

List of Figures

1-1. Full-Length Pipe Run with Additional Valve Force	3
1-2. Two Pipe Runs with Addition of an Elbow and Valve Forces	3
1-3. Three Separate Pipe Runs with Addition of Pipe T Section	3
2-1. Differential Stress Element with Normal and Shear Stresses	8
2-2. Mohr's Circle Representation of Principle Stresses	9
2-3. Hoop and Longitudinal Stresses acting on a Differential Element	12
2-4. Relationship between use of Mohr's Circle with Hoop and Longitudinal Stresses	13
2-5. Stress Distribution Created by Torsion Acting on a Cross- Section of a Bar	14
2-6. A Cantilever Bar Subjected to Downward and Axial Forces	14
2-7. Effect of External Force Results in a Bending Moment	15
2-8. Design Fatigue Curve of Series 3XX Alloy Steel. Curve A is a Load-Based Curve, and Curve B is the Mean Adjusted Curve (adapted from Appendix 5, Section VIII, Figure 5-110.2.2 [12])	19
2-9. Example of Criteria Document "Best-Fit" Equation to Aluminum 1100 (stress data from NASA, Technical Note -157 [17])	21
2-10. Example of Least Squares to the Logarithms Best-Fit Equation to Aluminum 1100 (stress data from NASA, Technical Note-1574 [17])	22
2-11. Yield Stress Limitation on a Stress-Strain Diagram	23
2-12. Modified Goodman Diagram (adapted from Shigley and Mishke [4])	24
2-13. Design Fatigue Curve of Series 3XX Alloy Steel. Curve A is a Load-Based Curve, and Curve B is the Mean Adjusted Curve (adapted from Appendix 5, Section VIII, Figure 5-110.2.2 [12])	26
2-14. Fatigue Curve of Aluminum 6061-T6 with Mean Stress Adjustment, and S_{al} Divided by a Factor of 2, and Number of Cycles Divided by a Factor of 20 ..	27
3-1. Stress Amplitude versus Number of Cycles to Failure Curves (after Flinn and Trojan [18])	29
3-2. Schematic Illustrating Cyclic Loading Parameters (after Fuchs and Stephens [20]) ...	31
3-3. Mean Stress States Affect on Total Stress. (a) Zero Mean Stress, (b) Non-Zero Mean Stress (adapted from Dowling [22])	32
3-4. Effect of Mean Stress on Fatigue Life (after Fuchs and Stephens [20])	33

3-5. Rotating Bending Testing Machine (after Callister [21])	35
3-6. Rotating-Bending Machine Test Specimen (after Fuchs and Stephens [20])	35
3-7. Test Machine for Reciprocating Bending (after Collins [19])	36
3-8. Reciprocating Bending Machine Test Specimen (after Fuchs and Stephens [20])	37
3-9. Machine for Direct-Force Testing (after Collins [19])	37
3-10. Direct-Force Machine Test Specimen (after Fuchs and Stephens [20])	37
3-11. True Stress, True Strain Hysteresis Loop (adapted from Shigley and Mitchell [10])	38
3-12. Illustration of Cyclic Strain Hardening or Strain Softening (after Collins [19])	40
3-13. Second-Order Log-Log Linear Regression Curve Fit of Nickel 200 Fatigue Data, with R^2 Value	43
3-14. Fatigue Curve of Nickel 200, with Allowable Stress, S_a Divided by a Factor of 2, and Number of Cycles, N , Divided by a Factor of 20	44
3-15. Fatigue Curve of Aluminum 6061-T6 with Mean Stress Adjustment, and S_a Divided by a Factor of 2, and Number of Cycles Divided by a Factor of 20 ..	46
3-16. Order of Operations for Pipe-Wall Thickness within T_{min}	49
3-17. Continuation of Figure 3-15 of Order of Operations for Pipe-Wall Thickness within T_{min}	52
4-1. 2-D Vertical Pipe-Span. Showing Forces on Piping	55
4-2. Q_e Diagram of 2-D vertical piping span	56
4-3. Shear and Bending Moment Diagram of a 2-D Vertical Piping Span	58
4-4. Example Moment Diagram with Additions of SIF Values Showing Drastic Moment Values	60
4-5. Differential Elements Shown on Left-End of Piping Span Section	62
4-6. Differential Elements 1 (a) and 3 (b) on a Piping Span End	62
4-7. Differential Elements 2 (a) and 4 (b) on a Piping Span End	63
4-8. Mohr's Circle Analysis of Element (a) in Figure 4-5	63
4-9. Differential Elements Shown on Piping Span Section-Shear and Moment Loads ...	64
4-10. Differential Elements 2 (a) and 4 (b) on 2-Axis Vertical piping Span End	65
4-11. Mohr's Circle Analysis of Element (a) in Figure 4-10	65
4-12. Case (a) Shows Hoop Stress Dominant. Case (b) Shows the Bending and Longitudinal Stresses as Dominant	66
4-13. a) Vertical Piping Span, b) Axial Load Plot of Vertical Piping Segment	67
4-14. a) Vertical Piping Span, b) Axial Tension Plot of Vertical Piping Segment	68
4-15. Differential Elements with Compressive Forces and Moments on Vertical Segment	66

4-16. Differential Elements 1 (a) and 3 (b) on 2-D vertical piping Span End	71
4-17. Differential Elements 2 and 4 on a Vertical piping Span End	71
4-18. Stationary Endpoint of a Stress Equation for the False Position Method	74
5-1. File Drop-Down Menu Additions	77
5-2. Input Form of T_{min} Showing Command Buttons	78
5-3. Save As Input Box for Saving Previous Piping	79
5-4. Help Button in an Input Box	80
5-5. Help Pop-Up Window Example	80
5-6. Piping-Span Input Form in T_{min}	81
5-7. 2-D vertical piping span Form	83
5-8. Input Box for Obtaining Pipe-Span Lengths	84
5-9. Input Box for a Valve in the Span Length	84
5-10. Valve Connection Form	85
5-11. Example Span with an Additional Weight	85
5-12. Critical-Piping Section Marked in Red on 2-D vertical piping span	86
6-1. Example One. Piping Diagram used for the Basic Configuration Analysis	90
6-2. Shear and Bending Moment Diagram for 2-D Vertical Piping Span for Figure 6-1	91
6-3. Example 1. Output tab for Final Pipe-Wall Thickness Values	98
6-4. Example 1. Final Output Screen Showing Critical Piping Section	99
6-5. Example 2. Vertical Piping Span with Valve in Upper Span	100
6-6. Close-Up of Zero Shear Crossing Point	101
6-7. Second Example Output Tab for Final Pipe-Wall Thickness Values.....	105
6-8. Second Example Output Screen for 2-D vertical piping span Analysis	106