

### 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:~~

- 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 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.

Issue #1, #2

Breaks and cracks are not postulated in the piping between the containment wall and the inboard or outboard isolation valves, which is designed in accordance with ASME Section III, NE - 1120. Pipe break exclusion design expands to the auxiliary building anchor wall beyond isolation valve and meets the following additional requirements:

#### 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:

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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.

$S$  = 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

Issue #3

~~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

- 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.~~ Issue #8

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.~~

Issue #9

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

penetration area, the requirements of Subsection 3.6.2.1.4.1.3

Issue #9

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

- 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.

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.

Issue #10

axial and

The flow from the crack is assumed to wet all unprotected components within the compartment with consequent flooding in the compartment and communicating compartments.

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.

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

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

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 **Issue # 11**

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.