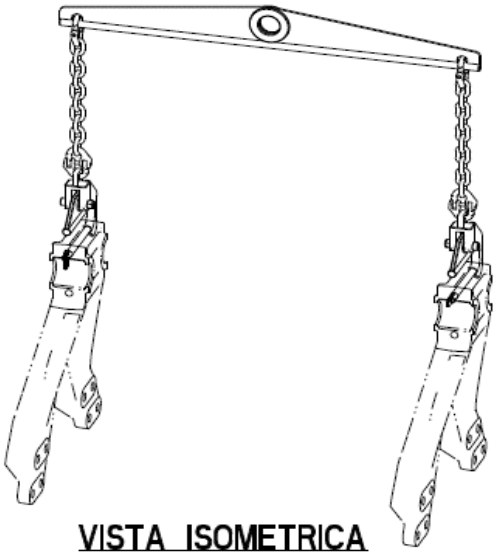
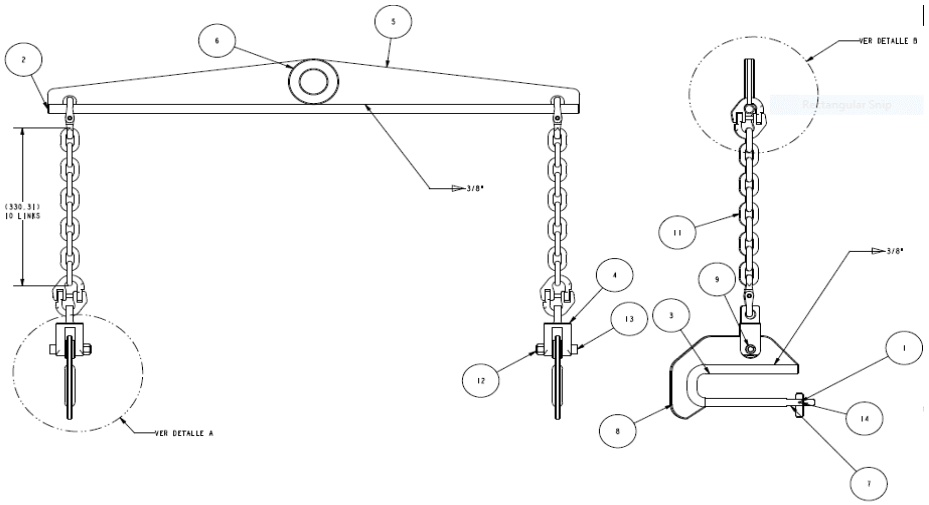
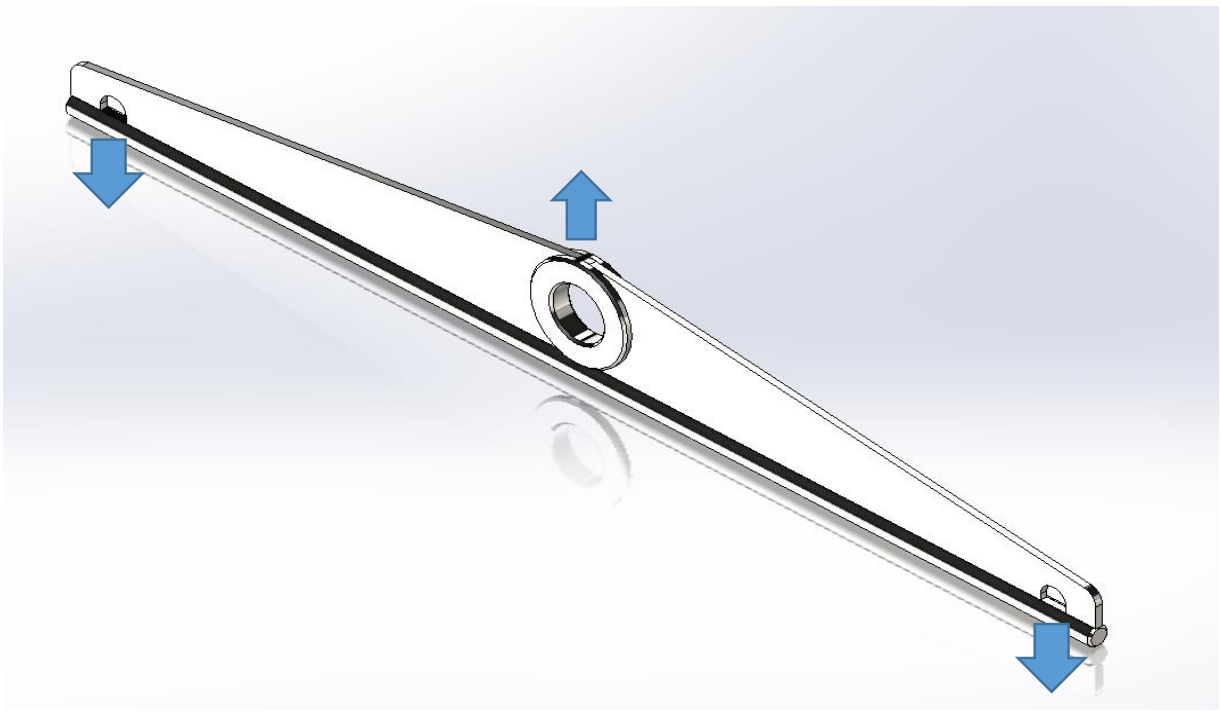
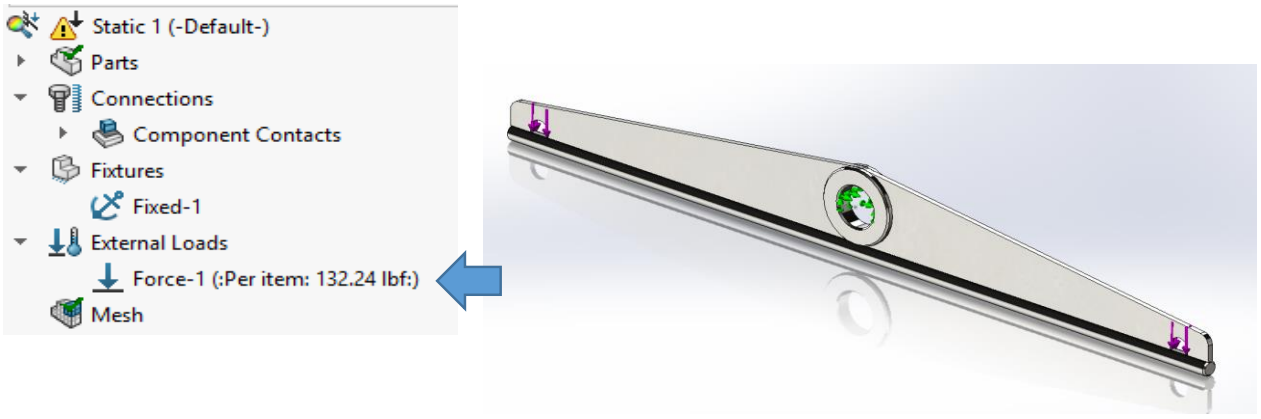
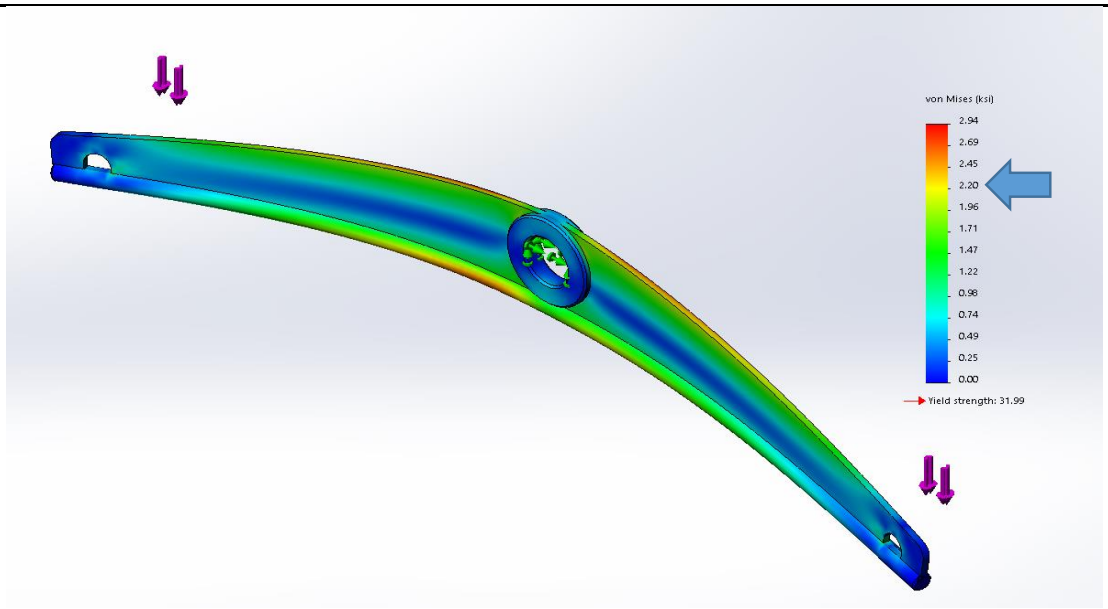
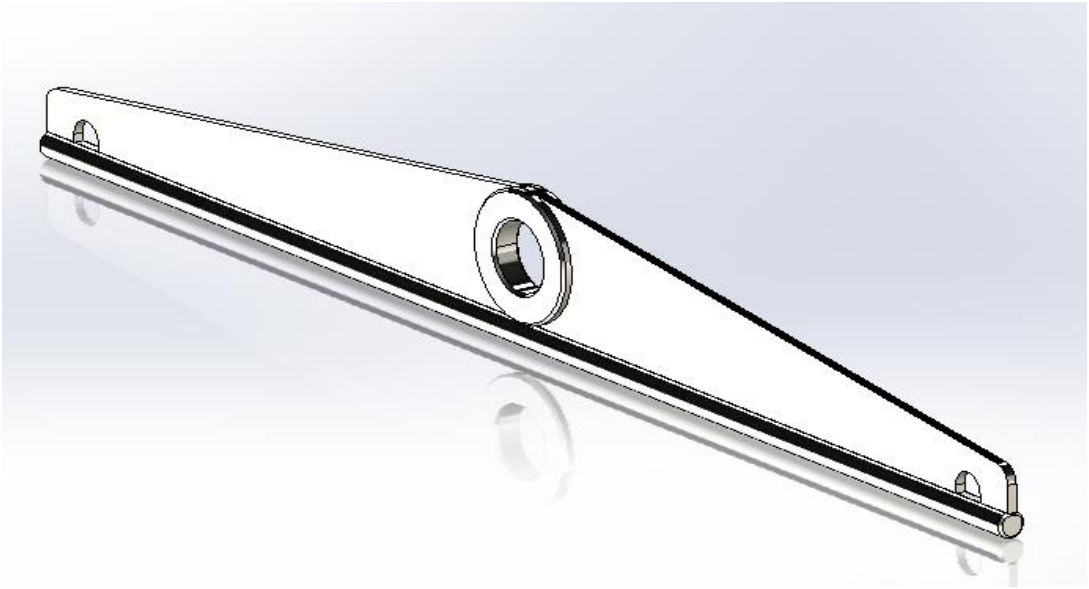
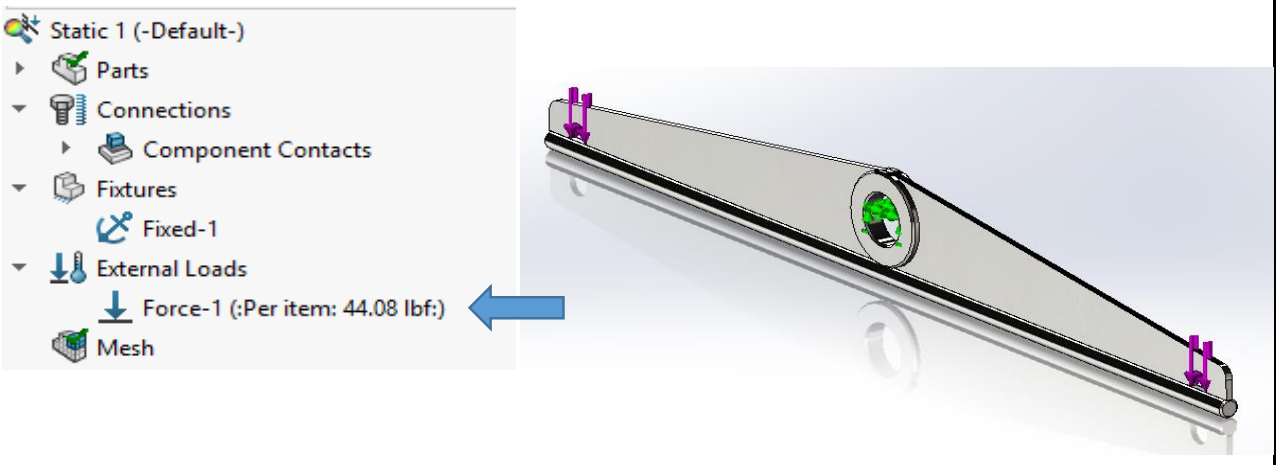
1	**Structural Calculations for DL-223 (LIFTING DEVICE FOR HANGERS)**
2	**Summary of Analysis: Lifting Device is rated for 40 kg (88.2 lbs), Service Class 3**
3	**CERTIFICACION** DISPOSITIVO DE LEVANTE PARA PERCHAS ALTA: No. HERRAMIENTA: **DL-223** PESO: 15 KG CAPACIDAD: 40 KG PRUEBA: 50 KG LOCACION: BASTIDORES CATEGORIA **B** SERVICIO **3**
4	 VISTA ISOMETRICA ESCALA 1:10
5	Basis of Analysis: The overall lifting device is analyzed using Solidworks simulation. The McMaster Carr items have rated loads.

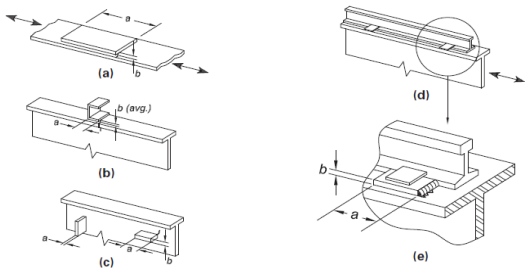
6	**Drawing of Lifting Device**		
7			
8	Code Reference: ASME BTH-1-2017, Below the Hook Lifting Devices; issued March 15, 2017		
9	Service Class	3	Per Drawing
10	**Table 2-3-1 Service Class** Service Class / Load Cycles 0 — 0–20,000 1 — 20,001–100,000 2 — 100,001–500,000 3 — 500,001–2,000,000 ⟵ 4 — Over 2,000,000		
11	Design Category	B	Lifters shall be designed to Design Category B, unless a qualified person determines that Design Category A is appropriate or that Design Category C is required for a special application.
12	Nominal Design Factor, N_d	3	Safety Factor for Static Strength Design
13	Nominal Design Factor, N_{dd}	3.6	The Safety Factor for Connections
14	Design Factor = the ratio of the limit state stress (es) or strength of an element to the permissible internal stress (es) or forces created by the external force (s) that act upon the element. (section 1-2).		

15	**3-1.3 Static Design Basis** (17) **3-1.3.1 Nominal Design Factors.** The static strength design of a below-the-hook lifting device shall be based on the allowable stresses defined in sections 3-2 and 3-3. The minimum values of the nominal design factor, N_d, in the allowable stress equations shall be as follows: N_d = 2.00 for Design Category A lifters = 3.00 for Design Category B lifters = 6.00 for Design Category C lifters		
16	*(b)* Design factors for Design Category B lifting devices shall be not less than 3.00 for limit states of yielding or buckling and 3.60 for limit states of fracture and for connection design.		
17	Job Load, J_{load} (kg)	40	Weight lifted by device (defined by client on drawings)
18	Job Load, J_{load} (lbs)	88.2	J_{load} x 2.2 lbs/kg
19	Using Solidworks, a model is created of the top lifting plate		
20			
21	Rated Force on Upper Connection Point, F (lbs)	88.2	Job Load
22	Design factor, Df	3	For Structure
23	Applied Force, AF (lbs)	264.48	F x Df
24	Applied Force per Load Point Aft, (lbs)	132.24	AF/2

25	Apply the load to the Model using Solidworks Simulation		
26			
27	Run the Model		
28			
29	Max Von Mises Stress, Fm (ksi)	2.20	See above
30	Yield Strength of Material, Fy (ksi)	36.30	Mild Steel; assume A36 as worst case mild steel
31	Safety Factor	16.50	Fy/Fm = 1 OK

32	**Fatigue Analysis**		
33	Worst case is the top of the lifting device. (shown in solidworks simulation above). See Fatigue Stress Categories below (Ref. Table 3-4.4.1, ASME BTH-1-2017):		
34			
35	Max Rated Load, W_{max} (lbs)	88.2	***Assumed loading 100% of time***
36	Max Rated Lift Point Load, W_{mc} (lbs)	44.08	$W_{max}/2$
37	See Fatigue Stress Categories below (Ref. Table 3-4.4.1, ASME BTH-1-2017):		
38			

39	

Description	Stress Category	Constant, C_f	Threshold, F_{TH}, ksi (MPa)	Potential Crack Site Initiation	Illustrative Typical Examples
Section 7 — Base Metal at Short Attachments [Note (1)]					
7.1 Base metal subject to longitudinal loading at details with welds parallel or transverse to the direction of stress where the detail embodies no transition radius and with detail length in direction of stress, a, and thickness of attachment, b:				Initiating in base metal at the weld termination or at the toe of the weld extending into the base metal	
a < 2 in. (50 mm)	C	44×10^8	10 (69)		
2 in. (50 mm) ≤ a ≤ lesser of 12b or 4 in. (100 mm)	D	22×10^8	7 (48)		
a > 12b or 4 in. (100 mm), when b ≤ 1 in. (25 mm)	E	11×10^8	4.5 (31)		
a > lesser of 12b or 4 in. (100 mm), when b > 1 in. (25 mm)	E′	3.9×10^8	2.6 (18)		

40	Service Class	3	Per drawing
41			

Table 2-3-1 Service Class

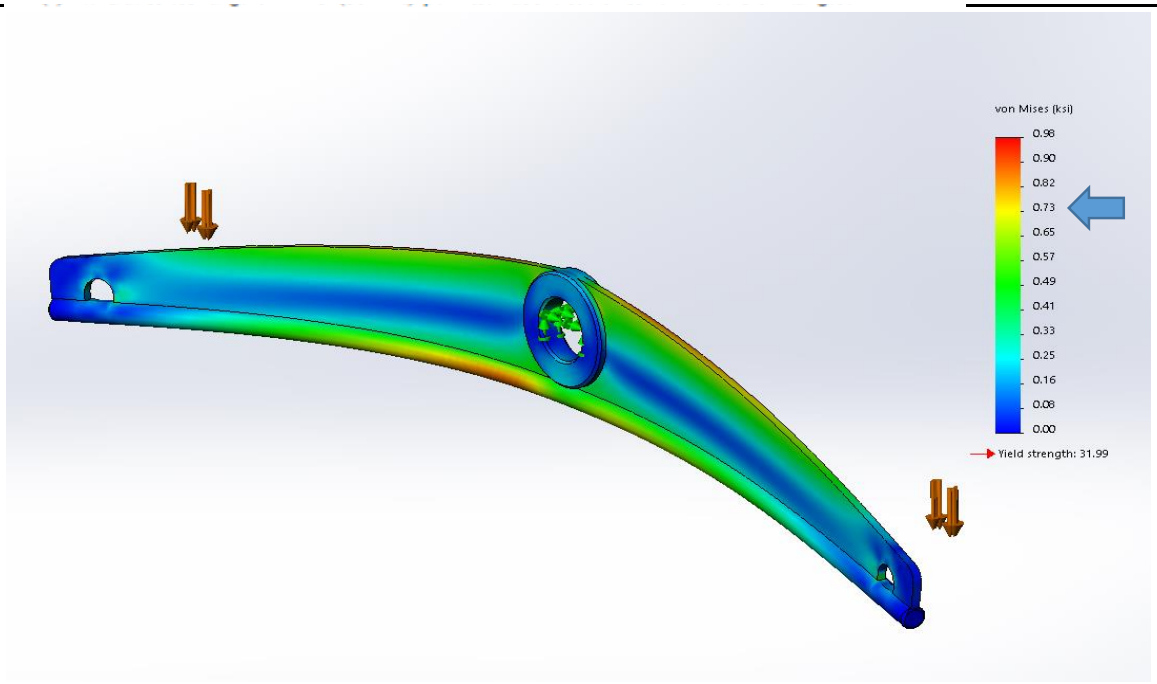
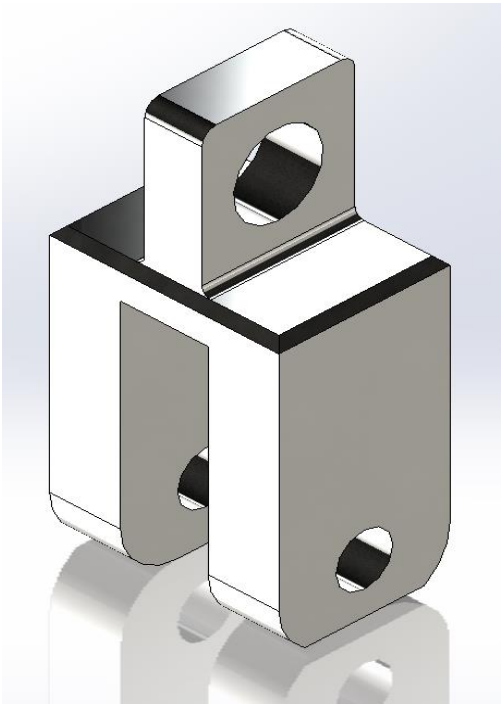
Service Class	Load Cycles
0	0–20,000
1	20,001–100,000
2	100,001–500,000
3	500,001–2,000,000
4	Over 2,000,000

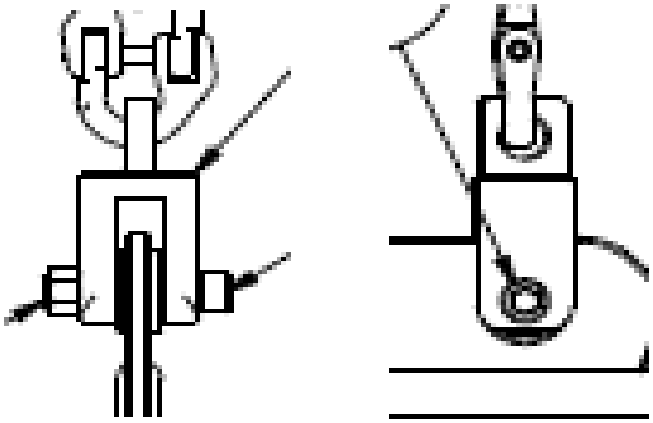
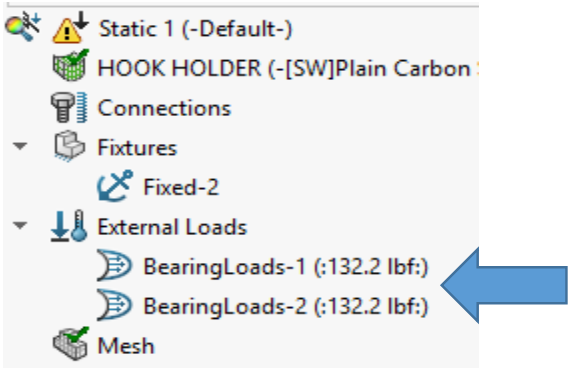
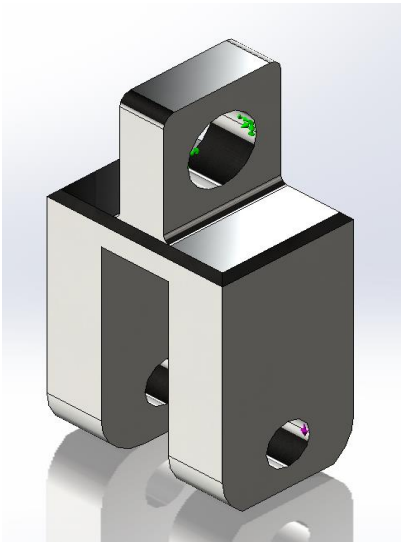
42	Allowable Stress Range, Fs (ksi)	8	Table 3-4.3-1, based on Service Class and worst case Stress Category for fatigue
43			

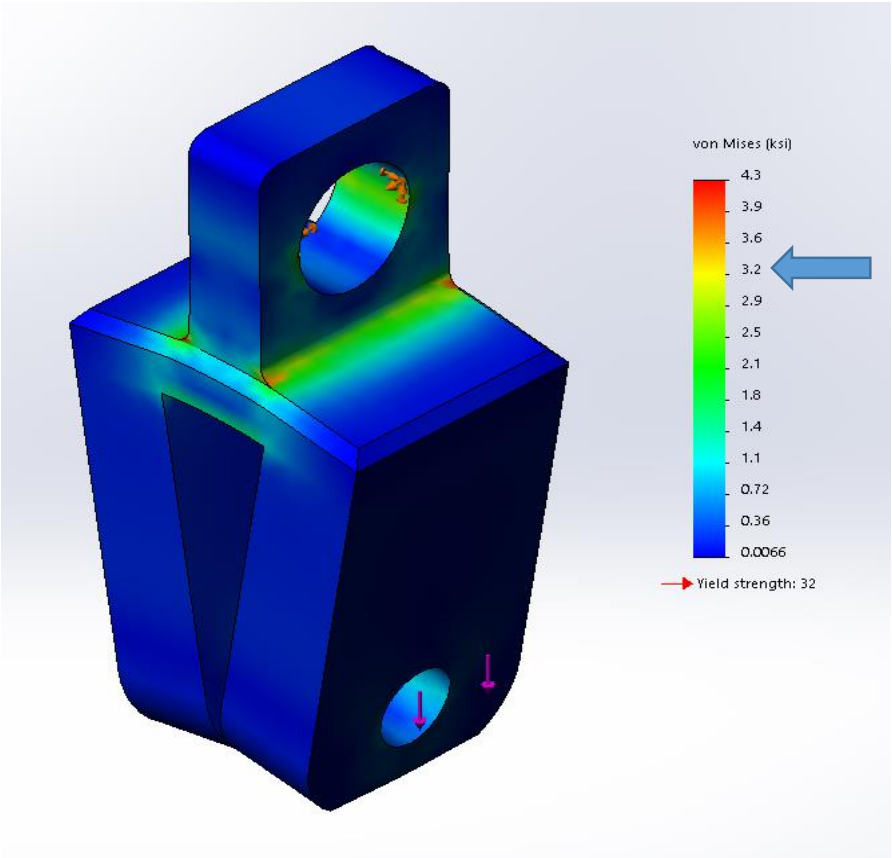
Table 3-4.3-1 Allowable Stress Ranges, ksi (MPa)

Stress Category (From Table 3-4.4-1)	Service Class 1	2	3	4
A	63 (435)	37 (255)	24 (165)	24 (165)
B	49 (340)	29 (200)	18 (125)	16 (110)
B′	39 (270)	23 (160)	15 (100)	12 (80)
C	35 (240)	21 (145)	13 (90)	10 (70) [Note (1)]
D	28 (190)	16 (110)	10 (70)	7 (48)
E	22 (150)	13 (90)	8 (55)	4 (34)
E′	16 (110)	9 (60)	6 (40)	3 (20)
F	15 (100)	12 (80)	9 (60)	8 (55)
G	16 (110)	9 (60)	7 (48)	7 (48)

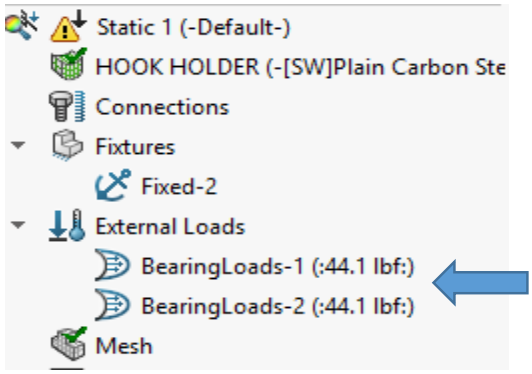
NOTE:
(1) Flexural stress range of 12 ksi (80 MPa) permitted at the toe of stiffener welds on flanges.

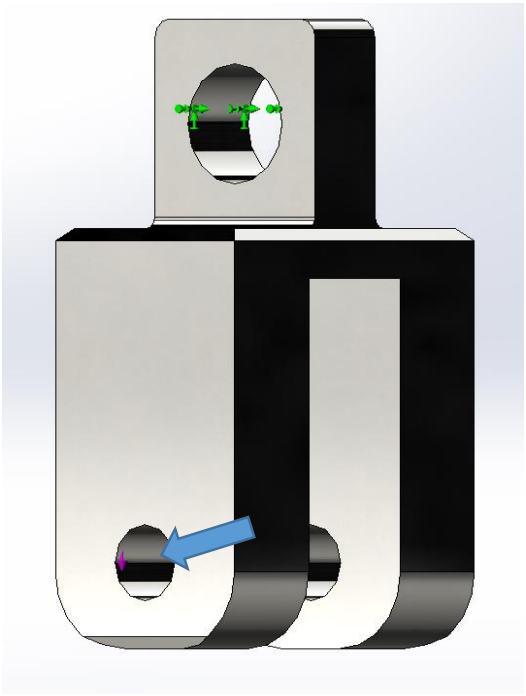
44			
45	Actual Stress, F_a (ksi)	0.73	See above
46	Safety Factor	10.96	$F_s/F_a > 1$ OK
47	Analysis of detail 4		
48			
49	Rated Force on Upper Connection Point, F (lbs)	88.2	Job Load

50			
51	Design factor, Df	3	For Structure
52	Applied Force, AF (lbs)	264.48	Actual Load x Df
53	Applied Force per Load Point Aft, (lbs)	132.2	AF/2
54	Apply the load to the Model using Solidworks Simulation		
55	 		

56	Run the Model		
57			
58	Max Von Mises Stress, Fm (ksi)	3.20	See above
59	Yield Strength of Material, Fy (ksi)	36.30	Mild Steel; assume A36 as worst case mild steel
60	Safety Factor	11.34	Fy/Fm >>1 OK
61	**Fatigue Analysis**		
62	Max Rated Load, W_{max} (lbs)	88.2	***Assumed loading 100% of time***
63	Max Rated Lift Point Load, W_{mc} (lbs)	44.1	$W_{max}/2$
64	See Fatigue Stress Categories below (Ref. Table 3-4.4.1, ASME BTH-1-2017):		

65





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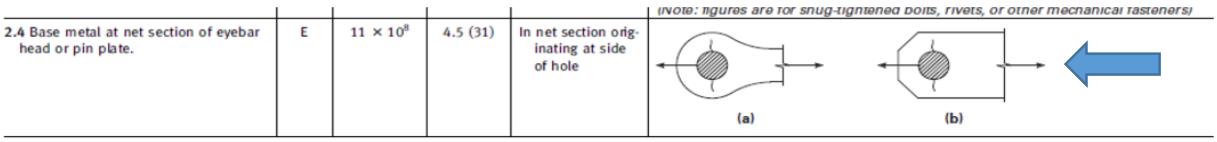


2.4 Base metal at net section of eyebar head or pin plate.	E	11×10^8	4.5 (31)	In net section originating at side of hole	(a) (b)

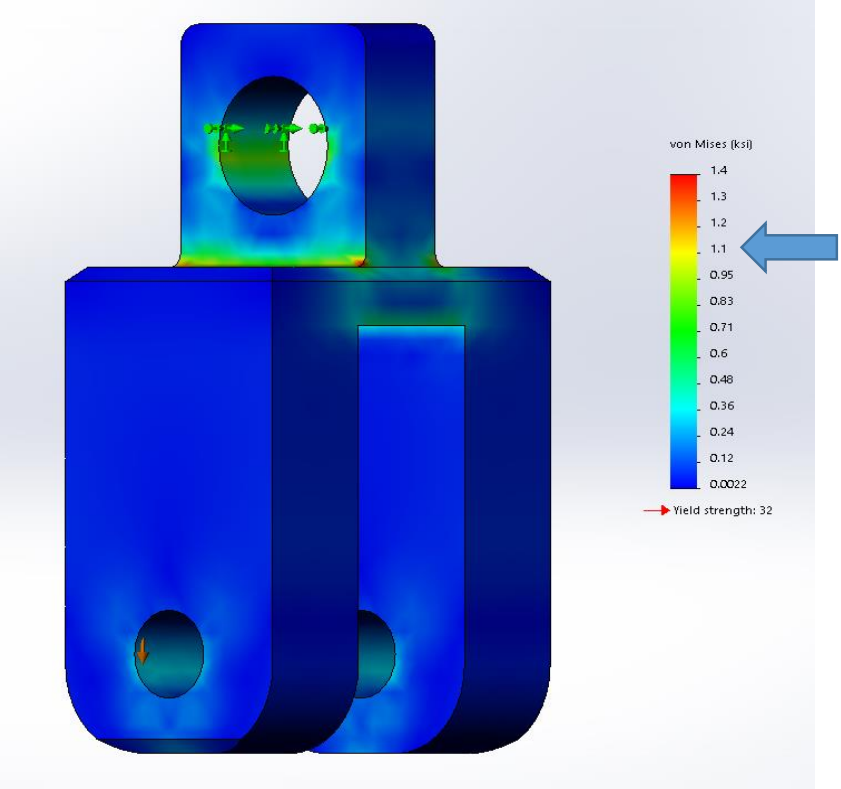
67

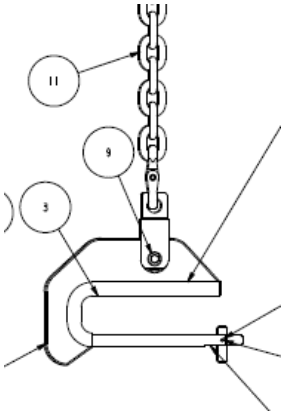
Service Class	3	Per drawing

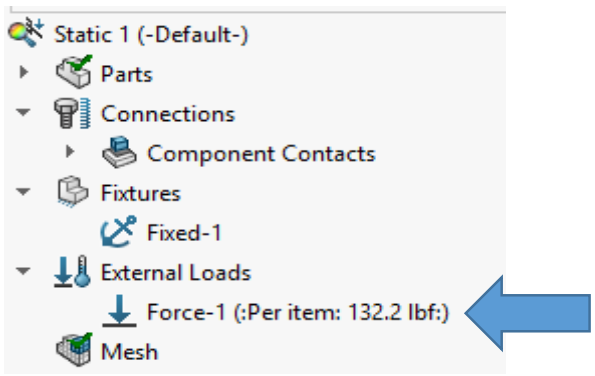
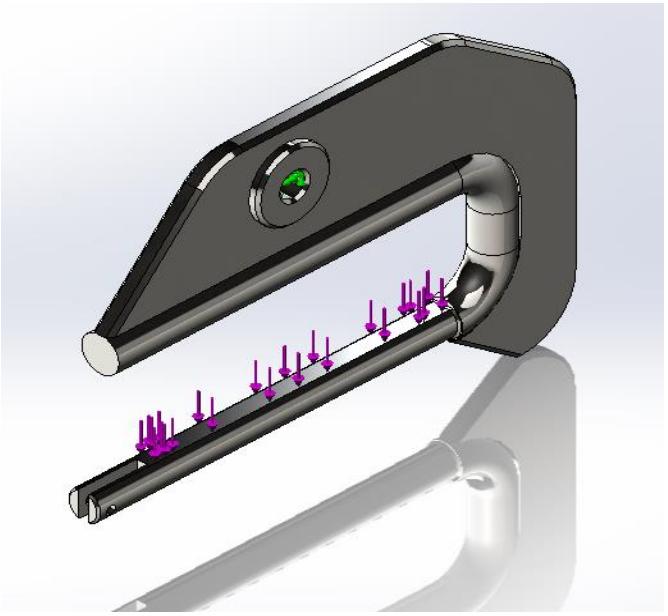
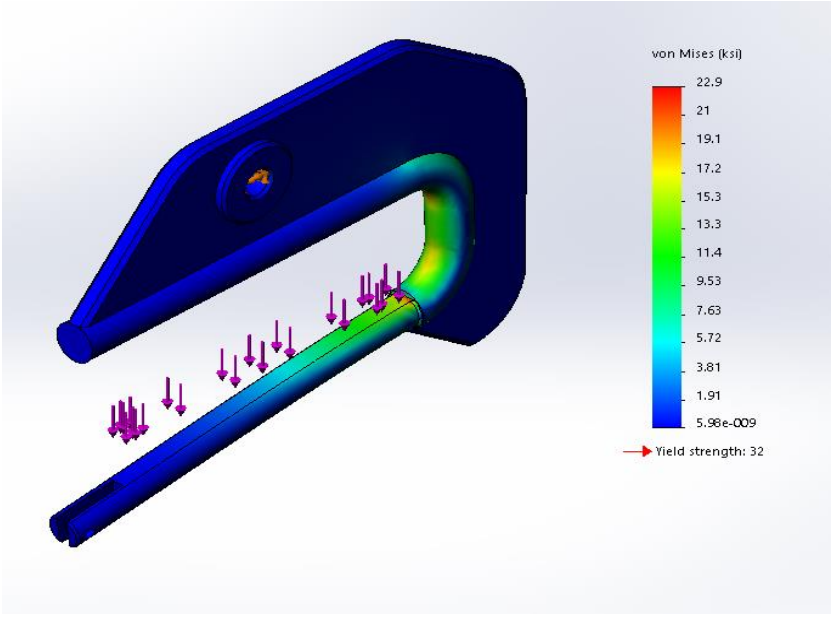
68

Table 2-3-1 Service Class

Service Class	Load Cycles
0	0–20,000
1	20,001–100,000
2	100,001–500,000
3	500,001–2,000,000
4	Over 2,000,000

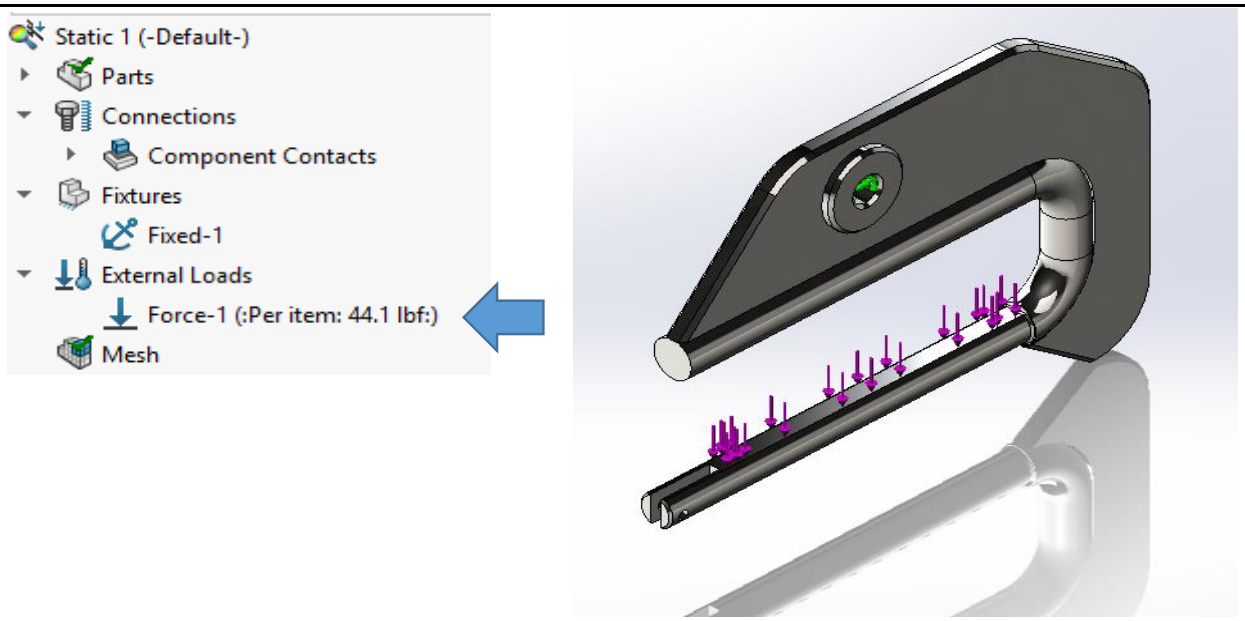
69	Allowable Stress Range, Fs (ksi)	8	Table 3-4.3-1, based on Service Class and worst case Stress Category for fatigue
70	**Table 3-4.3-1 Allowable Stress Ranges, ksi (MPa)** Stress Category (From Table 3-4.4-1) / Service Class 1 / 2 / 3 / 4 A: 63 (435) / 37 (255) / 24 (165) / 24 (165) B: 49 (340) / 29 (200) / 18 (125) / 16 (110) B': 39 (270) / 23 (160) / 15 (100) / 12 (80) C: 35 (240) / 21 (145) / 13 (90) / 10 (70) [Note (1)] D: 28 (190) / 16 (110) / 10 (70) / 7 (48) E: 22 (150) / 13 (90) / 8 (55) / 5 (34) E': 16 (110) / 9 (60) / 6 (40) / 3 (20) F: 15 (100) / 12 (80) / 9 (60) / 8 (55) G: 16 (110) / 9 (60) / 7 (48) / 7 (48) NOTE: (1) Flexural stress range of 12 ksi (80 MPa) permitted at the toe of stiffener welds on flanges.		
71			
72	Actual Stress, F_a (ksi)	1.1	See above
73	Safety Factor	7.27	Fs/Fa
74	**The lifting device meets the allowable stress range for Service Class 3 cycle requirements.**		

75	Analysis of detail 8 & 3		
76			
77	Rated Force on Upper Connection Point, F (lbs)	88.2	Job Load
78			
79	Design factor, Df	3	For Structure
80	Applied Force, AF (lbs)	264.48	Actual Load x Df
81	Applied Force per Load Point Aft, (lbs)	132.2	AF/2

82	Apply the load to the Model using Solidworks Simulation		
83	 		
84	Run the Model		
85			
86	Max Von Mises Stress, Fm (ksi)	15.30	See above
87	Yield Strength of Material, Fy (ksi)	36.30	Mild Steel; assume A36 as worst case mild steel
88	Safety Factor	2.37	Fy/Fm >>1 OK

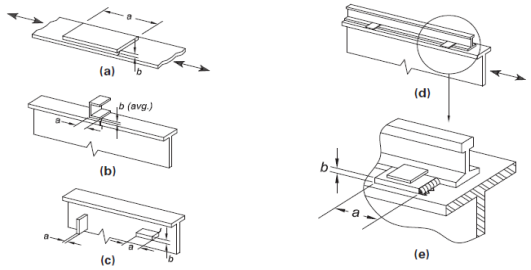
89	**Fatigue Analysis**		
90	Max Rated Load, W_{max} (lbs)	88.2	***Assumed loading 100% of time***
91	Max Rated Lift Point Load, W_{mc} (lbs)	44.1	$W_{max}/2$
92	See Fatigue Stress Categories below (Ref. Table 3-4.4.1, ASME BTH-1-2017):		

93



94

Description	Stress Category	Constant, C_f	Threshold, F_{TH}, ksi (MPa)	Potential Crack Site Initiation	Illustrative Typical Examples
Section 7 — Base Metal at Short Attachments [Note (1)]					
7.1 Base metal subject to longitudinal loading at details with welds parallel or transverse to the direction of stress where the detail embodies no transition radius and with detail length in direction of stress, a, and thickness of attachment, b:				Initiating in base metal at the weld termination or at the toe of the weld extending into the base metal	
a < 2 in. (50 mm)	C	44×10^8	10 (69)		
2 in. (50 mm) ≤ a ≤ lesser of 12b or 4 in. (100 mm)	D	22×10^8	7 (48)		
a > 12b or 4 in. (100 mm), when b ≤ 1 in. (25 mm)	E	11×10^8	4.5 (31)		
a > lesser of 12b or 4 in. (100 mm), when b > 1 in. (25 mm)	E′	3.9×10^8	2.6 (18)		



95	Service Class	3	Per drawing

96

Table 2-3-1 Service Class

Service Class	Load Cycles
0	0–20,000
1	20,001–100,000
2	100,001–500,000
3	500,001–2,000,000
4	Over 2,000,000

97	Allowable Stress Range, Fs (ksi)	8	Table 3-4.3-1, based on Service Class and worst case Stress Category for fatigue

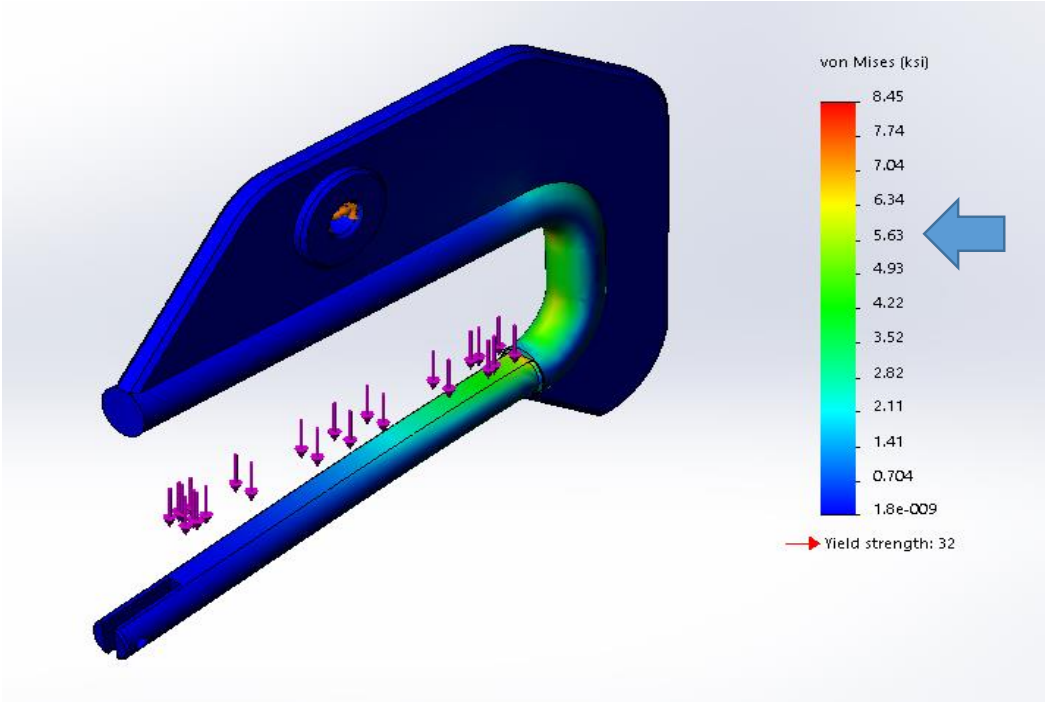
98

Table 3-4.3-1 Allowable Stress Ranges, ksi (MPa)

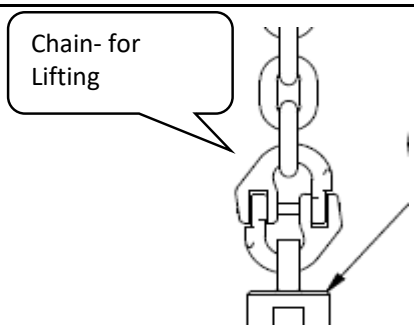
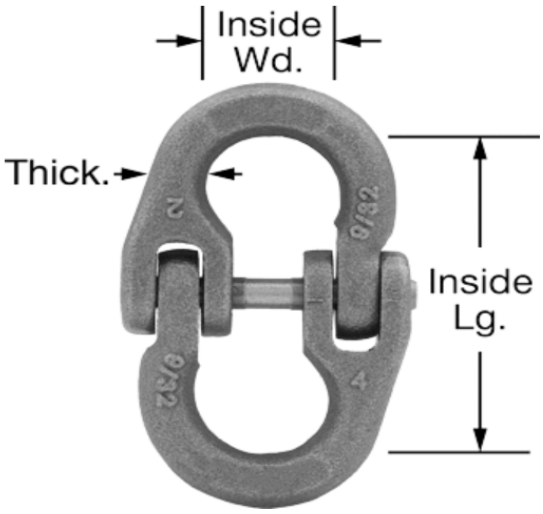
Stress Category (From Table 3-4.4-1)	Service Class 1	2	3	4
A	63 (435)	37 (255)	24 (165)	24 (165)
B	49 (340)	29 (200)	18 (125)	16 (110)
B'	39 (270)	23 (160)	15 (100)	12 (80)
C	35 (240)	21 (145)	13 (90)	10 (70) [Note (1)]
D	28 (190)	16 (110)	10 (70)	7 (48)
E	22 (150)	13 (90)	8 (55)	5 (34)
E'	16 (110)	9 (60)	6 (40)	3 (20)
F	15 (100)	12 (80)	9 (60)	8 (55)
G	16 (110)	9 (60)	7 (48)	7 (48)

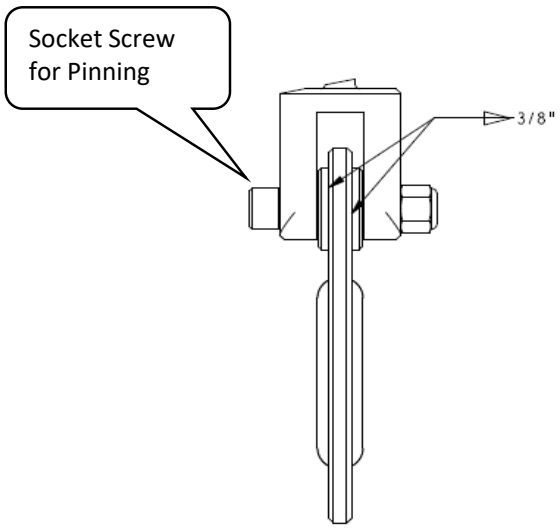
NOTE:
(1) Flexural stress range of 12 ksi (80 MPa) permitted at the toe of stiffener welds on flanges.

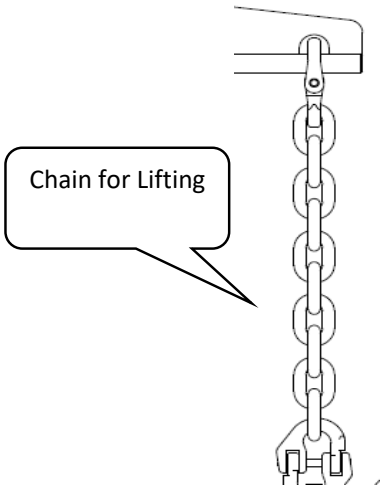
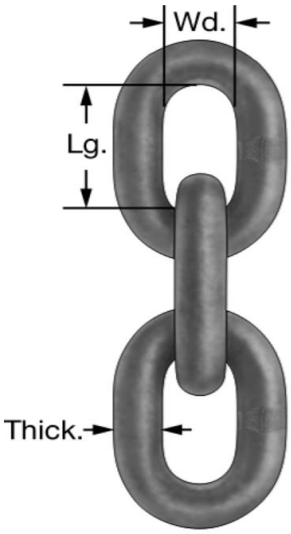
99



100	Actual Stress, F_a (ksi)	5.63	See above
101	Safety Factor	1.42	Fs/Fa
102	**The lifting device meets the allowable stress range for Service Class 3 cycle requirements.**		

75	**Other Rated Components**		
76			
77	**Figure-Eight Connecting Link - for Lifting** Removable, Grade 80, for 3/8 Chain Trade Size  Each ADD TO ORDER In stock $21.44 Each 3578T15 Grade: 80 Material: Alloy Steel For Chain Trade Size: 3/8 Thickness: 1/2" Inside Length: 2 27/64" Inside Width: 13/16" Capacity: 7,100 lbs. Fabrication: Forged Specifications Met: ASME B30.9 Fitting Type: Link/Ring Application: For Lifting RoHS: Not Compliant		
78	Part Rating, R (lbs)	14,200	x 2 for 2 eight connectors
79	Factored Job Load, FJ_{load} (lbs)	317.4	J_{load} x Nominal Design Factor
80	Safety Factor	44.74	R / Fjload >>1 OK

81			
82	**Black-Oxide Alloy Steel Socket Head Screw** **1/2"-13 Thread Size, 2-1/2" Long, Partially Threaded**  Packs of 10 — In stock $13.62 per pack of 10 ADD TO ORDER — 91251A722 Head Type: Socket Socket Head Profile: Standard Drive Style: Hex System of Measurement: Inch Thread Direction: Right Hand Thread Size: 1/2"-13 Screw Size Decimal Equivalent: 0.5" Thread Type: UNC Thread Fit: Class 3A Length: 2 1/2" Threading: Partially Threaded Min. Thread Length: 1 1/2" Thread Spacing: Coarse Head Diameter: 3/4" Height: 1/2" Drive Size: 3/8" Material: Black-Oxide Alloy Steel Tensile Strength: 170,000 psi Hardness: Rockwell C37 Specifications Met: ASTM A574 RoHS: Compliant		
83	Part Rating, R (lbs)	193,800	See above x 2 for 2 screws
84	Factored Job Load, FJ_{load} (lbs)	317.4	J_{load} x Nominal Design Factor
85	Safety Factor	610.63	R / Fjload >>1 OK

86			
87	**General Purpose Grade 80 Chain-for Lifting** Black Painted Steel, 3/8 Trade Size  Length, ft. 1 10 2 25 3 50 4 Other 5 Each ADD TO ORDER In stock $7.72 per ft. 3587T15 Chain Style: Straight Link Application: For Lifting Grade: 80 Material: Painted Steel Trade Size: 3/8 Metric Trade Size: 10 Thickness: 0.40" Inside Width: 0.57" Length: 1.22" Capacity: 7,100 lbs. Weight per ft.: 1.5 lbs. Approximate Number of Links per Foot: 9 For Fitting Thickness: 9/16" Color: Black		
88	Part Rating, R (lbs)	14,200	See above x 2 for 2 eight connectors
89	Factored Job Load, FJ_{load} (lbs)	317.4	J_{load} x Nominal Design Factor
90	Safety Factor	44.74	R / Fjload >>1 OK