INSERT A

IWB-3523.3 Allowable Flaw Standards for Volumetric Examination.

(a) The depth of an allowable preservice flaw shall not exceed 10% of weld thickness; the length shall not exceed 60% of weld thickness.

(b) The depth of an allowable inservice flaw shall not exceed 12.5% of weld thickness; the length shall not exceed 75% of weld thickness.

IWB-3600 ANALYTICAL EVALUATION OF PLANAR FLAWS

(a) A flaw that exceeds the size of allowable flaws defined in IWB-3500 may be analytically evaluated using procedures such as described in Nonmandatory Appendix A to calculate its growth until the next inspection or the end of service lifetime of the component.

(b) For purposes of analytical evaluation, the depth of flaws in clad components shall be defined in accordance with Figure IWB-3610-1 as follows:

1. Category 1 — A flaw that lies entirely in the cladding need not be analytically evaluated.

2. Category 2 — A surface flaw that penetrates the cladding and extends into the ferritic steel shall be analytically evaluated on the basis of the total flaw depth in both the ferritic steel and cladding.

3. Category 3 — A subsurface flaw that lies in both the ferritic steel and the cladding shall be treated as either a surface or a subsurface flaw depending on the relationship between S and d as shown in Figure IWB-3610-1.

4. Category 4 — A subsurface flaw that lies entirely in the ferritic steel and terminates at the weld metal interface shall be treated as either a surface or subsurface flaw depending on the relationship between S and d as shown in Figure IWB-3610-1.

5. Category 5 — A subsurface flaw contained entirely in the ferritic steel shall be treated as either a surface or a subsurface flaw depending on the relationship between S and d as shown in Figure IWB-3610-1.

6. When examination results do not permit accurate determination of the flaw category, the more conservative category shall be selected.

7. The component containing the flaw is acceptable for continued service during the evaluated time period if the following are satisfied:

1. the criteria of IWB-3611 or IWB-3612;

2. the primary stress limits of Article NB-3000, assuming a local area reduction of the pressure-retaining membrane that is equal to the area of the detected flaw(s) as determined by the flaw characterization rules of Article IWA-3000.
For purposes of analytical evaluation, the depth of flaws in clad piping items shall be defined in accordance with Figure IWB-3600-1. The flaw characterization rules of IWA-3300 shall be used for the transformation of a subsurface flaw to a surface flaw using dimensions $S$ and $d$. For Category 1, the flaw need not be analytically evaluated.
The analytical evaluation of flaws is addressed by the procedures in this subsection.

(a) A flaw that exceeds the size of allowable flaws defined in IWB-3500 may be analytically evaluated using procedures described in this section-subarticle to calculate flaw growth until the next inspection or the end of the service lifetime of the component or piping item.

(b) For purposes of analytical evaluation, the depth of flaws in clad components and piping items shall be defined in accordance with Figure IWB-3600-1 as follows:

   (1) Category 1 — A flaw that lies entirely in the cladding, as shown in Figure IWB-3600-1, need not be analytically evaluated.

   (2) Category 2 — A surface flaw that penetrates the cladding and extends into the ferritic steel shall be analytically evaluated on the basis of the total flaw depth in both the ferritic steel and cladding as shown in Figure IWB-3600-1.

   (3) Category 3 — A subsurface flaw that lies in both the ferritic steel and the cladding shall be treated as either a surface or a subsurface flaw depending on the relationship between $S$ and $d$ as shown in Figure IWB-3600-1.

   (4) Category 4 — A subsurface flaw that lies entirely in the ferritic steel and terminates at the weld metal interface shall be treated as either a surface or subsurface flaw depending on the relationship between $S$ and $d$ as shown in Figure IWB-3600-1.

   (5) Category 5 — A subsurface flaw contained entirely in the ferritic steel shall be treated as either a surface or a subsurface flaw depending on the relationship between $S$ and $d$ as shown in Figure IWB-3600-1.

   (c) The flaw characterization rules of IWA-3300 shall be used for the transformation of a subsurface flaw to a surface flaw using dimensions $S$ and $d$ illustrated in Figure IWB-3600-1.

   (d) When examination results do not permit accurate determination of the flaw category, the more conservative category shall be selected.
INSERT B

(a) A flaw that exceeds the size of allowable flaws defined in IWB-3510 and IWB-3512 may be analytically evaluated using procedures such as described in Nonmandatory Appendix A to calculate its growth until the next inspection or the end of service lifetime of the component.

(b) For purposes of analytical evaluation, the depth of flaws in clad components shall be defined in accordance with Figure IWB-3600-1. For Category 1, the flaw need not be analytically evaluated.
(1) The flaw characterization rules of IWA-3300 shall be used for the transformation of a subsurface flaw to a surface flaw using dimensions $S$, $a$, and $d$ as defined in this figure.
(2) The size of allowable surface flaws that penetrate through the cladding into base metal shall not exceed the standards of (a) above, except that the depth \( a \) of the flaw shall be the total depth minus the nominal clad thickness.

**IWC-3516** Standards for Examination Category C-H, All Pressure-Retaining Components

**IWC-3516.1 Visual Examination, VT-2.** A component whose visual examination (IWA-5240) detects any of the following relevant conditions shall meet IWC-3121 and IWA-5250 prior to continued service:

(a) any through-wall or through-weld, pressure-retaining material leakage from insulated and noninsulated components

(b) nonborated water leakage in excess of limits established by the Owner from mechanical connections (such as pipe caps, bolted connections, or compression fittings)

(c) areas of general corrosion of a component resulting in leakage

(d) leakage in excess of limits established by the Owner from components provided with leakage limiting devices (such as valve packing glands or pump seals)

(e) borated water leakage or evidence of borated water leakage (discoloration or accumulated residues on surfaces of components, insulation, or floor areas) not addressed in (a) or (d)

(f) leakages or flow test results from buried components in excess of limits established by the Owner

**IWB-3600** ANALYTICAL EVALUATION OF PLANAR FLAWS

**IWC-3610** ACCEPTANCE CRITERIA FOR FERRITIC COMPONENTS

These criteria are in the course of preparation. In the interim, the criteria of IWC-3610 may be applied.

**IWC-3640** ANALYTICAL EVALUATION PROCEDURES AND ACCEPTANCE CRITERIA FOR FLAWS IN AUSTENITIC AND FERRITIC PIPING

Piping containing flaws exceeding the acceptance standards of IWC-3514 may be analytically evaluated to determine acceptability for continued service to the next inspection or to the end of the evaluation period. A pipe containing flaws is acceptable for continued service for a specified evaluation time period if the criteria of IWC-3642, IWC-3643, or IWC-3644 are satisfied.

**IWC-3641** Analytical Evaluation Procedures

Analytical evaluation procedures based on flaw size or applied stress, such as those described in Nonmandatory Appendix C or H, may be used, subject to the following:

(a) The analytical evaluation procedures and acceptance criteria in Nonmandatory Appendix C are applicable to piping NPS 1 (DN 25) and greater. The procedures and
IWD-3500  ACCEPTANCE STANDARDS

IWD-3510  STANDARDS FOR EXAMINATION CATEGORY D-A, WELDED ATTACHMENTS FOR VESSELS, PIPING, PUMPS, AND VALVES

In the course of preparation. The requirements of IWC-3500 may be used.

IWD-3511  Standards for Examination Category D-B, All Pressure-Retaining Components

IWD-3511.1 Visual Examination, VT-2. A component whose visual examination (IWA-5240) detects any of the following relevant conditions shall meet IWD-3132 and IWA-5250 prior to continued service:

(a) any through-wall or through-weld, pressure-retaining material leakage from insulated and noninsulated components

(b) nonborated water leakage in excess of limits established by the Owner from mechanical connections (such as pipe caps, bolted connections, or compression fittings)

(c) areas of general corrosion of a component resulting in leakage

(d) leakage in excess of limits established by the Owner from components provided with leakage limiting devices (such as valve packing glands or pump seals)

(e) borated water leakage or evidence of borated water leakage (discoloration or accumulated residues on surfaces of components, insulation, or floor areas) not addressed in (a) or (d)

(f) leakages or flow test results from buried components in excess of limits established by the Owner

IWD-3600  ANALYTICAL EVALUATION OF PLANAR FLAWS

IWD-3610  ACCEPTANCE CRITERIA FOR FERRITIC COMPONENTS

In the course of preparation. The requirements of IWC-3610 may be used.

IWD-3640  ANALYTICAL EVALUATION PROCEDURES AND ACCEPTANCE CRITERIA FOR FLAWS IN AUSTENITIC AND FERRITIC PIPING

Piping containing flaws exceeding the acceptance standards of IWD-3500 may be analytically evaluated to determine acceptability for continued service to the next inspection or to the end of the evaluation period. A pipe containing flaws is acceptable for continued service for a specified evaluation time period if the criteria of IWD-3642, IWD-3643, or IWD-3644 are satisfied.

IWD-3641  Analytical Evaluation Procedures

Analytical evaluation procedures based on flaw size or applied stress, such as those described in Nonmandatory Appendix C or Nonmandatory Appendix H may be used subject to the following:

(a) The analytical evaluation procedures and acceptance criteria in Nonmandatory Appendix C are applicable to piping NPS 1 (DN 25) and greater. The procedures and criteria in Nonmandatory Appendix H are applicable to piping NPS 4 (DN 100) and greater. Nonmandatory Appendices C and H are applicable to portions of adjoining pipe fittings within a distance of \( \left( \frac{R_z t}{2} \right)^{1/2} \) from the weld centerline, where \( R_z \) is the outside radius and \( t \) is the thickness of the pipe. The weld geometry and weld-base metal interface are defined in Nonmandatory Appendix C.

(b) The analytical evaluation procedures and acceptance criteria are applicable to seamless or welded wrought carbon steel piping and pipe fittings, and associated weld materials, that have a specified minimum yield strength not greater than 40 ksi (280 MPa).

(c) The analytical evaluation procedures and acceptance criteria are applicable to seamless or welded, wrought or cast, austenitic pipe and pipe fittings and associated weld materials that are made of wrought stainless steel, Ni-Cr-Fe alloy, or cast stainless steel, and have a specified minimum yield strength not greater than 45 ksi (310 MPa).

(d) A flaw growth analysis shall be performed on the detected flaw to predict its growth due to fatigue or stress corrosion cracking mechanisms, or both, when applicable, during a specified evaluation time period. The time

<table>
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<th>Examination Category</th>
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<tr>
<td>D-A</td>
<td>Welded attachments for vessels, piping, pumps, and valves</td>
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</table>
ARTICLE C-2000
ANALYTICAL EVALUATION PARAMETERS

C-2100  SCOPE

This Article provides procedures for defining the flaw geometry (shape, proximity, orientation, and location), applied stress, and acceptance criteria.

C-2200  FLAW SHAPE

The flaw should be completely bounded by a rectangular or circumferential planar area in accordance with the methods of IWA-3300. Figures C-2200-1 and C-2200-2 illustrate flaw characterization for circumferential and axial pipe flaws respectively.

Surface or subsurface flaw characterization shall be used depending on the type of flaw. When the flaw is subsurface, but within the proximity limit of IWA-3340 from the surface of the component, the flaw shall be considered a surface flaw and shall be bounded by a rectangular or circumferential planar area with the base (major length) aligned along the surface.

C-2300  PROXIMITY TO CLOSEST FLAW

For multiple adjacent flaws, when the shortest distance between the boundaries of two adjacent flaws is within the proximity limits specified in IWA-3300, the adjacent flaws shall be bounded by a single rectangular or circumferential planar area in accordance with IWA-3300.

C-2400  FLAW ORIENTATION

Flaws that do not lie in either an axial or a circumferential plane should be projected onto these planes in accordance with the rules of IWA-3340. The axial and circumferential flaws obtained by these projections shall be analytically evaluated separately in accordance with this Appendix.

Figures C-2400-1, C-2400-2, and C-2400-3 illustrate flaw characterization for skewed flaws.

C-2500  DEFINITION OF PIPE STRESS

For the purpose of analysis, the flaw is to be considered in its pipe cross-section location. The stresses due to system loading shall be calculated at this location. The location-specific loading (forces and moments) can be obtained from the piping Design Report for each Service Level loading condition. The stresses to be used in the analytical evaluation are the unintensified pipe stress for membrane, bending (including torsion), and expansion (thermal and seismic anchor motion) defined as $\sigma_m$, $\sigma_b$, and $\sigma_e$, or pipe hoop stress, $\sigma_h$. The inclusion of torsion (torsion stress, $\tau$) in the method of combination of bending moments applies only when the torsion stress does not exceed 0.2 times the flow stress. The method of combination of bending moments including torsion shall be justified for higher levels of torsion stress.

(a) For circumferential flaws the unintensified stress can be calculated from the piping Design Report for each Service Level as follows

$$ \sigma_m = \frac{pD}{4t} $$

$$ \sigma_b = \frac{DM_b}{2t} $$
L-3300  ANALYTICAL EVALUATION PROCEDURES AND ALLOWABLE OPERATING PERIOD

The loadings in the Design Specification, plant specific loading cycles consistent with the plant design and operating practices, or actual plant operating data, shall be used, as appropriate, for analytical evaluations in this subarticle.

L-3310  ANALYTICAL EVALUATION PROCEDURES AND ALLOWABLE OPERATING PERIOD FOR FERRITIC STEEL COMPONENTS 4 in. (100 mm) OR GREATER IN THICKNESS

L-3311  Analytical Evaluation Procedures

(a) Nonmandatory Appendix A analytical evaluation procedures for fatigue crack growth may be used for ferritic steel components 4 in. (100 mm) or greater in thickness.

(b) The procedures in Article A-5000 may be used to calculate \( a_f \) and \( \ell_f \) for the postulated flaw in L-3200 during the evaluation period.

(c) The procedures in Article A-5000 may be used to calculate the minimum critical flaw sizes \( a_c \) and \( a_i \).

L-3312  Allowable Operating Period

(a) Calculate the operating periods \( P_n \) and \( P_o \) for the postulated flaw in L-3200 to grow to the allowable flaw depth corresponding to the acceptance criteria in IWB-3610(d) or IWB-3613, as applicable.

(b) The allowable operating period \( P \) is equal to the smaller of \( P_n \) or \( P_o \) in (a).

L-3320  ANALYTICAL EVALUATION PROCEDURES AND ALLOWABLE OPERATING PERIOD FOR FERRITIC STEEL COMPONENTS LESS THAN 4 in. (100 mm) THICK

These procedures and criteria are in the course of preparation. In the interim, the procedures and criteria of L-3310 may be applied.

L-3330  ANALYTICAL EVALUATION PROCEDURES AND ALLOWABLE OPERATING PERIOD FOR AUSTENITIC PIPING

L-3331  Analytical Evaluation Procedures

(a) Nonmandatory Appendix C analytical evaluation procedures may be used for austenitic stainless steel piping.

(b) The procedures in C-3200 for fatigue crack growth may be used to calculate \( a_f \) and \( \ell_f \) for the postulated flaw in L-3200 during the evaluation period.

(c) The allowable flaw depths \( a_n \) and \( a_o \) shall be determined using the limit load procedures in Article C-5000 or EPFM procedures in Article C-6000 as applicable.

L-3332  Allowable Operating Period

(a) Calculate the operating periods \( P_n \) and \( P_o \) for the postulated flaw in L-3200 to grow to the allowable flaw depths defined in L-3331(c).

(b) The allowable operating period \( P \) is equal to the smaller of \( P_n \) or \( P_o \) in (a).

L-3340  ANALYTICAL EVALUATION PROCEDURES AND ALLOWABLE OPERATING PERIOD FOR FERRITIC PIPING

L-3341  Analytical Evaluation Procedures

(a) Nonmandatory Appendix C analytical evaluation procedures may be used for ferritic piping.

(b) The procedures in C-3200 for fatigue crack growth may be used to calculate \( a_f \) and \( \ell_f \) for the postulated flaw in L-3200.

(c) The allowable flaw depths \( a_n \) and \( a_o \) shall be determined using the limit load procedures in Article C-5000, EPFM procedures in Article C-6000, or LEFM procedures in Article C-7000, as applicable.

L-3342  Allowable Operating Period

(a) Calculate the operating periods \( P_n \) and \( P_o \) for the postulated flaw in L-3200 to grow to the maximum allowable flaw depth defined in L-3341(c).

(b) The allowable operating period \( P \) is equal to the smaller of \( P_n \) or \( P_o \) in (a).

L-3400  EXAMINATION PROVISIONS

L-3410  EXAMINATIONS

(a) The absence of any flaw larger than the applicable acceptance standard referenced in Table IWB-3410-1, at the location of concern, shall be verified by surface or volumetric examination. Otherwise, this Appendix is not applicable, and the flaw shall be analytically evaluated in accordance with IWB-3400.

(b) Examinations shall be conducted in accordance with IWA-2220, IWA-2230, or IWA-2240, as applicable.

L-3420  SUCCESSIVE EXAMINATIONS

The component shall be examined at the location of concern in accordance with the successive inspection schedule provisions in Table L-3420-1. The successive inspection period shall not exceed that specified in Table L-3420-1 or IWB-2410.