Table C-8510-1M

<table>
<thead>
<tr>
<th>Material</th>
<th>( \Phi ) ( \text{[m/s][MPa\sqrt{m}]^{-\eta}} )</th>
<th>( \eta )</th>
<th>( \kappa_{\text{RH}} ) ( \text{[MPa}\sqrt{m}] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy 600</td>
<td>( 2.57 \times 10^{-12} )</td>
<td>1.16</td>
<td>9.0</td>
</tr>
<tr>
<td>Alloy 02</td>
<td>( 5.27 \times 10^{-12} )</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td>Alloy 182</td>
<td>( 1.5 \times 10^{-12} )</td>
<td>1.6</td>
<td>0</td>
</tr>
<tr>
<td>Alloy 132</td>
<td>( 1.5 \times 10^{-12} )</td>
<td>1.6</td>
<td>0</td>
</tr>
</tbody>
</table>

**GENERAL NOTE:** Factor \( \Phi \) is for \( \partial E \partial t \) in units of m/s and \( \kappa \) in units of MPa\sqrt{m}.

(U.S. Customary Units)

\[
C_1 = 1.6 \times 10^{-8} \text{[in./hr][ksi\sqrt{in.}]^{-\eta}}
\]

\[
C_2 = 5.0 \times 10^{-5} \text{in./hr}
\]

\( \eta = 2.5 \)

(SI Units)

\[
C_1 = 8.92 \times 10^{-14} \text{[m/s][MPa\sqrt{m}]^{-\eta}}
\]

\[
C_2 = 3.53 \times 10^{-10} \text{m/s}
\]

\( \eta = 2.5 \)

Reference SCC crack growth rate curves for Normal Water Chemistry are provided in Fig. C 8510 2 (Fig. C-8510-2M).

For a BWR environment with Hydrogen Water Chemistry, which is defined by ECP (electrochemical potential) \( \approx -230 \text{ mV SHF (standard hydrogen electrode)} \)

(U.S. Customary Units)

\[
C_1 = 3.2 \times 10^{-10} \text{[in./hr][ksi\sqrt{in.}]^{-\eta}}
\]

\[
C_2 = 5.0 \times 10^{-6} \text{in./hr}
\]

\( \eta = 3.0 \)

![Figure C 8510 1](image)

**SCC Curves for Alloy 600, 82, 182, and 132 in PWR Environment at 617°F**

For other temperatures, see C-6511
\[ C_1 = 1.70 \times 10^{-15} \text{ m/s} \left( \text{MPa} \sqrt{\text{m}} \right)^{-n} \]

\[ C_2 = 3.53 \times 10^{-11} \text{ m/s} \]

\[ \eta = 3.0 \]

Reference SCC crack growth rate curves for Hydrogen Water Chemistry are provided in Fig. C-8510-2.

**C-8520** \( \text{IGSCC in Austenitic Stainless Steel in BWR Reactor Water Environments} \)

\( \text{(a)} \) The following equation provides the IGSCC growth rate in the depth direction for fluence less than or equal to \( 5 \times 10^{20} \text{ n/cm}^2 \) at \( E > 1.0 \text{ MeV} \):

\[ \left( \frac{da}{dt} \right) = \exp \left[ -0.787 \text{Cond}^{-0.586} + 0.00362 \text{ ECP} \right. \]
\[ \quad + \left. \frac{6730}{0.5556 T_F + 255.2} - 28.073 \right] \left( K_I \right)^{2.181} \]

where

\[ \text{Cond} = \text{average conductivity (}\mu\text{S/cm}) \]
\[ \text{da/dt} = \text{crack growth rate (in./hr)} \]
\[ \text{ECP} = \text{corrosion potential (mV[SHE])} \]
\[ K_I = \text{stress intensity factor (ksi} \sqrt{\text{in.})} \]
\[ T_F = \text{temperature (°F)} \]

This equation is valid for \( \text{Cond} \) between 0.055 and 0.30 \( \mu\text{S/cm} \), ECP between -575 and 250 mV[SHE], \( T_F \) between 200°F and 552°F, and chloride and sulfate concentrations each less than or equal to 5 ppb, at the flaw location.

The following equation provides the IGSCC flaw growth rate in the depth direction for fluence less than or equal to \( 5 \times 10^{20} \text{ n/cm}^2 \) at \( E > 1.0 \text{ MeV} \):

\[ \left( \frac{da}{dr} \right) = \exp \left[ -0.787 \text{Cond}^{-0.586} + 0.00362 \text{ ECP} \right. \]
\[ \quad + \left. \frac{6730}{T_F - 33.235} \right] \left( K_I \right)^{2.181} \]

where

\[ \text{Cond} = \text{average conductivity (}\mu\text{S/cm}) \]
\[ \text{da/dr} = \text{crack growth rate (mm/s)} \]
\[ \text{ECP} = \text{corrosion potential (mV[SHE])} \]
\[ F_m = 1.1 \left( \frac{a'}{t} \right) 0.15241 + 16.722 \left[ \frac{a'}{t} \left( \frac{a'}{t} / \pi \right)^{0.855} \right] - 14.944 \left[ \frac{a'}{t} \left( \frac{a'}{t} / \pi \right)^{0.855} \right] \]
\[ F_k = 1.1 + \left( \frac{a'}{t} \right) - 0.09967 + 5.0057 \left[ \frac{a'}{t} \left( \frac{a'}{t} / \pi \right)^{0.555} \right] - 2.8329 \left[ \frac{a'}{t} \left( \frac{a'}{t} / \pi \right)^{0.555} \right] \]
\[ a' = a + \Delta a \]

In the above equations, \( a' \) is updated after each increment of ductile flaw extension, while \( \theta \) is fixed at its end-of-evaluation-period value. Residual stresses shall be included with a structural factor of 1.0.

**H-4520 AXIAL FLAWS**

Failure assessment point coordinates \( (S^c_r, K^c_r) \) for part-through-wall axial flaws with a specified amount of ductile flaw extension, \( \Delta a \), are given below. When the temperature is in the transition or lower-shelf region, \( J_o \) shall be replaced by \( J_{0c} \), and \( \Delta a \) shall be zero.

(a) The coordinate \( S^c_r \) is given by

\[ S^c_r = (S^m_r) p / P_o \]

where \( S^m_r \) is the structural factor on primary membrane stress specified in Table H-4200-2, and \( P_o \) is recalculated for each value of \( \Delta a \).

\[ p_a = \left( \frac{2}{\sqrt{3}} \right) \left[ 1 - \frac{1}{Z} \right] + \frac{v' / f(v)}{E} \]

\[ J(x) = (1 + 1.612)^{0.5} \]

\[ z = 0.1542 \frac{t^2}{[\Delta a (R_1/t) + 0.5]} \]

\[ a' = a + \Delta a \]

(b) The coordinate \( K^c_r \) is given by

\[ K^c_r = (\mu / J_o) 0.5 \]

where \( J_c \) and \( J_o \) are calculated for each value of \( \Delta a \). The linear elastic \( J \)-integral is given by

\[ J_o = \frac{1}{10000} K^2 / E \]

and

(U.S. Customary Units)

\[ K_i = (S^m_r) p (R_i / t) F_1 (\pi a' / Q)^{0.5} + K_{0r} \]

(SI Units)

\[ K_i = (S^m_r) p (R_i / t) F_1 (\pi a' / 10000 Q)^{0.5} + K_{0r} \]

\[ Q = 1 + 4.59/3 (a / \theta)^{0.65} \]

\[ F_1 = 0.17 \left[ M_1 + M_2 (a' / t)^2 + M_3 (a' / t)^4 \right] \frac{F_c}{F_1} \]

\[ F_c = \left[ (R_2^2 + R_1^2) (R_2^2 - R_1^2) + 1 - 0.5 (a / t)^{0.5} \right] / R_1 \]

\[ M_1' = 1.13 - 0.18 (a / t) \]

\[ M_2' = -0.54 + 0.445 / \left[ 0.1 + (a / t) \right] \]

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The Title for Category D-B in Table IWD-2500-1, 2010 Edition with 2011 Addenda, is “WELDED ATACHMENTS FOR VESSELS, PIPING, PUMPS, AND VALVES”, THE Title should be “ALL PRESSURE RETAINING COMPONENTS” per IWD-2500.
(c) Helical-coil threaded inserts shall be supplied with a Certified Material Test Report that provides traceability to the item, material specification, chemical composition, grade or class, and mechanical properties and heat-treated condition prior to final forming.

(d) Helical-coil threaded inserts shall be installed in accordance with the manufacturer’s instructions.

IWA-4300  DESIGN

IWA-4310  GENERAL REQUIREMENTS

(a)(10) IWA-4311  Material, Design, or Configuration Changes

When a change is made to the design or configuration of an item or system, including material substitution, the change shall meet the following requirements:

(a) When an analysis of the item or system prior to the change is available, the change shall be evaluated and documented to demonstrate that the existing analysis is bounding for all design conditions. If the existing analysis does not bound all design conditions for the change, a reanalysis shall be performed. The evaluation may show that reanalysis is not required. The evaluation or reanalysis shall document that the proposed change meets the Owner’s Requirements, and the Construction Code or alternative provisions of this Division. The evaluation or reanalysis shall be traceable in accordance with IWA-4180(d).

(b) When an analysis of the item or system prior to the change is unavailable (e.g., proprietary design, standard B16.5 flanges or fittings, standard B16.34 valve), an evaluation or a new analysis shall be performed to document that the proposed change meets the Owner’s Requirements and the Construction Code or alternative provisions of this Division. The evaluation may show that an analysis is not required. The evaluation or new analysis shall be maintained in the same manner as a Design Report in accordance with (a) and IWA-4180(d).

(c) Later Editions and Addenda of Construction Code or a later different Construction Code, in accordance with IWA-4221(c), either in its entirety or portions thereof, and Code Cases may be used, provided the requirements of IWA-4226 are met.

(d) Analyses shall be reviewed and certified in accordance with the requirements of the Construction Code and Owner’s Requirements. Evaluations shall be certified as required for analyses.

(e) For any design or configuration change that deviates from the Owner’s Requirements, Design Specification, or Design Report, the affected documents shall be revised or updated in accordance with IWA-4180(d).

IWA-4320  PIPING

IWA-4321  Class 1 Mechanical Joints

(a) Flanged joints may be used in Class 1 piping systems.

(b) Expanded joints shall not be used in Class 1 piping systems.

(c) Threaded joints in which the threads provide the only seal shall not be used in Class 1 piping systems. If a seal weld is employed as the sealing medium, the stress analysis of the joint shall include the stresses in the weld resulting from the relative deflections of the mated parts.

(d) Flared, flareless, and compression-type tubing fittings may be used for tubing sizes not exceeding 1 in. O.D. within the limitations of applicable standards and requirements of (2) and (3). In the absence of such standards or specifications, the Owner shall determine that the type of fitting selected is adequate and safe for the Design Conditions in accordance with the following requirements.

(1) The fitting pressure-temperature ratings shall be reconciled with the specified design and operating conditions.

(2) Fittings and their joints shall be suitable for the tubing with which they are to be used, in accordance with the minimum wall thickness of the tubing and method of assembly recommended by the manufacturer.

(3) Fittings shall not be used in services that exceed the manufacturer’s maximum pressure-temperature recommendations.

IWA-4330  RERATING

The provisions of this paragraph shall apply for rerating whether or not there is accompanying physical work.

IWA-4331  General Requirements

(a) The applicable design requirements of the Construction Code and Owner’s Requirements shall be met. Later Editions and Addenda of the Construction Code or a later, different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the requirements of IWA-4221 are met.

(b) Overpressure protection shall be evaluated in accordance with the Construction Code and Owner’s Requirements.

(c) The rerating shall be evaluated or analyzed in accordance with IWA-4311. The Owner’s Requirements shall be reviewed and revised or updated when necessary.

(d) Form NIS-2 shall be completed for rerating, except for rerating component supports.

(e) If a nameplate with pressure or temperature rating is attached to the item or piping system, the Owner or his designee shall attach a new nameplate as close as practical to the original nameplate. This nameplate shall contain the revised ratings and a reference to the rerating documentation.

(f) An ASME Certificate of Authorization is not required.
<table>
<thead>
<tr>
<th>CURRENT</th>
<th>PROPOSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWA-4310 GENERAL REQUIREMENTS</td>
<td>IWA-4310 GENERAL REQUIREMENTS</td>
</tr>
<tr>
<td>IWA-4311 Material, Design, or Configuration Changes</td>
<td>IWA-4311 Material, Design, or Configuration Changes</td>
</tr>
<tr>
<td>When a change is made to the design or configuration of an item or system, including material substitution, the change shall meet the following requirements: (a) When an analysis is available, the change shall be evaluated to determine if a reanalysis is required. If no reanalysis is performed, an evaluation shall be performed and documented. The evaluation or reanalysis shall document that the proposed change meets the Owner’s Requirements, and the Construction Code or alternative provisions of this Division. The evaluation or reanalysis shall be traceable in accordance with IWA-4311(e). (b) When an analysis is unavailable (e.g., proprietary design, standard B16.5 flanges or fittings, standard B16.34 valve), an evaluation or a new analysis shall be performed to document that the proposed change meets the Owner’s Requirements and the Construction Code or alternative provisions of this Division. The evaluation or new analysis shall be maintained in the same manner as a Design Report in accordance with IWA-4311(a) and (e). (c) Analyses shall be reviewed and certified in accordance with the requirements of the Construction Code and Owner’s Requirements. Evaluations shall be certified as required for analyses. (d) For any design or configuration change that deviates from the Owner’s Requirements, Design Specification, or Design Report, the affected documents shall be revised or updated in accordance with IWA-4311(e). (e) Changes made to material, design, or configuration shall be documented in revisions to existing reports, records, and specifications, or in a separate evaluation or update traceable to and from the original record or report. The review and certification requirements for these revisions, evaluations, or updates shall be in accordance with the Owner’s Requirements and the Construction Code. The following records shall be maintained current with respect to the item’s design and configuration: (1) Design Specification, (2) Design Report or analysis that demonstrates compliance with the Construction Code or the Owner’s Requirements, and (3) Overpressure Protection Report.</td>
<td>When a change is made to the design or configuration of an item or system, including material substitution, the change shall meet the following requirements: (a) When an analysis is available, the change shall be evaluated to determine if a reanalysis is required. If no reanalysis is performed, an evaluation shall be performed and documented. The evaluation or reanalysis shall document that the proposed change meets the Owner’s Requirements, and the Construction Code or alternative provisions of this Division. The evaluation or reanalysis shall be traceable in accordance with IWA-4311(e). IWA-4180(d). (b) When an analysis is unavailable (e.g., proprietary design, standard B16.5 flanges or fittings, standard B16.34 valve), an evaluation or a new analysis shall be performed to document that the proposed change meets the Owner’s Requirements and the Construction Code or alternative provisions of this Division. The evaluation or new analysis shall be maintained in the same manner as a Design Report in accordance with IWA-4311(a) and (e). IWA-4180(d). (c) Later Editions and Addenda of the Construction Code or a later different Construction Code, in accordance with IWA-4221(c), either in its entirety or portions thereof, and Code Cases, may be used, provided the requirements of IWA-4226 are met. (d) Analyses shall be reviewed and certified in accordance with the requirements of the Construction Code and Owner’s Requirements. Evaluations shall be certified as required for analyses. (e) For any design or configuration change that deviates from the Owner’s Requirements, Design Specification, or Design Report, the affected documents shall be revised or updated in accordance with IWA-4311(e). IWA-4180 (d). (f) Changes made to material, design, or configuration shall be documented in revisions to existing reports, records, and specifications, or in a separate evaluation or update traceable to and from the original record or report. The review and certification requirements for these revisions, evaluations, or updates shall be in accordance with the Owner’s Requirements and the Construction Code. The following records shall be maintained current with respect to the item’s design and configuration: (1) Design Specification, (2) Design Report or analysis that demonstrates compliance with the Construction Code or the Owner’s Requirements, and (3) Overpressure Protection Report.</td>
</tr>
</tbody>
</table>

IWA-4311(e) was moved to IWA-4180(d) under BC08-62.

Passed 08/09 WGDP: 15-0-0
Passed 11/09 WGDP: 17-0-0

ACTION
### Table IWB-3510-3
Allowable Linear Flaws [Note (1)]
Material: Ferritic steels that meet the requirements of NB-2331 and G-2110(b) of Section III

<table>
<thead>
<tr>
<th>Nominal Section Thickness, [Note (2)] t, in. (mm)</th>
<th>Surface Flaw, [Note (1)], [Note (3)] ( \ell/\ell ) %</th>
<th>Subsurface Flaw, [Note (1)] ( \ell/\ell ) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(\ell/2) (65) and less</td>
<td>17.4</td>
<td>20.6</td>
</tr>
<tr>
<td>4 (100) through 12 (300)</td>
<td>10.4</td>
<td>15.2</td>
</tr>
<tr>
<td>16 (400) and greater</td>
<td>8.0</td>
<td>11.2</td>
</tr>
</tbody>
</table>

NOTES:
(1) Applicable to linear flaws detected by surface examination (MT/PT) or radiographic examination (RT) method where flaw depth dimension \( a \) is indeterminate. If supplemental volumetric examination (UT) is performed which determines the \( a \) and \( \ell \) dimensions, the standards of Table IWB-3510-1 shall apply.
(2) For intermediate thickness, linear interpolation is permissible. Refer to IWA-3200.
(3) Applicable to linear flaws in surface region B-E shown in Fig. IWB-2500-5 only if the maximum postulated defect of G-2120, Appendix G of Section III, is justified. If a smaller defect size is used, Refer to IWB-3410.2.

### IWB-3514.1 Allowable Planar Flaws

(a) The size of allowable planar flaws within the boundary of the examination surfaces and volumes delineated in Figs. IWB-2500-8 through IWB-2500-11 shall be in accordance with the standards of IWB-3514.2, IWB-3514.3, and IWB-3514.4, as applicable. In addition, the requirements of IWB-3514.8 shall be satisfied for planar surface-connected flaws that are in contact with the reactor coolant environment during normal operation and are detected by preservice examination in materials that

### Table IWB-3512-1
Allowable Planar Flaws
Material: Ferritic steels that meet the requirements of NB-2331 and G-2110(b) of Section III

<table>
<thead>
<tr>
<th>Volumetric Examination Method, Nominal Wall Thickness, [Note (1)] t, in. (mm)</th>
<th>2(\ell/2) (65) and less</th>
<th>4 (100) through 12 (300)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspect Ratio, [Note (1)] ( a/\ell )</td>
<td>Surface Flaw, [Note (2)] ( a/\ell ) %</td>
<td>Subsurface Flaw, [Note (2)] - [Note (4)] ( a/\ell ) %</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>0.00</td>
<td>3.1</td>
<td>3.4(1.00)</td>
</tr>
<tr>
<td>0.05</td>
<td>3.3</td>
<td>3.8(1.06)</td>
</tr>
<tr>
<td>0.10</td>
<td>3.6</td>
<td>4.3(1.32)</td>
</tr>
<tr>
<td>0.15</td>
<td>4.1</td>
<td>4.9(1.48)</td>
</tr>
<tr>
<td>0.20</td>
<td>4.7</td>
<td>5.7(1.50)</td>
</tr>
<tr>
<td>0.25</td>
<td>5.5</td>
<td>6.6(1.84)</td>
</tr>
<tr>
<td>0.30</td>
<td>6.4</td>
<td>7.8(1.94)</td>
</tr>
<tr>
<td>0.35</td>
<td>7.4</td>
<td>9.0(1.99)</td>
</tr>
<tr>
<td>0.40</td>
<td>8.3</td>
<td>10.5(2.00)</td>
</tr>
<tr>
<td>0.45</td>
<td>8.5</td>
<td>12.3(2.00)</td>
</tr>
<tr>
<td>0.50</td>
<td>8.7</td>
<td>14.3(2.00)</td>
</tr>
<tr>
<td>Inside corner region</td>
<td>2.5</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

NOTES:
(1) Dimensions of \( a \) and \( \ell \) are defined in IWA-3300. For intermediate flaw aspect ratios \( a/\ell \) and thickness \( t \), linear interpolation is permissible. Refer to IWA-3200(b).
(2) See Table IWB-3512-2 for the appropriate component thickness \( t \) as a function of flaw location.
(3) The total depth of a subsurface flaw is \( 2\ell \) (Fig. IWA-3320-1).
(4) \( Y = [(S/a)/(a/\ell)] = (S/a) \). If \( S < 0.4d \), the flaw is classified as a surface flaw. If \( Y > 1.0 \), use \( Y = 1.0 \).
### TABLE IWB-3512-1
ALLOWABLE PLANAR FLAWS
Material: Ferritic steels that meet the requirements of NB-2331 and G-2110(b) of Section III

<table>
<thead>
<tr>
<th>Aspect Ratio, (a/\ell)</th>
<th>Volumetric Examination Method, Nominal Wall Thickness, (t/) in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2(\frac{1}{2}) and less</td>
</tr>
<tr>
<td></td>
<td>Surface Flaw, (a/t), %</td>
</tr>
<tr>
<td>0.00</td>
<td>3.1</td>
</tr>
<tr>
<td>0.05</td>
<td>3.3</td>
</tr>
<tr>
<td>0.10</td>
<td>3.6</td>
</tr>
<tr>
<td>0.15</td>
<td>4.1</td>
</tr>
<tr>
<td>0.20</td>
<td>4.7</td>
</tr>
<tr>
<td>0.25</td>
<td>5.5</td>
</tr>
<tr>
<td>0.30</td>
<td>6.4</td>
</tr>
<tr>
<td>0.35</td>
<td>7.4</td>
</tr>
<tr>
<td>0.40</td>
<td>8.3</td>
</tr>
<tr>
<td>0.45</td>
<td>8.5</td>
</tr>
<tr>
<td>0.50</td>
<td>8.7</td>
</tr>
<tr>
<td>Inside corner region</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Dimensions of \(a\) and \(\ell\) are defined in IWA-3300. For intermediate flaw aspect ratios \(a/\ell\) and \(t/\ell\), linear interpolation is permissible. 
2. See Table IWB-3512-2 for the appropriate component thickness \(t\) as a function of flaw location. 
3. The total depth of a subsurface flaw is \(2a\) (Fig. IWA-3320-1). 
4. \(Y = \frac{(t/a)(a/\ell)}{(S/a)}\). If \(S < 0.4a\), the flaw is classified as a surface flaw. If \(Y > 1.0\), use \(Y = 1.0\). 

### TABLE IWB-3512-2
COMPONENT THICKNESS VS FLAW LOCATION

<table>
<thead>
<tr>
<th>Location of Flaw [Note (1)]</th>
<th>Component Thickness, (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrel Type Nozzle [Fig. IWB-2500-7(a)]</td>
<td>Flange Type Nozzle [Fig. IWB-2500-7(b)]</td>
</tr>
<tr>
<td>Shell (or head) adjoining region</td>
<td>(t_s)</td>
</tr>
<tr>
<td>Attachment weld region</td>
<td>(t_s)</td>
</tr>
<tr>
<td>Nozzle cylinder region</td>
<td>((t_{n1} + t_{n2})/2)</td>
</tr>
<tr>
<td>Nozzle inside corner region</td>
<td>Smallest of (t_{n1}, t_{n2}, or t_s)</td>
</tr>
</tbody>
</table>

**NOTE:** 
1. See Figs. IWB-2500-7(a) through (d) for definition of the examination volume for each of the examination regions.
### TABLE IWB-3512-1
ALLOWABLE PLANAR FLAWS
Material: Ferritic steels that meet the requirements of NB-2331 and G-2110(b) of Section III

<table>
<thead>
<tr>
<th>Aspect, (a/l)</th>
<th>Surface Flaw, (a/t), %</th>
<th>Subsurface Flaw, (a/t), %</th>
<th>Surface Flaw, (a/t), %</th>
<th>Subsurface Flaw, (a/t), %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2½ and less</td>
<td></td>
<td>4 through 12</td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>3.1</td>
<td>3.4Y</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>0.05</td>
<td>3.3</td>
<td>3.8Y</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>0.10</td>
<td>3.6</td>
<td>4.3Y</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>0.15</td>
<td>4.1</td>
<td>4.9Y</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>0.20</td>
<td>4.7</td>
<td>5.7Y</td>
<td>2.8</td>
<td>3.3</td>
</tr>
<tr>
<td>0.25</td>
<td>5.5</td>
<td>6.6Y</td>
<td>3.3</td>
<td>3.8</td>
</tr>
<tr>
<td>0.30</td>
<td>6.4</td>
<td>7.8Y</td>
<td>3.8</td>
<td>4.4</td>
</tr>
<tr>
<td>0.35</td>
<td>7.4</td>
<td>9.0Y</td>
<td>4.4</td>
<td>5.1</td>
</tr>
<tr>
<td>0.40</td>
<td>8.3</td>
<td>10.5Y</td>
<td>5.0</td>
<td>5.8</td>
</tr>
<tr>
<td>0.45</td>
<td>8.5</td>
<td>12.3Y</td>
<td>5.1</td>
<td>6.7</td>
</tr>
<tr>
<td>0.50</td>
<td>8.7</td>
<td>14.3Y</td>
<td>5.2</td>
<td>7.6</td>
</tr>
<tr>
<td>Inside corner region</td>
<td>2.5</td>
<td>Not applicable</td>
<td>2.5</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Dimensions of \(a\) and \(l\) are defined in IWA-3300. For intermediate flaw aspect ratios \(a/l\) and thickness \(t\), linear interpolation is permissible. Refer to IWA-3200(b).
2. See Table IWB-3512-2 for the appropriate component thickness \(t\) as a function of flaw location.
3. The total depth of a subsurface flaw is \(2a\) (Fig. IWA-3320-1).
4. \(Y = (S/t)/(a/t) = (S/a)\). If \(S < 0.4d\), the flaw is classified as a surface flaw. If \(Y > 1.0\), use \(Y = 1.0\).

### TABLE IWB-3512-2
COMPONENT THICKNESS VS FLAW LOCATION

<table>
<thead>
<tr>
<th>Component Thickness, (t)</th>
<th>Barrel Type Nozzle [Fig. IWB-2500-7(a)]</th>
<th>Flange Type Nozzle [Fig. IWB-2500-7(b)]</th>
<th>Set-On Type Nozzle [Fig. IWB-2500-7(c)]</th>
<th>Integrally Cast Nozzle [Fig. IWB-2500-7(d)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell (or head) adjoining region</td>
<td>(t_s)</td>
<td>(t_s)</td>
<td>(t_s)</td>
<td>n/a</td>
</tr>
<tr>
<td>Attachment weld region</td>
<td>(t_s)</td>
<td>(t_s)</td>
<td>(t_s)</td>
<td>n/a</td>
</tr>
<tr>
<td>Nozzle cylinder region</td>
<td>((t_s + t_n)/2)</td>
<td>((t_s + t_n)/2)</td>
<td>(t_n)</td>
<td>n/a</td>
</tr>
<tr>
<td>Nozzle inside corner region</td>
<td>Smallest of (t_n), (t_s) or (t_n)</td>
<td>Smallest of (t_n), (t_s) or (t_n)</td>
<td>Smaller of (t_n) or (t_s)</td>
<td>Smaller of (t_n) or (t_s)</td>
</tr>
</tbody>
</table>

**NOTE:**
1. See Figs. IWB-2500-7(a) through (d) for definition of the examination volume for each of the examination regions.
at coolant temperatures less than 200°F (95°C) or at coolant temperatures corresponding to a reactor vessel metal temperature less than \( RT_{NDT} + 50°F \) (28°C), whichever is greater. LTOP systems shall limit the maximum pressure in the vessel to 100% of the pressure determined to satisfy Eq. (1).

(a) G-2216 Risk-Informed Allowable Pressure

The equations given in this paragraph provide an alternative risk-informed methodology to compute allowable pressure as a function of inlet temperature for reactor heat-up and cool-down at rates not to exceed 100°F/hr (56°C/hr). The allowable pressure is defined as

(U.S. Customary Units)

\[
p = \{33.2 + 20.734 \times \exp[0.02(T - RT_{NDT} - 110)] - K_0\} \times t/R_i \times 1/M_m
\]

where

- \( p \) = pressure (ksi)
- \( RT_{NDT} = RT_{NDT(0)} + \Delta RT_{NDT} \) and is the reference nil ductility temperature adjusted for irradiation effects at the maximum depth of the postulated quarter thickness flaw stipulated in G-2214.3, °F
- \( RT_{NDT(0)} \) = equivalent to the unirradiated \( RT_{NDT} \) calculated in accordance with NB-2300, °F
- \( \Delta RT_{NDT} \) = an adjustment for irradiation effects, °F
- \( T \) = temperature at the maximum depth of the postulated quarter thickness flaw stipulated in G-2214.3, °F

(SI Units)

\[
p = \{36.5 + 22.783 \times \exp[0.036(T - RT_{NDT} - 61)] - K_0\} \times t/R_i \times 1/M_m
\]

where

- \( p \) = pressure, MPa
- \( RT_{NDT} = RT_{NDT(0)} + \Delta RT_{NDT} \) and is the reference nil ductility temperature adjusted for irradiation effects at the maximum depth of the postulated quarter thickness flaw stipulated in G-2214.3, °C
- \( RT_{NDT(0)} \) = equivalent to the unirradiated \( RT_{NDT} \) calculated in accordance with NB-2300, °C
- \( \Delta RT_{NDT} \) = an adjustment for irradiation effects, °C
- \( T \) = temperature at the maximum depth of the postulated quarter thickness flaw stipulated in G-2214.3, °C

\( K_0 \) is as stipulated in G-2214.3, and \( t, R_i, M_m \) are as stipulated in G-2214.1. The evaluation is to be performed for all conditions, materials, and locations as described in G-2215.

The operational pressure-temperature limits are based on the temperature at the reactor coolant inlet temperature, which is assumed to equal the temperature at the vessel inner surface. Figure G-2214-1 or Fig. G-2214-1M and Fig. G-2214-2 can be used to determine the temperature at the vessel inner surface corresponding to the temperature at the maximum depth of the postulated quarter thickness flaw stipulated in G-2214.3.

\( \Delta RT_{NDT} \) is determined from plant-specific surveillance data, or the irradiation degradation model used to compute the risk-informed allowable pressure as shown in eq. (2), or other irradiation degradation models acceptable to the regulatory authority having jurisdiction at the plant site.

\[
\Delta RT_{NDT} = MF + CRP
\]

(U.S. Customary Units)

\[
MF = A[1 - 0.00171877] (1 + 6.13P M)^{-1} (\sigma_e)^{1/2}
\]

where

- \( A = 1.140 \times 10^{-7} \) for forgings
- \( A = 1.561 \times 10^{-7} \) for plates
- \( A = 1.417 \times 10^{-7} \) for welds
\[ T_i = \text{irradiation temperature, } ^\circ F \]
\[ P = \text{bulk material phosphorus content, wt. \%} \]
\[ Mn = \text{bulk material manganese content, wt. \%} \]
\[ \phi = \left\{ \begin{array}{ll}
\phi & \text{for } \phi \geq 4.39 \times 10^{10} \\
0.2595 & \text{for } \phi < 4.39 \times 10^{10}
\end{array} \right. \]
\[ \phi_e = \text{effective neutron fluence, cm}^{-2} \]
\[ \phi = \text{neutron fluence, cm}^{-2} \]
\[ \phi = \text{neutron flux, cm}^{-2} \text{s}^{-1} \]

\[ CRP = B \left( 1 + 3.77Ni^{1.191} \right) f(C_{ue}, P) g(C_{ue}, Ni, \phi_e) \]

where

\[ B = 102.3 \text{ for forgings} \]
\[ = 135.2 \text{ for plates in vessels manufactured by Combustion Engineering (CE)} \]
\[ = 102.5 \text{ for non-CE plates} \]
\[ = 155.0 \text{ for welds} \]
\[ Ni = \text{bulk material nickel content, wt. \%} \]
\[ C_{ue} = \begin{cases} 
0 & \text{for } Cu < 0.072 \\
\min \left[ Cu, Cu_{max} \right] & \text{for } Cu > 0.072
\end{cases} \]
\[ Cu_{ue} = \text{effective material copper content, wt. \%} \]
\[ Cu = \text{bulk material copper content, wt. \%} \]
\[ Cu_{max} = 0.243 \text{ for Linde 80 welds with } Ni > 0.5 \]
\[ = 0.301 \text{ for all other materials} \]
\[ f(C_{ue}, P) = \begin{cases} 
0 & \text{for } Cu \leq 0.072 \\
\left[ \left( C_{ue} - 0.072 \right) 0.668 \right] & \text{for } Cu > 0.072 \text{ and } P \leq 0.008 \\
\left[ \left( C_{ue} - 0.072 + 1.359 \left( P - 0.008 \right) \right) 0.668 \right] & \text{for } Cu > 0.072 \text{ and } P > 0.008
\end{cases} \]
\[ g(C_{ue}, Ni, \phi_e) = \frac{1}{2} + \frac{1}{2} \tanh \left( \frac{\log_{10}(\phi_e) + 1.139C_{ue}}{-0.445Ni - 18.120} \right) \]

\[ MF = A \left[ 0.945 - 0.0030927 \right] \left( 1 + 6.13P Mn_{max}^{0.5} \right) \phi_e^{1/2} \]

where

\[ A = 6.333 \times 10^{-8} \text{ for forgings} \]
\[ = 8.672 \times 10^{-8} \text{ for plates} \]
\[ = 7.872 \times 10^{-8} \text{ for welds} \]
\[ T_i = \text{irradiation temperature, } ^\circ C \]
\[ P = \text{bulk material phosphorus content, wt. \%} \]
\[ Mn = \text{bulk material manganese content, wt. \%} \]
General Requirements

The same general procedure as was used for the shell and head regions in G-2220 may be used for areas where more complicated stress distributions occur, but certain modifications of the procedures for determining allowable applied loads shall be followed in order to meet special situations, as stipulated in G-2222 and G-2223.

(a) G-2222 Consideration of Membrane and Bending Stresses

(a) Equation G-2215(1) requires modification to include the bending stresses which may be important contributors to the calculated \( K_i \) value at a point near a flange or nozzle. The terms whose sum must be \( <K_{ih} \) for Level A and B conditions are:

1. \( 2K_{pm} \) from G-2214.1 for primary membrane stress;
2. \( 2K_{pb} \) from G-2214.2 for primary bending stress;
3. \( K_{pm} \) from G-2214.1 for secondary membrane stress;
4. \( K_{pb} \) from G-2214.2 for secondary bending stress.

(b) For purposes of this evaluation, stresses which result from bolt preloading shall be considered as primary.

\[
\phi_e = \begin{cases} 
\phi \text{ for } \phi \geq 4.39 \times 10^{10} \\
\phi \left( \frac{4.39 \times 10^{10}}{\phi} \right)^{0.2595} \text{ for } \phi < 4.39 \times 10^{10}
\end{cases}
\]

\[
CRP = B \left( 1 + 3.77N_i^{1.191} \right) f(Cu_p, P)g(Cu_p, Ni, \phi_e)
\]

where

- \( B = 56.83 \) for forgings
- \( = 75.11 \) for plates in vessels manufactured by Combustion Engineering (CE)
- \( = 56.94 \) for non-CE plates
- \( = 86.11 \) for welds
- \( Ni = \) bulk material nickel content, wt. %

\[
Cu = \begin{cases} 
0 \text{ for } Cu < 0.072 \\
\text{minimum } [Cu, Cu_{max}] \text{ for } Cu > 0.072
\end{cases}
\]

\( Cu = \) effective material copper content, wt. %

\( Cu_{max} = 0.243 \) for Linde 80 welds with \( Ni > 0.5 \)

\( = 0.301 \) for all other materials

\[
f(Cu_p, P) = \left\{ \begin{array}{c}
\left[ Cu - 0.072 \right]^{0.668} \\
\left[ Cu - 0.072 \right]^{1.359 \left( P - 0.008 \right)}^{0.668}
\end{array} \right. 
\]

\( f(Cu_p, P) \) for \( Cu > 0.072 \) and \( P \leq 0.008 \)

\( f(Cu_p, P) \) for \( Cu > 0.072 \) and \( P > 0.008 \)

\[
g(Cu_p, Ni, \phi_e) = \frac{1}{2} + \frac{\tanh \left[ \frac{\log_{10}(\phi_e) + 1.139Cu_p}{-0.449Ni - 18.120}}{0.629} \right]
\]
Case N-700
Alternative Rules for Selection of Classes 1, 2, and 3 Vessel Welded Attachments for Examination
Section XI, Division 1

Inquiry: What alternative rules may be used in lieu of those required by Table IWB-2500-1, Table IWC-2500-1, and Table IWD-2500-1, Examination Categories B-K and C-C, footnote 4, and Examination Category D-A, footnote 3, for selection of vessel welded attachments for examination?

Reply: It is the opinion of the Committee that for multiple vessels of similar design, function and service, only one welded attachment of only one of the multiple vessels shall be selected for examination. For single vessels, only one welded attachment shall be selected for examination. The attachment selected for examination on one of the multiple vessels or the single vessel, as applicable, shall be an attachment under continuous load during normal system operation, or an attachment subject to a potential intermittent load (seismic, water hammer, etc.) during normal system operation if an attachment under continuous load does not exist.
ARTICLE O-3000
ANALYSIS

O-3100 SCOPE

This Article provides the methodology for flaw evaluation and describes the procedures to determine the flaw size at the end of the evaluation period.

O-3200 FLAW GROWTH ANALYSIS

(a) The maximum depth \(a_f\) and the maximum length \(l_f\) to which the detected flaw will grow in the plane of the flaw by the end of the evaluation period shall be determined. This Article describes the procedures for the flaw growth analysis.

(b) Crack growth in austenitic head penetration nozzles can be due to cyclic fatigue flaw growth, SCC under sustained load, or a combination of both. Flaw growth analysis shall be performed for normal operating conditions, as defined in A-5200 of Appendix A. Flaw growth is governed by the applied stress intensity factor.

O-3210 STRESS INTENSITY FACTOR DETERMINATION

Because the total stresses in this region are typically nonlinear, it is recommended that the distribution be fit to a cubic polynomial, as shown in eq. (1).

\[
\sigma(x) = A_0 + A_1 x + A_2 x^2 + A_3 x^3
\]

where

\(x\) = the coordinate distance into the nozzle wall
\(\sigma\) = stress perpendicular to the plane of the crack
\(A_i\) = coefficients of the cubic polynomial fit

For a surface flaw with a given ratio of length to depth, the stress intensity factor expression of Raju and Newman\(^\text{59}\) may be used. The stress intensity factor \(K_i(\phi)\) can be calculated anywhere along the crack front. The following expression is used for calculating \(K_i(\phi)\).

The units of \(K_i(\phi)\) are MPa\(\sqrt{m}\).

\[
K_i = \left[ \frac{pi}{Q} \right]^{0.5} \sum_{j=0}^{3} G_j \left( \frac{a}{c}, \frac{a}{t}, \frac{t}{R}, \Phi \right) A_j a^j
\]

where

\(G_0, G_1, G_2, G_3\) = factors obtained from the procedure outlined
\(\Phi\) = angular location around the crack\(^\text{60}\)
\(a\) = crack depth
\(c\) = half-crack length
\(t\) = wall thickness
\(R\) = inside radius of the tube
\(Q\) = shape factor as defined in footnote \(1\)

Alternatively, procedures such as those described in Section XI, A-3000 may be used to calculate the stress intensity factor.

O-3220 FLAW GROWTH DUE TO FATIGUE

(a) The fatigue crack growth rate of Alloy 600 material in PWR environments can be characterized in terms of the range of the applied stress intensity factor, \(K_i\). This characterization is of the form:

\[
da / dN = C_R S_{ENV} A K^n
\]

where \(n\) and \(C\) are constants dependent on the material and environmental conditions. These parameters are based on crack growth data obtained from specimens of the same material specification and product form, or suitable alternative. Material variability, environment, test frequency, mean stress, and other variables that affect the data shall be considered.

(b) The fatigue crack growth behavior of Alloy 600 materials is affected by temperature, \(R\) ratio \((K_{min}/K_{max})\), and environment. Reference fatigue crack growth rates for PWR water environments are given by eq. (3).

\[
C = 4.835 \times 10^{-14} + 1.622 \times 10^{-16} T - 1.490 \times 10^{-18} T^2 + 4.355 \times 10^{-21} T^3
\]

\[
S_R = (1 - 0.82R)^{-2.2}
\]

\[
S_{ENV} = 1 + A [C S_R A K]^m - 1 R^{-1} - m
\]

where

\(A = 4.4 \times 10^{-7}\)

\(m = 0.33\)

\(n = 4.1\)

\(T = \text{degrees C}\)

\(\Delta K = \text{range of stress intensity factor MPa}\sqrt{m}\)

\(R = K_{min}/K_{max}\)
| TABLE 1  
EXAMINATION CATEGORIES (CONT'D) |

NOTES (CONT'D):

(3) A VE may be performed during an outage when a volumetric examination is performed from the weld outer surface. An ultrasonic examination performed from the component inside or outside surface in accordance with the requirements of Table 1 and Appendix VIII (1995 Edition with the 1996 Addenda or later) shall be acceptable in lieu of the VE requirement of this table.

(4) Ultrasonic volumetric examination shall be used and shall meet the applicable requirements of Appendix VIII.

(5) Subsequent Inservice Inspection of Unmitigated Welds With Inside Surface Connected Planar Flaws
   
   (a) If planar surface flaws are detected in the butt weld/base metal inside surface, this weld shall be reexamined at the shorter frequency of every refueling outage or the frequency determined by the crack growth analysis of -3132.3.
   
   (b) This weld shall be subsequently examined at the frequency required by (a) unless mitigated.

(6) Pre-weld Overlay Examination for Full Structural and Optimized Weld Overlays
   
   (a) Except as provided in (b) and (c), volumetric examination shall be performed prior to full structural or optimized weld overlay and shall include the examination volume of Fig. 1.
   
   (b) As an alternative to (a), if the volumetric examination prior to the full structural weld overlay is not performed, it shall be assumed to be cracked and shall be classified F-1.
   
   (c) For reactor vessel nozzle welds at cold leg temperatures requiring the core internals to be removed to perform the examination, the volumetric examinations are not required prior to application of the weld overlay. If the pre-weld overlay volumetric examination is not performed, a post-weld overlay preservice examination consisting of a surface examination and a volumetric examination shall be performed after removal of the core internals. If these examinations do not detect cracks, the weld shall be considered to be uncracked and shall be subject to the examination requirements of Inspection Item C-1 or C-2. This post-weld overlay volumetric examination shall include the examination volume in Fig. 1 and the examination volume in Fig. 2(a) or Fig. 5(a). The post-weld overlay preservice surface examination shall be performed on the weld inside surface, extant E-F of Fig. 1, and shall consist of an eddy current examination in accordance with IWA-2223.
   
   (d) If the crack is completely removed by a repair/replacement activity in accordance with IWA-4000 and the weld overlay is then applied, the weld shall be reclassified Inspection Item C-1 or C-2.

(7) Alloy 52, Alloy 152, and other similar designations are common abbreviations used by industry, the regulatory authority, and research organizations for UNS N06052 (SFA-5.14, ERNiCrFe-7), UNS W86152 (SFA-5.11, ENICrFe-7), and UNS N06054 (SFA-5.14, ERNiCrFe-7A), respectively. These individual filler materials or any combination thereof are referred to as Alloy 52/152.

(8) Inservice Inspection of Full Structural Weld Overlay
   
   (a) The weld overlay examination volume in Fig. 2(a) shall be ultrasonically examined to determine the acceptability of the mitigated weld. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions.
   
   (b) The weld overlay shall meet the requirements of -3132. If in applying the acceptance standards to planar indications, the thickness L4 or L5, defined in Fig. 2(b), shall be used as the nominal wall thickness in IWB-3514. The base material beneath the flaw (i.e., safe cord, nozzle, or piping material) is not susceptible to PWSCC. For susceptible material, the crack shall be ranked. If the acceptance standards of IWB-3514 cannot be met, the weld overlay shall meet the acceptance standards of IWB-3600. Any indication characterized as having a flaw extension into the weld overlay material is unacceptable.
   
   (c) As an alternative to (a), for in-service inspection, the weld examination volume in Fig. 1 may be ultrasonically examined. If cracking is detected extending beyond the weld examination volume, the weld examination of (a) and (b) above shall be performed to determine the acceptability of the weld overlay.
   
   (d) If in-service examinations of (a), (b), or (c) reveal crack growth, or new cracking in the weld overlay or outer 25% of original weld/base material meeting the acceptance standards, the weld overlay examination volume shall be reexamined during the first or second refueling outage following detection of the crack growth or new cracking. The weld overlay examination volume shall be subsequently examined two additional times at the period of one or two refueling outages, i.e., a total of three examinations within six refueling outages of detection of the crack growth or new cracking.
   
   (e) If the examinations required by (d) reveal that the flaws remain essentially unchanged for three successive examinations, the weld examination schedule may revert to the sample and schedule of examinations identified in Table 1. This weld shall be included in the 25% sample.
### Table 1

#### Examination Categories (Cont'd)

<table>
<thead>
<tr>
<th>Table 1 Notes (Cont'd):</th>
</tr>
</thead>
<tbody>
<tr>
<td>(13) Inservice Inspection for Stress Improvement</td>
</tr>
<tr>
<td>(a) The required examination volume of Fig. 1 shall be ultrasonically examined to determine the acceptability of the mitigated weld.</td>
</tr>
<tr>
<td>(b) If in-service examinations of (a), (c), or (d) reveal crack growth or new cracking, the weld examination volume of Fig. 1 shall be examined during each of the next three refueling outages.</td>
</tr>
<tr>
<td>(c) If the examinations required by (b) reveal that the flaws remain essentially unchanged for three successive examinations, the weld examination schedule may revert to the sample and schedule of examinations identified in Table 1. This weld shall be included in the 25% sample.</td>
</tr>
</tbody>
</table>

#### Preservice Inspection for Optimized Weld Overlays

<table>
<thead>
<tr>
<th>Preservice Inspection for Optimized Weld Overlays</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) The examination volume in Fig. 5(a) shall be ultrasonically examined. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions, to locate and size any planar flaws that have propagated into the outer 50% of the original weld or base metal thickness or into the weld overlay. For weld overlays on cast austenitic stainless steel base materials only planar flaws that have propagated into the weld overlay or are in the overlay are required to be located and sized.</td>
</tr>
<tr>
<td>(b) As an alternative to (a), for weld overlays that can be shown to meet the requirements for full structural weld overlays with respect to wall thickness, the required examination volume of Fig. 5(a) may be used for scans in which the angle beam is directed perpendicular to the pipe axis. The examination volume of Fig. 5(a) shall be used for scans in which the angle beam is directed parallel to the pipe axis.</td>
</tr>
<tr>
<td>(c) The preservice examination acceptance standards of IWB-3514 shall be met for flaws in the weld overlay material and the outer 25% of the original weld/base material. In applying the acceptance standards to planar indications, the thickness, ( H ) or ( t ), defined in Fig. 5(b), shall be used as the nominal wall thickness in IWB-3514, provided the base material beneath the flaw (i.e., safe end, nozzle, or piping material) is not susceptible to PWSCC. For susceptible material, ( H ) shall be used. Planar flaws in the outer 25% to 50% of the original weld or base metal thickness shall meet the design analysis requirements of -3332.3(d).</td>
</tr>
<tr>
<td>(d) The flaw evaluation requirements of IWB-3640 shall not be applied to planar flaws in the weld overlay material, identified during preservice examination, that exceed the preservice examination acceptance standards of IWB-3514.</td>
</tr>
</tbody>
</table>

#### Alloy 52/52 Weld Inlay or Overlay Techniques are Applied, the Following shall be Met:

<table>
<thead>
<tr>
<th>Alloy 52/52 Weld Inlay or Overlay Techniques are Applied, the Following shall be Met:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Volumetric examinations shall be performed on these welds both immediately before application of inlay or overlay and after application as a preservice baseline examination.</td>
</tr>
<tr>
<td>(b) If the configuration of the inlay or overlay does not permit coverage in accordance with -25001(c) of the required preservice and in-service examination volume for each modified dissimilar metal weld, the weld shall be examined in accordance with Inspection Item A or B.</td>
</tr>
<tr>
<td>(c) If the capabilities of the volumetric examination for detection, length sizing, and through-wall sizing for the dissimilar metal weld are adversely affected by the inlay or overlay, the weld shall be examined in accordance with Inspection Item A or B.</td>
</tr>
<tr>
<td>(d) Preservice surface examinations shall be performed on the modified dissimilar metal weld after inlay or overlay application. Liquid penetrant examination in accordance with IWA-2222 or eddy current examination in accordance with IWB-3514 shall be performed. The acceptance standards of NB-5352 shall apply for the inlay or overlay, except that rounded indications with dimensions larger than the smaller of 2( \sqrt{H} ) in. (1.5 mm) or 50% of the thickness of the inlay or overlay are unacceptable. The balance of the surface examination area shall comply with the preservice examination acceptance standards of IWB-3514.</td>
</tr>
<tr>
<td>(e) Preservice volumetric examination shall be performed on the modified dissimilar metal weld. If flaws that were detected in (a) above, extending beyond the examination volume, remain in the original weld, planar flaws in the inlay or overlay shall meet the preservice examination standards of IWB-3514. Planar flaws in the balance of the dissimilar metal weld examination volume shall comply with the preservice examination acceptance standards of IWB-3514 or the requirements of IWB-3640.</td>
</tr>
<tr>
<td>(f) If the crack detected prior to weld inlay or overlay is completely removed by a repair/replacement activity in accordance with IWA-4000 and the weld inlay or overlay is then applied, the weld shall be reclassified as Inspection Item G or H, respectively.</td>
</tr>
</tbody>
</table>

#### Inservice Inspection Volumetric Examination for Weld Inlay or Weld Overlay

<table>
<thead>
<tr>
<th>Inservice Inspection Volumetric Examination for Weld Inlay or Weld Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Inservice examinations reveal crack growth, or new cracking, meeting the acceptance standards of -3332.3, the weld examination volume shall be reexamined during the first refueling outage following discovery of the growth or new cracking. The weld examination volume shall be sequentially examined during each of the next two refueling outages.</td>
</tr>
<tr>
<td>(b) Any volumetric examinations that reveal crack growth or new cracking, meeting the acceptance standards shall also be subject to a surface examination, see (Note (17)). This surface examination shall also be required in any subsequent examinations required by (a).</td>
</tr>
<tr>
<td>(c) If the examinations required by (a) reveal that the flaws remain essentially unchanged for three successive examinations, the weld examination schedule may revert to the sample and schedule of examinations identified in Table 1. This weld shall be included in the 25% sample population. If cracking penetrates beyond the thickness of the inlay or overlay, the weld shall be reclassified as Inspection Item A-1, A-2, or B, as appropriate, until corrected by repair/replacement activity in accordance with IWA-4000 or by corrective measures beyond the scope of this Case (e.g., stress improvement).</td>
</tr>
</tbody>
</table>
shall also receive a volumetric examination in accordance with -2500. The extent of the volumetric examination shall be in accordance with Figs. 1, 2, 3, 4, or 5, as applicable.

(b) A surface examination may also be performed to help further characterize the extent of the unacceptable condition and the need for corrective measures, analytical evaluation, or repair/replacement activity.

-9000 GLOSSARY

*cracked:* containing planar surface-connected flaws in contact with the reactor coolant environment during normal operation. A weld that is mitigated before it is examined shall be considered cracked. Reactor vessel nozzle welds at cold leg temperature requiring the core internals to be removed to perform the pre-mitigation examination may be considered uncracked if the requirements of Table 1, [Note 6(b) or [Note 12(e)], as appropriate, are met. (See uncracked.)

*full structural weld overlay:* deposition of weld reinforcement on the outside surface of the piping, component, or associated weld such that the weld reinforcement is capable of supporting the design loads without the piping, component, or associated weld beneath the weld reinforcement.

*inlay:* a corrosion resistant barrier applied on the inside surface of the component between the Alloy 82/182 weld and the reactor coolant, requiring excavation of some portion of the Alloy 82/182 weld.

*mitigation:* an activity to reduce or eliminate the susceptibility of Alloy 82/182 weld filler material or Alloy 600\(^{3}\) materials to crack initiation or crack propagation. Mitigation can be preemptive, i.e., before crack initiation, or repair, i.e., after crack initiation is discovered.

*lining:* a corrosion resistant barrier applied on the inside surface of the component between the Alloy 82/182 weld and the reactor coolant, not requiring excavation of some portion of the Alloy 82/182 weld.

*optimized weld overlay:* deposition of weld reinforcement on the outside surface of the piping, component, or associated weld, such that the weld reinforcement is capable of supporting the design and service loads with consideration of the outer 25% of the wall thickness of the piping, component, or associated weld beneath the weld reinforcement in the design.

*stress improvement:* a process that produces sufficient stress conditions on the inside wetted surface to inhibit initiation and propagation of primary water stress corrosion cracking. Stress improvement techniques without welding are not included in IWA-4000 and are not repair/replacement activities.

*uncracked:* examined in accordance with the requirements of -2500 with no planar surface-connected flaws in contact with the reactor coolant environment during normal operation.

\(^{3}\) Alloy 600 is a common abbreviation used by industry, the regulatory authority, and research organizations for UNS N06600.
(e) Except as provided in (b) and (c) below, volumetric examination shall be performed prior to full structural or optimized weld overlay and shall include the examination volume of Fig. 1.

(b) As an alternative to (a) above, if the volumetric examination of the full structural or optimized weld overlay is not performed, it shall be assumed to be cracked and classified F-1.

TABLE 1
EXAMINATION CATEGORIES (CONT'D)

<table>
<thead>
<tr>
<th>Category</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-weld Overlay Examination for Full Structural Weld Overlay</td>
<td>Pre-weld</td>
</tr>
<tr>
<td>Pre-weld Overlay Examination for Optimized Weld Overlay</td>
<td>Optimized</td>
</tr>
</tbody>
</table>

(c) Prior to application of the weld overlay. If the pre-weld overlay volumetric examination is not performed, a post-weld overlay preservative examination consisting of a surface examination and a volumetric examination shall be performed after removal of the core internals. If these examinations do not detect cracks, the weld shall be considered de-cracked and shall be subject to the examination requirements of Inspection Items 22(a) and 22(b). This post-weld overlay volumetric examination shall include the examination volume in Fig. 1 and the examination volume in Fig. 2(a).

(d) In the event of a weld overlay examination volume in Fig. 1(a) for which the weld overlay examination volume in Fig. 2(a) shall be ultrasonically examined to determine the acceptability of the weld overlay, and shall be determined if any crack or existing cracks have propagated into the outer 25% of the original weld or base material or into the overlay. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions.

(e) As an alternative to (a), for Inservice Inspection of Full Structural Weld Overlay, the weld examination volume in Fig. 1(a) may be ultrasonically examined. If cracking is detected extending beyond the weld examination volume, the weld examination of (a) and (b) above shall be performed to determine the acceptability of the weld overlay.

(f) If the examinations required by (d) reveal that the flaw remains essentially uncharged for three successive examinations, the weld examination shall revert to the sample and schedule of examinations identified in Table 1.

(g) Preservative Inspection for a Full Structural Weld Overlay

(a) The examination volume in Fig. 2(a) shall be ultrasonically examined. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions, to locate and size any planar flaws that have propagated into the outer 25% of the original weld or base metal thickness or into the overlay. For weld overlays on cast austenitic stainless steel base materials, if a 100% through-wall flaw is used for the crack growth analysis, only planar flaws that have propagated into the weld overlay or into the overlay and the overlay shall be located and sized.

(b) The preservative examination acceptance standards of IWB-2134 shall be met for flaws in the weld overlay material. In applying the acceptance standards to planar indications, the thickness, t, of the overlay shall be used. Is not susceptible to PWSSC. For susceptible material, the thickness, t, of the overlay shall be used. Planar flaws in the outer 25% of the original weld or base material thickness shall meet the design analysis requirements of -33.2.3(d).

(c) The flaw evaluation requirements of IWB-3640 shall not be applied to planar flaws in the weld overlay material, identified during preservative examination, that exceed the preservative examination acceptance standards of IWB-354.3(a).

(l) The 25% sample shall consist of the same welds in the highest operating temperature in the Inspection Item. If the argon and cold leg welds are included in the same Inspection Item, the initial 25% sample does not need to include the cold leg welds. Those welds not included in the 25% sample shall be examined prior to the end of the mitigation evaluation period if the plant is to be operated beyond that time.

This weld shall be included in the 25% sample.
TABLE I - EXAMINATION CATEGORIES (CONT'D)

<table>
<thead>
<tr>
<th>Items C-1 and C-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOTES (CONT'D):</td>
</tr>
<tr>
<td>(11) Deferral of Examinations</td>
</tr>
<tr>
<td>(a) Examinations of welds not classified Table 2 of Appendix B, Category A-2 or prior mitigation are not permitted to be deferred to the end of the interval.</td>
</tr>
<tr>
<td>(b) Examinations of welds not classified Table 2 of Appendix B, Category A-2 or prior mitigation may be deferred following welds inlay, overlay or stress improvement.</td>
</tr>
<tr>
<td>(12) Examinations performed following welds inlay, overlay, or stress improvement may be deferred to the end of the interval and performed coincident with the vessel nozzle examination required by Category B-0.</td>
</tr>
<tr>
<td>(13) Examination for inspection items shall be performed any time within 10 years of the most recent examination. Subsequent examinations for inspection items shall be performed following the first examination in accordance with this Section.</td>
</tr>
<tr>
<td>(14) Examinations required as a result of the configuration of such piping structural element and the postulated degradation mechanisms remaining after the mitigation.</td>
</tr>
</tbody>
</table>

If any

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Welds that were classified as molded during the examination cycle shall be classified as molded during the examination cycle.
as revised by the additional requirements of this Case shall be evaluated by comparing the examination results with the acceptance standards specified in -3142.1.

(b) Acceptance of welds for continued service shall be in accordance with -3142.

(c) Relevant conditions for the purposes of the VE shall include areas of corrosion, boric acid deposits, discoloration, and other evidence of pressure boundary leakage.

(d) In lieu of other visual examination requirements, requirements of this Case govern.

-3142 Acceptance

-3142.1 Acceptance by Bare Metal Visual Examination

(a) A weld whose VE confirms the absence of relevant conditions shall be acceptable for continued service.

(b) A weld whose VE detects a relevant condition shall be unacceptable for continued service unless the requirements of -3142.1(b)(1), (b)(2), and (b)(3) below are met.

(1) Welds with relevant conditions require further evaluation. This evaluation shall include determination of the source of the leakage and corrosion of the source of leakage in accordance with -3142.3.

(2) All relevant conditions shall be evaluated to determine the extent, if any, of pressure boundary degradation. The boric acid crystals and residue shall be removed to the extent necessary to allow adequate examination and evaluation of pressure boundary degradation, and a subsequent VE of the previously observed surfaces shall be performed prior to return to service. Any pressure boundary degradation detected shall be evaluated to determine if any corrosion has affected the structural integrity of the component. Corrosion that has reduced component wall thickness below the thickness required by the Construction Code shall be resolved through repair/replacement activity in accordance with IWA-4000.

(3) A weld whose VE indicates relevant conditions indicative of possible through-wall leakage shall be unacceptable for continued service unless it meets the requirements of -3142.2 or -3142.3.

-3142.2 Acceptance by Supplemental Examinations. A weld with relevant conditions indicative of possible through-wall leakage shall be acceptable for continued service if the results of supplemental examinations -32000(x) meet the requirements of -3130.

-3142.3 Acceptance by Corrective Measures or Repair/Replacement Activity

(a) A weld with relevant conditions indicative of possible through-wall leakage shall be acceptable for continued service if a repair/replacement activity corrects the condition in accordance with IWA-4000.

(b) A weld with relevant conditions not indicative of possible through-wall leakage is acceptable for continued service if the source of the relevant condition is corrected by repair/replacement activity or by corrective measures necessary to preclude pressure boundary degradation.

-3200 Supplemental Examinations

(a) Any visual examination that detects a relevant condition (21411) indicative of possible through-wall leakage shall also receive a volumetric examination in accordance with -2500. The extent of the volumetric examination shall be in accordance with Figs. 1, 2, 3, 4, or 5, as applicable.

(b) A surface examination may also be performed to help further characterize the extent of the unacceptable condition and the need for corrective measures, analysis, evaluation, or repair/replacement activity.

-9000 GLOSSARY with Master coolant environment

Cracked: a weld with a primary cause-crack condition causing, any (plane) surface flaw originating from the pipe inside surface of the Alloy 82/82 weld. A weld that is mitigated before it is examined shall be considered cracked. Reactor vessel nozzle welds at cold leg temperature requiring the core internals to be removed to perform any post-mitigation examination may be considered cracked if the requirements of Table 1, Note 600, or Note 1200, as appropriate, are met.

-9000 GLOSSARY with Master coolant environment

Component: a corrosion resistant barrier applied on the inside surface of the pipe between the Alloy 82/82 weld and the reactor coolant, requiring excavation of some portion of the Alloy 82/82 weld.

Component: a corrosion resistant barrier applied on the inside surface of the pipe between the Alloy 82/82 weld and the reactor coolant, requiring excavation of some portion of the Alloy 82/82 weld.

C. alloy 600: a corrosion resistant material used by industry, the regulatory authority, and research organizations for UNI N06600.
NOTES (CONT'D):

(26) For circumferential welds with intersecting longitudinal welds, surface examination of the longitudinal piping welds is required for those portions of the welds within the examination boundaries of intersecting Examination Category B-F and B-J circumferential welds.

(27) For circumferential welds with intersecting longitudinal welds, volumetric examination of the longitudinal piping welds is required for those portions of the welds within the examination boundaries of intersecting Examination Category B-F and B-J circumferential welds. The following requirements shall also be met:

(a) When longitudinal welds are specified and locations are known, examination requirements shall be met for both transverse and parallel flaws at the intersection of the welds and for that length of longitudinal weld within the circumferential weld examination volume.

(b) When longitudinal welds are specified but locations are unknown, or the existence of longitudinal welds is uncertain, the examination requirements shall be met for both transverse and parallel flaws within the entire examination volume of intersecting circumferential welds.

(28) For welds in carbon or low alloy steels, only those welds showing reportable preservice transverse indications need to be examined by the ultrasonic method for reflectors transverse to the weld length direction except that circumferential welds with intersecting longitudinal welds shall meet the requirements of Note (4).

(29) A 10% sample of FWR high pressure safety injection system circumferential welds in piping ≥ NPS 1 1/2 (DN 40) and < NPS 4 (DN 100) shall be selected for examination. This sample shall be selected from locations determined by the owner as most likely to be subject to thermal fatigue. Thermal fatigue may be caused by conditions such as valve leakage or turbulence effects.

(30) Weld buildup on nozzles that is in compression under normal conditions and provides only component support is excluded from examination. Examination is limited to those welded attachments that meet the following conditions:

(a) The attachment is on the outside surface of the pressure retaining component;

(b) The attachment is mounted with component support as defined in NF-1110;

(c) The attachment weld joins the attachment either directly to the surface of the component or to an integrally cast or forged attachment to the component, and

(d) The attachment weld is full penetration, fillet, or partial penetration, either continuous or intermittent.

(31) The extent of the examination includes essentially 100% of the length of the attachment weld at each attachment subject to examination.

(32) Selected samples of welded attachments shall be examined at each inspection interval.

(33) For multiple vessels of similar design, function and service, only one welded attachment of only one of the multiple vessels shall be selected for examination. For single vessels, only one welded attachment shall be selected for examination. The attachment selected for examination on one of the multiple vessels or the single vessel, as applicable, shall be an attachment under continuous load during normal system operation, or an attachment subject to a potential intermittent load (seismic, water hammer, etc.) during normal system operation if an attachment under continuous load does not exist.

(34) For piping, pumps, and valves, a sample of 10% of the welded attachments associated with the component supports selected for examination under IWB-2510 shall be examined.

(35) Examination is required whenever component support member deformation, e.g., broken, bent, or pulled out parts, is identified during operation, refueling, maintenance, examination, or testing.

(36) For the configurations shown in Figs. IWB-2500-13 and IWB-2500-14, a surface examination from an accessible side of the attachment weld shall be performed. Alternatively, for the configuration shown in Fig. IWB-2500-14, a volumetric examination of volume A-B-C-D from an accessible side of the attachment weld may be performed in lieu of the surface examination of surfaces A-B or C-D.

(37) Examinations are limited to at least one pump in each group of pumps performing similar functions in the system, e.g., recirculating coolant pumps.

(38) Examination is required only when a pump or valve is disassembled for maintenance, or repair. Examination of the internal pressure boundary shall include the internal pressure retaining surfaces made accessible for examination by disassembly. If a partial examination is performed and a subsequent disassembly of that pump or valve allows a more extensive examination, an examination shall be performed during the subsequent disassembly. A complete examination is required only once during the interval.

(39) Examinations are limited to at least one valve within each group of valves that are of the same size, structural design (such as globe, gate, or check valves), and manufacturing method, and that perform similar functions in the system (such as containment isolation and system overpressure protection).

(40) Areas to be examined shall include the spaces above and below the reactor core that are made accessible for examination by removal of components during normal refueling outages.

(41) The structure shall be removed from the reactor vessel for examination.

(42) At 1st refueling outage, and subsequent refueling outages at approximately 3 year intervals.

(43) The surface examination method shall be performed on the inside diameter of the penetration nozzle housing welds as shown in Fig. IWB-2500-18 for examination surface area C-D.

(44) Visual examination of IWA-5240.

(45) The system leakage test (IWB-5220) shall be conducted prior to plant startup following a reactor refueling outage.
### Table IWB-2500-1

**Examination Categories (Cont'd)**

#### NOTES (CONT'D):

13. For PWRs in the second and successive inspection intervals, these examinations may be deferred to the end of the interval, provided no repair/replacement activities have been performed on the examination item, and no flaws or relevant conditions requiring successive inspections in accordance with IWB-2420(b) are contained in the examination item.

14. Deferral is not permissible during the first interval. However, during successive intervals, the examinations may be performed coincident with the vessel nozzle examinations required by Examination Category B-D.

15. Bolting may be examined:
   - (a) in place under tension;
   - (b) when the connection is disassembled;
   - (c) when the bolting is removed.

16. Bushings are required to be examined only when the bolting is removed. Bushings may be examined in place.

17. Volumetric examination of bolting for heat exchangers, pumps, or valves may be conducted on one heat exchanger, one pump, or one valve among a group of heat exchangers, pumps, or valves that are similar in design, type, and function. In addition, when the component to be examined contains a group of bolted connections of similar design and size, such as flanged connections, the examination may be conducted on one bolted connection among the group.

18. Visual examination of bolting for heat exchangers, pumps, or valves is required only when the component is examined under Examination Category B-B, B-L-2, or B-M-2. Examination of a bolted connection is required only once during the interval.

19. The examination of flange bolting in piping systems may be limited to one bolted connection among a group of bolted connections that are similar in design, size, function, and service.

20. Examination includes 1 in. (25 mm) annular surface of flange surrounding each stud.

21. When bolts or studs are removed for examination, surface examination meeting the acceptance standards of IWB-3515 may be substituted for volumetric examination.

22. Bolting is required to be examined only when a connection is disassembled or bolting is removed.

23. For components other than piping, examination of bolting is required only when the component is examined under Examination Category B-A, B-B, B-L-2, or B-M-2. Examination of bolted connection is required only once during the interval.

24. The examination of flange bolting in piping systems may be limited to one bolted connection among a group of bolted connections that are similar in design, size, function, and service. Examination is required only when a flange is disassembled. Examination of a bolted connection is required only once during the interval.

25. Examinations shall include the following:
   - (a) All terminal ends in each pipe or branch run connected to vessels.
   - (b) All terminal ends and joints in each pipe or branch run connected to other components where the stress levels exceed either of the following limits under loads associated with specific seismic events and operational conditions:
     1. primary plus secondary stress intensity range of 2.4 $S_{m}$ for ferritic steel and austenitic steel
     2. cumulative usage factor $U$ of 0.4
   - (c) All dissimilar metal welds not covered under Category B-F.
   - (d) Additional piping welds so that the total number of circumferential butt welds (or branch connection or socket welds) selected for examination equals 25% of the circumferential butt welds (or branch connection or socket welds) in the reactor coolant piping system. This total does not include welds exempted by IWB-1220 or welds in Item No. B9.22. These additional welds may be located as follows:
     1. For PWR plants
        - (a) one hot-leg and one cold-leg in one reactor coolant piping loop
        - (b) one branch, representative of an essentially symmetric piping configuration among each group of branch runs that are connected to reactor coolant loops and that perform similar system functions
        - (c) each piping and branch run exclusive of the categories of loop and runs that are part of system piping of (a) and (b) above
     2. For BWR plants
        - (a) one reactor coolant recirculation loop (where a loop or run branches, only one branch)
        - (b) one branch run representative of an essentially symmetric piping configuration among each group of branch runs that are connected to a loop and that perform similar system functions
        - (c) one steam line run representative of an essentially symmetric piping configuration among the runs
        - (d) one feedwater line run representative of an essentially symmetric piping configuration among the runs (where a loop or run branches, only one branch)
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Parts Examined</th>
<th>Examination Requirements/Figure No.</th>
<th>Examination Method</th>
<th>Acceptance Standard</th>
<th>Extent and Frequency of Examination</th>
<th>Deferral of Examination to End of Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>B15.10</td>
<td>Pressure retaining components [IWB-5222(a)]</td>
<td>System leakage test (IWB-5220)</td>
<td>Visual, VT-2</td>
<td>IWB-3522</td>
<td>Each refueling outage [Note (45)]</td>
<td>Same as for first interval</td>
</tr>
<tr>
<td>B15.20</td>
<td>Pressure retaining components [IWB-5222(b)]</td>
<td>System leakage test (IWB-5220)</td>
<td>Visual, VT-2</td>
<td>IWB-3522</td>
<td>Once per interval [Note (46)]</td>
<td>Same as for first interval</td>
</tr>
</tbody>
</table>

**EXAMINATION CATEGORY B-Q, STEAM GENERATOR TUBING**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Parts Examined</th>
<th>Examination Requirements/Figure No.</th>
<th>Examination Method</th>
<th>Acceptance Standard</th>
<th>Extent and Frequency of Examination</th>
<th>Deferral of Examination to End of Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>B16.10</td>
<td>Steam Generator Tubing in Straight Tube Design</td>
<td>Entire length of tubing</td>
<td>Volumetric</td>
<td>[Note (48)]</td>
<td>[Note (47)]</td>
<td>[Note (47)]</td>
</tr>
<tr>
<td>B16.20</td>
<td>Steam Generator Tubing in U-Tube Design</td>
<td>Tubing hot leg side, U-bend portion and optionally cold leg side</td>
<td>Volumetric</td>
<td>IWB-3521</td>
<td>[Note (47)]</td>
<td>[Note (47)]</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Material (base metal) weld repairs where repair depth exceeds 10% nominal of the vessel wall. If the location of the repair is not positively and accurately known, then the individual shell plate, forging, or shell course containing the repair shall be included.
2. Includes essentially 100% of the weld length.
3. The shell-to-flange weld examination may be performed during the first and third periods, in which case 50% of the shell-to-flange weld shall be examined by the end of the first period, and the remainder by the end of the third period. During the first period, the examination need only be performed from the flange face, provided this same portion is examined from the shell during the third period.
4. During the first and second periods, the examination may be performed from the flange face, provided these same portions are examined from the head during the third period.
5. Deferral of the first inspection interval is not permitted. Deferral in successive inspection intervals is permitted provided that:
   - (a) no welded repair/replacement activities have been performed either on the shell-to-flange weld or head-to-flange weld or head-to-flange welds; and
   - (b) neither the shell-to-flange weld nor the head-to-flange weld contains identified flaws or relevant conditions that require successive inspections in accordance with IWB-2420(b).
6. The examination may be limited to one vessel among the group of vessels performing a similar function.
7. The weld selected for examination is that weld intersecting the circumferential weld.
8. The initially selected welds are to be examined in the same sequence during successive inspection intervals, to the extent practical.
9. Includes nozzles with full penetration welds to vessel shell (or head) and integrally cast nozzles, but excludes manways and handholes either welded to or integrally cast in vessel.
10. At least 25% but not more than 50% of the nozzles shall be examined by the end of the first inspection period, and the remainder by the end of the inspection interval.
11. If the nozzle weld is examined by the straight beam ultrasonic method from inside the nozzle bore, the remaining examinations required from the shell inside diameter may be performed at or near the end of the interval.
12. The examination volumes shall apply to the applicable Figure shown in Figs. IWB-2500-7(a) through IWB-2500-7(d).
New Note 28 - No Table IWB-2500-1 is note 7 below.

but note 7 is now note 28. Since old note 7 refers to note 5, but note 5 has also been changed and is now note 26, the new note 28 should refer to note 26, not note 4.

TABLE IWB-2500-1 (CONT'D)

EXAMINATION CATEGORIES

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Parts Examined</th>
<th>Examination Requirements/ Fig. No.</th>
<th>Examination Method</th>
<th>Acceptance Standard</th>
<th>First Inspection Interval</th>
<th>Successive Inspection Intervals (Note (5))</th>
<th>Deferral of Examination to End of Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>B9.10</td>
<td>NPS 4 or larger</td>
<td>IWB-2500-8</td>
<td>Surface and volumetric</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
<tr>
<td>B9.11</td>
<td>Circumferential welds</td>
<td>IWB-2500-8</td>
<td>Surface</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
<tr>
<td>B9.30</td>
<td>Less than NPS 4</td>
<td>IWB-2500-8</td>
<td>Volumetric</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
<tr>
<td>B9.33</td>
<td>Circumferential welds other than PWR high pressure safety injection systems</td>
<td>IWB-2500-9</td>
<td>Surface and volumetric</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
<tr>
<td>B9.34</td>
<td>Branch pipe connection welds</td>
<td>IWB-2500-9,-10,-11</td>
<td>Surface</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
<tr>
<td>B9.40</td>
<td>Less than NPS 4</td>
<td>IWB-2500-9</td>
<td>Surface</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
<tr>
<td></td>
<td>Socket welds</td>
<td>IWB-2500-9</td>
<td>Surface</td>
<td>IWB-3514</td>
<td>Same as for first interval</td>
<td>Same as for first interval</td>
<td>Not permissible</td>
</tr>
</tbody>
</table>

NOTES:

(1) Examinations shall include the following:
(a) All terminal ends in each pipe or branch run connected to other components where the stress levels exceed either of the following limits of stress associated with specific seismic events and operational conditions:
(i) Primary plus secondary stress intensity range of 2.4Sₐ for ferritic steel and austenitic steel
(ii) Cumulative usage factor U of 0.4
(b) All dissimilar metal welds not covered under Category B-F.
(c) Additional piping welds so that the total number of circumferential butt welds (or branch connection or socket welds) selected for examination equals 25% of the circumferential butt welds (or branch connection or socket welds) in the reactor piping system. This total does not include welds exempted by IWB-1220 or welds in Item 86. Additional welds may be located in one loop (one loop is defined for both PWR and BWR plants in the 1977 Edition).
(d) A 12% sample of PWR high pressure safety injection system circumferential welds in piping ≥ NPS 1½ (DN 40) and < NPS 4 (DN 100) shall be selected for examination. This sample shall be selected from locations determined by the Owner's most likely to be subject to thermal fatigue. Thermal fatigue may be caused by conditions such as valve leakage or turbulence effects.
(e) The initially selected welds are to be examined in the same sequence during successive inspection intervals, to the extent practical.
(f) Includes essentially 100% of weld length.
(g) For circumferential welds with intersecting longitudinal welds, surface examination of the longitudinal piping welds is required for those portions of the welds within the examination boundaries of intersecting examination Category B-F and B-J circumferential welds.
(h) For circumferential welds with intersecting longitudinal welds, volumetric examination of the longitudinal piping welds is required for those portions of the welds within the examination boundaries of intersecting examination Category B-F and B-J circumferential welds.
(i) The following requirements shall also be met:
(a) When longitudinal welds are specified and locations are known, examination requirements shall be met for both transverse and parallel flaws at the intersection of the welds and for that length of longitudinal weld within the circumferential weld examination volume.
(b) When longitudinal welds are specified but locations are unknown, or the existence of longitudinal welds is uncertain, the examination requirements shall be met for both transverse and parallel flaws within the entire examination volume of intersecting circumferential welds.
(j) For welds in carbon or low alloy steels, only those welds showing reportable preserve transverse indications need to be examined by the ultrasonic method for reflectors transverse to the weld length direction except that circumferential welds with intersecting longitudinal welds shall meet Note (61).
### Examination Categories

#### EXAMINATION CATEGORY C-A, PRESSURE RETAINING WELDS IN PRESSURE VESSELS [Note (1)]

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Parts Examined</th>
<th>Examination Requirements/Figure No.</th>
<th>Examination Method</th>
<th>Acceptance Standard</th>
<th>Extent of Examination [Note (3)], [Note (4)]</th>
<th>Frequency of Examination [Note (5)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1.10</td>
<td>Shell Circumferential Welds</td>
<td>IWC-2500-1</td>
<td>Volumetric</td>
<td>IWC-3510</td>
<td>Cylindrical-shell-to-conical-shell-junction welds and shell (or head)-to-flange welds</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C1.20</td>
<td>Head Circumferential Welds</td>
<td>IWC-2500-1</td>
<td>Volumetric</td>
<td>IWC-3510</td>
<td>Head-to-shell weld</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C1.30</td>
<td>Tubesheet-to-Shell Weld</td>
<td>IWC-2500-2</td>
<td>Volumetric</td>
<td>IWC-3510</td>
<td>Tubesheet-to-shell weld</td>
<td>Each inspection interval</td>
</tr>
</tbody>
</table>

#### EXAMINATION CATEGORY C-B, PRESSURE RETAINING NOZZLE WELDS IN PRESSURE VESSELS [Note (1)]

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Parts Examined</th>
<th>Examination Requirements/Figure No.</th>
<th>Examination Method</th>
<th>Acceptance Standard</th>
<th>Extent of Examination [Note (4)]</th>
<th>Frequency of Examination [Note (6)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2.10</td>
<td>Nozzles in Vessels ≤ 1/2 in. (13 mm) Nominal Thickness</td>
<td>IWB-2500-3</td>
<td>Surface</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.11</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Weld</td>
<td>IWB-2500-3</td>
<td>Surface</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.20</td>
<td>Nozzles Without Reinforcing Plate in Vessels &gt; 1/2 in. (13 mm) Nominal Thickness</td>
<td>IWB-2500-7(a), IWB-2500-7(b), or IWB-2500-7(d)</td>
<td>Surface and volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.21</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Weld</td>
<td>IWB-2500-7(a), IWB-2500-7(b), or IWB-2500-7(d)</td>
<td>Volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.22</td>
<td>Nozzle Inside Radius Section</td>
<td>IWB-2500-7(a), IWB-2500-7(b), or IWB-2500-7(d)</td>
<td>Volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.30</td>
<td>Nozzles With Reinforcing Plate in Vessels &gt; 1/2 in. (13 mm) Nominal Thickness</td>
<td>IWB-2500-4</td>
<td>Surface</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.31</td>
<td>Reinforcing Plate Welds to Nozzle and Vessel</td>
<td>IWB-2500-4</td>
<td>Volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.32</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Welds When Inside of Vessel Is Accessible</td>
<td>IWB-2500-4</td>
<td>Volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.33</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Welds When Inside of Vessel Is Inaccessible</td>
<td>[Note (9)]</td>
<td>Visual, VT-2</td>
<td>No leakage</td>
<td>All nozzles at terminal ends [Note (7)] of piping runs [Note (9)]</td>
<td>Each inspection period</td>
</tr>
<tr>
<td>Item No.</td>
<td>Parts Examined</td>
<td>Examination Requirements/Fig. No.</td>
<td>Examination Method</td>
<td>Acceptance Standard</td>
<td>Extent of Examination</td>
<td>Frequency of Examination</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>C2.10</td>
<td>Nozzles in Vessels ≤ $\frac{1}{2}$ in. (13 mm) Nominal Thickness</td>
<td></td>
<td>Surface</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.11</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Weld</td>
<td>IWC-2500-3</td>
<td>Surface and volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.20</td>
<td>Nozzles Without Reinforcing Plate in Vessels &gt; $\frac{1}{2}$ in. (13 mm) Nominal Thickness</td>
<td></td>
<td>Surface and volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.21</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Weld</td>
<td>IWC-2500-4(a), (b), or (d)</td>
<td>Volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.22</td>
<td>Nozzle Inside Radius Section</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2.30</td>
<td>Nozzles With Reinforcing Plate in Vessels &gt; $\frac{1}{2}$ in. (13 mm) Nominal Thickness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2.31</td>
<td>Reinforcing Plate Welds to Nozzle and Vessel</td>
<td>IWC-2500-4(c)</td>
<td>Surface</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.32</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Welds When Inside of Vessel is Accessible</td>
<td>IWC-2500-4(c)</td>
<td>Volumetric</td>
<td>IWC-3511</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection interval</td>
</tr>
<tr>
<td>C2.33</td>
<td>Nozzle-to-Shell (Nozzle to Head or Nozzle to Nozzle) Welds When Inside of Vessel is Inaccessible</td>
<td>Note (6)</td>
<td>Visual, VT-2</td>
<td>No leakage</td>
<td>All nozzles at terminal ends of piping runs</td>
<td>Each inspection period</td>
</tr>
</tbody>
</table>

NOTES:
1. These requirements do not apply to atmospheric or 0 psig to 15 psig (0 kPa to 100 kPa) storage tanks.
2. In the case of multiple vessels of similar design, size, and service (such as steam generators, heat exchangers), the required examinations may be limited to one vessel or distributed among the vessels.
3. The nozzles selected initially for examination shall be reexamined in the same sequence over the service lifetime of the component, to the extent practical.
4. Includes nozzles welded to or integrally cast in vessels that connect to piping runs (manways and handholes are excluded).
5. Includes only those piping runs selected for examination under Examination Category C-F.
6. The telltale hole in the reinforcing plate shall be examined for evidence of leakage while vessel is undergoing the system leakage test (IWC-5220) as required by Examination Category C-H.
Figure IWC-2500-3
Nozzle-to-Vessel Welds

Exam. surface A - B

(a)

Exam. surface A - B

(b)

GENERAL NOTES:
(a) \( \frac{1}{2} \) in. = 13 mm
(b) Nozzle sizes over NPS 4 (DN 100); vessel thickness \( \leq \frac{1}{2} \) in. (13 mm).
Figure 1WC-2500-4
Nozzle-to-Vessel Welds (Cont'd)

(d) See Notes (1) and (2)

GENERAL NOTES:
(a) \( \frac{1}{4} \) in. = 6 mm
(b) \( \frac{1}{2} \) in. = 13 mm
(c) NPS 12 = DN 300

NOTES:
(1) Nozzle sizes over NPS 4 (DN 100); vessel thickness over \( \frac{1}{2} \) in. (13 mm).
(2) Configurations may include nozzle-to-shell or reinforcing-plate-to-nozzle welds that are other than full-penetration welds.