

Approval Date: June 30, 2017

Code Cases will remain available for use until annulled by the applicable Standards Committee.

**Case N-877**  
**Alternative Characterization Rules for Multiple**  
**Subsurface Radially Oriented Planar Flaws**  
**Section XI, Division 1**

*Inquiry:* When multiple subsurface radially oriented planar flaws are detected by volumetric examination, what alternative flaw characterization requirements may be applied in lieu of IWA-3330, IWA-3350, and IWA-3380?

*Reply:* It is the opinion of the Committee that the following alternative to the requirements of IWA-3330, IWA-3350, and IWA-3380 may be used for the characterization of multiple subsurface radially oriented planar flaws. When used, this Case shall be applied to all planar flaws within the examination volume as defined in Table IWB-2500-1, Table IWC-2500-1, or Table R-2500-1. This Case shall not be used for cast austenitic stainless steel piping.

**1 PLANAR FLAWS**

(a) A continuous indication shall be characterized as a planar flaw if the detected flaw area is oriented primarily in any single plane, other than parallel to the surface of the component.

(b) The requirements of IWA-3310 and IWA-3320 shall be applied to characterize planar flaws as surface or subsurface flaws, respectively.

(c) A subsurface flaw shall be characterized as a surface flaw if any portion of the flaw is less than  $0.4a$  from the surface of the component nearest the flaw. If the nearest surface of the component is clad,  $S$  shall be measured to the clad-base metal surface.  $S$  is shown in Figure 1.

(d) This Case applies only to those planar flaws characterized as subsurface.

**2 MULTIPLE COPLANAR FLAWS**

(a) This paragraph applies to coplanar flaws separated by a distance  $H = 0$ , as specified in Figure 2.

(b) Multiple subsurface coplanar flaws shall be combined into a single flaw, if the distance between adjacent flaws meets the criteria in 5(a).

(c) The dimensions  $\alpha$  and  $\ell$  of the combined flaws shall be those of the square or rectangle that contains the detected area of all flaws within the proximity limits defined in 5(a), as shown in Figure 3.  $2\alpha$  is the flaw depth in the wall thickness dimension, while  $\ell$  is the flaw length in the transverse direction.

(d) Combination of multiple subsurface coplanar flaws is not required for fatigue crack growth assessment.

**3 PARALLEL PLANAR FLAWS**

(a) This paragraph applies to parallel planar flaws separated by a distance  $H > 0$ , according to Figure 2.

(b) Multiple subsurface parallel planar flaws shall be combined into a single flaw, if the distance between adjacent flaws meets the criteria in 5(a).

(c) The dimensions  $\alpha$  and  $\ell$  of the combined flaws shall be those of the square or rectangle that contains the detected area of all flaws within the proximity limits defined in 5(a), as shown in Figure 3.

(d) Combination of multiple subsurface parallel planar flaws is not required for fatigue crack growth assessment.

**4 FLAW ORIENTATION**

(a) Subsurface planar flaws that do not lie in a plane perpendicular to the direction of the maximum principal stresses shall be projected into that plane, following the requirements of IWA-3340.

(b) This projection of flaws into a plane leads to a Mode I loading condition, as shown in Figure 4.

**5 PROXIMITY LIMIT CRITERIA**

(a) Multiple adjacent subsurface planar flaws shall be combined into a single flaw, if all three of the following proximity criteria below are met, as shown in Figure 2:

- (1)  $S_x < \min(2d_{1-eq}, 2d_{2-eq})$
- (2)  $S_y < \min(2d_{1-eq}, 2d_{2-eq})$
- (3)  $H < \min(2d_{1-eq}, 2d_{2-eq})$

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

Where  $d_{i-eq} = d_i/[E(k)]^2$ ,  $E(k)$  is the complete elliptical integral of the second kind of eccentricity  $k$

For  $2d_i/L_i < 1$ ,  $[E(k)]^2 = 1 + 1.464(2d_i/L_i)^{1.65}$

For  $2d_i/L_i > 1$ ,  $[E(k)]^2 = 1 + 1.464(L_i/2d_i)^{1.65}$

$2d_i$  and  $L_i$  being the depth and length of the flaw  $i$ , as shown in Figure 2.

(b) For multiple subsurface planar flaws that do not lie in a plane perpendicular to the maximum principal stress direction, the distance  $H$  shall be determined using the projection of those flaws given in 4(a), as shown in Figure 4.

(c) If multiple flaws exist, each flaw shall be evaluated for its interaction with each adjacent flaw on an individual flaw basis, using the original flaw dimensions. If two or

more flaws are combined by the proximity rules, it is not required to consider further interactions based on the dimensions of the combined flaw with other flaws.

## 6 ASSESSMENT OF COMBINED FLAWS

(a) A combined flaw shall be characterized as a single elliptical flaw with dimensions  $\alpha$  and  $\ell$  of the square or rectangle that contains the area of all flaws within the proximity limits defined in 5(a), as shown in Figure 3.

(b) A combined flaw of subsurface planar flaws remains a subsurface planar flaw.



a

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**Section XI, Division 1**

**Case N-8XX**

**Alternative Characterization Rules for Multiple Subsurface Radially-Oriented Planar Flaws**  
**Section XI, Division 1**

*Inquiry:* When multiple subsurface radially-oriented planar flaws are detected by volumetric examination, what alternative flaw characterization requirements may be applied in lieu of IWA-3330, 3350, and 3380?

*Reply:* It is the opinion of the Committee that the following alternative to the requirements of IWA-3330, 3350, and 3380 may be used for the characterization of multiple subsurface radial planar flaws. When used, this Case shall be applied to all planar flaws within the examination volume as defined in Table IWB-2500-1, IWC-2500-1, or R-2500-1. This eCase shall not be used for cast austenitic stainless steel piping.

**1 Planar Flaws**

- (a) A continuous indication shall be characterized as a planar flaw if the detected flaw area is oriented primarily in any single plane, other than parallel to the surface of the component.
- (b) The requirements of IWA-3310 and IWA-3320 shall be applied to characterize planar flaws as surface or subsurface flaws, respectively.
- (c) A subsurface flaw shall be characterized as a surface flaw if any portion of the flaw is less than  $0.4a$  from the surface of the component nearest the flaw. If the nearest surface of the component is clad,  $S$  shall be measured to the clad-base metal surface.  $S$  is shown in Figure 1.
- (d) This Case applies only to those planar flaws characterized as subsurface.

**2 Multiple Coplanar Flaws**

- (a) This paragraph applies to coplanar flaws separated by a distance  $H = 0$ , as specified in Figure 2.
- (b) Multiple coplanar flaws shall be combined into a single flaw, if the distance between adjacent flaws meets the criteria in 5 (a).
- (c) The dimensions  $a$  and  $\ell$  of the combined flaws shall be those of the square or rectangle that contains the detected area of all flaws within the proximity limits defined in 5 (a), as shown in Figure 3.  $2a$  is the flaw depth in the wall thickness dimension, while  $\ell$  is the flaw length in the transverse direction.
- (d) Combination of multiple coplanar flaws is not required for fatigue crack growth assessment.

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**3 Parallel Planar Flaws**

- (a) This paragraph applies to parallel planar flaws separated by a distance  $H > 0$ , according to Figure 2.
- (b) Multiple subsurface parallel planar flaws shall be combined into a single flaw, if the distance between adjacent flaws meets the criteria in 5 (a).
- (c) The dimensions  $a$  and  $\ell$  of the combined flaws shall be those of the square or rectangle that contains the detected area of all flaws within the proximity limits defined in 5 (a), as shown in Figure 3.
- (d) Combination of multiple subsurface parallel planar flaws is not required for fatigue crack growth assessment.

**4 Flaw Orientation**

- (a) Subsurface planar flaws that do not lie in a plane perpendicular to the direction of the maximum principal stresses shall be projected into that plane, following the requirements of IWA-3340.
- (b) This projection of flaws into a plane leads to a Mode I loading condition, as shown in Figure 4.

**5 Proximity Limit Criteria**

- (a) Multiple adjacent subsurface planar flaws shall be combined into a single flaw, if all three of the following proximity criteria below are met, as shown in Figure 2.

(1)  $S_x < \min(2d_{1\text{-eq}}, 2d_{2\text{-eq}})$

(2)  $S_y < \min(2d_{1\text{-eq}}, 2d_{2\text{-eq}})$

(3)  $H < \min(2d_{1\text{-eq}}, 2d_{2\text{-eq}})$

where  $d_{i\text{-eq}} = d_i / [E(k)]^2$ ,  $E(k)$  is the complete elliptical integral of the 2<sup>nd</sup> kind of eccentricity  $k$ ,

for  $2d_i/L_i \leq 1$ ,  $[E(k)]^2 = 1 + 1.464(2d_i/L_i)^{1.65}$

for  $2d_i/L_i > 1$ ,  $[E(k)]^2 = 1 + 1.464(L_i/2d_i)^{1.65}$

$2d_i$  and  $L_i$  being the depth and length of the flaw  $i$ , as shown in Figure ~~1~~2.

- (b) For multiple subsurface planar flaws that do not lie in a plane perpendicular to the maximum principal stress direction, the distance  $H$  shall be determined using the projection of those flaws given in 4 (a), as shown in Figure 4.

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- (c) If multiple flaws exist, each flaw shall be evaluated for its interaction with each adjacent flaw on an individual flaw basis, using the original flaw dimensions. If two or more flaws are combined by the proximity rules, it is not required to consider further interactions based on the dimensions of the combined flaw with other flaws.

**6 Assessment of Combined Flaws**

- (a) A combined flaw shall be characterized as a single elliptical flaw with dimensions  $a$  and  $\ell$  of the square or rectangle that contains the area of all flaws within the proximity limits defined in 5 (a), as shown in Figure 3.
- (b) A combined flaw of subsurface planar flaws remains a subsurface planar flaw.

Figure 1  
Planar flaws oriented in plane normal to pressure-retaining surface

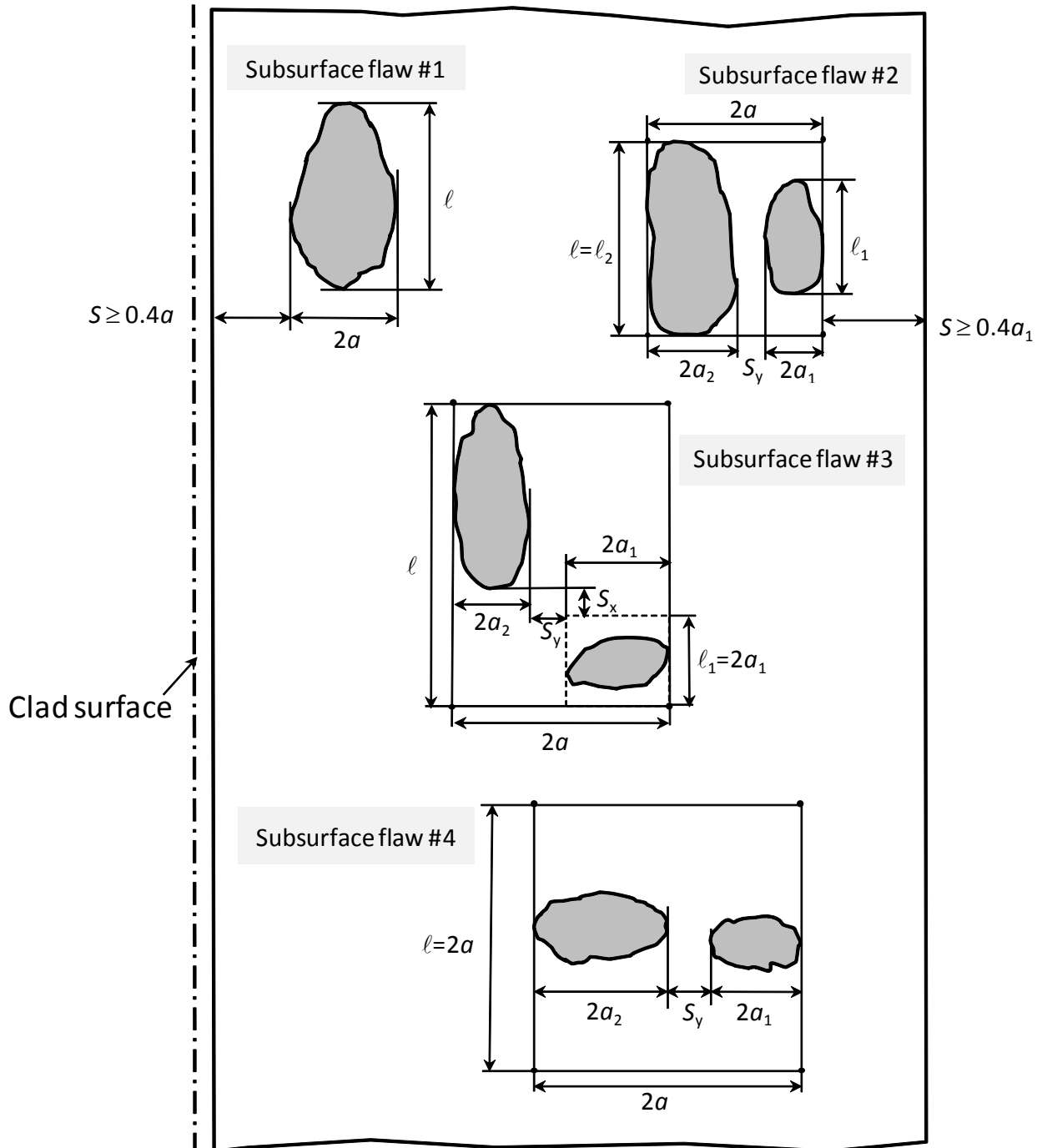


Figure 2  
Planar flaws perpendicular to maximum principal stress, on multiple planes

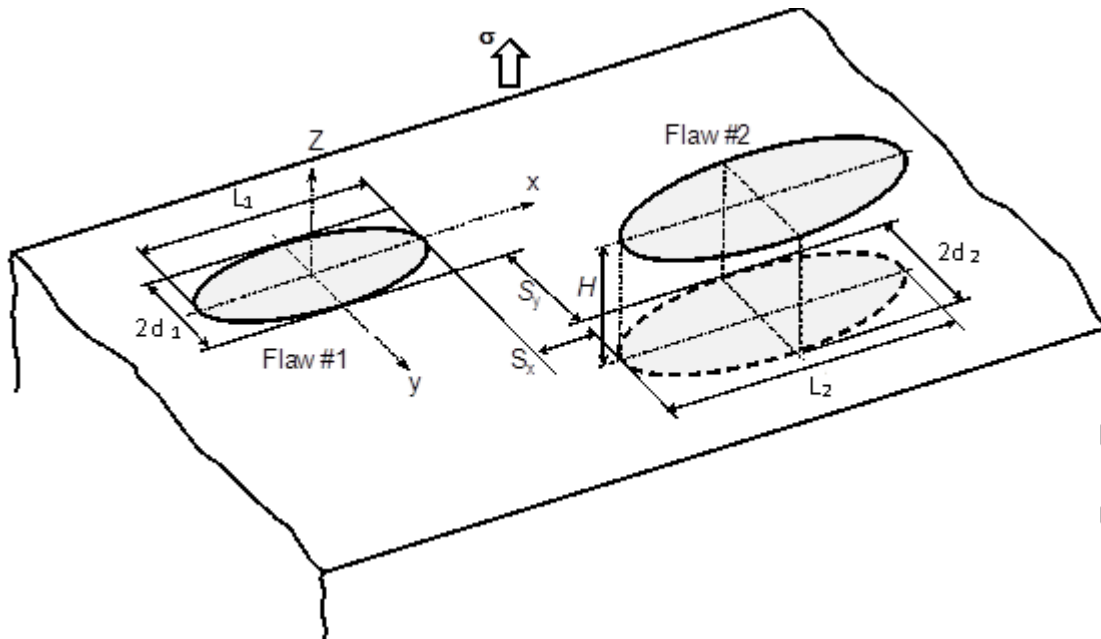
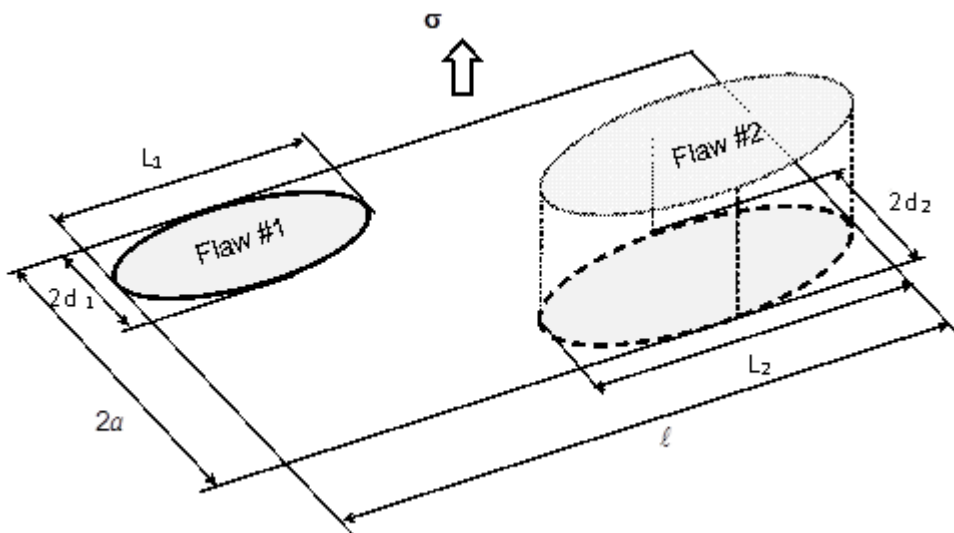


Figure 3  
Rectangle giving depth  $2a$  and length  $\ell$  for combined flaw



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Figure 4  
Planar flaws in arbitrary planes

