Response to Action Item 3-52 Section 3.6.2

DCD Tier 2, SECTION 3.6.2

Issue #3 (AI 3-52.6)

DCD Tier 2, Subsection 3.6.2.1.4.1.1 states that a terminal end is defined as an extremity of a piping run that connects to structures, components, or pipe anchor that acts as a rigid constraint to piping motion and thermal expansion for Class 1 piping. However, it is not clear whether other piping geometric configurations (e.g., a branch connection to a main piping run) as identified in Footnote 3 of BTP 3-4 are also applicable to APR1400 design and therefore, should be considered as terminal ends for postulating pipe ruptures. In addition, the applicant is to address whether the same terminal end definition is also applicable to the piping systems (e.g., Class 2 piping) identified in other subsections throughout DCD Tier 2, Section 3.6.2.

Response

Branch lines connected to main piping line are also considered as a terminal end according to Footnote 3 of BTP 3-4. The definition of terminal end is applicable to all Class 1, 2, and 3 APR1400 piping systems. Additional clarity on terminal ends will be added to DCD Subsection 3.6.2.1.4.1.1.

Impact on DCD

DCD Section 3.6.2.1.4.1.1 will be revised as shown in 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 and 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:

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:

A terminal end is defined as an extremity of a piping run that connects to structures, components, or pipe anchor that acts as a rigid constraint to piping motion and thermal expansion. Branch lines connected to main piping run are considered as terminal end in accordance with BTP 3-4.

S = primary-plus-secondary stress-intensity range under the combination of loadings for which either Level A or Level B service limits have been specified, as calculated from Equations (10), (12), and (13)

S_m = allowable stress-intensity value

U = cumulative usage factor

~~A terminal end is defined as an extremity of a piping run that connects to structures, components, or pipe anchor that acts as a rigid constraint to piping motion and thermal expansion.~~

As a result of piping reanalysis due to differences between the design configuration and the as-built configuration, the highest stress or cumulative usage factor locations may be shifted. However, the initially determined intermediate break locations need not be changed unless one of the following conditions exists:

a. The dynamic effects from the new (as-built) intermediate break locations are not mitigated by the original pipe whip restraints and jet shields.

b. A change is required in pipe parameters such as major differences in pipe size, wall thickness, and routing.

ASME Section III, Class 2, Class 3, or Seismically Analyzed ASME B31.1 (Reference 10) Piping

With the exceptions of the portions of piping identified in Subsection 3.6.2.1.3, breaks in ASME Section III Class 2&3 piping are postulated at the following locations in each piping and branch run:

a. At terminal end

b. At intermediate locations selected by one of the following criteria:

1) At each pipe fitting (e.g., elbow, tee, cross, flange, nonstandard fitting), welded attachment, and valve or where the piping contains no fittings, welded

Response to Action Item 3-52 Section 3.6.2

DCD Tier 2, SECTION 3.6.2

Issue #8 (AI 3-52.11)

The applicant is to clarify the criterion used for determining the crack locations for Class 1 piping. Item (a) of DCD Tier 2, Subsection 3.6.2.1.4.1.2 states that through-wall leakage cracks are not postulated at locations where, for Class 1 piping, the calculated value of S is less than 0.4 times the stress or usage limits. The applicant is to define the stress value "S." In addition, the applicant is to clarify the criterion of "0.4 times the stress or usage limits" and to justify any departure from the staff's guideline as described in BTP 3-4, Part B, Item A(v)(1).

Response

For Class 1 piping, the calculated value of stress range (from Equation (10) in ASME Section III, Division 1, NB-3653) is less than 1.2Sm. This section of the DCD will be revised to reflect this through-wall crack criteria for Class 1 piping.

Impact on DCD

DCD Section 3.6.2.1.4.1.2 will be revised as shown in 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 and Environmental Reports.

a. At terminal ends of the pressurized portions of the network

b. At each intermediate location of potential high stress or fatigue, such as pipe fittings, valves, flanges, and welded-on attachments

3.6.2.1.4.1.2 Crack Locations

Through-wall Cracks

Through-wall cracks are postulated in all high-energy and moderate-energy piping systems having a nominal diameter greater than 2.54 cm (1 in), except that through-wall cracks are not postulated at locations where:

a. For Class 1 piping, the calculated value of ~~S is less than 0.4 times the stress or usage limits.~~ stress range by equation (10) in ASME Section III, Division 1, NB−3653 is less than 1.2 S_m.

b. For Class 2, Class 3, or seismically analyzed ASME B31.1 piping, the calculated value of S is less than 0.4 times the stress limits.

c. For the containment penetration area, the requirements of Subsection 3.6.2.1.4.1.3 are satisfied.

d. For moderate-energy piping near high-energy piping where a break in high-energy piping is postulated that results in more limiting environmental conditions, the through-wall crack in the moderate-energy piping is not postulated.

e. Through-wall cracks, instead of breaks, are postulated for the piping classified as moderate energy as defined in subsection 3.6.1.1.2 due to its short operational period in the high-energy condition.

Leakage Cracks

A leakage crack is postulated in place of a circumferential break, longitudinal break, or through-wall crack if justified by an analysis performed on the pipeline in accordance with the requirements described in Subsection 3.6.3.

Response to Action Item 3-52 Section 3.6.2

DCD Tier 2, SECTION 3.6.2

Issue #9 (AI 3-52.12)

The applicant is to clarify the criterion used for determining the crack locations for Class 2 and 3 piping or seismically analyzed ASME B31.1 piping. Item (b) of DCD Tier 2, Subsection 3.6.2.1.4.1.2 states that through-wall leakage cracks are not postulated at locations where the calculated value of S is less than 0.4 times the stress limits. The applicant is to define the stress value "S." In addition, the applicant is to clarify the criterion of "0.4 times the stress limits" and to justify any departure from the staff's guideline as described in BTP 3-4, Part B, Item A(v)(2). Moreover, the applicant is to address the criteria used for determining the crack locations for non-seismically analyzed ASME B31.1 piping, if applicable.

Response

For Class 2, Class 3 piping and seismically analyzed non-safety related ASME B31.1 piping, the calculated stress (from the sum of Equations (9) and (10) in ASME Section III, Division 1, NC/ND-3653) is less than 0.4 times the summation of the stress limits in NC/ND-3653. This section of the DCD will be revised to reflect this through-wall crack criteria for Class 2 and 3 piping. Through-wall cracks for non-seismically designed ASME B31.1 piping are assumed at the locations that result in severe environmental conditions.

Impact on DCD

DCD Section 3.6.2.1.4.1.2 will be revised as shown in 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 and Environmental Reports.

a. At terminal ends of the pressurized portions of the network

b. At each intermediate location of potential high stress or fatigue, such as pipe fittings, valves, flanges, and welded-on attachments

3.6.2.1.4.1.2 Crack Locations

Through-wall Cracks

Through-wall cracks are postulated in all high-energy and moderate-energy piping systems having a nominal diameter greater than 2.54 cm (1 in), except that through-wall cracks are not postulated at locations where:

a. For Class 1 piping, the calculated value of S is less than 0.4 times the stress or usage limits.

b. For Class 2, Class 3, or seismically analyzed ASME B31.1 piping, the calculated ~~value of S~~ is less than 0.4 times ~~the stress limits.~~

stress by the sum of equations(9) and (10) in NC/ND−3653

the sum of the stress limits given in NC/ND−3653.

ment penetration area, the requirements of Subsection 3.6.2.1.4.1.3

d. For moderate-energy piping near high-energy piping where a break in high-energy piping is postulated that results in more limiting environmental conditions, the through-wall crack in the moderate-energy piping is not postulated.

e. Through-wall cracks, instead of breaks, are postulated for the piping classified as moderate energy as defined in subsection 3.6.1.1.2 due to its short operational period in the high-energy condition.

Leakage Cracks

A leakage crack is postulated in place of a circumferential break, longitudinal break, or through-wall crack if justified by an analysis performed on the pipeline in accordance with the requirements described in Subsection 3.6.3.

Response to Action Item 3-52 Section 3.6.2

DCD Tier 2, SECTION 3.6.2

Issue #10 (AI 3-52.13)

DCD Tier 2, Subsection 3.6.2.1.4.2 (b), "Crack Configuration," states that through-wall cracks are postulated at those axial locations specified in DCD Tier 2, Subsection 3.6.2.1.4.1.2. It further states that for high-energy piping, through-wall cracks are postulated in those circumferential locations that result in the most severe environmental consequences. However, it should be noted that, according to the staff's guideline as described in BTP 3-4, Part B, Item B(iii)(2) for the moderate-energy fluid system piping, leakage cracks should be postulated at axial and circumferential locations that result in the most severe environmental consequences. The applicant is to justify the departure from the staff's guideline regarding the postulated crack configuration (i.e., at both axial and circumferential locations that result in the most severe environmental consequences) for the moderate-energy fluid system piping.

Response

Through-wall cracks in moderate-energy piping are postulated at axial and circumferential locations that result in the most severe environmental consequences as described in BTP 3-4. DCD subsection 3.6.2.1.4.2 will be updated to include that moderate-energy piping cracks are postulated in axial locations as well as circumferential locations.

Impact on DCD

DCD Section 3.6.2.1.4.2 will be revised as shown in 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 and Environmental Reports.

b. Crack configurations

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

high and moderate-

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.

axial and

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

DCD Tier 2, SECTION 3.6.2

Issue #11 (AI 3-52.14)

11. With respect to the method of dynamic analysis of unrestricted pipes, DCD Tier 2, Subsection 3.6.2.3.2.2 discusses the assessment of the impact of unrestrained pipe on a barrier (e.g., the division wall). However, it does not address the impact of unrestrained pipe on adjacent pipe. The applicant is to discuss whether its methodology used for evaluating the impact of unrestrained pipe on adjacent pipe is consistent with the staff's guideline as delineated in SRP 3.6.2 Section III.2.

Response

The impact of an unrestrained pipe on an adjacent pipe is considered in high-energy line break analysis. An unrestrained broken pipe is postulated to cause a rupture to an adjacent pipe if the diameter and wall thickness is smaller than the whipping pipe. A through-wall crack is postulated if the impacted pipe has a nominal pipe diameter larger or equal to the whipping pipe, but has a thinner wall thickness. If the impacted pipe diameter and wall thickness is equal to or greater than the whipping pipe, then the pressure boundary is postulated to remain intact. DCD Section 3.6.2.3.2.2 will be updated to include the methodology for evaluating the damage from an unrestrained whipping pipe. This is consistent with SRP 3.6.2 Section III.2.

Impact on DCD

DCD Section 3.6.2.3.2.2 will be revised as shown in 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 and Environmental Reports.

The impact velocity V_I is found from the expression for the kinetic energy:

$$V_I^2 = \frac{2\,gKE}{W_{eq}}$$

Where:

W_{eq} = equivalent weight of the cantilever

For a straight run of pipe rotating about a plastic hinge, the zone of influence of the whipping pipe accounts for an increasing length due to a traveling hinge point caused by strain hardening effects. The impact energy of unrestrained pipe into a barrier (e.g., the divisional wall) is governed by the vector component of its velocity at impact that is perpendicular to the barrier. Impact of small piping into building structures conservatively assumes that all of the impact energy is imparted to the barrier with no dissipation due to local crushing deformation of the pipe.

Bearing area of impact on building structure is generally elliptical, but is treated as a circle of equivalent area, with dimensions based on experimental data for pipe crush behavior. As the impact load is greatest on the periphery of the ellipse, this yields a conservative force distribution into the barrier. Long-term loading on the barrier subsequent to impact due to system blowdown and continued deceleration of remaining pipe (beyond the impact zone) is accounted for in addition to the initial impulsive loading.

3.6.2.4 Dynamic Analysis Methods to Verify Integrity and Operability

3.6.2.4.1 Pipe Whip Restraints

This section applies to pipe whip restraints for all piping other than that whose dynamic effects due to pipe breaks are eliminated from the design basis by LBB evaluation.

When required, pipe whip restraints are provided to protect the safety-related component against the effects of pipe whipping during postulated pipe break. The design of pipe whip restraints is governed not only by the pipe break blowdown thrust, but also by functional requirements, deformation limitations, properties of whipping pipe, and the

Unless a detailed analysis is performed to evaluate the response of an impacted pipe, the impacted pipe of smaller size and wall thickness is assumed to be failed at the point of initial contact. The impacted pipe of larger or equal size with thinner wall thickness is assumed to develop a through-wall crack. If the impacted pipe has both nominal size and wall thickness larger than or equal to that of the whipping pipe, its pressure boundary integrity is assumed to be undamaged.