This technical report is the result of the evaluation of the load carrying capacity of API 6A integral flanges, including the end tension and bending moment in addition to the conventional rated pressure and makeup forces. The effect of a temperature difference corresponding to 250 °F on the inside and 30 °F on the outside is also evaluated. Three-dimensional finite element meshes are generated for the Type 6B, and Type 6BX flanges. The computer program SESAM is used to obtain the stresses at selected critical flange and hub sections and to determine the gasket reaction due to each of the four unit load cases and the temperature difference load case. The leakage criterion is defined as the load combination with reduces the initial makeup compressive forces in the gasket to zero. The stresses in each defined section are linearized in accordance with the ASME Section VIII, Division 2, procedure to determine the membrane and membrane-plus-bending stress intensities. The stress intensities are checked against the allowable conditions specified in Spec 6A.
11 Maximum Shear Stress Contours Due to Unit Makeup ........................................... 13
12 Maximum Shear Stress Contours Due to Unit Pressure ........................................ 14
13 Maximum Shear Stress Contours Due to Unit Tension ......................................... 14
14 Maximum Shear Stress Contours Due to Unit Bending Moment .............................. 15
15 Von Mise’s Equivalent Stress Contours for 2 1/16 in. 3,000 psi Type 6B Flange Under 52.5 ksi Makeup and 6,000 psi Test Pressure .................................................. 15
16 Bolt Stress ($\sigma_z$) Contours for Unit Makeup ...................................................... 16
17 Bolt Stress ($\sigma_z$) Contours for Unit Pressure .................................................... 16
18 Bolt Stress ($\sigma_z$) Contours for Unit Tension ..................................................... 17
19 Bolt Stress ($\sigma_z$) Contours for Unit Bending Moment ...................................... 17
20 Typical Heat Conduction 2-D Mesh for Type 6BX Flanges .................................. 19
21 Typical Leakage Load Combination Charts for 52.5 ksi and 40 ksi Makeup Loads .......... 22
22 Stress Linearization ............................................................................................... 24
23 Critical Section Locations .................................................................................... 25
24 Comparison Between 2-D and 3-D Results for Leakage Criteria for 2 1/16 in. 3,000 psi 6B Flange ................................................................. 27
25 Comparison Between 2-D and 3-D Results for Leakage Criteria for 16 3/4 in. 3,000 psi 6B Flange ................................................................. 27
26 Stress Limiting Criteria for 2 1/16 in. 3,000 psi 6B Flange .................................. 28
27 Stress Limiting Criteria for 16 3/4 in. 3,000 psi 6B Flange .................................. 28
28 Leakage Criteria with Temperature Effect for 2 1/16 in. 3,000 psi 6B Flange ........... 29
29 Leakage Criteria with Temperature Effect for 16 3/4 in. 3,000 psi 6B Flange .......... 29
30 Stress Criterion with Temperature Effect for 2 1/16 in. 3,000 psi 6B Flange .......... 30
31 Stress Criterion with Temperature Effect for 16 3/4 in. 3,000 psi 6B Flange .......... 30
32 Bolt Stress Contours for 5 1/8 in. 10,000 psi Type 6BX Flange ............................. 32
33 Bolt Stress Contours for 11 in. 10,000 psi Type 6BX Flange ................................ 32
34 Finite Element Model of Flange with Lockdown Screw Holes ............................. 35
35 Effect of Lockdown Screw Holes on Leakage Charts ........................................... 36
36 Effect of Lockdown Screw Holes on Stress Charts .............................................. 37
A.1 Hopper Chart (from ASME Boiler and Pressure Vessel Code, Appendix 4) ................ 44