ENGINEERING REPORT

Date: 5 August 2008
From: Walt Whitaker, P.E.
Subject: Final Report, Stress Calculations for XPR-10 Two Post Lift

Summary:

After a careful evaluation and resizing of members, it was found that the XPR -10 (standard, extended & asymmetric) models meet and/or exceed all ALI specifications for strength of the structure. The structural analysis was based on obtaining a factor of safety of 3:1 on all mechanical members made out of ductile materials and a factor of safety of 5:1 on all mechanical members made out of brittle materials over that of the material's ultimate tensile strength. The analysis investigated bending; bearing, compression; shear and tensile stresses induced on the arms, lift head and structure by the rated load as well structure weights. All load cases considered were done in accordance with ALI loading parameters.

XPR-10 System Loading Analysis

Load Case Considered

The major load cases consider during the design a[illegible]sis include
specified by the ALI 2006 standard[illegible]din[illegible]d she[illegible]s a
in Appendix A. Shear a[illegible]m[illegible]ran[illegible]ving[illegible]ain[illegible]m[illegible]ing
are presented i[illegible]Ap[illegible]

LOA[illegible]	L[illegible] VAR[illegible]	OAD / FORCE DESC[illegible]	LOAD VALUE (LbF)
	[illegible]	Load Point 1 (Forwa[illegible] on left side)	2,500
	WL	L[illegible] (Rea[illegible] lef[illegible]	2,500
	WL	L[illegible] Forw[illegible] on r[illegible]de)	2,500
	[illegible]	Lo[illegible]ar a[illegible]de)	2,500
2	[illegible]	C[illegible] Loa[illegible]ating + cable pulley friction)	2,964*

* Refer to A[illegible]A for a[illegible]and cable loads

[illegible]ble 1: Listing of forces induced on major system members.

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	[illegible]	Lo[illegible]ar a[illegible]de)	2,500
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System Loading

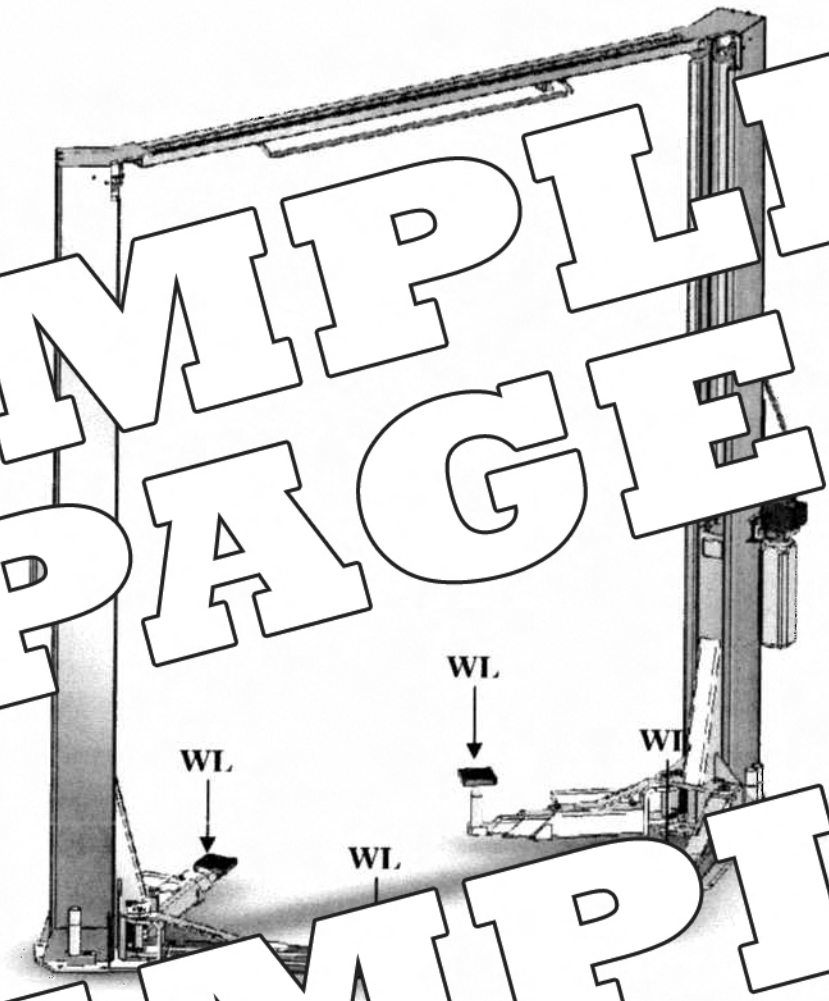


Figure 1: Displa g on
AC owi

XPR-10 Materials

Materials Used in Construction

The material used in the construction of the XPR-10 seri omotive li ver under the internationally recognized A nd r so ha AWS standards for weldin he f ste at ound and channel used in th str lude 36, ASTI ANSI A500, Q235, GB/T 699 G Grad l welding wire used in the fabrication s conf S an -7 n load cables us ith the ndard sp w ated at point of c lat

SAMPLE PAGE

XPR-10 Stress Analysis

Item of Interest 1) Synchronization Lift Cables

Figure 2 Cable Under Loa

A sis :

Ar e

e ress: Tensile

Base Eq

$$\frac{F_{ult}}{F}$$

Force Par F = 2,964 LbF (CL load case 2, Table 1)

Material Parameter: F_{ult} = 13,940 LbF (10mm 7x19 IWRC RRL 1870MPa GALV wire rope)

Load: F = 2,964 LbF

=4

Analysis 1b)

Location of Analysis: Cable threaded end

Type of Stress: Tensile

Force Parameter: F = 2,964 LbF (CL load case 2, Ta

Base Equations: τ = $\frac{F}{A}$ &: $\frac{\quad}{\quad}$

Par te $_{ult}$ in (Cross sectional ro x 2.5)

ate S_{ult} = 65,250 si (GF 9 Grade 20)

Load: τ = Sa acto **SF= 7.75**

Item of Interest 2) Hydraulic Cylinder Lift Ring

Figure 3: Hydraulic Cylinder Lift Ring Under Load.
Refer to Appendix A for Actuator Loading.

Analysis 2a)

Location of Analysis: Hydraulic cylind

Type of Stress: C essi

quatio $\sigma = \frac{F}{A_g}$ &: $SF = \frac{S_{ut}}{\sigma}$

ran A LbF (See Ap actu d p adi

try Parameter: (R se rea)

Material Parameter: S_{ut} psi

Load: σ = 3,085 psi **Safety Factor: SF= 17.62**

Analysis 2b)

Location of Analysis: Hydraulic cylinder lift ring

Type of Stress: Weld shear

Base Equations: $\tau_w = \frac{F_w}{A_w}$ &: $SF = \frac{0.577 \times S_{ult}}{\tau_w}$

&: $A_w = 0.707 L_w \times T$ gth

Force Parameter: = 8 (Se A, actu ey loading table)

Par: te .385 in diameter ld)

T_w = 0.25 in .25 in weld)

L_w =

Materia S_{ult} = 275 -70S-6 welds S_{ult} =70,000 psi use Q235 mating materials S_{ult})

Load: τ_w = 6,051 psi **Safety Factor: SF= 5.18**

Analysis 2c)

Location of Analysis: Hydraulic lind

Type of Str tress

quati $= \frac{P}{2}$ &: $SF = \frac{S_{ult}}{\sigma_{hoop}}$

ra eter: P = 2,550 1 L ^{2} are

Geometry Parameter: (Cyli in eter)

T in (Cylinder wall)

Material Parameter: S_{ult} = 54,375 psi (Q235)

Load: σ_{hoop} = 13,643 psi **Safety Factor: SF= 3.99**

Item of Interest 3) Cable Sheave Bracket and Pin

Figure ed B etuator.
Pulley Fricti ef pp r Pulley Loading

Analysis 3a)

Location of Analysis: Cable sheave clevis pin

Type of Stress: Bearing

Base Equations: $A_{bearing} = 2*D*T$ &: $\sigma = \frac{F}{\_\_\_\_\_}$ $SF = \frac{S_{ult}}{\sigma}$

Force Parameter: $F = 5{,}727$ lbF

Geometry P D

0.2

$A_{bearing} = 0.464$ in^2 (

Material Param S_{ult} = (Q

Load: Safety Factor: **SF= 4.41**

Analysis 3b)

Location of Analysis: Cable sheave clevis pin

Type of Stress: Tensile tearout

Base Equations: $A_{tto} = 2$ x W &: $\_\_\_\_\_$ $SF = \frac{S_{ult}}{\sigma}$

Force Para 5,727

Geometry P in

$T = 0.236$ in

0.7

Material Parameter: S_u 375 psi (

Load: $\sigma = 7{,}904$ psi Safety Factor: **SF= 6.88**

Analysis 3c)

Location of Analysis: Cable sheave clevis pin

Type of Stress: Shear tearout

Base Equations: $A_{sto} = 4*L_{cl}*T$ &: $\tau = \frac{F}{A_{sto}}$ &: $F = \frac{0.57}{\tau}$

Force Parameter: F = 5,727

Geometry P n (Di om center of hole to edge)

0

$A_{sto} = 0.82$ in^2

Material Par (Q2

Load: τ **Safety Factor: SF= 4.50**

Analysis 3d)

Location of Analysis: Cable Sheave Clevis pin

Type of Stress: Shear

Base Equations: $\tau = \frac{F}{A}$ &:

For ...aran...

...Para...ter: ... in (Pin cross sect... ar... es)

D = 0.0...

Material P... ... = ...0... (GE... ...5)

Load: τ ... psi **Safety Factor: <u>SF= 13.34</u>**

Analysis 3e)

Location of Analysis: Cable Sheave Clevis

Type of Stress: Weld stres...

Ba... Equat... $= \frac{F_w}{A_w}$ ... S_{ult}

...0... T_w (T_w is filet length)

...ra...eter: F_w = 5,727 l...

Geometry Parameter...

$T_...$ in (fillet weld)

$Aw = 0.842$ in^2

Material Parameter: S_{ult} = 54,375 psi (ER-70S-6 welds S_{ult}= 70,000 psi use Q235 mating materials S_{ult})

Load: σ_w = 6,802 psi **Safety Factor: <u>SF= 4.61</u>**

Item of Interest 3) Cable Sheave Bracket and Weld Bending

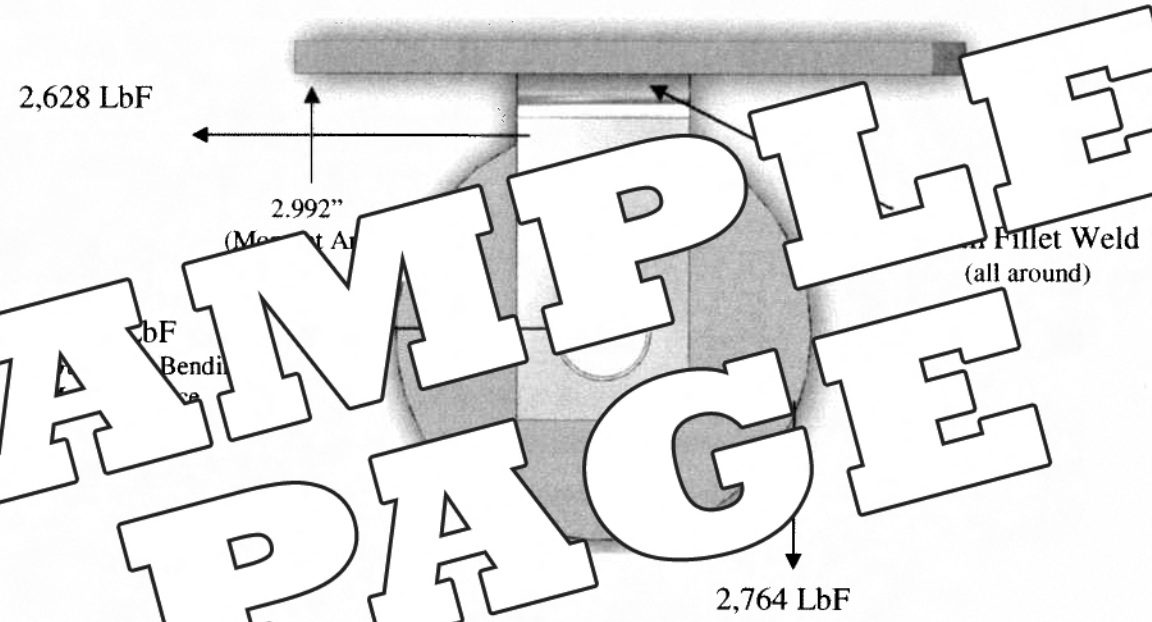


Figure 5: Sheave with Side Load due to 90 Degree Cable Routing. Pulley Bushing Friction Included. Side Load Creates a Bending Moment on Sheave Bracket and Wel
Refer to Appendix A for Pulley Loading.

Analysis 3f)

Locatio[illegible] **si**[illegible] heav[illegible] ket

[illegible] **of St**[illegible] B[illegible] ng [illegible] ensile Stress

Base Equations: $M=$ [illegible] &: σ [illegible] M^* [illegible] $SF = \frac{S_{ult}}{\sigma}$

[illegible] max [illegible]

Force [illegible] **eter**: F_{rea} [illegible] 2,628 LbF (Refer to Figure 5)

Geom[illegible] **y Parameter:** I = 0.84 in^4 (20 mm wide sheave, 6 mm thick bracket arms)

C= 1.26 in (2.52 in wide bracket)

d= 2.677 in (A[illegible] st[illegible] le[illegible] 992 [illegible] 31[illegible]

[illegible] i[illegible] t cros[illegible] n, both arm[illegible])

ateri[illegible] **er:** S_u [illegible] 54 [illegible] si

[illegible] b = 10 [illegible] psi [illegible] 2 [illegible] psi

[illegible]: σ [illegible] = 12,810 psi **S**[illegible] **acto**[illegible] **= 4.**[illegible]

Analysis 3g)

Location of Analysis: Cable Sheave Bracket

Type of Stress: Weld Stress

Base Equations: $\tau_p = F_{reactio}$[illegible] $_{eld}$ ([illegible] : [illegible] $=D^*$ [illegible]

&: τ [illegible] C [illegible] (b[illegible]) [illegible] A [illegible] $= 0.707 * 2 * h *$ [illegible]

τ [illegible] τ_p [illegible] $+ \tau_b * \tau_b)^{1/2}$ & [illegible] 577* [illegible]

&: $Iu = d^2*(3*b+d)/6$

Force Parameter: $F_{reaction}$ = 2,628 LbF (P

Geometry Paramet

2.

2.992 in

b =

= (eld

Material P r: S_{ult} = 54,375 psi (ER-70S-6 welds S_{ult}= 70,000 psi use Q235 mating materials S_{ult})

M = 7,863 LbF – in

A = 1.682 in^2

Iu = 15.951 in^3

I = 2.662 in^4

62 ps

Load: τ = 5,238 psi **Factor of Safety SF = 5.99**

Item of Interest 4) Lift Arm

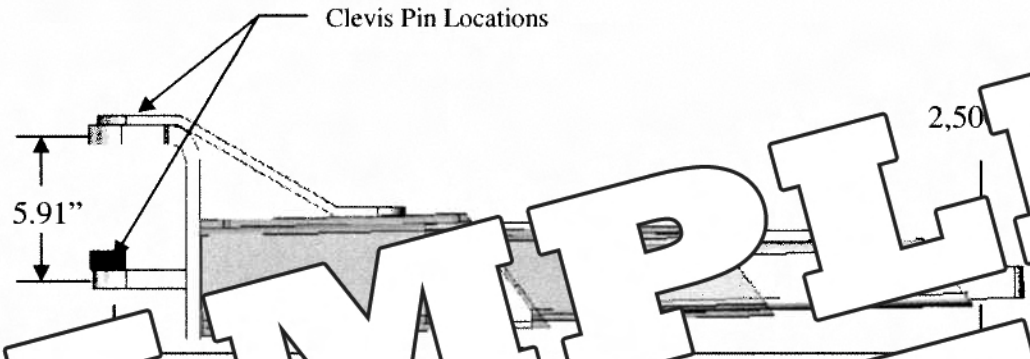


Figure 5: Lift A ad.

ample calculatio sho on 4. pen for plete set of arm stress c

Analysi

Location alysis: Lift arm tube (Arm LP800893 at 25.51 in. from clevis pin)

Type of Stress: Bending

Base Equations: $M=L*F$ &: $\sigma = \frac{M*C}{I}$ &: $\sigma \leq S_{ut}$

Force Parameter: F = 2,50 L 1, Ta

Geometry I = m ork

l (From Solidworks)

L= 32.48 in (D n loa 99 51

Material Parameter: S psi (

Load: σ = 17,219 psi **Safety Factor: SF= 3.16**

Analysis 4b through 4d Clevis Load)

Location of Analysis: Lift arm clevis loads

Type of Stress: Calculation of clevis moment and reaction forces for b t
analysis. Calculation for longest arm (LP-800893) fully worse ca g.

Base Equations: $M = D*F$ &

Force Para WL se 1, Table

ry Par te is (Distance from clevis lines)

$D =$ 57.99 in (Distan n lo to clev cen e)

oad: F_{clevis} = Lb

Analysi

Location of Analysis: Lift arm clevis

Type of Stress: Bearing

Base Equations: $A_{bearing} = D*T$ &; σ σ

Force Parame is =

try Pa n = 1.

1.023 in (Thip

n^2

Material Parameter: S_u psi (

Load: σ = 16,023 psi **Safety Factor:** **SF= 3.40**

Analysis 4c)

Location of Analysis: Lift arm clevis

Type of Stress: Tensile tearout

Base Equations: $A_{tto} = W_{to} * T$ &

Force Param

y Par te

$T = 0.787$ in

A_{tto}

Materia et $_{ult}$ = 235)

Load: σ = psi **Safety Factor: SF= 4.02**

Analysis 4d)

Location of Analysis: Lift arm clevis

Type of Stress: Shear tear

quatr $2*L_{cl}$ & A_{tto} &

Fore ra F_{clevis} = 24,531 LbF

Geometry Parameter 1.8 (Di ter of hole to edge)

7 7 in

A_{sto} = 2.975 in^2

Material Parameter: S_{ult} = 54,375 psi (Q235)

Load: τ = 8,246 psi **Safety Factor: SF= 3.80**

Analysis 4e)

Location of Analysis: Lift arm clevis pin

Type of Stress: Shear

Base Equations: $\tau = \frac{F_{clevis}}{A}$ &;

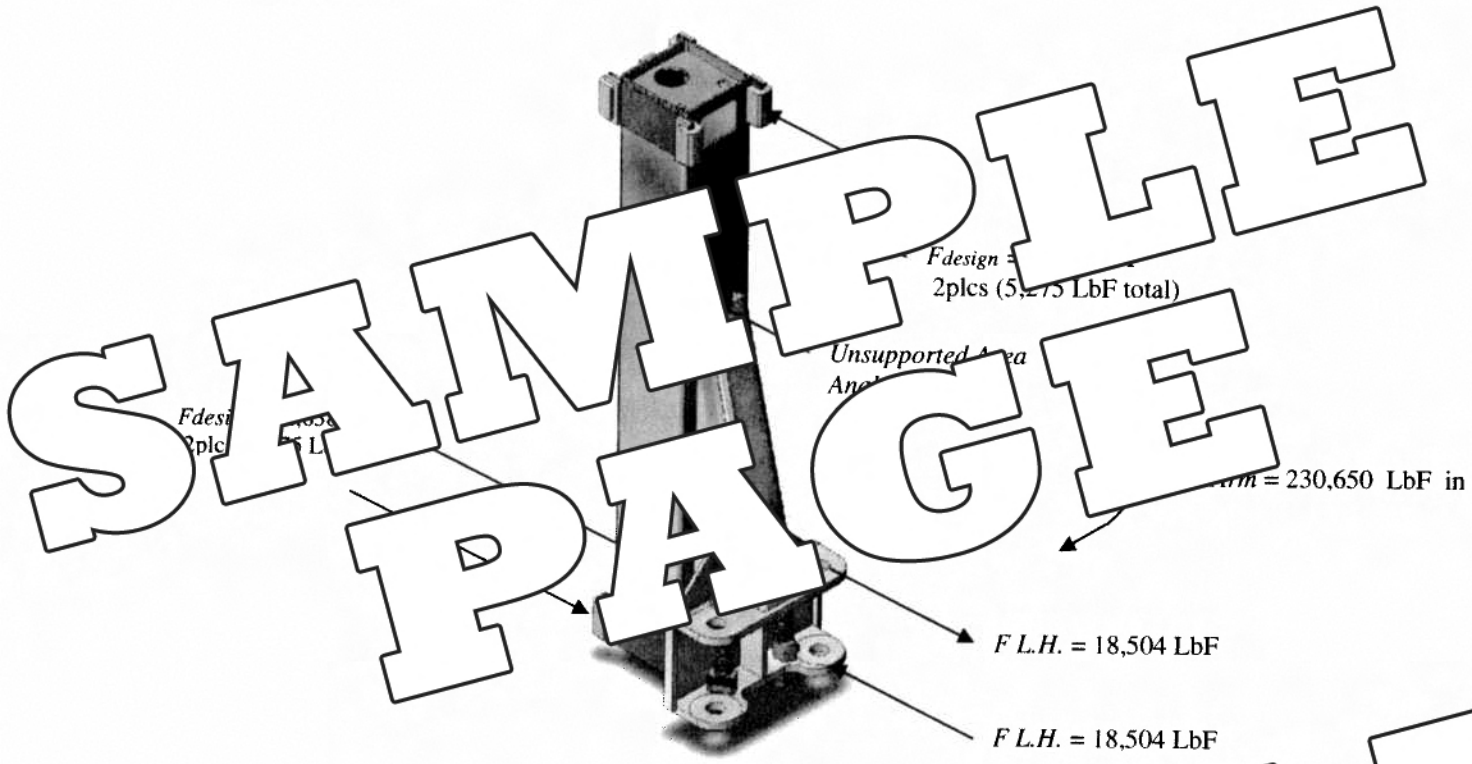
Fore[illegible]ram[illegible]; [illegible]pF

A[illegible] Para[illegible]er: [illegible] (Pin cross secti[illegible] ar[illegible]

[illegible]ter[illegible]meter: S_{ult} = 87.0[illegible]i (GF[illegible]9 Grad[illegible])

Load: [illegible] **Factor:** **SF= 3.60**

Item of Interest 5) Lift Head



Figu : L Under

Analysis 5a)

Location of Analysis: Lift head clevis

Type of Stress: Bearing stress

Base Equations: $A_{bearing} = D*T$ &: $\sigma = \frac{F_{L.H.}}{A_{bearing}}$ &: $\sigma = \frac{S_{ult}}{}$

Force Parameter: $F_{L.H.}$ = F (L ad cle ppendix B
p L arm loadi eadsheet)

C y P .

0.1 in

A_{bear} in^2

Materi = 3 (Q2

Load: σ psi **Safety Factor: SF= 3.12**

Analysis 5b)

Location of Analysis: Lift head clevis

Type of Stress: Tensile tearout

Base Equati W_{to} $\frac{F}{A}$ &: $\frac{S_{ult}}{\sigma}$

Paran 18,5 F ad on lift head clevi App
page 2 of arm loadi eadsheet)

y Parameter: W_{to} = 2 (3. – 1. hol

A 16 in^2

Material Parameter: S_{ult} = 54,375 psi (Q235)

Load: σ = 10,783 psi **Safety Factor: SF= 5.04**

Analysis 5c

Location of Analysis: Lift head clevis

Type of Stress: Shear tearout

Base Equations: $A_{sto} = 2*L_{cl}*T$ [illegible]: [illegible] &: [illegible]

Frame [illegible].5 [illegible] (Lift head clevis. Refe[illegible]endix B page 2 of arm loading [illegible])

Com[illegible]ra[illegible]ter: L_{cl} = 1.960 i[illegible] (Dista[illegible]om center of [illegible]ed

T = [illegible]

A_{sto} [illegible].79[illegible]

Material P[illegible]r: S_{ult} = 54,375 psi (Q235)

Load: τ = 6,658 psi

Safety Factor: **SF= 4.71**

Analysis 5d)

Location of Analysis: Lift head main post

Type of Load: Reaction forces on lift head

Base Equations: $M_{arms}=L*F$ … &: … $=$ … &: … σ

… 110 … stment for improper vehicle placement)

… amet … $F=$ … % of load rating)

… om … rameter L= 46.15 in (Dista… om load)

… $D=$ … Lift … ctio… acing)

***F**$_{design}$* = 5… actio… rce… ead post)

Location of Analysis: Lift head main post

Type of Stress: Reaction Bending

Base Equations: $M=d*F_{design}$ &: σ … $M*C$ … SF …

Force Paramet… … $_{ign}$ = … ac… orces … ead post)

… try P… … = 3… in … om … dworks)

… = 3.54 in (From … rks)

… ns… or … anc…

Material Parameter: S… 75 psi (…

Load: σ = 8,870 psi **Safety Factor:** <u>**SF= 6.13**</u>

Analysis 5e)

Location of Analysis: Lift head lift plate

Type of Stress: Shear

Base Equations: $\tau = \frac{F}{A}$ ...

...rameter: F ... L... (See Appendix A, actuator ... ding table)

...: A_{ring} = 3.53 in^2 (3.0 in ... thic...

...erial Parameter: S_{ult} = ... (Q2...

Load: ... 9... **Safety Factor:** **SF= 13.83**

Analysis 5f)

Location of Analysis: Lift head lift plate

Type of Stress: Weld shear

...quatio... $= \frac{F_w}{A_w}$ ... $= \frac{...}{\tau_w}$ &: A_w = 0... * L...

For...: F_w = 8,011 LbF (See ..., act... and ... load...)

Geometry Parameter: L ... (2.50 ... m... ...)

T ... in (fillet weld)

A_w = 1.387 in^2

Material Parameter: S_{ult} = 54,375 psi (ER-70S-6 welds S_{ult}= 70,000 psi use Q235 mating materials S_{ult})

Load: τ_w = 5,776 psi **Safety Factor:** **SF= 5.43**

Analysis 5g)

Location of Analysis: Safety latch pin

Type of Stress: Shear

Base Equations: $\tau = \frac{F}{A}$ [illegible]

[illegible]rame[illegible] [illegible] L[illegible]/2 r[illegible] plus movable li[illegible]

[illegible]om[illegible] ra[illegible]eter: A = 0.789 [illegible] (Pin c[illegible]ctional [illegible]ea, [illegible] di[illegible]r, 2 slices)

Material Pa[illegible] S_{ult} [illegible] (G[illegible] G[illegible]45)

Load: τ [illegible] **Safety Factor:** <u>**SF= 7.40**</u>

Analysis 5h)

Location of Analysis: Safety Release Plate

Type of Stress: Bearing stress (Note: Be[illegible]ss [illegible] than shear tearout[illegible]

Base Equat[illegible] [illegible] D [illegible] $\frac{F}{A}$ [illegible] $SF = \frac{S_{ult}}{\sigma}$

[illegible]ran[illegible]r: F [illegible] LbF (1/2 rated lo[illegible]s mo[illegible]ft wei[illegible]

[illegible]y Parameter: D= [illegible]

T [illegible] (2 bea[illegible]u[illegible] mm each)

A [illegible]670 in^2

Material Parameter: S_{ult} = 54,375 psi (Q235)

Load: σ = 7,985 psi **Safety Factor:** <u>**SF= 6.81**</u>

Item of Interest 6) Column

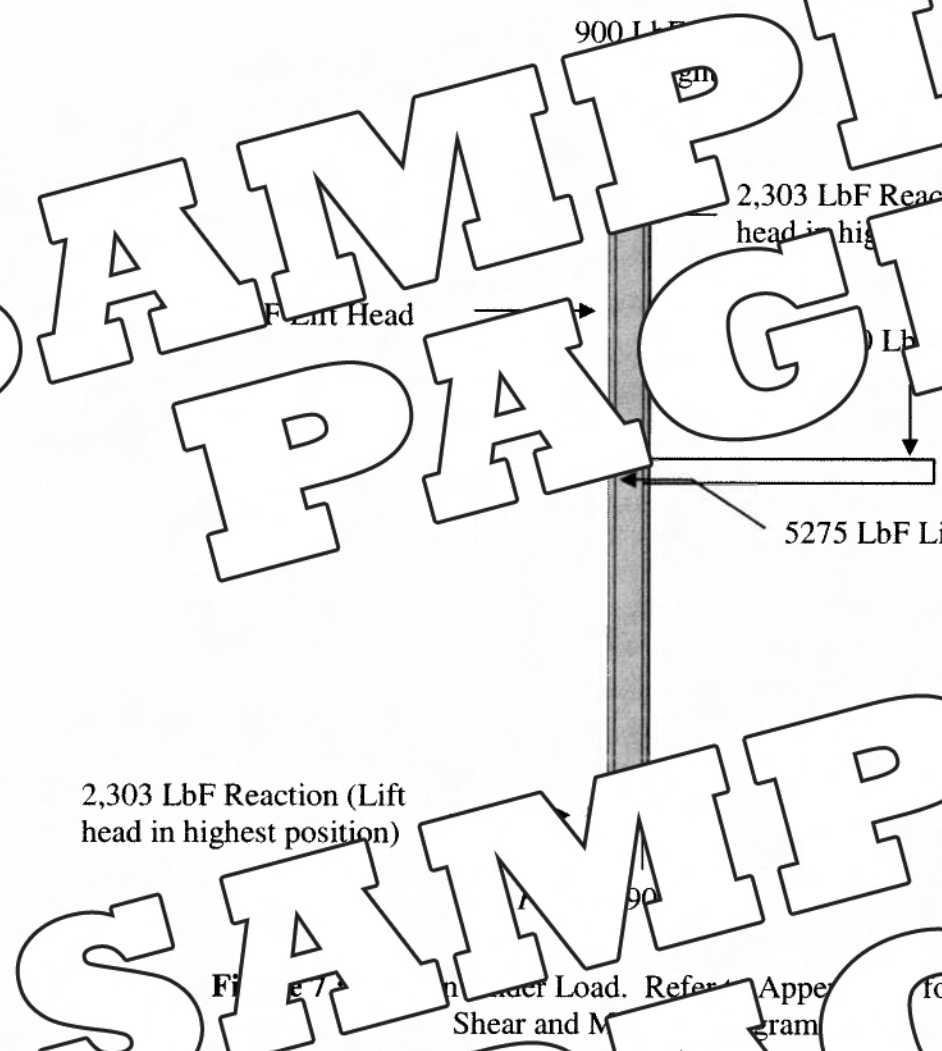


Figure 7 Column Under Load. Refer to Appendix for Column Shear and Moment Diagram

Analysis 6a)

Location of Analysis: Main column

Type of Stress: Bending

Base Equations: σ = [illegible] σ

[illegible]rame [illegible] 8[illegible] in. [illegible] to shear and mo[illegible] in
[illegible] Ma[illegible]ment is when lift h[illegible] is i[illegible]west position)

[illegible]ameter: I = 99.0[illegible] (Fro[illegible] work[illegible])

[illegible]=5[illegible] [illegible]m [illegible]

Material [illegible] S_{ult} = [illegible]75 [illegible](235)

Load: σ [illegible]psi **Safety Factor: SF= 7.62**

Analysis 6b)

Location of Analysis: Main column

Type of Stress: Compressi[illegible]

[illegible]quati[illegible] $\frac{F}{\text{[illegible]}} = \sigma$

To[illegible]m[illegible]n = σCompression (ax[illegible]ding [illegible]a)

Force Parameter: F = [illegible]0[illegible]

Geometry Parameter: [illegible] [illegible]6 in^2

Material Parameter: S_{ult} = 34,375 psi (Q235)

Load: σ = 924 psi Compression (Axial)

Total Compression: σ = 8,057 psi **Safety Factor: SF= 6.75**

Item of Interest 7) Top Beam (Trough)

Analysi

Location of Analysis: Top Beam at weld. Top beam material failure at weld is worse case loading and is analyzed in 7.

Type of Stress: Shear

Base Equations: $\tau = \frac{F_w}{A}$ $\frac{S_{ult}}{}$ $A = L_w * T$

Param 1,931 (2 Lb ley load + 2,302 olu tion)

Pa et 8.346 in (2 wel in e

Th et id that d)

A

Material Parameter: S 5 psi

Load: τ = 5,001 psi **Safety Factor: SF= 6.27**

Appendix A:

Actuator and Pulley Loading

SAMPLE PAGE

Cable Friction and Pulley Sheave Loading

Pulley	Load Description	Load	Pulley dia.	Shaft dia	Pulley	U
		lbs.	D - in.	d -		
	ALI Cable Load	2,500				
Pulley 1-90 deg vertical	Friction			1.0		0.16
Pulley 1-90 deg vertical	Load w/ Friction	62	2	1.0		0.16
Pulley 2-90 deg vertical	Friction	135				0.16
Pulley 2-90 deg vertical	Load w/ Friction	2,763			3,814	0.16
Pulley 3-180 deg	Friction	201	.62	1.0		0.16
Pulley 3-180 deg	Cable Load w/	2,964	4.52		5,727	0.16

Cable Friction and Pulley Sheave Loading

Pulley	Load Description	Load	Pulley dia.	Shaft dia	Pulley	U
		lbs.	D - in.	d -		
	ALI Cable Load	2,500				
Pulley 1-90 deg vertical	Friction			1.0		0.16
Pulley 1-90 deg vertical	Load w/ Friction	62	2	1.0		0.16
Pulley 2-90 deg vertical	Friction	135				0.16
Pulley 2-90 deg vertical	Load w/ Friction	2,763			3,814	0.16
Pulley 3-180 deg	Friction	201	.62	1.0		0.16
Pulley 3-180 deg	Cable Load w/	2,964	4.52		5,727	0.16

Actuator and Pulley Loading

XPR-10 Loading		
Rating	10,000	lbs.
Movable Lift Weight	716	lbs.
Total Lift Load	716	lbs.
Actu		
Act	2,550	
Actua		in.
uator Design Load	8,	
um		
	8,011	lbs.
l Requirement	2,964	lbs.
Pulley Sheave Pin	5,727	lbs.

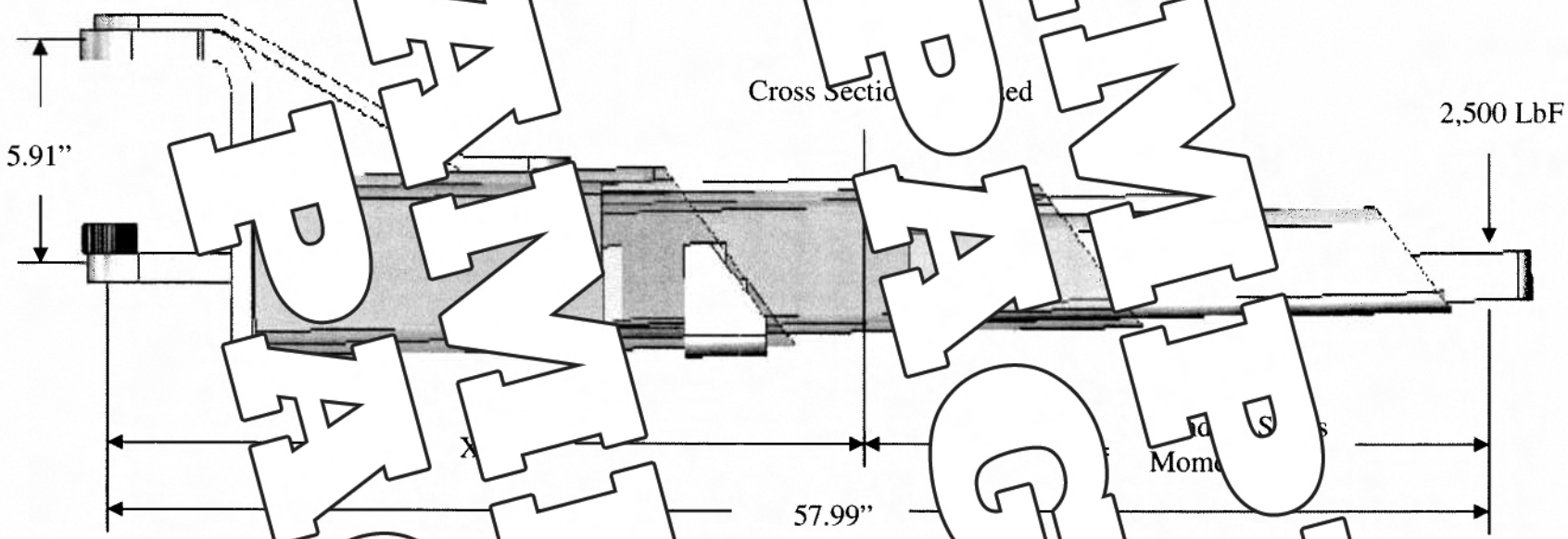
SAMPLE PAGE

Appendix B:

Arm Loading Spreadsheets

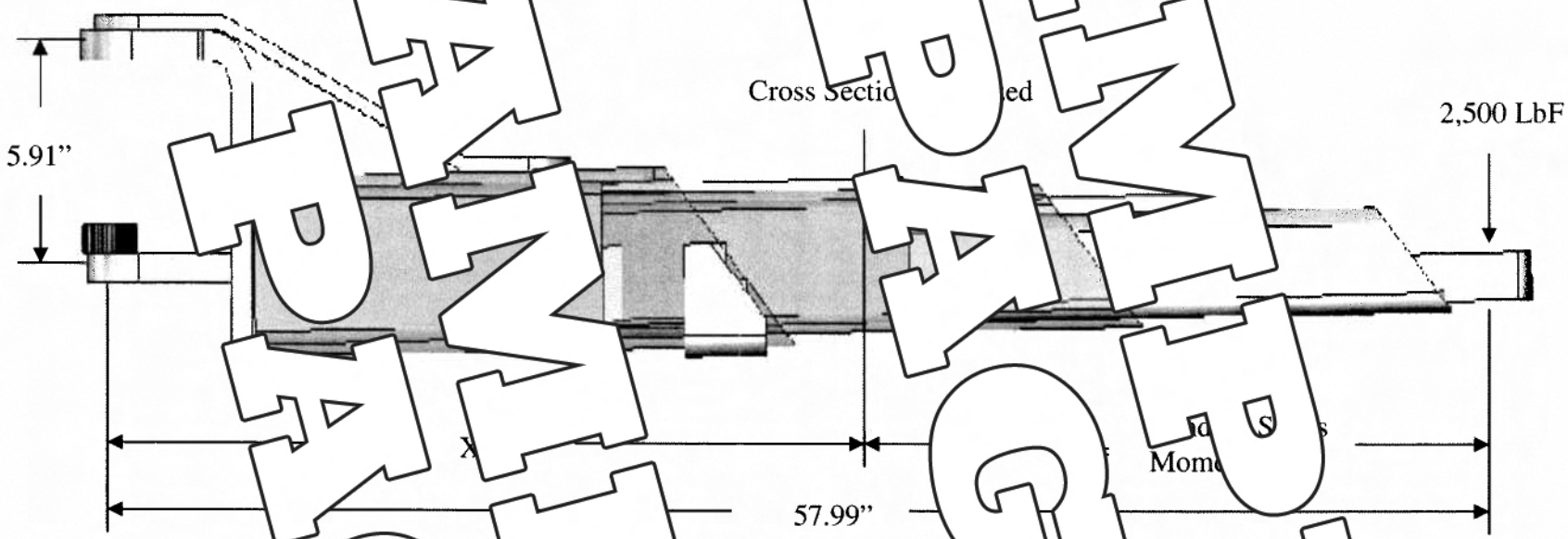
SAMPLE PAGE

Appendix B) L[illegible]nalysis



[illegible]igure 9 : Lift Arm Under Load.

Appendix B) L[illegible]nalysis



[illegible]igure 9 : Lift Arm Under Load.

XPR-10 ALI LP-800893 Q235 Long Arm Stress Calcs | **XPR-10AC** | **XPR**

08/07/08 | 10:29 AM

art # = **LP800893**

oad = **10,000** | 2,500 | # per Arm

d ment = 144,980

Station	X-Load Dist. (Inches)	L-M (In	ment (#)	Ixx (Inches)4	c (nches)	Fb Applied (Psi)	Fb Allow. (Psi)	S.F.
A	0.00	5	1 80		8.32	17,154	54,375	3.17
B	4.17	53	1 47		.34	14,527	54,375	3.74
C (100 mm Sq. x 8 mm Wall W	19.06	38.93	0	14 1	47	16,978	54,375	3.20
100 8 mm)	25.51	32.48	00		1.97	17,219	54,375	3.16
E (70 mm all W mm Caps)	37.85	20.14	50,355		1	17,864	54,375	3.04
mm x 1.25" Wid	47.76	10.23		2.29		15,419	54,375	3.53
70 n Sq.	56.26	1.73				17,693	54,375	3.07
	57.99	0.00						

XP-10 Lift Ear Pa 00986/184 | Spacing = .91 | M

ens. Load (#) = 4,531

			Fut=	54,375 psi
			Fus=	31,374 psi

ngth (in.) | Part # = 80 | Ma | 69

		Gr	Fut=	87,000 psi
			Fus=	50,199 psi

ar Pi 1.496

iting Ear Width = 99

Arm iting Ear Thickn 7

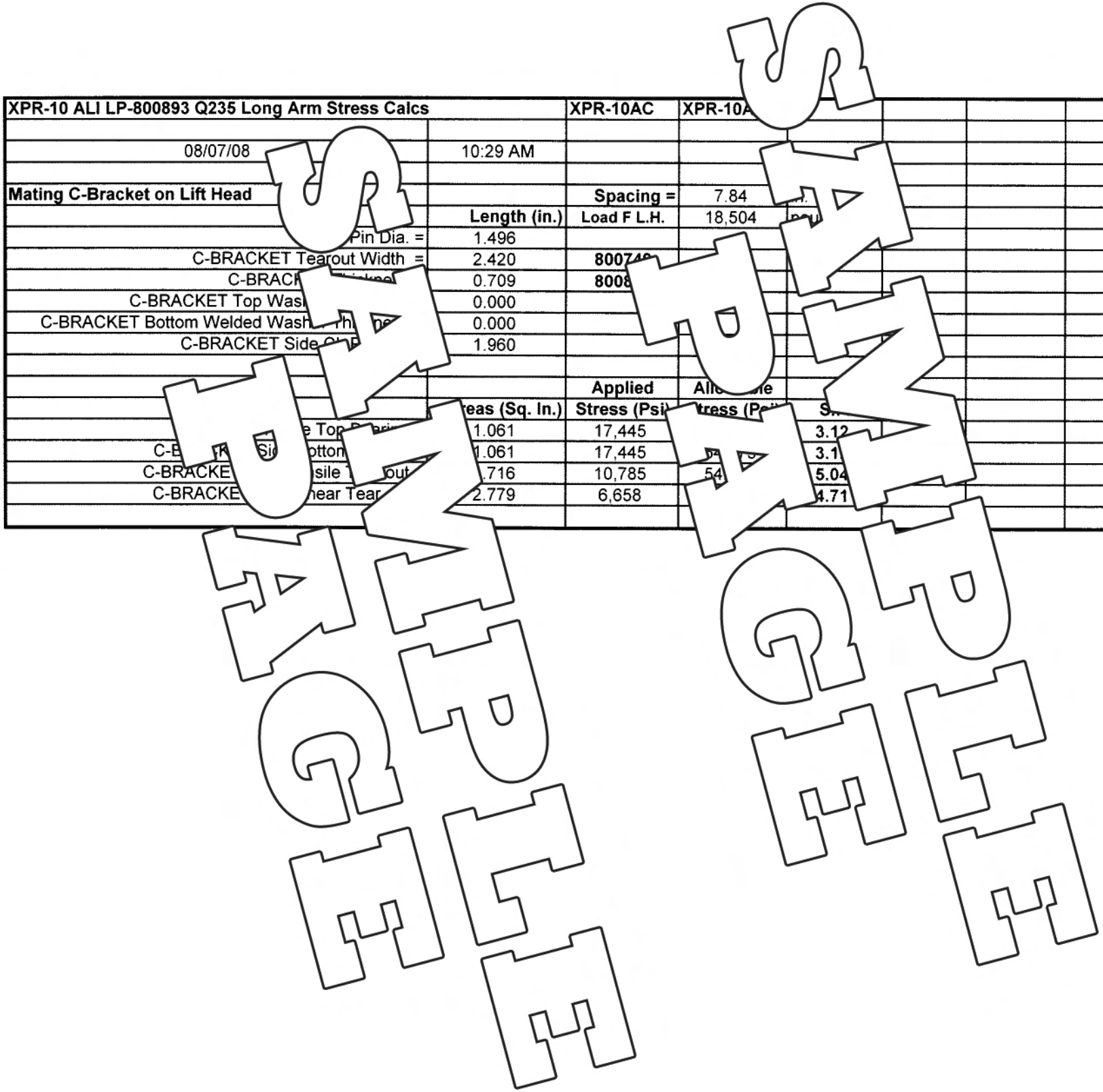
Arm S Top Brace Thickn

Arm Side Bottom Welde hickne

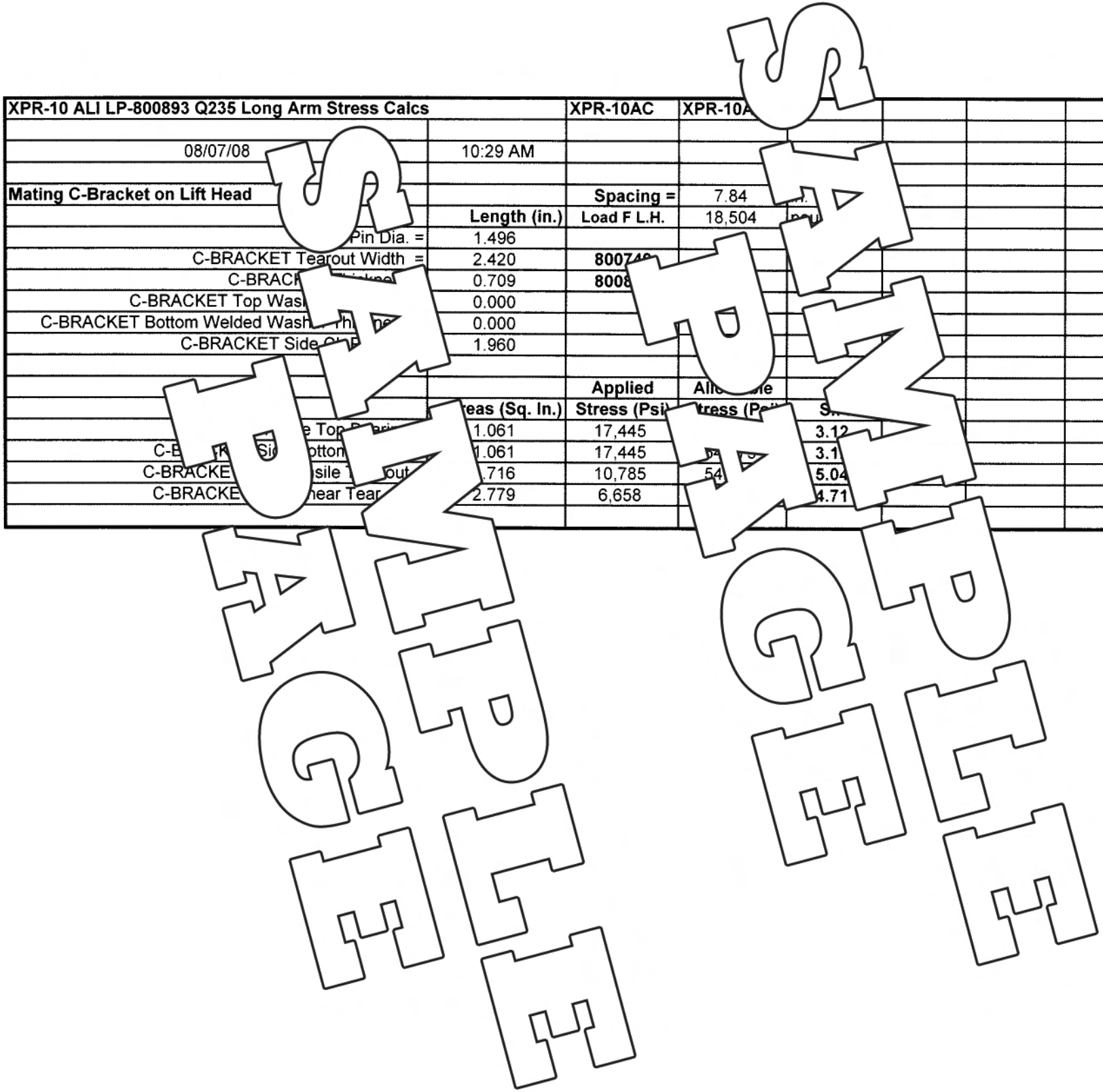
Arm st (In

	Areas (Sq. In.)	Applied Stress (Psi)	Allow Stress	
A ring =	1.76	13,879	54,37	3.9
Arm Side ottom Bearing=		16,022	54,375	3.3
Arm Side Tensile T ut =		13,528	54,375	4.02
Arm S ut =	976	8,242	31,374	3.81
=	1.758	13,955	50,199	3.60

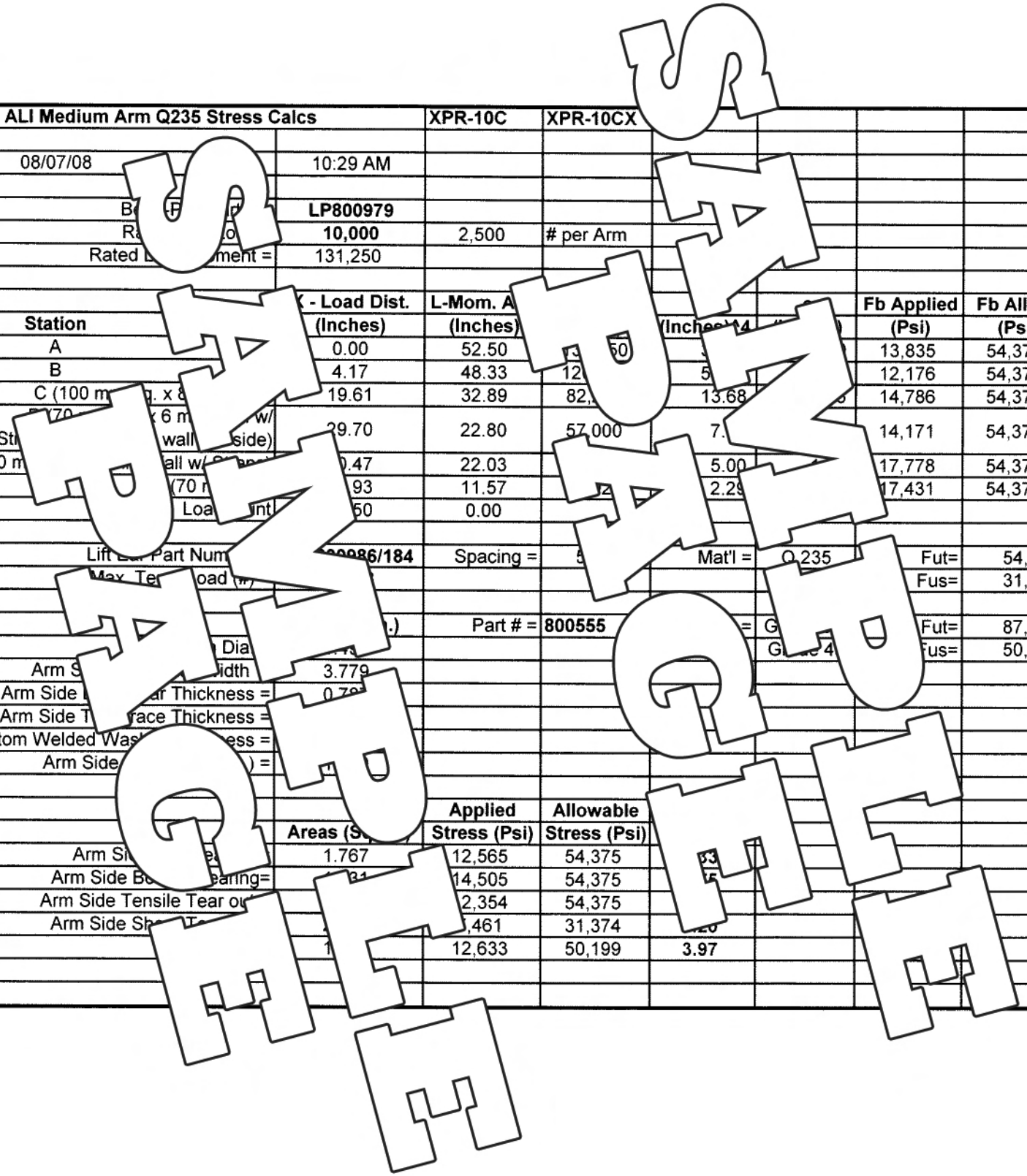
XPR-10 ALI LP-800893 Q235 Long Arm Stress Calcs		XPR-10AC	XPR-10A				
08/07/08	10:29 AM						
Mating C-Bracket on Lift Head		**Spacing =**	7.84				
	Length (in.)	**Load F L.H.**	18,504				
Pin Dia. =	1.496						
C-BRACKET Tearout Width =	2.420	**800748**					
C-BRACK	0.709	**8008**					
C-BRACKET Top Wash	0.000						
C-BRACKET Bottom Welded Wash	0.000						
C-BRACKET Side	1.960						
		Applied	**Allo**				
	eas (Sq. In.)	**Stress (Psi)**	**tress (Ps**	**S**			
e Top	1.061	17,445		**3.12**			
C-B K Sid ottom	1.061	17,445		**3.1**			
C-BRACKE sile	.716	10,785	54	**5.04**			
C-BRACKE hear Tear	2.779	6,658		**4.71**			



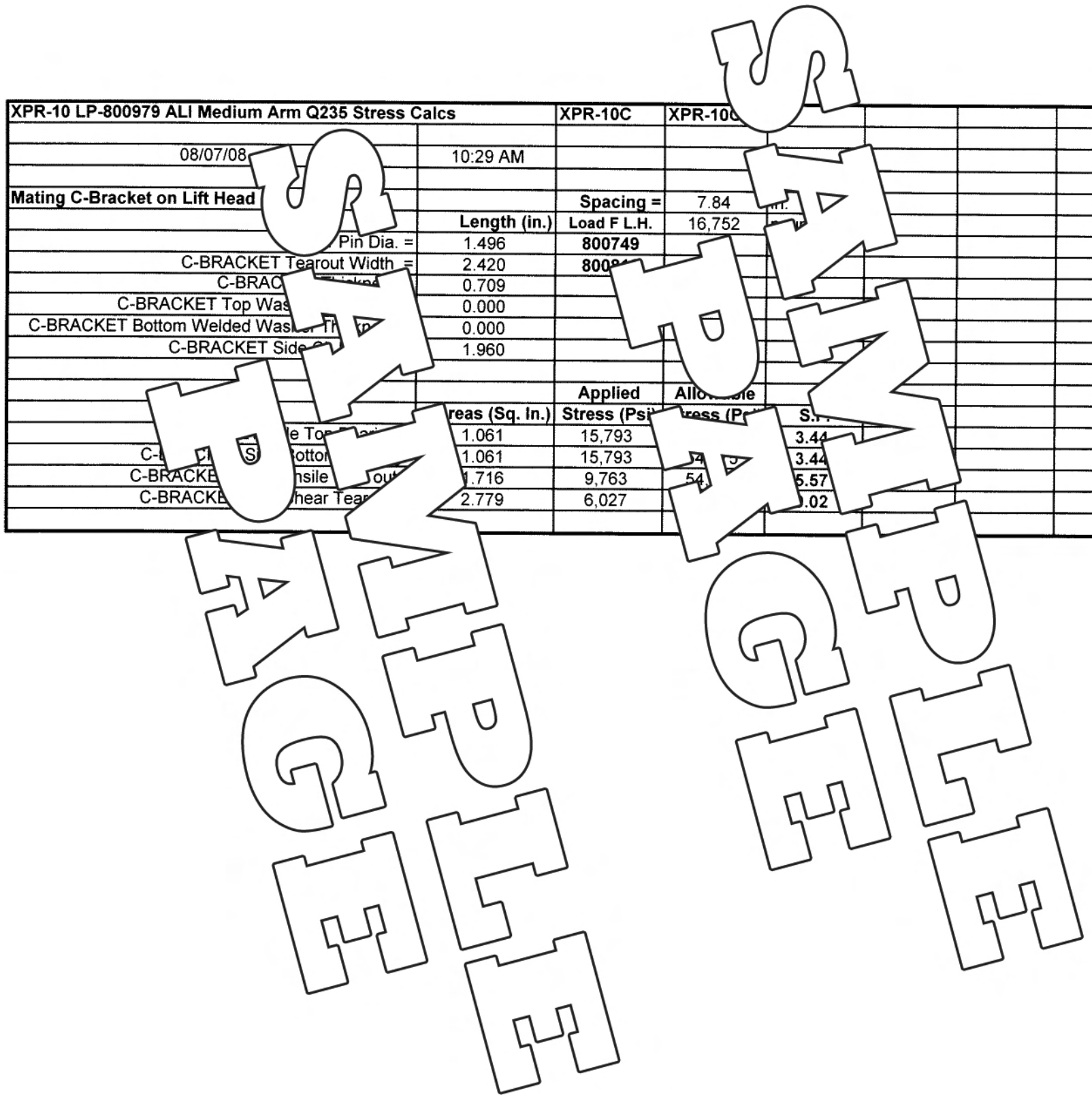
XPR-10 ALI LP-800893 Q235 Long Arm Stress Calcs		XPR-10AC	XPR-10A				
08/07/08	10:29 AM						
Mating C-Bracket on Lift Head		**Spacing =**	7.84				
	Length (in.)	**Load F L.H.**	18,504				
Pin Dia. =	1.496						
C-BRACKET Tearout Width =	2.420	**800748**					
C-BRACK	0.709	**8008**					
C-BRACKET Top Wash	0.000						
C-BRACKET Bottom Welded Wash	0.000						
C-BRACKET Side	1.960						
		Applied	**Allo**				
	eas (Sq. In.)	**Stress (Psi)**	**tress (Ps**	**S**			
e Top	1.061	17,445		**3.12**			
C-B K Sid ottom	1.061	17,445		**3.1**			
C-BRACKE sile	.716	10,785	54	**5.04**			
C-BRACKE hear Tear	2.779	6,658		**4.71**			



XPR-10 LP-800979 ALI Medium Arm Q235 Stress Calcs		XPR-10C	XPR-10CX					
08/07/08	10:29 AM							
B[illegible]	**LP800979**							
R[illegible]	**10,000**	2,500	# per Arm					
Rated L[illegible]ment =	131,250							
	X - Load Dist.	**L-Mom. A**				**Fb Applied**	**Fb Allow.**	**S.F.**
Station	**(Inches)**	**(Inches)**	**(Inches)**			**(Psi)**	**(Psi)**	
A	0.00	52.50	50			13,835	54,375	**3.93**
B	4.17	48.33	12[illegible]	5[illegible]		12,176	54,375	**4.47**
C (100 m[illegible]g. x 8[illegible]	19.61	32.89	82[illegible]	13.68		14,786	54,375	**3.68**
[illegible]70[illegible] x 6 m[illegible] w/								
St[illegible] wall[illegible]side)	29.70	22.80	57,000	7.[illegible]		14,171	54,375	**3.84**
E (70 m[illegible] all w/ [illegible]	0.47	22.03		5.00		17,778	54,375	**3.06**
[illegible](70 r[illegible]	93	11.57	[illegible]2	2.29		17,431	54,375	**3.12**
Loa[illegible]nt	50	0.00						
Lift [illegible] Part Num[illegible]	**00986/184**	Spacing =	5[illegible]	Mat'l =	Q 235	Fut=	54,375	psi
Max. Te[illegible]oad (#)						Fus=	31,374	psi
[illegible].)		Part # =	**800555**	=	G[illegible]	Fut=	87,000	psi
[illegible] Dia[illegible]					G[illegible] 4	Fus=	50,199	psi
Arm S[illegible]idth	3.779							
Arm Side L[illegible]ar Thickness =	0.78[illegible]							
Arm Side T[illegible]face Thickness =	[illegible]							
Arm Side Bottom Welded Was[illegible]ess =	[illegible]							
Arm Side[illegible]) =	[illegible]							
		Applied	**Allowable**					
	Areas (S[illegible]	**Stress (Psi)**	**Stress (Psi)**					
Arm Si[illegible]e[illegible]	1.767	12,565	54,375	[illegible]33				
Arm Side Be[illegible]earing=	[illegible].31	14,505	54,375	[illegible]45				
Arm Side Tensile Tear ou[illegible]	[illegible]	2,354	54,375					
Arm Side Sh[illegible]T[illegible]	[illegible]	[illegible],461	31,374	[illegible]26				
	1[illegible]	12,633	50,199	**3.97**				

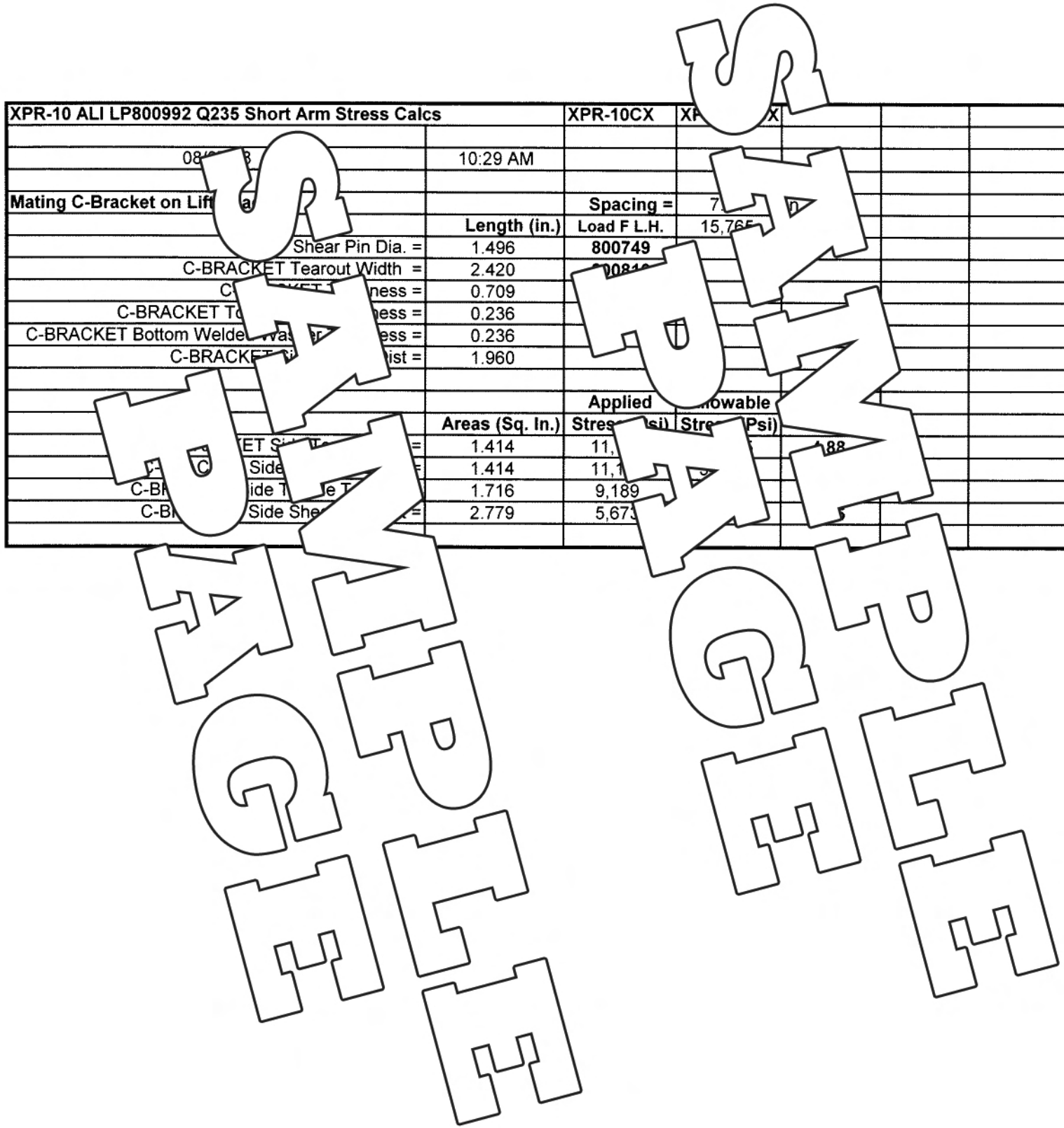


XPR-10 LP-800979 ALI Medium Arm Q235 Stress Calcs		XPR-10C	XPR-10C				
08/07/08	10:29 AM						
Mating C-Bracket on Lift Head			**Spacing =**	7.84			
	Length (in.)		**Load F L.H.**	16,752			
Pin Dia. =	1.496		**800749**				
C-BRACKET Tearout Width =	2.420		**800**				
C-BRAC	0.709						
C-BRACKET Top Was	0.000						
C-BRACKET Bottom Welded Was	0.000						
C-BRACKET Side	1.960						
			Applied	**Allo**			
	reas (Sq. In.)		**Stress (Psi**	**ress (P**		**S.**	
le To	1.061		15,793			3.44	
C- Bottor	1.061		15,793			3.44	
C-BRACKE nsile Tout	1.716		9,763	54		5.57	
C-BRACKE hear Tear	2.779		6,027			.02	



XPR-10 ALI LP800992 Q235 Short Arm Stress Calcs		XPR-10CX	XPR-					
08/07/	10:29 AM							
art # =	LP800992							
oad =	10,000	2,500	# per Arm					
ad Moment =	123,523							
	X - Load Dist.	L-M	ent	Ixx	c	Fb Applied	Fb Allow.	S.F.
Station	(Inches)	(In	#)	(Inches)	ches)	(Psi)	(Psi)	
A	0.00	4	12 3		12	12,353	54,375	4.40
B	4.17	45.24	0		10	11,099	54,375	4.90
C (120 mm S 3 mm	11.85	37.56	3	23	85	11,466	54,375	4.74
mm mm Wall)	17.11	32.30	48		2.36	11,394	54,375	4.77
E mm With Ca	24.00	25.41	63,52			16,125	54,375	3.37
m So	28.35	21.06		6.32		15,553	54,375	3.50
G (m W	39.37	10.04		3		12,710	54,375	4.28
Sq. x m	39.38	10.03		2.		15,087	54,375	3.60
L	49.41	0.00						
							psi	
R-10 Lif r Part	800986/184	Spacing =	6.02	M		Fut=	54,375	
ens. L d (#)	0,505					Fus=	31,374	
	ngth (in.)	Part # =	80	Mat'	SB	Fut=	87,000	
ear P a. =	1.196				Gra	Fus=	50,199	
Lifting Ear Width =	79							
Arm Lifting Ear Thick	7							
Arm Side T Thickn	4							
Arm Side Bottom Wel ickn	0							
A ist (in.) =								
		Applied	Allow		F			
	Areas (n.)	Stress (Psi)	Stress (					
A Top Bearing =		11,601	54,375		4.6			
Arm Side Bottom ring=		17,407	54,375		3.12			
Arm Side Te ut =		11,407	54,375		4.77			
Arm S ut =	2.976	6,889	31,374		4.55			
r =	1.758	11,665	50,199		4.30			

XPR-10 ALI LP800992 Q235 Short Arm Stress Calcs		XPR-10CX	XP X				
08 3	10:29 AM						
Mating C-Bracket on Lift a		**Spacing =**	7 0				
	Length (in.)	**Load F L.H.**	15,765				
Shear Pin Dia. =	1.496	**800749**					
C-BRACKET Tearout Width =	2.420	800810					
C ness =	0.709						
C-BRACKET T ness =	0.236						
C-BRACKET Bottom Welde Was ess =	0.236						
C-BRACKET ist =	1.960						
		Applied	owable				
	Areas (Sq. In.)	**Stres si)**	**Stre Psi)**				
ET S =	1.414	11,	88				
C Side =	1.414	11,1					
C-B ide T e T =	1.716	9,189					
C-B Side She =	2.779	5,673					



XPR-10 ALI LP-800987 Q235 Short Arm Stress Calcs		XPR-10C	XPR-10					
08/07/08	10:29 AM							
er # =	LP800987							
n d =	10,000	2,500	# per Arm					
Ra Moment =	109,252							
	X - Load Dist.	L-Mor	nt	Ixx	c	Fb Applied	Fb Allow.	S.F.
Station	(Inches)	(Inch		(Inches)^4	ches)	(Psi)	(Psi)	
A	0.00	43.7	09		3.43	14,702	54,375	**3.70**
B	4.17	39.5			4.54	8,632	54,375	**6.30**
C (120 mm Sq. x 8 mm Wall With	11.85	31.85			3.92	13,321	54,375	**4.08**
D (12 Sq. Wall)	15.00	28.70			2.36	10,110	54,375	**5.38**
E (95 mm With m Caps)	21.97	21.73	54,327		17	13,115	54,375	**4.15**
Sq. x 6 mm Wall	26.11	17.59		6.22	7	13,221	54,375	**4.11**
G (70 mm Sq Wa ith 1	32.83	10.87			2	16,292	54,375	**3.34**
H q. x Wall	33.35	10.35	2			15,594	54,375	**3.49**
I Load	43.70	0.00						
XPR-10 Lift Ear N 0986/184		Spacing =	2	Ma			Fut= 54,375	psi
s. Load (#) = 330							Fus= 31,374	psi
gth (in.)		Part # =	8005		Mat'l	B 99	Fut= 87,000	psi
Pin 1.496						Gra	Fus= 50,199	psi
Ar ing Ear Width = 3								
Arm Si ing Ear Thickne								
Arm Side Top P Thickness								
Arm Side Bottom Welded kness								
Arm S (In.)								
		Applied	Allowab					
	Areas (Sq. In.)	Stress (Psi)	Stress (P					
Arm aring =	1.767	10,371	54,375					
Arm Side Bottom Bearing=		15,560	54,375					
Arm Side Tensile Te =		10,197	54,375					
Arm Side =	976	6,158	31,374					
	758	10,427	50,199					

XPR-10 ALI LP-800987 Q235 Short Arm Stress Calcs		XPR-10C	XPR-10AC				
08/07/08	10:29 AM						
Mating C-Bracket on Lift Head		**Spacing =**	7.84				
	Length (in.)	**Load F L.H.**	13,944	pound			
[illegible] in Dia. =	1.496	**800749**					
C-BRACKET Tearout Width =	2.420	**800816**					
C-BRACKET [illegible]	0.709						
C-BRACKET Top Washer [illegible]	0.000						
C-BRACKET Bottom Welded Washer [illegible]	0.000						
C-BRACKET Side Clearance	1.960						
		Applied	**Allowable**				
	Areas (Sq. In.)	**Stress (Psi)**	**Stress (Psi)**	**S.F.**			
C-BRACKET Top Bearing	1.061	13,146		**4.14**			
C-BRACKET Side Bottom	1.061	13,146		**4.14**			
C-BRACKET Tensile Tearout =	1.716	8,127	54,3[illegible]	**6.69**			
C-BRACKET Shear Tear out =	2.779	5,017		**11.25**			

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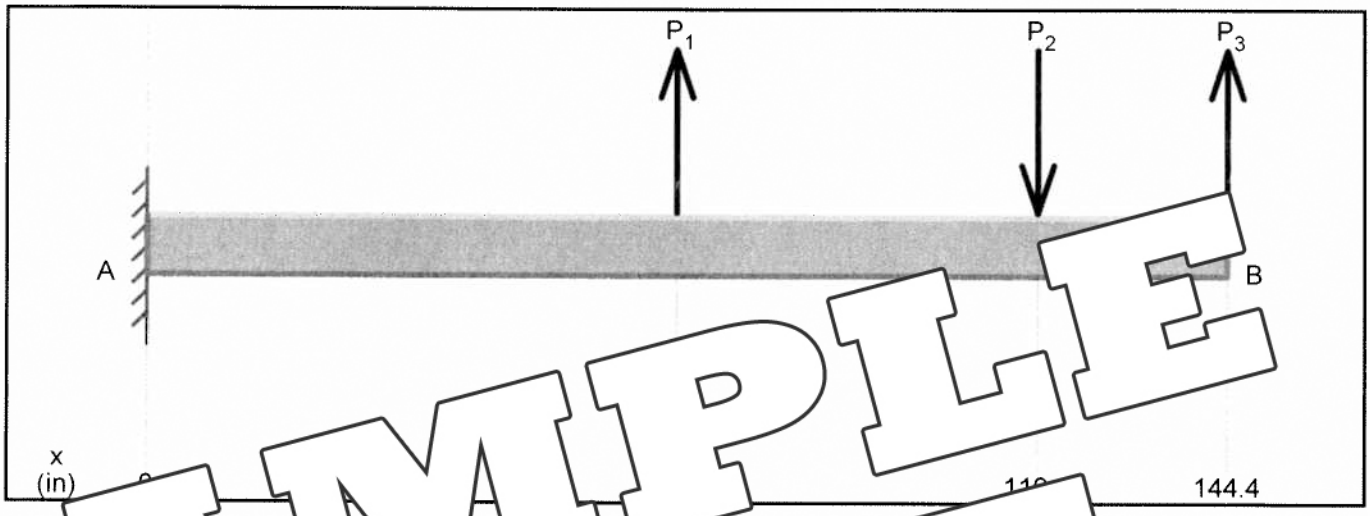
Appendix C:

Main Column Shear and Moment Diagrams

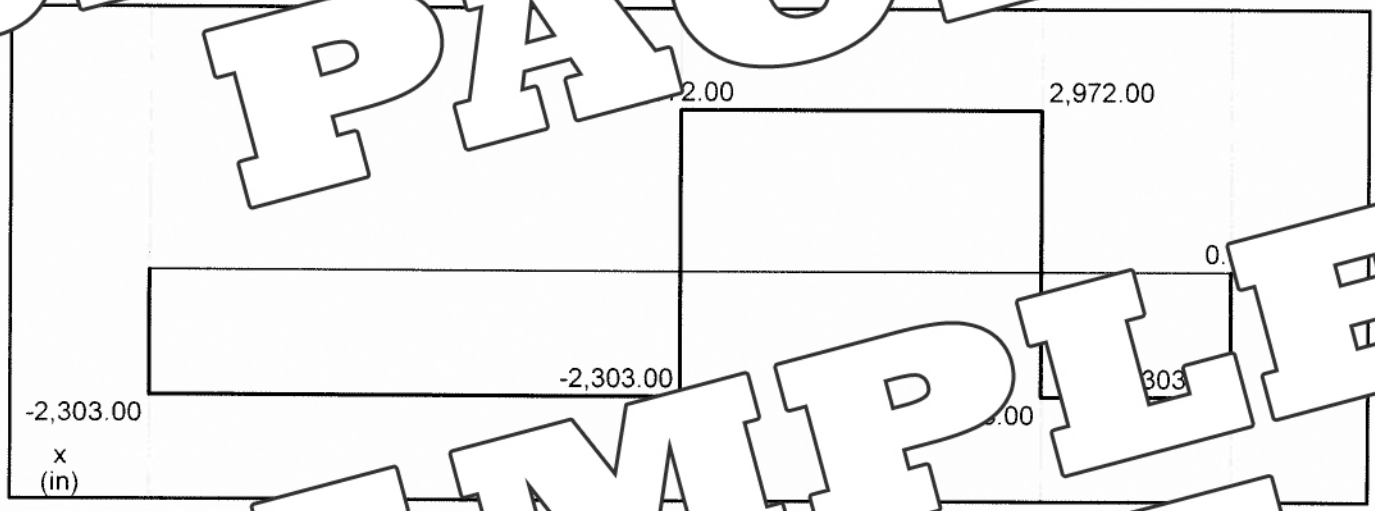
SAMPLE PAGE

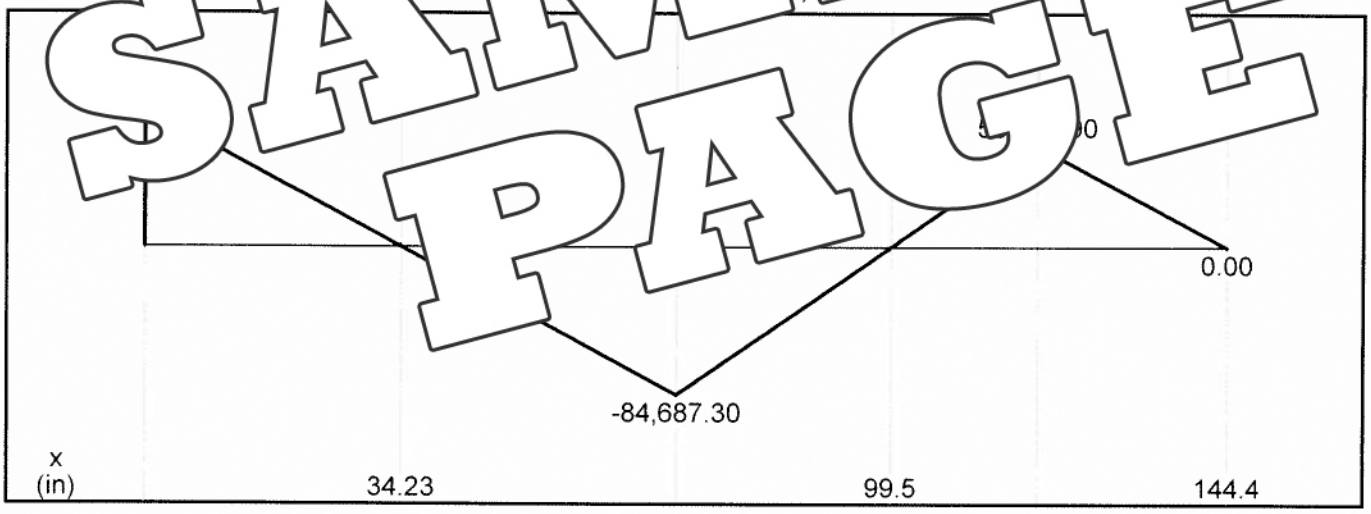
XPR-10 Max trough Load (Lift Head in Highest Position)



Lo Diagram

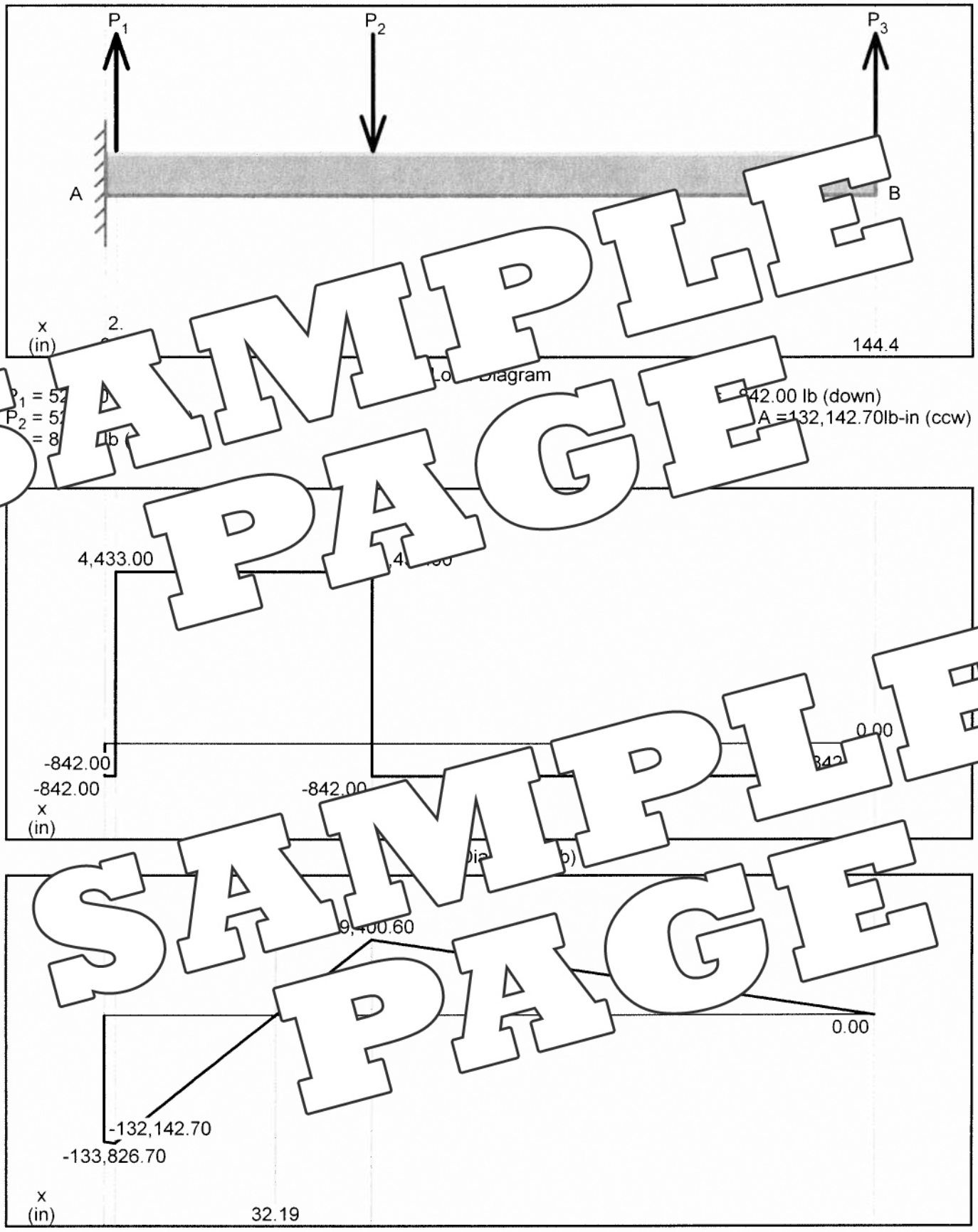
= 2,303.00 lb (down)
nt A =78,825.70 lb-in (cw)





Moment Diagram (lb-in)

XPR-10 Max Moment (Lift Head in Lowest Position)



Moment Diagram (lb-in)