(2) Service fluid for proprietary fluids specific properties needed for design, e.g., gas, liquid, density, etc.

(c) Vessel Configuration and Controlling Dimensions

(1) Outline drawings
(2) Vertical or horizontal
(3) Openings, connections, closures including quantity, type and size, and location (i.e., elevation and orientation)
(4) Principal component dimensions in sufficient detail so that volume capacities can be determined
(5) Support method

(d) Design Conditions

(1) Specified design pressure. The specified design pressure is the design pressure, see 4.1.5.2(a), required at the top of the vessel in its operating position. It shall include suitable margins required above the maximum anticipated operating pressure to ensure proper operation of the pressure relief devices. The MAWP of the vessel may be set equal to this specified design pressure. If the actual MAWP of the vessel is calculated, it shall not be less than the specified design pressure.

(2) Design temperature and coincident specified design pressure (see 4.1.5.2(d)).

(3) Minimum Design Metal Temperature (MDMT) and coincident specified design pressure (see 4.1.5.2(e)).

(4) Dead loads, live loads, and other loads required to perform the load case combinations required in Parts 4 and 5.

(e) Operating Conditions

(1) Operating pressure and pressure load factor for occasional load combinations in Tables 4.1.2 and 5.3
(2) Operating temperature
(3) Fluid transients and flow and sufficient properties for determination of steady-state and transient thermal gradients across the vessel sections, if applicable (see 5.5.2)

(4) Dead loads, live loads, and other operating loads required to perform the load case combinations required in Part 5

(f) Design Fatigue Life

(1) Cyclic operating conditions and whether or not a fatigue analysis of the vessel as required shall be determined in accordance with 4.1.1.4. When a fatigue analysis is required, provide information in sufficient detail so that an analysis of the cyclic operation can be carried out in accordance with 5.5.

(2) When a vessel is designed for cyclic conditions, the number of design cycles per year and the required vessel design life in years shall be stated.

(3) When cyclic operating conditions exist and a fatigue analysis is not required based on comparable equipment experience, this shall be stated. The possible harmful effects of the design features listed in 5.5.2.2(a) through 5.5.2.2(f) shall be evaluated when contemplating comparable equipment experience.

(4) Corrosion Fatigue

(-a) The design fatigue cycles given by eqs. (3-F.1) and (3-F.4) do not include any allowances for corrosive conditions and may be modified to account for the effects of environment other than ambient air that may cause corrosion or subcritical crack propagation. If corrosion fatigue is anticipated, a factor should be chosen on the basis of experience or testing, by which the calculated design fatigue cycles (fatigue strength) should be reduced to compensate for the corrosion.

(-b) When using eq. (3-F.4), an environmental modification factor shall be specified in the User’s Design Specification.

(-c) If due to lack of experience it is not certain that the chosen stresses are low enough, it is advisable that the frequency of inspection be increased until there is sufficient experience to justify the factor used. This need for increased frequency should be stated in the User’s Design Specification.

(g) Materials of Construction

(1) Material specification requirements shall be in accordance with one or more of the following criteria.

(-a) Specification of materials of construction in accordance with Part 3.

(-b) Generic material type (i.e., carbon steel or Type 304 Stainless Steel). The user shall specify requirements that provide an adequate basis for selecting materials to be used for the construction of the vessel. The Manufacturer shall select the appropriate material from Part 3, considering information provided by the user per (3).

(2) The user shall specify the corrosion and/or erosion allowance.

(3) The user, when selecting the materials of construction, shall consider the following:

(-a) Damage mechanisms associated with the service fluid at design conditions. Informative and nonmandatory guidance regarding metallurgical phenomena is provided in Section II, Part D, Nonmandatory Appendix A; API RP 571; and WRC Bulletins 488, 489, and 490.

(-b) Minimum Design Metal Temperature and any additional toughness requirements.

(-c) The need for specific weld filler material to meet corrosion resistance requirements, see 6.2.5.8.
ANNEX 3-F
DESIGN FATIGUE CURVES

(Normative)

3-F.1 SMOOTH BAR DESIGN FATIGUE CURVES

3-F.1.1

Fatigue analysis performed through direct interpretation of the smooth bar fatigue curves found in 3-F.5 requires the calculated stress amplitude, \( S_a \), be corrected for temperature by the ratio of the modulus of elasticity of the given fatigue curve to the value used in the analysis. The equations used to correct \( S_a \) for the temperature effect based upon the different material fatigue curves are provided in Table 3-F.1. The temperature-corrected stress amplitude, \( S_{a,c} \), is then used to enter the smooth bar fatigue curves to determine the number of allowable cycles, \( N \).

NOTES:

(1) For Carbon, Low Alloy, Series 4XX, High Alloy, and High Tensile Strength Steels for temperatures not exceeding 371°C (700°F), the fatigue curve values may be interpolated for intermediate values of the ultimate tensile strength.

(2) For Wrought 70–30 Copper–Nickel for temperatures not exceeding 371°C (700°F), the fatigue curve values may be interpolated for intermediate values of the minimum specified yield strength.

3-F.1.2

Fatigue analysis performed using smooth bar fatigue curve models in equation form is provided below. The fatigue curves and the associated equations for different materials are also shown below.

\( (a) \) Carbon, Low Alloy, Series 4XX, High Alloy, and High Tensile Strength Steels for temperatures not exceeding 371°C (700°F). The fatigue curve values may be interpolated for intermediate values of the ultimate tensile strength.

\[
Y = \log \left( \frac{28.3 \times 10^4 \left( \frac{S_a}{E} \right)}{Y} \right)
\] (3-F.1)

\( (1) \) For \( \sigma_{uts} \leq 552 \) MPa (80 ksi) (see Figures 3-F.1M and 3-F.1) and for 48 MPa (7 ksi) \( \leq S_a \leq 3999 \) MPa (580 ksi)

\[
X = \frac{4706.5245 + 1813.6228Y + \frac{6785.5644}{Y} - 368.12404Y^2 - \frac{5133.7345}{Y^2} + 30.708204Y^3 + \frac{1596.1916}{Y^3}}{1 + 1.802247Y^2 - 4.689047Y^4 + 2.26536Y^6}
\] for \( 10^Y \leq 20 \) (3-F.2)

\[
X = \frac{38.1309 - 60.1705Y^2 + 25.0352Y^4 - 1.05987Y^6}{1.0 + 1.802247Y^2 - 4.689047Y^4 + 2.26536Y^6}
\] for \( 10^Y \leq 20 \) (3-F.3)

\( (2) \) For \( \sigma_{uts} = 793 \) MPa to 892 MPa (115 ksi to 130 ksi) (see Figures 3-F.2M and 3-F.2) and for 77.2 MPa (11.2 ksi) \( \leq S_a \leq 2896 \) MPa (420 ksi)

\[
X = \frac{5.37689 - 5.25401Y + 1.14427Y^2}{1 - 0.960816Y + 0.291399Y^2 - 0.0562968Y^3}
\] for \( 10^Y \geq 43 \) (3-F.4)

\[
X = \frac{-9.41749 + 14.7982Y - 5.941Y^2}{1 - 3.4628Y + 3.63495Y^2 - 1.21849Y^3}
\] for \( 10^Y < 43 \) (3-F.5)

\( (b) \) Series 3XX High Alloy Steels, Nickel–Chromium–Iron Alloy, Nickel–Iron–Chromium Alloy, and Nickel–Copper Alloy for temperatures not exceeding 427°C (800°F) (see Figures 3-F.3M and 3-F.3) and for 93.7 MPa (13.6 ksi) \( \leq S_a \leq 6000 \) MPa (870 ksi)
(2) For a maximum nominal stress \( > 2.75 S_M \) (see Figures 3-F.9M and 3-F.9) and for \( 37 \) MPa (5.3 ksi) ≤ \( S_o \) ≤ 7 929 MPa (1,150 ksi)

\[
X = - 9.0006161 + \frac{51.928295}{\gamma} - \frac{86.121576}{\gamma^2} + \frac{73.1573}{\gamma^3} - \frac{29.945507}{\gamma^4} + \frac{4.7332046}{\gamma^5}
\]  
(3-F.20)

3-F.1.3

The design number of design cycles, \( N \), can be computed from eq. (3-F.21) based on the parameter \( X \) calculated for the applicable material.

\[
N = 10^X
\]  
(3-F.21)

3-F.2  WELDED JOINT DESIGN FATIGUE CURVES

3-F.2.1

Subject to the limitations of 5.5.5, the welded joint design fatigue curves in 3-F.5 can be used to evaluate welded joints for the following materials and associated temperature limits:

(a) Carbon, Low Alloy, Series 4XX, High Alloy, and High Tensile Strength Steels for temperatures not exceeding 371°C (700°F)

(b) Series 3XX High Alloy Steels, Nickel– Chromium– Iron Alloy, Nickel– Iron– Chromium Alloy, and Nickel– Copper Alloy for temperatures not exceeding 427°C (800°F)

(c) Wrought 70 Copper– Nickel for temperatures not exceeding 371°C (700°F)

(d) Nickel– Chromium– Molybdenum– Iron, Alloys X, G, C-4, and C-276 for temperatures not exceeding 427°C (800°F)

(e) Aluminum Alloys

3-F.2.2

The number of allowable design cycles for the welded joint fatigue curve shall be computed as follows.

(a) The design number of allowable design cycles, \( N \), can be computed from eq. (3-F.22) based on the equivalent structural stress range parameter, \( \Delta S_{ess,k} \), determined in accordance with 5.5.5 of this Division. The constants \( C \) and \( h \) for use in eq. (3-F.22) are provided in Table 3-F.2. The lower 99% Prediction Interval (−3\( \sigma \)) shall be used for design unless otherwise agreed to by the Owner-User and the Manufacturer.

\[
N = \frac{f_j}{f_p} \left( \frac{C}{\Delta S_{ess,k}} \right)^\frac{1}{h}
\]  
(3-F.22)

(b) If a fatigue improvement method is performed that exceeds the fabrication requirements of this Division, then a fatigue improvement factor, \( f_I \), may be applied. The fatigue improvement factors shown below may be used. An alternative factor determined may also be used if agreed to by the user or user’s designated agent and the Manufacturer.

(1) For burr grinding in accordance with Figure 6.2

\[
f_I = 1.0 + 2.5 \cdot (10)^q
\]  
(3-F.23)

(2) For TIG dressing

\[
f_I = 1.0 + 2.5 \cdot (10)^q
\]  
(3-F.24)

(3) For hammer peening

\[
f_I = 1.0 + 4.0 \cdot (10)^q
\]  
(3-F.25)

In the above equations, the parameter is given by the following equation:

\[
q = -0.0016 \left( \frac{\Delta S_{ess,k}}{C_{500}} \right)^{1.6}
\]  
(3-F.26)