Environmental Monitoring Program.

6.5.2.3 Design Evaluation

Subsection 15.6.5.5.1 describes the iodine removal parameters for the APR1400. The CSS is credited for mitigating the effects of a DBA that releases radioactive material into the containment. Subsection 15.6.5.5 describes the radiological consequence evaluation for the limiting DBA, including fission product removal by the CSS. Subsection 15.0.3 describes the evaluation methods.

6.5.2.3.1 Containment Mixing

CS nozzles are installed at the upper dome and below the operating deck in the containment building to remove fission products as well as to reduce the pressure and temperature in the containment building.

The containment atmosphere is divided into a sprayed region and unsprayed region to evaluate the mix and removal of fission products released from the reactor coolant system (RCS). Therefore, mixing of the sprayed and unsprayed volumes of the containment is calculated, and air mixing is accomplished by flows due to the density difference between the regions resulting from the effect of the spray. The sprayed region is approximately 75 percent of the total containment net free volume. The remaining 25 percent does not get sprayed directly because of obstruction to the falling spray drops. However, most of the unsprayed region still has good communication with the sprayed region. The design data of the sprayed and the unsprayed regions in the containment are provided in Table 6.5-3.

The minimum mixing rate of two unsprayed volumes per hour is used in the analysis to transport the post-LOCA activity between the sprayed and unsprayed regions in accordance with SRP 6.5.2 (Reference 10).

6.5.2.3.2 Containment Spray pH Control

The pH of IRWST water is evaluated to provide reasonable assurance that the calculated minimum and maximum pH values under any possible water chemistry conditions caused by a LOCA are between 7.0 and 8.5.

After a LOCA, the spray water from the spray nozzles removes the fission product from the containment atmosphere drops to the floor of the containment. The spray water that drops to the containment floor accumulates in the HVT. During a LOCA, TSP stored in baskets in the HVT becomes immersed in water, and the resulting solution overflows into the IRWST. If the pH of IRWST water during the post-accident is maintained above 7.0, the radioactive iodine dissolved into IRWST water does not re-evaporate into the containment atmosphere.

Stainless steel baskets, which are attached to the walls of the HVT, have a solid top and bottom with mesh sides to permit submergence of the TSP. The elevation of the baskets is below the IRWST spillway.

The principal water sources that contribute to the pH control are from the IRWST, the RCS including the pressurizer, the safety injection tanks (SITs), safety injection system piping, and CSS piping.

The volume of TSP required to establish a minimum pH of 7.0 in the recirculated containment spray solution is calculated using the following conservative assumptions:

a. Maximum boron concentration for each water source

b. Maximum water sources

c. Minimum IRWST water temperature

For this analysis, it is assumed that one CS pump is running.

On the other hand, the maximum pH is conservatively calculated using the previously determined TSP volume and the following initial conditions:

a. Minimum boron concentrations for each water source

b. Minimum water sources

c. Maximum IRWST water temperature

The major parameters used in pH calculations are presented in Table 6.5-4. The results of the calculations show that the time required to reach a pH of 7.0 for the minimum pH condition is estimated to be 157 minutes after the onset of a LOCA. The maximum pH value is calculated not to exceed 8.5 for the maximum pH condition. Therefore, the pH of IRWST water is maintained between 7.0 and 8.5 after 157 minutes.

6.5.2.3.3 Airborne Fission Product Removal Coefficient

The fission products are released from the RCS into the containment atmosphere following a DBA through the three steps: coolant activity release, gap activity release, and early in-vessel release according to NUREG-1465 (Reference 11). Fission products are divided into eight radionuclide groups on the basis of chemical behavior. Of the radioiodine released from the RCS to the containment atmosphere, 95 percent is particulate iodine, 4.85 percent is elemental iodine, and 0.15 percent is organic iodine. With the exception of elemental and organic iodine and noble gases, fission products are assumed to be in a particulate form.

The removal of airborne radioactivity in the containment by natural deposition is credited by acceptable models for elimination of iodine and aerosols in SRP 6.5.2 and in NUREG/CR-6189 (Reference 12). The removal of airborne radioactivity in the containment by CSS is credited by acceptance models in SRP 6.5.2.

The removal rates of elemental and particulate iodine by natural deposition (process) or by containment spray are used based on the above regulations and as described below.

Elemental Iodine Removal by Containment Spray

The elemental iodine removal coefficients are estimated using the following equation:

$$\lambda_s = \frac{6K_g \cdot T \cdot F}{V \cdot D}$$

Where:

λ_s = elemental iodine removal coefficient by spray wash-out (hr^{-1})

K_g = gas phase mass transfer coefficient (ft/hr)

T = falling time of drops (hr)

F = spray flow rate (ft^3/hr)

V = volume of sprayed region (ft^3)

D = mass mean drop diameter (ft)

This equation represents a first-order approximation if a well-mixed droplet model is used for the spray efficiency. The equation is valid for λ_s values equal to or greater than 10 hr^{-1}. The parameter λ_s is limited to 20 hr^{-1} to prevent extrapolation beyond the existing data for a boric acid solution with a pH of 5. The effectiveness of the spray in removing elemental iodine is terminated when the maximum elemental iodine decontamination factor of 200 is reached according to SRP 6.5.2.

Organic Iodide Removal by Containment Spray

Per SRP 6.5.2, it is conservative to assume that organic iodides are not removed by either spray or wall deposition. Therefore, this calculation does not develop an organic iodide spray removal rate.

Particulate (Aerosol) Iodine Removal by Containment Spray

The first-order removal coefficient for particulate aerosols can be determined using the following equation from SRP 6.5.2:

$$\lambda_p = \frac{3hFE}{2VD} = \frac{3hF}{2V} \cdot \frac{E}{D}$$

Where:

λ_p = particulate aerosol removal coefficient by spray wash-out (hr^{-1})

h = spray drop fall height (ft)

F = spray flow (ft^3/hr)

E/D = ratio of a dimensionless collection efficiency (E) to the average spray drop diameter (dimensionless)

V = containment building net-free volume (ft^3)

It is conservative to assume the E/D to be 10 per meter initially (i.e., 1 percent efficiency for spray drops of 1 millimeter in diameter), changing abruptly to 1 spray drop per meter after the particulate aerosol mass has been depleted by a factor of 50 (i.e., 98 percent of the suspended mass is 10 times more readily removed than the remaining 2 percent). Per SRP 6.5.2, there is no need to limit the decontamination factor for particulate iodine because the removal mechanisms for particulate iodine are significantly different from and slower than the mechanisms for elemental iodine.

Particulate (Aerosol) Removal by Natural Deposition

A simplified model in NRC NUREG/CR-6189 to estimate the aerosol decontamination by natural deposition in the containment building under DBA conditions is used for the DBA analyses in Chapter 15. This model was derived by correlating the results of Monte Carlo uncertainty analyses for aerosol behaviors under the accident conditions. The aerosol behaviors include aerosol deposition by gravitational settling, thermophoresis, diffusiophoresis, and turbulent diffusion, except for the electrostatic effects.

Uncertainty distributions for effective decontamination coefficients (λe) are correlated with time and reactor thermal power for the 90, 50 (median), and 10 percentile values. These correlations can be used to estimate the decontamination by natural aerosol processes as presented in Table 6.5-5.

In the radiological consequence analyses for the LOCA and CEA ejection accident, which release aerosols to the containment building, reduction in aerosol by natural deposition

within the containment building is credited using a 10 percentile value of the Powers model built into RADTRAD 3.03 (Reference 13).

The mechanisms for the removal and control of the fission products used for the radiological consequence analyses in Chapter 15 are summarized in Table 6.5-6.

6.5.2.4 Tests and Inspections

Preoperational tests are performed to verify the proper operation of the CSS. The preoperational tests include calibrating the instrumentation, verifying adequate pump performance and the operability of all associated valves, and verifying that the spray headers and spray nozzles are free of obstructions.

The CSS also undergoes preoperational hydrostatic tests in accordance with ASME Section III.

Tests of individual components or of the complete CSS are controlled to provide reasonable assurance that plant safety is not jeopardized and that undesirable transients do not occur.

Preoperational test results are used to perform analyses that confirm the as-built CSS fulfills operability requirements and provides a level of performance that satisfies the safety analyses.

Each installed CSS division is tested to measure the CSP-developed differential pressure at a flow rate equal to or greater than the pump's design flow rate. An analysis is performed to use the test results to determine pump performance at design conditions after an accident. The calculated performances are within the limits used to perform a safety analyses.

Testing is performed to confirm that the CSP mini-flow rate in the installed system meets or exceeds the pump minimum flow of 1,608.8 L/min (425 gpm).

Testing is performed to confirm that the CSP return line to the IRWST allows each CSP to be operated at a flow rate equal to or greater than the design flow during in-service testing.

The available NPSH to the CSPs are determined based on as-built elevations, piping arrangements, and system performance parameters measured during testing. Measured pump suction pressures and flow rates are used in an analysis to demonstrate that adequate available NPSH is provided to each CSP assuming the following post-accident conditions:

a. Minimum IRWST level during an accident

b. Saturated IRWST fluid conditions

c. As-built piping arrangement for pump inlet piping and components

The calculated minimum available NPSH exceeds the NPSH required by the pump vendor.

Testing is performed to demonstrate that an SCP in a division can perform the pumping function of the CSP in the same division. The SCP is tested by aligning its suction to the CSP suction and its discharge to the CSP discharge. The SCP provides a flow rate through the CSHX that is greater than or equal to the CSP design flow rate.

Section 14.2 describes the test program that demonstrates component and system operation prior to plant operations.

The CSS is designed and installed to permit in-service inspection and testing in accordance with ASME Section XI (Reference 14) and ASME OM Code (Reference 15). The complete schedule for the tests and inspections of the CSS, including TSP, is described in Chapter 16.

6.5.2.5 Instrumentation Requirements

The CSS instrumentation requirements are addressed in Subsection 6.2.2.5.

6.5.2.6 Materials

TSP is added to the IRWST through the TSP basket in the HVT. Technical Specification 3.5.5 provides the surveillance requirements to verify the amount and pH controlling capability of TSP.

6.5.3 Fission Product Control System

The primary fission product control system following a DBA is the CSS and the containment. The fission product leakage to the environment is reduced below the release limit by the fission product removal function of the containment spray and the leaktight pressure boundary of the containment. Chapter 15 describes the radiological consequences following the DBAs. The in-service leakage testing program monitors the containment leakage rate as detailed in Subsection 6.2.6.

6.5.3.1 Primary Containment

The containment is a pre-stressed, post-tensioned concrete structure with stainless steel liner plates that form a leaktight pressure boundary. The containment serves as a defense-in-depth boundary of fission product with the containment isolation system. Details of the containment structural design characteristics are described in Subsection 3.8.1. The containment design characteristics for containment integrity and fission product release after DBAs are described in Section 6.2. The containment isolation system is described in Subsection 6.2.4.

Containment purge system operation is not required during a DBA. The heat and fission product released into the containment during a DBA, such as a LOCA or an MSLB, is removed by the CSS, which is described in Subsection 6.5.2. The APR1400 design does not include a containment hydrogen purge system.

6.5.3.2 Secondary Containment

The secondary containment is not applicable to the APR1400.

6.5.4 Ice Condenser as a Fission Product Cleanup System

This subsection is not applicable to the APR1400.

6.5.5 Pressure Suppression Pool as a Fission Product Cleanup System

This subsection is not applicable to the APR1400.

6.5.6 Combined License Information

COL 6.5(1) The COL applicant is to provide the operational procedures and maintenance program as related to leak detection and contamination control.

COL 6.5(2) The COL applicant is to maintain the complete documentation of system design, construction, design modifications, field changes, and operations.

6.5.7 References

1. Regulatory Guide 1.52, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post-Accident Engineered-Safety-Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," Rev. 4, U.S. Nuclear Regulatory Commission, June 2012.

2. ASME N509-2002, "Nuclear Power Plant Air-Cleaning Units and Components," The American Society of Mechanical Engineers, 2002.

3. ASME N510-2007, "Testing of Nuclear Air-Cleaning Units and Components," The American Society of Mechanical Engineers, 2007.

4. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room," U.S. Nuclear Regulatory Commission.

5. ASHRAE 52.2-2012, "Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size," American Society of Heating, Refrigerating and Air Conditioning Engineers, 2012.

6. ASME AG-1-2009, "Code on Nuclear Air and Gas Treatment," The American Society of Mechanical Engineers, 2009.

7. 10 CFR 50.34, "Contents of Applications; Technical Information," U.S. Nuclear Regulatory Commission

8. 10 CFR 20.1406 "Radiological Criteria for Unrestricted," U.S. Nuclear Regulatory Commission.

9. Regulatory Guide 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," U.S. Nuclear Regulatory Commission.

10. NUREG-0800, Standard Review Plan, Section 6.5.2, "Containment Spray as a Fission Product Cleanup System," Rev. 4, U.S. Nuclear Regulatory Commission, March 2007.

11. NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants," U.S. Nuclear Regulatory Commission, 1992.

12. NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments," U.S. Nuclear Regulatory Commission, July 1996.

13. NUREG/CR-6604,"RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation," U.S. Nuclear Regulatory Commission , June 1997.

14. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

15. ASME OM Code, "Code for Operation and Maintenance of Nuclear Power Plants," The American Society of Mechanical Engineers.

Table 6.5-1 (1 of 2)

Engineered Safety Feature Filter Systems – Component Specification

Control Room Emergency Makeup Air Cleaning System

Description	Specification	
HEPA filter	Quantity	One bank per ACU
	Efficiency	99 %
	Type	Extended media, ASME AG-1 Table FC-4110 Designation 8 (based on minimum rated air flow of 3400 cmh (2,000 scfm))
Carbon Adsorber	Quantity	One per ACU
	Efficiency	99 percent
	Type	Impregnated activated carbon (maximum 5 % impregnant)
	Bed dimension	At least 0.25 seconds residence time in charcoal per 50.8 mm (2 in) of bed
Fan	Quantity	Two per ACU
	Type	Centrifugal
	Capacity	13,592 cmh (8,000 cfm)

Table 6.5-1 (2 of 2)

Auxiliary Building Controlled Area Emergency Exhaust System

Description	Specification	
HEPA filter	Quantity	One bank per ACU
	Efficiency	99%
	Type	Extended media, ASME AG-1 Table FC-4110 Designation 8 (based on minimum rated air flow 3,400 cmh (2,000 scfm))
Carbon Adsorber	Quantity	One per ACU
	Efficiency	99 %
	Type	Impregnated activated carbon (maximum 5 % impregnant)
	Bed dimension	At least 0.25 seconds residence time in charcoal per 50.8 mm (2 in) of bed
Fan	Quantity	One per ACU
	Type	Centrifugal
	Capacity	5,097 cmh (3,000 cfm)

Fuel Handling Area Emergency Exhaust System

Description	Specification	
HEPA filter	Quantity	One bank per ACU
	Efficiency	99%
	Type	Extended media, ASME AG-1 Table FC-4110 Designation 8 (based on minimum rated air flow of 3,400 cmh (2,000 scfm))
Carbon Adsorber	Quantity	One per ACU
	Efficiency	99 %
	Type	Impregnated activated carbon (maximum 5 % impregnant)
	Bed dimension	At least 0.25 seconds residence time in charcoal per 50.8 mm (2 in) of bed
Fan	Quantity	One per ACU
	Type	Centrifugal
	Capacity	8,495 cmh (5,000 cfm)

Table 6.5-2 (1 of 8)

Engineered Safety Feature Filter Systems – Comparison to Regulatory Guide 1.52, Rev. 4

No.	Regulatory Position Summary	APR1400 Design
1	General Design and Testing Criteria	Applicable to APR1400 Design
2	Environmental Design Criteria	
2.a	The design of an ESF atmosphere cleanup system should be based on the anticipated range of operating parameters of temperature, pressure, relative humidity, radiation levels, and airborne iodine concentrations during and following the postulated DBA.	The design of an ESF filter system is based on the anticipated range of operating parameters during and following the postulated DBA.
2.b	The location and layout of each ESF atmosphere cleanup system should consider the radiation dose to essential services and personnel in the vicinity, integrated over the 30-day period following the postulated DBA.	ESF cleanup systems are separated by a shielding wall to control access, and to maintain, enough space around the each system.
	The radiation source term should be consistent with the assumptions found in NRC RGs 1.3, 1.4, 1.25, or 1.183.	The source term for the APR1400 is assumed to be consistent with the NRC RG 1.183.
2.c	The design of each adsorber should be based on the concentration and relative abundance of the iodine species (elemental, particulate, and organic)	Adsorber is designed to provide sufficient removal efficiencies for iodine species required to meet the criteria for radiological release and MCR habitability during the design basis accidents.
2.d	The operation of any ESF atmosphere cleanup system should not degrade the operation of other ESFs	Separation criterion is applied to ESF filter system and other ESFs.
2.e	Components of systems during a postulated accident should be designed for the post-accident effects of both the lowest and highest predicted temperatures.	The components of the ESF filter system is designed for both the lowest and highest predicted temperatures.
2.f	The design of an ESF atmosphere cleanup system should consider any significant contaminants that may occur during a DBA	The design of an ESF atmosphere cleanup system considers contaminants during a DBA.

Table 6.5-2 (2 of 8)

No.	Regulatory Position Summary	APR1400 Design
3	System Design Criteria	
3.a	ESF atmosphere cleanup systems should have redundant units (trains) to provide assurance that an operable unit will be available during the DBA.	Each ESF filter system consists of two 100 percent redundant divisions.
	A typical unit is composed of the following components: (1) moisture separator, (2) prefilter, (3) heater, (4) HEPA filter, (5) iodine adsorber, (6) HEPA filter or medium-efficiency postfilter, (7) fan, and (8) interspersed ducts, motors, dampers, valves, and related instrumentation.	Each ACU for the ESF filter system consists of a moisture separator, electric heating coil, prefilter, HEPA filter, carbon adsorber, postfilter, and fan along with ducts and dampers, and related instrumentation.
3.b	The redundant ESF atmosphere cleanup units should be physically separated and generation of missiles should be considered in the design for separation and protection.	The redundant ESF filter systems are physically separated and are located in a missile-protected structure.
3.c	If necessary, the system should be protected from postulated accident pressure surges.	N/A
3.d	All components of an ESF atmosphere cleanup system whose failure would lead to the release that exceed the regulatory limits should be designated as seismic Category I.	The components of the ESF filter system are designed to seismic Category I criteria.
3.e	ESF system construction materials should effectively maintain their intended function under the postulated radiation levels.	Applicable to APR1400 Design
3.f	The volumetric airflow rate of each cleanup unit should be limited to approximately 30,000 cfm.	• CREACS ACU : 13,592 cmh (8,000 cfm) • FHAEES ACU : 8,495 cmh (5,000 cfm) • ABCAEES ACU : 5,097 cmh (3,000 cfm)
	The adsorber residence time is not less than the design value (typically 0.25 seconds per 2 inches of activated carbon)	The adsorber residence time is at least 0.25 seconds per 50.8 mm (2 in).

Table 6.5-2 (3 of 8)

No.	Regulatory Position Summary	APR1400 Design
3.g	The ESF atmosphere cleanup system should be instrumented to signal, alarm, and record pertinent pressure drops and flow rates at the control room.	Flow rate, pressure drop, status indication, and temperatures of the ACUs are provided based on Table 1 of NRC RG 1.52. The relevant readout, recordings, and alarms are monitored in the MCR and RSR.
3.h	The power supply and electrical distribution system should be designed in accordance with NRC RG 1.32. All instrumentation and equipment controls should be designed to IEEE Standard 603-1991. The ESF system should be qualified and tested under NRC RGs 1.89. 1.30, 1.100, 1.118, and 1.40 should be considered in the design.	Applicable to APR1400 Design
3.i	ESF atmosphere cleanup system should be automatically activated upon the ESF actuation signal or radiation monitor.	ESF actuation signals as well as radiation monitor signals actuate emergency ACUs.
3.j	ESF atmosphere cleanup systems and components should be designed to control leakage and facilitate maintenance, inspection, and testing in accordance with the guidance of NRC RG 8.8. The ESF atmosphere cleanup unit should be totally enclosed.	ESF filter system and components are designed in accordance with the guidance of NRC RG 8.8. The ACUs of the ESF filter system are totally enclosed.
3.k	Outdoor air intake openings should be equipped with louvers, grills, screens, or similar protective devices to minimize the effects of high winds, rain, snow, ice, trash, and other contaminants on the operation of the system.	Air intakes for the MCR HVAC system are equipped with louvers, grilles, and screens.
3.l	The housings and ductwork should be designed to exhibit on test a maximum total leakage rate as defined in section HA-4500 and section SA-4500, respectively, of ASME AG-1-2009 with addenda. Duct and housing leak tests should be performed in accordance with section TA-4300 of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
3.m	The ESF atmosphere cleanup systems and components should be designed, maintained, and operated to minimize contamination in accordance with the guidance of NRC RG 4.21.	Applicable to APR1400 Design

Table 6.5-2 (4 of 8)

No.	Regulatory Position Summary	APR1400 Design
4	Component Design Criteria and Qualification Testing	
4.a	Moisture separators should be designed, constructed, and tested in accordance with section FA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.b	Air heaters should be designed, constructed, and tested in accordance with section CA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.c	Prefilters should be designed, constructed, and tested in accordance with section FB or FJ of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.d	HEPA filters should be designed, constructed, and tested in accordance with section FC of ASME AG-1-2009 with addenda. Each HEPA filter should be tested in accordance with section TA of ASME AG-1-2009 with addenda. Testing and documentation should be in accordance with a quality assurance program consistent with Appendix B, 10 CFR 50.	Applicable to APR1400 Design
4.e	The HEPA filter and Type II adsorber cell mounting frames should be constructed and designed in accordance with section FG of ASME AG-1-2009 with addenda.	The HEPA filter frames are constructed and designed in accordance with section FG of ASME AG-1-2009 with addenda.
4.f	Filter and adsorber banks should be arranged in accordance with section HA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.g	System filter housings, including floors and doors, should be constructed and designed in accordance with section HA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.h	Water drains should be designed in accordance with the recommendations of section HA of ASME AG-1-2009 with addenda, including Appendix HA-B. Special design features should be incorporated into drain systems to prevent contaminated air bypassing filters or adsorbers through the drain system. Procedures should be in place to routinely verify the water level.	• Applicable to APR1400 Design • Isolation valves are provided on the drain lines to prevent contaminated air bypassing filters or adsorbers through the drain system.

Table 6.5-2 (5 of 8)

No.	Regulatory Position Summary	APR1400 Design
4.i	Humidity control maintaining the relative humidity at less than or equal to 70 percent.	Electric heating coils are sized to reduce the humidity of the air stream to at least 70 percent relative humidity.
4.j	Adsorbers should be designed, constructed, and tested in accordance with section FD (for Type II adsorber cells) or section FE (for Type III adsorber cells) of ASME AG-1-2009 with addenda.	Adsorbers are Type III and are designed, constructed, and tested in accordance with section FE of ASME AG-1-2009 with addenda.
	The design of the adsorber section should consider possible iodine desorption and adsorbent auto-ignition that may result from radioactivity-induced heat in the adsorbent and concomitant temperature rise.	A water spray system for fire protection is mounted within the housing and located to provide reasonable assurance that both deep-seated and surface fires can be extinguished.
	The fire system should use open spray nozzles or devices of sufficient size, number, and location to provide complete coverage over the entire surface of the combustible filter media.	The outlet nozzles are located in such a position that they completely wet the carbon in the filter.
	The fire system should be hard piped and supplied with a reliable source of water at adequate pressure and volume.	The reliable fire protection water system supplies the water to a water spray system that provides coverage of the carbon adsorber filter. It is a reliable source of water at adequate pressure and volume.
	The location of the manual release (or valve) for the fire system should be remote from the cleanup system housing and should be consistent with the ALARA guidance in NRC RG 8.8.	The non-radioactive systems are separated from the radioactive system for maintaining occupational exposure ALARA.

Table 6.5-2 (6 of 8)

No.	Regulatory Position Summary	APR1400 Design
4.j	Automatic fire systems should include a reliable means of detection to actuate the system. Cross-zoning of detectors is acceptable. Manual fire systems should include a reliable means of internal monitoring for determining when to manually actuate the fire systems.	Manual fire systems include a reliable means of internal monitoring for determining when to manually actuate the fire systems. • Continuously monitor the temperature downstream of the carbon adsorber • Raise a high temperature alarm and isolate the ACU • Raise a high-high temperature alarm
	The monitoring indication should be remote from the cleanup system housing in accordance with ALARA practices.	The non-radioactive systems are separated from the radioactive system for maintaining occupational exposure ALARA.
4.k	The adsorber section of the ESF atmosphere cleanup system may contain any adsorbent material demonstrated to remove gaseous iodine (elemental iodine and organic iodides) from air at the required efficiency.	The adsorbent media is coconut shell and is treated with iodine compounds, or other additives of sufficient concentrations to obtain the required methyl iodine adsorption-efficiencies.
	Each original or replacement batch or lot of impregnated activated carbon used in the adsorber section should meet section FF-5000 of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
	The adsorber system should be designed for an average atmosphere residence time of 0.25 seconds per 2 inches of adsorbent bed by sections FD and FE of ASME AG-1-2009 with addenda.	The adsorber residence time is at least a 0.25 seconds per 50.8 mm (2 in).
	The adsorption unit should be designed for a maximum loading of 2.5 milligrams of total iodine per gram of activated carbon.	The quantity of the carbon adsorber is based on retention of 2.5 mg iodine/g carbon.
	No more than 5 percent of impregnate should be used. The radiation stability of the type of carbon specified should be demonstrated and certified.	Applicable to APR1400 Design

Table 6.5-2 (7 of 8)

No.	Regulatory Position Summary	APR1400 Design
4.k	If sample canisters are used, they should be designed in accordance with section 4.13(b) and Appendix I to ASME N509-2002.	Test canisters are provided for each carbon adsorber. Test canisters are designed in accordance with section 4.13(b) and Appendix I to ASME N509-2002.
4.l	Ducts and filter housings should be laid out with a minimum of ledges, protrusions, and crevices.	Applicable to APR1400 Design
4.m	Dampers should be designed, constructed, and tested in accordance with section DA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.n	The system fan, its mounting, and the ductwork connections should be designed, constructed, and tested in accordance with Section BA (for blowers) and Section SA (for ducts) of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
	Each driver should be qualified in accordance with Class 1E qualification standards in ANSI/IEEE Standard 323. Ductwork should be designed, constructed, and tested in accordance with section SA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
4.o	If used as postfilters, medium-efficiency filters of minimum efficiency reporting value 15 or higher should be used. Postfilters should be designed and constructed in accordance with Section FB of ASME AG-1-2009 with addenda.	The medium-efficiency filter of MERV 15 is used as a postfilter and the postfilter is designed and constructed in accordance with Section FB of ASME AG-1-2009 with addenda.
5	Maintainability Criteria	
5.a	The accessibility of components for maintenance should be considered in the design of ESF atmosphere cleanup systems in accordance with section HA of ASME AG-1-2009 with addenda.	Applicable to APR1400 Design
5.b	The cleanup components that are used during construction of the ventilation systems should be replaced before the system is declared operable.	The HEPA filters, prefilters, and adsorbers that are used during construction are completely replaced before the system is declared operable.

Table 6.5-2 (8 of 8)

No.	Regulatory Position Summary	APR1400 Design
5.c	Provisions for duct access for maintenance and inspection should be provided in accordance with Section 4.3.4 of National Fire Protection Association (NFPA) 90A.	Applicable to APR1400 Design
6	In-Place Testing Criteria	Applicable to APR1400 Design
7	Laboratory Testing Criteria for Activated Carbon	Applicable to APR1400 Design

Table 6.5-3

Sprayed and Unsprayed Regions

Description	Volume	
	m^3	ft^3
Containment Net Free Volume	8.86×10^4	3.13×10^6
Sprayed Volume (75 %)	6.65×10^4	2.35×10^6
Gross volume above the operating floor refueling canal	6.65×10^4	2.35×10^6
Unsprayed Volume (25 %)	2.21×10^3	7.82×10^5
Volume of pressurizer compartment (bottom to top)	3.4×10^2	0.12×10^5
Volume of 2 S/G compartment (bottom to top)	5.78×10^3	2.04×10^5
Volume below operating floor	1.6×10^4	5.66×10^5

Table 6.5-4

Major Parameters Used in pH Calculations

pH Values	Minimum	Maximum
Water mass, kg (lbm)	3.27E+06 (7.21E+06)	2.24E+06 (4.94E+06)
Boron Concentration, ppm	4,400	3,596
TSP Mass, kg (lbm)	26,471 (58,358)	
PO_4 Concentration, ppm	2,000	2,712
Flow rate of one CS pump, L/min (gpm)	18,927 (5,000)	

Table 6.5-5

Correlation of Effective Decontamination Rates for Natural Deposition of Aerosols

Material	Time Intervals (s)	Correlation
Gap	0-1,800 (0-0.5 hr)	λ_e (90) = 0.0365 + 3.580E-06 × P (MW) λ_e (50) = 0.0268 + 3.475E-06 × P (MW) λ_e (10) = 0.0182 + 3.260E-06 × P (MW)
Gap	1,800-6,480 (0.5-1.8 hr)	λ_e (90) = 0.1036 [1-exp (-2.239 × P (MW) / 1000] λ_e (50) = 0.0820 [1-exp (-1.159 × P (MW) / 1000] λ_e (10) = 0.0645 [1-exp (-0.938 × P (MW) / 1000]
Early In-vessel	1,800-6,480 (0.5-1.8 hr)	λ_e (90) = 0.0522 [1-exp (-2.458 × P (MW) / 1000] λ_e (50) = 0.0417 [1-exp (-1.258 × P (MW) / 1000] λ_e (10) = 0.0326 [1-exp (-0.910 × P (MW) / 1000]
Gap + Early In-vessel	6,480-13,680 (1.8-3.8 hr)	λ_e (90) = 0.421 [1-exp (-2.530 × P (MW) / 1000] λ_e (50) = 0.196 [1-exp (-1.040 × P (MW) / 1000] λ_e (10) = 0.094 [1-exp (-0.869 × P (MW) / 1000]
Gap + Early In-vessel	13,680-49,680 (3.8-13.8 hr)	λ_e (90) = 0.1920-1.35E-06 × P (MW) λ_e (50) = 0.1382 + 6.85E-06 × P (MW) λ_e (10) = 0.0811 + 10.15E-06 × P (MW)
Gap + Early In-vessel	49,680-80,000 (13.8-22.22 hr)	λ_e (90) = 0.1010 λ_e (50) = 0.0912 λ_e (10) = 0.0860 [1-exp (-2.384 × P (MW) / 1000]

Table 6.5-6

Major Mechanisms for Fission Product Removal and Control

Mechanism	Noble Gases	Iodine		
		Particulate	Elemental	Organic
Containment Spray System (1) (Subsection 6.5.2.3.3)	N/A	Applicable 6.25 hr^{-1} (0 ~ 2.40 hrs) 0.625 hr^{-1} (2.40~ 4 hrs)	Applicable 20 hr^{-1} (0 ~ 2.25 hrs)	N/A
Natural Deposition Effects (Subsection 6.5.2.3.3)	N/A	Applicable (Powers Model 10th percentile)	N/A	N/A
Containment (2) Leak Surveillance Requirement 3.6.1.1)	Applicable	Applicable 0.1 v/o/day (0 ~ 24 hrs) 0.05 v/o/day (24 ~ 270 hrs)	Applicable 0.1 v/o/day (0 ~ 24 hrs) 0.05 v/o/day (24 ~ 270 hrs)	Applicable 0.1 v/o/day (0 ~ 24 hrs) 0.05 v/o/day (24 ~ 270 hrs)
Radio Nuclide Decay	Applicable	Applicable	Applicable	Applicable

(1) The pH of CSS water is controlled by TSP.

(2) Containment free volume is 3.128×10^6 ft^3 (88,575 m^3), and pre-stressed, post-tensioned concrete structure with0.25 in stainless steel liner plates is used for containment structure.

6.6 In-service Inspection of Class 2 and 3 Components

This section describes preservice and in-service inspection and system pressure test for ASME Section III Class 2 and 3 components. The COL applicant is to identify the implementation milestones for ASME Section Xl in-service inspection program for ASME Section III Class 2 and 3 components in accordance with the requirements of 10 CFR 50.55a(g) (Reference 1) (COL 6.6(1)).

6.6.1 Components Subject to Examination

A preservice inspection (PSI) and an in-service inspection (ISI) are performed for the examination of ASME Code Class 2 and 3 components in accordance with ASME Section XI (Reference 2). Table 3.2-1 specifies safety Classes for components that have a safety function in accordance with ASME Section III (Reference 3), Article NCA-2000. Subsection 3.2.2 defines the relationship between these safety Classes and NRC Regulatory Guide (RG) 1.26 (Reference 4). The purpose of the in-service inspection is to periodically monitor the systems or components requiring in-service inspection in order to identify and repair the indications that do not meet acceptance standards.

ASME Code Class 2 and 3 pressure retaining components are examined in accordance with the requirements of ASME Section XI, Articles IWC-2500 and IWD-2500, respectively.

ASME Section XI, IWC-1220 or IWD-1220, allows exemption of examination to certain components or portions of components, and those exempted items are listed in the in-service inspection program. Approved Code Cases that are listed in NRC RG 1.147 (Reference 5) may be used. Subsection 3.13.2 describes the preservice and in-service inspection applicable to threaded fasteners in conformance with the criteria of ASME Code, Section XI for bolting and mechanical joints.

6.6.2 Accessibility

Provisions for accessibility are incorporated in the design processes for ASME Code Class 2 and 3 components in accordance with ASME Section XI, IWA-1500.

Accessibility to equipment for maintenance, testing, and inspection is a basic element of design process. Provisions are made in the design and layout of Code Class 2 and 3 systems to allow for conformance with the in-service inspection requirements contained in ASME Section XI, Articles IWC-2000 and IWD-2000, and as defined in the in-service inspection program. ASME Code Class 2 and 3 components requiring inspection are designed for and are provided with access to enable the performance of ASME Section XI inspections onsite. Systems and components are designed so that design, materials, and geometry do not restrict inspections required by ASME Section XI.

Welds and other areas requiring periodic inspection are made accessible. Reinforcing pads, supports, piping, and equipment are located so as not to obstruct welds. Insulating materials are removable to provide accessibility for the required in-service inspection.

6.6.3 Examination Techniques and Procedures

The examination techniques to be used for in-service inspection include visual, surface, and volumetric examination methods. Procedures for all examinations are prepared to include descriptions of the equipment, inspection technique, operator qualifications, calibration standards, flaw evaluation, and records. The techniques and procedures meet the requirements of ASME Section XI, Articles IWC-2000 and IWD-2000. PSI and subsequent ISI are conducted with equivalent equipment and techniques.

For the preservice inspection, all of the items selected for in-service inspection are performed once in accordance with ASME Section XI, IWC-2000 and IWD-2000.

Ultrasonic examination personnel, equipment, and procedures are qualified in accordance with ASME Section XI, Appendix VII and VIII.

Approved Code Cases that are listed in NRC RG 1.147 are used.

6.6.4 Inspection Intervals

Inspection schedules and intervals for Class 2 and 3 components are in accordance with ASME Section XI, Subarticles IWA-2400, IWC-2400, and IWD-2400.

The examination program for the 120-month inspection interval is defined in the in-service inspection plan. The initial in-service inspection program incorporates the latest edition and addenda of the ASME Boiler and Pressure Vessel Code approved in 10 CFR 50.55a(b) on the date 12 months before the initial fuel load. In-service inspection of components and system pressure tests conducted during successive 120-month inspection intervals conformwith the requirements of the latest edition and addenda of the Code incorporated by reference in 10 CFR 50.55a(b) 12 months before the start of the 120-month inspection interval, subject to the conditions listed in 10 CFR 50.55a(b).

6.6.5 Examination Categories and Requirements

The examination categories and requirements meet ASME Section XI.

Examination categories for ASME Code Class 2 pressure retaining components include the following:

a. C-A, pressure retaining welds in pressure vessels

b. C-B, pressure retaining nozzle welds in pressure vessels

c. C-C, weld attachments for vessels, piping, pumps, and valves

d. C-D, pressure retaining bolting greater than 2 inches in diameter

e. C-F-1, pressure retaining welds in austenitic stainless steel or high alloy piping

f. C-F-2, pressure retaining welds in carbon or low alloy piping

g. C-H, all pressure retaining components

Examination categories for ASME Code Class 3 pressure retaining components include the following:

a. D-A, welded attachments for vessels, piping, pumps, and valves

b. D-B, all pressure retaining components

6.6.6 Evaluation of Examination Results

Evaluation of nondestructive examination results for ASME Code Class 2 and 3 systems and components is made in accordance with ASME Section XI, Articles IWC-3000 and IWD-3000.

Where acceptance standards for a particular component or examination category are in preparation, the evaluation is based on acceptance standards for materials and welds specified in the ASME Section III edition applicable to the construction of the component. The results of the examinations and evaluations are documented in accordance with ASME Section XI, Article IWA-6000.

Repair and replacement activities for ASME Code Class 2 and 3 components are in accordance with ASME Section XI, IWA-4000.

6.6.7 System Pressure Test

Class 2 systems subject to system pressure tests are tested in accordance with ASME Section XI, Articles IWA-5000 and IWC-5000 and Table IWC-2500-1.

Class 3 systems subject to system pressure tests are tested in accordance with ASME Section XI, Articles IWA-5000 and IWD-5000 and Table IWD-2500-1.

6.6.8 Augmented ISI Protect against Postulated Piping Failure

High-energy fluid system piping between containment isolation valves are subject to augmented in-service inspection in accordance with the following criteria:

a. Protective measures, structures, and guard pipes do not prevent the access required to conduct the in-service examinations as specified in ASME Section XI, Division 1.

b. For those portions of high-energy fluid system piping between the containment penetration wall and auxiliary building anchor wall beyond isolation valve, the extent of in-service examination completed during each inspection interval provides 100 percent volumetric examination of circumferential and longitudinal pipe welds within the boundary of these portions of piping.

c. The areas subject to examination are defined in accordance with examination categories C-F-1 and C-F-2 for Class 2 piping welds in ASME Section XI, Article IWC-2000.

Information concerning areas subject to examination, method of examination and frequency of examination is contained in the in-service inspection program. The program includes the high-energy fluid piping systems described in Subsection 3.6.1 and 3.6.2.

An augmented in-service inspection is conducted to provide reasonable assurance of the structural integrity of cold-worked austenitic stainless steel components (refer to Subsection 6.1.1.1). The COL applicant is to identify the implementation milestone for the augmented in-service inspection program (COL 6.6(2)).

6.6.9 Combined License Information

COL 6.6(1) The COL applicant is to identify the implementation milestones for ASME Section Xl in-service inspection program for ASME Section III Class 2 and 3 components.

COL 6.6(2) The COL applicant is to identify the implementation milestone for the augmented in-service inspection program.

6.6.10 References

1. 10 CFR 50.55a (g), “Inservice Inspection Requirements,” U.S. Nuclear Regulatory Commission.

2. ASME Boiler and Pressure Vessel Code, Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

3. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

4. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," Rev. 4, U.S. Nuclear Regulatory Commission, March 2007.

5. Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Rev. 16, U.S. Nuclear Regulatory Commission, October 2010.

6.7 Main Steamline Isolation Valve Leakage Control System (Boiling Water Reactors Only)

Not applicable to the APR1400.

6.8 In-containment Water Storage System

The in-containment water storage system (IWSS) performs water collection, delivery, storage, and heat sink functions inside the containment during normal operation and accident conditions. The IWSS comprises the in-containment refueling water storage tank (IRWST), holdup volume tank (HVT), and cavity flooding system (CFS).

The IRWST and the HVT are integral parts of the containment building internal structure (refer to Subsection 3.8.3). The IRWST and the HVT are reinforced concrete structures with a stainless steel liner on surfaces expected to be in direct contact with borated water. Elevation views of the IRWST and the HVT are shown in Figures 1.2-2 and 1.2-3. A plan view is shown in Figure 6.8-1. The CFS is shown in detail as an elevation section in Figure 6.8-2.

A flow diagram of the IWSS is shown in Figure 6.8-3. Table 6.8-1 lists component parameters of IWSS.

6.8.1 Design Bases

The IRWST is designed to perform the following functions:

a. Source of borated water for the safety injection (SI) system when the SI system is in a standby mode during normal operating conditions

b. Source of borated water for filling the refueling pool during refueling operations

c. Safety-grade source of borated water for the containment spray system (CSS)

d. Primary heat sink for pilot-operated safety relief valve (POSRV) discharges

e. Source of water for the CFS

The HVT performs water collection and storage functions during accident conditions. The HVT is designed to perform the following functions:

a. Prevents any leakage from any of the CFS HVT spillway valves from reaching the reactor cavity

b. Serves as the low-collection point in the containment and receives water from pipe breaks and containment sprays during accident conditions

c. Receives water discharged from the IRWST to flood the reactor cavity

The function of the CFS is to flood the reactor cavity in the event of a severe accident. The flooding covers core debris in the reactor cavity with water to facilitate debris cooling and stabilization.

6.8.2 System Design

6.8.2.1 System Description

6.8.2.1.1 Normal operation

The IRWST stores borated water for refueling, injection into the reactor coolant system (RCS) by the SI system, the CSS, supply of cavity flooding, and quenching POSRV discharges.

As necessary, during normal operation, the IRWST water is maintained (purified) by the spent fuel pool (SFP) cooling and cleanup system, as described in Subsection 9.1.3. The chemical and volume control system (CVCS) provides a means to add makeup and adjust the boron concentration of the IRWST, as described in Subsection 9.3.4.

If necessary, during normal operation, the IRWST water can be cooled by the shutdown cooling (SC) heat exchangers (shown in Figure 6.3.2-1).

For refueling, water from the IRWST is transferred to the refueling pool using one or both of the CS pumps (shown in Figure 6.2.2-1). The water in the RCS and the refueling pool during refueling is cooled by SC heat exchangers.

Following refueling, water is transferred from the refueling pool to the IRWST by diverting a portion of the SC pump discharge downstream of the SC heat exchanger to the IRWST. The refueling pool is drained in this manner down to the reactor vessel flange. Subsequent draining of the refueling pool is performed by the SFP cleanup pumps directly to the IRWST, followed by gravity draining directly to the IRWST (shown in Figure 9.1.3-1).

6.8.2.1.2 Accident conditions

The IRWST is cooled by the CS heat exchangers during a LOCA or secondary side pipe break. The CS pumps take suction from the IRWST and pump the water through the CS heat exchangers where it is cooled before being sprayed through the spray nozzles into the containment atmosphere. The containment atmosphere is cooled by heat transfer to the falling spray water. The spray water drains into the HVT and is ultimately returned to the IRWST through the IRWST spillways once the HVT water level reaches the IRWST spillways.

During the bleed phase of RCS rapid depressurization, the IRWST can be cooled by the SC or the CS heat exchangers.

The CFS is used to flood the reactor cavity in the event of a severe accident to cover core debris in the reactor cavity with water. The CFS takes water from the IRWST and directs it to the reactor cavity. The water flows first into the HVT through HVT flooding lines and then into the reactor cavity through reactor cavity flooding lines. Two 35.36 cm (14 inch) diameter HVT flooding lines, two 30.48 cm (12 inch) diameter reactor cavity flooding lines, and related motor operated valves and controls are used to deliver the water from the IRWST to the reactor cavity. The motor-operated valves (MOVs) are normally closed, de-energized, and remotely opened by operator action from the main control room (MCR). The motive force for the flooding is gravity and the static head of water between the IRWST water level and the HVT water level. Flooding of the HVT progresses until the water level in the HVT reaches the level of the reactor cavity flooding lines, at which time reactor cavity flooding commences. Flooding stops when an equal water level in the IRWST, HVT, and reactor cavity is attained.

6.8.2.1.3 Design Features for Minimization of Contamination

The IWSS is designed with specific features to meet the requirements of 10 CFR 20.1406 (Reference 1) and NRC RG 4.21 (Reference 2). The basic principles of NRC RG 4.21 and the methods of control suggested in the regulations are specifically delineated into four design objectives and two operational objectives discussed in Subsection 12.4.2. The following evaluation summarizes the primary features to address the design and operational objectives for the IWSS.

The IWSS has been evaluated for leak identification from the SSCs that contain radioactive or potentially radioactive materials, the areas and pathways where probable leakage may occur, and the methods of leakage control incorporated in the system design. The leak identification evaluation indicated that the IWSS is designed to facilitate early leak detection and the prompt assessment and response to manage collected fluids. Thus, unintended contamination to the facility and the environment is minimized and/or prevented by the SSC design, supplemented by operational procedures, programs, inspection, and maintenance activities.

Prevention/Minimization of Unintended Contamination

a. The IWSS components, primarily the IRWST and the HVT located inside containment, are constructed of reinforced concrete lined with austenitic stainless steel. The IRWST and the HVT are interconnected by two spillways. The bottom of the spillway is submerged below the surface of the water in the IRWST and the top of the spillway is below the IRWST ceiling during normal operation. This limits the amount of water vapor and possible gaseous radioactivity that can enter the containment atmosphere. This design approach prevents unintended contamination of the facility and the environment.

b. The top of the basemat inside the containment is provided with a steel liner. This design approach prevents unintended contamination of the basemat and the environment.

c. The IRWST uses the SFP cooling and cleanup system (FC) components to maintain and purify the water contents, thus minimizing the spread of contamination and unintended contamination of the facility and the environment.

d. The system piping is fabricated from stainless steel to minimize corrosion and erosion. Granulated tri-sodium phosphate (TSP) is provided in a stainless steel basket to minimize the corrosion of the stainless steel piping during LOCA conditions.

e. The IWSS sump pits are designed with steel liner plates to provide impermeable barriers to prevent contamination of the basemat.

Adequate and Early Leak Detection

a. The IRWST is designed to prevent the spread of contamination due to overflow. Four wide range (0 to 100 percent) level indicating channels are provided locally and in the MCR. Adequate instrumentation, including temperature and pressure elements, is provided to monitor and control the operations of preventing overpressurization or vacuum, thus minimizing the spread of contamination and waste generation.

b. The HVT has one narrow range and four wide range level indicating channels. The narrow range level channel is used to detect the presence of fluid in the HVT. Upon detection of water, the narrow range channel actuates an alarm in the MCR to alert for operator actions.

c. The reactor cavity has four wide range level indicating channels. The four wide range channels provide level indication in the MCR to facilitate monitoring fluid level after an accident.

Reduction of Cross-Contamination, Decontamination, and Waste Generation

a. The SSCs are designed with life-cycle planning through the use of materials compatible with the chemical, physical, and radiological environment, thus minimizing waste generation.

b. During normal operation, the IRWST water can be cooled by the SC heat exchangers and purified by the FC system. The CVCS provides a means to add makeup and adjust the boron concentration in the IRWST. This design approach

minimizes the spread of contamination to the facility and the environment, and waste generation.

Decommissioning Planning

a. The SSCs are designed for the full service life. All structures inside the IRWST are simple and smooth in contour to facilitate its lining with stainless steel. The bottom of the tank is flat to avoid having sharp corners. This design approach minimizes potential for damages to the liner, which can result in unintended leakage and contamination.

b. The SSCs are designed with smooth surface finishes to minimize the need for decontamination and hence waste generation during decommissioning.

Operations and documentation

a. The IRWST is designed with adequate instrumentation for remote operation and monitoring.

b. A maintenance access hatch is provided to facilitate inspections and the maintenance of spargers and other hardware inside the tank.

c. The COL applicant is to provide the operational procedures and maintenance program related to leak detection and contamination control (COL 6.8(1)). Procedures and maintenance programs are to be completed before fuel is loaded for commissioning.

d. The COL applicant is to provide the preparation of cleanliness, housekeeping, and foreign materials exclusion program (COL 6.8(2)). This program addresses other debris sources, such as latent debris, inside containment. This program minimizes foreign materials in the containment.

e. The COL applicant is to maintain the complete documentation of system design, construction, design modifications, field changes, and operations (COL 6.8(3)). Documentation requirements are included as a COL Information item.

Site Radiological Environmental Monitoring

The IRWST is designed to provide safety features for uninterrupted operation of the plant. Through monitoring, in-service inspection, and lessons learned from industry experiences, the integrity of the IRWST is well maintained, and contributes a very low level of contamination to the facility. Because of its location inside containment, the potential for environmental contamination of soil and groundwater from liquid leakages is minimized. Hence, this system is not required to be included in the site radiological environmental monitoring program.

6.8.2.2 Component Description

6.8.2.2.1 In-containment Refueling Water Storage Tank

The IRWST is located below an elevation of 100 ft in the floor slab between the secondary shield wall outside and the inner containment wall inside. The tank has a continuous ring around the lower containment. The IRWST is a protected, reliable, and safety-related source of borated water for the CS and SI.

The IRWST is also used to fill the refueling pool in support of refueling operations. It contains a minimum of 2,373.5 m^3 (83,818 ft^3) of borated water, which is monitored for level, temperature, and homogenous boron concentration. The IRWST is designed with sufficient capacity to meet long-term post-LOCA coolant needs, including holdup volume losses. The total water volume held up in the containment is shown in Table 6.8-2. Normal operating water volume used to fill the refueling cavity is 2,456.7 m^3 (86,759 ft^3).

The IRWST contains a freeboard space that is approximately 1.24 m (4 ft) high and between the normal water level at elevation of 28.3 m (93 ft) and the bottom 29.56 m (97 ft) of the 100 ft floor elevation slab. The freeboard provides approximately 836.4 m^3 (29,537.87 ft^3) of air space. The bottom of the slab at elevation 100 ft is designed to avoid pockets where combustible gas could collect.

As described in Chapter 3, the IRWST is designed as safety Class 3, seismic Category I, with a design temperature of 143.3 °C (290 °F). Pressure in the IRWST air space is relieved to the containment atmosphere through the vent stacks.

Four vent stacks are installed through the IRWST ceiling and discharge into the containment atmosphere above. The vent stacks act to equalize the IRWST and the containment free volume air pressure when the SI pumps or CS/SC pumps take suction and draw down the IRWST water level. Eight overpressure protection swing panels are installed on the two side walls of each vent stack. Four vacuum protection swing panels are installed on one side wall of each vent stack. The swing panels are closed to minimize the release of vaporized IRWST water into the containment atmosphere during normal plant operation. The swing panels are described in Subsection 6.8.2.2.5.

The containment purge system is used for venting the IRWST during normal fill of the IRWST (i.e., transfer from the refueling pool to the IRWST following refueling) to prevent discharging contaminated air from the IRWST to the containment. For water transfer from the IRWST, the containment purge system is used to provide air intake into the IRWST. The swing panels also allow air intake into the IRWST if required. The containment purge system is used to purge and clean the IRWST atmosphere before entry for maintenance or inspections.

Surfaces in the IRWST that are in direct contact with borated water are lined with stainless steel. The liner prevents leaks and the interaction of the boric acid with the concrete structure. Leaks that occur are collected, monitored, and quantified by the equipment and floor drainage system (EFDS). All structures inside the IRWST are simple and smooth to facilitate lining the IRWST with stainless steel. The bottom of the IRWST is flat to avoid a sharp corner at the primary shield wall.

A maintenance access hatch, 3.05 m × 2.74 m × 2.64 m (10 ft × 9 ft × 8 ft 8 in), is provided in the top of the IRWST to allow replacement of the hardware inside the tank.

To minimize the corrosion of the stainless steel in the containment and to keep radioactive iodine dissolved in IRWST water during a LOCA and long-term post-LOCA, pH control of the IRWST water is provided by TSP, which is stored in baskets in the HVT. The stainless steel baskets have a solid top and bottom with mesh sides to provide reasonable assurance of dissolution when submerged in water.

The IRWST spillways allow accumulated water in the adjacent HVT to spill into the IRWST, thereby replenishing the IRWST water volume. The spillways enter the IRWST and are directed so that the top of the spillways are below the IRWST ceiling. This

prevents gases that accumulate in the IRWST freeboard space from entering the containment atmosphere and minimizes humidity loading into the containment. The spillways are adequately sized to allow the maximum flow into the HVT to be returned to the IRWST after filling.

As shown in Figure 6.8-1, each quadrant of the IRWST contains paired suction piping and the IRWST sump arrangements for the CS/SC pumps and SI pumps. The open end of each suction pipe is equipped with a debris strainer (emergency core cooling/containment spray (ECC/CS) strainer) that satisfies NEI 04-07 and conforms to the guidance in NRC RG 1.82 (Reference 3).

Technical Report "Design Features to Address GSI-191" (Reference 4) provides additional description of the APR1400 design features that limit the impact of post-accident debris accumulation on SIS and CSS performance. The Technical Report summarizes the performance evaluations and component test program and compares the design to the regulatory positions of NRC RG 1.82.

Seismically designed vertical screens are provided at the entrance of the HVT to prevent debris from entering the HVT and thus the IRWST. In addition, the height of the spillway from the HVT to the IRWST also minimizes the entrance of debris into the IRWST. Strainers at the entrance to the pump suction line are designed to provide reasonable assurance that the strainer design meets the requirements in NRC RG 1.82 and takes into consideration the effects of all types of debris that may exist in the containment on strainer blockage.

Following an accident, water introduced into containment drains to the HVT. Any debris in the containment could be transported to the HVT with this fluid. Debris greater than 3.81 cm (1.5 in) in diameter is prevented from entering the HVT by a vertical trash rack at the entrance to the HVT (shown in Figure 6.8-4.). A trench at the base of the trash rack prevents any high-density debris swept along the floor by fluid flow toward the HVT from reaching the trash rack. The vertical orientation of the trash rack helps impede the deposition of debris buildup on the strainer surface. Particles that are smaller than the trash rack mesh enter the HVT.

High-density debris that enters through the trash rack accumulates in the bottom of the HVT. The IRWST spillways are located at a high elevation to provide reasonable

assurance that much of the higher density debris and debris that tends to sink slowly settles to the bottom of the HVT before spilling over into the IRWST. Debris that remains in suspension makes its way to the IRWST spillways. The spillways are shown in Figure 6.8-1.

The fine debris introduced into the IRWST is prevented from entering the pump suction by the IRWST strainers. The IRWST strainers can remove debris greater than 2.38 mm (3/32 in) in diameter. The strainer design includes redundancy, a large surface area to account for potential debris blockage and maintain safety performance, corrosion resistance, and a strainer hole size to minimize downstream effects. Additional design attributes are described in Reference 4.

6.8.2.2.2 Holdup Volume Tank

The HVT is located between the primary shield wall and the IRWST inner wall.

During accidents, water from breaks and CS are drained and collected in the HVT. The collected water reaches the IRWST spillways and then flows into the IRWST.

The HVT delays cavity flooding after the actuation of the CFS to allow MCR operators to abort the cavity flooding if desired.

6.8.2.2.3 Cavity Flooding System

The function of the CFS is to flood the reactor cavity in the event of a severe accident to cover core debris in the reactor cavity with water. Covering the core debris facilitates the cooling and stabilization of the debris.

6.8.2.2.4 Valves

The relative location, valve type, operator type, position during normal plant power operation, and failure position of IRWST and CFS valves are shown in Figure 6.8-3.

HVT flooding valves are normally closed, and these motor-operated gate valves are in the flow paths that connect the IRWST to the HVT. Reactor cavity flooding valves IW-0003

and -0004 are normally closed, and these motor-operated gate valves are in the flow paths that connect the HVT to the reactor cavity. These two groups of valves are designated as the CFS valves. These valves are opened by the operator from the MCR to flood the reactor cavity in the event of a severe accident. Controls are provided to allow the valves to be opened either individually or simultaneously for reactor cavity flooding.

Normally closed motor-operated gate valves are located in the IRWST suction line to the boric acid makeup pumps. These gate valves are opened from the MCR to allow adjustments of the IRWST boron concentration during normal operation or to supply the borated water to the reactor cavity for external reactor vessel cooling operation in a severe accident condition. These valves automatically close upon receiving a containment isolation actuation signal (CIAS).

Local-manual valves are normally locked open gate valves located upstream of the MOVs in each flow path connecting the IRWST to the HVT. These local manual valves are closed during stroke testing of the MOVs to prevent draining the IRWST.

6.8.2.2.5 IRWST Pressure Devices

Protection for overpressure and vacuum of the IRWST is provided by 12 swing panels on the side walls of four vent stacks. The vent stacks are located on the concrete slab at elevation 100 ft, the top of the IRWST. The swing panels are installed on three side walls of each vent stack as pressure relief device (two swing panels for overpressure protection and one swing panel for vacuum protection).

The swing panels are self-actuated by IRWST pressure and provided for hydrogen venting during a severe accident. The panels accommodate the consequences of a design basis accident (DBA) steam release and POSRV actuation, assuming that no cooling of the IRWST is available.

The swing panels provide 13.38 m^2 (144 ft^2) of free vent area for a severe accident with POSRV actuation. The swing panels work with the passive autocatalytic recombiners (PARs) to prevent detonable hydrogen concentrations in the IRWST during a severe accident. The PARs are located at the IRWST vent stack area to prevent an accumulation in the IRWST. The hydrogen mitigation system is addressed in Subsection 6.2.5.

The swing panels are also actuated by a vacuum in the IRWST, which prevents a vacuum from being drawn in the IRWST during SI actuation, CS actuation, and normal drain down from the IRWST to the refueling pool.

The swing panels are located to minimize impact on maintenance laydown space on the 100 ft elevation. They are also located to prevent jetting from the spargers in the IRWST during POSRV actuation. The IRWST vent stacks and swing panels locations are shown in Figure 6.8-4.

The swing panels are arranged to prevent water from entering the IRWST through the swing panels during normal operation or after an accident. This arrangement provides reasonable assurance that the water enters the IRWST from the holdup volume and that the TSP baskets are used for pH control during DBAs. This is accomplished by swing panels that are installed at the vent stack above the maximum flood elevation and by providing covers above the swing panels.

6.8.2.2.6 IRWST Strainer

The four independent sets of strainers are located in the IRWST and each strainer is for one of the four SI pumps, and for one of two SC pumps and two CS pumps. Each strainer has enough surface area of 55.74 m^2 (600 ft^2) and perforated plate hole size of 2.38 mm (3/32 in). These strainers prevent debris from entering the reactor and causing inadequate core or containment cooling. The strainers are designed to be fully submerged during all postulated events requiring the actuation of the ECC or containment spray, which minimizes the effects of floating or buoyant debris on the integrity of strainer and on subsequent head loss. The strainers are design to meet safety Class 2 and seismic Category I requirements.

Additional design features are described further in Reference 4 and Subsection 6.8.4.5.

6.8.3 Instrumentation

IWSS instrumentation is designed in accordance with the applicable portions of the IEEE standards and NRC RGs that are identified in Subsection 7.1.2.

6.8.3.1 Level

a. IRWST

1) Four wide range (0 to 100 percent) level indication channels are provided.

2) Each channel indicates IRWST fluid level locally.

3) Four channels provide level indication in the MCR and RSR. These channels are designed to electrical Class 1E requirements. Level alarms are provided in the MCR and RSR. A high level setpoint of elevation 28.39 m (93.15 ft) is established to warn the operator when the IRWST is overfilled. A low level alarm setpoint of 28.30 m (92.85 ft) elevation is established to warn the operator when the level is reduced to the volume required for SI/CS pump operation in consideration of the instrument uncertainties and the unrecovered water volume that would probably have accumulated in the containment building as a result of the post-accident SI and CS.

4) Each channel is used for post-accident monitoring of IRWST fluid level.

b. Holdup volume tank (HVT)

1) One narrow range and four wide range (0 to 100 percent) level indication channels are provided.

2) The narrow range channel is used to detect the presence of fluid in the HVT; this channel is non-class 1E. The narrow range channel actuates an alarm in the MCR to alert the operator that the HVT is being filled with water.

3) The four wide range (0 to 100 percent) percent channels are powered by the vital instrument bus. Level indication is provided in the MCR and RSR to allow the operator to monitor HVT level after an accident.

c. Reactor cavity

1) One narrow range and four wide range (0 to 100 percent) percent level indication channels are provided.

2) The narrow range level channel (non-class 1E) is used to detect the presence of fluid in the reactor cavity. The narrow range channel actuates an alarm in the MCR and RSR to alert the operator that the reactor cavity is being filled with water. The narrow range level channel is identified in Subsection 9.3.3.

3) The four wide range (0 to 100 percent) channels are powered by the vital instrument bus. Level indication is provided in the MCR and RSR to allow the operator to monitor reactor cavity fluid level after an accident.

6.8.3.2 Temperature

Four IRWST fluid temperature measurement channels are provided.

One channel is designated as non-class 1E and provides IRWST a fluid temperature indication inside the containment.

The three remaining channels are designed to electrical Class 1E requirements. These channels provide a IRWST fluid temperature indication in the MCR; a high/low temperature alarm of 10.0 °C (50 °F) and 48.88 °C (120 °F) is provided to alert the operator when IRWST temperature approaches the minimum or maximum allowable Technical Specification (Chapter 16) limits. The range of the channels is adequate to cover the maximum temperature expected to occur during operation of the POSRVs.

6.8.3.3 Pressure

Four wide range channels powered by the vital instrument bus are provided to indicate the IRWST pressure. Each channel provides an indication of IRWST pressure in the MCR and RSR. The range of the instrumentation is adequate to cover the maximum pressure expected to occur during safety depressurization and vent system operation.

6.8.4 Design Evaluation

6.8.4.1 Borated Water Volume of IRWST

The minimum normal operating water volume of IRWST is 2,373.5 m^3 (627,000 gal). This volume is enough to be supplied to the refueling pool and fuel transfer channel during refueling operation.

6.8.4.2 Available Net Positive Suction Head

The SI and CS pumps are located in the auxiliary building and are placed low enough below the minimum IRWST fluid level to provide reasonable assurance of adequate and available NPSH. The minimum total IRWST fluid volume after an accident is 993.3 m^3 (262,388 gal). This corresponds to a water level elevation of 1.52 m (5.0 ft). The calculated available NPSH for the SI pump and SC pumps or CS pumps at the maximum expected flow, which is equal to both SI pump and SC pump or CS pump taking suction from same line, is provided in Table 6.2.2-1. The calculated available NPSH exceeds the required NPSH of SI pump and SC pump or CS pump from the bottom of IRWST.

The minimum water volume of IRWST during normal operation is 2,373.5 m^3 (627,000 gal). This volume provides sufficient available NPSH to the SI pumps and SC pumps or CS pumps.

6.8.4.3 Hydrodynamic Loads on the IRWST

Pressure variations in the IRWST are related to the discharge of water, air, and single- and two-phase steam from the POSRV into the IRWST. The primary time varying pressure load on the IRWST is due to the discharge of air present in the lines prior to actuation of valves. This air coalesces into bubbles resulting in periodic variations in pressure in the fluid as the bubbles oscillate prior to the start of steam injection. Oscillatory loads can occur near the end of the discharge due to intermittent condensation related to low quality steam or IRWST inventory approaching saturation.

The largest dynamic loads on the IRWST are dependent on the pressure and frequency of the air bubble formed during the air clearing phase. The scaling factors to determine the

source pressure of the air bubble are developed based on the boiling water reactor (BWR) test results. Pressure calculations are performed based on a source pressure of 1.49 kg/cm^2D (21.2 psid). The dominant bubble frequency is scaled as range of 4 to 14 Hz. Predictions include the effect of the asymmetry in the sparger location relative to the boundaries of the IRWST.

6.8.4.4 Pool Temperature of IRWST

The spargers are designed to effectively condense the steam and to minimize the loads on the structure. However, if the pool temperature of the IRWST increases, significantly high loads on the IRWST structure may occur due to unstable steam condensation. Therefore, for the APR1400 design, the following regulatory requirement has been selected, so the limited pool temperature of each type of sparger in the IRWST is specified to prevent unstable steam condensation phenomena and as the most conservative pool temperature condition in the condensation sump of the BWR: "The local suppression pool temperature should not exceed 93.3 °C (200 °F)" (ASME Section XI).

In the event of the inadvertent operation of the POSRV as the DBA, the analyses of average and local pool temperature are performed. The analysis of the average pool temperature is conducted using analytical calculations, and the local pool temperature analysis is conducted using the ANSYS-CFX code (Reference 5). According to the results, both of average and local pool temperature in the IRWST are maintained less than 93.3 °C (200 °F). The local pool temperature is set as the temperature of the node above the spargers, corresponding to the definition of local pool temperature in NUREG-0783 (Reference 6).

6.8.4.5 Performance of the IRWST Sump Strainer

The performance evaluation of IRWST sump strainer during a LOCA and long-term post-LOCA related to Generic Safety Issue (GSI)-191 is described in Reference 4 in accordance with NRC RG 1.82 (Reference 3). The following subsections are the summary of key information to address GSI-191.

6.8.4.5.1 Break Selection

The design basis accidents (DBAs) requiring engineered safety features (ESF) system action result in full ESF initiation, which initiates four safety injection pumps (SIPs), and two containment spray pumps (CSPs). The shutdown cooling pumps (SCPs) may be initiated when the CSP is not available.

The design basis accidents that result in debris generation are categorized as 3 scenarios, Large Break loss-of-coolant accident (LBLOCA), Small Break loss-of-coolant accident (SBLOCA), and other high-energy-line break (HELB).

Break location is selected considering the determination of the size and location of HELBs that produce debris and potentially challenge the performance of the IRWST sump strainers. Based on the pipe break sizes and locations which are determined as a result of the above reviews of the accident analysis and operational procedures that require the ECCS and CSS to take suction from the IRWST sumps, the postulated break location is selected by considering the guidance recommended in NEI 04-07 (Reference 7) and Safety Evaluation (SE) for NEI 04-07 (Reference 8).

Based on the break criteria in SE for NEI 04-07, the junction of the RCS HL pipe (42 in) and SG included in LBLOCA was selected as the postulated limiting break location. This selection for break location is reasonable because the SGs have a larger volume of insulation applied to them than does RCS piping and most of the primary system piping is located in this compartment. The larger amount of insulation presents and volume of debris are transported to the IRWST sump strainer comparing to other scenarios. This results in the maximum head loss across the IRWST sump strainer.

6.8.4.5.2 Debris Generation

The sources of debris in the APR1400 are insulation debris, coating debris, and latent debris. For the insulation debris, the Reflective Metal Insulation (RMI) is considered as a potential debris source following a HELB.

In estimating the debris generation, the spherical ZOI is used. All significant debris sources (e.g., insulation, fixed debris) within the ZOI were evaluated. For insulation (RMI)

and coating debris, the diameter of the ZOI is defined as 2 and 4 (10 for IOZ) times of diameter of the broken pipe respectively.

For latent debris, 90.72 kg (200 lbs) of latent debris with a 7.5 percent / 92.5 percent (fiber to particulate) spilled is assumed as latent debris loads. To deal with the quantity of miscellaneous debris, a 9.29 m^2 (100 ft^2) penalty of sacrificial strainer surface area per sump is applied.

Total amount of debris generated during an LBLOCA are provided in Table 6.8-3.

6.8.4.5.3 Debris Characteristics

Three potential sources of debris are evaluated for their impacts on the APR1400 recirculation flow path and LTCC.

All fibrous latent debris within containment is assumed as fines easily remains suspended in water (even relatively quiescent water) and collected in the sumps following the SE for Nuclear Energy Institute (NEI) 04-07 (reference 8).

For RMI, it is assumed to consist of 75 percent for small fines and 25 percent for large pieces as the size distribution of any type of RMI inside a pipe break ZOI in accordance with NEI 04-07 guideline (Reference 7). RMI is sufficiently dense and the flow rates are also sufficiently small so that the RMI debris is considered as non-suspended and is not transported to the strainer.

For coatings, all qualified coatings within the ZOI are considered small fine particles based on Section 3.4.3.2 of NEI 04-07 (Reference 7). All coating debris will be suspended and transported in the recirculating water along with the latent debris to the strainers.

For chemical precipitates, detail information is provided in Subsection 6.8.4.5.7.

The size range of the debris materials is based on (i) the assumption that 100 percent of particulates will bypass the ECCS strainers, and (ii) guidance from NEI 04-07 Volume 2 Appendix V (Reference 7). The concentration of the post-LOCA fluid constituents is

conservatively estimated. The detail information is provided in Subsection 4.2.2.6 and Table 4.2-5 of Reference 4.

In addition, bypass debris size distribution is provided in Strainer Bypass Test Report (Appendix B of Reference 4).

6.8.4.5.4 Debris Transport

Debris transport quantifies debris that transports to the sump strainer. The amount of debris generation and characteristics of debris transport are used to determine debris accumulation. The blockage of the strainers and its effect on the net positive suction head (NPSH) of the pumps are considered conservatively when the accumulation has reached its maximum. In accordance with the guidance provided in Section 3.6.1 of NEI 04-07 (Reference 7), four major debris transport modes (blowdown, washdown, pool fill-up, and recirculation) are considered.

RMI is assumed to be transported to the containment floor. However, RMI is not to be transported to the IRWST sump strainer because of the containment bottom floor's (El. 100 ft) lower postulated flow velocity.

All particulate and coating debris are assumed to be fine enough to remain in suspension due to turbulence and to be transported to the IRWST sump strainers. This assumption provides the most conservative upper limit for the debris transport evaluation and has the debris breaking down to its minimum size initially so no further particle size reduction occurs during transport. Latent debris is categorized as fiber and particulates and assumed to be uniformly distributed. All latent fiber is assumed to have the same fiber diameter as Nukon insulation.

The APR1400 design has four ECCS/CS trains with an independent strainer for each train. The design requires a minimum three trains in operation assuming another trains have a single failure. Therefore, transported debris in the IRWST is assumed to be distributed to three sumps. However, the APR1400 design assumes that all of break-generated coating, latent debris, and chemical recipitates will be transported directly to a single sump for conservatism for the strainer head loss evaluation and the NPSH evaluation. For the bypass debris fraction, the number of available sumps should maximize the amount of

bypass debris, i.e., assume four operating sumps. No credit is taken for debris settlement on the floor or entrapment in ineffective pool.

6.8.4.5.5 Debris Head Loss

The IRWST sump strainer is designed to fit over the top of the IRWST sump pits with flow directly into the pit to minimize clean strainer head losses. As a calculation results of the clean strainer head losses, 7.62 cm (0.25 ft) for a temperature of 60 °C (140 °F) is determined.

The strainer head loss testing was planned and conducted to develop experimental head loss data with the design debris loading. This testing was designed to either demonstrate that the head loss associated with the strainer is acceptable for the design debris loading or to identify the maximum allowable debris loading that will result in acceptable head loss.

A 46.45 m^2 (500 ft^2) effective strainer area is conservatively applied considering a 9.29 m^2 (100 ft^2) penalty of sacrificial strainer surface area for miscellaneous debris such as signs, placards, tags or stickers. As a result of testing, the maximum head loss for the 46.45 m^2 (500 ft^2) effective strainer area with the maximum debris load is 24.69 cm (0.81 ft) at the design flow rate and includes a clean screen component of 15.85 cm (0.52 ft). Therefore, the debris only head loss is 8.84 cm (0.29 ft). The test result is provided in Appendix B of Reference 4.

The prototype debris head loss test results and calculated clean strainer head loss were combined to provide a total strainer head loss that is compared to the allowable head loss. The total strainer head loss value is the sum of the clean strainer head loss and debris head loss. This will be conservatively calculated by double counting the clean screen component (using the analytical value and the test value inherent in the measure debris head loss) or 7.62 cm (0.25 ft) plus 24.69 cm (0.81 ft) equals 32.31 cm (1.06 ft) at 60 °C (140 °F). Consequently, the result of a total strainer head loss less than the allowable head loss (0.61 m (2 ft)) validates the design.

6.8.4.5.6 Vortexing, Flashing, and Deaeration

Vortexing, flashing and deaeration is one of the primary safety concerns about long-term recirculation cooling following a LOCA in RG 1.82 (Reference 3). Visual observation and analysis were conducted to verify the IRWST sump strainer performance.

For vortexing, visual observation during the strainer head loss test was performed at the submergence requirement of 0.61 m (2 ft) submergence and no vortices were observed. Additionally, there is no possibility to occur vortexing and air ingestion geometrically because the IRWST sump strainers are mounted at the top of the pit with the suction taken at the bottom of the pit.

For flashing, the strainer flashing requirement is conservatively met if the pressure drop across the debris bed is less than the submergence. Based on the IRWST minimum water level for ECC/CS pump NPSH, 0.61 m (2 ft) submergence under LOCA conditions is obtained and the maximum strainer head loss is 32.32 cm (1.06 ft) at 60 °C (140 °F) as result of the strainer head loss test. Therefore, flashing will not occur across the strainer surface.

For deaeration, the IRWST sump strainer submergence during post-LOCA is greater than the observed head loss under loss of coolant conditions. Since solubility of gas in water is directly proportional to the fluid pressure, the increase in solubility of air due to the static pressure increase of the water above the strainer is more than enough to compensate for the decrease in solubility of air due to the head loss across the strainer. Therefore, deaeration of fluid will not occur.

6.8.4.5.7 Chemical Effects

In order to assess potential chemical effects in the APR1400 sump, the materials in the containment building that may react with coolant in the post-accident containment environment have been identified. The primary corrosion products contributing to these chemical precipitates are calcium, silicon and aluminum, and the precipitates that can form are aluminum oxy-hydroxide, calcium phosphate and sodium aluminum silicate.

Surrogate suspensions of chemical precipitates representing this chemical debris can be included as an additional debris source to the strainer testing program to qualify the strainer for "chemical effects". The quantities of chemical precipitates are based on reactive material surface areas and quantities, temperature, water level, pH and other parameters related to the plant specific environment and postaccident evolution. The calculated result based on the WCAP-16530-NP (Reference 9) methodology referenced in RG 1.82 (Reference 3) is provided in Table 6.8-3.

6.8.4.5.8 Upstream Effects

The evaluation of upstream effect is a review of the flow paths leading to the IRWST, identifying those flow paths which could result in blocking the return water that could challenge the IRWST minimum water level evaluation. The evaluation also includes identifying the hold-up volumes, such as recessed areas and enclosed rooms, for which trapped water will not return to the IRWST. All of the hold-up volumes were taken account of in the minimum water level calculation. Detail holdup volume is provided in Table 6.8-2.

Figure 6.2.1-20 show a schematic of containment spray and blowdown return pathways, and the schematic of potential water traps in containment. During long-term cooling subsequent to a RCS pipe break, borated water is drawn from the IRWST by the SIPs and injected into the RV for core cooling. This water is ejected to the bottom floor of the containment within the secondary shield wall through the horizontal platforms which are constructed of open grating within the SG compartments. The CSPs also draw water from the IRWST sumps to cool the containment building. This water rains down on all containment surfaces, and then drains to the bottom floor of containment within secondary shield wall and annulus via the stairway and a ring of deck grating around much of the circumference of the building.

Water spilled from RCS break and the uniformly distributed containment spray water drain back to the HVT, and then drains to the IRWST via spillways. Since there are four pathways on the bottom floor of the containment, the debris will not clog these pathways. As a result of evaluation, no choke points that may block the flow paths of return water are identified. Therefore, only the hold-up volumes may challenge the minimum water level of the IRWST.

The minimum water level of the IRWST during a LOCA was calculated by subtracting the hold-up volume from the initial water volume in the IRWST and by adding the three SITs volume. The minimum water level used in the NPSH evaluation is calculated as 5 ft above the IRWST bottom (El. 81 ft). Detail information for IRWST water level is provided in Figure 3.9-3 of Reference 4.

6.8.4.5.9 Downstream Effects

The requirements of USNRC RG 1.82, Rev. 4 (Reference 3), state that potential IRWST sump strainer downstream flow restrictions due to debris blockage shall be evaluated to ensure appropriate longterm recirculation cooling, containment cooling, and containment pressure control capabilities. To evaluate the downstream components, a determination of the quantity of the bypass debris is necessary. Given that the strainer is fabricated from perforated plate, the strainer should be sized large enough to produce an acceptable pressure drop for the debris load, but not excessively large that it passes too much bypass debris.

The key material in the blockage of downstream components is the fibrous debris. While particulates and chemical precipitates effects can become entrained in the recirculation flow path, without any fibrous materials, a debris bed and blockage point is difficult to form. The total fibrousdebris load at the strainer has been established at 6.80 kg (15 lbs) of latent fiber. There are four independent 55.74 m^2 (600 ft^2) ECCS strainer trains in the APR1400.

To establish the quantity of fibrous debris that could potentially penetrate (bypass) the strainer, strainer bypass testing was performed. The testing was performed with only fibrous debris as adding particulates may reduce the amount of bypass debris due to clogging at the strainer. During the fuel blockage testing, varying amounts of particulate to fiber ratios can be explored to determine the limiting amount of particulate (up to the maximum amount). Additionally, unlike strainer head loss testing, the most conservative approach with bypass testing is to assume all sump strainers are active running at the maximum flow rates since it stands to reason that more mass flow rate and more perforated plates causes more bypass. The strainer bypass test result is provided in Appendix B of Reference 4.

The evaluation result of ex-vessel downstream effect is that ECCS and CSS of the APR1400 are fully designed to perform their safety function under post-LOCA conditions.

This result also verifies that inadequate core or containment cooling does not occur because of debris blockage at flow restrictions, plugging or excessive wear of close-tolerance component (e.g., pumps, heat exchangers, piping, valves, spray nozzles) in the flow path. The component design parameter used in the evaluation of ex-vessel downstream effect is listed in Table 6.2.2-2, 6.3.2-1, and 6.8-4.

As a result of strainer bypass test, the amount of bypass fiber per fuel assembly (FA) is less than the 15 gram limit. Based on this information, the evaluation result of in-vessel downstream effect is that the maximum total deposit thickness and the peak cladding temperature are maintained within the WCAP-16793-NP (Reference 10) LTCC criteria with enough margin, and the LTCC can be maintained.

6.8.4.5.10 Potential Debris Source Control

Programmatic controls are established to ensure that potential sources of debris introduced into containment (e.g., insulation, coatings, foreign material, aluminum), and plant modifications do not adversely impact the SI and CS/SC recirculation function.

Programmatic controls are established consistent with the guidance in NRC RG 1.82, Rev. 4 (Reference 3), which provides reasonable assurance that (1) potential quantities of post-accident debris are maintained within the bounds of the analyses and design bases that support the safety injection (SI), containment spray (CS), and shutdown cooling (SC) recirculation functions and (2) the long-term core cooling requirements of 10 CFR 50.46 (Reference 11) are met.

The following is a summary of the programmatic controls that are implemented to provide reasonable assurance of the proper operation of IRWST sump strainer and limits the quantities of latent debris (e,g., unintended dirt, dust, paint chips, fibers) and miscellaneous debris (e.g., tape, tags, stickers) are limited inside containment:

a. Preparation of a cleanliness, housekeeping, and foreign materials exclusion program. This program addresses latent and miscellaneous debris inside containment. An acceptance criterion below the conservative assumption of 90.72 kg (200 lb) for latent debris inside containment is consistent with Reference 4. The programs also ensure that the quantity of miscellaneous debris, such as signs, placards, tags or stickers in the containment is limited so that the 9.29 m^3

(100 ft^2) strainer sacrificial area per sump is met to provide reasonable assurance of the IRWST sump strainer operation.

b. Procedures are implemented to ensure of administrative controls established forregulatory and quality requirements for plant modifications and temporary changes thatinclude consideration of materials introduced into the containment that could contribute to sump strainer blockage. Included are requirements for controlling temporary modifications to systems, structures, and components (SSCs) in a manner that provides reasonable assurance of compliance with 10 CFR 50.46. Future plant modifications will be evaluated in accordance with the requirements of 10 CFR 50.59 (Reference 12) and 10 CFR 52.63 (Reference 13).

c. Maintenance activities, including associated temporary changes, are subject to the provisions of 10 CFR 50.65(a)(4) (Reference 14), which requires a licensee to assess and manage the increase in risk that can result from the proposed maintenance activities, prior to performing the activities. These activities can be shown to be acceptable with respect to the IRWST sump strainers by any of the following means:

1) Performing the activities when the IRWST sump strainers are not required to be operable and restoring conditions consistent with the design bases prior to reestablishing operability

2) Deterministic evaluation that concludes the specific activities do not create a condition that adversely affects strainer performance

3) Control of maintenance activities within the bounds established by approved programs that provides reasonable assurance of no adverse impact (e.g., activities do not result in exceeding limits established for temporary use of material inside containment)

4) Risk assessment for a specific activity

The COL applicant is responsible for the establishment and implementation of the Maintenance Rule program in accordance with 10 CFR 50.65 (COL 6.8(4)).

d. A containment coating monitoring program is implemented in accordance with the requirements of NRC RG 1.54, Rev. 2 (Reference 15). The coatings program is described in Subsection 6.1.2.

6.8.5 Testing and Inspection

Inservice inspection and testing of ASME Section III Class 2 and 3 components are conducted in accordance with the programs described in Subsection 3.9.6 and Section 6.6.

6.8.6 Combined License Information

COL 6.8(1) The COL applicant is to provide the operational procedures and maintenance program for leak detection and contamination control.

COL 6.8(2) The COL applicant is to provide the preparation of cleanliness, housekeeping, and foreign materials exclusion program.

COL 6.8(3) The COL applicant is to maintain the complete documentation of system design, construction, design modifications, field changes, and operations.

COL 6.8(4) The COL applicant is responsible for the establishment and implementation of the Maintenance Rule program in accordance with 10 CFR 50.65.

6.8.7 References

1. 10 CFR 20.1406, “Radiological Criteria for Unrestricted Use,” U.S. Nuclear Regulatory Commission.

2. Regulatory Guide 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," Rev. 0, U.S. Nuclear Regulatory Commission, June 2008.

3. Regulatory Guide 1.82, “Water Source For Long-Term Recirculation Cooling Following a Loss-Of-Coolant Accident,” Rev. 4, U.S. Nuclear Regulatory Commission, March 2012.

4. APR1400-E-N-NR-14001-P (Proprietary) & NP (Non-Proprietary), “Design Features to Address GSI-191,” Rev. 0, KHNP, 2014.

5. ANSYS, Inc., “ANSYS-CFX User’s Manual,” Release 12.0.

6. NUREG-0783, “Suppression Pool Temperature Limits for BWR Containments,” U.S. Nuclear Regulatory Commission, November 1981.

7. NEI-04-07, “NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," May 2004.

8. Safety Evaluation By The Office Of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), "Pressurized Water Reactor Sump Performance Evaluation Methodology," December 2004.

9. WCAP-16530-NP-A, Rev.0, "Evaluation of post-Accident Chemical Effect in Containment Sump Fluid to Support GSI-191," April 2008.

10. WCAP-16793-NP, Revision 2, “Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid,” October 2011.

11. 10 CFR 50.46, “Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors,” U.S. Nuclear Regulatory Commission.

12. 10 CFR 50.59, “Change, Tests and Experiments,” U.S. Nuclear Regulatory Commission.

13. 10 CFR 52.63, “Finality of Standard Design Certifications,” U.S. Nuclear Regulatory Commission.

14. 10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” U.S. Nuclear Regulatory Commission.

15. Regulatory Guide 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, December 2010.

Table 6.8-1 (1 of 3)

IWSS Component Parameters

In-containment Refueling Water Storage Tank	
Quantity	1
Safety class	3
Code	Refer to Subsection 3.8.3
Seismic category	I
Design temperature	143.3 °C (290 °F)
Normal operating water level	Elevation 93 ft 0 in
Normal operating water volume	2,456.7 m^3 (86,759 ft^3)
Normal operating freeboard volume	836.4 m^3 (29,537.87 ft^3)
Fluid	Borated water, 4,000 to 4,400 ppm
Material	Reinforced concrete, austenitic stainless steel lined
Holdup Volume Tank	
Quantity	1
Safety classification	3
Code	Refer to Subsection 3.8.3
Seismic category	I
Design temperature	143.3 °C (290 °F)
Volume Normal operation Accident	 Empty 212.3 m^3 (7,497 ft^3) prior to spillover to IRWST
Fluid	Containment spray
Material	Reinforced concrete, austenitic stainless steel lined

Table 6.8-1 (2 of 3)

Holdup Volume Tank Spillway Valves	
Quantity	2
Safety classification	2
Code	ASME Section III, Class 2
Size	355.6 mm (14 in) diameter
Type	Gate
Operator	Electric motor, 460V ac(1)
Design pressure	5.625 kg/cm^{2}g (80 psig)
Normal operating pressure	0.914 kg/cm^{2}g (13 psig)
Design temperature	182.2 °C (360 °F)
Fluid	Borated water, 4,000 to 4,400 ppm
Body material	Austenitic stainless steel
Reactor Cavity Spillway Valves	
Quantity	2
Safety classification	2
Code	ASME Section III, Class 2
Size	30.48 cm (12 in) diameter
Type	Gate
Operator	Electric motor, 460V ac(1)
Design pressure	5.625 kg/cm^{2}g (80 psig)
Design temperature	182.2 °C (360 °F)
Fluid	Borated water, 4,000 to 4,400 ppm
Body material	Austenitic stainless steel

(1) Rated for 460 Vac but fed from a 125 Vdc power source through an inverter

Table 6.8-1 (3 of 3)

IRWST Purification Valves	
Quantity	2
Safety classification	2
Code	ASME Section III, Class 2
Size	100 mm (4 inch) diameter nominal
Type	Gate
Operator	Electric motor, 460V ac
Design pressure	5.625 kg/cm^{2}g (80 psig)
Design temperature	143.3 °C (290 °F)
Fluid	Borated water, 4,000 to 4,400 ppm
Body material	Austenitic stainless steel
IRWST Strainer	
Quantity	4
Safety classification	2
Code	AISC N690
Seismic category	I
Surface area	55.74 m^2 (600 ft^2) per strainer
Type	cartridge
Hole size	2.38 mm (3/32 in)
Design flow	25.21 m^3/min (6,660 gpm)
Debris head loss	32.3 cm (1.06 ft) at 60 ^{o}C (140 ^{o}F)

Table 6.8-2

Holdup Volume in the Containment

Volume Source	Volume	
	m^3	ft^3
[1] Holdup volume on the way to the IRWST		
Containment spray suspended water in the containment atmosphere	3.1	110
Containment spray steam water	170.7	6,028
Initial filling water for SI System and CS System pipe	30.6	1,080
Water stream on the floor at El. 100 ft	229.6	8,109
Water stream on the floor of refueling pool	42.4	1,496
Miscellaneous hold-up volume	140.0(1)	4,944
Subtotal [1]	616.4	2,250
[2] Inactive pool volume in reactor containment building		
Holdup volume tank (HVT) volume	212.3	7,497
Reactor cavity and ICI cavity volume	621.5	21,949
Containment drain sump volume	11.8	416
ICI cavity sump volume	3.4	120
Subtotal [2]	849.0	29,982

(1) The miscellaneous hold-up volume is water volume held-up elsewhere such as water on a horizontal surface area before cascading through openings on its way back to the IRWST (assuming that floor drains are clogged), film of water in vertical surfaces of concrete structures, film of water on side surface of equipment, and puddles trapped on top of the concrete structure and equipment.

Table 6.8-3

Design Basis Debris

Debris Type		Debris Amount
Reflective Metal Insulation (RMI)		3.44 / 121.5 (m^3/ft^3)
Qualified Epoxy Coating		132.2 / 291.4 (kg/lbm)
Latent Debris	Particulate	83.9 / 185 (kg/lbm)
	Fibers	6.8 / 15 (kg/lbm)
Miscellaneous		Note
Chemical	Aluminum Oxy-hydroxide	180.6 / 398.2 (kg/lbm)
	Sodium Alumium Silicate	4.3 / 9.5 (kg/lbm)
	Calcium Phosphate	0.7 / 1.5 (kg/lbm)

Note:

To deal with the quantity of miscellaneous debris, a 9.29 m^2 (100 ft^2) penalty of sacrificial strainer surface area per sump is applied.

Table 6.8-4 (1 of 4)

Components in the Flow Path during a LBLOCA

Component	Description
Pumps	
SI pump (SI-PP02A/02B/02C/02D)	Type: Multi-Stage Centrifugal Pump Arrangement: Horizontal Flow rate: ~4,675 L/min (1,235 gpm) (maximum)(1)
CS Pump (CS-PP01A/01B)	Type: Centrifugal Arrangement: Vertical Flow rate: ~24,605 L/min (6,500 gpm) (maximum)(1)
Heat Exchangers	
CS Heat Exchanger (CS-HX01A/01B)	Type: Shell and Tue, U-Tube, Horizontally Mounted Number of Shell in Series:1 Number of Tube Passes: 2 Tube Material; Austenitic Steel Flow rate: ~18,927 L/min (5,000 gpm) (During LBLOCA Containment Spray)
Valves	
CS-V1001/1002	Swing check, 18 in
CS-V1003/1004	Gate (Manual), 18 in
CS-V1007/1008	Swing check, 14 in
CS-V1015/1016/1017/1018	Globe (Manual), 4 in
CS-V001/002/003/004	Gate (MOV), 14 in
SI-V304/305	Gate (MOV), 20 in
SI-V470/402/130/131	Gate (Manual), 10 in
SI-V404/405/434/446	Swing check, 4 in
SI-V435/447/476/478	Gate (Manual), 4 in
SI-V308/309	Gate (MOV), 20 in
SI-V347/348	Gate (MOV), 18 in
SI-V157/158	Swing check, 18 in
SI-V340/342	Gate (MOV), 18 in

(1) Including minimum bypass flow

Table 6.8-4 (2 of 4)

Component	Description
Valves (Cont.)	
SI-V424/426/448/451	Swing check, 4 in
SI-V410/411/412/413	Globe (Manual), 4 in
SI-V302/303	Globe (MOV), 4 in
SI-V100/101	Swing check, 10 in
SI-V395	Gate (MOV), 10 in
SI-V959	Gate (Manual), 10 in
SI-V106/107	Gate (Manual), 18 in
SI-V568/569	Swing check, 14 in
SI-V578/579	Gate (Manual), 14 in
SI-V341/343	Gate (MOV), 14 in
SI-V265/269	Globe (Manual), 4 in
SI-V604/609	Gate (MOV), 4 in
SI-V344/346	Gate (MOV), 18 in
SI-V159/160	Swing check, 18 in
SI-V616/626/636/646	Globe (MOV), 4 in
SI-V113/123/133/143	Swing check, 4 in
SI-V540/541/542/543	Swing check, 4 in
SI-V614/624/634/644	Gate (MOV), 12 in
SI-V217/227/237/247	Swing check, 12 in
SI-V217/227/237/247	Swing check, 12 in
SI-V321/331	Globe (MOV, throttling), 4 in
SI-V523/533	Swing check, 4 in
SI-V957/V958	Gate (Manual), 4 in
SI-V522/532	Swing check, 4 in

Table 6.8-4 (3 of 4)

Component	Description
Orifice	
CS-OR01A/B	CS pump miniflow orifice, 4 in
CS-FE338/348	CS pump outlet flow instrument orifice, 14 in
CS-02A/B, 03A/B	CS main spring ring header orifice, 8 in
CS-OR04A/B	CS main spring ring header orifice, 4 in
CS-OR05A/B, 06A/B	CS auxiliary spring ring header orifice, 4 in
SI-OR01A/B/C/D, 08A/B/C/D, 20A/B/C/D	SI pump miniflow orifice, 4 in
SI-OR02A/B	SC pump miniflow orifice, 4 in
SI-OR06A/B/C/D	SI pump outlet flow orifice, 12 in
SI-OR07A/B	Hotleg injection flow orifice, 4 in
SI-FE311D/321B/331C/341A	SI pump outlet flow instrument orifice, 4 in
SI-FE390C/390D	Hotleg injection flow instrument orifice, 4 in
Containment Spray Nozzle	
Main spray nozzle	Orifice size 0.516 in
Auxiliary spray nozzle	Orifice size 0.22 in

Table 6.8-4 (4 of 4)

Component	Description
Piping	
16" CS Pump Suction Line (SS Sch. 80)	
14" CS Pump Discharge Line (SS Sch. 80)	
12" CS Pump Discharge Line (SS Sch. 80S)	
14" CS Spray Header Line (SS Sch. STD)	
12" CS Spray Header Line (SS Sch. 40S)	
8" CS Spray Header Line (SS Sch 40S)	
6" CS Spray Ring Line (SS Sch 40S)	
4" CS Spray Ring Line (SS Sch 40S)	
24" SI Pump Suction Line (SS Sch. 80)	
20" SI pump Suction Line (SS Sch. 80)	
10" SI Pump Suction Line (SS Sch. 80S)	
4" SI Pump Discharge Line (SS Sch. 120)	
4" SI Pump Miniflow Line (SS Sch. 120)	
4" SI Pump Hotleg Injection (SS Sch. 120)	
4" SI Pump Discharge Line (SS Sch. 160)	
12" SI Pump Discharge Line (SS Sch. 160)	

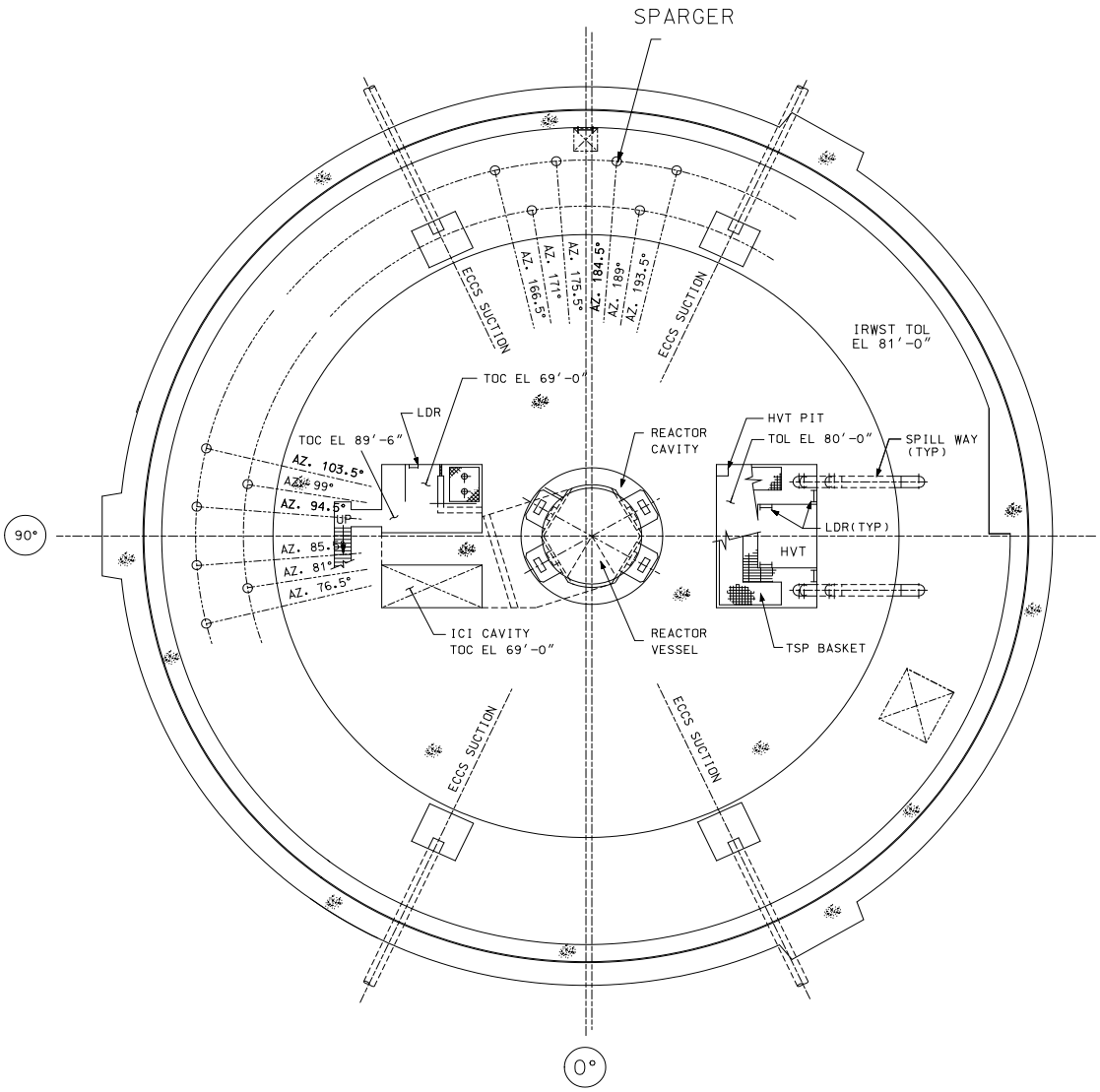


Figure 6.8-1 IRWST and HVT Plan View

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.8-2 IRWST and Cavity Flooding System

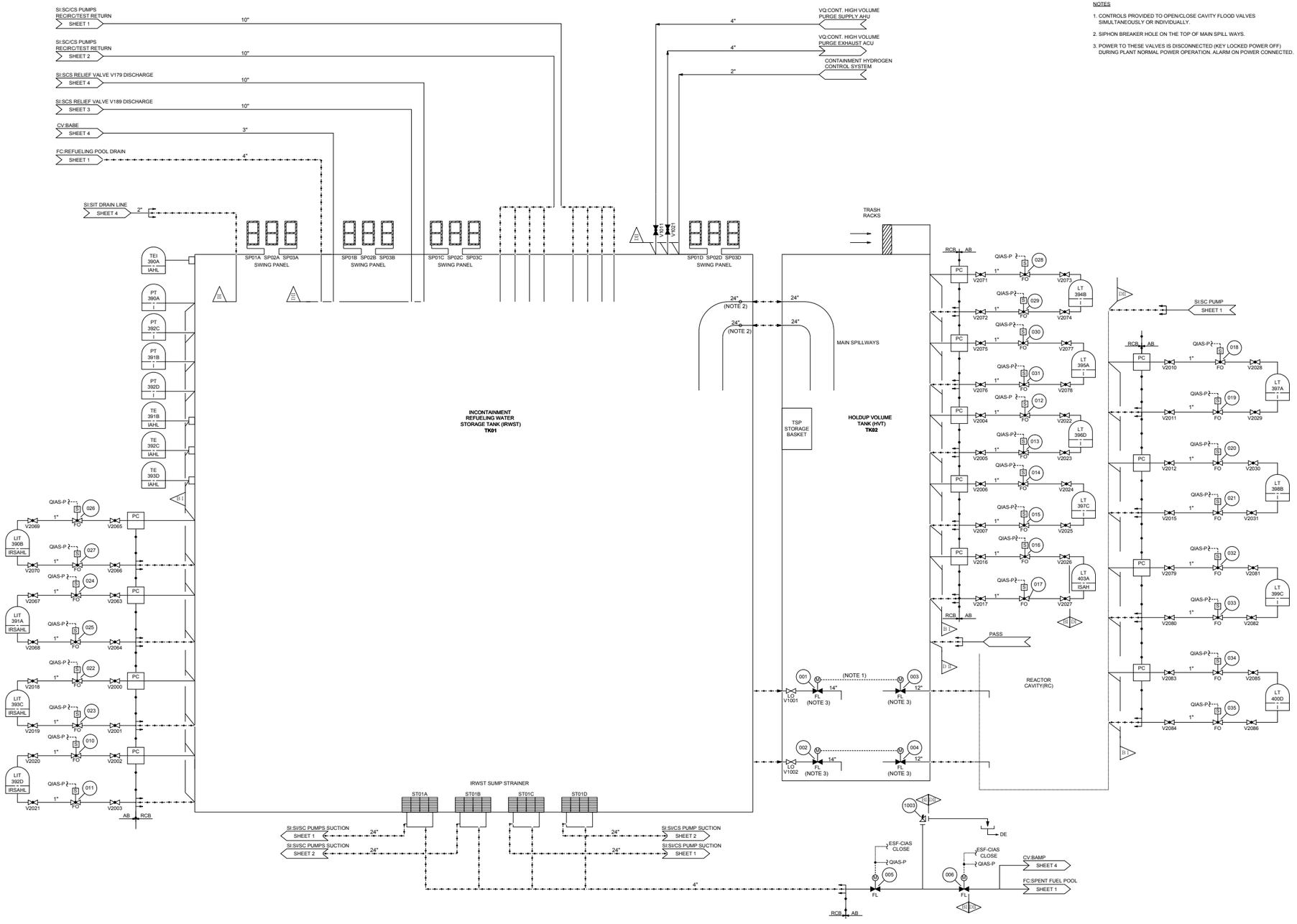


Figure 6.8-3 In-containment Water Storage System Flow Diagram

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 6.8-4 IRWST Vent Location

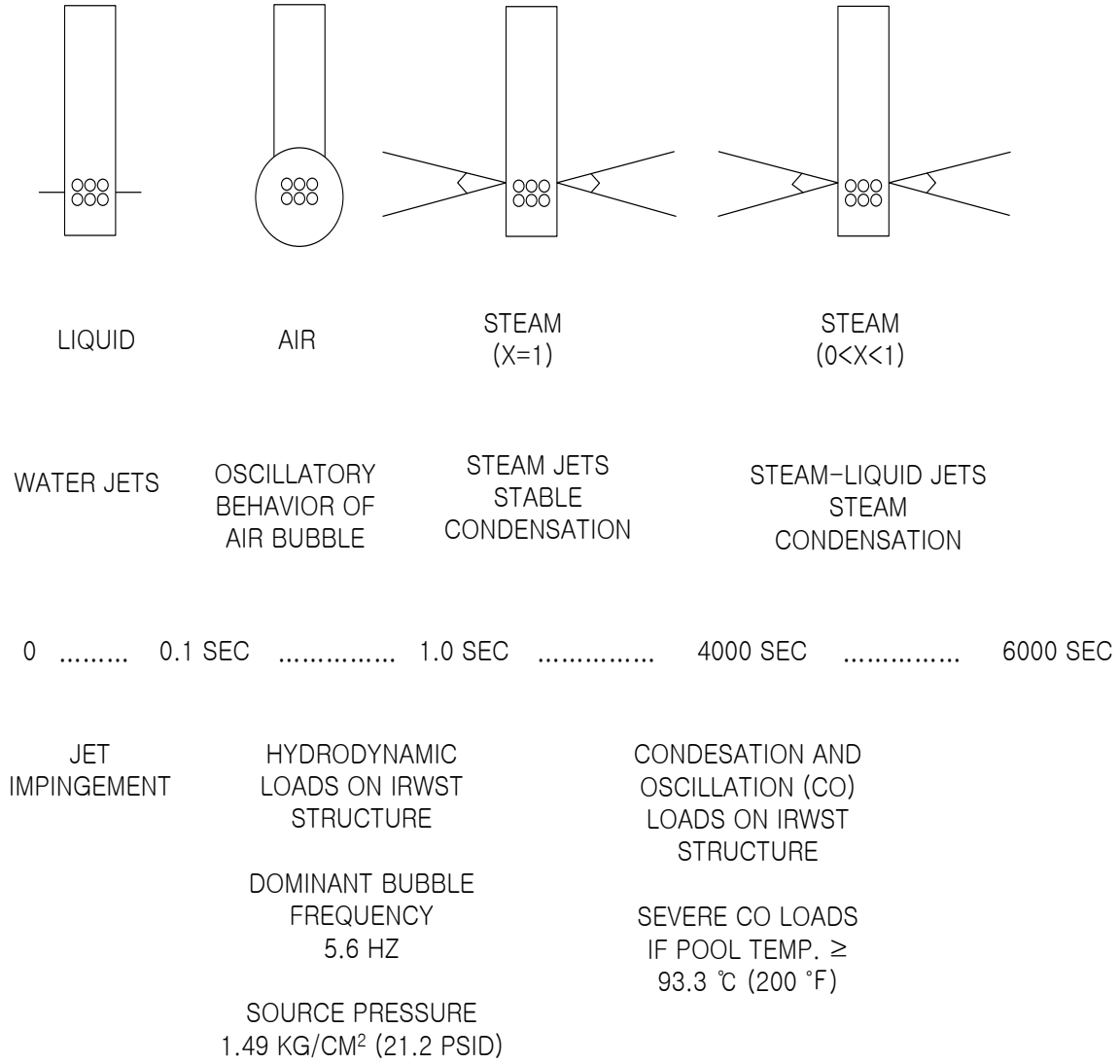
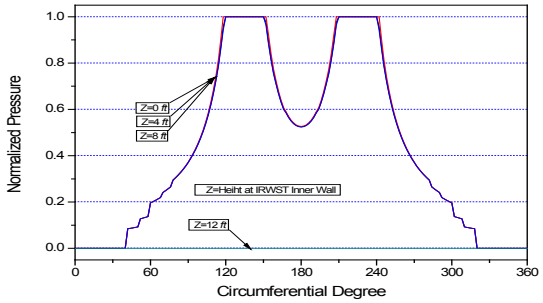
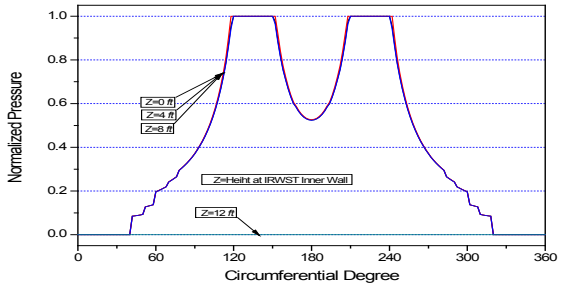


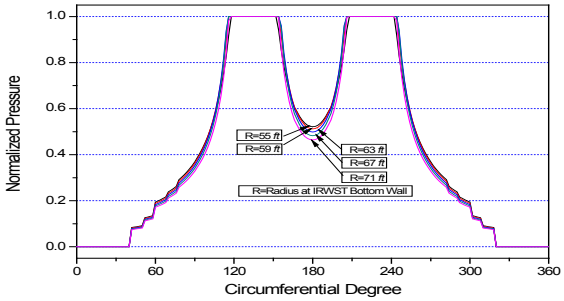
Figure 6.8-5 Effect of Discharge from Sparger vs. Time on IRWST Loads



(a) Inner Wall



(b) Outer Wall



(c) Bottom Floor

Figure 6.8-6 Normalized Pressure Distribution on the Submerged Wall of the IRWST