3.6 Protection Against Dynamic Effects Associated with Postulated Rupture of Piping

This section describes the design bases and measures needed to protect the reactor pressure vessel (RPV) and other essential systems and components inside or outside the containment, including components of the reactor coolant pressure boundary (RCPB), against the effects of blowdown jet, reactive forces, and pipe whip resulting from postulated rupture of piping located either inside or outside of containment.

Section 3.6.1 provides the design bases and criteria required to demonstrate essential systems and components are protected against piping failures outside containment. This section also identifies the high- and moderate-energy systems representing the potential source of dynamic effects associated with pipe rupture. Additionally, the criteria for separation and the effects of adverse consequences are defined in this section.

Section 3.6.2 describes the criteria for determining the location and configuration of postulated breaks and cracks in high- and moderate-energy piping inside and outside of containment; the methods used to define the jet thrust reaction at the break or crack location and the jet impingement loading on adjacent safety-related structures, systems and components (SSC); and the design criteria for pipe whip restraints, jet impingement barriers and shields, and guard pipes.

Section 3.6.3 describes the application of leak-before-break (LBB) criteria used to eliminate from the design basis the dynamic effects of certain pipe ruptures and demonstrate that the probability of pipe rupture is extremely low under conditions consistent with the design basis for the piping.

3.6.1 Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside of Containment

In the event of a high- or moderate-energy pipe failure within the plant, protection is provided so that the essential systems and components[1] are not adversely impacted by the effects of postulated piping failure. The U.S. EPR systems and components that meet the definition of "essential systems and components" are safety-related and are designed to Seismic Category I requirements. These systems and components are listed in Section 3.2.

This section describes the process steps used in designing the plant to protect essential systems and components from the consequences of postulated piping failures outside containment. These steps include:

1. BTP 3-4 defines "essential systems and components" as those "systems and components necessary to shut down the reactor and mitigate the consequences of a postulated pipe rupture without offsite power."

- Identification of the systems and components that are located proximate to high- or moderate-energy pipe systems, that are deemed essential to plant safety, and that are required to safely shut down the plant. The safety-related SSC which require protection from pipe rupture are listed in Section 3.2.
- Identification of the failures for which protection is being provided and design basis assumptions used in the evaluations (Section 3.6.1.1.2).
- Identification of the protection considerations that are utilized in the design to safeguard the essential equipment from the postulated failures (Section 3.6.1.2). Separation and redundancy of essential systems, methods of analyzing the dynamic and environmental effects of the postulated piping failures, and habitability of the main control room (MCR) are also addressed.

The following GDC apply to this section:

- GDC 2 as it relates to protection against natural phenomena, such as seismically-induced failures of non-seismic piping. The application of GDC 2 to this section is to incorporate environmental effects of full-circumferential ruptures of non-seismic moderate-energy piping in areas where effects are not already bounded by failures of high-energy piping. As noted in Section 3.6.1.1, the criteria used to evaluate pipe failure protection conform to the guidance in BTP 3-3 (Reference 1). Additionally, seismic classifications of SSC are provided in Section 3.2.
- GDC 4 as it relates to SSC important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with postulated pipe rupture. In the event of a high- or moderate-energy pipe failure within the plant, protection is provided so that essential SSC are not impacted by the adverse effects of the postulated piping failure. Also, as noted in Section 3.6.1.1, the criteria used to evaluate pipe failure protection conform to the guidance in BTP 3-3. The U.S. EPR design also prevents the dynamic effects of postulated pipe ruptures based on the application of the LBB approach as described in Section 3.6.3.

Table 3.6.1-1 lists those systems that contain high- and moderate-energy lines that are considered when determining the need for protection of essential systems. Table 3.6.1-2 provides a listing of terminal end breaks for the high-energy systems, and provides the location for these breaks by building and room number. Table 3.6.1-3 provides a summary of the evaluation of a subset of the terminal end breaks where there are nearby essential systems and components requiring protection. Table 3.6.1-3 also lists the essential system targets, as well as the type of protection to be designed.

The design of protective structures (such as those used for protection against piping failures) in connection with the review of other Seismic Category I structures is described in Section 3.8.4. The locations and types of piping failures, the design of piping restraints and other protective measures, and the resultant dynamic effects are evaluated in Section 3.6.2. Internal flooding protection from piping failures is

described in Section 3.4. The environmental effects of pipe rupture, (e.g., temperature, humidity, and spray-wetting) are addressed in Section 3.11. The inservice inspection criteria of piping within protective structures or guard pipes are provided in Section 6.6.

BTP 3-4 (Reference 2) defines the criteria used for postulating the locations of breaks and leakage cracks in high-energy lines and leakage cracks in moderate-energy lines. Per Reference 1, full circumferential breaks in non-seismic moderate-energy piping are considered, in addition to the ruptures required by Reference 2. Reference 2 does not consider full circumferential breaks in moderate-energy piping, only through-wall cracks.

3.6.1.1 Design Basis

This section describes the design basis for protection of essential systems and components against the following postulated pipe ruptures outside of containment:

- High-energy line breaks (circumferential and longitudinal).
- High-energy line through-wall leakage cracks.
- Moderate-energy through-wall leakage cracks.
- Breaks in the main steam (MS) and main feedwater (MFW) lines in containment penetration areas.

3.6.1.1.1 Criteria and Assumptions

The criteria used to evaluate pipe failure protection are consistent with NRC guidelines including those in the Standard Review Plan (Reference 3) Sections 3.6.1 and 3.6.2, and References 1 and 2.

The following criteria and assumptions were used to determine the protection requirements for high- and moderate-energy fluid system piping failures outside containment:

- The postulated pipe failure type is based on whether the piping system is a high- or moderate-energy system. A system is considered to be high-energy when the maximum operating temperature exceeds 200°F and/or the maximum operating pressure exceeds 275 psig during normal conditions (operating conditions during reactor startup, operation at power, hot standby, or reactor cooldown to cold shutdown conditions).
- Systems which are pressurized above atmospheric pressure during plant operating conditions that do not meet the high-energy system requirements are considered moderate-energy.

- Piping systems are also considered moderate-energy if they only exceed 200°F or 275 psig for two percent or less of the time they are in operation, or experience high-energy temperatures or pressures less than one percent of plant operation time.

- The events for which the high- and moderate-energy lines are evaluated include breaks and cracks. Breaks and through-wall leakage cracks are analyzed for their dynamic and environmental effects. Dynamic effects include jet impingement and pipe whip, while the environmental effects include flooding (Section 3.4), spray wetting, and increased temperature, pressure, and humidity inside the rooms affected by the postulated failure. Other considerations in conjunction with these postulated pipe failures include loss of offsite power (LOOP), and single active component failure.

- While breaks are evaluated for both their dynamic effects and their environmental effects, only the environmental effects of through-wall cracks need to be evaluated. Not all through-wall cracks will cause flooding; therefore, cracks need to be analyzed for flooding only if the amount of time taken to correct the failure causes significant flooding.

- If a pipe were to break, split, or crack, the resulting pipe whip and jet plume could damage components and instrumentation that are used to safely shut down the plant or prevent unacceptable offsite doses. Separation, isolation, and train redundancies may be used to limit the evaluations of these failure events.

- Pipe whip restraints and protective enclosures may be used to protect essential systems and components against postulated pipe failures.

- When breaks in high-energy lines (circumferential or longitudinal), or through-wall leakage cracks in high- or moderate-energy lines, are considered they are evaluated separately as single initial events that occur during normal plant operating conditions.

- Pumps and valve bodies are excluded from the analysis or evaluation of postulated piping failures due to the larger wall thicknesses than that of the connected pipe.

- Components that are in the path of subcooled flashing liquid or two phase (quality less than 0.75) jets are assumed to fail if they are within a distance of ten pipe diameters (broken pipe outside diameter) from the break and are not designed to withstand the forces or environmental conditions caused by jet impingement, per the guidance provided in NUREG\CR-2913 (Reference 4). Components that are in the path of steam jets are assumed to fail if they are within a distance of 25 pipe diameters from the break and are not designed to withstand the forces or environmental conditions caused by jet impingement, based on test data documented in NEA/CSNI/R(95)11 (Reference 7). Jet loads are calculated, as described in Section 3.6.2, when the failure of impinged components adversely affects the safe shutdown of the plant. Components are considered undamaged at distances greater than ten pipe diameters for subcooled flashing liquid or two phase jets and 25 diameters for steam jets.

- The feasibility of carrying out operator actions is evaluated on the basis of ample time and access to equipment being available for the proposed actions.
- Non-safety-related systems are not required to be protected from the dynamic and environmental effects associated with pipe rupture. If there is non-seismic, moderate-energy piping whose continued function is not required, but whose failure or interaction could degrade the functioning of safety-related equipment to an unacceptable level, then this piping is analyzed and designed for the safe shutdown earthquake (SSE) using the same methods as specified for Seismic Category I piping.

3.6.1.1.2 Postulated Piping Failures and Ruptures

Several factors are considered when defining postulated piping failures, such as material characteristics, the system energy level, pipe stress level, and location, as described in Section 3.6.2.

Breaks in high-energy lines are classified into two categories: circumferential (guillotine) breaks, where a through-wall crack extends around the entire circumference of the pipe; or longitudinal breaks (splits), where a through-wall crack runs parallel to the longitudinal axis of the pipe. The effects of a break are not limited to the broken system, but can also affect systems that are in close proximity.

Breaks in high-energy lines require an evaluation of jet discharge forces (thrust), evaluation of jet impingement, analysis of essential system piping due to a break in attached piping, evaluation of the development of pipe whip hinges, and evaluation for the location of pipe whip restraints. These evaluations and analyses are described in Section 3.6.2.

Through-wall leakage cracks are postulated to occur in non-safety class piping at locations where they cause the most severe environmental damage, except in cases where they are located by the stress criteria given in Section 3.6.2.

For postulated longitudinal or circumferential breaks in high-energy lines, pressurization loads on components and structures are also evaluated. Section 3.8 describes the pressurization loads on structures.

Protection for essential systems and components is determined by the evaluation of the dynamic and environmental effects of a high-energy pipe failure. Where postulated, each longitudinal or circumferential break in high-energy fluid system piping, leakage crack in high-energy piping, or through-wall crack in high-energy or moderate-energy fluid system piping is considered separately as a single initial event occurring during normal plant conditions. For systems not seismically analyzed for an SSE, the SSE is assumed to cause a pressure boundary failure.

3.6.1.1.3 High-Energy Line Ruptures

The postulated locations of high-energy line breaks and through-wall cracks are described in Section 3.6.2.

3.6.1.1.4 Moderate-Energy Line Ruptures

The postulated locations of moderate-energy through-wall cracks are described in Section 3.6.2.

3.6.1.1.5 Leak-Before-Break

LBB methodology is not applied to piping systems outside of containment.

3.6.1.1.6 Containment Penetration Exclusion Zones

Breaks and cracks do not need to be postulated in portions of piping from the containment wall to, and including, inboard or outboard isolation valves if the piping meet the requirements of the ASME Boiler and Pressure Vessel Code Section III, Subarticle NE-1120 (Reference 5) and the criteria in Section 3.6.2. For the MS and MFW systems, an assumed non-mechanistic longitudinal pipe break of one square foot cross-sectional area is postulated at a location that has the greatest effect on essential equipment.

3.6.1.1.7 Other Considerations

Single Active Component Failure

A single active component failure is the loss or malfunction of an electrical or fluid system either spontaneously or when called upon to perform its safety function. Single active component failures are assumed in systems used to mitigate the effects of a postulated pipe break or to safely shutdown the reactor, with the exception of dual-purpose component failures described below. The single active failure is assumed to happen in addition to a postulated piping failure, including any direct consequences of the pipe failure (e.g., a unit trip or LOOP).

Dual-Purpose Component Failure

In accordance with Reference 1, when a postulated piping failure is assumed to occur in one of two or more redundant trains of a dual-purpose, moderate-energy, essential system, single active failures of components in the other train or trains of that system (or other systems necessary to mitigate the consequences of the piping failure and shutdown the reactor) need not be assumed, provided the systems are:

- Designed to Seismic Category I standards.
- Powered from both offsite and onsite sources.

- Constructed, operated, and inspected to quality assurance, testing, and inservice inspection standards appropriate for nuclear safety systems.

Examples of systems that qualify as dual-purpose essential systems include the essential service water system, component cooling water system, and residual heat removal system.

Loss of Offsite Power

Pipe rupture events are evaluated assuming a LOOP. In the event of a LOOP, each safeguard division is powered by a separate emergency diesel generator.

Components Used in Accident Mitigation

Single active component failures are assumed in systems used to mitigate the effects of a postulated pipe break or to safely shut down the reactor, except as previously noted in the case of dual-purpose components.

Pipe-to-Pipe Impacts

A whipping pipe is capable of causing circumferential and longitudinal breaks in smaller diameter pipes regardless of wall thickness. Similarly, a whipping pipe can cause a through-wall crack in a pipe of equal or larger diameter with a smaller wall thickness. This assumes that only the pipe, and no valves or other components, is impacting the lines. The piping and support geometry define the pipe whip and the movement occurs in the direction of the jet reaction. The pipe will usually form a hinge about a calculated point or elbow, or about the nearest pipe restraint or wall penetration that is capable of resisting the pipe whip load, provided that it has a constant source of energy.

3.6.1.2 Protection Considerations

Piping materials, layout, dimensions, and equipment arrangement are considered when selecting the appropriate measure of protection against a postulated pipe failure. Protection methods include separation of essential systems and components by distance or intervening structures, protective enclosures around the high-energy piping, barriers between components, and pipe whip restraints. Additional information on protection considerations is provided below.

3.6.1.2.1 Plant Arrangement

Separation and Redundancy

The U.S. EPR utilizes a combination of redundancy and separation such that the reactor can be safely shut down after a postulated piping failure. The U.S. EPR has four redundant safety trains for many of its essential systems (refer to Section 1.2).

This configuration can safely shut down the plant in the event that one safety train is inoperable, one train is out for maintenance, and one train is out due to a single active failure. For example, the safety injection system (SIS) is a safety-related system consisting of a low head safety injection (LHSI) system and a medium head safety injection (MHSI) system, utilizing water from an in-containment refueling water storage tank (IRWST). The four safety divisions containing the four SIS trains are physically separated; therefore, an accident in one division does not affect the other divisions. Additionally, the remaining MHSI trains will re-establish the water inventory, thus allowing core residual heat removal by the unaffected LHSI trains.

Protection of essential systems is also achieved by physically separating them from other high- and moderate-energy lines by:

- Distance or through the use of an intervening structure or barrier.
- Providing protective enclosures around the portions of essential systems and components subject to damage from a postulated piping failure.
- Enclosing high- or moderate-energy piping that can damage essential system piping.

When physically separating two systems with a structure or barrier, the structure or barrier is qualified to withstand the effects of the postulated pipe failure.

Barriers and Shields

Where separation is not practical, barriers and shielding are used to protect essential components and equipment from the effects of jet impingement and pipe whip resulting from postulated pipe breaks. Barriers are designed for loads based on the postulated piping failure that generates the largest load on the barrier. The missile barrier design procedures described in Section 3.5.3 are used to design the pipe whip barriers. Barriers and shields (e.g., walls, floors, and structures) are designed to provide protection from postulated pipe breaks. Their design is based on elastic methods and elastic-plastic methods for dynamic analysis. Design criteria and loading combinations are described in Sections 3.8.3 and 3.8.4.

Special Protection Considerations

The analysis of the consequences of pipe breaks, through-wall cracks, and leakage cracks includes the following considerations:

- When it is not practical to separate or shield essential equipment from postulated pipe failures due to design or maintenance restrictions, special measures are taken to protect the operability of safety-related features. For example, pipe whip restraints can be used to prevent a pipe from whipping into essential equipment.

- Protective measures and pipe whip restraints for high-energy line failures are designed so that the initial postulated line break does not cause a rupture in any pipe or component in close proximity, if the consequences of the secondary break are unacceptable for the initial postulated line break.

Special protection is provided for the high-energy piping that penetrates the Reactor Building (RB). Restraints are designed to be as close to the isolation valves as possible to maintain operability of these valves after a pipe failure. This design will also protect the integrity of the penetration and isolation valve in the event of non-safety-related and safety-related piping failures beyond the restraint.

3.6.1.2.2 Design Features

Seismic Requirements

Essential systems and components are designed to meet the seismic requirements of RG 1.29 as described in Section 3.2. Seismic design requirements are also described in Section 3.7, Section 3.8, and Section 3.9.3.

Protective Structures

Structural walls and compartments are designed to protect essential systems and components from the effects of piping failures. The protective structures are Seismic Category I, and are required to withstand an SSE, along with effects of postulated piping failures such as jet impingement, pipe whip, compartment pressurization, and flooding.

One of the interactions of subcompartments with fluid systems is compartment pressurization. In the case of a piping failure, the pressure in the room can rise rapidly. For compartments with high- and moderate-energy lines, a pressurization analysis is performed using the break locations defined in Section 3.6.2 and the LBB crack locations defined in Section 3.6.3.

Fluid Piping Systems Located In Containment Penetration Areas

The U.S. EPR RB consists of a Shield Building that encloses the Containment Building, with an annulus between these structures. The high-energy piping penetrating these two structures is enclosed within guard pipes such that the annulus is not affected by pipe ruptures inside or outside containment. High- and moderate-energy fluid systems in containment penetration areas are designed as described in Section 3.6.1.1.6, with no breaks or through-wall leakage cracks postulated in the containment penetration exclusion zones.

Piping Classification in Containment Penetration Areas

Piping classification as recommended by RG 1.26 is maintained without change until beyond the outboard restraint. If the restraint is located at the isolation valve, a classification change at the valve interface is acceptable.

3.6.1.2.3 Design Evaluation - Analysis and Effects of Postulated Piping Failures

Main Control Room Habitability

There are MS and MFW lines that penetrate the top of Safeguard Buildings 1 and 4 (SB-1 and SB-4). These lines are located outside of SB-2 and SB-3, and are routed toward the Turbine Island. The MCR and remote shutdown station (RSS) are located in SB-2 and SB-3. The MS and MFW lines are physically separated from the MCR, thus a postulated pipe rupture in the MS and MFW will not adversely affect MCR habitability.

In addition to the separation of the MCR from high-energy lines, the MCR also has a dedicated heating, ventilation, and air conditioning system, so that any postulated accident in an SB will not affect the atmosphere inside the MCR.

Further discussion of the MCR habitability systems, including the RSS, is provided in Section 6.4. The RSS is not subject to the adverse effects of high-energy pipe rupture.

Functional Capability of Essential Systems

In the event of a postulated accident, the functional capabilities of essential systems will be maintained. See Section 3.5 of U.S. EPR Piping Analysis and Pipe Support Design (Reference 6) for the criteria used to provide the functional capabilities of piping systems due to ASME Level D loadings.

3.6.1.3 Failure Mode and Effects Analysis

As noted in SRP Section 3.6.1, for cases where neither physical separation nor protective enclosures are considered practical by the applicant, redundant design features or additional protections (assuming a single active failure in any required system) are to be provided so that safety features will perform for all failure situations. These analyses are done under the criteria and assumptions of item B.3 of Reference 1. Section 3.6.1.1.1 provides the criteria and assumptions, based on Reference 1, used to evaluate pipe failure protection. This includes consideration of:

- Availability of offsite power (Section 3.6.1.1.7).
- Failure of single active components in systems used to mitigate the consequences of the piping failure (Section 3.6.1.1.7).
- Special provisions applicable to certain dual-purpose systems (Section 3.6.1.1.7).

- Use of available systems to mitigate the consequences of the piping failure (Section 3.6.1.1.7).

Additionally, Section 3.6.1.2.1 describes the combination of separation and redundancy of the U.S. EPR design which provides further assurance that safety features perform properly. Furthermore, as noted in Section 3.6.1.2.1, where separation is not practical, deflectors, shielding, and barriers are used to protect essential components and equipment. Therefore, failure modes and effects have been evaluated to verify that the consequences of failures of high- and moderate-energy lines do not affect the ability to safely shut down the plant.

3.6.1.4 References

1. Branch Technical Position 3-3, Revision 3, “Protection Against Postulated Piping Failures in Fluid Systems Outside Containment,” U.S. Nuclear Regulatory Commission, March 2007.

2. Branch Technical Position 3-4, Revision 2, “Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment,” U.S. Nuclear Regulatory Commission, March 2007.

3. NUREG-0800, Revision 3, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, March 2007.

4. NUREG/CR-2913, “Two-Phase Jet Loads,” U.S. Nuclear Regulatory Commission, January 1983.

5. ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Facility Components,” The American Society of Mechanical Engineers, 2004.

6. ANP-10264NP-A, Revision 0, “U.S. EPR Piping Analysis and Pipe Support Design Topical Report,” AREVA NP Inc., November 2008.

7. NEA Report NEA/CSNI/R(95)11, “Knowledge Base for Emergency Core Cooling System Recirculation Reliability,” February 1996.

Table 3.6.1-1—High-Energy and Moderate-Energy Fluid Systems Considered for Protection of Essential Systems[1]
Sheet 1 of 2

System	High-Energy	Moderate-Energy
Chemical and Volume Control	•	
Component Cooling Water (Supply Train)[3]		•
Component Cooling Water (Common Header)[3]		•
Coolant Treatment		•
Demineralized Water		•
Emergency Feedwater[6]	•	
Essential Service Water		•
Extra Borating[3]		•
Feedwater	•	
Fuel Handling		•
Fuel Pool Cooling		•
Fuel Pool Purification[2]		•
Gaseous Waste Processing	•	
In-Containment Refueling Water Storage Tank		•
Leak-Off		•
Low Head Safety Injection[7]	•	
Main Condensate	•	
Medium Head Safety Injection[3]		•
Main Steam[5]	•	
Nuclear Island Drain and Vent[8]	•	
Nuclear Sampling[9]		•
Operational Chilled Water		•
Potable and Sanitary Water		•
RC Pump Seal Injection of CVCS	•	
Reactor Coolant[4,5]	•	
Residual Heat Removal[6]	•	
Safety Chilled Water		•
Sampling for SG Blowdown[9]		•
Seal Water Supply		•
Severe Accident Heat Removal[3]		•

Table 3.6.1-1—High-Energy and Moderate-Energy Fluid Systems Considered for Protection of Essential Systems[1] Sheet 2 of 2

System	High-Energy	Moderate-Energy
Stationary Fire Protection		•
Steam Generator Blowdown	•	

Notes:

1. Systems included in this list are high- or moderate-energy fluid systems. Systems that operate at approximately atmospheric pressure, such as vents and drains, have been excluded. Moderate-energy gas systems have also been excluded.

2. This system is considered to be moderate-energy, as it operates above the high-energy limits less than 2% of the system's total operating time.

3. This system is considered to be moderate-energy, as it operates above the high-energy limits less than 1% of the total plant operating time.

4. The reactor coolant loop has been analyzed for LBB criteria.

5. Main steam inside containment and the pressurizer surge line have been analyzed to LBB criteria.

6. This system is only high-energy from its connection to the reactor coolant pressure boundary (RCPB) for the residual heat removal (RHR) system (or SG secondary side for the emergency feedwater (EFW) system) upstream to its isolation valve. The remainder of this system does not operate during normal plant operations, and thus falls under the 1% rule.

7. Portions of this system fall under the 1% or 2% rules.

8. Only a small portion of this system has been identified as high-energy.

9. This system is a sampling system with only high-energy conditions following an accident; thus it falls under the 2% rule.

Table 3.6.1-2—Building, Room, and Postulated Pipe Ruptures[1,2]
Sheet 1 of 5

Compartment		Lines Evaluated to LBB		Lines Not Evaluated to LBB	
Building	Room No.	System	Terminal End	System	Terminal End
Reactor Building	UJA07-018	None	None	Condensate	Blowdown Cooler 1 Nozzle
				Condensate	Blowdown Cooler 2 Nozzle
				SG Blowdown	Blowdown Flash Tank Nozzle
				SG Blowdown	Blowdown Cooler 1 Nozzles
				SG Blowdown	Blowdown Cooler 2 Nozzles
	UJA07-024	None	None	NI Drain & Vent	Reactor Coolant Drain Tank Nozzle
	UJA07-026	None	None	CVCS	CVCS Cooler Nozzles
	UJA07-027	None	None	CVCS	CVCS Cooler Nozzles
	UJA11-002	Reactor Coolant	Crossover to RCP	CVCS	Connection to Crossover
	UJA11-003	None	None	RHR	Closed Isolation Valve
				Low Head SI	Closed Isolation Valve
	UJA11-004	None	None	RHR	Closed Isolation Valve
				Low Head SI	Closed Isolation Valve
	UJA11-005	Reactor Coolant	Crossover to RCP	CVCS	Connection to Crossover
	UJA11-006	Reactor Coolant	Crossover to RCP	CVCS	Connection to Crossover
	UJA11-007	None	None	RHR	Closed Isolation Valve
				Low Head SI	Closed Isolation Valve
	UJA11-008	None	None	RHR	Closed Isolation Valve
				Low Head SI	Closed Isolation Valve
	UJA11-009	Reactor Coolant	Crossover to RCP	CVCS	Connection to Crossover
	UJA11-018	None	None	SG Blowdown	Blowdown Flash Tank Nozzles

Table 3.6.1-2—Building, Room, and Postulated Pipe Ruptures[1,2]
Sheet 2 of 5

Compartment		Lines Evaluated to LBB		Lines Not Evaluated to LBB	
Building	**Room No.**	**System**	**Terminal End**	**System**	**Terminal End**
Reactor Building (Cont'd.)	UJA11-019	None	None	PZR Relief Disch.	PZR Relief Tank Nozzles
	UJA11-024	None	None	CVCS	CVCS Regen. HX Nozzles
	UJA15-001	Reactor Coolant	RPV Cold Leg and Hot Leg Nozzles	None	
	UJA15-002	Reactor Coolant	RCP Cold Leg Nozzle	RC Pump	RCP Nozzles
				Low Head SI	Cold Leg Connection
	UJA15-003	Reactor Coolant	SG Crossover & Hot Leg Nozzle	RHR	Hot Leg Connection
				SG Blowdown	SG Nozzles
	UJA15-004	Reactor Coolant	SG Crossover & Hot Leg Nozzle	RHR	Hot Leg Connection
				SG Blowdown	SG Nozzles
	UJA15-005	Reactor Coolant	RCP Cold Leg Nozzle	RC Pump	RCP Nozzles
				RC Pressurizing	Cold Leg Connection
				Low Head SI	Cold Leg Connection
				CVCS	Cold Leg Connection
	UJA15-006	Reactor Coolant	RCP Cold Leg Nozzle	RC Pump	RCP Nozzles
				RC Pressurizing	Cold Leg Connection
				Low Head SI	Cold Leg Connection
	UJA15-007	Reactor Coolant	SG Crossover to Hot Leg Connection	RHR	Hot Leg Connection
		RC Pressurizing	Surge Line to Hot Leg Connection	SG Blowdown	SG Nozzles
	UJA15-008	Reactor Coolant	SG Crossover to Hot Leg Connection	RHR	Hot Leg Connection
				SG Blowdown	SG Nozzles

Table 3.6.1-2—Building, Room, and Postulated Pipe Ruptures[1,2]
Sheet 3 of 5

Compartment		Lines Evaluated to LBB		Lines Not Evaluated to LBB	
Building	**Room No.**	**System**	**Terminal End**	**System**	**Terminal End**
Reactor Building (Cont'd.)	UJA15-009	Reactor Coolant	RCP Cold Leg Nozzle	RC Pump	RCP Nozzles
				Low Head SI	Cold Leg Connection
				CVCS	Cold Leg Connection
	UJA15-013	None	None	Low Head SI	LHSI Accumulator Nozzle
				Low Head SI	2" to 12" Branch Connection
	UJA15-014	None	None	Low Head SI	LHSI Accumulator Nozzle
				Low Head SI	2" to 12" Branch Connection
	UJA15-015	None	None	Low Head SI	LHSI Accumulator Nozzle
				Low Head SI	2" to 12" Branch Connection
	UJA15-016	None	None	Low Head SI	LHSI Accumulator Nozzle
				Low Head SI	2" to 12" Branch Connection
	UJA18-003	None	None	Steam Generator	(4) SG Nozzles
	UJA18-004	None	None	Steam Generator	(4) SG Nozzles
	UJA18-007	None	None	Steam Generator	(4) SG Nozzles
	UJA18-008	None	None	Steam Generator	(4) SG Nozzles
	UJA18-019	RC Pressurizing	Surge Line to PZR Nozzle	None	None
	UJA23-013	None	None	Low Head SI	LHSI Accumulator Nozzle
	UJA23-014	None	None	Low Head SI	LHSI Accumulator Nozzle
	UJA23-015	None	None	Low Head SI	LHSI Accumulator Nozzle
	UJA23-016	None	None	Low Head SI	LHSI Accumulator Nozzle

Table 3.6.1-2—Building, Room, and Postulated Pipe Ruptures[1,2]
Sheet 4 of 5

Compartment		Lines Evaluated to LBB		Lines Not Evaluated to LBB	
Building	**Room No.**	**System**	**Terminal End**	**System**	**Terminal End**
Reactor Building (Cont'd.)	UJA29-003	None	None	Feedwater	SG Nozzle
				Emergency FW	SG Nozzle
				Emergency FW	Closed Isolation Valve
	UJA29-004	None	None	Feedwater	SG Nozzle
				Emergency FW	SG Nozzle
				Emergency FW	Closed Isolation Valve
	UJA29-007	None	None	Feedwater	SG Nozzle
				Emergency FW	SG Nozzle
				Emergency FW	Closed Isolation Valve
	UJA29-008	None	None	Feedwater	SG Nozzle
				Emergency FW	SG Nozzle
				Emergency FW	Closed Isolation Valve
	UJA29-019	None	None	RC Pressurizing	PZR Nozzles
	UJA34-003	MS	SG Nozzle	None	None
	UJA34-004	MS	SG Nozzle	None	None
	UJA34-007	MS	SG Nozzle	None	None
	UJA34-008	MS	SG Nozzle	None	None
	UJA34-019	None	None	RC Pressurizing	PZR Nozzles
				PZR Relief Disch.	PZR Nozzles

Table 3.6.1-2—Building, Room, and Postulated Pipe Ruptures[1,2]
Sheet 5 of 5

Compartment		Lines Evaluated to LBB		Lines Not Evaluated to LBB	
Building	**Room No.**	**System**	**Terminal End**	**System**	**Terminal End**
Safeguard Building 1	1UJE26-001	None	None	Feedwater	Piping Anchors
	1UJE29-002	None	None	MS	Decoupled Branch Connections
	1UJK26-030	None	None	Feedwater	Piping Anchors
				MS	Piping Anchors
	2UJE29-002	None	None	MS	Decoupled Branch Connections
	2UJE34-003	None	None	Condensate	Piping Anchors
Safeguard Building 2	N/A	None	None	None	None
Safeguard Building 3	N/A	None	None	None	None
Safeguard Building 4	3UJE26-001	None	None	Feedwater	Piping Anchors
	3UJE29-002	None	None	MS	Decoupled Branch Connections
	4UJE29-002	None	None	MS	Decoupled Branch Connections
	4UJK26-030	None	None	Feedwater	Piping Anchors
				MS	Piping Anchors
Fuel Building	UFA01-035	None	None	CVCS	CVCS Charging Pump Nozzle
	UFA01-085	None	None	CVCS	CVCS Charging Pump Nozzle

Notes:

1. The high-energy breaks listed are terminal end breaks associated with the systems in Table 3.6.1-1 which do not fall under the 1% or 2% rules. The terminal end breaks where the piping has been evaluated to LBB criteria have also been shown as such.
2. The U.S. EPR subscribes to the Kraftwerks Kennzeichen System (KKS) for coding and nomenclature of structures, systems, and components.

Table 3.6.1-3—Building, Room, Break, Target, and Protection Required[1,2]
Sheet 1 of 2

Compartment		Terminal End Break		Essential System Targets	Protection Required
Building	Room No. [2]	System	Terminal End		
Reactor Building	UJA07-018	SG Blowdown	Blowdown Cooler 1 Nozzle	Concrete Floor Above IRWST	Whip Restraint
		SG Blowdown	Blowdown Cooler 2 Nozzle	Concrete Floor Above IRWST	Whip Restraint
	UJA11-024	CVCS	2 Regen. HX Nozzles	Electrical Cable Trays Assumed to Contain SR Cables	Jet Shields and/or Whip Restraints
	UJA15-002	Low Head SI	Cold Leg Connection	Electrical Conduits Assumed to Contain SR Cables	Whip Restraint
	UJA15-005	Low Head SI	Cold Leg Connection	Electrical Conduits Assumed to Contain SR Cables	Whip Restraint
	UJA15-006	Low Head SI	Cold Leg Connection	Electrical Conduits Assumed to Contain SR Cables	Whip Restraint
	UJA15-009	Low Head SI	Cold Leg Connection	Electrical Conduit Assumed to Contain SR Cable(s)	Whip Restraint
	UJA15-013	Low Head SI	LHSI Accumulator Nozzle	Concrete Floor Above Numerous SR Components	Whip Restraint
	UJA15-014	Low Head SI	LHSI Accumulator Nozzle	Concrete Floor Above Numerous SR Components	Whip Restraint
	UJA15-015	Low Head SI	LHSI Accumulator Nozzle	Concrete Floor Above Numerous SR Components	Whip Restraint
	UJA15-016	Low Head SI	LHSI Accumulator Nozzle	Concrete Floor Above Numerous SR Components	Whip Restraint
	UJA29-003	Feedwater	SG Nozzle	Steam Generator Cubicle Wall	Whip Restraint

Table 3.6.1-3—Building, Room, Break, Target, and Protection Required[1,2]
Sheet 2 of 2

Compartment		Terminal End Break		Essential System Targets	Protection Required
Building	Room No.[2]	System	Terminal End		
Reactor Building	UJA29-004	Feedwater	SG Nozzle	Steam Generator Cubicle Wall	Whip Restraint
	UJA29-007	Feedwater	SG Nozzle	Steam Generator Cubicle Wall	Whip Restraint
	UJA29-008	Feedwater	SG Nozzle	Steam Generator Cubicle Wall	Whip Restraint
Safeguard Building 1	1UJK26-030	Feedwater	Piping Anchor	Concrete Wall Isolating FW and MS Pipes	Whip Restraint
	2UJE34-003	Condensate	Piping Anchors	MS Valve Room Concrete Wall	Whip Restraints
Safeguard Building 2	N/A	None	None	None	None
Safeguard Building 3	N/A	None	None	None	None
Safeguard Building 4	N/A	None	None	None	None
	4UJK26-030	Feedwater	Piping Anchor	Concrete Wall Isolating FW and MS Pipes	Whip Restraint
Fuel Building	UFA01-035	CVCS	Charging Pump Nozzle	Electrical Cable Trays Assumed to Contain SR Cables	Jet Shield and/or Whip Restraint
	UFA01-085	CVCS	Charging Pump Nozzle	Electrical Cable Trays Assumed to Contain SR Cables	Jet Shield and/or Whip Restraint

Notes:

1. The high-energy breaks listed are terminal end breaks from Table 3.6.1-2, which upon evaluation have been shown to be capable of jeopardizing the operation of essential system components unless protection is provided.

2. The U.S. EPR subscribes to the Kraftwerks Kennzeichen System (KKS) for coding and nomenclature of structures, systems, and components.

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