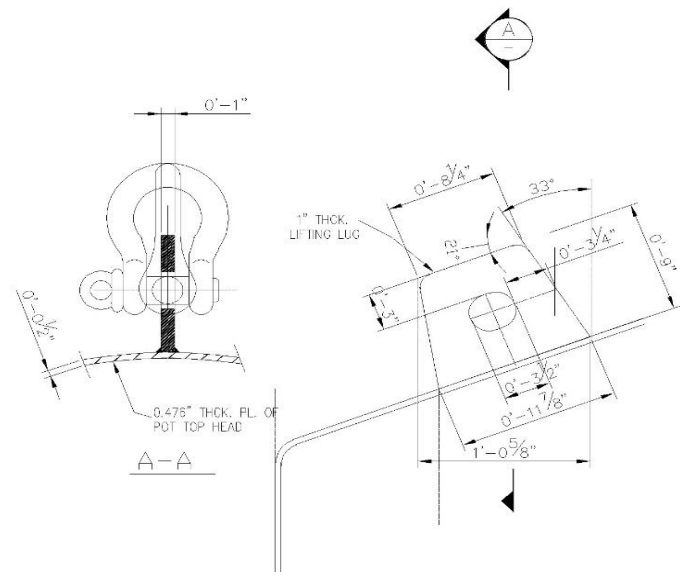
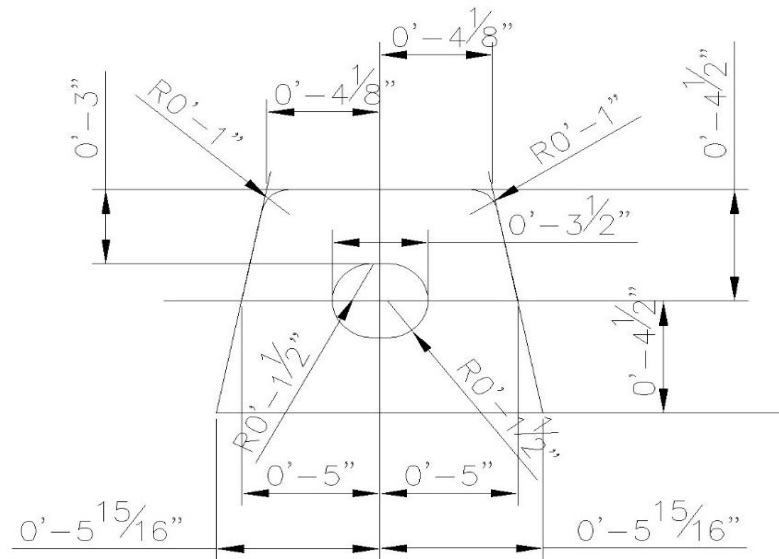


	A	B	C	D	E	F	G	H	I	J	K
1											
2	3-3.3 PINNED CONNECTION				Reference 1 : ASME BTH-1-2005: Design of Below-the hook lifting devices, Chapter 3, Structural Design						
3											
4	LUG PLATE DESIGN CHECK				Reference 2 : Work Safe BC, Part 15 Rigging						
5											
6	3-3.3.1	STATIC STRENGTH OF THE PLATES									
7											
8	PLATE MATERIAL										
9	Fy=		300 mPa								
10	Fu=		450 mPa								
11											
12	ALLOWABLE TENSILE STRENGTH THROUGH THE PIN HOLE Pt SHALL BE:										
13											
14	$P_t = \frac{F_u}{1.20 * N_d} * 2 * t * b_{eff} \quad (3-45), \text{ ref 1}$										
15											
16											
17											
18	As per Table C3-3 Design Category B Static Load Spectrum ref 1										
19											
20	Nd=		3.6 FOR CONNECTION (LUG PLATE)								
21	b _{eff} =		effective width of each side of the pin hole								
22											
23	b _{eff} ≤		4t		≤						
24											
25											
26											
27	b _e =		3.25 inch		=						82.55 mm
28	t =		1 inch		=						25.4 mm
29	Dh =		3 inch		=						76.2 mm
30											
31	b _{eff}	=	82.55 mm	=	3.25 inch	(3-46), ref 1					
32											



	A	B	C	D	E	F	G	H	I	J	K
33											
34											
35	$b_{eff} \leq be * 0.6 * \frac{Fu}{Fy} * \sqrt{\left(\frac{Dh}{be}\right)} \leq be \quad (3-47)$										
36											
37											
38	$b_{eff} = 71.38 \text{ mm} = 2.81 \text{ inch} \quad (3-47)$										
39											
40	$b_{eff} = 71.38 \text{ mm} = 2.81 \text{ inch}$										
41											
42	$Pt = 377.72 \text{ kN} = 38503.66 \text{ kg} = 38.50 \text{ T}$										
43											
44	ALLOWABLE SINGLE PLANE FRACTURE STRENGTH BEYOND THE PIN HOLE Pb IS:										
45											
46	$Nd_{fract} = Nd = 3.60 \quad \text{\S 3-1.3. (b)}$										
47											
48											
49	$Pb = \frac{Fu}{1.20 * Nd_{fract}} * \left[1.13 * \left(R - \frac{Dh}{2} \right) + 0.92 * be / \left(1 + \frac{be}{Dh} \right) \right] * t \quad (3-48)$										
50											
51											
52											
53	$R = 114 \text{ mm} = 4.488188976 \text{ inch}$										
54	distance from the center of the hole to the edge of the plate										
55											
56	$Pb = 316.64 \text{ kN} = 32277.08 \text{ kg} = 32.28 \text{ T}$										
57											
58	The allowable double plane shear strength beyond the pin hole Pv is										
59											
60	$Pv = 0.70 * \frac{Fu}{1.20 * Nd} * Av \quad (3-49)$										
61											
62											

	A	B	C	D	E	F	G	H	I	J	K	
63												
64	Av= total area of the two shear planes beyond the pin hole											
65												
66	$A_v = 2 * \left(R - \frac{D_h}{2} * \cos 45 \text{ deg} \right) * t$						(3-50)		Π=		3.141593	
67												
68												
69												
70	Av=		4422.61 mm2									
71												
72	Pv=		322.48 kN			=		32872.77 kg		=		32.87 T
73												
74												
75												
76												
77												
78												
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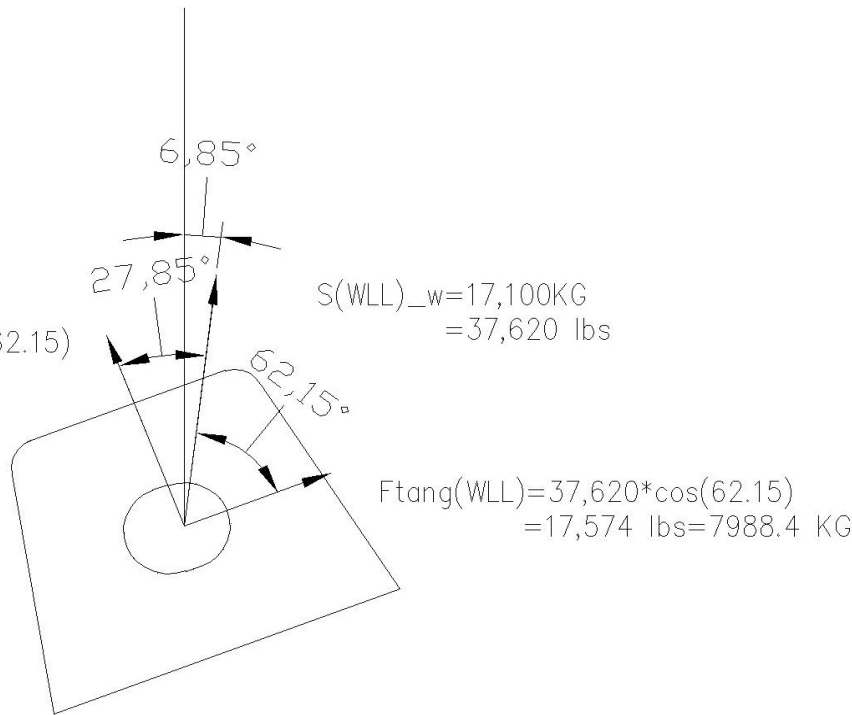


	A	B	C	D	E	F	G	H	I	J	K
94	OVERALL CAPACITY OF ONE LUG-PLATE BASED ON 4 MODES OF FAILURE:						WORKING LOAD LIMIT, WLL (PER ONE 1 LUG PLATE)				
95	angle: VERTICAL										
96	WLL(1)=		316.64 kN	=	32277.08 kg		=	32.28 T			
97	BELOW THE HOOK WLL (TOTAL FOR BOTH LUGS)										
98											
99	WLL, vert=		633.28	=	64554.17 kg		=	64.55 T			
100											
101											
102	LIFTING OF THE LOAD-OTHER THEN VERTICAL										
103	3-3.3.2 COMBINED STRESSES										
104	SLING ANGLE										
105	θ= angle in between sling and the horizontal line connecting the c/c of lifting lugs										
106	DISTANCE C/C OF LUG PLATES, dist_lugs				58 INCH		1473.2 mm				
107	LENGTH OF THE SLING (ALONG THE ANGLE),				243.5 INCH		6184.9 mm				
108	sling_lngth										
109	$\theta = \arccos\left(\frac{dist_{lugs}}{2 * sling_{lngth}}\right)$										
110											
111											
112	θ=		83.16 deg								
113											
114	PLATE ANGLE										
115	α angle in between the horizontal and the centerline of the hole parallel to the base line										
116											
117	α=		21 deg								
118											
119	angle in between the sling line and the c.l. thru hole parallel to base line of the lifting lug, ψ										
120											
121	ψ=θ-α										
122	ψ=		62.16003756 deg								
123											
124	angle in between the vertical c.l. thru the hook and sling line, ω										
125											
126	ω=		6.839962441 deg								

	A	B	C	D	E	F	G	H	I	J	K	
127		Based on Table 15-3 : WLL-reduction for slings at an angle						ref 2				
128		reduction=	90.00%									
129		nominal S(WLL) on one sling (for vertical sling line)				19 T	=		186.39 kN			
130		reduced S(WLL) _ω				17.1 T	=		167.751 kN			
131		S(WLL) is axial tension force in one sling for total WLL under the hook										
132												
133		$S(WLL) = \frac{WLL}{2\cos(\omega)}$										
134												
135												
136		F norm (WLL) IS THE TENSION ON THE LIFTING LUG (direction normal to base line of the plate)										
137		F tang (WLL) IS THE SHEAR/TANGENTIAL FORCE ON THE LIFTING LUG (direction PARALLEL to base line of the plate)										
138												
139												
140		$F_{norm}(WLL) = S(WLL) * \cos(90 - \psi)$										
141												
142		$F_{tang}(WLL) = S(WLL) * \cos(\psi)$										
143												
144		assume WLL to be reduced by sin of angle ψ										
145												
146												
147		WLL _ψ =WLL _{vert} *cos ψ										
148												
149		WLL _ψ =										
150												
151		S(WLL) _ψ =		167.75 kN								
152												
153		Fnorm(WLL)=	148.33 kN			15120.76848 KG						
154		Ftang(WLL)=	78.34 kN			7985.759867 KG						

	A	B	C	D	E	F	G	H	I	J	K
155							SECTIONAL FORCES AT SECTION BB-BB				
156											
157	$S(WLL)_w = 17,100 \text{ KG}$ $= 37,620 \text{ lbs}$										
158							$F_{norm} = 15119$ 148.32 kN				
159							$F_{tang} = 7988.4$ 78.37 kN				
160							$\text{lever arm} = 64$ 0.064 m				
161							$M(BB) = F_{tang} * \text{lever arm} = 5.01543706 \text{ kN-m}$				
162	$F_{norm}(WLL) = 37,620 * \cos(90 - 62.15)$ $= 33,262.6 \text{ lbs}$ $= 15,119 \text{ KG}$										
163							length of gross section at the section BB-BB				
164							$l_s = 268$ 0.268 m				
165							length of one side (half) of netsection at the section BB-BB, l_{eff}				
166							104 0.104 m				
167							60				
168							164 lever arm for moment				
169											
170											
171							stresses:				
172							normal stresses				
173							normal stress from F_n				
174							$f_t(N) = F_n / (2 * l_{eff} * t)$				
175											
176											
177											
178											
179							$f_t(N) = 28.0734 \text{ mPa}$				

	A	B	C	D	E	F	G	H	I	J	K	
180	normal stress from moment											
181	M=	5.02 kN-m										
182	Vertical force from moment resolution					total normal stress						
183												
184	lever arm=	164 mm			ft,total=ft(N)+ftb							
185	Vl=-Vr	30.58 kN										
186	stress	ftb=Vr/(0.7*leff*t)			ft,total=							44.61 mPa
187												
188												
189	ftb=	16.54 mPa										
190												
191												
192												
193												
194												
195												
196												
197												
198												
199												
200												
201	Fnorm(WLL)=37,620*cos(90-62.15)					(1) COMBO AXIAL TENSION+						
202	=33,262.6 lbs					TENSION (BENDING)						
203	=15,119 KG					$\frac{ft}{Ft} + \frac{f_{bt}}{Fb} \leq 1.0$ $Ft = \frac{Fu}{1.20 * Nd_{fract}}$ $Fb = Fy * \frac{1.25}{Nd}$						
204												
205												
206												
207												
208												
209												
210												
211												
212												



Ft= 104.17 mPa

Fb= 104.17 mPa

	A	B	C	D	E	F	G	H	I	J	K	
213		SHEAR STRESS						TOTAL NORMAL STRESS:				
214		$fv = \frac{Ft}{leff * t * 2}$						Ftn/Ft=	<u>0.269505</u>			
215												
216												
217								SUM	0.4283 ok			
218								NORMAL+				
219												
220		allowable stress Fv						$Fv = 0.70 * \frac{Fu}{1.20 * Nd_{fract}}$				
221												
222												
223								Fv=	72.92 mPa			
224												
225		$\frac{fv}{Fv} \leq 1.0$										
226												
227												
228												
229												
230												
231		(2) COMBINED NORMAL AND SHEAR STRESSES										
232												
233		$fcr = \sqrt{(fx^2 - fx * fy + 3 * fv^2)} \leq Fcr$										
234												
235												
236								fxtotal=	44.61 mPa	fy=	0	
237								fv=	14.83 mPa			
238												
239								fcr=	51.48 mPa			
240												
241		$Fcr = \frac{Fy}{Nd}$										
242												
243												
244								Fcr=	83.33 mPa			
245												

	A	B	C	D	E	F	G	H	I	J	K	
246		$\frac{fcr}{Fcr} = 0.62 \text{ ok}$										
247												
248												
249												
250		Since all checks are passed we can adopt:										
251		WLL_ψ=2*S(WLL)_ψ*cos(ω)										
252												
253		WLL_ψ= 333.11 kN			33.96 T							
254												
255		WLL BASED ON CAPACITY OF THE LIFTING LUGS, ONLY=										
256												
257		WLL_ψ= 539.22 kN			54.97 T							
258												
259												
260												