Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #1 (AI 3-52.4)

DCD Tier 2, Subsection 3.6.2.1.4.3.1, Items (a) through (f) describe the design requirements for the high-energy piping in the break exclusion area. However, this section does not address whether the design also meets the requirements of the ASME Section III, NE-1120. The applicant is to clarify whether the design of the high-energy piping in the break exclusion areas meets the requirements of the ASME Section III, NE-1120. If not, the applicant is to justify the departure from the staff's guideline as described in Branch Technical Position (BTP) 3-4, Part B, Subsection B(ii).

Response

The high-energy piping in break exclusion area is designed according to ASME Section III, NE-1120. DCD Section 3.6.2.1.4.1.3.1 will be revised to specify compliance to that BTP 3-4 requirement.

Impact on DCD

DCD Section 3.6.2.1.4.1.3.1 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

3.6.2.1.4.1.3 Fluid System Piping in Containment Penetration Areas

3.6.2.1.4.1.3.1 High-Energy Piping

~~There is no ASME Section III Class 1 piping in containment penetration areas. Breaks and cracks are not postulated between the containment penetration wall and auxiliary building anchor wall beyond isolation valves in ASME Section III Class 2 piping, which meets the following additional requirements:~~

Issue #1,#2

ASME Section III Class 2 piping is used in containment penetration areas. Breaks or cracks are not postulated in those portions of piping between the containment wall and the inboard or outboard isolation valves, because they are designed with beak exclusion by meeting the design criteria of the ASME Section III, NE-1120 and the following additional requirements:

a. The following design stress and fatigue limits are not exceeded:

1) The maximum stress as calculated by the sum of Equations (9) and (10) in Paragraph NC-3653, ASME Section III, considering those loads and conditions thereof for which level A and level B stress limits have been specified in the system's Design Specification (i.e., sustained loads, occasional loads, and thermal expansion), excluding earthquake loads, does not exceed 0.8 (1.8 S_h + S_A). The S_h and S_A are allowable stresses at maximum (hot) temperature and allowable stress range for thermal expansion, respectively, as defined in Article NC-3600 of ASME Section III.

2) The maximum stress, as calculated by Equation (9) in Paragraph NC-3653, ASME Section III, under the loadings resulting from a postulated piping failure of fluid system piping beyond these portions of piping, does not exceed the lesser of 2.25 S_h and 1.8 S_y.

3) Primary loads include those that are deflection limited by whip restraints. The exceptions permitted in ~~(c) above~~ BTP 3-4, Part B, Item A(ii)(1)(c) may also be applied provided that when the piping between the outboard isolation valve and the restraint is constructed in accordance with Power Piping Code ANSI B31.1 (see ASB 3-1 B.2.c.[4]), the piping is either of seamless construction with full radiography of all circumferential welds, or all longitudinal and circumferential welds are fully radiographed.

b. Welded attachments for pipe supports or other purposes to these portions of piping are avoided except where detailed stress analyses or tests are performed to demonstrate conformance with the limits of Item a above.

c. The number of circumferential and longitudinal piping welds and branch connections is minimized. Specific access provisions are made to permit in-service volumetric examination of the longitudinal and circumferential welds.

d. The length of these portions of piping is reduced to the minimum length practical.

e. The design of pipe anchors or restraints (e.g., connections to containment penetrations, pipe whip restraints) does not require welding directly to the outer surface of the piping (e.g., flued integrally forged pipe fittings may be used) except where such welds are 100 percent volumetrically examinable in service and a detailed stress analysis is performed to demonstrate conformance with the limits in Item 1 above.

f. A 100 percent volumetric in-service examination of all pipe welds is conducted during each inspection interval as defined in IWA-2400, ASME Section XI (Reference 11).

Insert A

Even though portions of the main steam and feedwater lines meet the break exclusion requirements of Subsection ~~3.6.2.1.4.1.3~~ 3.6.2.1.4.1.3.1., they are separated from essential equipment.

Essential equipment is not concentrated in the break exclusion zone. Essential equipment is protected from the environmental effects of an assumed nonmechanistic longitudinal break of the main steam and feedwater lines. Each assumed nonmechanistic longitudinal break has a cross-sectional area of at least 1 ft^2 and is postulated to occur at a location that has the greatest effect on essential equipment.

3.6.2.1.4.1.3.2 Moderate-Energy Piping

For moderate-energy fluid systems, through-wall cracks are not postulated in those portions of piping from the containment wall to and including the inboard or outboard isolation valves provided that they meet the requirements of the ASME Section III, NE-1120, and the

A

Since guard pipes are not used, the guard pipe design requirements addressed in BTP 3-4, Part B, Item A(ii)(6) are excluded from the additional requirements. Pipe break exclusion design expands to the auxiliary building wall anchor beyond the isolation valve.

Portions of system piping that are designed using break exclusion criteria are as follows:

a. The main steam piping from the containment penetration to the auxiliary building MSVH anchor wall, which is downstream of the main steam isolation valve.

b. The main feedwater piping from the containment penetration to the auxiliary building MSVH anchor wall, which is upstream of the isolation valve.

c. The steam generator blowdown piping from the containment penetration outboard weld to the auxiliary building wall, which is downstream of the isolation valve.

d. The startup feedwater piping from the containment penetration outboard weld to the auxiliary building MSVH anchor wall, which is upstream of the isolation valve.

Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #2 (AI 3-52.5)

The descriptions of the break/crack exclusion area for which pipe ruptures are not postulated are inconsistent between two DCD subsections. DCD Tier 2, Subsection 3.6.2.1.4.3.2 states that cracks are not postulated in moderate-energy ASME Section Class 2 piping from the containment wall to and including the inboard or outboard isolation valves. This statement is consistent with the staff's guideline as described in BTP 3-4 Part B, Subsection A(ii). However, the break exclusion area for high-energy ASME Section Class 2 piping described in DCD Tier 2, Subsection 3.6.2.1.4.3.1 is between the containment penetration wall and auxiliary building anchor wall beyond isolation valves. The applicant is to clarify the inconsistencies in the criteria used for determining the break/crack exclusion area for high-energy and moderate-energy piping and to justify the departure, if any, from the staff's guideline as described in BTP 3-4, Part B, Item A(ii).

Response

For high-energy ASME Section Class 2 piping from the containment wall up to and including the inboard or outboard isolation valves, both pipe break and pipe cracks do not need to be postulated by meeting the ASME Section III, NE-1120 and additional requirements specified in DCD Section 3.6.2.1.4.1.3.1. Pipe break exclusion expands to the auxiliary building anchor wall beyond the isolation valve. DCD Section 3.6.2.1.4.1.3.1 will be revised for consistency with 3.6.2.1.4.1.3.2.

Impact on DCD

DCD Section 3.6.2.1.4.1.3.1 will be revised as shown in the Attachment of issue #1.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #4 (AI 3-52.7)

For non-seismically analyzed ASME B31.1 piping attached to seismic piping, the applicant states that the attached non-seismic piping up to the analyzed/unanalyzed boundary is designed not to cause a failure of the seismic piping during a seismic event. It should be noted that RG 1.29, Section C.3 provides the staff's guideline for the interface between seismic Category I and non-seismic Category I SSCs. Specifically, it states that at the interface between seismic Category I and non-seismic Category I SSCs, the seismic Category I dynamic analysis requirements should be extended to either the first anchor point in the non-seismic system or a sufficient distance into the non-seismic Category I system so that the seismic Category I analysis remains valid. The applicant is to describe how "the analyzed/unanalyzed boundary" is determined for the APR1400 piping design.

Response

The seismically analyzed/unanalyzed boundary is defined as the interface between the safety and non-safety piping and is usually designed with an anchor at that location. However, in instances where installation of an anchor is not feasible at the Code break interface, then the seismic Category I design is extended to the first anchor point.

For example, the Main Steam Valve House (MSVH) wall is designed as an anchor wall and is "the analyzed/unanalyzed boundary."

Impact on DCD

DCD Tier 2, Section 3.6.2.1.4.1.1 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

attachments, or valves at one location at each extreme of the piping adjacent to the protective structure.

2) At intermediate locations where the stress S exceeds 0.8 (X + Y)

Where, as defined in ASME Section III, Division 1 paragraph NC/ND-3653

S = stresses under the combination of loadings for which either level A or level B stress limits have been specified, as calculated from the sum of Equations (9) and (10)

X = Equation (9) service level B allowable stress

Y = Equation (10) allowable stress

As a result of piping reanalysis due to differences between the design configuration and the as-built configuration, the highest stress locations may be shifted; however, the initially determined intermediate break locations may be used unless a redesign of the piping resulting in a change in pipe parameters (diameter, wall thickness, routing) is required, or the dynamic effects from the new (as-built) intermediate break locations are not mitigated by the original pipe whip restraints and jet shields.

Non-Seismically Analyzed ASME B31.1 Piping

Safety class systems and piping are seismically analyzed. Most non-safety systems and piping are required to be non-seismically analyzed. Therefore, rules are isolation and separation in order to avoid impact to safety-related systems from non-safety-related piping failure effects caused by an earthquake. In cases where it is not possible or practical to isolate the seismic piping, adjacent non-seismic piping is analyzed according to seismic Category II criteria.

For non-seismic piping attached to seismic piping, the dynamic effects of the non-seismic piping are simulated in the modeling of the seismic piping. The attached non-seismic piping up to the analyzed/unanalyzed boundary is designed not to cause a failure of the seismic piping during a seismic event. as described in Subsection 3.12.3.7

Breaks are postulated at the following locations in each non-safety-related, ASME B31.1 piping network that is not seismically analyzed.

Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #5 (AI 3-52.8)

The applicant is to clarify whether the design criteria for a structure that separates a high-energy line from an essential component is consistent with the staff's guideline described in BTP 3-4, Part B, Item A(iii)(4). Specifically, if a structure separates a high-energy line from an essential component, the separating structure should be designed to withstand the consequences of the pipe break in the high-energy line that produces the greatest effect at the structure, irrespective of the fact that the criteria identified in DCD Tier 2, Subsection 3.6.2.1.4.1.1 might not need such a break location to be postulated.

Response

In accordance with BTP 3-4, structures separating a high-energy line from an essential component are designed to withstand the consequences of a pipe break including associated pipe whip, jet impingement and sub-compartment pressurization.

Impact on DCD

DCD Section 3.6.1.2.1.2 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

3.6.1.2.1.2 Barriers and Shields

Protection requirements are met through the protection afforded by the walls, floors, and columns in many cases. Where adequate protection does not exist due to separation, additional barriers, deflectors, or shields are provided as necessary to meet the functional protection requirements. Where compartments, barriers, and structures are required to provide the necessary protection, they are designed to withstand the effects of the postulated failure concurrent with an earthquake event.

Structures separating a high−energy line from an essential component are designed to withstand the consequences of a pipe break including associated pipe whip, jet impingement and subcompartment pressurization.

3.6.1.2.1.3 Piping Restraints

Where adequate protection does not exist due to separation, barriers, or shields, piping restraints are provided as necessary to meet the functional protection requirements. Restraints are not provided when it can be shown that the postulated pipe breaks would not cause unacceptable damage to essential systems or components.

The design criteria for pipe whip restraints are given in Subsection 3.6.2.4.

3.6.1.2.2 Specific Protection Consideration

The design criteria define acceptable types of isolation for safety-related elements and for high-energy lines from similar elements of the redundant train. Separation is accomplished by:

a. Routing the redundant trains through separate compartments

b. Physically separating the redundant trains by a specified minimum distance

c. Separating the redundant trains by structural barriers

The design criteria provide reasonable assurance that a postulated failure of a high-energy line or a safety-related element cannot take more than one safety-related train out of service. The failure of a component or subsystem of one train may cause failure of another portion of the same train; for example, a Division II high-energy pipe may cause failure of a Division II component electrical tray but not failure of any Division I component. The

Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #6 (AI 3-52.9)

The applicant is to clarify that appropriate pipe breaks and leakage cracks (whichever results in the most severe environment) are to be included in the design bases for environmental qualification of the safety-related electrical and mechanical equipment both inside and outside the containment as delineated in BTP 3-4, Part B, Item A(iii)(5). If not, justification for the departure should be provided.

Response

Pipe breaks and cracks which result in the most severe environmental consequences are analyzed to determine the design conditions for environmental qualification of mechanical and electrical equipment as described in Tier 2 Table 3.11-2.

Impact on DCD

DCD Tier 2, Section 3.6.2.1.4.2 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

b. Crack configurations

Through-wall cracks are postulated at those axial locations specified in Subsection 3.6.2.1.4.1.2.

For high-energy piping, through-wall cracks are postulated to be in those circumferential locations that result in the most severe environmental consequences. The flow from the crack is assumed to wet all unprotected components within the compartment with consequent flooding in the compartment and communicating compartments.

for determining environmental conditions described in Table 3.11-2

Fluid flow from a leakage crack is based on a circular orifice with a cross-sectional area equal to that of a rectangle of one-half the pipe inside diameter in length and one-half the pipe wall thickness in width.

3.6.2.1.5 Details of Containment Penetrations

Details of containment penetrations are described in Subsections 3.8.1 and 3.8.2.

3.6.2.2 Guard Pipe Assembly Design Criteria

Guard pipes are not used in all containment penetrations of high-energy piping.

3.6.2.3 Analytical Methods to Define Forcing Functions and Response Models

3.6.2.3.1 Leak-Before-Break Applied Piping

There are no forcing functions or response models for the piping qualified for LBB.

3.6.2.3.2 Analytical Methods to Define Forcing Functions and Response Models for Piping Not Applied to Leak-Before-Break

This subsection applies to all high-energy piping other than that whose dynamic effects due to pipe breaks are eliminated from the design basis by LBB evaluation.

Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #7 (AI 3-52.10)

The applicant is to clarify whether its criteria used for postulating breaks in complex system is consistent with the staff's guideline described in BTP 3-4, Part B, Item A(iv). Specifically, for complex systems such as those containing arrangements of headers and parallel piping running between headers, all such piping should be identified and included within a designated run for the purposes of break postulation.

Response

The postulated pipe break locations are selected in accordance with BTP 3-4, Part B, Item A(iv). For the selection of break locations in complex piping systems, all pipes are identified and included.

Impact on DCD

DCD Tier 2, Section 3.6.2.1.4.1.1 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

3.6.2.1.4 Piping Not Applied to Leak-Before-Break

This section applies to all high- and moderate-energy piping other than that whose dynamic effects due to pipe breaks are eliminated from the design basis by LBB evaluation, as identified in Subsection 3.6.2.1.3.

3.6.2.1.4.1 Postulated Rupture Locations

3.6.2.1.4.1.1 Break Locations for High-Energy Fluid System Piping in Areas Other than Containment Penetration

Both circumferential and longitudinal breaks of high-energy piping systems are postulated to occur, but not concurrently, considering the following exceptions:

a. Circumferential breaks are not postulated in piping runs of a nominal diameter equal to or less than 2.54 cm (1 in).

b. Longitudinal breaks are not postulated in piping runs of a nominal diameter less than 10.16 cm (4 in).

c. Longitudinal breaks are not postulated at terminal ends.

ASME Section III (Reference 9) Class 1 Piping

With the exceptions of the portions of piping identified in Subsection 3.6.2.1.3, breaks in ASME Section III Class 1 piping are postulated at the following locations in each piping and branch run:

The postulated pipe break locations are determined in accordance with BTP 3-4, Part B, item A(iv). All pipes are identified and considered for the selection of break locations.

a. At terminal end

b. At intermediate locations where U exceeds 0.1 or S from Equation (10) plus Equation (12) or (13) exceeds 2.4 S_m

Where, as defined in ASME Section III, Division 1, Paragraph NB-3653:

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<u>MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2</u>

<u>Issue #12 (AI 3-52.15)</u>

DCD Tier 2, Subsection 3.6.1.2.1.2, “Barriers and Shields,” states that where adequate protection does not exist due to separation, additional barriers, deflectors, or shields are provided as necessary to protect the nearby essential SSCs. It further states that where barriers and structures are required to provide the necessary protection, they are designed to withstand the effects of the postulated pipe failure concurrent with an earthquake event. Moreover, DCD Tier 2, Section 3.6.11 discusses the importance of protective features such as pipe whip restraints in providing reasonable assurance of safe shutdown capability following a postulated high-energy line break. However, the staff noted that the relevant DCD Tier 2 subsections including Subsection 3.2.1 do not clearly address the seismic classification, design code, and allowable stress associated with these protective features. The applicant is to provide information regarding the seismic classification, design code and allowable stress for the protective devices (e.g., barriers, shields, and pipe whip restraints) used in the APR1400 design for protections against postulated pipe failures.

<u>Response</u>

The information regarding the seismic classification, design code for protective devices (barriers, shields, and whip restraints) will be described in DCD Tier 2, Table 3.2-1. The concrete structures that function as barriers or shields are designed with the same design code and seismic category of the building in which they are located. Table 3.2-1 shows the code classification of those structures. The design method and information of pipe whip restraints including allowable stresses is described in DCD Tier 2, Subsection 3.6.2.4. DCD Tier 2, Table 3.2-1 will be revised to indicate the code classification for pipe whip restraints.

Impact on DCD

DCD Table 3.2-1 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

Table 3.2-1 (1 of 86)

Classification of Structures, Systems, and Components[1]

Item No. / Principal SSCs	Location[2]	Safety Class	Quality Group	Codes and Standards	10 CFR 50, App. B[3]	Seismic Category	Remarks
I. Major Structures							
1. Containment Building (including mechanical and electrical penetrations)		SC-2	B	ASME Sec. III NE-2007 with 2008 addenda, ASME Sec. III CC-2001 with 2003 Addenda	Yes	I	
2. Containment Building Internal Structures (including radiation shield) and pipe whip restraints		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	
3. Auxiliary Building (includi		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	(4)
4. Turbine Generator Building		NNS	N/A	ACI 318-2008 AISC 360-2005	A	II	(3)(d)
5. Compound Building		NNS	N/A	ACI 318-2008 AISC 360-2005	A	II	(3)(d), (4)
6. Emergency Diesel Generator Building		SC-3	N/A	ACI 349-1997, ANSI/AISC N690-1994 incl. Supp. 2 (2004)	Yes	I	
7. Alternate AC Generator Building		NNS	N/A	ACI318-2008	A	II	(3)(d)
8. Essential Service Water Building		SC-3	N/A	ACI349-1997, ANSI/AISC N690-1994 incl. supp. 2(2004)	Yes	I	

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MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #13 (AI 3-52.16)

The applicant is to clarify whether its criteria for determining the initial condition of a piping which is pressurized during operation at power is to be the greater of the contained energy at either hot standby or 102 percent power as delineated in SRP 3.6.2 Section III.2.A.

Response

For the APR1400 high-energy line break analysis, the initial conditions used are the higher energy operating condition of 102 percent power or hot standby condition in accordance with SRP 3.6.2, Section III.2.A. Hot standby conditions are used for the main steam piping.

Impact on DCD

DCD Tier 2, Section 3.6.2.3.2.1.1 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

3.6.2.3.2.1 Determination of Pipe Thrust and Jet Loads

3.6.2.3.2.1.1 Dynamic Force of the Fluid Jet Discharge

The dynamic force of the fluid jet discharge from either a postulated circumferential or longitudinal break is based on a circular break area equal to the cross-sectional flow area of the pipe at the break location and on a calculated fluid pressure multiplied by an analytically determined thrust coefficient, as determined for a circumferential break at the same location.

Flow limiters, positive pump-controlled flow, and the absence of energy reservoirs are taken into account, as applicable, in the reduction of jet discharge.

Piping movement is assumed to occur in the direction of the jet reaction, unless limited by structural members or piping restraints.

Blowdown thrust force (F_{thrust}) is determined by multiplication of three parameters (i.e., appropriately calculated thrust coefficient considering the fluid condition, piping internal pressure, cross-sectional area at the break location). For the realistic calculation, P_aA acting on the outside of the pipe may be subtracted from the thrust force acting on the inside of the pipe.

The initial conditions of piping pressurized during operation at power are the greater of the contained energy at 102 percent power or hot standby in accordance with SRP 3.6.2, Section III.2.A.

$$F_{thrust} = (C_T P_o - P_a) A$$

At first, initial, intermediate, and final thrust coefficients are calculated.

$$F_{ini} = 1.0 P_o A, \text{ or } \quad F_{ini} = (1.0 P_o - P_a) A$$

$$F_{inter} = C_{TI} P_o A, \text{ or } \quad F_{inter} = (C_{TI} P_o - P_a) A$$

$$F_{final} = C_{TS} P_o A, \text{ or } \quad F_{final} = (C_{TS} P_o - P_a) A$$

Where:

D	=	pipe inside diameter based on the average or nominal pipe wall thickness
P_o	=	initial fluid pressure in source or pipe
P_a	=	atmospheric pressure
A	=	pipe flow area

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MEB Issue List Regarding APR-1400, DCD TIER 2, SECTION 3.6.2

Issue # 14 (AI 3-52.17)

SRP 3.6.2 Section III.4.A, "Dynamic Analysis Criteria," provides the staff's guideline for determining the allowable capacity of crushable material, such as honeycomb used in pipe whip restraint system. It states that the allowable capacity of crushable material should be limited to 80 percent of its rated energy dissipating capacity as determined by dynamic testing, at loading rate within +/- 50 percent of the specified design loading rate. The applicant is to clarify whether this guideline is applicable to APR1400 pipe whip restraint system design.

Response

Crushable honeycomb material is not considered in the materials of the pipe whip restraint system in the APR1400 DC design. Therefore, the SRP guideline is not applicable and no details are necessary for crushable material. Subsection 3.6.2.4.1.1 will be revised to clarify that the APR 1400 does not use crushable material in pipe whip restraint systems.

Impact on DCD

DCD Subsection 3.6.2.4.1.1 will be revised as indicated in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

capacity of the support structure. The restraint is designed for the impact force induced by the maximum possible initial gap between the whip restraint and the process pipe.

The impact energy is usually too high for an elastic restraint system or support structure to absorb. Therefore, energy-absorbing restraints are designed using the energy balance approach (impact energy + external work = internal energy of pipe restraint system).

3.6.2.4.1.1 <u>Pipe Whip Restraint Components</u>

Pipe whip restraints typically consist of the components listed below. The typical shape of a pipe whip restraint is shown in Figure 3.6-1.

a. Energy-absorbing members

   Members that absorb energy by significant plastic deformations under the influence of impacting pipes (pipe whip).

Crushable honeycomb material is not used in pipe whip restraint systems.

b. Non-energy-absorbing members

   Components that form a direct link between the pipe and the structure.

c. Structural attachments

   Fasteners that provide the method of attaching connecting members to the structure (e.g., welds, bolts).

d. Support structure

   Steel and concrete support structures that ultimately carry the restraint load. Design criteria are specified in Subsections 3.8.3 and 3.8.4.

3.6.2.4.1.2 <u>Methods for the Dynamic Analysis of Pipe Whip</u>

A clearance between a pipe whip restraint and pipe is usually provided for thermal expansion during normal operation. If a break occurs, the restraints or anchors nearest the

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Issue # 15 (AI 3-52.18)

SRP 3.6.2, Section III.2.B(i) and (ii) provide the staff's guideline for the dynamic analysis of postulated ruptured pipe and the pipe whip restraint system. For both the energy balance analysis model and the lumped parameter analysis model, the staff's guideline states that the maximum possible initial gap between the pipe whip restraint and the pipe should be used to account for the most adverse dynamic effects of pipe whip. The staff noted that DCD Tier 2, Subsection 3.6.2.4.1, "Pipe Whip Restraints," states that the pipe whip restraint is designed for the impact force induced by the maximum possible initial gap between the pipe whip restraint and the pipe. The applicant is to clarify that this pipe whip design criterion is applicable for both the energy balance method and the lumped parameter method described in DCD Tier 2, Subsection 3.6.2.4.1.2, "Methods for the Dynamic Analysis of Pipe Whip."

Response

In the design of the APR1400, pipe whip restraints are designed with consideration for the thermal movement of pipe during operation and the maximum possible initial gap in the dynamic analysis using the energy balance method. The lumped parameter method is not considered in the dynamic analysis of pipe whip restraint systems. DCD Tier 2 Subsection 3.6.2.4.1.2 will be revised to incorporate the clarification for the dynamic analysis of pipe whip restraints.

Impact on DCD

DCD Subsection 3.6.2.4.1.2 will be revised as indicated in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

capacity of the support structure. The restraint is designed for the impact force induced by the maximum possible initial gap between the whip restraint and the process pipe.

The impact energy is usually too high for an elastic restraint system or support structure to absorb. Therefore, energy-absorbing restraints are designed using the energy balance approach (impact energy + external work = internal energy of pipe restraint system).

3.6.2.4.1.1 Pipe Whip Restraint Components

Pipe whip restraints typically consist of the components listed below. The typical shape of a pipe whip restraint is shown in Figure 3.6-1.

a. Energy-absorbing members

   Members that absorb energy by significant plastic deformations under the influence of impacting pipes (pipe whip).

b. Non-energy-absorbing members

   Components that form a direct link between the pipe and the structure.

c. Structural attachments

   Fasteners that provide the method of attaching connecting members to the structure (e.g., welds, bolts).

d. Support structure

   Steel and concrete support structures that ultimately carry the restraint load. Design criteria are specified in Subsections 3.8.3 and 3.8.4.

3.6.2.4.1.2 Methods for the Dynamic Analysis of Pipe Whip

A clearance between a pipe whip restraint and pipe is ~~usually~~ provided for thermal ~~expansion during normal operation~~. If a break occurs, the restraints or anchors nearest the

movement of pipe during normal operation and used as the maximum possible initial gap in the dynamic analysis.

break point prevent unlimited movement of the pipe at the point of break. In the absence of analytical justification, a dynamic load factor (DLF) of 2.0 is applied in determining a restraint loading to consider dynamic nature of the piping thrust load. Elasto-plastic pipe and whip restraint material properties may be considered as applicable. The effect of rapid strain rate of material properties is considered in accordance with ANSI/ANS 58.2-1988. A 10 percent increase in yield strength is used to account for strain rate effects.

two

In general, the loading that may result from a break of piping is determined using either a dynamic blowdown or a conservative static blowdown analysis. The ~~three~~ methods for analyzing the interaction effects between a whipping pipe and a restraint are energy balance method, ~~lumped parameter method,~~ and equivalent static method.

that are used

delete

The energy balance method is based on the principle of conservation of energy. The kinetic energy of the whipping pipe generated during the first quarter-cycle of movement is assumed to be converted into equivalent strain energy, which is distributed to the pipe or the whip restraint.

delete

~~The lumped-parameter method is carried out using a lumped-mass model. Lumped mass points are interconnected by springs to take into account inertia and stiffness properties of the system. A dynamic forcing function or equivalent static loads may be applied at each postulated break location with pipe whip interactions. A nonlinear elasto-plastic analysis of the piping-restraint system is used.~~

An equivalent static analysis model is used for rigid rupture restraints. In order to obtain the design load for a rigid restraint, the following equation is used:

$$F = 2 \times 1.1 \times F_B = 2.2F_B$$

Where:

F = design load

F_B = maximum blowdown force

The DLF is taken as 2.0 and rebound effects are accounted for by a factor of 1.1.

Response to Action Item 3-52 Section 3.6.2

MEB Issue List Regarding APR-1400, DCD Tier 2, SECTION 3.6.2

Issue #16 (AI 3-52.19)

DCD Tier 2, Subsection 3.6.2.1.1 provides an outline of the pipe rupture analysis report. The staff reviewed the outline of the applicant's pipe rupture analysis report and determined that the applicant is to clarify whether the postulated crack locations for both high-energy line and moderate-energy line are to be identified in the pipe rupture analysis report.

Response

Crack locations for high- and moderate-energy piping will be identified in the pipe rupture hazard analysis report and will be described in DCD Tier 2, Section 3.6.2.1.1 and 3.6.2.1.4.2.

Impact on DCD

DCD Section 3.6.2.1.1 and 3.6.2.1.4.2 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

1) Identification of break and crack locations in high−energy and moderate−energy piping

described in Section 3.11. The evaluation of the required systems and components demonstrates that the protection requirements of Subsection 3.6.1 are met.

The pipe break analysis is considered for postulated high-energy and moderate-energy line failure. Considering the following information, the plant can be shut down safely and maintained in cold safe shutdown when postulated pipe failure occurs. The results are to be summarized in the pipe rupture analysis report.

a. Dynamic effect analysis from high-energy line break

~~1)~~ 2) Scope of dynamic effect analysis (Class 1 piping inside containment and piping connected NSSS component.)

~~2)~~ 3) Identification of terminal end break and intermediate break (result of stress analysis according to BTP 3-4)

~~3)~~ 4) High-energy line markup P&ID and break point dimensional isometric drawing

~~4)~~ 5) Essential target and dynamic load from pipe break and protection features

~~5)~~ 6) Summary of subcompartment pressure and temperature analysis for a 1 ft^2 break on the main steam and main feed lines, within the pipe break exclusion zone.

b. Environmental analysis of the high-energy and moderate-energy piping systems to protect safety-related system from flooding and other adverse environmental effects.

3.6.2.1.2 <u>Postulated Rupture Descriptions</u>

a. Circumferential break

A circumferential break is assumed to result in pipe severance with full separation of the two severed pipe ends unless the extent of separation is limited by

b. Crack configurations

Through-wall cracks are postulated at those axial locations specified in Subsection 3.6.2.1.4.1.2.

For high-energy piping, through-wall cracks are postulated to be in those circumferential locations that result in the most severe environmental consequences. The flow from the crack is assumed to wet all unprotected components within the compartment with consequent flooding in the compartment and communicating compartments.

for determining environmental conditions described in Table 3.11-2

Fluid flow from a leakage crack is based on a circular orifice with a cross-sectional area equal to that of a rectangle of one-half the pipe inside diameter in length and one-half the pipe wall thickness in width.

3.6.2.1.5 Details of Containment Penetrations

Details of containment penetrations are described in Subsections 3.8.1 and 3.8.2.

3.6.2.2 Guard Pipe Assembly Design Criteria

Guard pipes are not used in all containment penetrations of high-energy piping.

3.6.2.3 Analytical Methods to Define Forcing Functions and Response Models

3.6.2.3.1 Leak-Before-Break Applied Piping

There are no forcing functions or response models for the piping qualified for LBB.

3.6.2.3.2 Analytical Methods to Define Forcing Functions and Response Models for Piping Not Applied to Leak-Before-Break

This subsection applies to all high-energy piping other than that whose dynamic effects due to pipe breaks are eliminated from the design basis by LBB evaluation.