KF-826.1 Contact Between Layers The following requirements shall be satisfied.

The locations of these additional spots shall be determined by the Inspector or Manufacturer as provided for in the original spot examination.

(c) If either of the two additional spots examined shows welding which does not comply with the minimum quality requirements of the applicable paragraphs of Article KE-3, the entire unit of weld represented shall be rejected. The entire rejected weld shall be removed and the joint shall be rewelded or, at the Manufacturer’s option, the entire unit of weld represented shall be completely examined and defective welding only need be corrected.

(d) Repair welding shall be performed using a qualified procedure and in a manner acceptable to the Inspector. The rewelded joint or the weld repaired areas shall be random spot examined at one location in accordance with the requirements of KF-825.3(a) and KF-825.3(c).

KF-826 GAPS BETWEEN LAYERS

(a) After weld preparation and before welding circumferential seams, the height of the radial gaps between any two adjacent layers shall be measured at the ends of the layered shell section or layered head section at right angles to the vessel axis, and also the length of the relevant radial gap in inches shall be measured, neglecting radial gaps of less than 0.010 in. (0.25 mm) as nonrelevant. An approximation of the area of the gap shall be calculated as indicated in Figure KF-826.

(b) In the case of layered spheres or layered heads, if the gaps cannot be measured as required in (a), measurement of gap heights shall be taken through vent holes (see KF-824) in each layer course to ensure that the height of gaps between any two layers does not exceed the gap permitted in (c). The spacing of the vent holes shall be such that gap lengths can be determined. In the event an excessive gap height is measured through a vent hole, additional vent holes shall be drilled as required to determine the gap length. There shall be at least two vent holes per layer segment.

(c) The maximum number and size of gaps permitted in any cross section of a layered vessel shall be limited by the most stringent conditions given in (d) through (f).

(1) Maximum gap between any two layers shall not exceed the value of \( h \) given by eq. (1) or \( \frac{3}{16} \) in. (5 mm), whichever is less:

\[
h = 0.05\left(2.5 - \frac{P}{0.67S_yR_g} - \frac{0.67S_yR_g}{E}\right)
\]

\[\text{where}\]

- \( E \) = modulus of elasticity, ksi (MPa)
- \( h \) = gap between any two layers, in. (mm)
- \( P \) = design pressure, ksi (MPa)
- \( R_g \) = outside radius of layer above which the gap is located, in. (mm)
- \( S_y \) = yield stress at design temperature, ksi (MPa)

(2) Maximum permissible number of gaps and their corresponding arc lengths at any cross section of a layered vessel shall be calculated as follows. Measure each gap and its corresponding length throughout the cross section, \( h \) and \( b \); then calculate the value of \( F \) for each of the gaps using eq. (2):

\[
F = 0.0109 \frac{b h}{R_g}
\]

\[\text{where}\]

- \( b \) = length of gap, in. (mm)
- \( F \) = gap value (dimensionless)
- \( h \) = gap between any two layers, in. (mm)
KF-827 CIRCUMFERENTIAL EXPANSION DURING HYDROTEST

The following measurements shall be taken at the time of the hydrostatic test to check on the contact between successive layers, and the effect of gaps which may or may not be present between layers:

(a) The circumference shall be measured at the mid-point between adjacent circumferential joints, or between a circumferential joint and any nozzle in a shell course. Two sets of measurements are to be taken. The first is to be taken at zero pressure prior to hydrotest. The second set is to be taken during the hydrotest (see KT-330). After the hydrotest pressure has been successfully maintained for a minimum of 5 min, the measurements shall be made while the hydrotest pressure is maintained. The difference in measurements shall be averaged for each course in the vessel and the results recorded as average middle circumferential expansion \( e_m \) in inches.

(b) The theoretical circumferential expansion \( e_{th} \) of a solid vessel shall be calculated in accordance with KD-822.

KF-830 HEAT TREATMENT OF WELDMENTS

(c) Acceptance criteria for circumferential expansion at the hydrotest pressure shall be in accordance with KD-822.

(d) All measured data from (a), (b), and (c) shall be documented and reported to the Designer who signs the Manufacturer's Design Report.

KF-826.3 be evaluated in accordance with KF-826.3

Separate Sheet 1
KF-826.2 Evaluation For Maximum Gap The maximum gap between any layers based on number of design cycles shall be evaluated as follows:

(a) The longitudinal stress of the shell and the bending stress due to pressure and the gap can be calculated respectively as:

\[
\sigma_{ml} = \frac{R_i^2}{R_o^2 - R_i^2} P \tag{2}
\]

\[
\sigma_{bl} = \frac{1.812Eh}{R_g} \tag{3}
\]

\(\sigma_{ml}\) and \(\sigma_{bl}\) may be obtained by analysis using analysis model with maximum gap.

(b) The maximum gap shall be evaluated in accordance with KD-340. The allowable cycle for maximum gap and design pressure shall be equal to or greater than design cycle.

Where,
- \(E\) = modulus of elasticity, ksi (MPa)
- \(h\) = maximum gap between any two layers, in (mm)
- \(P\) = design pressure, ksi (MPa)
- \(R_g\) = outside radius of layer above which the gap is indicated, in (mm)
- \(R_i\) = inside diameter, in (mm)
- \(R_O\) = outside diameter, in (mm)
- \(\sigma_{bl}\) = longitudinal bending stress due to gap between any two layers, in (mm)
- \(\sigma_{ml}\) = longitudinal membrane stress due to pressure, ksi (MPa)

KF-826.3 Evaluation For Maximum Permissible Number Of Circumferential Gaps The maximum permissible number of circumferential gaps and their corresponding lengths due to pressure can be evaluated as follows:

(a) The circumferential stress of the cylindrical shell due to pressure and gaps can be calculated as follows:

\[
\sigma_{tp} = \frac{R_o^2}{R_o^2 - R_i^2} P \tag{4}
\]

\[
\sigma_{tg} = \frac{E}{1 - v^2} \Sigma F \tag{5}
\]

\(\sigma_{tp}\) and \(\sigma_{tg}\) may be obtained by analysis using analysis model with maximum permissible number of circumferential gaps.

(b) \(\sigma_{tg}\) shall be satisfied as follow:

\[
\sigma_{tg} \leq (\Delta \sigma N - \sigma_{tp}) \tag{6}
\]
Where,

\[ E \quad = \quad \text{modulus of elasticity, ksi (MPa)} \]
\[ P \quad = \quad \text{design pressure} \]
\[ R_i \quad = \quad \text{inside diameter, in (mm)} \]
\[ R_O \quad = \quad \text{outside diameter, in (mm)} \]
\[ \Delta \sigma_N \quad = \quad \text{structural stress range corresponding to design cycle per KD-340} \]
\[ \nu \quad = \quad \text{poisson's ratio} \]
\[ \Sigma F \quad = \quad \text{total sum of the value of } F \text{ (all of the accumulated gap strain, see KF-826.1 (c) (2))} \]
\[ \sigma_{tg} \quad = \quad \text{circumferential stress in a layer due to all the accumulated gap strains} \]
\[ \sigma_{tp} \quad = \quad \text{circumferential stress due to pressure} \]

The structural stress range \( \Delta \sigma_N \) corresponding to design cycle shall be obtained in accordance with KD-340.