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 $0.25t_{\text{nom}}$, 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 $R = \text{predicted rate of metal loss during the evaluation period, in./yr (mm/yr)}$.

The Committee’s function is to establish rules of safety, relating only to pressure integrity, governing the construction of boilers, pressure vessels, transport tanks and nuclear components, and in-service inspection for pressure integrity of nuclear components and transport tanks, and to interpret these rules when questions arise regarding their intent. This Code does not address other safety issues relating to the construction of boilers, pressure vessels, transport tanks and nuclear components, and the in-service inspection of nuclear components and transport tanks. The user of the Code should refer to other pertinent codes, standards, laws, regulations or other relevant documents.
Replace with new Figure -3210-1

Editor's Note:
This Figure -3210-1 is to be deleted and replaced with the Figure -3210-1 on the following page. Editorial changes to the figure are enclosed in red.
Figure -3210-1
General Flow Chart

Determine \( t_w \), current wall thickness, using -3220

Select Evaluation Period, \( \tau \)

Select a shorter Evaluation Period length, \( \tau \)

Determine \( t_p \), predicted wall thickness, at end of evaluation period using -3220

Is \( t_{p,\text{min}} \leq 0.25t_{\text{nom}} \)?

NO

YES

(a) \( f_p \) or \( f_{p,\text{min}} \) satisfies the Construction Code

(b) \( t_p \) or \( f_{p,\text{min}} \) satisfies -3500

(c) \( f_p \) or \( f_{p,\text{min}} \) satisfies -3600

Requirements of (a), (b), or (c) satisfied?

NO

YES

Reinspect in accordance with -3210(f)

Is the measured metal loss rate of -3220(d) \( \leq R \)?

YES

NO

Update metal loss rate per -3220(d)

Repair or replace

2 (N-597-34)
The Owner shall be responsible for determining the rate of future metal loss, \( R \), and factors to account for uncertainties in the metal loss rate. The known rate of metal loss for the specific degradation mechanism based on operating experience or laboratory tests shall be used if available. For metal loss caused by flow-accelerated corrosion, a future wall thinning rate calculated using the average actual rate over the service or inspection history, including an appropriate uncertainty factor, is acceptable. If the wall thinning rate is calculated based on the total time in service, the Owner shall not assume an initial pipe wall thickness less than \( t_{n,\text{nom}} \) unless initial wall thickness measurements are available.

\( t_p \): the minimum value of \( t_p \) in the metal loss region is \( t_{p,\text{min}} \), as illustrated in Figure -3622-3.

### -3500 WALL THICKNESS ACCEPTANCE STANDARDS

\( t_p \): The Owner shall verify that the rate of metal loss calculated using the wall thickness measurement at the beginning of the evaluation period and the measurements obtained during the evaluation period is less than or equal to the predicted rate of metal loss \( R \) used to establish the evaluation period length.

\( t_p \): The metal loss rate is verified if the measured metal loss rate does not exceed \( R \). If the rate of metal loss exceeds the metal loss rate used to establish the evaluation period length, the evaluation period length shall be re-calculated using a higher value for the predicted metal loss rate. The factor for uncertainty applied to the metal loss rate shall be modified to account for the difference between the measured metal loss and the predicted level of metal loss at the time of the measurement. The evaluation period length shall not be increased based on reanalysis of the metal loss rate.

\( 0.875t_{n,\text{nom}} \): For the pipe size at the large end, the required thickness shall be gradually reduced from that required at the large end to that required at the small end (see Figure -3622-2).

\( 0.875t_{n,\text{nom}} \): For tees and branch connections, \( t_p \) shall be not less than \( 0.875t_{n,\text{nom}} \) for the same size pipe for regions outside the limits of reinforcement required by the Construction Code used in the evaluation. For regions within the limits of reinforcement, \( t_p \) shall be not less than the thickness required to meet the branch reinforcement requirements of the Construction Code.

\( 0.875t_{n,\text{nom}} \): For regions of piping items designed to specific wall thickness requirements, including designed weld counterbores and regions with integral reinforcement, \( t_p \) shall be not less than the minimum design thickness, including tolerances and excluding any corrosion allowances, specified in the original design analysis for the piping item.

\( 0.875t_{n,\text{nom}} \): As an alternative to the requirements of (2) and (3), for reducers, tees, or branch connections purchased to fitting standards allowed in NB-3132 and for which baseline as-installed thickness measurements exist, \( t_p \) shall not be less than 0.875 times the as-installed thickness measurements, except that the thickness shall be not less than 0.875\( t_{n,\text{nom}} \).

### -3600 ANALYTICAL EVALUATION

#### -3610 General Requirements

\( (a) \): Analytical evaluations shall be conducted using the predicted wall thickness profile, \( t_p \), at the end of the evaluation period for the piping item.

\( (b) \): Analytical evaluation shall be conducted in accordance with the Construction Code. Later Construction Code Editions and Addenda may be used.

\( (c) \): A piping item is acceptable for continued service if the minimum pipe wall thickness, branch reinforcement requirements, and piping stress criteria of the Construction Code used in the analytical evaluation are met for all specified loading conditions.

\( (d) \): As an alternative to \( (b) \) and \( (c) \), butt welded pipe, pipe bend, elbow, branch connection, and reducer piping items may be evaluated in accordance with -3620.

#### -3620 Analytical Evaluation of Pipe, Pipe Bends, Elbows, Branch Connections, and Reducers

\( (a) \): Analytical evaluations shall be conducted using the loadings, load combinations, material properties, and other conditions applicable to the pipe bend, elbow, branch connection, or reducer piping item. The analysis shall determine in accordance with -3622 the acceptable value of \( L_m \) used in -3622.

\( (b) \): An analytical evaluation shall be conducted in accordance with -3622 to determine the acceptability of the thinned region for hoop stress due to internal pressure.

\( (c) \): An analytical evaluation shall be conducted in accordance with -3623 to determine the acceptability of the thinned region for longitudinal stress due to internal pressure and moments.

\( (d) \): An analytical evaluation shall be conducted in accordance with -3624 to determine the acceptability of the thinned region for buckling of the thinned region shall be evaluated. Analytical evaluation methods and acceptance criteria shall be specified by the Owner.

\( (e) \): For a branch connection or tee, the region within the limits of reinforcement defined in the Construction Code shall also meet the requirements of -3624.

\( (f) \): Requirements for the analytical evaluation of cyclic operation are given in -3625.

\( (g) \): If the ratio \( R_p/t_p \) is greater than 50, the potential for buckling of the thinned region shall be evaluated. Analytical evaluation methods and acceptability criteria shall be specified by the Owner.