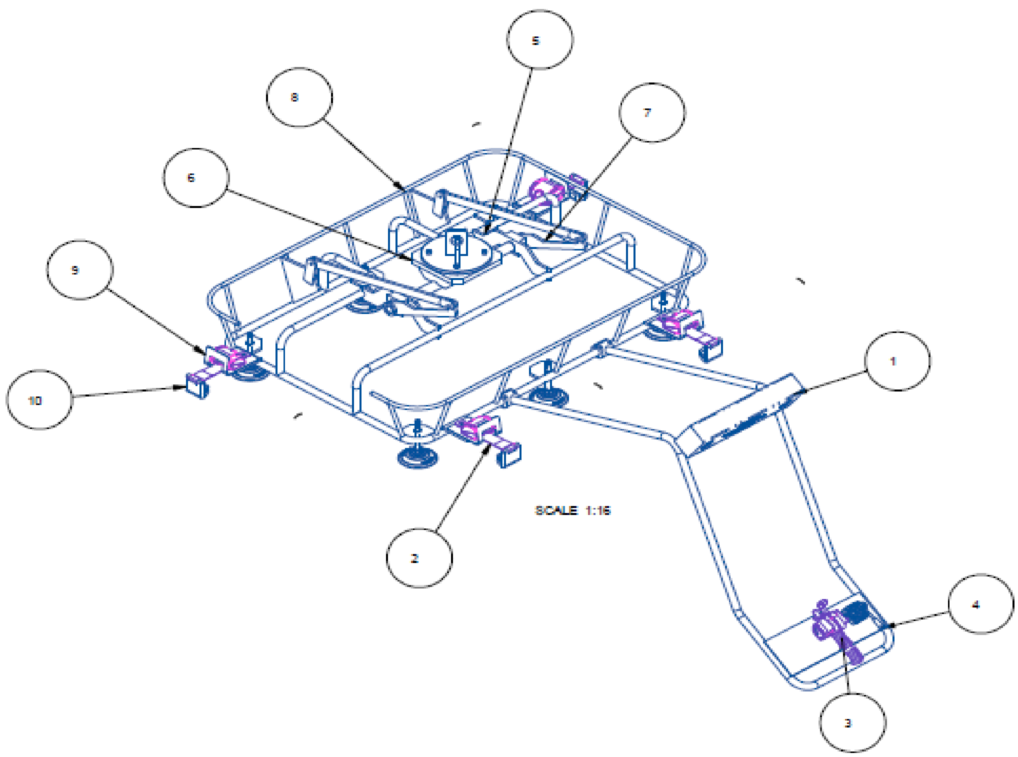
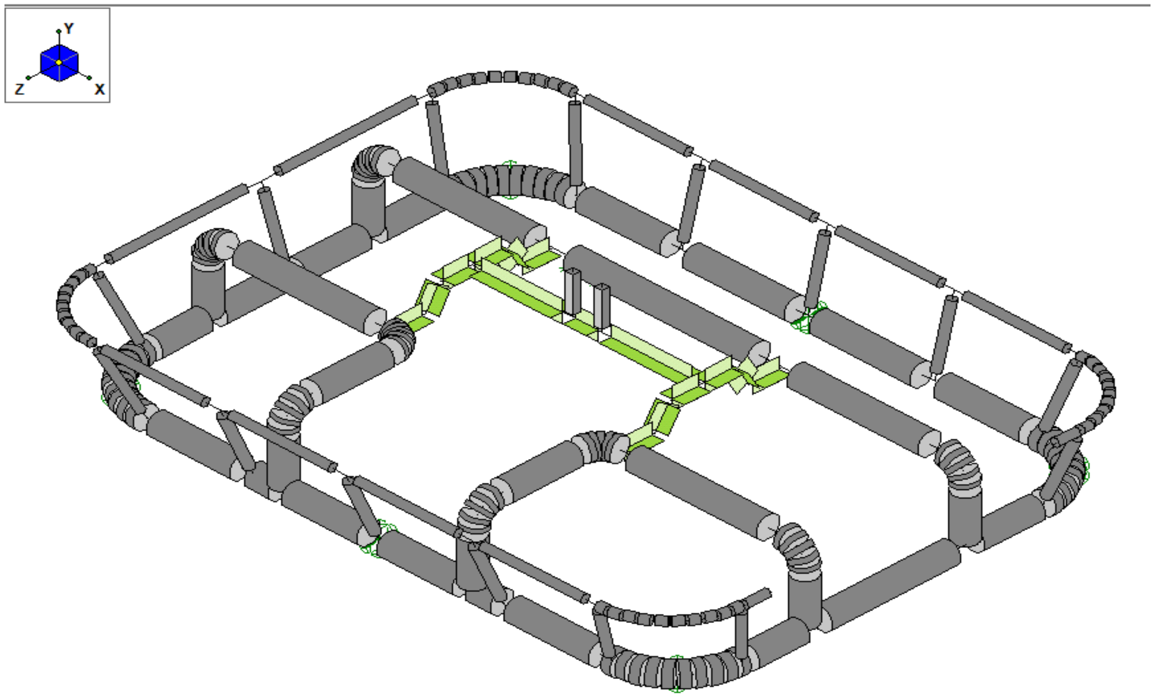
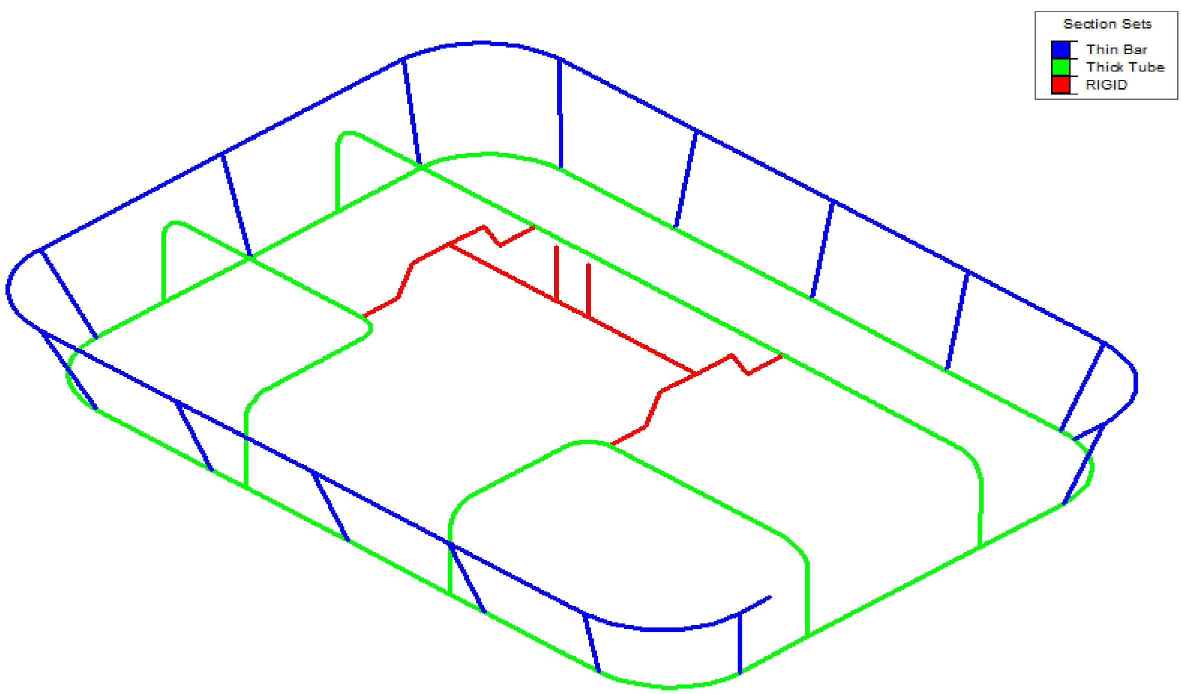
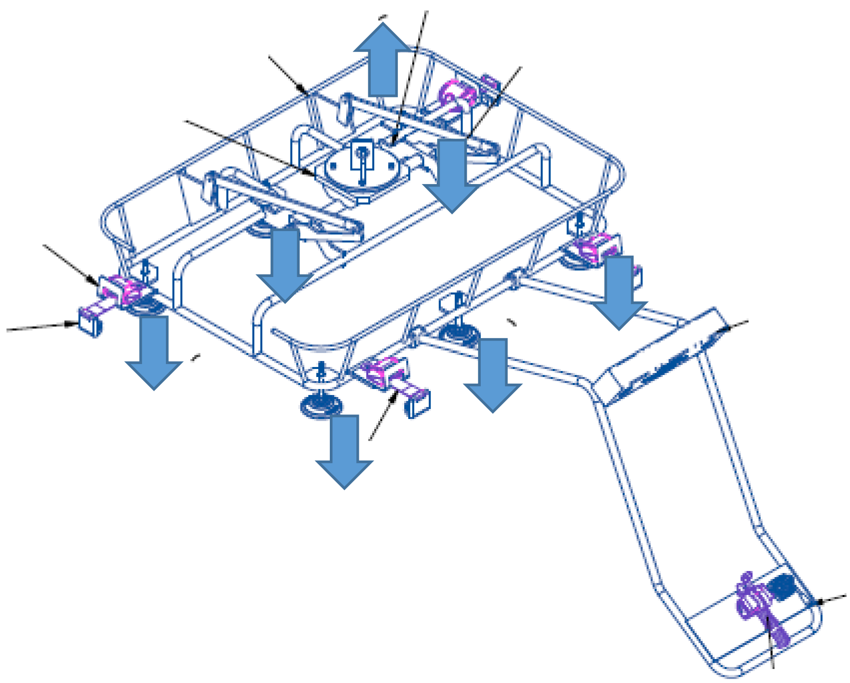
1	**Structural Calculations for DL 391 (Lifting Device For Deflector 52")**
2	**Summary of Analysis: Device is rated for 150 kg (331 lbs), Service Class 2**
3	(see certification table below)
4	
5	**Basis of Analysis: Develop a RISA model of the Lifting Device to determine its overall performance**

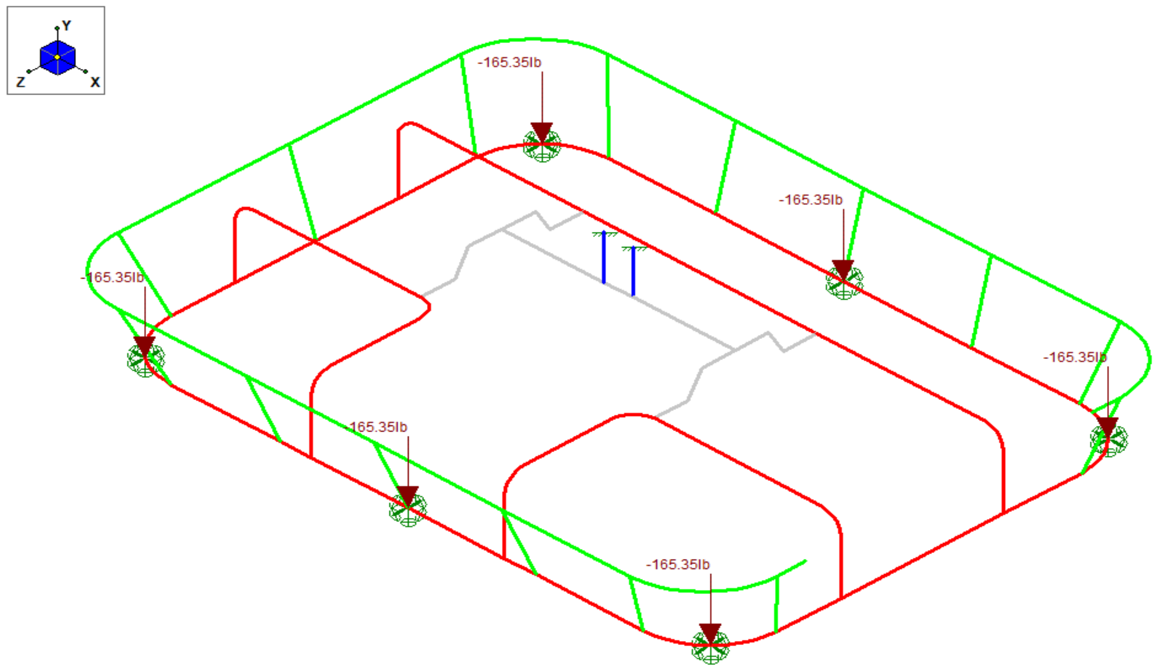
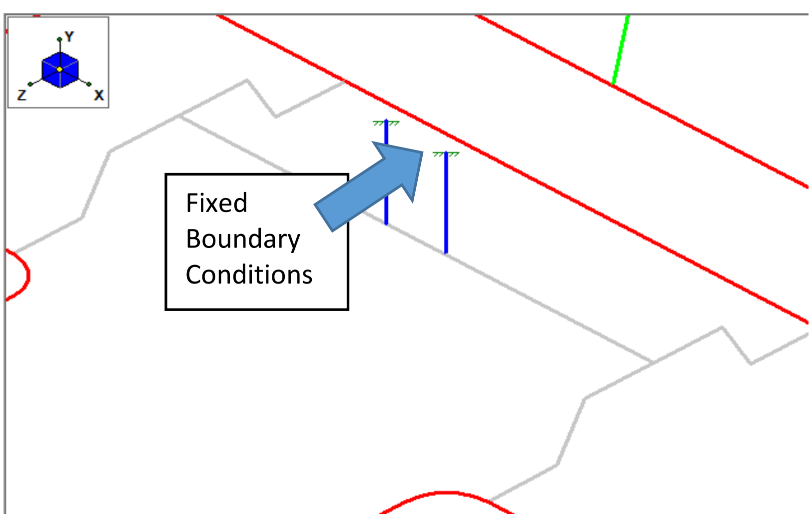
CERTIFICACION

DISPOSITIVO DE LEVANTE PARA DEFLECTOR 52"

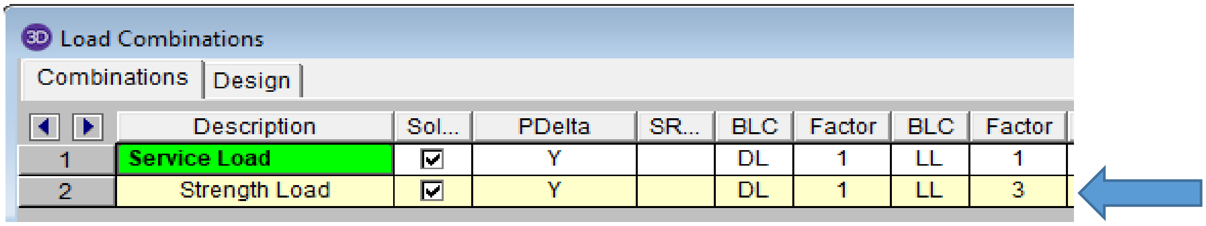
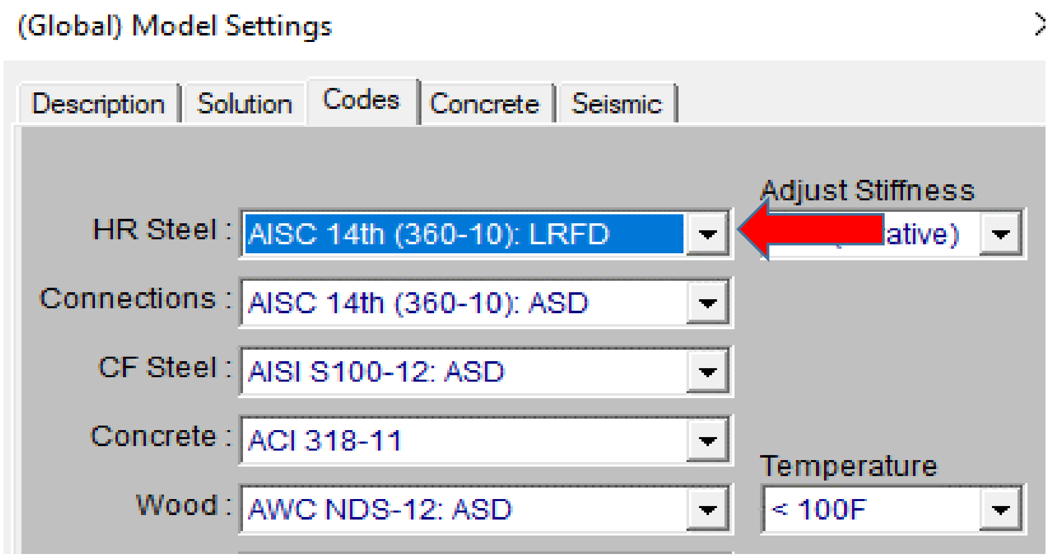
ALTA:	
No. HERRAMIENTA:	DL-391
PESO:	80 KG
CAPACIDAD:	150 KG
PRUEBA:	190 KG
LOCACION:	PLASTICOS
CATEGORIA	B
SERVICIO	2

6	The RISA Model is shown below
7	
8	

<table>
<tr><td>9</td><td colspan="3">Section Sets Defined</td></tr>
<tr><td>10</td><td colspan="3">Hot Rolled Steel Section Sets
Hot Rolled | Cold Formed | Wood | Concrete | Aluminum | Stainless | General
<table>
<tr><th></th><th>Label</th><th>Shape</th><th>Type</th><th>Design List</th><th>Material</th></tr>
<tr><td>1</td><td>Thin Bar</td><td>1/2" Bar</td><td>None</td><td>None</td><td>A36 Gr.36</td></tr>
<tr><td>2</td><td>Thick Tube</td><td>25.4mm x 3.5mm</td><td>None</td><td>None</td><td>A36 Gr.36</td></tr>
</table></td></tr>
<tr><td>11</td><td>Yield Strength of Material, F_y (ksi)</td><td>36</td><td>A36 Steel</td></tr>
<tr><td>12</td><td>Ultimate Strength of Material, F_u (ksi)</td><td>58</td><td>A36 Steel</td></tr>
<tr><td>13</td><td colspan="3">Loading of the Model</td></tr>
<tr><td>14</td><td colspan="3"></td></tr>
<tr><td>15</td><td>Item</td><td>Value</td><td>Comment</td></tr>
<tr><td>16</td><td>Rated Load, W_{max} (kg)</td><td>150.0</td><td>See Above</td></tr>
<tr><td>17</td><td>Rated Load, W_{max} (lbs)</td><td>331</td><td>W_{max}*2.20462</td></tr>
</table>

18			
19	Load at each Connection Point, L_c (lbs)	55.12	$R_{load}/6$
20	Design factor, Df	3	Used in RISA load Combinations
21	Applied Force, AF (lbs)	165.35	F x Df
22	**Define Boundary Conditions used to keep the model stable**		
23			

<table>
<tr><td>24</td><td colspan="3">Code Reference: ASME BTH-1-2017; issued March 15, 2017</td></tr>
<tr><td>25</td><td colspan="3">Design of
Below-the-Hook
Lifting Devices</td></tr>
<tr><td>26</td><td>Design Category</td><td>B</td><td>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.</td></tr>
<tr><td>27</td><td colspan="3">2-2.2 Design Category B
(a) Design Category B should be designated when the magnitude and variation of loads applied to the lifter are not predictable, where the loading and environmental conditions are severe or not accurately defined.
(b) The nominal design factor for Design Category B shall be in accordance with para. 3-1.3.</td></tr>
<tr><td>28</td><td>Nominal Design Factor, N_d</td><td>3</td><td>Design Factor for yielding and buckling</td></tr>
<tr><td>29</td><td>Nominal Design Factor, N_{dd}</td><td>3.6</td><td>Design Factor for fracture and connections</td></tr>
<tr><td>30</td><td colspan="3">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</td></tr>
<tr><td>31</td><td colspan="3">(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.</td></tr>
<tr><td>32</td><td colspan="3">RISA Analysis Step 1: Adjust the following Factors of Safety and run for Strength:
Live Load from 1.6 to 3.0
Dead Load from 1.2 to 1.0</td></tr>
</table>

<table>
<tr><td>33</td><td>Define Load Combinations</td></tr>
<tr><td>34</td><td>
</td></tr>
<tr><td>35</td><td>Define Code Compliance</td></tr>
<tr><td>36</td><td>
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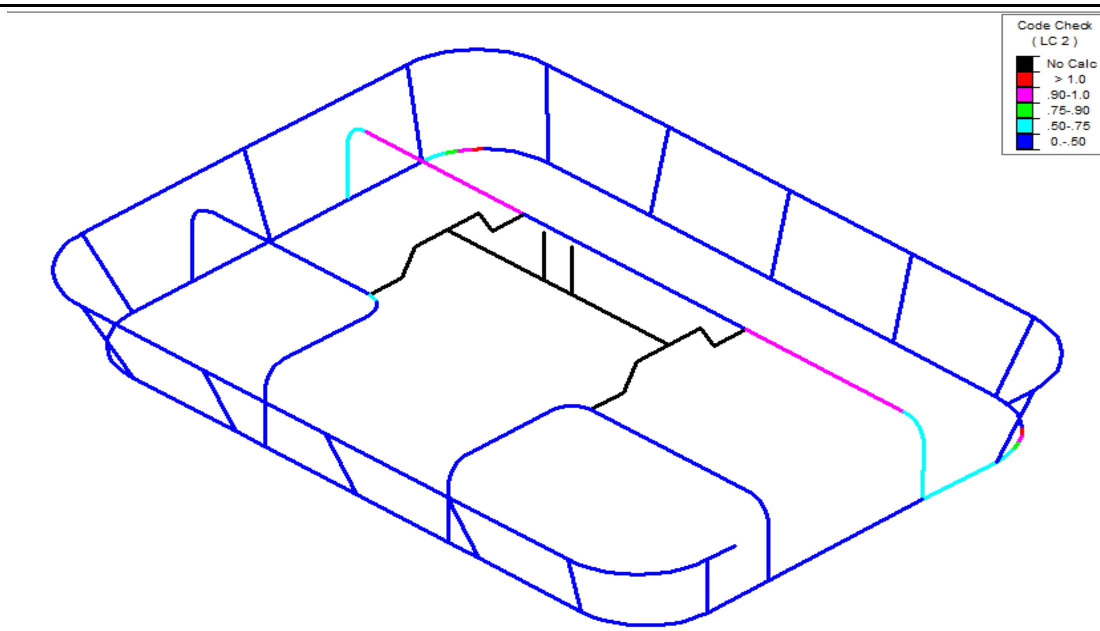
<tr><td>37</td><td>
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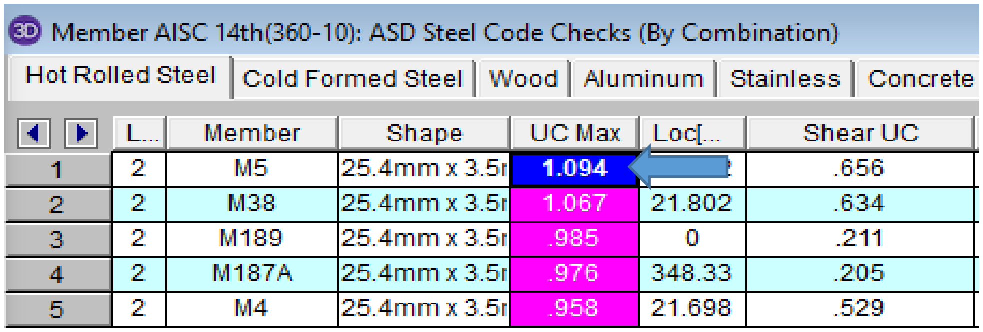
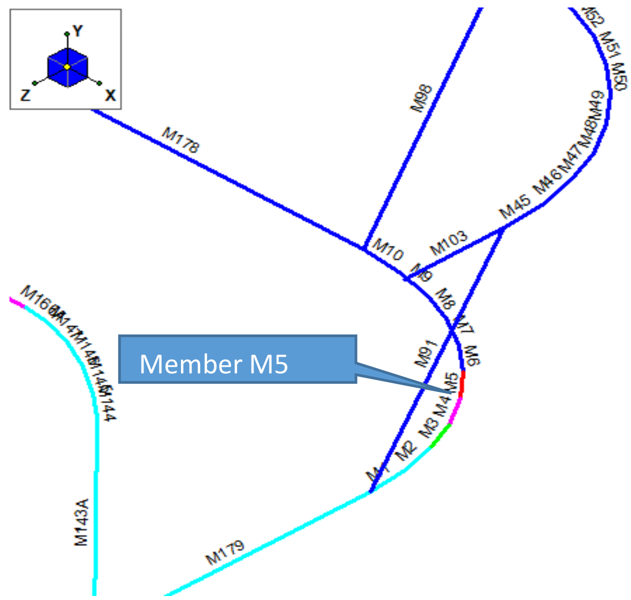


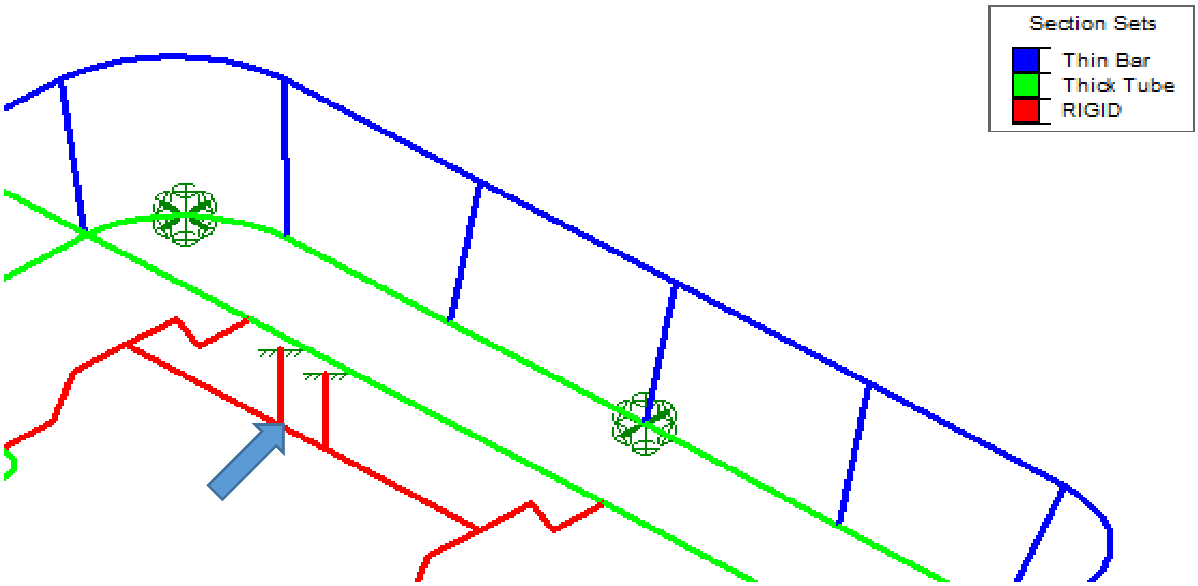
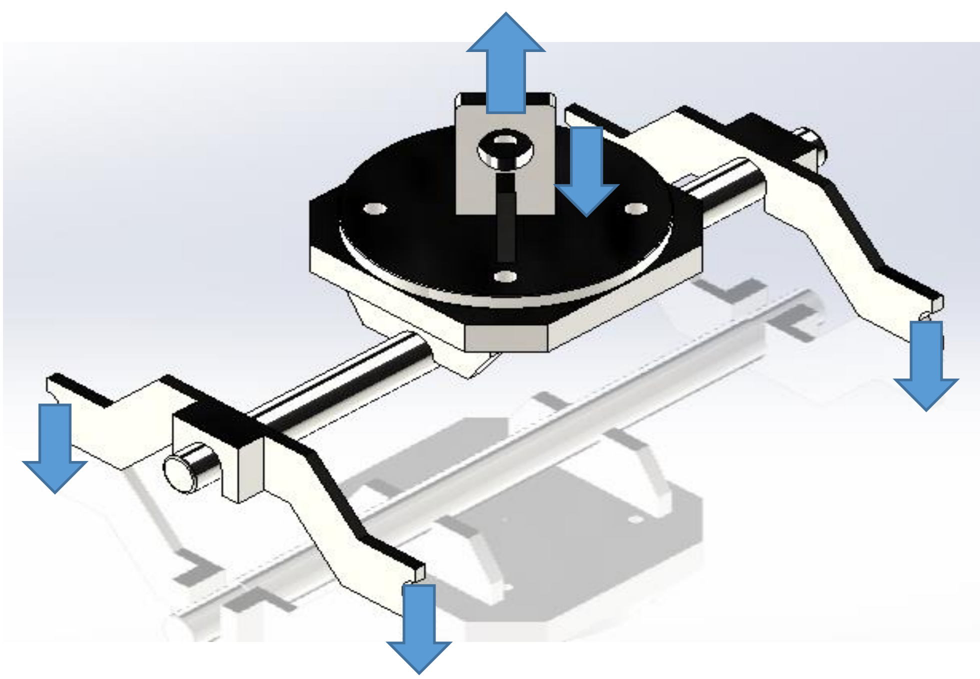
Member AISC 14th(360-10): ASD Steel Code Checks (By Combination)

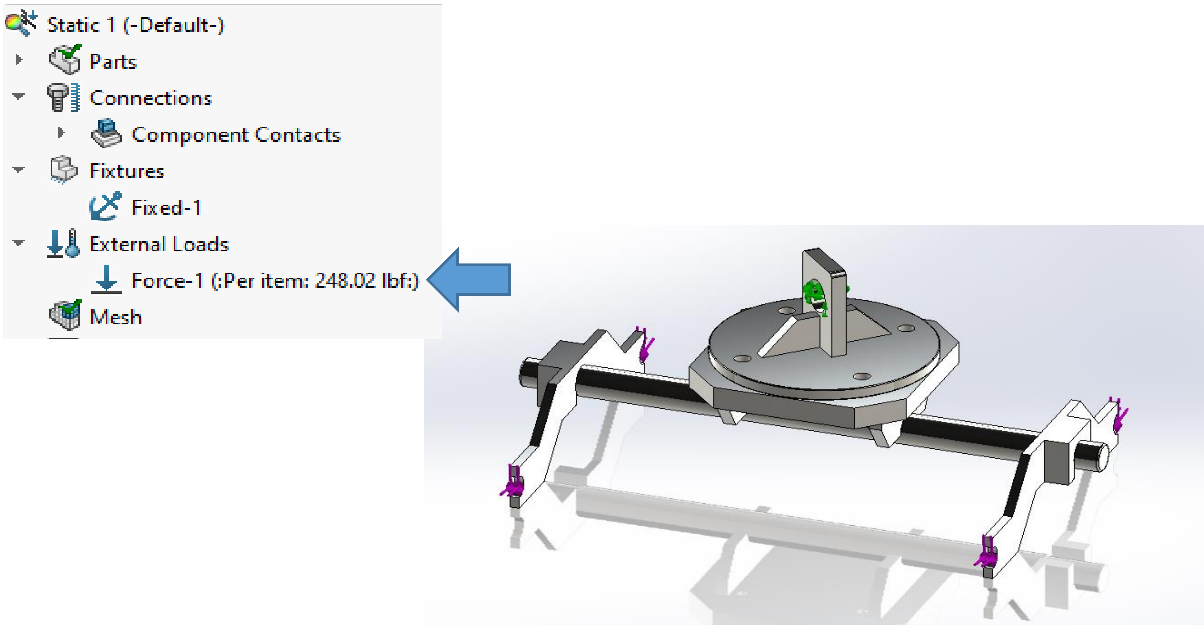
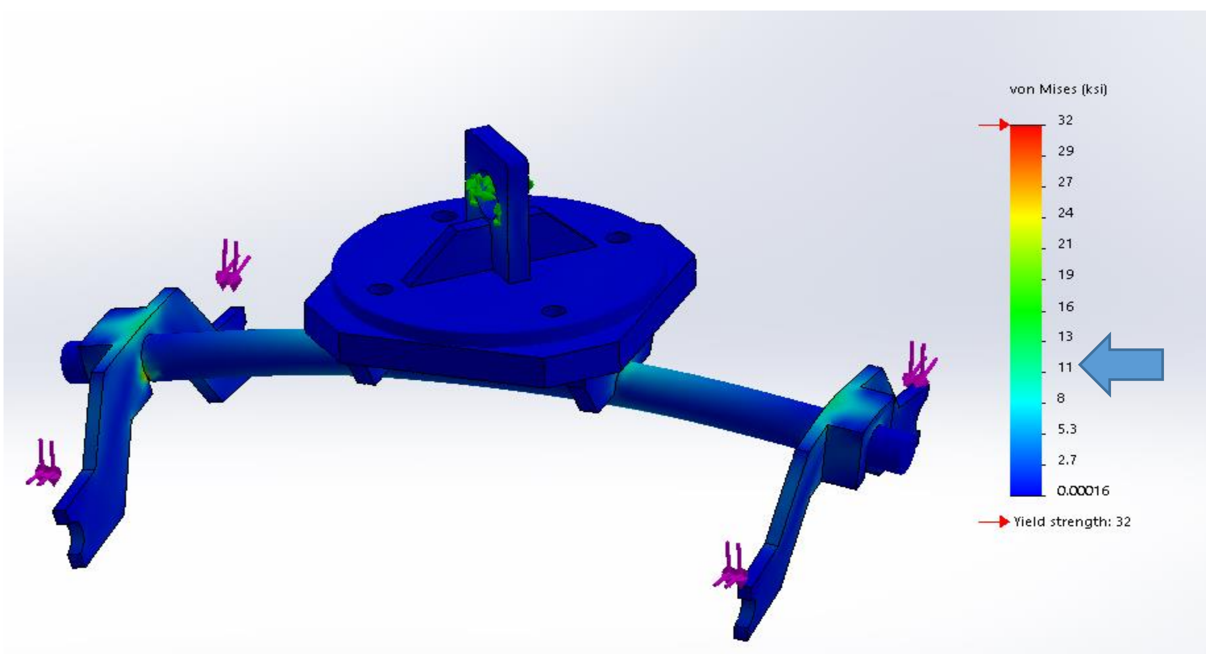
Hot Rolled Steel | Cold Formed Steel | Wood | Aluminum | Stainless | Concrete

<table>
<tr><th></th><th>L...</th><th>Member</th><th>Shape</th><th>UC Max</th><th>Loc[...</th><th>Shear UC</th></tr>
<tr><td>1</td><td>2</td><td>M5</td><td>25.4mm x 3.5r</td><td>1.094</td><td>[illegible]</td><td>.656</td></tr>
<tr><td>2</td><td>2</td><td>M38</td><td>25.4mm x 3.5r</td><td>1.067</td><td>21.802</td><td>.634</td></tr>
<tr><td>3</td><td>2</td><td>M189</td><td>25.4mm x 3.5r</td><td>.985</td><td>0</td><td>.211</td></tr>
<tr><td>4</td><td>2</td><td>M187A</td><td>25.4mm x 3.5r</td><td>.976</td><td>348.33</td><td>.205</td></tr>
<tr><td>5</td><td>2</td><td>M4</td><td>25.4mm x 3.5r</td><td>.958</td><td>21.698</td><td>.529</td></tr>
</table>
</td></tr>
<tr><td>39</td><td colspan="2">


</td></tr>
<tr><td>40</td><td>Code Check results of Design Stress from RISA output above</td><td>1.094</td><td>OK if less than or equal to 1 (round to 1/10th);

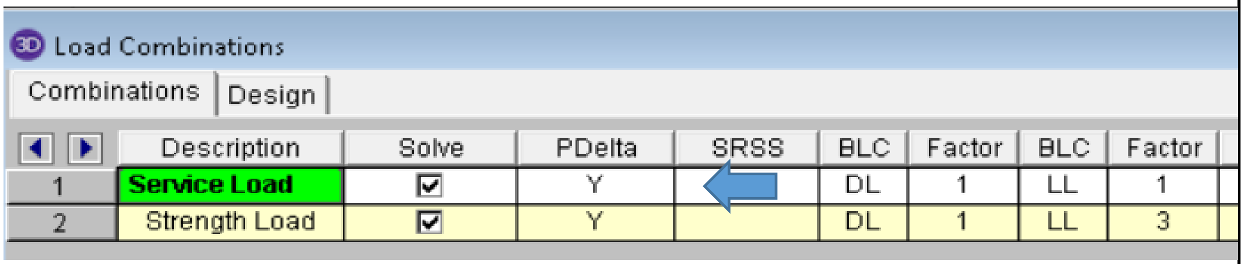
NOTE: RISA checks all of the allowable stresses contained in Section 3-2 of ASME BTH-1-2017</td></tr>
<tr><td>41</td><td colspan="3">The code check values are the UC Max and Shear UC shown on the bridge; they must all be less than 1. The colors represent a factored ratio of actual to allowable load for LFRD based on the provisions of the Aluminum Design Manual 15th Edition. Ratios greater than 1 are shown in RED; therefore, any member in RED is not acceptable.</td></tr>
</table>

42	**Rigid Member Stresses Using Solidworks**		
			
43			
44	Rated Force on Upper Connection Point, F (lbs)	330.7	Job Load
45	Design factor, Df	3	For Structure
46	Applied Force, AF (lbs)	992.08	F x Df
47	Applied Force per Load Point Aft, (lbs)	248.02	AF/4

<table>
<tr><td>48</td><td colspan="3">Apply the load to the Model using Solidworks Simulation</td></tr>
<tr><td>49</td><td colspan="3">
</td></tr>
<tr><td>50</td><td colspan="3">Run the Model</td></tr>
<tr><td>51</td><td colspan="3">
</td></tr>
<tr><td>52</td><td>Max Von Mises Stress, Fm (ksi)</td><td>3.30</td><td>See above</td></tr>
<tr><td>53</td><td>Yield Strength of Material, Fy (ksi)</td><td>36.30</td><td>Mild Steel; assume A36 as worst case mild steel</td></tr>
<tr><td>54</td><td>Safety Factor</td><td>11.00</td><td>Fy/Fm = 1 OK</td></tr>
</table>

55	**RISA Analysis Step 2: Run Service Load Combination to check for actual stress on member**

56

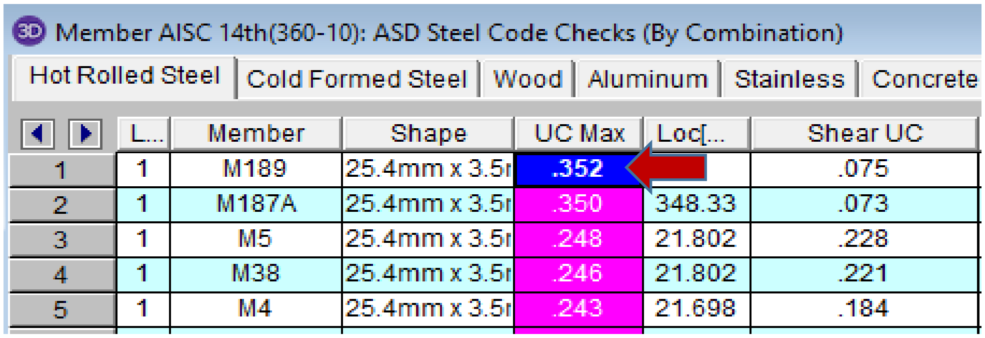


Load Combinations

Combinations | Design

	Description	Solve	PDelta	SRSS	BLC	Factor	BLC	Factor
1	Service Load	☑	Y		DL	1	LL	1
2	Strength Load	☑	Y		DL	1	LL	3

57

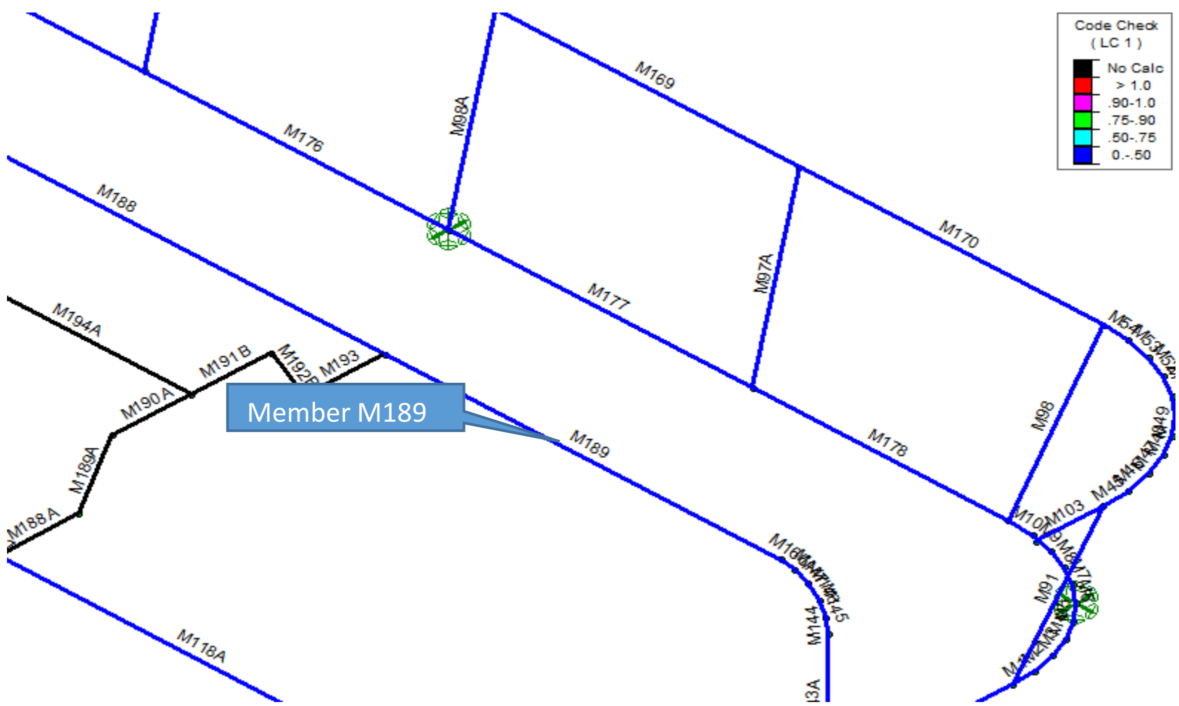


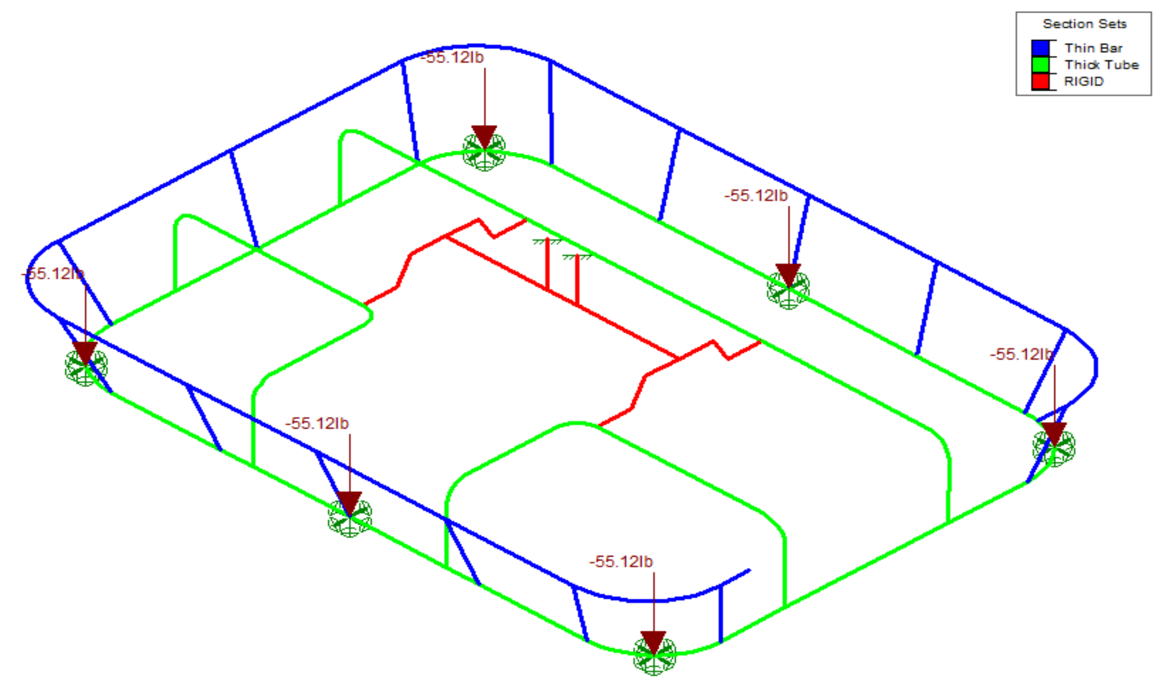
Member AISC 14th(360-10): ASD Steel Code Checks (By Combination)

Hot Rolled Steel | Cold Formed Steel | Wood | Aluminum | Stainless | Concrete

	L...	Member	Shape	UC Max	Loc[...	Shear UC
1	1	M189	25.4mm x 3.5r	.352		.075
2	1	M187A	25.4mm x 3.5r	.350	348.33	.073
3	1	M5	25.4mm x 3.5r	.248	21.802	.228
4	1	M38	25.4mm x 3.5r	.246	21.802	.221
5	1	M4	25.4mm x 3.5r	.243	21.698	.184

58



59	Code Check results of Design Stress from RISA output above	0.352	OK if less than or equal to 1 (round to 1/10th); *NOTE: RISA checks all of the allowable stresses contained in Section 3-2 of ASME BTH-1-2017*
60	The code check values are the UC Max and Shear UC shown on the bridge; they must all be less than 1. The colors represent a factored ratio of actual to allowable load for LFRD based on the provisions of the Aluminum Design Manual 15th Edition. Ratios greater than 1 are shown in RED; therefore, any member in RED is not acceptable.		
61	**Fatigue Analysis**		
62	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):		
63			
64	Max Rated Load, W_{max} (lbs)	330.69	***Assumed loading 100% of time***
65	Max Rated Lift Point Load, W_{mc} (lbs)	55.12	$W_{max}/6$

66	See Fatigue Stress Categories below (Ref. Table 3-4.4.1, ASME BTH-1-2017):

67

Member Section Stresses (By Combination)

	L...	Member Label	S...	Axial[ksi]	y Shear[ksi]	z Shear[ksi]	y top Bending[ksi]	y bot Bending[ksi]
1	1	M189	1	-.18	.441	.113	-10.551	10.551
2			2	-.18	.439	.113	-6.585	6.585
3			3	-.18	.437	.113	-2.636	2.636
4			4	-.18	.435	.113	1.296	-1.296
5			5	-.18	.433	.113	5.209	-5.209
6	1	M187A	1	-.181	-.433	-.109	5.187	-5.187
7			2	-.181	-.435	-.109	1.283	-1.283

68

Description	Stress Category	Constant, C_f	Threshold, F_{TH}, ksi (MPa)	Potential Crack Site Initiation	Illustrative Typical Examples
Section 1 — Plain Material Away From Any Welding					
1.1 Base metal, except noncoated weathering steel, with rolled or cleaned surface. Flame-cut edges with surface roughness value of 1,000 μin. (25 μm) or less, but without re-entrant corners.	A	250×10^8	24 (165)	Away from all welds or structural connections	 (a) (b)
1.2 Noncoated weathering steel base metal with rolled or cleaned surface. Flame-cut edges with surface roughness value of 1,000 μin. (25 μm) or less, but without re-entrant corners.	B	120×10^8	16 (110)	Away from all welds or structural connections	

69	Service Class	2	Per drawing

70

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

71	Allowable Stress Range, Fs (ksi)	29	Table 3-4.3-1, based on Service Class and worst case Stress Category for fatigue

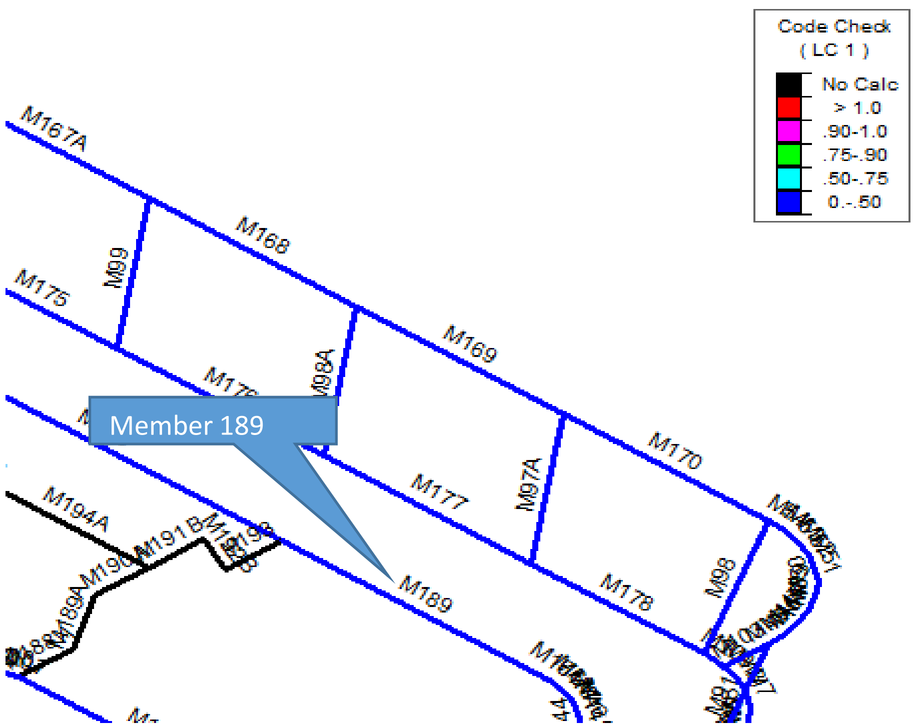
72

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

Stress Category (From Table 3-4.4-1)	Service Class 1	Service Class 2	Service Class 3	Service Class 4
A	63 (435)	37 (255)	[illegible] (165)	24 (165)
B	49 (340)	29 (200)	[illegible] 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.

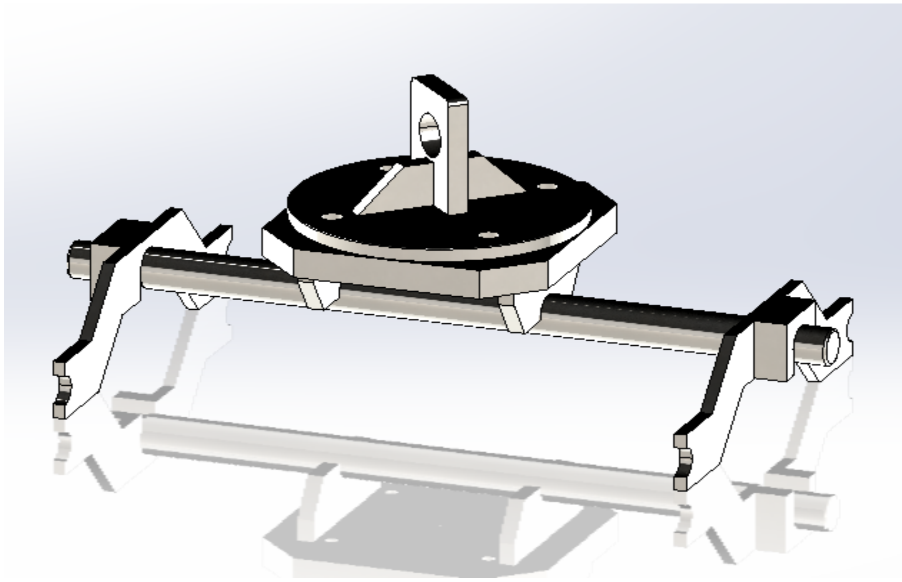
73



74	Actual Stress, F_a (ksi)	10.551	See above
75	Safety Factor	2.75	$F_s/F_a > 1$ OK

62	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):		

63



64

Description	Stress Cate-gory	Constant, C_f	Threshold, F_{TH}, ksi (MPa)	Potential Crack Site Initiation	Illustrative Typical Examples
Section 1 — Plain Material Away From Any Welding					
1.1 Base metal, except noncoated weathering steel, with rolled or cleaned surface. Flame-cut edges with surface roughness value of 1,000 μin. (25 μm) or less, but without re-entrant corners.	A	250×10^8	24 (165)	Away from all welds or structural connections	 (a) (b)
1.2 Noncoated weathering steel base metal with rolled or cleaned surface. Flame-cut edges with surface roughness value of 1,000 μin. (25 μm) or less, but without re-entrant corners.	B	120×10^8	16 (110)	Away from all welds or structural connections	

65	Max Rated Load, W_{max} (lbs)	330.7	***Assumed loading 100% of time***
66	Max Rated Lift Point Load, W_{mc} (lbs)	82.67	$W_{max}/4$
67	Service Class	2	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)	29.0	Table 3-4.3-1, based on Service Class and worst case Stress Category for fatigue

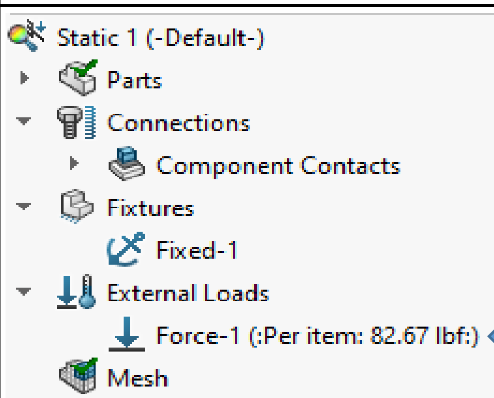
70

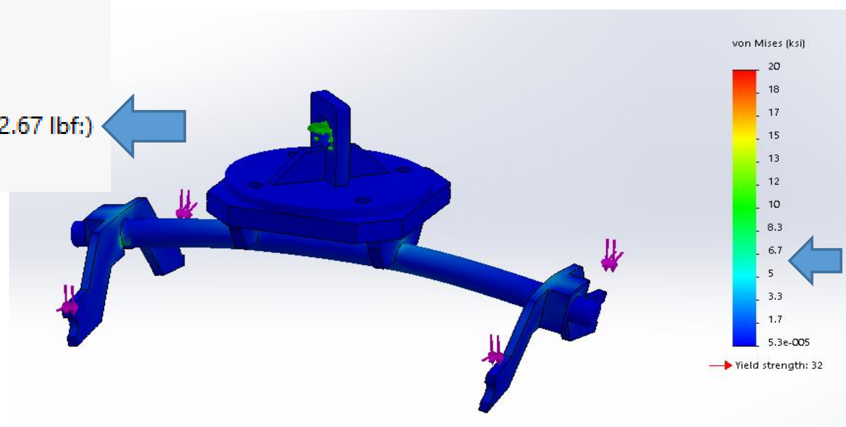
Table 3-4.3-1 Allowable Stress Ranges, ksi (MPa)

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)

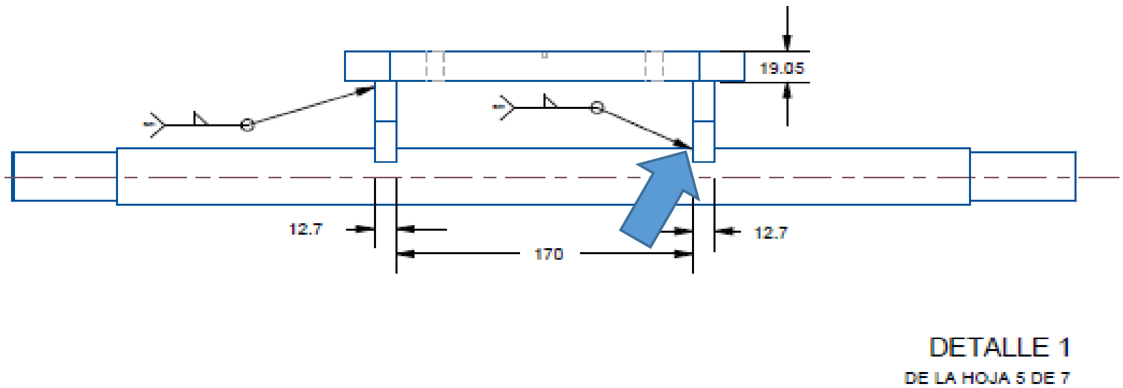
NOTE:
(1) Flexural stress range of 12 ksi (80 MPa) permitted at the toe of stiffener welds on flanges.

71





72	Actual Stress, F_a (ksi)	6	See above
73	Safety Factor	4.83	Fy/Fm = 1 OK

74	**Connection Weld Analysis -Top Lift Tab**		
75	 		
76	*(b)* The design strength of fillet or partial-joint-penetration groove welds subject to shear shall be equal to the effective area of the weld multiplied by the allowable stress F_v given by eq. (3-55). Stresses in the base metal shall not exceed the limits defined in section 3-2. $F_v = \frac{0.60Exx}{1.20N_d}$ (3-55)		
77	Allowable Stress, F_v (ksi)	11.667	See above Eqn. 3-55
78	Nominal Tensile Strength of weld material, E_{xx} (ksi)	70	Typical Value

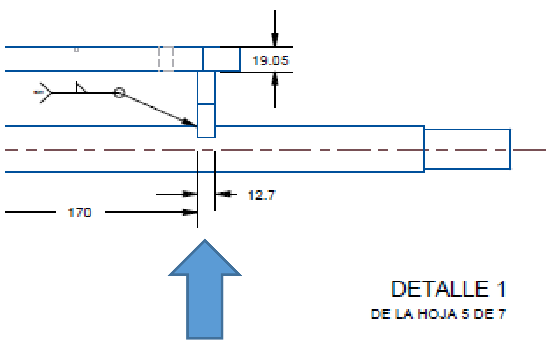
79

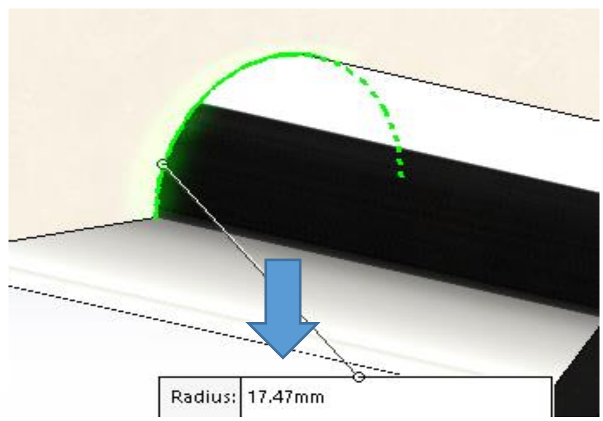
Table 3-3.4.3-1 Minimum Sizes of Fillet Welds

Material Thickness of Thicker Part Joined, in. (mm)	Minimum Size of Fillet Weld, in. (mm)
To $\frac{1}{4}$ (6)	$\frac{1}{8}$ (3)
Over $\frac{1}{4}$ (6) to $\frac{1}{2}$ (13)	$\frac{3}{16}$ (5)
Over $\frac{1}{2}$ (13) to $\frac{3}{4}$ (19)	$\frac{1}{4}$ (6)
Over $\frac{3}{4}$ (19)	$\frac{5}{16}$ (8)

80	Tensile Load, T_n (kips)	0.33	Iterative until safety factor met
81	Length of Tab, L (in)	2.16	(2πr/2)
82	Thickness of Tab, t (in)	0.50	
83	Length of Fillet Weld, L (in)	5.32	(2πr/2) x 2 + t x 2

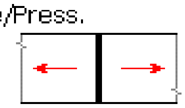
84





85	Weld Leg, W_{leg} (in)	0.13	Approximated from observation
86	Nominal Stress on Weld, F_n (ksi)	0.70	See below eqn (area of weld = length x effective throat thickness)

87

Load	Rated stress [MPa, psi]
Tensile/Press. 	$\sigma_\perp = \frac{F_n}{A_w} = \frac{F_n}{L \cdot a}$

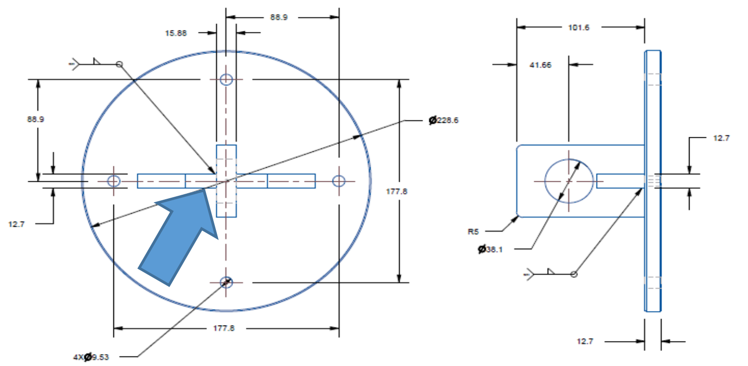
a = .707 x Wl

88	Safety Factor	16.57	F_v/F_n > 1 OK

89

Connection Weld Analysis -Top Lift Tab

90



91

(*b*) The design strength of fillet or partial-joint-penetration groove welds subject to shear shall be equal to the effective area of the weld multiplied by the allowable stress F_v given by eq. (3-55). Stresses in the base metal shall not exceed the limits defined in section 3-2.

$$F_v = \frac{0.60Exx}{1.20N_d} \qquad (3\text{-}55)$$

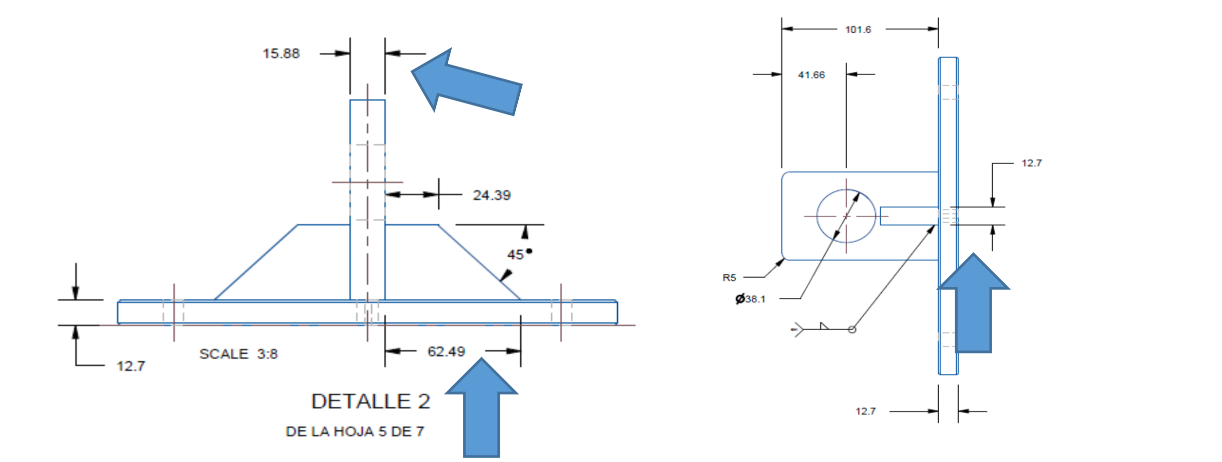
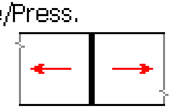
92	Allowable Stress, F_v (ksi)	11.667	See above Eqn. 3-55
93	Nominal Tensile Strength of weld material, E_{xx} (ksi)	70	Typical Value

94

Table 3-3.4.3-1 Minimum Sizes of Fillet Welds

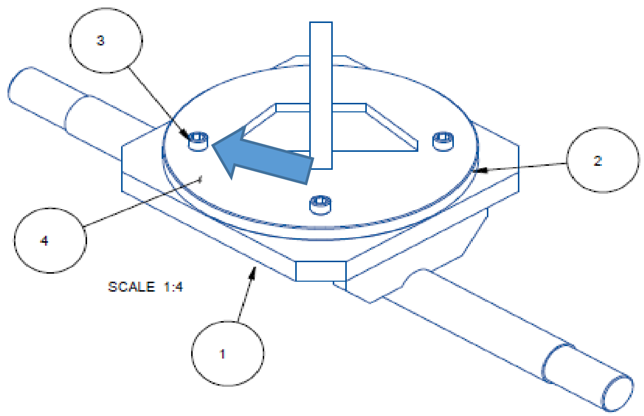
Material Thickness of Thicker Part Joined, in. (mm)	Minimum Size of Fillet Weld, in. (mm)
To $^1/_4$ (6)	$^1/_8$ (3)
Over $^1/_4$ (6) to $^1/_2$ (13)	$^3/_{16}$ (5)
Over $^1/_2$ (13) to $^3/_4$ (19)	$^1/_4$ (6)
Over $^3/_4$ (19)	$^5/_{16}$ (8)

95	Tensile Load, T_n (kips)	0.33	Iterative until safety factor met
96	Length of Tab, L (in)	5.50	L Total
97	Thickness of Tab, t (in)	0.50	

<table>
<tr><td>98</td><td>Length of Fillet Weld, L (in)</td><td>12.00</td><td>L x 2 + W x 2</td></tr>
<tr><td>99</td><td colspan="3">
</td></tr>
<tr><td>100</td><td>Weld Leg, W_{leg} (in)</td><td>0.13</td><td>Approximated from observation</td></tr>
<tr><td>101</td><td>Nominal Stress on Weld, F_n (ksi)</td><td>0.31</td><td>See below eqn (area of weld = length x effective throat thickness)</td></tr>
<tr><td>102</td><td colspan="3"><table><tr><td>Load</td><td>Rated stress [MPa, psi]</td></tr><tr><td>Tensile/Press. </td><td>$$\sigma_{\perp} = \frac{F_n}{A_w} = \frac{F_n}{L \cdot a}$$</td></tr></table>
a = .707 x Wl</td></tr>
<tr><td>103</td><td>Safety Factor</td><td>37.38</td><td>F_v/F_n > 1 OK</td></tr>
</table>

104 **Shear Analysis**

105



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3/8"-16 Thread Size, 1-1/2" Long

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Head Type	Socket
Socket Head Profile	Standard
Drive Style	Hex
System of Measurement	Inch
Thread Direction	Right Hand
Thread Size	3/8"-16
Screw Size Decimal Equivalent	0.375"
Thread Type	UNC
Thread Fit	Class 3A
Length	1 1/2"
Threading	Fully Threaded
Thread Spacing	Coarse
Head	
Diameter	9/16"
Height	3/8"
Drive Size	5/16"
Material	Black-Oxide Alloy Steel
Tensile Strength	170,000 psi

106	Max Rated Load, W_{max} (lbs)	11.0	***Assumed loading 100% of time***
107	Max Rated Lift Point Load, W_{mc} (lbs)	248.02	$W_{max/4}$
108	Surface Area, A (in²)	0.442	$A = \pi r^2 \times 2$
109	Shear stress, τ (psi)	561.40	$\tau = F/A$
110	Tensile Strength of Material, ft (psi)	170,000.0	See Above
111	Shear Strength of Material, ν (psi)	98,090.00	$0.577 \times f_y$
112	Safety Factor	174.72	=V/τ >1 OK