Inquiry: What methods may be used for evaluation of Class 2 and 3 piping items subjected to internal or external wall thinning?

Reply: It is the opinion of the Committee that the following methods may be used for evaluation of Class 2 and 3 piping items subjected to internal or external wall thinning.

-1000 SCOPE

(a) This Case provides requirements for evaluation of Class 2 and 3 piping items (e.g., pipe and fittings) with internal or external wall thinning.

(b) This Case is applicable to wall thinning due to flow-accelerated corrosion and other corrosion mechanisms.

(c) The provisions of this Case apply to Class 2 and 3 butt-welded pipe, pipe bend, elbow, tee, branch connection, or reducer piping items.

(d) This Case shall not be applied to planar flaws.

(e) This Case shall not be applied to wall thinning locations in piping items that are not accessible for either volumetric examination or direct physical measurement.

-3000 ACCEPTANCE STANDARDS

-3100 PRESERVICE EXAMINATION

Piping items examined prior to commercial service are acceptable for service when the measured wall thickness meets the requirements of the Construction Code.

-3200 INSERVICE EXAMINATION

-3210 General

(a) The current wall thickness of the metal loss region, \( t_c \), shall be determined in accordance with -3220.

(b) The predicted wall thickness in the metal loss region, \( t_p \), shall be determined at the end of the evaluation period \( \tau \), in accordance with -3220.

(c) If the minimum predicted wall thickness at the end of the evaluation period, \( t_{p, \text{min}} \), is less than 0.25\( t_{\text{nom}} \), further use of this Case is not permitted. Alternatively, the Owner may select a shorter evaluation period and determine a new \( t_p \) and \( t_{p, \text{min}} \).

(d) The metal loss region shall be evaluated in accordance with the requirements of the Construction Code or the acceptance criteria in either -3500 or -3600 of this Case.

(e) The metal loss region of the piping item shall be subjected to volumetric re-examination or direct physical measurement in accordance with -3220 at intervals that do not exceed the length of the evaluation period.

(f) If the metal loss region of the piping item does not meet the acceptance criteria of this Case, a repair/replacement activity shall be performed.

-3220 Characterization of Metal Loss

Current wall thickness of the metal loss region, \( t_c \), shall be characterized by volumetric thickness measurement or by physical measurement. The condition of the full pipe circumference shall be assessed, and the metal loss region shall be inspected to characterize the extent of degradation.

(a) The rate of metal loss during the evaluation period shall be determined. The rate of metal loss shall account for concurrent internal and external metal loss, as applicable, at the affected location.

(b) For each position along the profile of the metal loss region, the local predicted remaining wall thickness at the end of the evaluation period, \( t_p \), shall be calculated as follows:

\[
 t_p = t_c - R \times \tau
\]

where

\( R \) = predicted rate of metal loss during the evaluation period, and which includes a factor for uncertainty in metal loss rate, in./yr (mm/yr)

\( t_c \) = current local wall thickness at the position along the profile of the metal loss region corresponding to \( t_p \), in. (mm)

\( \tau \) = length of the evaluation period, yr
(b) The branch piping shall be evaluated in accordance with the requirements of -3622 and -3623.

-3624.2 Branch Connections Requiring Reinforcement.

(a) Branch reinforcement requirements shall be determined in accordance with the Construction Code used in the analytical evaluation.

(b) For the region of the piping run that provides branch reinforcement, the value of $t_p$ at any location shall be not less than $t_{min}$ for the nominal pipe run plus any required reinforcement at that location.

(c) For the region of the branch pipe that provides branch reinforcement, $t_p$ shall be not less than $t_{min}$ for the branch pipe plus any required reinforcement.

Table -3625-1
Modified Stress Range Reduction Factors

<table>
<thead>
<tr>
<th>Number of Equivalent Full Temperature Cycles</th>
<th>$N$</th>
<th>Stress Range Reduction Factor $f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>650 or less</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>&gt;650 to 1100</td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>&gt;1100 to 2000</td>
<td></td>
<td>0.8</td>
</tr>
<tr>
<td>&gt;2000 to 3900</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>&gt;3900 to 6500</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>&gt;6500 to 21,000</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>over 21,000</td>
<td></td>
<td>0.4</td>
</tr>
</tbody>
</table>

NOTES:
(1) Cycles to the end of the evaluation period or repair/replace activity.
(2) The modified stress range reduction factors are based on an increase in the stress intensification factor, $i$, by a factor of 2 over the life of the component.

-3625 Analytical Evaluation for Cyclic Operation

(a) For piping items with $t_{min}$ not less than 0.75$t_{nom}$ and subject to no more than 150 equivalent full temperature cycles at the end of the evaluation period, in accordance with the Construction Code used in the analytical evaluation, piping stress equations that include thermal expansion and anchor movement stresses need not be evaluated.

(b) For piping items not meeting the provisions of (a) above, when the design includes consideration of thermal expansion stresses, the allowable stress range for expansion stress shall be determined in accordance with the Construction Code used in the analytical evaluation, except that the stress intensification factor, $i$, shall be revised to take into account the geometry of the thinned region. As an alternative to establishing a revised stress intensification factor, the stress range reduction factors of Table -3625-1, which are based on an increase in the stress intensification factor by a factor of 2 over the life of the component, may be used.

(c) The potential for local overstrain in the thinned region for the combination of maximum sustained plus thermal expansion stresses shall be evaluated. Sustained loads include pressure, weight, and other sustained mechanical loads. Local overstrain is defined in NC-3672.6

(b). Analytical evaluation methods and acceptance criteria shall be specified by the Owner.

-3626 Nomenclature

- $A_i$ = predicted inside cross-sectional area for a pipe that has experienced wall thinning
- $A_m$ = predicted metal cross-sectional area for a pipe that has experienced wall thinning
- $A_o$ = total cross-sectional area of pipe based on nominal outside diameter, $\frac{\pi D_o^2}{4}$
- $A_p$ = predicted metal cross-sectional area of pipe
- $A_{rein}$ = the reinforcement area available in the pipe wall based on the predicted thickness distribution in excess of $t_{min}$ and within the limits of reinforcement of the Construction Code for an opening with diameter $L_m$ at the region of local thinning
- $D_1$ = outside diameter at the large end of the reducer
- $D_1$ = nominal inside diameter of a branch connection
- $D_o$ = nominal outside diameter of piping item
- $d_o$ = maximum outside diameter of a reducer at the thinned location
- $f$ = stress range reduction factor
- $I_{min}$ = predicted minimum moment of inertia of the thinned pipe about the neutral axis of the pipe section, considering all orientations of the section neutral axis
- $i$ = stress intensification factor of the Construction Code (not less than 1.0)
- $L$ = maximum extent of a local thinned area with wall thickness less than $t_{nom}$
- $L_m$ = maximum extent of a local thinned area with wall thickness less than $t_{min}$
- $L_{m(a)}$ = maximum axial extent of a local thinned area with wall thickness less than $t_{min}$
- $L_{m(a), max}$ = maximum of the axial extents of two adjacent local thinned areas with wall thickness less than $t_{min}$
- $L_{m(c)}$ = maximum circumferential extent of a local thinned area with wall thickness less than $t_{min}$
- $L_{m, avg}$ = average of the extents of thickness less than $t_{min}$ for two adjacent thinned areas
- $M_b$ = resultant bending moment from the design analysis of record for each loading condition under consideration
- $P$ = design pressure
- $R$ = rate of metal loss
- $R_b$ = bend radius of an elbow to the elbow center line