shall consider the need to prevent fractures during installation. See paras. 434.8.5 and A434.8.5.

(e) Design Against Loss of In-Place Stability. Design against loss of in-place stability shall be in accordance with the provisions of para. A402.3.5(e), except that the installation design wave and current conditions shall be based upon the provisions of para. A401.9.3. If the pipeline is to be trenched, it shall be designed for stability during the period prior to trenching.

(f) Impact. During the period when the pipe is susceptible to impact damage during installation and testing, consideration shall be given to impacts due to

(1) anchors
(2) trawl boards
(3) vessels
(4) ice keels
(5) other foreign objects

(g) Residual Stresses. The pipeline system shall normally be installed in a manner so as to minimize residual stresses. The exception shall be when the designer purposefully plans for residual stresses (e.g., reeled pipe, cold springing of risers, pull-tube risers).

(h) Flexible Pipe. The manufacturer's recommended installation procedures should be adhered to during installation. Flexible pipe shall be designed or selected to prevent failure due to the combined effects of external pressure, internal pressure, torsional forces, axial forces, and bending. (See API RP 17B.)

A402.3.5 Strength Criteria During Operations

(a) Allowable Stress Values. Allowable stress values for steel pipe during operation shall not exceed those calculated by the equations in paras. A402.3.5(a)(1) through (3).

(1) Hoop Stress. For offshore pipeline systems, the tensile hoop stress due to the difference between internal and external pressures shall not exceed the values given below, in eq. (1).

\[ S_h = (P_i - P_e) \frac{D}{2t} \]  

(1)

where
\[ D = \text{nominal outside diameter of pipe, in. (mm)} \]
\[ F_1 = \text{hoop stress design factor from Table A402.3.5-1} \]
\[ P_e = \text{external pressure, psig (bar)} \]
\[ P_i = \text{internal design pressure, psig (bar)} \]
\[ S_h = \text{hoop stress, psi (MPa)} \]
\[ t = \text{nominal wall thickness, in. (mm)} \]

\[ S_h \leq F_1(S_h) \]

(2) Longitudinal Stress. For offshore pipeline systems, the longitudinal stress shall not exceed values found from

\[ |S_L| \leq F_3(S_p) \]

where
\[ A = \text{cross-sectional area of pipe material, in}^2 \text{ (mm}^2) \]
\[ F_a = \text{axial force, lb (N)} \]
\[ F_2 = \text{longitudinal stress design factor from Table A402.3.5-1} \]
\[ F_3 = \text{combined stress design factor from Table A402.3.5-1} \]
\[ i_i = \text{in-plane stress intensification factor from Table 402.1-1} \]
\[ i_o = \text{out-of-plane stress intensification factor from Table 402.1-1} \]
\[ M_i = \text{in-plane bending moment, in.-lb (N-m)} \]
\[ M_o = \text{out-of-plane bending moment, in.-lb (N-m)} \]
\[ S_a = \text{axial stress, psi (positive tensile or negative compressive) (MPa)} \]
\[ S_a = \frac{F_a}{A} \]
\[ S_b = \text{maximum resultant bending stress, psi (MPa)} \]
\[ S_a = \text{maximum longitudinal stress, psi (positive tensile or negative compressive) (MPa)} \]
\[ S_a = S_a + S_b \text{ or } S_a - S_b, \text{ whichever results in the larger stress value} \]
\[ S_a = \text{specified minimum yield strength, psi (MPa)} \]
\[ Z = \text{section modulus of the pipe, in}^3 \text{ (cm}^3) \]
\[ |F_3| \leq \text{absolute value} \]

(3) Combined Stress. For offshore pipeline systems, the combined stress shall not exceed the value given by the Maximum Shear Stress Equation (Tresca Combined Stress)

\[ 2 \left[ \frac{(S_L - S_h)^2}{2} + S_s^2 \right] \leq F_3(S_p) \]

where
\[ A = \text{pipe cross-sectional area, in}^2 \text{ (mm}^2) \]
\[ F_a = \text{axial force, lb (N)} \]
\[ F_3 = \text{combined stress design factor from Table A402.3.5-1} \]
\[ i_i = \text{in-plane stress intensification factor from Table 402.1-1} \]
\[ i_o = \text{out-of-plane stress intensification factor from Table 402.1-1} \]