Fermilab
KTeV Experiment
MS 231

2 May 1995

To: Bruce Baller - MS 208
Greg Bock - MS 231
Igor Churin, MS 219
Paul Czarapata, MS 220
Doug Jensen - MS 231
Peter Kasper, MS 222
Jim Kilmer, MS 219
Rafael Silva - MS 219
Rich Stanek - MS 219
Andrew Stefanik - MS 219
Chuck Worel - MS 220

From: Dave Pushka

Subj.: Results from the Internal Technical Review of KTeV's Vacuum Window Safety Barrier.

Dear Gentlemen:

The following should provide the results of our recent RD internal technical review of the vacuum window safety barrier held 10:30 am Friday, 28 April 1995 in WH13SW:

1) A copy of Chuck Worel's letter providing the interlock group's plan of action is attached. Mounts for the switches requested by Chuck will be included in the frame. Answers to the three questions are; 1) If the barrier fails to close, that will be apparent on position indicator lights at the access points. The interlock group will provide these lights to show the position of the vacuum window safety barrier. There will not be an audible alarm. 2) There is no need for an inhibit switch to prevent the barrier from cycling up and down after a controlled access is made. 3) Position status should be made available on EPICURE. However, we do not need control to raise and lower the vacuum window safety barrier via EPICURE.

2) It was suggested to consider providing a valve blocking the air in the cylinder when the upper line is ruptured or the compressor fails. Incorporating this suggestion would cause the shutter to no longer fail to a safe (closed) position. It is desirable for the shutter to close during a loss of air condition or a mechanical failure. Therefore, this suggestion is not being incorporated.

3) It was suggested to use adjustable cushions in the cylinder. - This is being done as the cylinder chosen is normally provided with adjustable cushions.

4) It was suggested to consider using a bolted connection between the pulley bracket and the frame. This suggestion was considered but is not being incorporated as the connection becomes more complicated.

5) It was suggested to consider including a mechanical lock to retain the barrier in the upper position for the set up. However, no one has been able to identify any assembly or maintenance function which could not be performed with the barrier in the down (or closed) position. Therefore, this suggestion is not being incorporated.

6) It was suggested that having only two guides at the edges of the plate could allow the plate to rotate about the z-axis and the two guides would cease to restrain the plate from motion along the z axis. The use of additional guides to prevent plate rotation about the z axis is being incorporated.

To my best understanding, the above list includes all relevant comments made about the vacuum window safety shutter during the review. If I have omitted any substantial comment, please bring it to my attention.

Sincerely,

Dave Pushka

Fermilab

April 24th 1995

To: Dave Pushka

From: Chuck Worel, RD / EED Interlocks

Subject: Response to request for review of KTev's Vacuum Window Safety Barrier.

After review of materials supplied for "KTev's Vacuum Window Safety Barrier" the Interlock Group has come up with the following plan of action.

1. We will provide a 24V DC signal to the control valve when the enclosure is interlocked and all keys are in the keytree. This signal is the same signal used for magnet power supply enclosure interlocks.This 24V DC signal will only be present when the enclosure is interlocked and NO controlled access is in progress. Note: opening and closing the keytree would cause the barrier to cycle.

2. To sense the "barrier up" position we will need two Mirco Switch, limit switches #LSA4L, with #LS2A operating heads mounted on the frame. These will be used as inputs to the Critical Device Controller. This is how we will prevent beam from being delivered if the barrier is not fully opened. We will supply these switches, these are commonly used switch by our group, and have proven very reliable.

3. To sense the "barrier down" position we will need two Mirco Switch, limit switches #LSA4L, with #LS2A operating heads mounted on the frame.

Now for the questions:

1. If the barrier fails to close (down position) what do we want to see happen? Sound an alarm, (audible) turn lights on?

2. ___ Is an inhibit switch (lock-out) needed to keep the barrier in the down position after a controlled access is made and there is no desire to take beam for a while? This would keep the barrier from cycling up and down needlessly during experimenter controlled access for equipment adjustment.

3. Is there is a reason to have barrier up and down (open and close) position status on EPICURE? Do we need EPICURE control to raise and lower the barrier?

Fermilab
KTeV Experiment
MS 231

20 April 1995

To: Paul Czarapata, MS 220
Peter Kasper, MS 222
Jim Kilmer, MS 219
Igor Churin, MS 219

cc: B. Baller - MS 208 (w/o attachments)
G. Bock - MS 231 (w/o attachments)
D. Jensen - MS 231 (w/o attachments)
R. Silva - MS 219 (w/o attachments)
R. Stanek - MS 219 (w/o attachments)
A. Stefanik - MS 219 (w/o attachments)

From: Dave Pushka

Subj.: Request for an Internal Technical Review of KTeV's Vacuum Window Safety Barrier.

Dear Gentlemen:

As I've mentioned to most of you, KTeV has requested the Mechanical Support Department to design a vacuum window safety barrier. It will be located immediately downstream of the 71 inch diameter vacuum window in the KTeV experimental hall. The enclosed assembly drawing and engineering design note provide the results of the design effort.

I would like to request each of you (or your designated expert) to spend a few minutes reviewing the enclosed documentation. Following your review, I'd like to arrange an informal meeting with the design engineer to discuss your conclusions. This will also provide an opportunity for any details specific to the needs of the Electrical and Operations Departments to be included into the design. If possible, I'd like to tentatively suggest we meet Tuesday, 25 April at 1:30 PM in WH13 SW. Please let me know if that time is acceptable.

The following should provide you more information about the purpose of the vacuum window safety barrier:

1) The vacuum window safety barrier is designed for remote operation. It will be closed (placed in front of the vacuum window) whenever it is necessary for people to enter the experimental hall while the vacuum system is under vacuum.

2) The vacuum window safety barrier will be interlocked to prevent putting beam on the target while the vacuum window safety barrier is in the closed position. This is necessary to prevent the accidental loss described in

— section 6.5.2.iii in the KTeV Beam Systems Design Report Version 1.1 dated June 1994.

3) The vacuum window safety barrier is designed using ASME pressure vessel allowable stresses, to take the differential pressure resulting from full vacuum on one side and atmospheric pressure on the other side. It is designed to be forced against the vacuum window flange in the event of a window failure. A clearance will be provided to allow air into the vacuum vessels, repressurizing them.

4) The primary functions of the vacuum window safety barrier are to prevent access to the front of the vacuum window (thereby eliminating the potential for accidental window puncture) and to isolate people from the shock wave which would occur during a window failure.

5) The vacuum window safety barrier is NOT designed to protect equipment in the experimental hall should the vacuum window fail while the shield is in the open position.

The vacuum window safety barrier described above is being provided to mitigate potential hazards to personnel.

I look forward to discussing this request with you at your convenience.

Sincerely,

Dave Pushka

Fermilab
KTeV Experiment
MS 231

13 March 1995

To: B. Baller - MS 208
cc: G. Bock - MS 231
D. Jensen - MS 231
R. Stanek - MS 219
A. Stefanik - MS 219
R. Silva - MS 219

From: Dave Pushka

Subj.: Request for an Internal Technical Review of KTeV's Vacuum Window Safety Barrier.

Dear Bruce:

I would like to request a technical review of KTeV's Vacuum Window Safety Barrier. This device is near the end of the design stage within RD/MSD/MSG and it is an appropriate time to request a technical review of the design. The goals of this technical review are:

1) To technically evaluate the design and suggest improvements if deemed necessary by the reviewers

2) To alert all of the affected groups within the Research Division of potential secondary effects of having an automated vacuum window safety barrier (e.g. closing the barrier during beam-on conditions could 'put a proverbial brick in the beam')

As part of the proposed review, I would like to suggest the following people be considered as potential reviewers:

J. Kilmer, RD/MSD	extensive mechanical background
Paul Lahn, FESS	expertise in cranes and moving devices
Paul Czarapata, RD/ED	(or his designate) as a representative of the interlocks group
Peter Kasper, RD/OD	(or his designate) as a representative of the operations and beams groups
Ernie Villegas, RD/MSD	extensive mechanical background

I anticipate that the drawings and calculations will be available for this review during the last week in March and would like to tentatively schedule the review for the first week in April.

The following should provide you more information about the purpose of the vacuum window safety barrier:

Since there are inherent dangers with thin vacuum windows, the KTeV project has always recognized the need for a vacuum window safety barrier. This barrier was designed with the following criteria:

1) The vacuum window safety barrier is designed for remote operation. It will be closed (placed in front of the vacuum window) whenever it is necessary for people to enter the experimental hall while the vacuum system is under vacuum.

2) The vacuum window safety barrier will be interlocked to prevent putting beam on the target while the vacuum window safety barrier is in the closed position. This is necessary to prevent the accidental loss described in section 6.5.2.iii in the KTeV Beam Systems Design Report Version 1.1 dated June 1994.

3) The vacuum window safety barrier is designed using ASME pressure vessel allowable stresses, to take the differential pressure resulting from full vacuum on one side and atmospheric pressure on the other side. It is designed to be forced against the vacuum window flange in the event of a window failure. A clearance will be provided to allow air into the vacuum vessels, repressurizing them.

4) The primary functions of the vacuum window safety barrier are to prevent access to the front of the vacuum window (thereby eliminating the potential for accidental window puncture) and to isolate people from the shock wave which would occur during a window failure.

5) The vacuum window safety barrier is NOT designed to protect equipment in the experimental hall should the vacuum window fail while the shield is in the open position.

The vacuum window safety barrier described above is being provided to mitigate potential hazards to personnel.

I look forward to discussing this request with you at your convenience.

Sincerely,

Dave Pushka

	Fermilab **Research Division** **Mechanical Support Department**	Engineering Note # MSD EN -1.1.1.9.b Date: March / 30 / 1995

Title	Vacuum Window Safety Barrier and DC-1 Support Frame

Author(s)	Rafael Silva
Reviewer	Zhijing Tang 4-13-95
Key Words	
Abstract/ Summary	Vacuum Window Safety Barrier and DC-1 Support Frame Design Notes

Summary:

1. General
2. Vacuum Chamber Seal and Rubber Cushion
3. Shield Plate Material Selection and Allowable Stresses
4. Shield Plate Stress Analysis (ANSYS F.E.A. by Ang Lee)
5. Wire Rope, Fittings, Pin, Lead Blocks, Swivel, and Turnbuckle
6. Air Cylinder
7. Frame Design, Stress and Deflections Analysis (ANSYS F.E.A. by Ang Lee)

1. General

The downstream end of the KTeV vacuum chamber is closed by a membrane made of Kevlar and Mylar referred as vacuum window. The safety barrier is a metallic plate that should be placed in front of the vacuum window whenever people are in the proximity. The objective of the safety barrier is to protect people not equipment. The main design goals are listed bellow:

- **Location**. The distance between the bolt heads of the flange of the vacuum window and drifting chamber 1 (DC-1) is about 3.9 inches, and the barrier should fit there. It should have a clearance of 6 inches from the ceiling and does not be connected to the walls.

- **Operation**. The barrier should be remotely operated, interlocked and design to close if fail occurs. In case of power outage it should close automatically or allow manual return to the closed position.

- **Sealing**. When closed, the barrier should seal the vacuum window to prevent enormous amounts of air to be drawn into the vacuum chamber at extremely high speeds.

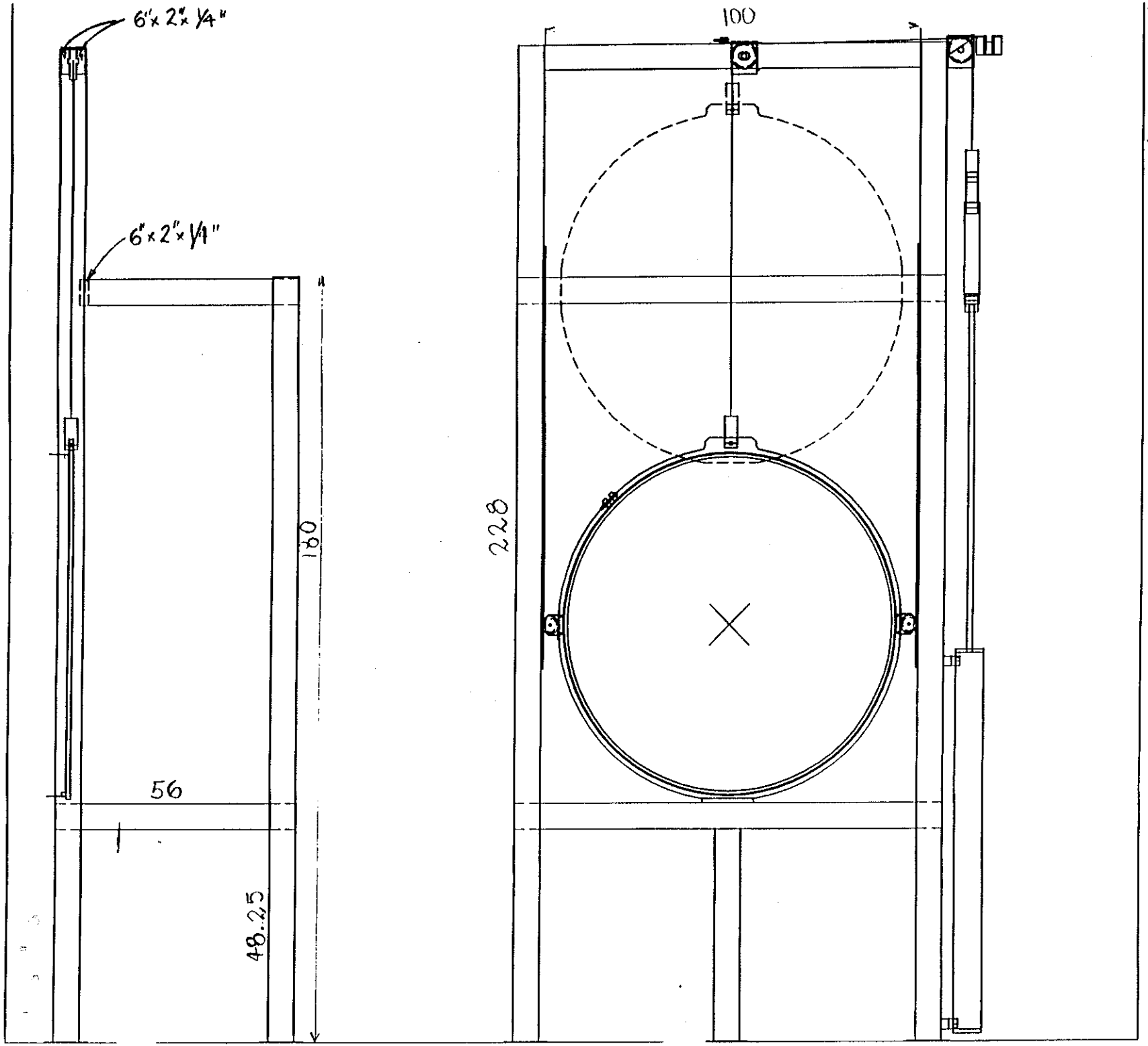
- **Additional function**. The barrier frame should also support DC-1.

- **Helium bag**. There will be a helium bag enveloping the barrier. The upstream side of the bag will be glued to the vacuum chamber and the downstream side will have a Mylar window that will fit between the barrier and DC-1.

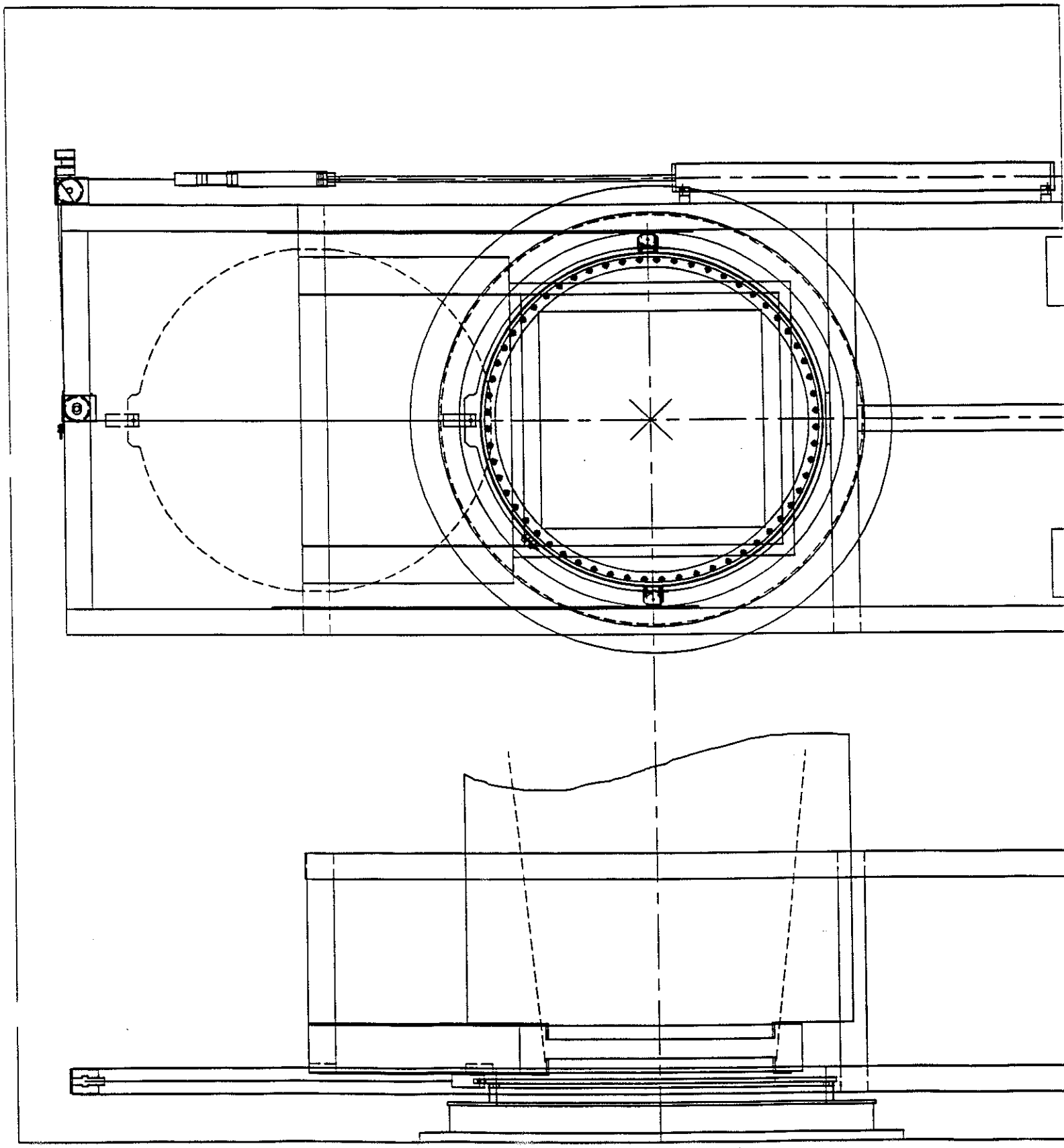
The original idea was to move the barrier sideways but the maximum clearance at the sides of its frame would be about 4 feet, considered unsatisfactory. Other configurations were explored and prevailed the vertical movement alternative. The movement of the barrier plate is going to be provided by an air cylinder in such way that when there is a deficiency in the air supply or a power outage the barrier returns to the closed position.

In case of vacuum window rupture, if the barrier is closed, the differential pressure compresses the barrier plate against the plastic seal around the vacuum flange. A small amount of air may infiltrate into the vacuum chamber in the moment of the rupture and after that only a minuscule leakage through the plastic seal may happen. The vacuum chamber should then be repressurized by usual means.

The wire, its fittings and lead blocks should be sent assembled to the frame manufacturer. The wheel guides for the barrier plate can be easily assembled and disassembled allowing easy installation of the barrier plate into the frame. The next two pages show the barrier and surroundings.



- ALL TUBING 6x6 x 1/4 EXCEPT THE 3 ONES MARKED (6"x2"x 1/4")
- DIMENSIONS IN INCHES
- ALL CONNECTIONS WELDED.

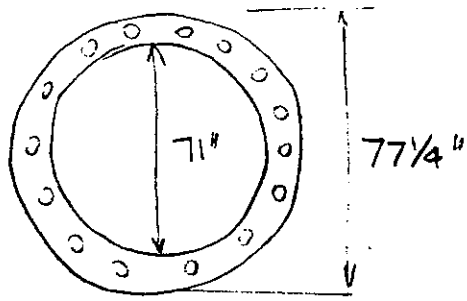


2. Vacuum Chamber Seal and Rubber Cushion

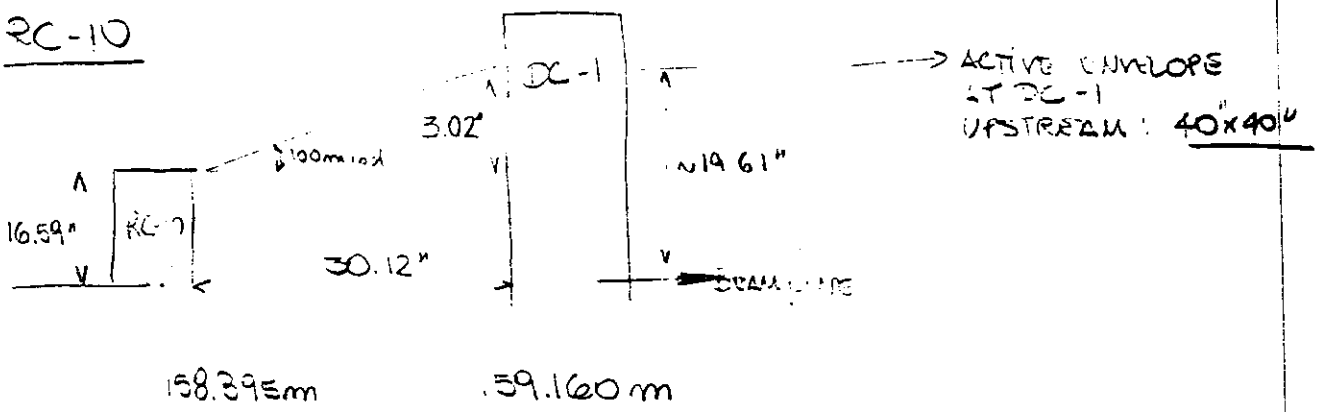
(2) VACUUM WINDOW SAFETY BARRIER POSITIONING AND SEAL.

NUMBERS BASED ON THE PRELIMINARY DESIGN MADE BY D. PUSHKA.

VACUUM WINDOW



RC-10



THE ACTIVE ENVELOPE IS NOT A CONCERN (40" << 71").

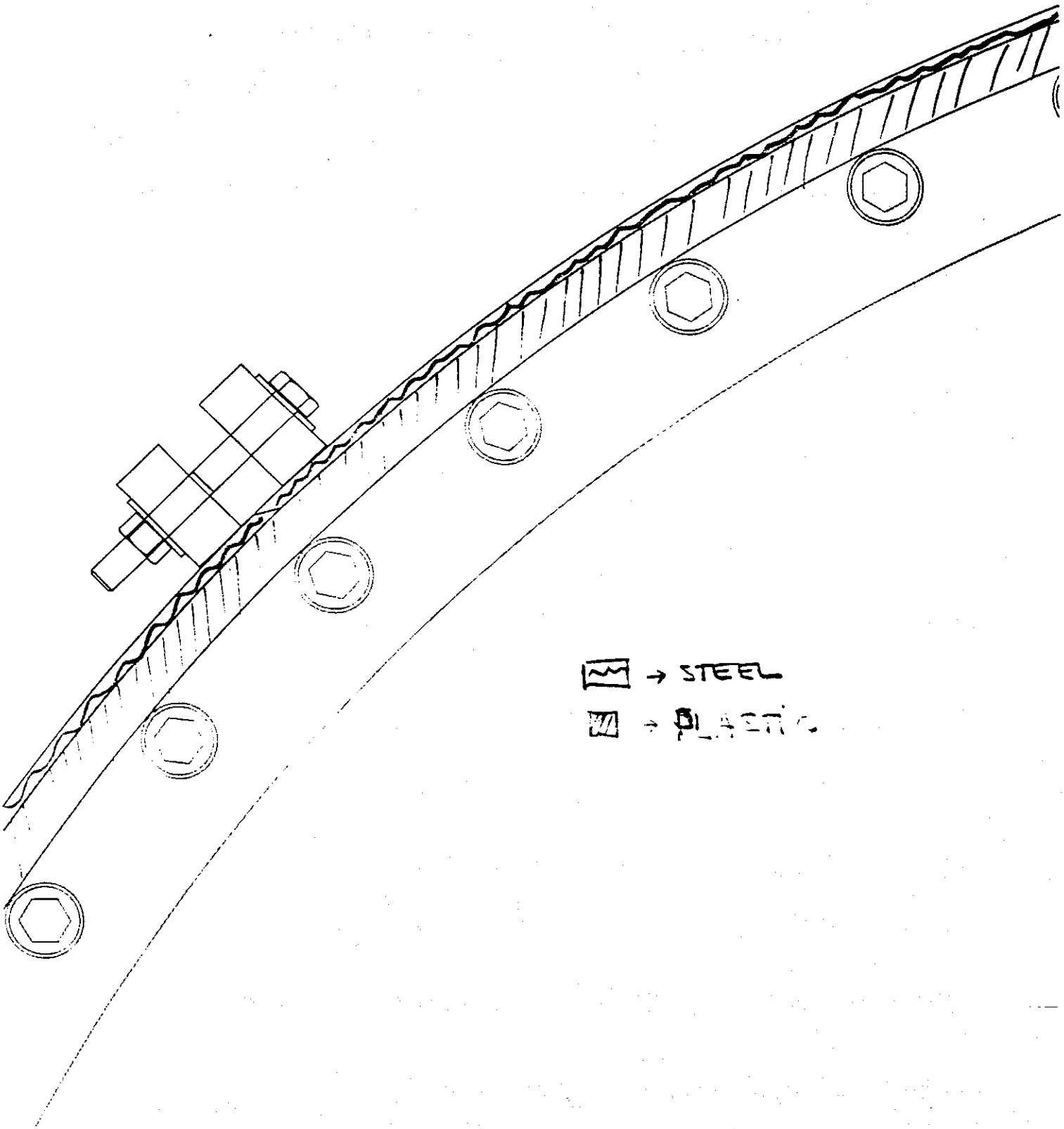
NOTES

TO CREATE A SEAL BETWEEN THE SHUTTO AND THE CHAMBER, A RING WILL BE ADDED TO THE CHAMBER

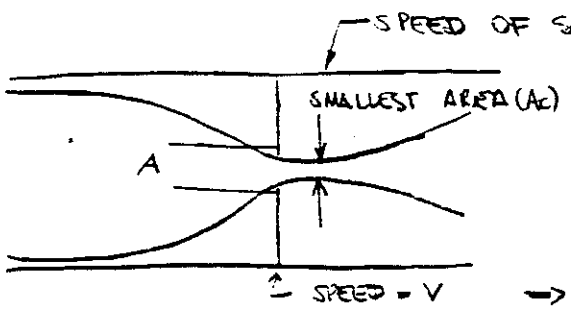
THE RING ALSO WORKS AS A SPACER AND A STOP.

BESIDES, TO ENSURE THE DETECTABILITY OF A RUPTURE OF THE WINDOW, A PRESSURE INDICATOR OR TRANSDUCER MAY BE CONNECTED TO THE RING.

SEE SKETCH ATTACHED.


→ STEEL
→ PLASTIC

KTeV VACUUM SHIELD



IN THIS CASE THE SMALLEST AREA = 0.6 . A

$\Rightarrow V \cdot A = m \cdot A_c \Rightarrow V = m \cdot A_c/A = 0.6$

THE SPEED OF PROPAGATION OF THE WAVE FRONT IS THE SPEED OF SOUND

SPEED OF AIR AROUND THE WINDOW AT THE RUPTURE MOMENT:

$V = m\ 0.6 \simeq 1{,}100\ ft/s \times 0.6 = 660\ ft/s.$

$FLOW = A \times 660\ ft/s.$

— FLANGE — 4 IN — 8 BOLTS — AREA OF BOLT HEADS

$A_{MAX} = \pi \cdot (74.375) \cdot 7/8 - 60 \times (0.867)$

$\Rightarrow A_{MAX} = 204.45 - 52.02 \Rightarrow A_{MAX} = 152.43\ in^2 = \underline{1.06\ ft^2}$

$FLOW = 660 \times 1.06 \simeq \underline{700\ ft^3/s}$ (42,000 cfm / 2,520,000 cfh)

$\Rightarrow$ TOTAL VOLUME (OF VACUUM CHAMBER) $\simeq 6{,}000\ ft^3 \Rightarrow \underline{8.6\ s}.$

$700\ ft^3 = (8.9\ ft)^3 \rightarrow$ UNACCEPTABLE!

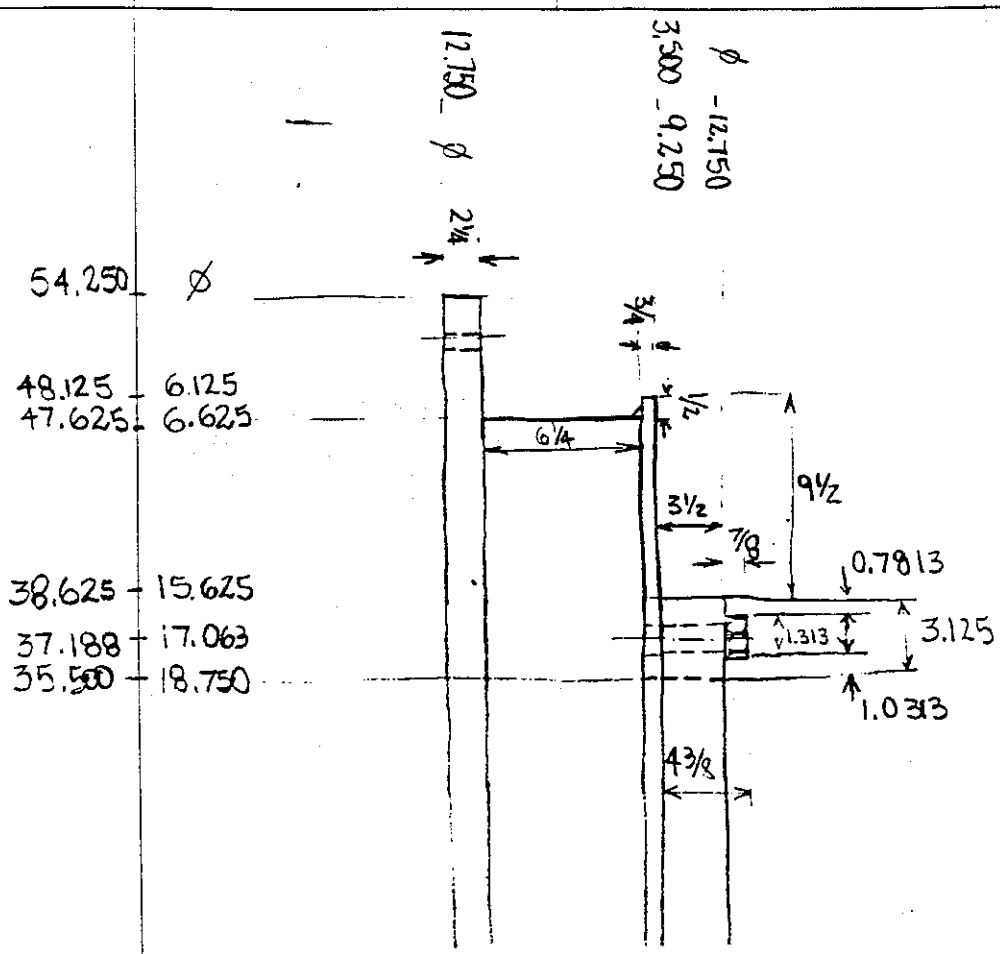
REDUCING THE AREA TO ABOUT $1\ in^2 \Rightarrow 0.007\ ft^2 \Rightarrow$

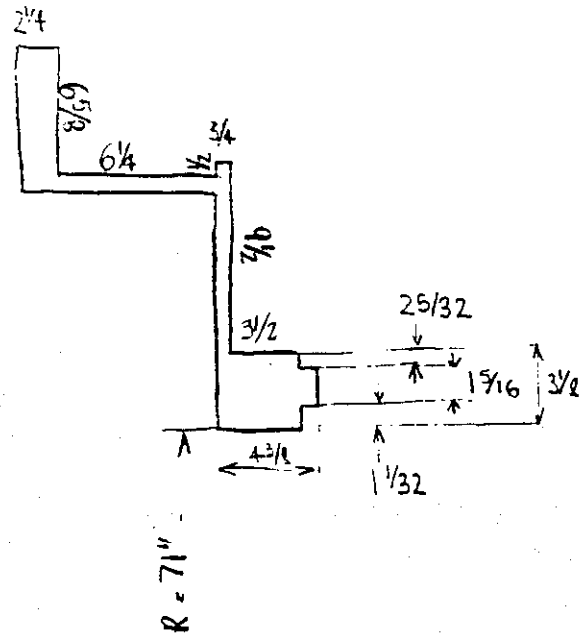
$FLOW = 660 \times 0.007 \Rightarrow \underline{Q \simeq 4.6\ ft^3/s}$ (275 cfm / 16,500 cfh)

TOTAL VOLUME $\simeq 6{,}000\ ft^3 \Rightarrow 1{,}310\ s \sim 22$ minutes OR MORE

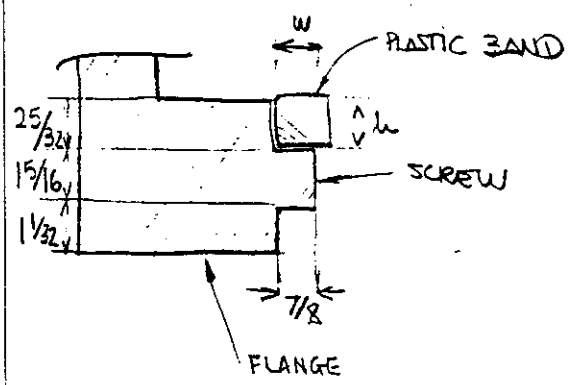
$\rightarrow$ THE SEAL WILL HAVE NO OPENINGS.

VACUUM WINDOW AREA





PLASTIC BAND



GOALS: - SEAL THE OPENNINGS ARROUND THE SCREWS AND MINIMIZE THE AIR FLOW IN CASE OF RUPTURE,
- GUIDE THE SHIELD WHEN MOVING UP AND DOWN,
- SUPPORT THE SHIELD IN CASE THE KEVLAR WINDOW BREAKES.

NOTE: THERE WILL BE NO SHOCK WAVES. (ZHIJING)

MATERIAL: UHMW PE → SELF-LUBRICATING, HIGH IMPACT RESISTENCE, CHEAP

PROPERTIES $\sigma_y = 3{,}100$ psi
$\mu_{max} = 0.20$
$E = > 100$ ksi ($= E_{HDPE}$)

LOAD: $\frac{\pi D^2}{4} \cdot \frac{q}{\pi D \cdot h} = \frac{D q}{4h}$; $D = 77\frac{1}{4}$, $q = 15$ psi, $h = 3/4''$ (THICKESTAVAILABLE)

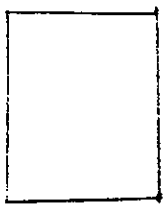
$\Rightarrow L = \frac{(77\frac{1}{4}) \cdot 15}{4 \cdot (3/4)} \Rightarrow L = 386.25$ psi.

DEFORMATION: TAKING $h = 3/4$ AND CONSIDERING (E). WE HAVE

$\sigma = E\varepsilon \Rightarrow \varepsilon = \frac{\sigma}{E} = 2 \times \frac{386.25}{100{,}000} \Rightarrow \varepsilon = 0.008 = 0.8\%$

$W_{MIN} = 7/8 \times 1.008 \Rightarrow W_{MIN} = 0.882''$ (SCREW HEAD HEIGHT)

McMASTER-CARR, p. 2553, UHMW RECTANGULAR BAR, 3/4" THICK, 1" WIDE, # 8702K112, \$9.80 / BAR, 1 BAR = 5' ⇒ TOTAL = 242.7" ⇒ 4 BARS



RADIUS OF BENDING: 38.625"
DEPTH OF BAR: 3/4"
} $R = 51.5d$.

SIZES: THICKNESS: $3/4 \begin{smallmatrix} -0.08 \\ +0.08 \end{smallmatrix}$ → CHECK FOR + 1/32 MAX.

WIDTH: $1'' \begin{smallmatrix} -0.06 \\ +0.06 \end{smallmatrix}$

LENGTH: $60'' \begin{smallmatrix} -0.06 \\ -0.06 \end{smallmatrix}$

PHYSICAL PROPERTIES

	PROPERTY	UNITS	ASTM TEST	Polystone M* (UHMW-PE) NATURAL		XL CROSS LINKED	MPG GLAS FILLED
MECHANICAL	Density	gm/cm³	D792	.930 - .938		.932	.96
	Tensile Strength at Yield 73°F	psi	D638	3100		2900	2700
	Tensile Modulus of Elasticity 73°F	psi	D638	-		-	-
	Elongation 73°F	%	D638	350		300	300
	Flexural Modulus of Elasticity 73°F	psi	D790	-		-	-
	Flexural Strength 73°F	psi	D790	-		-	-
	Shear Strength 73°F	psi	D732	-		-	-
	*Relative Volumetric Abrasion Loss	*	*	100		85	75
	Coefficient of Friction 73°F	-	-	Static Kinetic	.15 - .20 .10 - .20	.15 - .20 .10 - .20	.15 - .20 .10 - .20
	IZOD Impact Strength 73°F	ft-lbs/inch	D256	Notched Double 15°V Notch	No Break 26	No Break 26	No Break 24
	Hardness 73°F	-	D785	Rockwell Shore	- D 62-66	- D 62-67	- D 62-67
	Tensile Impact	ft-lbs/inch	D1822	-		-	-
	Deformation Under Load	%	D621	-		-	-
THERMAL	Melting Point	°F	D789	275° - 280°		275° - 280°	275° - 280°
	Coefficient of Linear Thermal Expansion	1/K	D696	2.0×10^{-4}		1.0×10^{-4}	1.0×10^{-4}
	Continuous Service Temperature in Air (Max)	°F	-	180		180	180
	Deflection Temperature 66 psi	°F	D648	-		-	-
	Deflection Temperature 264 psi	°F	D648	-		-	-
	Flammability - According to UL 94 (1)	*	UL 94	-		-	-
	Flammability - According to ASTM (2)	%	D2863	-		-	-
ELECTRICAL	Comparitive Tracking Index	-	D3638	-		-	-
	Volume Resistivity	Ohm/cm	D257	$>10^{15}$		$>10^{15}$	$>10^{15}$
	Dielectric Constant (10^3 Hz)	-	D150	2.3		2.3	2.3
	Dielectric Constant (10 x Hz)	-	D150	-		-	-
	Dissipation Factor (Tan :- at 10^3 Hz)	-	D150	1.9×10^{-4}		1.9×10^{-4}	1.9×10^{-4}
	Dielectric Strength	KV/mm	D149	900		900	900

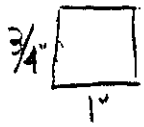
* Industry standard testing method using slurry of 60% aluminum oxide and 40% water at a rotation speed of 1750 rpm for 2 hours. Results indicate the ability of each material, relative to the other, to resist abrasion under typical UHMW applications. A lower number indicates better abrasion resistance.

- **Polystone® UHMW-PE** is an easily machined, highly abrasion-resistant material accepted by the USDA and FDA. This lig weight material combines a very low coefficient of friction with broad temperature and chemical resistance. With little or no moisture absorption, this self-lubricating product has been engineered to achieve an extremely high-impact strength so tha will not break or shatter.

- **Sustarin Acetal**, in its copolymeric form, exhibits high-strength characteristics and excellent thermal properties. This conductive material has very low moisture absorption and thermal expansion, combined with surface and volume resistanc
- Homopolymer **Sustarin** is a tough, very strong product exhibiting extremely low cold flow and thermal properties. Good dimensional stability make this material suitable for a wide range of applications.

PLASTIC SEAL FASTENNING.

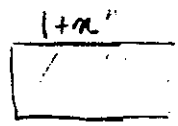
DIMENSIONAL TOLERANCE: ±10% (WIDTH AND HEIGHT)



$x = 2 \times (0.1) \times 1" = 0.2"$

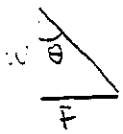
$\theta = \arctg(0.2/77.25) \Rightarrow \theta = 0.15°$

EXTREMELY CONSERVATIVELLY, ASSUMING $x = 1/2$ (TO INCLUDE ALL POSSIBLE DIFFERENCES), WE HAVE:



$\theta = \arctg(0.5/77.25) \Rightarrow \underline{\theta = 0.4°}$

REACTION FORCE



$F = w \sin\theta = 1{,}500 \sin(0.4) \Rightarrow$

$F = 10.5$ lb

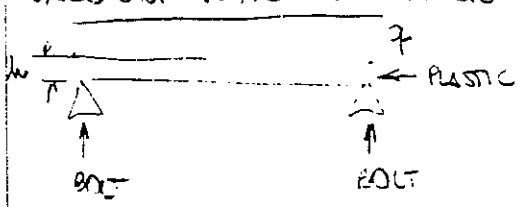
FRICTION $= \mu . F$, $\mu_{MAX} = 0.2 \Rightarrow$ FRICTION $= 0.2 \times 10.5 \Rightarrow$

$\Rightarrow$ FRICTION $= 2.1$ lb.

STRENGHT OF ADHESIVE 3M 4693 $\simeq 3.4$ lb/in
(IN PEELING, FOR POLYETHYLENE FILM AND ALUMINUM, INTERNAL TEST)

SO: ADHESIVE SHOULD SUFFICE, BOLTS ONLY ON SEAMS ($\emptyset \simeq 1/4"$)

VACUUM WINDOW FLANGE BOLTS ("BACK UP").



$M_{MAX} = \frac{w l^2}{8}$ $\quad \sigma_{MAX} = \frac{M_{MAX}}{S}$

$S = \frac{bh^2}{6} \Rightarrow \sigma_{MAX} = \frac{w l^2}{4 \cdot \frac{bh^2}{3}} \Rightarrow$

$\Rightarrow \sigma_{MAX} = \frac{3}{4} \frac{w}{b} \cdot \left(\frac{l}{h}\right)^2$

EXTRAPOLATING AISC/ASD, p. 5-43, F2.1, F2-1, $F_b = 0.75 F_y$ TO THIS CASE, WE HAVE:

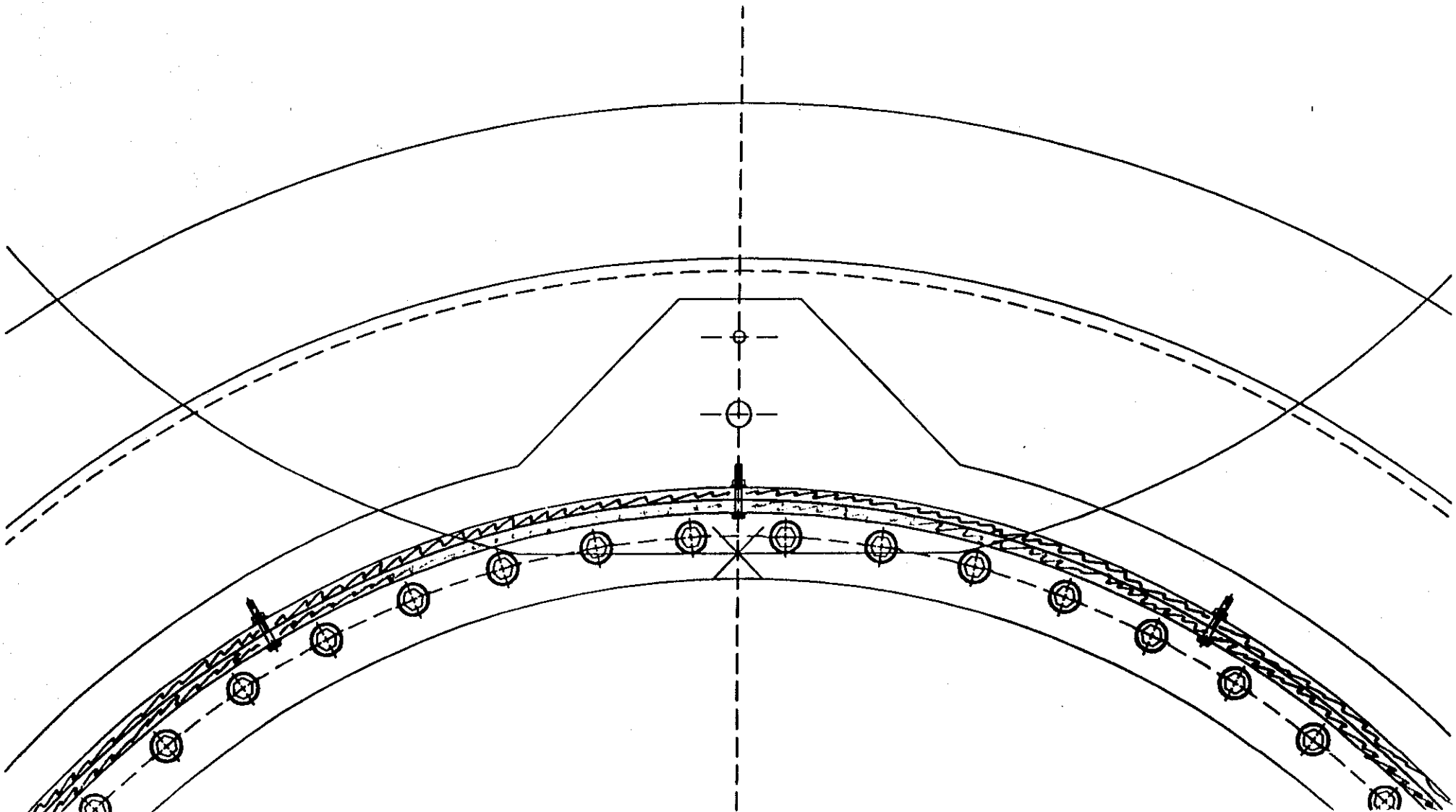
$F_b = 0.75 (3{,}100) = 2{,}325$; $h = 3/4"$, $w = \frac{1{,}500}{l}$, $b = 1" \Rightarrow$

$\Rightarrow 2{,}325 = \left(\frac{3}{4}\right) \frac{1}{1} \cdot \left(\frac{1{,}500}{\cancel{l}}\right) \cdot \frac{l^{\cancel{2}}}{(3/4)^{\cancel{2}}} \Rightarrow l = 2.07"$ (ABOUT BOLT DISTANCES)

$\Rightarrow$ IF BONDING FAILS, THE BOLTS OF THE VACUUM WINDOW FLANGE SHOULD BE ENOUGH TO PREVENT THE PLASTIC FROM FALLING IN THE BEAM LINE

→ STEEL BAND – FROM TRANSITION VESSEL TO BOLT HEADS (~4½")

SUPPORTING BAND – FROM VACUUM WINDOW FLANGE
TO ½" LONGER THAN STEEL BAND (~1⅛")

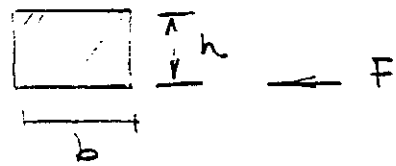


SEAL

STEEL BAND

SIZING FOR COMPRESSION (IN CASE OF WINDOW RUPTURE):

CROSS SECTION



$b = 4\frac{1}{4}$ AND $h = \frac{1}{4}$ WILL BE CHECKED (RYERSON p 107) $\left(\frac{1/4}{\sqrt{12}}\right)$

AISC/ASD, E2, p.5.42, $F_y = 36$, $E = 29{,}000$, $\ell = 4\frac{1}{4}$, $r = 0.072$, $K = 1$

$\Rightarrow$ E2-1, $F_a = 17.5$ ksi

FORCE: $\frac{\pi(77.2\,\Xi)^2}{4} \times 15^{\text{1 ATM}} = 70{,}304$ lb

AREA: $242 \times 1/4 = 60.5$ in^2

$\sigma = \frac{70{,}304}{60.5} \Rightarrow \sigma = 1{,}162$ psi $\Rightarrow SF_{TOTAL} \approx \frac{36}{1.2} \cong \underline{30} \Rightarrow \underline{OK}$

h Tem rature Plastics

Teflon® FEP Heat Shrinkable Tubes

al for extending conveyor roller life where up of materials, cleaning, and corrosion are a em. Regardless of substrate material, any carrying may be covered with these tubes—they form a seamless, low friction sheath.
these tubes on rollers with moderately low roll pressures and transverse forces, and in temperatures below +400° F. Nominal thickness is .020".

When heated to at least +350° F, tubes will quickly and easily shrink on to rollers.

NOTE: See pages 1226-1229 for a complete selection of heat guns.

	1¼" ID		1½" ID		2" ID		2½" ID		3" ID	
th	No.	NET EACH	No.	NET EACH	No.	NET EACH	No.	NET EACH	No.	NET EACH
	8703K82	$21.89	8703K83	$26.17	8703K84	$34.97	8703K85	$42.63	8703K86	$52.63
	8703K12	28.73	8703K13	34.35	8703K14	45.90	8703K15	55.95	8703K16	68.98
	8703K72	36.05	8703K73	43.11	8703K74	57.60	8703K75	70.21	8703K76	86.68
	8703K22	42.56	8703K23	50.89	8703K24	67.97	8703K25	82.89	8703K26	102.33
	8703K62	50.91	8703K63	60.76	8703K64	81.35	8703K65	99.16	8703K66	122.53
	8703K32	56.42	8703K33	67.34	8703K34	90.16	8703K35	109.90	8703K36	135.80
	8703K42	58.62	8703K43	69.96	8703K44	93.67	8703K45	114.18	8703K46	141.09

Teflon® FEP High Impact Sheets and Rods

one (FEP) features extremely high tional non-adhesiveness. Working 400° F. Ideal for use as lining in pipe ment. Color is natural white.

Sheets measure 12" × 12"

Rods ⅛" to ¼" dia. are furnished in 6-ft lengths. Rods ⅜" dia. and up are furnished in 1-ft increments up to a max. length of 6 feet for ⅜" and ½" sizes; 4 feet for sizes ¾" and up. Specify No. and length.

	Sheets			Rods			Rods		
Thick.	No.	NET EACH	Dia.	No.	NET/FOOT	Dia.	No.	NET/FOOT
½"	85375K154	$328.41	⅛"	85325K14	$1.37	½"	85325K34	$12.41
⅝"	85375K164	395.01	3/16"	85325K16	2.01	¾"	85325K38	29.05
¾"	85375K174	442.40	¼"	85325K24	3.80	1"	85325K44	40.49
1"	85375K184	553.01	⅜"	85325K28	6.65	1½"	85325K48	81.62

Torlon (Polyamide-Imide) Sheets and Rods

Made of Torlon 4301, these sheets and rods feature superior mechanical strength, good dimensional stability and creep, and are thermally stable in temperatures of +450° F to +500° F. They're also impact, wear, and chemical resistant. Polyamide-imide offers low flammability, and if ignited, produces little smoke.

Rods are furnished in one foot increments up to a maximum length of 4 feet. Specify No. and length.

	12" × 12" Sheets		12" × 24" Sheets		12" × 48" Sheets		Rods	
Thick.	No.	NET EACH	No.	NET EACH	No.	NET EACH	Dia.	No.	NET/FOOT
¼"	8563K521	$429.48	8563K522	$824.82	8563K524	$1598.40	¼"	8566K81	$9.83
⅜"	8563K541	598.52	8563K542	1157.15	8563K544	2256.45	⅜"	8566K83	18.57
½"	8563K551	639.88	8563K552	1228.51	8563K554	2395.60	½"	8566K84	22.90
¾"	8563K571	890.09	8563K572	1735.68	8563K574	3471.35	¾"	8566K85	60.99
1"	8563K581	1167.08	8563K582	2275.80	8563K584	4551.60	1"	8566K86	82.03

Kel-F CTFE Sheets and Rods

nically inert, Kel-F features high di- est vapor transmission rate of any s −400° F to +400° F. Ideal for use le translucent

Sheets measure 12" × 12"

Rods ⅛" to ½" diameter are furnished in 6 foot lengths. Rods 1" diameter and up are furnished in one foot increments up to a maximum length of 6 feet. Specify No. and length.

	Sheets			Rods			Rods	
Thick.	No.	NET EACH	Dia.	No.	NET/FOOT	Dia.	No.	NET/FOOT
½"	85425K28	$578.51	⅛"	85415K15	$1.88	½"	85415K55	$19.25
⅝"	85425K32	747.60	3/16"	85415K25	3.55	1"	85415K65	78.16
¾"	85425K34	890.00	¼"	85415K35	5.64	1¼"	85415K77	149.63
1"	85425K36	1161.45	⅜"	85415K45	10.68	1½"	85415K85	225.24

Kynar PVDF Sheets and Rods

ures greater strength, wear resis- han FEP Teflon. PVDF also resists cluding oxidizers. These sheets and rods can be used continuously in temperatures up to +300° F.

Rods are furnished in one foot increments up to a maximum length of 5 feet. Specify No. and length.

	12" × 24" Sheets		12" × 48" Sheets		24" × 48" Sheets		Rods	
CH	No.	NET EACH	No.	NET EACH	No.	NET EACH	Dia.	No.	NET/FOOT
.90	8688K626	$137.80	8688K622	$254.40	8688K623	$472.46	¼"	8683K51	$2.18
.72	8688K636	193.32	8688K632	359.03	8688K633	670.19	⅜"	8683K52	4.12
.37	8688K646	231.45	8688K642	429.83	8688K643	798.35	½"	8683K53	6.68
.78	8688K656	328.46	8688K652	609.39	8688K653	1142.80	¾"	8683K54	14.11
.60	8688K666	376.26	8688K662	699.35	8688K663	1316.90	1"	8683K55	25.58
							1½"	8683K56	52.57

Vespel® Rods

of jet engines, Vespel® high-performance polyimide wear, and low friction at high pressures and veloc- excellent lubricated and unlubricated performance. ers, valve seats, gaskets, and static seals. Withstands 000 psi-fpm. Continuous temperature range is −400° to 900° F without melting. Vespel® resists fuels, sol- y other compounds. Machinable with standard met-

Dia.	No.	NET EACH
⅛"	87405K21	$105.56
3/16"	87405K22	124.44
¼"	87405K23	152.23
⅜"	87405K25	172.22

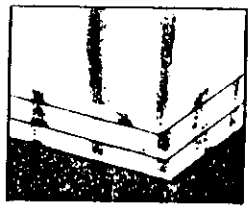
UHMW Sheets, Bars & Rods

Ultra-High Molecular Weight Polyethylene (UHMW)

- **Excellent Abrasion Resistance**
- **Working Temperature Range: −300° F to +180° F**
- **Excellent Dielectric Properties**
- **Good Chemical Resistance**
- **Self Lubricating**
- **Natural White Color**

Referred to as the 'poor man's Teflon', economical UHMW has almost the same nonsticking effectiveness as Teflon. Ideal for lining conveyor belts, guide rails, chutes, bearing surfaces, and work tables. Great for making large bearings and bushings.

UHMW Sheets

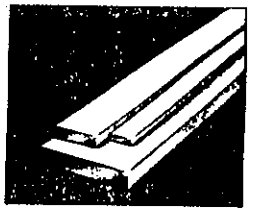


Tolerances—Thickness: ± 10%; length and width: ± ⅛".

	24" × 36"		24" × 48"		48" × 48"		48" × 96"		Add'l Sizes ♦
Thick.	No.	NET EACH	No.	NET EACH	No.	NET EACH	No.	NET EACH	No. NET/SQ. FT.
⅛"	8752K511	$22.33	8752K611	$26.58	8752K811	$49.92	8752K911	$95.68	8752K11 $4.85
3/16"	8752K512	28.34	8752K612	33.80	8752K812	64.76	8752K912	127.64	8752K12 5.69
¼"	8752K513	33.96	8752K613	40.58	8752K813	73.75	8752K913	143.71	8752K13 6.64
⅜"	8752K514	45.65	8752K614	54.84	8752K814	74.53	8752K914	197.60	8752K14 8.44
½"	8752K515	60.82	8752K615	72.80	8752K815	133.47	8752K915	263.47	8752K15 10.92
¾"	8752K516	83.92	8752K616	99.35	8752K816	186.55	8752K916	370.18	8752K16 13.84
1"	8752K517	111.30	8752K617	133.20	8752K817	248.69	8752K917	494.12	8752K17 18.31
1½"	8752K518	153.29	8752K618	185.26	8752K818	355.84	8752K918	698.99	8752K18 25.00

♦ 12" × 12", 12" × 24", 12" × 36", 24" × 24". Specify No. and size desired.

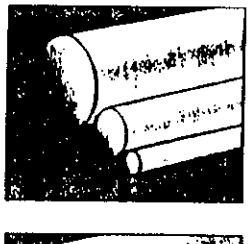
UHMW Rectangular Bars



Tolerances—Length and width: ± .060". Thickness: ⅛" ± 0.010", ¼" to ⅜" ± 0.020", ½" to ¾" ± 10%. **Furnished in 5-foot lengths.**

	⅛" Thick		¼" Thick		⅜" Thick		½" Thick		¾" Thick	
Width	No.	NET EACH	No.	NET EACH	No.	NET EACH	No.	NET EACH	No.	NET EACH
½"	8702K18	$2.13	8702K61	$2.58	8702K71	$3.77	8702K81	$4.97		
¾"	8702K22	2.90	8702K62	3.42	8702K72	4.97	8702K82	6.65	8702K111	$7.68
1"	8702K19	3.06	8702K63	4.29	8702K73	6.32	8702K83	7.43	8702K112	9.80
1½"	8702K24	4.45	8702K64	5.43	8702K74	8.03	8702K84	10.60	8702K113	13.93
2"	8702K25	5.65	8702K65	6.97	8702K75	10.29	8702K85	12.05	8702K114	18.03
3"	8702K27	6.68	8702K67	10.00	8702K77	13.13	8702K87	17.50	8702K116	23.31
4"	8702K28	8.77	8702K68	11.53	8702K78	17.23	8702K88	20.49	8702K117	30.36

UHMW Rods



Tolerances—Plus (+) tolerance for machining down to size.

Rod sizes ½" to 2¼" diameter are furnished in 5 foot lengths. **Rod sizes 2½" diameter and up are furnished in one foot increments up to a maximum length of 5 feet. Specify No. and length.**

Dia.	No.	NET/FOOT	Dia.	No.	NET/FOOT	Dia.	No.	NET/FOOT	Dia.	No.	NET/FOOT
½"	8701K41	$1.00	1½"	8701K47	$4.20	2½"	8701K53	$8.67	4½"	8701K61	$22.37
¾"	8701K43	1.84	1¾"	8701K48	5.05	3"	8701K55	10.19	5"	8701K63	23.83
1"	8701K45	2.32	2"	8701K49	6.10	3½"	8701K57	13.80	5½"	8701K65	33.37
1¼"	8701K46	3.10	2¼"	8701K51	7.04	4"	8701K59	17.49	6"	8701K67	34.40

UHMW Hollow Rods

OD and ID are sufficient for machine finishing to fractional sizes listed. **Furnished in 5-foot lengths.**

OD × ID	No.	NET EACH	OD × ID	No.	NET EACH	OD × ID	No.	NET EACH	OD × ID	No.	NET EACH
⅞" × ¼"	8705K31	$17.30	1½" × ½"	8705K49	$22.22	2" × 1½"	8705K18	$23.23
1" × ½"	8705K33	18.54	1½" × 1"	8705K14	19.90	2" × 1¾"	8705K71	27.60
1⅛" × ⅝"	8705K35	21.11	1⅝" × 1¼"	8705K59	22.70	2½" × 2"	8705K23	30.51
1⅛" × ¾"	8705K37	19.90	1⅝" × 1½"	8705K63	34.43	3" × 2½"	8705K82	42.82

Static-Resistant, Ultraviolet-Inhibited UHMW Sheets

Static resistance allows partial transmission of electrical charge, so that static is reduced. Ideal for chute and slide liners, electronic assembly conveyor components, and hopper liners in dust collection systems. Resistance to ultraviolet radiation makes these sheets suitable for outdoor applications such as dock fender facings, dump trailer liners, snowplow mold boards, and much more.

The sheets resist abrasion and corrosion and have a low coefficient of friction. Color is black.

	24" × 24"		48" × 24"		48" × 48"		48" × 96"	
Thick.	No.	NET EACH	No.	NET EACH	No.	NET EACH	No.	NET EACH
⅛"	85705K26	$13.10	85705K27	$22.83	85705K25	$47.65	85705K24	$93.72
¼"	85705K36	19.85	85705K37	38.72	85705K35	70.99	85705K34	138.32
½"	85705K46	38.72	85705K47	70.13	85705K45	139.40	85705K44	255.38
1"	85705K56	70.13	85705K57	139.23	85705K55	257.04	85705K54	474.24

UHMW Polyethylene Film

Film has self-lubricating and high-slip properties that make it ideal for guide rails, wear strips, bearings, chute linings for bulk-material handling, and for use with pressure sensitive adhesives. Film is acceptable for food and drug contact applications. It has high-impact resistance and stress resistance.

lengths. Please specify No. and length when ordering. For additional lengths, specify to the nearest foot.

Thickness	No.	NET/FOOT
.005"	85655K12	$1.28
.010"	85655K13	2.49

Silica e Rubber

ber Sheets

Range: −60° to +500° F

50/60/70

With the widest temperature nge of any of the polymers, sil-one rubber is the solution to any high-temperature sealing, sketing, insulation, and nission-control problems.

This rubber has extended resis-nce to weather, sunlight, mois-re, radiation, oxidation, and zone. It has good electrical resis-nsulation.

aturn nearly to its original thick-

producing chemicals and is non-ontoxic. It makes an excellent re-ed to metal, glass, ceramics, and leets spec. ZZ-R-765-B, Class 2 A ter 40 and 50, 700 psi; for durom-ardness, Shore A: 40 is 40 ± 5.50

ometer. To order, please specify ness required.

24" × 24" NET EACH		36" × 36" No.	NET EACH
32K51	$27.53	8632K91	$48.20
32K52	38.80	8632K92	66.83
32K53	50.73	8632K93	87.78
12K54	62.73	8632K94	108.45
2K55	90.05	8632K95	155.80
2K56	99.58	8632K96	175.71
12K57	148.96	8632K97	257.64
32K58	172.64	8632K98	298.72

ne Rubber Sheets

ge: −80° to +450° F

ometer Hardness, Shore A: 45-55

You can see through this rub-ber to identify product and flow status. Ideal for many gasketing, sealing, diaphragm, and vacuum bagging applications. It's tear re-sistant, elastic, and resilient, as well as odorless, tasteless, and nontoxic. Makes a good release surface. Weather resistant. It can be used indoors and outdoors.

24" × 24" ET EACH		36" × 36" No.	NET EACH
1	$30.10	86465K71	$59.64
33	48.39	86465K73	96.36
5K35	93.14	86465K75	184.87

rylic-Polymer Sheets

ure Range: −40° to +280° F

ometer Hardness, Shore 00: 35

You get three times the shock-sorbing power of conventional ma-rials. This unique, solid-state foam vides two-stage shock absorp-n: vibration damping plus shock at-nuation in one material. It is micro-ellular like a polymeric foam, with ny, solid, viscoelastic spheres which eform rather than compress when aded. Cells change shape under low her loads, providing equal impact ab-n, and shear. Material is partially self-tive to foam and felt in mounting ap-lus die-cut squares and circles.

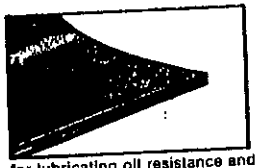
12" × 12" Sheet No.	NET EACH	24" × 24" Sheet No.	NET EACH
86385K42	$12.58	86385K62	$40.24
86385K43	13.95	86385K63	44.64

CIRCLES (3 mm thk.)

H Up	Dia.	No.	CH Up
	1"	86385K81	$ 0.50

Fiber Glass Reinforced Silicone Rubber Sheeting

- Color: Red • Temperature Range: −65° to +400°
- Tensile Strength: Not rated • Durometer Hardness, Shore A: 60-80



Extra-durable sheeting is made from silicone rubber stock with a 0.013" thick fiber glass insert for high breaking strength of 300 psi.

This premium-quality, tough, hard material is excellent for use as press pads, belting, and gasketing. It is specially formulated to meet AMS 3320F specifications for lubricating oil resistance and compression set.

Silicone rubber is flexible, nonstretching, and resistant to aging. The sheeting retains its electrical resistance and insulating ability under elevated temperatures. Chemical and fluid resistance is good. Nonstick characteristic makes it a good release surface.

WIDTH IS 36"

Thickness	No.	NET/LIN. FT.
1/16"	8612K21	$26.15
3/32"	8612K32	36.11
1/8"	8612K43	43.39

Loaded Silicone Rubber Sheeting With Fiber Glass Backing

- Color: Dark Gray/White Fiber Glass Backing
- Temperature Range: −90° to +400° F
- Tensile Strength: Warp−215 pplmin.; Fill−100 pplmin.
- Durometer Hardness, Shore A: 60-80

Fiber glass-backed, solid silicone rubber sheeting is designed for acoustical transmission loss and fire-retardant applications. It s nontoxic with virtually no smoke generation upon combustion. Also contains no lead. Sheeting is an excellent acoustical and fire barrier. Meets Vertical Burn FAR 25.853 (A & B).

WIDTH IS 36"

Thick.	Density	No.	NET/LIN. FT.
.050"	0.50"	86175K33	$37.14
.075"	0.75"	86175K35	54.55
.100"	1.00"	86175K37	65.45
.150"	1.50"	86175K39	79.34

High-Purity Silicone Rubber Sheeting

- Color: Cream • Temperature Range: −40° to +450° F
- Tensile Strength: 650 psi • Durometer Hardness, Shore A: 30-40

Thin, very rubbery, cast silicone sheeting is perfect for use where a material with very high elasticity is needed.

It's excellent for gasketing, sealing, diaphragm material, vacuum bagging, and laboratory valves. Furnished with protective mylar film (remove film before cutting).

WIDTH IS 36"

Thickness	No.	NET/LIN. FT.
.010"	86435K14	$23.70
.015"	86435K16	25.20
.020"	86435K21	27.54

Conductive Polyurethane Rubber Sheeting

- Color: Black • Temperature Range: −40° to +185° F
- Tensile Strength: 4000 psi • Durometer Hardness: Not Rated

Electrically conductive sheeting safely grounds electricity, helping to prevent hazardous buildup and sparking.

Some of its applications include linings, protective covers, and laboratory countertop covers. Made of polyurethane on nylon twill.

Sheeting conforms to National Fire Protection Association Specification 56A, Article 4631, and Federal Specification ZZ-C-450 Type I with the exception of thickness.

Thickness is .008" ± .001". Weight is 4.3 oz./sq. yd. The resistivity is less than 5000 ohms, with electrodes contacting fabric 30" apart. Breaking strength is 100 psi.

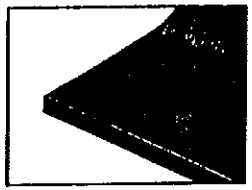
WIDTH IS 54"

No.	NET/LIN. FT.
8712K92	$6.67

Specialty Ru

Standard SBR Rubber Sheeting

- Colors: Black, Red • Temperature Range: −20° to +170° F
- Tensile Strength (psi): Black, 700; Red, 400; Reinforced, 400
- Durometer Hardness, Shore A: Black/Red, 70-80; Reinforced, 60-70



General-purpose styrene butadiene rubber (SBR) is widely used for gasketing and washers to resist low-pressure water and air. It has excellent abrasion resistance; not resistant to oil.

Standard Black and Red—May be used against steam up to 100 psi. They meet ASTM D-2000-75E, Type AA.

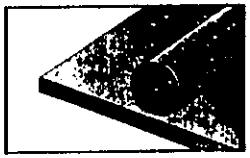
Reinforced Black—The rubber is inserted with polyester fabric plies for high strength—excellent for flange gaskets and for saturated steam and low-pressure steam.

WIDTH IS 36"

Thick.	Standard Black No.	NET/LIN. FT.	Standard Red No.	NET/LIN. FT.	Reinforced Black No.	NET/LIN. FT.
1/16"	8634K11	$4.78	9454K2	$3.23	8617K51	$4.97
3/32"	8634K27	5.13	9454K3	5.10		
1/8"	8634K12	8.13	9454K4	6.53	8617K53	9.58
3/16"	8634K13	12.53	9454K5	10.33	8617K54	13.43
1/4"	8634K14	16.73	9454K6	13.70	8617K55	17.72
3/8"	8634K15	26.71				
1/2"	8634K16	30.62				
3/4"	8634K18	46.18				
1"	8634K19	60.15				

Rock Hard SBR Rubber Rods and Sheets

- Color: Black • Temperature Range: +20° to +180° F
- Tensile Strength: 6000 psi • Durometer Hardness, Shore D: 73-83



As hard as most plastics, this rubber can be used as an economical alternative to UHMW polyethylene. It can be machined into small parts, spacers, and washers. It resists abrasion, impact, chemicals, and flame, and is a good electrical insulator. Meets ASTM D 2135-G4440.

RODS—35" ± 1"

Dia.	No.	NET EACH	Dia.	No.	NET EACH
1/8"	8621K51	$4.80	5/8"	8621K35	$19.62
3/16"	8621K52	6.11	3/4"	8621K36	26.53
1/4"	8621K73	7.00	1"	8621K38	40.72
5/16"	8621K31	8.04	1 1/4"	8621K61	57.55
3/8"	8621K32	9.60	1 1/2"	8621K6	81.17
1/2"	8621K34	13.22	2"	8621K63	141.25

SHEETS

Approximate Size: 24" × 24"

Thick.	No.	NET EACH	Thick.	No.	NET EACH
1/16"	8620K12	$96.67	1/8"	8620K18	$267.16
1/8"	8620K14	106.67	1/4"	8620K22	285.71
1/2"	8620K16	194.03			

Sorbothane Viscoelastic Rubber Sheets

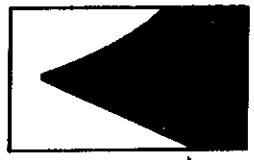
- Color: Black • Temperature Range: −40° to +230° F
- Tensile Strength: 124 psi • Durometer Hardness, Shore 00: 45-55

This advanced solid polymer material is like a liquid in both its mechanical damping and energy absorption abilities. After repeated compressions, it returns virtually to its original shape. It is excellent for acoustical damping, shock absorption, anti-fatigue mats, and vibration isolation. Resistance to chemicals, diesel fuel, and kerosene, and ultraviolet is good. Sorbothane is nontoxic, nonirritating, and noncaustic. It is stable over a broad temperature range.

Thick.	12" × 12" No.	NET EACH	24" × 24" No.	NET EACH
1/8"	8514K11	$16.55	8514K31	$44.56
3/16"	8514K13	21.93	8514K33	61.28
1/4"	8514K15	24.76	8514K35	65.82
3/8"	8514K17	36.16	8514K37	98.93
1/2"	8514K19	42.80	8514K39	140.17
5/8"	8514K22	50.30	8514K42	159.82
3/4"	8514K24	63.42	8514K44	192.63
1"	8514K26	84.50	8514K46	258.48

V

- Color: Black
- Tensile Strength: 1500 psi • Durometer Hardness, Shore A: 70-80



One of the best rubbers available for fuel, oil, and chemical resistance, Viton also has an outstanding temperature range.

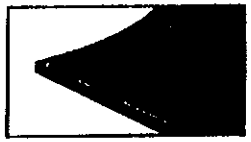
Made with fluorocarbon elastomer, Viton has excellent resistance to weather, oxidation, and ozone. It is ideally suited for gasketing, packing, sealing, and O-rings.

This rubber meets ASTM D 2000-75E, Type HK and MIL-[illegible]-83248 Type 2, Class 1.

Thick.	12" × 12" Sheets No.	NET EACH	12" × 24" Sheets No.	NET EACH	36" Wide Rolls No.	NET/LIN. FT.
1/32"	8625K21	$32.33	8625K41	$57.47	8625K61	$74.22
1/16"	8625K22	53.13	8625K42	95.64	8625K62	119.76
3/32"	8625K23	71.74	8625K43	130.44	8625K63	164.40
1/8"	8625K24	93.26	8625K44	169.56	8625K64	211.65
3/16"	8625K29	127.84	8625K45	234.37	8625K69	293.58
1/4"	8625K25	156.63	8625K46	289.17	8625K65	383.79

EPDM Rubber Sheeting

- Color: Black • Temperature Range: −40° to +240° F
- Tensile Strength: 1000 psi • Durometer Hardness, Shore A: 55-65



A good rubber to use when you require a wide temperature range and excellent resistance to weather and ozone. Uses include automotive body mounts and pads, conveyor belting, and wire and cable insulation jacketing. Not oil resistant.

Thick.	12" × 12" Sheets No.	NET EACH	12" × 24" Sheets No.	NET EACH	36" Wide Rolls No.	NET/LIN. FT.
1/32"	8610K81	$2.66	8610K71	$4.83	8610K22	$6.32
1/16"	8610K82	3.45	8610K72	6.11	8610K11	8.01
3/32"	8610K83	5.16	8610K73	9.17	8610K33	11.95
1/8"	8610K84	6.09	8610K74	10.68	8610K12	13.91
3/16"	8610K85	9.34	8610K75	16.38	8610K34	21.35
1/4"	8610K86	9.83	8610K76	17.47	8610K35	22.78
3/8"	8610K87	15.31	8610K77	27.56	8610K44	35.93
1/2"	8610K88	18.96	8610K78	34.47	8610K55	44.95

Black Oil-Resistant Vinyl Rubber Sheeting

- Color: Black • Temperature Range: +20° to +160° F
- Tensile Strength: 1000 psi • Durometer Hardness, Shore A: 60-70

This smooth sheeting is ideal for low-pressure washer and gasket applications. In addition to withstanding oil, it also resists water, chemicals, oxidizing agents, abrasion, ozone, and weather. Meets MIL-R-3584.

WIDTH IS 36"

Thick.	No.	NET/LIN. FT.
1/16"	8513K22	$2.63
1/8"	8513K24	4.72
3/16"	8513K26	6.44
1/4"	8513K28	7.73

White FDA Vinyl/Nitrile Rubber Sheeting

- Color: White • Temperature Range: −25° to +240° F
- Tensile Strength: 2000 psi • Durometer Hardness, Shore A: 65-75

Polyblend food-grade sheet rubber is made of FDA-approved ingredients. It's especially useful in food handling and drug and cosmetic manufacturing. Sheeting is nontoxic, nonallergenic, and nonmarking. It stands up to greasy, oily, and abrasive conditions and also resists heat and ozone. Meets ASTM D 2000-4BK720.

Thick.	12" × 12" Sheets No.	NET EACH	12" × 24" Sheets No.	NET EACH	36" Wide Rolls No.	NET/LIN. FT.
1/32"	8615K81	$4.54	8615K91	$7.98	8615K61	$10.39
1/16"	8615K82	5.57	8615K92	9.75	8615K62	12.72
3/32"	8615K83	7.97	8615K93	13.95	8615K63	18.20
1/8"	8615K84	10.29	8615K94	17.98	8615K64	20.83
3/16"	8615K85	13.78	8615K95	24.49	8615K[illegible]	11.94
1/4"	8615K86	16.64	8615K96	29.94	8615K[illegible]	9.05

3. Shield Plate Material Selection and Allowable Stresses

KTeV Vacuum Chamber Safety Barrier		Steel Plate			Aluminum Plate		
	Material Specification	A 36	T-1 A (*)	E4130AQ-N	2024 - T351	6061-T6	7075-T651
yield	ksi	36	100	70	47	40	73
ultimate	ksi	58	110	90	68	45	83
fatigue	ksi	-	-	-	20	14	23
E	1000 ksi	29.0	29.0	29.0	10.6	10.0	10.4
elongation	%	20	16	8	19	12	11
hardness	Brinell (max.)	137	293	197	120	95	150
thickness	(Mat.yield/T1-A yield)	3	1	1 1/2	2.250	2.500	1.500
density	lb/cuin.	0.283	0.283	0.283	0.101	0.098	0.101
weight	lb	5709	1903	2854	1528	1647	1019
cost / lb	$/lb	0.35	0.59	-	-	1.91	2.93
cost	$	1998.04	1122.71	-	-	3146.50	2984.75
machine	-	-	-	-	B	C	B
weld	-	-	-	-	D	A	D
corrosion	-	-	-	-	C	A	C
uses	-	-	-	-	wheels	structures	aircrafts
min. bend radii	-	-	-	-	9.5	5	9.5

(*) ASTM A514 Gr. B

(3) ALLOWABLE STRESSES

THE SHIELD IS A CIRCULAR PLATE SIMPLY SUPPORTED ON THE EDGES:

THE MATERIAL CHOSEN IS ASTM A 514 gr. B, CARBON STEEL.

AVERAGE COMPOSITION (%):

0.5 Cr, 0.2 Mo, 0.06 V, 0.17 C, 0.85 Mn, 0.28 Si, 0.02 Ti, 0.03 B

MECHANICAL PROPERTIES ($3/4" < t < 2\frac{1}{2}"$)

$\sigma_u = 110$ TO 130 ksi, $\sigma_{y\,MIN} = 100$ ksi, $e(\%) = 18$

ON RJY, p.711, IT IS WRITTEN: "IT CAN BE SEEN THAT THE ORDINARY ASSUMPTION THAT SUDDEN LOADING CAUSES TWICE AS MUCH STRESS AND DEFLECTION AS STATIC LOADING IS ALWAYS A SAFE ONE TO MAKE." ON ART. 15.4, p.713, THIS IS REAFFIRMED. NOTE THAT IN ELASTIC DEFORMATION REGIME STRESSES ARE LINEARLY PROPORTIONAL TO DEFLECTIONS

EXTRAPOLATING THE RECOMMENDATIONS FOUND ON AISC/ASD, p.5-48, F2.1, F2-1: $F_b = 0.75 F_y$ FOR WEAK AXIS BENDING OF RECTANGULAR PLATES TO ROUND PLATES AND ADDING THE FACTOR 2 FROM ABOVE TO IT, WE HAVE:

$$\sigma_A = \frac{0.75 F_y}{2} \Rightarrow \sigma_A = 0.375 F_y \; ; \; \sigma_A = 37{,}500 \text{ psi}$$

ANOTHER APPROACH IS TO USE A PRESSURE VESSEL CODE TO ESTABLISH THE ALLOWABLE STRESS

ACCORDING TO TABLE 1A, SECTION 2, PART D, OF ASME SECTION VIII DIVISION 1, p. 30 TO 33, FOR SA-517 GRADE B PLATES, WE HAVE:

0.5 Cr, 0.2 Mo, V (P# 11B, GROUP 4, COMMENTS (3))

$\sigma_u = 115$ Ksi, $\sigma_y = 100$ Ksi;

$\sigma_A = 28.8$ Ksi (FROM $-20°F$ UP TO $600°F$)

AS THIS LAST APPROACH IS MORE CONSERVATIVE, IT WILL BE CHOSEN. SO:

$\sigma_A = 28{,}800$ psi ($\Rightarrow \sigma_A = 0.288\,\sigma_y$, SF = 3.47)

PLATE — ASTM A514 (T-1) Alloy Steel

QUENCHED & TEMPERED

Conforms to ASTM A514

Sizes in Stock

Size in inches	Weight per Sq. Ft. in Lbs.	T-1 Type A A514 Grade B	T-1 Type B A514 Grade H	T-1 Type A A514 Grade F	T-1 Type C A514 Grade Q
3/16 x 60	7.660	X	..	..	..
84	7.660	X	..	..	..
96	7.660	X	..	..	..
1/4 x 72	10.21	X	..	..	..
84	10.21	X	..	..	..
96	10.21	X	..	..	..
5/16 x 96	12.76	X	..	..	..
3/8 x 72	15.32	X	..	..	..
96	15.32	X	..	..	..
1/2 x 84	20.42	X	..	..	..
96	20.42	X	..	..	..
5/8 x 84	25.53	X	..	..	..
96	25.53	X	..	..	..
3/4 x 72	30.63	X	..	..	..
84	30.63	X	..	..	..
96	30.63	X	..	..	..
7/8 x 84	35.74	X	..	..	..
96	35.74	X	..	..	..
1 x 84	40.84	X	..	..	..
90	40.84	X	..	..	..
96	40.84	X	..	..	..
1 1/4 x 84	51.05	X	..	..	..
96	51.05	X	..	..	..
1 1/2 x 84	61.26	..	X	..	..
96	61.26	..	X	..	..
1 3/4 x 84	71.47	..	X	..	..
96	71.47	..	X	..	..
2 x 84	81.68	..	X	..	..
96	81.68	..	X	..	..
2 1/4 x 96	91.89	..	..	X	..
2 1/2 x 84	102.1	..	..	X	..
96	102.1	..	..	X	..
2 3/4 x 84	112.3	..	..	..	X
96	112.3	..	..	..	X
3 x 84	122.5	..	..	..	X
90	122.5	..	..	..	X
96	122.5	..	..	..	X
3 1/2 x 60	142.9	..	..	..	X
84	142.9	..	..	..	X
96	142.9	..	..	..	X
4 x 60	163.4	..	..	..	X
84	163.4	..	..	..	X
96	163.4	..	..	..	X
4 1/2	183.8	..	..	..	X
	183.8	..	..	..	X

GUIDE TO SELECTION

PRESSURE VESSEL QUALITY PLATES

Specific, tightly controlled ASTM specs produce a superior carbon or alloy steel to withstand the pressure found in vessels, boilers, etc. The known, consistent properties of these tightly controlled plates make them desirable for many other applications.

All PVQ plates are subjected to a series of tests to assure consistent, controlled properties. **PVQ-S4** plates are ordered with supplemental S-4 testing (as outlined by ASTM A20) to assure conformance to mechanical property requirements. Ryerson stocks carbon and alloy steel **PVQ** plates to the following ASTM specs:

ASTM A285. (ASME SA285) — A popular, moderate strength steel for stationary service vessels and boilers. Stocked up to 2" thick, they have excellent formability and weldability. Stocked in PVQ-S4 Grade C. Ident. color: blue and gold.

ASTM A387 GR 11 CLASS 1 ANNEALED. (ASME SA 387) — A chrome/moly alloy. Intended primarily for elevated temperature service. Ident. color: blue-black-green.

ASTM A387 GR 22 CLASS 2 NORMALIZED AND TEMPERED. (ASME SA 387) — Similar to A387 Gr. 11 but with more chrome/moly. Designed primarily for elevated temperature service. Ident. color: blue-black-silver.

ASTM A515. (ASME SA 515) — More strength than A285 for intermediate and high temperature service. Weldable with proper recommended techniques, A515 plates have coarse grain structure and are silicon killed. Stocked in PVQ-S4 (Gr. 55, Gr. 60, Gr. 65 and Gr. 70) in the as rolled or normalized condition. Sizes of Grade 70, 2 1/4" thick and heavier are stocked in the normalized condition. Ident. color: Grade 55 — blue, silver, blue; Grade 60 — blue, silver, gold; Grade 65 — blue, brown and white; Grade 70 (as rolled) — blue and brown; Grade 70 (normalized) — blue and silver.

ASTM A516. (ASME SA 516) — Similar to A515 with identical yield points. Intended for low temperatures where improved notch toughness is required. ASTM A516 has fine grain structure and is silicon killed. Grade 70, stocked in the as rolled or normalized condition, with S-4 supplemental testing. Additional S-5 testing for selected items in the normalized condition. Ident. color: blue and red.

Mechanical Properties

ASTM Specification	Minimum Yield, psi	Tensile Strength, psi	Carbon Max.*
A285 — Gr. C	30,000	55 to 65,000	.28
A387 — Gr. 11	35,000	60 to 85,000	.17
A387 — Gr. 22	45,000	75 to 100,000	.15
A515 — Gr. 55[1]	30,000	55 to 75,000	.20/.28
Gr. 60	32,000	60 to 80,000	.24/.31
Gr. 65	35,000	65 to 77,000	.28/.33
Gr. 70[1]	38,000	70 to 85,000	.31/.35
— Gr. 70[1]	38,000	70 to 85,000	.27/.31

4. Shield Plate Stress Analysis (ANSYS F.E.A. by Ang Lee)

(4) SHIELD PLATE ANALYSIS

ALLOWABLE STRESS: $\sigma_A = 28.8$ ksi (SEE (3))

TAKEN IN CONSIDERATION $D = 77\frac{1}{4}''$, $q = 15$ psi, AND:

- THE PLATE IS GOING TO BE SUPPORTED BY PLASTIC MATERIAL, CAPABLE OF ABSORBING ENERGY;
- ANY LEAKS ARE FAVORABLE;
- THE HIGHER STRESSES HAPPEN IN THE CENTER OF THE PLATE, FAR AWAY FROM THE BEARING AREA;
- THE NATURAL FREQUENCY IS ESTIMATED IN LESS THAN 5 Hz;

AND ASSUMING 1 INCH THICK PLATE, WE GET:

R&Y → $\sigma_{MAX_Y} = 27.7$ Ksi, $y_{MAX} = 0.80''$

ANSYS → $\sigma_{MAX_{SI}} = 26.1$ Ksi, $y_{MAX} = 0.70''$ (BY ANG LEE)

CONSIDERING THE F.E.A. RESULTS, WE HAVE

$\sigma_{MAX_{SI}} = 0.261\ \sigma_y \Rightarrow$ <u>SF = 3.83</u>

(SEE PAGES ATTACHED)

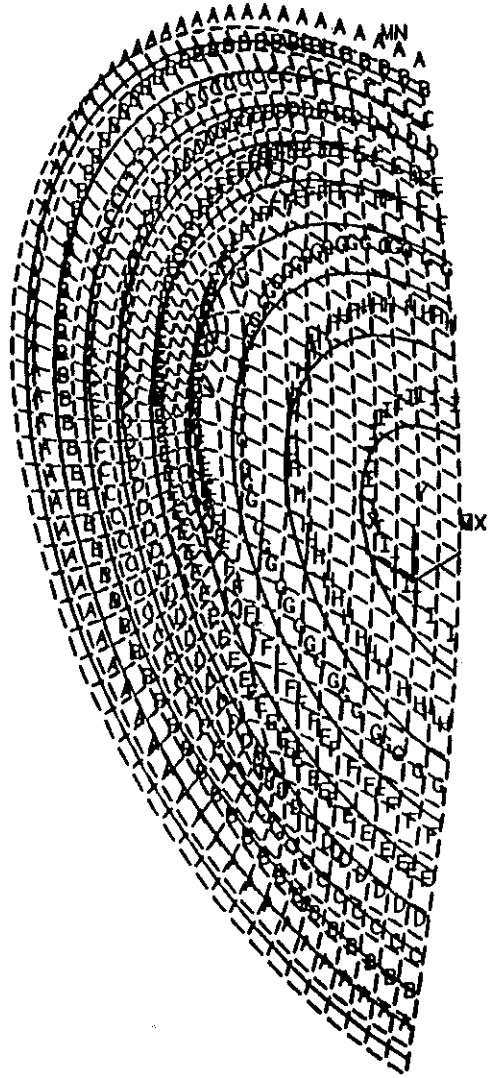
RAW MATERIAL:

RYERSON, P. 38, 1 x 84 x , 40.84 lb/ft², TI-A, A514 GTB

TOLERANCES: THICKNESS : $1''^{+0.11}_{-0.01}$

WIDTH : $90''^{+1\frac{1}{8}}_{-\frac{1}{4}}$

LENGTH : $90''^{+1\frac{1}{8}}_{-\frac{1}{4}}$



ANSYS 5.0 A
FEB 7 1995
09:06:48
PLOT NO. 1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SINT (AVG)
TOP
DMX =0.700846
SMN =6369
SMX =26112
A =7466
B =9660
C =11853
D =14047
E =16241
F =18434
G =20628
H =22822
I =25015

KTeV Vacuum Window Shield (half), R=38.625", t=1", load = 15 psi(static

BY ANG LEE

From: FNALV::ALEE 7-FEB-1995 13:24:50.14 BY ANG LEE
To: RAFAEL
CC:
Subj: input file for 38.625" window shield

```
c****** Analysis: KTeV Vacuum Chamber Window Shield
/prep7
/tit,KTeV Vacuum Window Shield (half), R=38.625",  t=1", load = 15 psi(static)
c********
acel,0,1,0              ****** y acel (g): F=ma, F=lbf &  m=lb => a=1!
c****** Shield constants
c****** Material: ASTM A514 Gr.B, suitable for welding (known as "T1 type A")
c****** = high yield strength, 100 ksi (min.)
c****** = low carbon alloy (Ni, Mo, Va, Bo, ...), Q&T steel
c********
dipp=15                 ****** Pressure: 1 atm ~ 15 psi
Eshield=29e6            ****** Steel: E=29000ksi
tshield=1               ****** thickness: 1"
dshield=0.283           ****** 0.284 lb/cuin
rad=38.625                ****** radius of window (support) update to 41"
lip=1                   ****** vacuum chamber flange lip update to 0.5 "
c******
et,1,63
mp,ex,1,Eshield
mp,dens,1,dshield
r,1,tshield
c********
csys,1
k,1,0
k,2,rad,0
k,3,rad,90
k,4,rad,-90
a,1,4,2,3
esize,2
amesh,all
c********
nsel,s,loc,x,rad
d,all,uz,0
csys
nsel,s,loc,x,0
dsym,symm,x
nsel,s,loc,x,0
nsel,r,loc,y,rad
d,all,uy,0
allsel,all
sf,all,press,15
c*******
allsel,all
save
fini
/solu
lumpm,off
antype,static
cnvtol,f,,0.0001
nlgeom,on
sstif,on
nropt,auto
neqit,40
solve
fini
```

VARIABLE SHEET

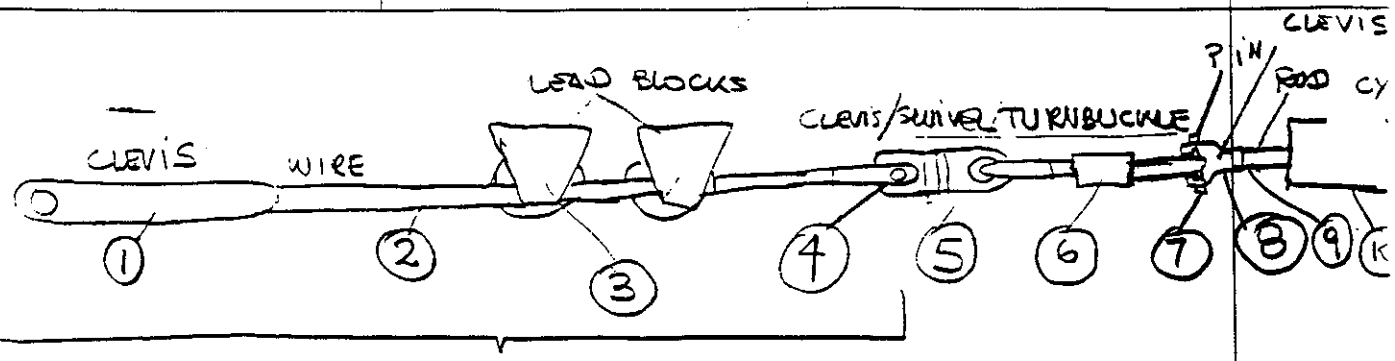
St	Input	Name	Output	Unit	Comment
		.			Case 10 - Solid Circular plate with uniformly distributed pressure. p.429 Chapter 10
	15	q		psi	Uniform pressure
	0	r0		in	Radius to start of pressure
					Table 24 - Roark & Young (6 ed) Formulas for flat circular plates of constant thickness
		case	'Case_10a		Reference number
			'_		Material
			'_		ASTM A514Gr.B (T-1 A)
			'_		Fy = 100 ksi, Fu = 110 ksi
					e(%) = 18
	2.9E7	E		psi	Young's Modulus
	.3	nu			Poisson's ratio
	38.625	a		in	Outer Radius
	1	t		in	Plate Thickness
		D	2655677.7	in-lb	Plate Constant
					AT RADIUS:
	0	r		in	Radius
		y	-.8008338	in	Deflection
		th	0	rad	Radial Slope Angle
		Mr	4615.537	in-lb/in	Radial Bending Moment
		Mt	4615.537	in-lb/in	Tangential Bending Moment
		Qr	0	lb/in	Shear Force
		sigma_r	27693.22	psi	Radial Bending Stress
		sigma_t	27693.22	psi	Tangential Bending Stress
					AT OUTER EDGE:
		ya	0	in	Deflection
		tha	.0312959	rad	Radial Slope Angle
		Mra	0	in-lb/in	Radial Bending Moment
		Qa	-289.688	lb/in	Shear Force
					AT CENTER:
		yc	-.8008338	in	Deflection
		Mc	4615.537	in-lb/in	Radial Bending Moment
					Case 10 - Solid Circular plate with uniformly distributed pressure. p.429 Simply supported at edges
					Remarks:
	100000	Fy	psi		
		w	1331.2558	lb	Weight
		SF	3.6109922		Safety Factor = Fy/sigma_t

```
---------------------- VARIABLE SHEET ----------------------------------------------
St Input---- Name--- Output--- Unit----- Comment-------------------------------
                                         Table 36,Case 11a-Roark & Young (6 ed)
                                         Natural Frequencies of Vibration,
                                         continuous members. Page 716
                                         Chapter 15
                                         Circular flat plate, uniformly loaded,
                                         Edge simply supported
             case     'Case_11a           Reference Number
   2.9E7     E                  psi      Young's Modulus
   .3        nu                          Poisson's Ratio
   38.625    r                  in       Radius
   1         t                  in       Thickness
   386.22    g                  in/sec^2 Gravitational acceleration
   15        w                  psi      Uniform load
   1         n                           Mode:  n=1 -> Fundamental mode
                                                n=2 -> one nodal diameter
                                                n=3 -> two nodal diameters
                                                n=4 -> one nodal circle
             fn       4.402      Hz       Natural frequency

             D        2655677.7  in-lb    Plate constant
```

5. Wire Rope, Fittings, Pin, Lead Blocks, Swivel, and Turnbuckle

(5)



. JORDAN,
HN SAKASH,
RCH/08/95,
WEEKS DELIVERY,
CES INCLUDE
% DISCOUNT

TO BE ASSEMBLED BY WIRE ROPE COMPANY
(SUG. JOHN SAKASH, PHONE: 833-3940)

EE (4) (1) - CLEVIS FITTING FOR WIRE ROPE.

ELECTROLINE, FORGED SERIES, CLEVIS ASSEMBLY, SPECIAL ORDER:
IT IS A 7/16 WIRE ROPE SIZE WITH 3/8" WIRE ROPE PLUG
AND SLEEVE (SEE P. 34, JOHN SAKASH, 7/16")

PART # GD143MS5050-3/8, ($44.18 FROM FACTORY)
GALVANIZED

EE (4) (2) - WIRE ROPE (LENGTH FROM FITTING TO FITTING = 165.11")
FOR QUOTE. 177.5" FROM PIN TO PIN.
3/8" DIA., 6x37 IWRC, EIP GRADE, STEEL CORE,
GALVANIZED.
6.63 TONS MINIMAL STRENGTH (13,250 lb) (p. 3, J. SAKASH)
($1.21/ft) (SF ~ 8.8)

150.62 (3) LEAD BLOCKS

CROSBY VERTICAL LEAD BLOCK MODEL 601-5, $
GALVANIZED, SHEAVE DIAMETER = 6", STOCK # 772202,
WL = 4,000 lb, 3/8" WIRE ROPE, 12 lb EACH. (p. 244, CROSBY)

+(2)+(4)
. $109.75 (4) - CLEVIS FITTING FOR WIRE ROPE $45.0

SAME AS (1) (MAKES INSTALATION SIMPLER)

. 187.00 (5) SWIVEL
PART # 297057, STYLE 35-5
CROSBY, STYLE EYE & EYE (S-5), WORKING LOAD = 3 TONS $
(6,000 lb), HOLES = 1.03", LENGTH = 9.41", HOLE TO END = 0.735"
(p. 85, CROSBY)

(6) - TURNBUCKLE W/ LOCKNUTS (4)

$63.07 CROSBY, HG-227, JAW & EYE #1032171, 1x6, PIN - 0.88", CLEARANCE (WL = 10,
x $2.05 ≈2.06" MAX 1.46 MIN, LENGTH = 27" OPEN 21" CLOSED, EYE FITS (limit)
x $3.78 PIN WITH Ø = 1.00", PIN TO END = 0.88". (CROSBY, p. 108)
CROSBY LOCKNUTS, 2xHG4060, 1" #1075277, 2xHG4061, 1", #1075

$8.00 (7) - CYLINDER CLEVIS PIN

PARKER # 68370, 1", WL = 34,300 lb

(8) - CYLINDER CLEVIS

$60.00 PARKER # 133285, PIN = 1", WL = 19,500 lb

THREAD = 1-14, HEIGHT UP TO PIN CENTER = 3 1/8

EE (10) (9) - CYLINDER ROD

PARKER #1, 1 3/8" O.D., STYLE #4, 1-14 THREAD.

)+(10) = (10) CYLINDER

$1980.00 PARKER # 6" CC-2A US14AC80

2A HEAVY DUTY AIR CYLINDER

6" BORE x 80" STROKE AND 4" STOP TUBE

(76" OF USABLE STROKE)

ROD #1 (STANDARD), O.D. = 1 3/8"

ROD END = STYLE 4 (STANDARD), 1-14 THREAD

CUSHION ON BOTH ENDS

SIDE LUG MOUNTINGS.

WIRE & FITTINGS

ACCORDING TO MACHINERY'S HANDBOOK p. 331, SAFETY FACTOR FOR OPERATING ROPES SHOULD BE BETWEEN 5 AND 12. TO AVOID ROTATION THE LOAD SHOULD BE ABOUT 10% OF THE BREAKING LOAD

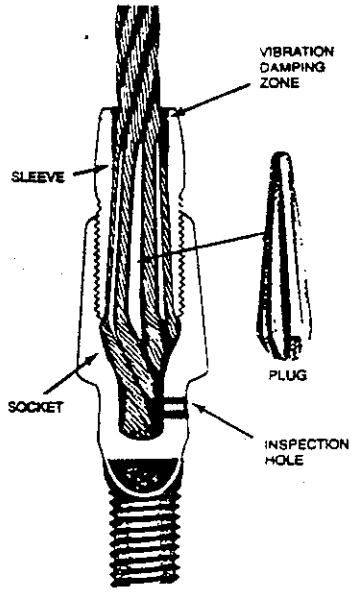
FROM FEDERAL SPECIFICATION RR-517a, THE SHEAVE DIAMETER FOR A 6 x 37 WIRE ROPE SHOULD BE 27 x d. 6 x 37 REQUIRES THE SMALLEST SHEAVE DIAMETER AMONG USUAL WIRES. IT ALSO HAVE THE BEST FLEXIBILITY.

DAN PARKHILL AND MR. MAL FROM JOHN SAKASH CO. BOTH RECOMMENDED 6 x 37 WIRE ROPE.

JOHN SAKASH, p 3, 3/8, 6 x 37 IWRC, EIP GRADE, STEEL CORE, GALVANIZED, MINIMAL STRENGHT = 7.55 x 0.975 x 0.9 x 2000 = 13,250 lb => SF = 13,250/1,500 => SF ≃ 8.8

FOR THE LEAD BLOCK => TOTAL LOAD = 1,500 x (1/cos 45°) => WL = 2,121 lb = 1.1 tons.

TYPICAL ASSEMBLY



Electroline fittings are the first real advance in connecting practices since the development of wire rope. These fittings are remarkably compact assemblies of three basic units:

1. The **sleeve**, which slips over the end of the rope.
2. The **plug**, (see inset photo) which is inserted to separate and hold the rope strands in the sleeve.
3. The covering **socket**.

The combination of these three units literally locks the rope into a strong, solid assembly.

ELECTROLINE

1-800-321-Ø87Ø

Safe working loads

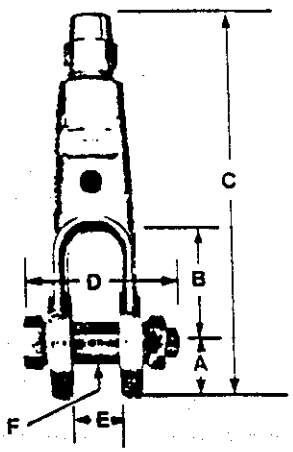
Electroline terminations, when properly assembled, will hold the "normal" or "rated" breaking strength of the IPS wire rope. They are certified by the "Underwriters Laboratory, Inc." (Safety Appliance No. 799) to hold no less than 85% of the rated breaking strength of the rope. Fittings are designed for linear loads only.

Electroline terminations are NOT marked with a safe working load (SWL) as the termination is a component of an assembly which includes the wire rope. Due to the many different types of ropes with which our termination may be used, the safe working load is dependent upon the type of rope and the usage.

Electroline terminations are designed to have a breaking strength greater than 6x19 IPS IWRC wire rope of the corresponding size. Our safety factor is 1.3 for the machined fittings and 2.0 for the forged types. However, the rope is the weakest component of the assembly, and these safety factors cannot be used to determine the SWL of the assembly.

7/16 w/ 3/8 sleeve: GD143MS5050-3/3
$44.18, STOCK PART.

Clevis Assemblies



Forged Series: Clevis Socket Assembly

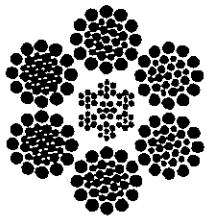
Rope Size	Catalog Numbers		Dimensions (inches)					
	Self-Colored Steel	Galvanized Steel	A	B	C	D	E	F
1/4	GD-125-N	GD-125-X	11/16	1-1/4	4-1/2	1-23/32	17/32	1/2
5/16	GD-131-N	GD-131-X	13/16	1-1/2	5-3/8	2-1/32	11/16	9/16
3/8	GD-137-N	GD-137-X	13/16	1-1/2	5-1/2	2-5/32	11/16	5/8
7/16	GD-143-N	GD-143-X	1-1/16	2	7-3/16	2-29/32	1	3/4
1/2	GD-150-N	GD-150-X	1-1/16	2	7-3/16	2-31/32	1	7/8
9/16	GD-156-N	GD-156-X	1-1/4	2-1/2	8-5/8	3-7/16	1-1/4	1
5/8	GD-162-N	GD-162-X	1-1/4	2-1/2	8-5/8	3-7/16	1-1/4	1
3/4	GD-175-N	GD-175-X	1-7/16	3	10-3/16	4	1-1/2	1-1/8
7/8	GD-187-N	GD-187-X	1-5/8	2-5/8	11	4-3/8	1-9/16	1-1/2
1	GD-199-N	GD-199-X	1-13/16	3	12-11/16	4-7/8	1-7/8	1-1/4
1-1/8	GD-1112-N	GD-1112-X	2-3/16	3-5/16	16-1/4	5-1/2	1-15/16	1-3/4
1-1/4	GD-1125-N	GD-1125-X	2-3/16	3-5/16	17	5-5/8	1-15/16	1-13/16

GENERAL PURPOSE WIRE ROPE . . .
6 x 37 CLASSIFICATION

. . . 6 x 37 Classification Ropes have a third layer of wires that makes them more flexible but less abrasion resistant than 6 x 19 classification ropes.

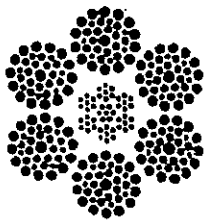
Each strand contains numerous small diameter wires. As the number of wires increases, flexibility increases, flexibility increases. 6 x 37 ropes contain 6 strands with from 27 through 49 wires, no more than 18 of which are outside wires.

THE MOST POPULAR 6 x 37 CLASSIFICATION CONSTRUCTIONS:



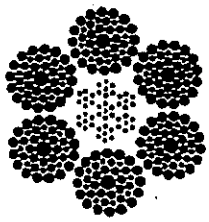
6x31 WARRINGTON SEALE

12 Outside Wires. Slightly more flexible than 6x25 rope with the same abrasion resistance.



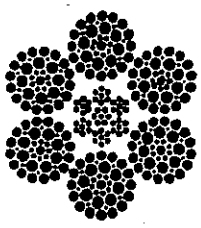
6x36 WARRINGTON SEALE

14 Outside Wires. More fatigue resistance but less abrasion resistance than 6 x 25 rope.



6 x 41 WARRINGTON SEALE

16 Outside Wires. Good combination of fatigue and abrasion resistance for operating ropes.



6x41 SEALE FILLER WIRE

16 Outside Wires. Good combination of fatigue and abrasion resistance for operating ropes.

6 x 37 CLASSIFICATION CAPACITY TABLE . . . NOMINAL STRENGTH* IN TONS

	EEIP Grade	EIP Grade	IPS Grade		Approximate Wt./Ft., lb.	
Rope Dia. (In.)	IWRC Steel Core	IWRC Steel Core 274/ft	IWRC Steel Core	Fiber Core	IWRC	Fiber Core
1/4		3.40	2.94	2.74	0.116	0.105
5/16		5.27	4.58	4.26	0.180	0.164
3/8		7.55	6.56	6.10	0.260	0.236
7/16		10.2	8.89	8.27	0.35	0.32
1/2	14.6	13.3	11.5	10.7	0.46	0.42
9/16	18.5	16.8	14.5	13.5	0.59	0.53
5/8	22.7	20.6	17.9	16.7	0.72	0.66
3/4	32.3	29.4	25.6	23.8	1.04	0.95
7/8	43.8	39.8	34.6	32.2	1.42	1.29
1	57.5	51.7	44.9	41.8	1.85	1.68
1 1/8	71.5	65.0	56.5	52.6	2.34	2.13
1 1/4	87.9	79.9	69.4	64.6	2.89	2.63
1 3/8	106.0	96.0	83.5	77.7	3.50	3.18
1 1/2	125.0	114.0	98.9	92.0	4.16	3.78
1 5/8	145.0	132.0	115.0	107.0	4.88	4.44
1 3/4	168.0	153.0	133.0	124.0	5.67	5.15
1 7/8	191.0	174.0	152.0	141.0	6.50	5.91
2	218.0	198.0	172.0	160.0	7.39	6.72

* Acceptance strength is not less than 2 1/2% below the nominal strengths listed.

Note: For EIP and IPS Class A galvanized ropes deduct 10% from the nominal strength.

Stainless steel also available. CALL US!

Diameters up to 5" available in some grades.

ORDERING GUIDE

To select and order the wire rope you need. SPECIFY

1. Wire Diameter
2. Construction
3. Grade
4. Core
5. Bright or Galvanized
6. Lay . . . Regular, Lang, Right or Left

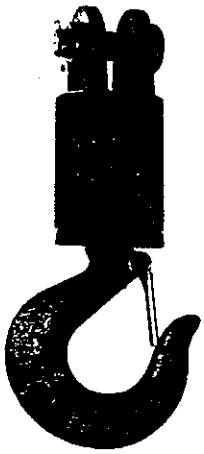
NEED HELP? CALL US!

Our highly trained staff of sales professionals are ready to serve you.

Crosby® Swivels

EQUIPPED WITH TAPERED ROLLER THRUST BEARING

(For swiveling under loads)



S-1
JAW & HOOK

S-3
JAW & EYE

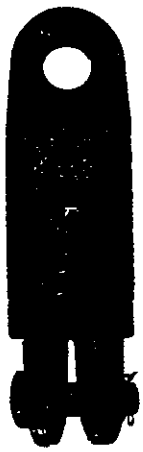
S-5
EYE & EYE

Load Rated*

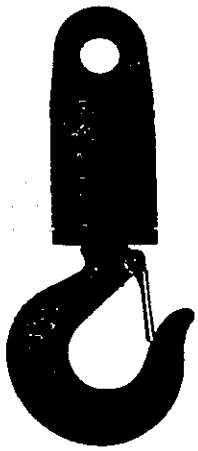
Swivel Number (Type)	Part No.	Working Load Limit (Tons)	Pin Diameter (Inches)	Weight (Lbs.)
3-S-1	297011	3	½	9.50
3-S-2	297020	3	½	9.25
3-S-3	297039	3	½	9.00
3-S-4	297048	3	½	9.00
3-S-5	297057	3	½	8.50
3-S-6	297066	3	½	9.00
5-S-1	297217	5	⅝	16.50
5-S-2	297226	5	⅝	14.25
5-S-3	297235	5	⅝	13.50
5-S-4	297244	5	⅝	13.75
5-S-5	297253	5	⅝	12.25
5-S-6	297262	5	⅝	15.25
8½-S-1	297413	8 ½	¾	33.50
8½-S-2	297422	8 ½	¾	29.25
8½-S-3	297431	8 ½	¾	29.25
8½-S-4	297440	8 ½	¾	29.00
8½-S-5	297459	8 ½	¾	29.25
8½-S-6	297468	8 ½	¾	32.00
10-S-1	297618	10	⅞	46.75
10-S-2	297627	10	⅞	45.75
10-S-3	297636	10	⅞	43.50
10-S-4	297645	10	⅞	44.00
10-S-5	297654	10	⅞	42.00
10-S-6	297663	10	⅞	45.50
15-S-1	297814	15	1	73.75
15-S-2	297823	15	1	62.75
15-S-3	297832	15	1	61.00
15-S-4	297841	15	1	61.00
15-S-5	297850	15	1	61.00
15-S-6	297869	15	1	74.00
25-S-1	298118	25	—	140.00
25-S-2	298127	25	—	140.00
25-S-3	298136	25	—	135.00
25-S-4	298145	25	—	135.00
25-S-5	298154	25	—	130.00
25-S-6	298163	25	—	135.00
35-S-1	298216	35	—	220.00
35-S-2	298225	35	—	155.00
35-S-3	298234	35	—	150.00
35-S-4	298243	35	—	150.00
35-S-5	298252	35	—	145.00
35-S-6	298261	35	—	215.00
45-S-1	298314	45	—	250.00
45-S-2	298323	45	—	235.00
45-S-3	298332	45	—	225.00
45-S-4	298341	45	—	225.00
45-S-5	298350	45	—	215.00
45-S-6	298369	45	—	270.00

* Individually Proof tested to 2 times the Working Load Limit. Ultimate Load is 5 times the Working Load Limit.

S-2
JAW & JAW



S-4
EYE & JAW



S-6
EYE & HOOK

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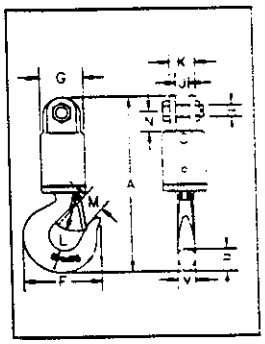
Crosby® Swivels

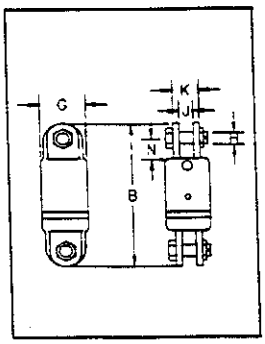
EQUIPPED WITH TAPERED ROLLER THRUST BEARING

- Designed to swivel under load.
- All swivels individually proof tested with certification.
- All hooks furnished with latches assembled.
- All jaws complete with bolts, nuts and cotter pins.
- Pressure lube fitting provided.
- NOT TO BE USED ON DEMOLITION (WRECKING) BALLS.
- Other types and capacities up to 600 tons, available to meet your requirements.

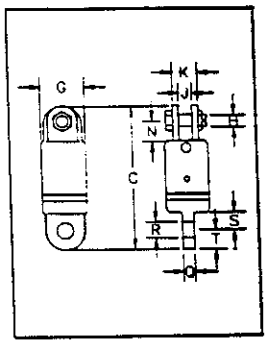
Important - Crosby Swivels should only be used with the recommended wire rope. Contact the wire rope manufacturer for the proper wire rope to be used with Crosby Swivels.



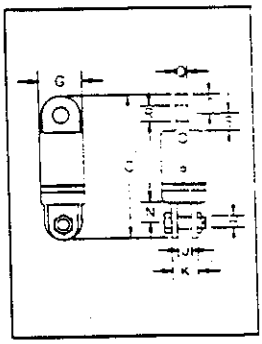
S-1
JAW & HOOK



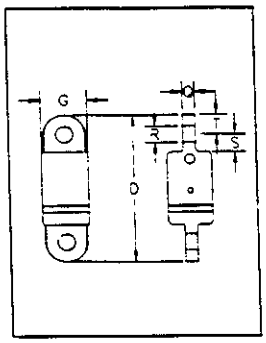
S-2
JAW & JAW



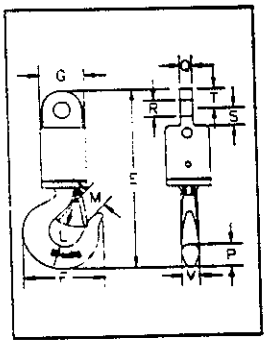
S-3
JAW & EYE



S-4
EYE & JAW



S-5
EYE & EYE



S-6
EYE & HOOK

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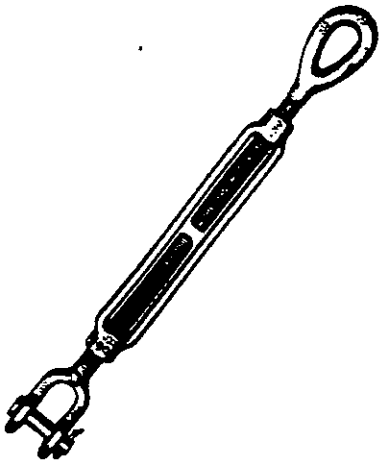
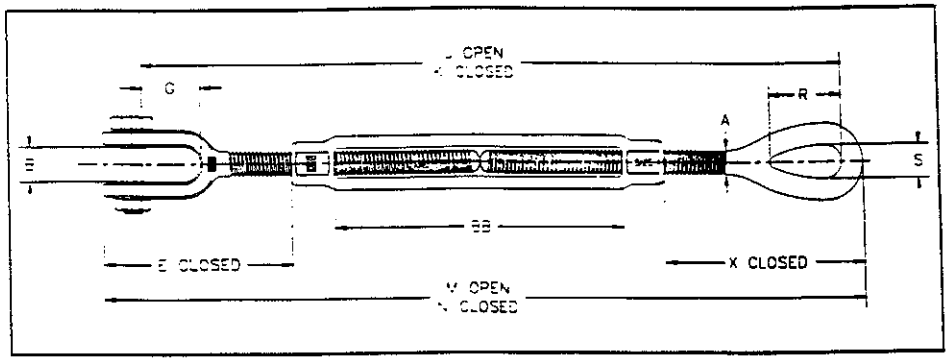
3	11.38	9.28	9.34	9.41	11.44	4.94	2.75	.75	.88	1.62	1.38	1.34	1.31	1.44	.75	1.03	1.12	1.25	1.12
5	13.31	10.31	10.06	9.81	13.06	6.50	3.00	.88	1.00	2.25	1.78	1.69	1.62	1.81	1.00	1.28	1.25	1.25	1.38
8½	16.44	12.62	12.25	11.88	16.06	7.56	4.00	1.00	1.56	2.81	2.12	2.06	2.12	2.25	1.25	1.41	1.62	1.50	1.62
10	19.72	16.75	16.12	15.50	19.09	8.69	4.50	1.50	1.75	3.38	2.56	2.25	3.50	2.59	1.69	1.69	2.75	1.88	1.94
15	22.00	17.12	16.75	16.38	21.62	11.00	5.00	1.50	1.75	3.38	2.88	3.00	3.50	3.00	1.94	2.03	2.75	2.12	2.38
25	26.78	20.75	21.50	22.25	27.53	13.62	6.00	2.00	2.00	4.62	3.44	3.62	3.69	3.66	2.25	2.31	3.88	2.38	3.0
35	29.94	20.75	21.50	22.25	30.69	14.06	6.50	2.00	2.00	4.62	3.88	3.75	3.69	4.56	2.25	2.31	3.88	2.38	3.1
45	35.06	25.25	25.88	26.50	35.69	15.44	7.00	2.25	2.50	5.00	4.75	4.25	4.00	5.06	2.50	2.53	4.00	3.00	3.25

* Individually Proof tested to 2 times the Working Load Limit. Ultimate load is 5 times the Working Load Limit.

Crosby® Jaw & Eye Turnbuckle





HG-227
JAW & EYE

Meets the requirements of Federal Specifications FF-T-791b, Type 1, Form 1 — CLASS 8.

- Hot Dip galvanized steel.
- End fittings are Quenched and Tempered, bodies heat treated by normalizing.
- Turnbuckle eyes are forged and elongated, by design, to maximize easy attachment in system and minimize stress in the eye. For turnbuckle sizes ¼" through 2½", a shackle one size smaller can be reeved through eye.
- Forged jaw ends are fitted with bolts and nuts for ¼" through ⅝", and pins and cotters on ¾" through 2¾" sizes.
- Modified UNJ thread for improved fatigue properties.
- TURNBUCKLES RECOMMENDED FOR STRAIGHT OR IN-LINE PULL ONLY.
- Lock Nuts available for all sizes (see page 114).

Thread Diameter & Take Up (in.)	Stock No. Galv.	Working Load Limit * (lbs.)	Weight Each (lbs.)	Dimensions (in.) A	B	E Closed	G	J Open	K Closed	M Open	N Closed	R	S	X Closed	BB
¼ x 4	1031877	500	.32	.25	.41	1.58	.62	11.35	7.35	12.07	8.07	.78	.34	1.75	4.00
5/16 x 4½	1031895	800	.47	.31	.47	1.98	.87	13.71	8.71	14.01	9.51	.94	.44	2.09	4.50
⅜ x 6	1031911	1200	.76	.38	.50	2.12	.87	16.81	10.81	17.77	11.77	1.12	.53	2.52	6.00
½ x 6	1031939	2200	1.53	.50	.63	2.75	1.06	18.29	12.29	19.48	13.48	1.44	.72	3.23	6.00
½ x 9	1031957	2200	1.71	.50	.63	2.75	1.06	24.29	15.29	25.48	16.48	1.44	.72	3.23	9.00
½ x 12	1031975	2200	2.06	.50	.63	2.75	1.06	30.29	18.29	31.48	19.48	1.44	.72	3.23	12.00
⅝ x 6	1031993	3500	2.35	.63	.75	3.50	1.31	19.74	13.74	21.28	15.28	1.75	.88	3.90	6.00
⅝ x 9	1032019	3500	3.06	.63	.75	3.50	1.31	25.74	16.74	27.28	18.28	1.75	.88	3.90	9.00
⅝ x 12	1032037	3500	3.78	.63	.75	3.50	1.31	31.74	19.74	33.28	21.28	1.75	.88	3.90	12.00
¾ x 6	1032055	5200	4.00	.75	.94	4.18	1.50	21.19	15.19	23.11	17.11	2.09	1.00	4.69	6.00
¾ x 9	1032073	5200	4.75	.75	.94	4.18	1.50	27.19	18.19	29.11	20.11	2.09	1.00	4.69	9.00
¾ x 12	1032091	5200	5.36	.75	.94	4.18	1.50	33.19	21.19	35.11	23.11	2.09	1.00	4.69	12.00
¾ x 18	1032117	5200	7.00	.75	.94	4.18	1.50	45.19	27.19	47.11	29.11	2.09	1.00	4.69	18.00
⅞ x 12	1032135	7200	8.00	.88	1.13	4.85	1.75	34.34	22.34	36.57	24.57	2.38	1.25	5.10	12.00
⅞ x 18	1032153	7200	9.75	.88	1.13	4.85	1.75	46.34	28.34	48.57	30.57	2.38	1.25	5.10	18.00
1 x 6	1032171	10000	8.92	1.00	1.19	5.53	2.06	24.34	18.34	26.89	20.89	3.00	1.44	6.36	6.00
1 x 12	1032199	10000	11.20	1.00	1.19	5.53	2.06	36.34	24.34	38.89	26.89	3.00	1.44	6.36	12.00
1 x 18	1032215	10000	13.30	1.00	1.19	5.53	2.06	48.34	30.34	50.89	32.89	3.00	1.44	6.36	18.00
1 x 24	1032233	10000	17.00	1.00	1.19	5.53	2.06	60.34	36.34	62.89	38.89	3.00	1.44	6.36	24.00
1¼ x 12	1032251	15200	20.00	1.25	1.75	7.21	2.81	38.82	26.82	42.05	30.05	3.56	1.81	7.72	12.00
1¼ x 18	1032279	15200	24.18	1.25	1.75	7.21	2.81	50.82	32.82	54.05	36.05	3.56	1.81	7.72	18.00
1¼ x 24	1032297	15200	28.50	1.25	1.75	7.21	2.81	62.82	38.82	66.05	42.05	3.56	1.81	7.72	24.00
1½ x 12	1032313	21400	28.99	1.50	2.06	7.88	2.81	40.50	28.50	44.25	32.25	4.06	2.12	8.62	12.00
1½ x 18	1032331	21400	35.00	1.50	2.06	7.88	2.81	52.50	34.50	56.25	38.25	4.06	2.12	8.62	18.00
1½ x 24	1032359	21400	39.18	1.50	2.06	7.88	2.81	64.50	40.50	68.25	44.25	4.06	2.12	8.62	24.00
1¾ x 18	1032395	28000	53.75	1.75	2.38	9.40	3.38	55.38	37.38	59.78	41.78	4.62	2.38	10.00	18.00
1¾ x 24	1032411	28000	60.68	1.75	2.38	9.40	3.38	67.38	43.38	71.78	47.78	4.62	2.38	10.00	24.00
2 x 24	1032439	37000	89.00	2.00	2.50	11.86	3.69	72.62	48.62	77.95	53.95	5.75	2.69	13.09	24.00
2½ x 24	1032457	60000	150.00	2.50	2.88	13.56	4.44	75.80	51.80	82.40	58.40	6.50	3.12	13.78	24.00
2¾ x 24	1032475	75000	183.00	2.75	3.50	15.22	4.19	77.88	53.88	85.50	61.50	7.00	3.25	15.22	24.00

* Proof Load is 2 times the Working Load Limit. Ultimate Load is 5 times Working Load Limit.

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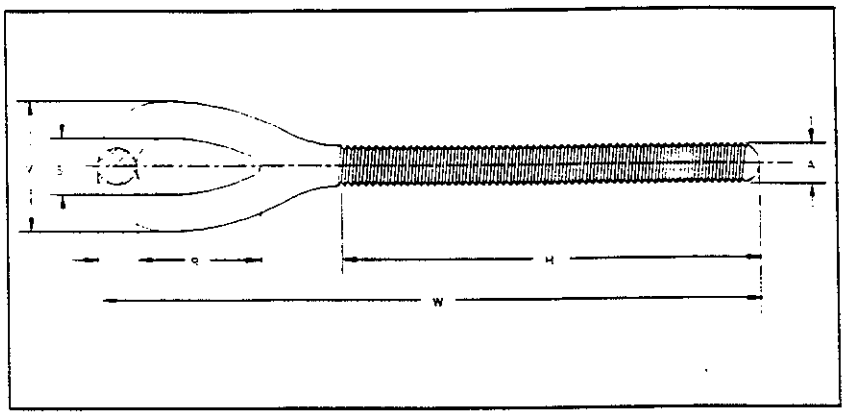
Turnbuckle — Eye End Fittings

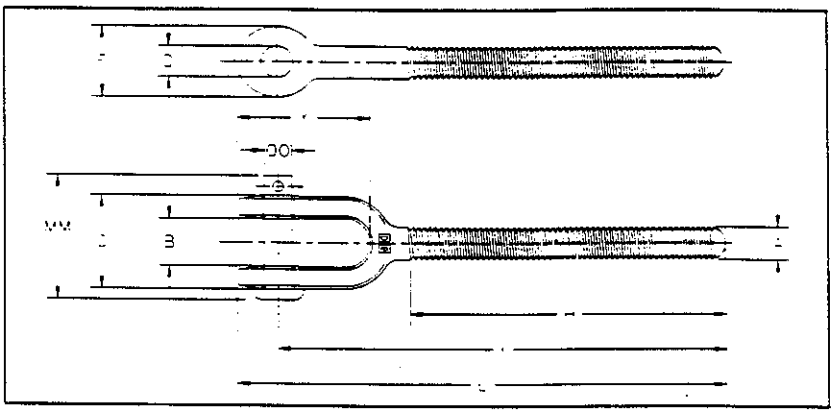
HG-4037 EYE END FITTINGS



- Hot Dip galvanized steel.
- Quenched and Tempered.
- Turnbuckle eyes are forged elongated, by design, to maximize easy attachment in system and minimize stress in the eye. For turnbuckle sizes 1/4" through 2 1/2", a shackle one size smaller can be reeved through eye.
- Modified UNJ thread for improved fatigue properties.

Shank Diameter & Take Up (In.)	RH Eye Stock No. Galv.	LH Eye Stock No. Galv.	Working Load Limit (lbs.)	Weight Each (lbs.)	Dimensions (In.)						
					A	H	R	S	U	V	W
1/4 x 4	1071057	1071672	500	.07	.25	2.55	.78	.34	.22	.78	4.12
5/16 x 4 1/2	1071075	1071690	800	.14	.31	2.92	.94	.44	.28	1.00	4.81
3/8 x 6	1071093	1071716	1200	.24	.38	3.80	1.12	.53	.34	1.22	6.08
1/2 x 6	1071119	1071734	2200	.47	.50	4.05	1.44	.72	.44	1.59	6.98
1/2 x 9	1071137	1071752	2200	.56	.50	5.55	1.44	.72	.44	1.59	8.48
1/2 x 12	1071155	1071770	2200	.64	.50	7.05	1.44	.72	.44	1.59	9.98
5/8 x 6	1071173	1071798	3500	.83	.63	4.30	1.75	.88	.50	1.88	7.84
5/8 x 9	1071191	1071814	3500	.96	.63	5.80	1.75	.88	.50	1.88	9.34
5/8 x 12	1071217	1071832	3500	1.04	.63	7.30	1.75	.88	.50	1.88	10.84
3/4 x 6	1071235	1071850	5200	1.23	.75	4.55	2.09	1.00	.62	2.25	8.81
3/4 x 9	1071253	1071878	5200	1.40	.75	6.05	2.09	1.00	.62	2.25	10.31
3/4 x 12	1071271	1071896	5200	1.60	.75	7.55	2.09	1.00	.62	2.25	11.81
3/4 x 18	1071299	1071912	5200	1.98	.75	10.55	2.09	1.00	.62	2.25	14.81
7/8 x 12	1071315	1071930	7200	2.55	.88	7.80	2.38	1.25	.75	2.75	12.41
7/8 x 18	1071333	1071958	7200	3.06	.88	10.80	2.38	1.25	.75	2.75	15.41
1 x 6	1071351	1071976	10000	3.09	1.00	5.05	3.00	1.44	.88	3.19	10.86
1 x 12	1071379	1071994	10000	3.75	1.00	8.05	3.00	1.44	.88	3.19	13.86
1 x 18	1071397	1072010	10000	4.44	1.00	11.05	3.00	1.44	.88	3.19	16.86
1 x 24	1071413	1072038	10000	4.64	1.00	14.05	3.00	1.44	.88	3.19	19.86
1 1/4 x 12	1071431	1072056	15200	6.50	1.25	8.28	3.56	1.81	1.12	4.06	15.28
1 1/4 x 18	1071459	1072074	15200	7.30	1.25	11.28	3.56	1.81	1.12	4.06	18.28
1 1/4 x 24	1071477	1072092	15200	8.30	1.25	14.28	3.56	1.81	1.12	4.06	21.28
1 1/2 x 12	1071495	1072118	21400	7.70	1.50	8.72	4.06	2.12	1.25	4.62	16.50
1 1/2 x 18	1071510	1072136	21400	13.00	1.50	11.72	4.06	2.12	1.25	4.62	19.50
1 1/2 x 24	1071538	1072154	21400	11.63	1.50	14.72	4.06	2.12	1.25	4.62	22.50
1 3/4 x 18	1071574	1072190	28000	17.25	1.75	12.16	4.62	2.38	1.50	5.38	21.19
1 3/4 x 24	1071592	1072216	28000	18.38	1.75	15.16	4.62	2.38	1.50	5.38	24.19
2 x 24	1071618	1072234	37000	31.17	2.00	15.59	5.75	2.69	1.75	6.19	27.59
2 1/2 x 24	1071636	1072252	60000	42.76	2.50	17.20	6.50	3.12	2.00	7.12	29.31
2 3/4 x 24	1071654	1072270	75000	69.88	2.75	17.33	7.00	3.25	2.25	7.75	30.75

HG-4037 JAW END FITTINGS



- Hot dip galvanized steel.
- Quenched and Tempered.
- Forged jaw ends are fitted with bolts and nuts on sizes ¼" through ⅝", and pins and cotters on sizes ¾" through 2¾".
- Modified UNJ thread for improved fatigue properties.

Shank Diameter & Take-Up (in.)	RH Jaw Stock No. Galv.	LH Jaw Stock No. Galv.	Working Load Limit (lbs.)	Weight Each (lbs.)	Dimensions (in.) A	B	C	D	F	H	I	L	Y	MM	OO
¼ x 4	1072298	1072911	500	.12	.25	.41	.90	.30	.63	2.55	3.58	3.95	1.12	1.41	.25
5/16 x 4½	1072314	1072939	800	.20	.31	.47	1.00	.30	.69	2.92	4.30	4.70	1.39	1.41	.25
⅜ x 6	1072332	1072957	1200	.29	.38	.50	1.08	.36	.81	3.80	5.22	5.69	1.49	1.58	.31
½ x 6	1072350	1072975	2200	.57	.50	.63	1.36	.42	1.00	4.05	5.94	6.50	1.81	1.86	.38
½ x 9	1072378	1072993	2200	.63	.50	.63	1.36	.42	1.00	5.55	7.44	8.00	1.81	1.86	.38
½ x 12	1072396	1073019	2200	.71	.50	.63	1.36	.42	1.00	7.05	8.94	9.50	1.81	1.86	.38
⅝ x 6	072412	1073037	3500	1.07	.63	.75	1.68	.55	1.31	4.30	6.64	7.44	2.35	2.44	.50
⅝ x 9	1072430	1073055	3500	1.20	.63	.75	1.68	.55	1.31	5.80	8.14	8.94	2.35	2.44	.50
⅝ x 12	1072458	1073073	3500	1.33	.63	.75	1.68	.55	1.31	7.30	9.64	10.44	2.35	2.44	.50
¾ x 6	1072476	1073091	5200	1.72	.75	.94	1.97	.69	1.62	4.55	7.31	8.30	2.80	2.56	.62
¾ x 9	1072494	1073117	5200	1.81	.75	.94	1.97	.69	1.62	6.05	8.81	9.80	2.80	2.56	.62
¾ x 12	1072519	1073135	5200	2.09	.75	.94	1.97	.69	1.62	7.55	10.31	11.30	2.80	2.56	.62
¾ x 18	1072537	1073153	5200	2.46	.75	.94	1.97	.69	1.62	10.55	13.31	14.30	2.80	2.56	.62
⅞ x 12	1072555	1073171	7200	3.31	.88	1.13	2.43	.81	1.88	7.80	11.05	12.16	3.23	3.09	.75
⅞ x 18	1072573	1073199	7200	3.81	.88	1.13	2.43	.81	1.88	10.80	14.05	15.16	3.23	3.09	.75
1 x 6	1072591	1073215	10000	3.90	1.00	1.19	2.63	.94	2.12	5.05	8.80	10.03	3.73	3.44	.88
1 x 12	1072617	1073233	10000	4.56	1.00	1.19	2.63	.94	2.12	8.05	11.80	13.03	3.73	3.44	.88
1 x 18	1072635	1073251	10000	5.16	1.00	1.19	2.63	.94	2.12	11.05	14.80	16.03	3.73	3.44	.88
1 x 24	1072653	1073279	10000	5.76	1.00	1.19	2.63	.94	2.12	14.05	17.80	19.03	3.73	3.44	.88
1¼ x 12	1072671	1073297	15200	7.43	1.25	1.75	3.60	1.22	2.62	8.28	13.22	14.77	4.91	4.53	1.12
1¼ x 18	1072699	1073313	15200	8.37	1.25	1.75	3.60	1.22	2.62	11.28	16.22	17.77	4.91	4.53	1.12
1¼ x 24	1072715	1073331	15200	9.46	1.25	1.75	3.60	1.22	2.62	14.28	19.22	20.77	4.91	4.53	1.12
1½ x 12	1072733	1073359	21400	12.39	1.50	2.06	3.96	1.47	3.12	8.72	13.96	15.75	5.31	5.12	1.38
1½ x 18	1072751	1073377	21400	13.89	1.50	2.06	3.96	1.47	3.12	11.72	16.96	18.75	5.31	5.12	1.38
1½ x 24	1072779	1073395	21400	15.39	1.50	2.06	3.96	1.47	3.12	14.72	19.96	21.75	5.31	5.12	1.38
1¾ x 18	1072813	1073439	28000	19.74	1.75	2.38	4.66	1.72	3.50	12.16	18.49	20.59	6.28	6.00	1.62
1¾ x 24	1072831	1073457	28000	21.10	1.75	2.38	4.66	1.72	3.50	15.16	21.49	23.59	6.28	6.00	1.62
2 x 24	1072859	1073475	37000	36.35	2.00	2.50	5.60	2.09	4.19	15.59	23.76	26.36	7.28	6.88	2.00
2½ x 24	1072877	1073493	60000	62.33	2.50	2.88	5.82	2.38	5.62	17.20	25.61	29.09	9.04	7.50	2.25
2¾ x 24	1072895	1073518	75000	94.64	2.75	3.50	6.56	2.88	6.12	17.35	26.75	30.75	9.56	8.44	2.75

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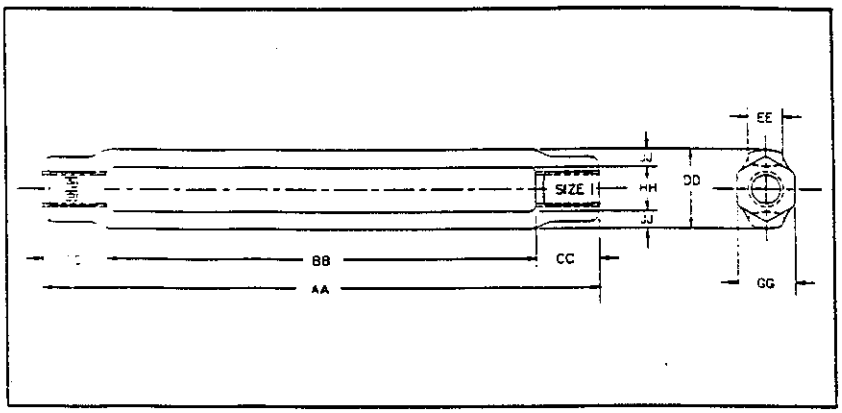
Turnbuckle — Body Only

HG-2510 BODY ONLY



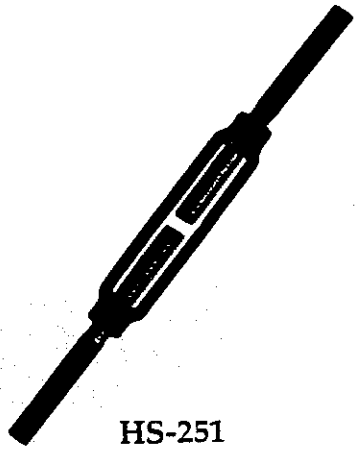
- Hot Dip galvanized.
- Heat treat by normalizing.

Meets the requirements of Federal Specifications FF-T-791b, Type 1, Form 1 - CLASS 2.

1/4 x 4	1033893	500	.15	4.75	4.00	.38	.72	.34	.50	.38	.17
5/16 x 4 1/2	1033919	800	.19	5.44	4.50	.47	.81	.38	.56	.44	.19
3/8 x 6	1033937	1200	.29	7.12	6.00	.56	.88	.38	.62	.50	.19
1/2 x 6	1033955	2200	.60	7.50	6.00	.75	1.12	.50	.81	.62	.25
1/2 x 9	1033973	2200	.68	10.50	9.00	.75	1.12	.50	.81	.62	.25
1/2 x 12	1033991	2200	1.00	13.50	12.00	.75	1.12	.50	.81	.62	.25
5/8 x 6	1034017	3500	.90	7.88	6.00	.94	1.38	.62	1.00	.75	.31
5/8 x 9	1034035	3500	1.18	10.88	9.00	.94	1.38	.62	1.00	.75	.31
5/8 x 12	1034053	3500	1.43	13.88	12.00	.94	1.38	.62	1.00	.75	.31
3/4 x 6	1034071	5200	1.30	8.25	6.00	1.12	1.69	.75	1.12	.94	.38
3/4 x 9	1034099	5200	1.75	11.25	9.00	1.12	1.69	.75	1.12	.94	.38
3/4 x 12	1034115	5200	2.08	14.25	12.00	1.12	1.69	.75	1.12	.94	.38
3/4 x 18	1034133	5200	2.50	20.25	18.00	1.12	1.69	.75	1.12	.94	.38
7/8 x 12	1034179	7200	2.70	14.62	12.00	1.31	1.94	.88	1.31	1.06	.44
7/8 x 18	1034197	7200	3.80	20.62	18.00	1.31	1.94	.88	1.31	1.06	.44
1 x 6	1034213	10000	2.48	9.00	6.00	1.50	2.25	1.00	1.50	1.25	.50
1 x 12	1034231	10000	3.93	15.00	12.00	1.50	2.25	1.00	1.50	1.25	.50
1 x 18	1034259	10000	5.28	21.00	18.00	1.50	2.25	1.00	1.50	1.25	.50
1 x 24	1034277	10000	7.38	27.00	24.00	1.50	2.25	1.00	1.50	1.25	.50
1 1/4 x 12	1034339	15200	5.25	15.12	12.00	1.56	2.62	1.25	1.88	1.50	.56
1 1/4 x 18	1034357	15200	7.75	21.12	18.00	1.56	2.62	1.25	1.88	1.50	.56
1 1/4 x 24	1034375	15200	10.17	27.12	24.00	1.56	2.62	1.25	1.88	1.50	.56
1 1/2 x 12	1034437	21400	8.75	15.75	12.00	1.88	3.00	1.50	2.25	1.75	.62
1 1/2 x 18	1034455	21400	11.00	21.75	18.00	1.88	3.00	1.50	2.25	1.75	.62
1 1/2 x 24	1034473	21400	13.69	27.75	24.00	1.88	3.00	1.50	2.25	1.75	.62
1 3/4 x 18	1034552	28000	16.38	22.38	18.00	2.19	3.62	1.75	2.62	2.12	.75
1 3/4 x 24	1034570	28000	21.25	28.38	24.00	2.19	3.62	1.75	2.62	2.12	.75
2 x 24	1034632	37000	27.60	29.00	24.00	2.50	4.12	2.00	3.00	2.38	.88
2 1/2 x 24	1034678	60000	54.00	31.06	24.00	3.53	5.62	2.75	3.88	3.12	1.25
2 3/4 x 24	1034696	75000	54.00	31.06	24.00	3.53	5.62	2.75	3.88	3.12	1.25

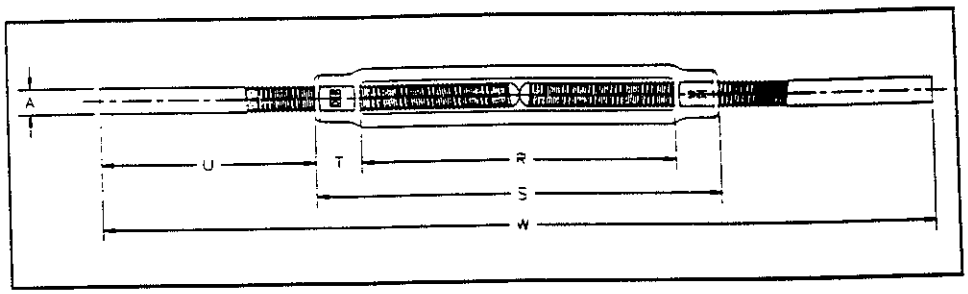
Turnbuckles

STUB END TURNBUCKLES



HS-251

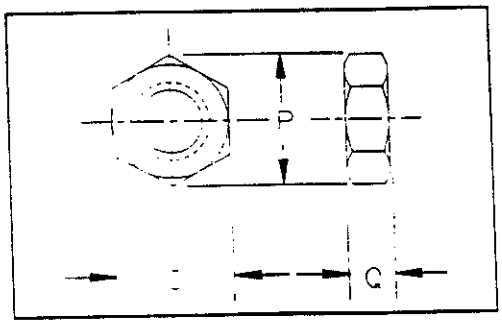
- Complete assembly is self - colored.
- End fittings are Quenched and Tempered, bodies heat treated by normalizing.
- Reference American Welding Society Specifications for proper welding procedures.



Meets the requirements of Federal Specifications FF-T-791b, Type 1 Form 1 — CLASS 3.

Shank Diameter & Take up (In.)	HS-251 Stock No. S.C.	Working Load Limit (lbs.)	Weight Each (lbs.)	Dimensions (In.)					
				A	R	S	T	U	W
3/8 x 6	1033143	1200	.75	.38	6.00	7.13	.56	4.44	16.00
1/2 x 6	1033161	2200	1.25	.50	6.00	7.50	.75	4.25	16.00
5/8 x 6	1033223	3500	2.00	.63	6.00	7.88	.94	4.06	16.00
3/4 x 6	1033287	5200	3.25	.75	6.00	8.25	1.13	4.38	17.00
7/8 x 6	1033367	7200	4.78	.88	6.00	8.63	1.31	4.69	18.00
1 x 6	1033429	10000	6.33	1.00	6.00	9.00	1.50	5.00	19.00
1 x 12	1033447	10000	9.50	1.00	12.00	15.00	1.50	5.00	25.00
1 1/8 x 6	1033508	12400	8.88	1.13	6.00	9.13	1.56	4.94	19.00
1 1/4 x 6	1033526	15200	10.18	1.25	6.00	9.13	1.56	5.44	20.00
1 1/4 x 12	1033544	15200	14.00	1.25	12.00	15.12	1.56	5.44	26.00
1 1/2 x 12	1033642	21400	22.00	1.50	12.00	15.75	1.88	5.38	26.50

LOCKNUTS



HG-4060 / HG-4061

Thread Diameter (In.)	Stock No.		Weight Per 100 (lbs.)	Dimensions (In.)		
	HG-4060 Right Hand	HG-4061 Left Hand		O	P	Q
1/4	1075115	1075491	.80	.44	.50	.16
5/16	1075133	1075516	1.30	.50	.56	.19
3/8	1075151	1075534	2.00	.56	.64	.22
1/2	1075197	1075570	4.00	.75	.86	.31
5/8	1075213	1075598	7.00	.94	1.06	.38
3/4	1075231	1075614	11.00	1.13	1.26	.42
7/8	1075259	1075632	16.30	1.31	1.50	.48
1	1075277	1075650	23.80	1.50	1.69	.55
1 1/4	1075311	1075696	62.50	1.88	2.13	.72
1 1/2	1075357	1075730	72.00	2.25	2.53	.84
1 3/4	1075393	1075776	112.00	2.75	3.18	1.00
2	1075419	1075794	150.00	3.12	3.61	1.12
2 1/2	1075455	1075838	330.00	3.88	4.47	1.50
2 3/4	1075473	1075856	425.00	4.25	4.91	1.62

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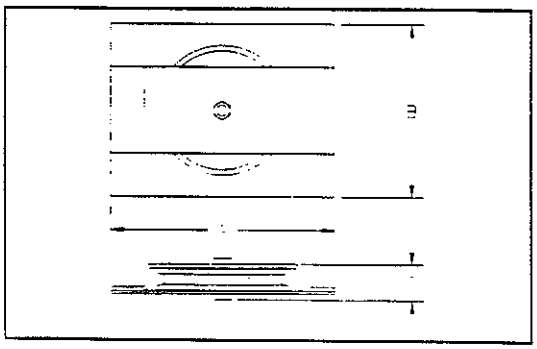
Western® Lead Blocks

SEE APPLICATION AND WARNING INFORMATION

See Pages 172 - 179

HORIZONTAL LEAD BLOCK



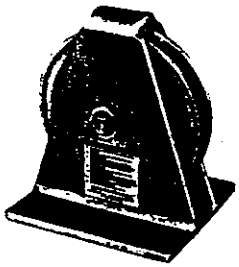
- Available painted or galvanized.
- Fitted with steel sheaves.
- Self-Lubricated Bronze Bushed.

600-S

Sheave Diameter (in.)	Stock No. 600-S Painted	Stock No. 600-S Galv.	Resultant Working Load Limit* (tons)	Wire Rope Diameter (in.)	Weight Each (lbs.)	Dimensions (in.) A	Dimensions (in.) B	Dimensions (in.) C
6	771999	772006	2	3/8	12.25	11.00	6.38	2.50
8	772015	772024	2½	½	21.00	13.00	8.50	3.00
10	772033	772042	3	5/8	36.00	15.00	10.50	3.25
12	772051	772060	4	3/4	61.00	17.00	12.50	4.00
14	772079	772088	5	7/8	96.00	19.00	14.50	4.00

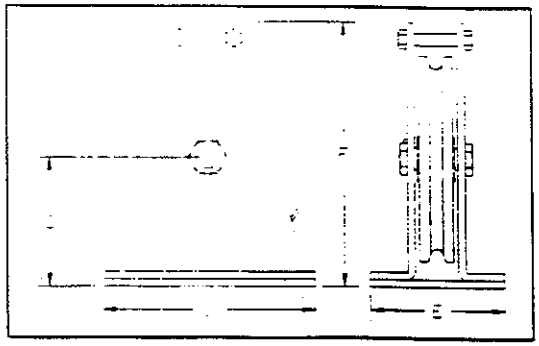
* Ultimate load is 4 times Resultant Working Load Limit.

VERTICAL LEAD BLOCK



601-S

- Available painted or galvanized.
- Fitted with steel sheaves.
- Self-Lubricated Bronze Bushed.



Sheave Diameter (in.)	Stock No. 601-S Painted	Stock No. 601-S Galv.	Resultant Working Load Limit* (tons)	Wire Rope Diameter (in.)	Weight Each (lbs.)	Dimensions (in.) C	Dimensions (in.) D	Dimensions (in.) E	Dimensions (in.) F
6	772195	772202	2	3/8	12.00	3.50	6.00	5.50	7.88
8	772211	772220	2½	½	23.00	4.88	8.00	6.75	9.75
10	772239	772248	3	5/8	31.50	6.38	10.00	7.75	11.75
12	772257	772266	4	3/4	63.00	7.25	12.00	8.00	15.25
14	2003424	2003425	5	7/8	98.00	8.75	14.00	9.00	18.00

* Ultimate load is 4 times Resultant Working Load Limit.

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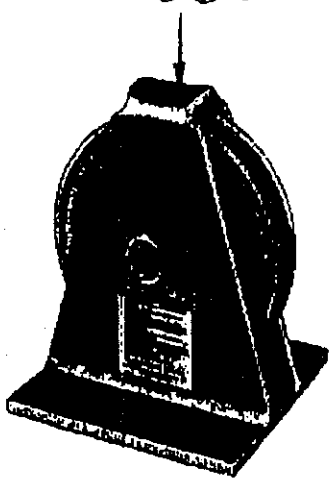
12	772051	772060	4		¾	61.00	17.00	12.50	4.0
14	772079	772088	5		8	96.00	19.00	14.50	4.0

* Ultimate load is 4 times Resultant Working Load Limit.

WYNELL

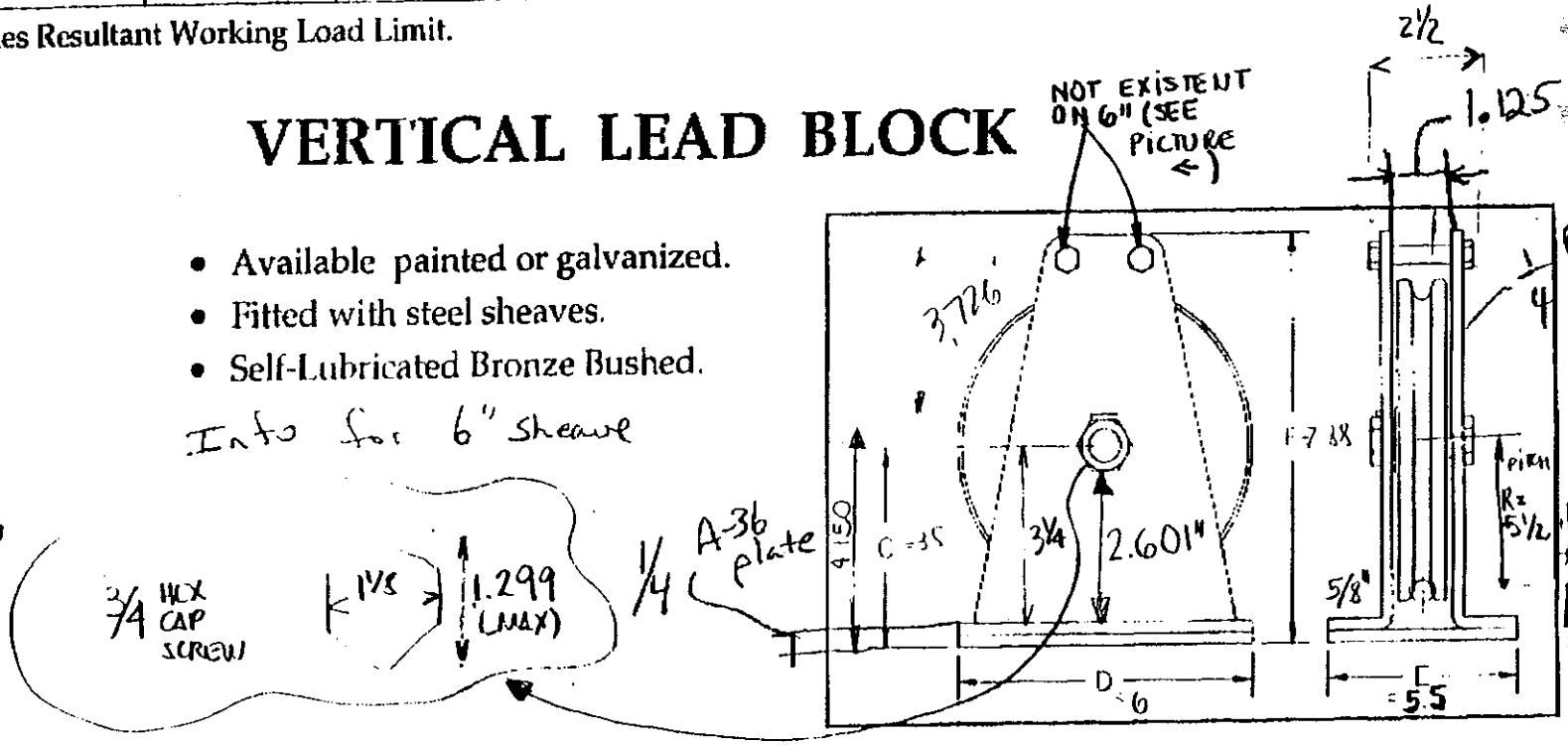
VERTICAL LEAD BLOCK



601-S

- Available painted or galvanized.
- Fitted with steel sheaves.
- Self-Lubricated Bronze Bushed.

Info for 6" sheave



Sheave Diameter (in.)	Stock No. 601-S Painted	Stock No. 601-S Galv.	Resultant Working Load Limit* (tons)	Wire Rope Diameter (in.)	Weight Each (lbs.)	Dimensions (in.) C	D	E	F
6 +0.25 −0.00	772195	772202	2	⅜	12.00	3.50	6.00	5.50	7.88
8	772211	772220	2½	½	23.00	4.88	8.00	6.75	9.75
10	772239	772248	3	⅝	31.50	6.38	10.00	7.75	11.75
12	772257	772266	4	¾	63.00	7.25	12.00	8.00	15.25
14	2003424	2003425	5	⅞	98.00	8.75	14.00	9.00	18.00

* Ultimate load is 4 times Resultant Working Load Limit.

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6. Air Cylinder

AIR CYLINDER

THE CYLINDER WILL WORK ONLY ON TENSION (NO COMPRESSION). IN THIS CASE, THE ROD CAN BE THE STANDARD SIZE FOR ANY LOAD

BECAUSE OF THE LONG STROKE (76") IT IS RECOMMENDABLE TO HAVE A STOP TUBE OF 4 INCHES

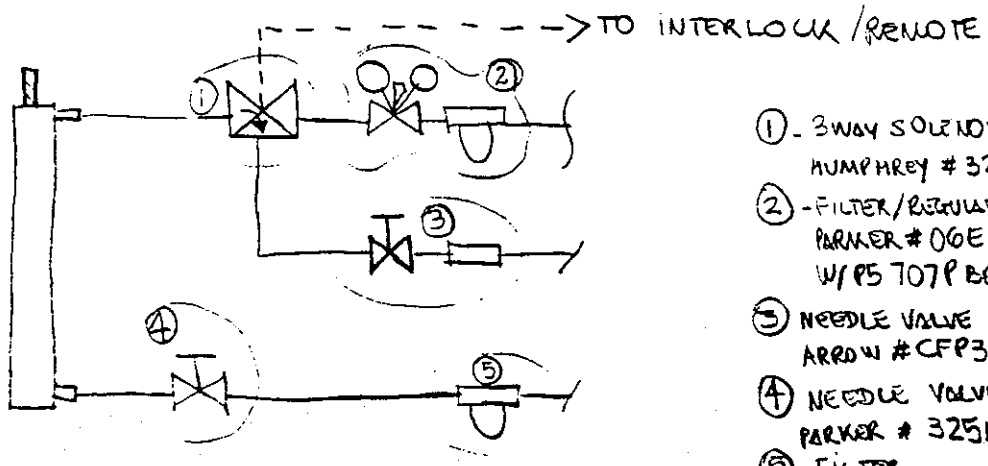
SELECTION:

PARKER 6" CC - 2AUS14AC80
2A HEAVY DUTY AIR CYLINDER
6" BORE, 80" STROKE AND 4" STOP TUBE (76" OF USABLE STROKE)
ROD #1 (STANDARD) O.D. = 1 3/8"
ROD END = STYLE 4 (STANDARD), 1-14 THREAD
CUSHION ON BOTH ENDS
SIDE LUG MOUNTINGS.
NPTF PORTS

PULL FORCE: CONSIDERING 90 psi => F = 2,544 - 134 =>
F = 2,410 ; L = 1500 => 61% OVER

MINIMUM REQUIRED PRESSURE TO MOVE THE LOAD: ~68 psi
" " " " SECURE " ~57 psi
" AVAILABLE PRESSURE 80 psi
MAXIMUM " 100 psi

P&I



1. 3 WAY SOLENOID HUMPHREY # 320-24V- $42.50
2. FILTER/REGULATOR PARKER # 06E1 FA18A W/ P5 707P BRACKET $75.50
3. NEEDLE VALVE ARROW # CFP35C $4.85
4. NEEDLE VALVE PARKER # 32510250P $15.60
5. FILTER $1.95

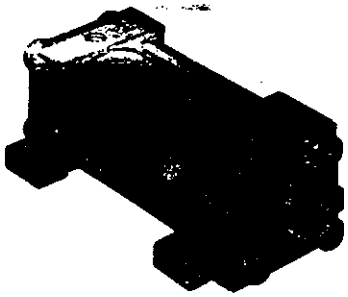
Side Lugs, Centerline Lugs and Side Tapped Mountings

1" to 6" bore sizes

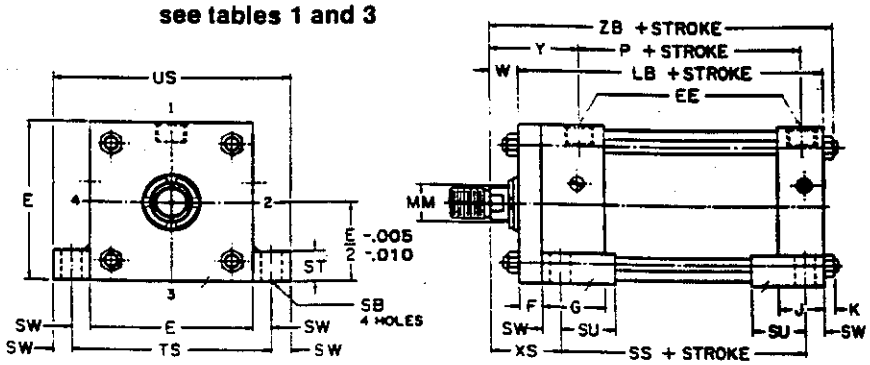
Parker Fluidpower

Parker Series 2A Heavy Duty Air Cylinders

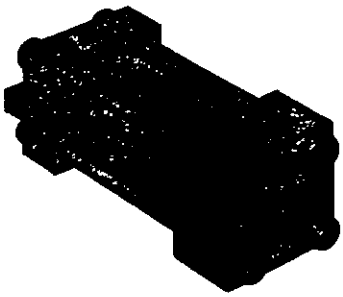
Side Lug Mountings Parker Style C (NFPA Style MS2)



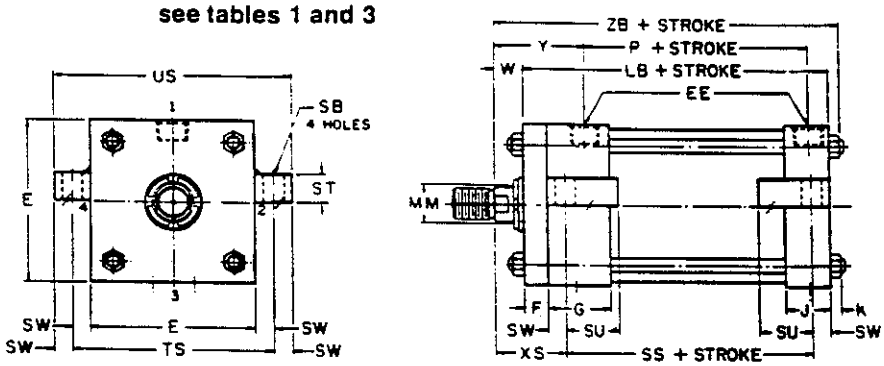
Envelope and mounting dimensions—see tables 1 and 3



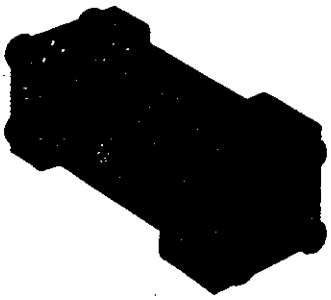
Centerline Lugs Mounting Parker Style E (NFPA Style MS3)



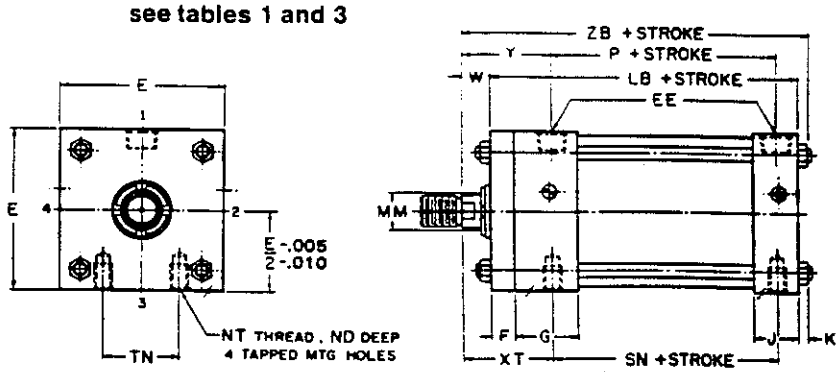
Envelope and mounting dimensions—see tables 1 and 3



Side Tapped Mounting Parker Style F (NFPA Style MS4)

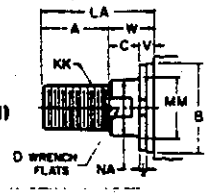


Envelope and mounting dimensions—see tables 1 and 3

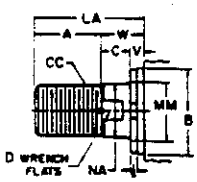


Rod end dimensions—see table 2

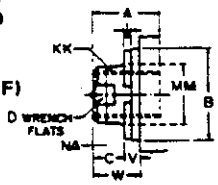
PARKER THREAD STYLE 4 (NFPA STYLE SM)



PARKER THREAD STYLE 8 (NFPA STYLE 1M)



PARKER THREAD STYLE 9 (NFPA STYLE SF)



A high strength rod end stud is supplied on thread style #4 through 2" diameter rods and on thread style #8 through 1¾" diameter rods. Larger sizes or special rod ends are cut threads. Style 4 rod ends are recommended where the workpiece is secured against the rod shoulder. When the workpiece is not shouldered, style 4 rod ends are recommended through 2" piston rod diameters and style 8 rod ends are recommended on larger diameters. Use style 9 for applications where female rod end threads are required. If rod end is not specified, style 4 will be supplied.

"SPECIAL" THREAD STYLE 3

Special thread, extension, rod eye, blank, etc., are also available.

To order, specify "Style 3" and give desired dimensions for CC or KK, A and LA. If otherwise special, furnish dimensioned sketch.

Parker Series 2A Heavy Duty Air Cylinders

Parker Fluidpower

Side Lugs, Centerline Lugs and Side Tapped Mountings

1" to 6" bore sizes

Table 1—Envelope and mounting dimensions

BORE	E	EE (NPTF)	F	G	J	K	NT	SB*	ST	SU	SW	TN	TS	US	ADD STROKE LB	P	SN	SS
1‡	1½	¼	⅜	1½	1	5/16	10-24	9/32*	5/16*	¾*	5/16*	9/16	2⅛*	2¾*	3⅞	2⅛	2⅛	2⅞*
1½	2	⅜†	⅜	1½	1	¼	¼-20	7/16	½	1 5/16	⅜	⅝	2¾	3½	4	2¼	2¼	2⅞
2	2½	⅜†	⅜	1½	1	5/16	5/16-18	7/16	½	1 5/16	⅜	⅞	3¼	4	4	2¼	2¼	2⅞
2½	3	⅜†	⅜	1½	1	5/16	⅜-16	7/16	½	1 5/16	⅜	1¼	3¾	4½	4⅛	2⅜	2⅜	3
3¼	3¾	½	⅝	1¾	1¼	⅜	½-13	9/16	¾	1¼	½	1½	4¾	5¾	4⅞	2⅝	2⅝	3¼
4	4½	½	⅝	1¾	1¼	⅜	½-13	9/16	¾	1¼	½	2 1/16	5½	6½	4⅞	2⅝	2⅝	3¼
5	5½	½	⅝	1¾	1¼	7/16	⅝-11	13/16	1	1 9/16	11/16	2 11/16	6⅞	8¼	5⅛	2⅞	2⅞	3⅛
6	6½	¾	¾	2	1½	7/16	¾-10	13/16	1	1 9/16	11/16	3¼	7⅞	9¼	5¾	3⅛	3⅛	3⅝

‡ Cushions not available on 1" bore.

* Upper surface spotfaced for socket head screws.

† On 1", 1½", 2" and 2½" bore sizes, the head-end (only) pipe thread is not full depth on cylinders with No. 2 rods. Minimum of three full threads available.

* Mounting style E not available in 1" bore.

Table 2—Rod dimensions

BORE	ROD NO.	ROD DIA. MM	THREAD CC Style B	THREAD KK Style 4 & 9	ROD EXTENSIONS AND PILOT DIMENSIONS A	B +.000 −.002	C	D	LA	NA	V	W
1	1 (Std.)	½	5/16-20	5/16-24	⅝	.999	⅜	⅜	1¼	7/16	¼	⅝
	2	⅝	½-20	5/16-20	¾	1.124	⅜	½	1⅜	9/16	¼	⅝
1½	1 (Std.)	⅝	½-20	5/16-20	¾	1.124	⅜	½	1⅜	9/16	¼	⅝
	2	1	⅞-14	3/4-16	1⅛	1.499	½	⅞	2⅛	1 5/16	½	1
2	1 (Std.)	⅝	½-20	5/16-20	¾	1.124	⅜	½	1⅜	9/16	¼	⅝
	2	1⅜	1¼-12	1-14	1⅝	1.999	⅝	1⅛	2⅞	1 5/16	⅝	1¼
	3	1	⅞-14	3/4-16	1⅛	1.499	½	⅞	2⅛	1 5/16	½	1
2½	1 (Std.)	⅝	½-20	5/16-20	¾	1.124	⅜	½	1⅜	9/16	¼	⅝
	2	1¾	1½-12	1¼-12	2	2.374	¾	1½	3½	1 11/16	¾	1½
	3	1	⅞-14	3/4-16	1⅛	1.499	½	⅞	2⅛	1 5/16	½	1
	4	1⅜	1¼-12	1-14	1⅝	1.999	⅝	1⅛	2⅞	1 5/16	⅝	1¼
3¼	1 (Std.)	1	⅞-14	3/4-16	1⅛	1.499	½	⅞	1⅞	1 5/16	¼	¾
	2	2	1¾-12	1½-12	2¼	2.624	⅞	1 11/16	3⅝	1 15/16	½	1⅜
	3	1⅜	1¼-12	1-14	1⅝	1.999	⅝	1⅛	2⅝	1 5/16	⅜	1
	4	1¾	1½-12	1¼-12	2	2.374	¾	1½	3¼	1 11/16	½	1¼
4	1 (Std.)	1	⅞-14	3/4-16	1⅛	1.499	½	⅞	1⅞	1 5/16	¼	¾
	2	2½	2¼-12	1⅞-12	3	3.124	1	2 1/16	4⅝	2⅜	⅝	1⅝
	3	1⅜	1¼-12	1-14	1⅝	1.999	⅝	1⅛	2⅝	1 5/16	⅜	1
	4	1¾	1½-12	1¼-12	2	2.374	¾	1½	3¼	1 11/16	½	1¼
	5	2	1¾-12	1½-12	2¼	2.624	⅞	1 11/16	3⅝	1 15/16	½	1⅜
5	1 (Std.)	1	⅞-14	3/4-16	1⅛	1.499	½	⅞	1⅞	1 5/16	¼	¾
	2	3½	3¼-12	2½-12	3½	4.249	1	3	5⅛	3⅜	⅝	1⅝
	3	1⅜	1¼-12	1-14	1⅝	1.999	⅝	1⅛	2⅝	1 5/16	⅜	1
	4	1¾	1½-12	1¼-12	2	2.374	¾	1½	3¼	1 11/16	½	1¼
	5	2	1¾-12	1½-12	2¼	2.624	⅞	1 11/16	3⅝	1 15/16	½	1⅜
	6	2½	2¼-12	1⅞-12	3	3.124	1	2 1/16	4⅝	2⅜	⅝	1⅝
	7	3	2¾-12	2¼-12	3½	3.749	1	2⅝	5⅛	2⅞	⅝	1⅝
6	1 (Std.)	1⅜	1¼-12	1-14	1⅝	1.999	⅝	1⅛	2½	1 5/16	¼	⅞
	2	4	3¾-12	3-12	4	4.749	1	3⅜	5½	3⅞	½	1½
	3	1¾	1½-12	1¼-12	2	2.374	¾	1½	3⅛	1 11/16	⅜	1⅛
	4	2	1¾-12	1½-12	2¼	2.624	⅞	1 11/16	3½	1 15/16	⅜	1¼
	5	2½	2¼-12	1⅞-12	3	3.124	1	2 1/16	4½	2⅜	½	1½
	6	3	2¾-12	2¼-12	3½	3.749	1	2⅝	5	2⅞	½	1½
	7	3½	3¼-12	2½-12	3½	4.249	1	3	5	3⅜	½	1½

* Mounting style E not available in 1" bore.

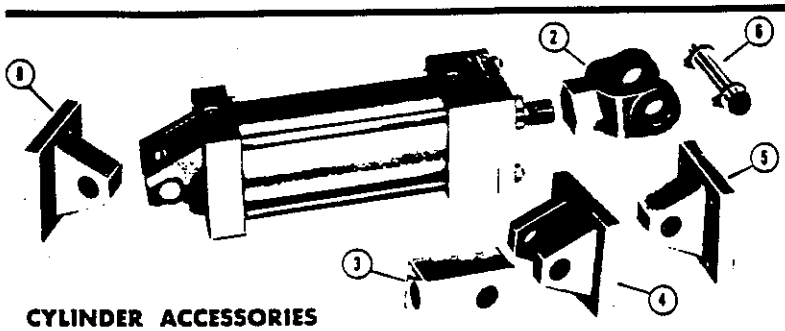
Table 3—Envelope and mounting dimensions

ND	XS	XT	Y	ADD STROKE ZB
¼	1 3/16*	1 15/16	1 15/16	4⅝
¼	1 5/16*	1 15/16	1 15/16	4⅝
3/16	1⅜	1 15/16	1 15/16	4⅞
3/16	1¾	2 5/16	2 5/16	5¼
11/32	1⅜	1 15/16	1 15/16	4 15/16
11/32	2	2 9/16	2 9/16	5 9/16
11/32	1¾	2 5/16	2 5/16	5 5/16
7/16	1⅜	1 15/16	1 15/16	5 1/16
7/16	2¼	2 13/16	2 13/16	5 13/16
7/16	1¾	2 5/16	2 5/16	5 7/16
7/16	2	2 9/16	2 9/16	5 11/16
½	1⅞	2 7/16	2 7/16	6
½	2½	3 1/16	3 1/16	6⅜
½	2⅛	2 11/16	2 11/16	6¼
½	2⅜	2 15/16	2 15/16	6½
⅝	1⅞	2 7/16	2 7/16	6
⅝	2¾	3 5/16	3 5/16	6⅞
⅝	2⅛	2 11/16	2 11/16	6¼
⅝	2⅜	2 15/16	2 15/16	6½
⅝	2½	3 1/16	3 1/16	6⅝
¾	2 1/16	2 7/16	2 7/16	6 5/16
¾	2 15/16	3 5/16	3 5/16	7 3/16
¾	2 5/16	2 11/16	2 11/16	6 9/16
¾	2 9/16	2 15/16	2 15/16	6 13/16
¾	2 11/16	3 1/16	3 1/16	6 15/16
¾	2 15/16	3 5/16	3 5/16	7 3/16
¾	2 15/16	3 5/16	3 5/16	7 3/16
⅞	2 5/16	2 13/16	2 13/16	7 1/16
⅞	2 15/16	3 7/16	3 7/16	7 11/16
⅞	2 9/16	3 1/16	3 1/16	7 3/16
⅞	2 11/16	3 3/16	3 3/16	7 7/16
⅞	2 15/16	3 7/16	3 7/16	7 11/16
⅞	2 15/16	3 7/16	3 7/16	7 11/16
⅞	2 15/16	3 7/16	3 7/16	7 11/16

Cylinder Accessories

Parker Fluidpower

Parker Series 2A Heavy Duty Air Cylinders



CYLINDER ACCESSORIES

Parker offers a complete range of cylinder accessories to assure you of greatest versatility in present or future cylinder applications.

ROD END ACCESSORIES

Accessories offered for the rod end of the cylinder include Rod Clevis, Eye Bracket, Knuckle, Clevis Bracket and Pivot Pin. To select the proper part number for any desired acccessory, refer to Chart A below and look opposite the thread size of the rod end as indicated in the first column. The Pivot Pins, Eye Brackets and Clevis Brackets are listed opposite the thread size which their mating Knuckles or Clevises fit.

CHART A

	MATING PARTS			MATING PARTS			
THREAD SIZE	ROD CLEVIS	EYE BRACKET	PIN	KNUCKLE	CLEVIS BRACKET	PIN	ALIGNMENT COUPLER
¾-24	51221	74077	—	74075	74076	74078	144500-0105
⅞-20	50940	69195	68368	69089	69205	68368	144500-0107
⅞-20	50941	69195	68368	69090	69205	68368	144500-0108
⅞-16	50942	69196	68369	69091	69206	68369	144500-0112
⅞-16	133284	69196	68369	69091	69206	68369	144500-0112
1-14	50943	▲85361	68370	69092	69207	68370	144500-0114
1-14	50944	▲85361	68370	69093	69207	68370	144500-0116
1-14	133285	▲85361	68370	69093	69207	68370	144500-0116
1¼-12	50945	69198	68371	69094	69208	68371	144500-0120
1¼-12	133286	69198	68371	69094	69208	68371	144500-0120
1½-12	50946	▲85362	68372	69095	69209	68372	Consult Factory
1¾-12	50947	▲85363	68373	69096	69210	69215	
1¾-12	50948	▲85363	68373	69097	69210	69215	
2½-12	50949	▲85364	68374	69098	69211	68374	
2½-12	50950	▲85365	68375	69099	69212	68375	
2¾-12	50951	▲85365	68375	69100	69213	69216	
3¼-12	50952	73538	73545	73536	73542	73545	
3½-12	50953	73539	73547	73537	73542	73545	
4-12	50954	73539	73547	73538	73543	82181	
4½-12	—	—	—	73439	73544	73547	

NOTE: For economical accessory selection, it is recommended that rod end style 4 be specified on your cylinder order.

▲Cylinder accessory dimensions conform to NFPA recommended standard NFPA/T3.6.8 R1-1984, NFPA recommended standard fluid power systems — cylinder — dimensions for accessories for cataloged square head industrial types. Parker adopted this standard in April, 1985. Eye brackets or mounting plates shipped before this date may have different dimensions and will not necessarily interchange with the NFPA standard. For dimensional information on older style eye brackets or mounting plates consult Drawing #144805.

ACCESSORY LOAD CAPACITY

The various accessories on Pages 30 and 31 have been load rated for your convenience. The load capacity in lbs., shown on Page 31, is the recommended maximum load for that accessory based on a 4:1 design factor in tension. (Pivot pin is rated in shear.) Before specifying, compare the actual load or the tension (pull) force at maximum operating pressure of the cylinder with the load capacity of the accessory you plan to use. If load or pull force of cylinder exceeds load capacity of accessory, consult factory.

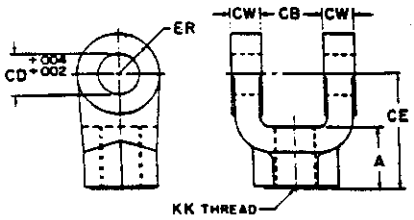
MOUNTING PLATES

Mounting Plates for Style BB and Style BC (clevis mounted) cylinders are offered. To select proper part number for your application, refer to Chart B below.

CHART B

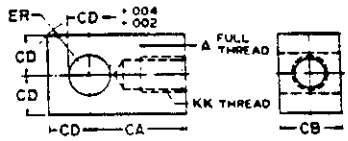
MTG. PLATE	SERIES "2A"
Part No.	Bore Size
74076*	1"
69195	1½", 2", 2½"
69196	3¼", 4", 5"
▲85361	6", 7", 8"
69198	10"
▲85362	12"
▲85363	14"

*Mounting plate for 1" bore single lug BC & BB cylinder mounting style is Clevis Bracket P/N 74076.



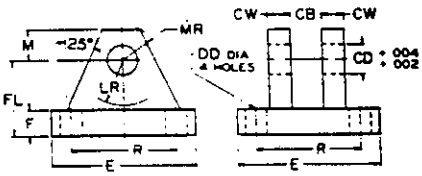
2 FEMALE ROD CLEVIS

Order to Fit Thread Size.



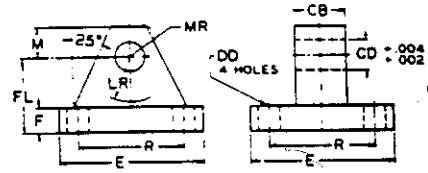
3 KNUCKLE (Female Rod Eye)

Order to Fit Thread Size.



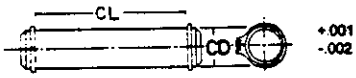
4 CLEVIS BRACKET FOR KNUCKLE

Order to Fit Knuckle.



8 MOUNTING PLATE OR 5 EYE BRACKET

1. When used to mate with the Rod Clevis, select from Chart A.
2. When used to mount the Style BB or BC cylinders, select from the Mounting Plate Selection Table. See Chart B at lower left.



6 PIVOT PIN

1. Pivot Pins are furnished with Clevis Mounted Cylinders as standard.
2. Pivot Pins are furnished with (2) Retainer Rings.
3. Pivot Pins must be ordered as a separate item if to be used with Knuckles, Rod Clevises, or Clevis Brackets.

Parker Series 2A Heavy Duty Air Cylinders

Parker Fluidpower

Cylinder Accessories

	Female Rod Clevis Part Number																		
	51221†	50940	50941	50942	133284	50943	50944	133285	50945	133286	50946	50947	50948	50949	50950	50951	50952	50953	50954
A	15/16	3/4	3/4	1 1/4	1 1/8	1 3/8	1 3/8	1 3/8	2	2	2 1/4	3	3	3 1/2	3 1/2	3 1/2	3 1/2‡	4‡	4‡
CB	17/32	3/4	3/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2	3	3	3	4	4 1/2	4 1/2
CD	5/16	1/2	1/2	3/4	3/4	1	1	1	1 3/8	1 3/8	1 3/4	2	2	2 1/2	3	3	3 1/2	4	4
CE	2 1/4	1 1/2	1 1/2	2 1/2	2 3/4	2 15/16	2 15/16	3 1/8	3 3/4	4 1/2	4 1/2	5 1/2	5 1/2	6 1/2	6 3/4	6 3/4	7 3/4	8 13/16	8 13/16
CW	13/64	1/2	1/2	5/8	5/8	3/4	3/4	3/4	1	1	1 1/8	1 1/4	1 1/8	1 1/2	1 1/2	1 1/2	2	2 1/8	2 1/8
ER	19/64	1/2	1/2	3/4	3/4	1	1	1	1 3/8	1 3/8	1 3/4	2	2	2 1/2	2 3/4	2 3/4	3 1/2	4	4
KK	5/16-24	7/16-20	1/2-20	3/4-16	3/4-16	7/8-14	1-14	1-14	1 1/4-12	1 1/4-12	1 1/2-12	1 3/4-12	1 7/8-12	2 1/4-12	2 1/2-12	2 3/4-12	3 1/4-12	3 1/2-12	4-12
LOAD CAPACITY LBS.	2800	4250	4800	11200	11200	18800	19500	19500	33500	33500	45800	65600	65600	98200	98200	98200	156700	163200	221200

	Knuckle Part Number																
	74075	69089	69090	69091	69092	69093	69094	69095	69096	69097	69098	69099	69100	73536	73437	73438	73439
A	3/4	3/4	3/4	1 1/8	1 1/8	1 3/8	2	2 1/4	2 1/4	3	3 1/2	3 1/2	3 5/8	4 ‡	5	5 1/2	5 1/2
CA	1 1/2	1 1/2	1 1/2	2 1/4	2 3/8	2 13/16	3 7/16	4	4 3/8	5	5 13/16	6 1/8	6 1/2	7 5/8	7 5/8	8 1/8	8 1/8
CB	7/16	3/4	3/4	1 1/4	1 1/2	1 1/2	2	2 1/2	2 1/2	2 1/2	3	3	3 1/2	4	4	4 1/2	5
CD	7/16	1/2	1/2	3/4	1	1	1 3/8	1 3/4	2	2	2 1/2	3	3	3 1/2	3 1/2	4	4
ER	19/32	23/32	23/32	1 1/4	1 7/16	1 7/16	1 31/32	2 1/2	2 27/32	2 27/32	3 9/16	4 1/4	4 1/4	4 31/32	4 31/32	5 11/16	5 11/16
KK	5/16-24	7/16-20	1/2-20	3/4-16	7/8-14	1-14	1 1/4-12	1 1/2-12	1 3/4-12	1 7/8-12	2 1/4-12	2 1/2-12	2 3/4-12	3 1/4-12	3 1/2-12	4-12	4 1/2-12
LOAD CAPACITY LBS. ⊖	3300	5000	5700	12100	13000	21700	33500	45000	53500	75000	98700	110000	123300	161300	217300	273800	308500

	Clevis Bracket for Knuckle Part Number												
	74076	69205	69206	69207	69208	69209	69210	69211	69212	69213	73542	73543	73544
CB	15/32	3/4	1 1/4	1 1/2	2	2 1/2	2 1/2	3	3	3 1/2	4	4 1/2	5
CD	7/16	1/2	3/4	1	1 3/8	1 3/4	2	2 1/2	3	3	3 1/2	4	4
CW	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2
DD	17/64	13/32	17/32	21/32	21/32	29/32	1 1/16	1 3/16	1 5/16	1 5/16	1 13/16	2 1/16	2 1/16
E	2 1/4	3 1/2	5	6 1/2	7 1/2	9 1/2	12 3/4	12 3/4	12 3/4	12 3/4	15 1/2	17 1/2	17 1/2
F	3/8	1/2	5/8	3/4	7/8	7/8	1	1	1	1	1 11/16	1 15/16	1 15/16
FL	1	1 1/2	1 7/8	2 1/4	3	3 5/8	4 1/4	4 1/2	6	6	6 11/16	7 11/16	7 11/16
LR	5/8	3/4	1 3/4	1 1/2	2	2 3/4	3 3/16	3 1/2	4 1/4	4 1/4	5	5 3/4	5 3/4
M	3/8	1/2	3/4	1	1 3/8	1 3/4	2 1/4	2 1/2	3	3	3 1/2	4	4
MR	1/2	5/8	29/32	1 1/4	1 21/32	2 7/32	2 25/32	3 1/8	3 19/32	3 19/32	4 1/8	4 7/8	4 7/8
R	1.75	2.55	3.82	4.95	5.73	7.50	9.40	9.40	9.40	9.40	12.00	13.75	13.75
LOAD CAPACITY LBS. ⊖	3600	7300	14000	19200	36900	34000	33000	34900	33800	36900	83500	102600	108400

	Eye Bracket and Mounting Plate Part Number										
	74077	69195	69196	▲85361	69198	▲85362	▲85363	▲85364	▲85365	73538	73539
CB	5/16	3/4	1 1/4	1 1/2	2	2 1/2	2 1/2	3	3	4	4 1/2
CD	5/16	1/2	3/8	1	1 3/8	1 3/4	2	2 1/2	3	3 1/2	4
DD	17/64	13/32	17/32	21/32	21/32	29/32	1 1/16	1 3/16	1 5/16	1 13/16	2 1/16
E	2 1/4	2 1/2	3 1/2	4 1/2	5	6 1/2	7 1/2	8 1/2	9 1/2	12 5/8	14 7/8
F	3/8	3/8	5/8	7/8	7/8	1 1/8	1 1/2	1 3/4	2	1 11/16	1 15/16
FL	1	1 1/8	1 7/8	2 3/8	3	3 3/8	4	4 3/4	5 1/4	5 11/16	6 7/16
LR	5/8	3/4	1 1/4	1 1/2	2 1/4	2 1/4	2 1/2	3	3 1/4	4	4 1/2
M	3/8	1/2	3/4	1	1 3/8	1 3/4	2	2 1/2	2 3/4	3 1/2	4
MR	1/2	9/16	7/8	1 1/4	1 5/8	2 1/8	2 7/16	3	3 1/4	4 1/8	5 1/4
R	1.75	1.83	2.55	3.25	3.82	4.95	5.73	6.58	7.50	9.82	11.45
LOAD CAPACITY LBS. ⊖	1700	4100	10500	20400	21200	49480	70000	94200	121900	57400	75000

	Pivot Pin Part Number													
	74078	68368	68369	68370	68371	68372	68373	69215	68374	68375	69216	73545	82181	73547
CD	7/16	1/2	3/4	1	1 3/8	1 3/4	2	2	2 1/2	3	3	3 1/2	4	4
CL	1 5/16	1 7/8	2 5/8	3 1/8	4 1/8	5 3/16	5 3/16	5 11/16	6 3/16	6 1/4	6 3/4	8 1/4	8 5/8	9
SHEAR CAPACITY LBS. ⊖	6600	8600	19300	34300	65000	105200	137400	137400	214700	309200	309200	420900	565800	565800

⊖ See Accessory Load Capacity notes on page 30
• These sizes supplied with cotter pins.
† INCLUDES PIVOT PIN
‡ Consult appropriate cylinder rod end dimensions for compatibility.

▲Cylinder accessory dimensions conform to NFPA recommended standard NFPA/T3.6.8 R1-1984. NFPA recommended standard fluid power systems — cylinder — dimensions for accessories for cataloged square head industrial types. Parker adopted this standard in April, 1985. Eye brackets or mounting plates shipped before this date may have different dimensions and will not necessarily interchange with the NFPA standard. For dimensional information on older style

THEORETICAL PUSH AND PULL FORCES FOR PNEUMATIC AND HYDRAULIC CYLINDERS

PUSH FORCE AND DISPLACEMENT

CYL. BORE SIZE (INCHES)	PISTON AREA (SQ. IN.)	CYLINDER PUSH STROKE FORCE IN POUNDS AT VARIOUS PRESSURES										CU. FT. FREE AIR AT 80 LBS. PRESSURE, REQUIRED TO MOVE MAX. LOAD 1 INCH	DISPLACEMENT PER INCH OF STROKE (GALLONS)
		25	50	65	80	100	250	500	1000	2000	3000		
1	.785	20	39	51	65	79	196	392	785	1570	2355	.00293	.00340
1½	1.767	44	88	115	142	177	443	885	1770	3540	5310	.00659	.00765
2	3.14	79	157	204	251	314	785	1570	3140	6280	9420	.01171	.0136
2½	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	.01830	.0213
3½	8.30	208	415	540	664	830	2075	4150	8300	16600	24900	.03093	.0359
4	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	.04685	.0544
5	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	.07320	.0850
6	28.27	707	1414	1838	2262	2827	7068	14135	28270	56540	84810	.10541	.1224
7	38.49	962	1924	2502	3079	3849	9623	19245	38490	76980	115470	.14347	.1666
8	50.27	1257	2513	3268	4022	5027	12568	25135	50270	100540	150810	.18740	.2176
10	78.54	1964	3927	5105	6283	7854	19635	39270	78540	157080	235620	.29280	.3400
12	113.10	2828	5655	7352	9048	11310	28275	56550	113100	226200	339300	.42184	.4896
14	153.94	3849	7697	10006	12315	15394	38485	76970	153940	307880	461820	.57389	.6664

DEDUCTIONS FOR PULL FORCE AND DISPLACEMENT

PISTON ROD DIA. (INCHES)	PISTON ROD AREA (SQ. IN.)	PISTON ROD DIAMETER FORCE IN POUNDS AT VARIOUS PRESSURES — To determine Cylinder Pull Force or Displacement, deduct the following Force or Displacement corresponding to Rod Size, from selected Push Stroke Force or Displacement corresponding to Bore Size in table above										CU. FT. FREE AIR AT 80 LBS. PRESSURE, REQUIRED TO MOVE MAX. LOAD 1 INCH	DISPLACEMENT PER INCH OF STROKE (GALLONS)
		25	50	65	80	100	250	500	1000	2000	3000		
½	.196	5	10	13	16	20	49	98	196	392	588	.00073	.0009
⅝	.307	8	15	20	25	31	77	154	307	614	921	.00114	.0013
1	.785	20	39	51	65	79	196	392	785	1570	2355	.00293	.0034
1⅜	1.49	37	75	97	119	149	373	745	1490	2980	4470	.00554	.0065
1¾	2.41	60	121	157	193	241	603	1205	2410	4820	7230	.00897	.0104
2	3.14	79	157	204	251	314	785	1570	3140	6280	9420	.01171	.0136
2½	4.91	123	245	319	393	491	1228	2455	4910	9820	14730	.01830	.0213
3	7.07	177	354	460	566	707	1767	3535	7070	14140	21210	.02635	.0306
3½	9.62	241	481	625	770	962	2405	4810	9620	19240	28860	.03587	.0416
4	12.57	314	628	817	1006	1257	3143	6285	12570	25140	37710	.04685	.0544
4½	15.90	398	795	1033	1272	1590	3975	7950	15900	31800	47708	.05929	.0688
5	19.64	491	982	1277	1571	1964	4910	9820	19640	39280	58920	.07320	.0850
5½	23.76	594	1188	1544	1901	2376	5940	11880	23760	47520	71280	.08857	.1028
7	38.49	962	1924	2502	3079	3849	9623	19245	38490	76980	115470	.14347	.1666
8½	56.75	1419	2838	3689	4540	5675	14187	28375	56750	113500	170250	.21157	.2455

GENERAL FORMULA

The cylinder output forces are derived from the formula:

$$F = P \times A$$

Where F = Force in pounds.
P = Pressure at the cylinder in pounds per square inch, gauge.
A = Effective area of cylinder piston in square inches.

Free Air refers to normal atmospheric conditions of the air at sea level (14.7 psi). Use above cu. ft. free air required data to compute CFM required from a compressor at 80 psi. Cu. ft. of free air required at other pressures can be calculated using formula below.

$$V_1 = \frac{(P_2 + 14.7)\,V_2}{14.7}$$

where V_1 = Free air consumption per inch of stroke (cubic feet).
V_2 = Cubic feet displaced per inch of stroke.
P_2 = Gauge pressure required to move maximum load.

For additional information – call your local Parker Fluidpower Motion & Control Distributor.

7. Frame Design, Stress and Deflections Analysis (ANSYS F.E.A. by Ang Lee)

Summary

- Bending Allowable Stresses, Weights, and Lateral Load.
- Members Identification.
- Member 1 - Loading, Bending, Compression, Combined, Concentrated Loads.
- Members 3 & 4 - Loading, Bending.
- Member 2 - Loading, Compression.
- Member 5 - Loading, Bending, Concentrated Loads.
- Members 10 & 11 - Loading, Bending, Compression, Combined;
- Frame / ANSYS / F.E.A. (by Ang Lee)
- Members 10 & 11 - Concentrated Loads.
- Lead Block Bracket - Top Plate and Triangular Plate
- Welds
- Anchor Bolts

Note: For members 6,7,8, and 9, see analysis of member 2.
For members 12 and 13, see analysis of members 10 and 11.

FRAME

BENDING ALLOWABLE STRESSES & WEIGHTS.

THE MEMBERS OF THE FRAME WERE INITIALLY SELECTED TO PROVIDE PROPER INSTALLATION AND PERFORMANCE OF THE BARRIER.

THE MEMBERS WILL BE VERIFIED IN ACCORDANCE WITH AISC / ASD AND A F.E.A WILL VERIFY THE CALCULATIONS.

IT WILL BE ADDED A LATERAL FORCE EQUAL TO 10% OF THE TOTAL LOAD TO VERIFY FRAME STABILITY.

ALL THE MEMBERS (EXCEPT FOR THE LEAD BLOCK BRACKET) ARE STEEL TUBING, ASTM A 500 gr. B, $F_y = 46$ KSI

Tb. 85.1, TO BE COMPACT $b/t \leq \frac{190}{\sqrt{F_y}} = 28$

$$\left.\begin{array}{l} \text{IF } t = 1/4'' \Rightarrow b \leq 112'' \\ \text{IF } t = 1/2'' \Rightarrow b \leq 56'' \end{array}\right\} \underline{\text{OK}}$$

F3.1, p.5-48:

$L_{C\,MAX} = (1950)\, b / F_y \Rightarrow$ WORST CASE $= \frac{1950 \cdot 2}{46} \Rightarrow$ ← 6x2x1/4

$\Rightarrow L_C = 84.8$ ft $\Rightarrow$ OK

So: $F_b = 0.66 F_y \Rightarrow \underline{F_b = 30.4 \text{ ksi}}$

WEIGHTS

SHIELD PLATE: $(8.288) \times 1 \times (0.2936) = 1{,}500$ lb

FRAME: 101 ft $(6 \times 6 \times 1/4) + 25$ ft $(6 \times 2 \times 1/4) = 1921 + 306 = 2{,}227$ lb

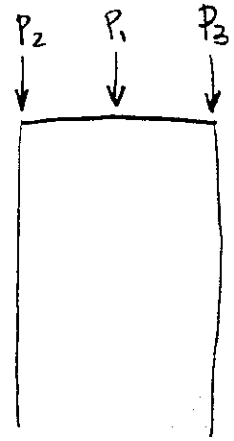
CYLINDER: ≤ 200 lb, WIRES AND ACCESSORIES: ≤ 170 lb

TOTAL WEIGHT: $1{,}500 + \underbrace{2{,}230 + 200 + 170}_{2{,}600}$ + (BRACKET, BASE PLATES, ETC.) $\Rightarrow$ ~100 lb (CONS.)

$\Rightarrow$ TOTAL WEIGHT $\simeq \underline{4{,}200 \text{ lb}}$ (STATIC)

NOTE: ALL REFERENCES TO EQUATIONS, TABLES, FIGURES, PAGES, ETC., ARE FROM AISC / ASD 9th ED., EXCEPT WHEN NOTED.

DURING TRANSPORTATION AND INSTALLATION, THE SHIELD PLATE AND THE DC WILL NOT BE IN PLACE. HENCE THE MAXIMUM LOAD CONDITION WILL OCCUR DURING OPERATION:



$$P_1 = \overset{\text{DYNAMIC}}{2} \times [\text{SHIELD} + \text{FRICTION}] + \text{TOP BEAMS} + \text{ACCESSORIES} \Rightarrow$$

$$P_1 = 2 \times [1{,}500 \times 1.1] + 204 + 170 =$$

$$= 3{,}674 \Rightarrow \underline{P_1 = 3{,}700 \text{ lb}}$$

$$P_2 = \frac{1}{2}[(\text{STRUCTURE} - \text{TOP BEAMS}) + \text{CYLINDER} + \text{OTHERS}]$$

$$= \frac{1}{2}[(2230 + 102) + 200 + 100] = 1{,}316 \Rightarrow$$

$$P_2 = \underline{1{,}320 \text{ lb}}$$

$$P_3 = P_2 + (\text{CYLINDER FORCE}) = 1{,}320 + \overset{\text{DYNAMIC}}{2}(1{,}500 \times \overset{\text{FRICTION}}{1.1}) \Rightarrow$$

$$\Rightarrow \underline{P_3 = 4{,}620 \text{ lb}}$$

TOTAL "DYNAMIC" WEIGHT: $P_1 + P_2 + P_3 = 3{,}700 + 1{,}320 + 4{,}620 =$

$= \underline{9{,}640 \text{ lb}}$

FOR LATERAL LOAD, IT WILL BE ASSUMED ~10% OF THAT $\Rightarrow$

$\underline{P_L = 1{,}000 \text{ lb}}$

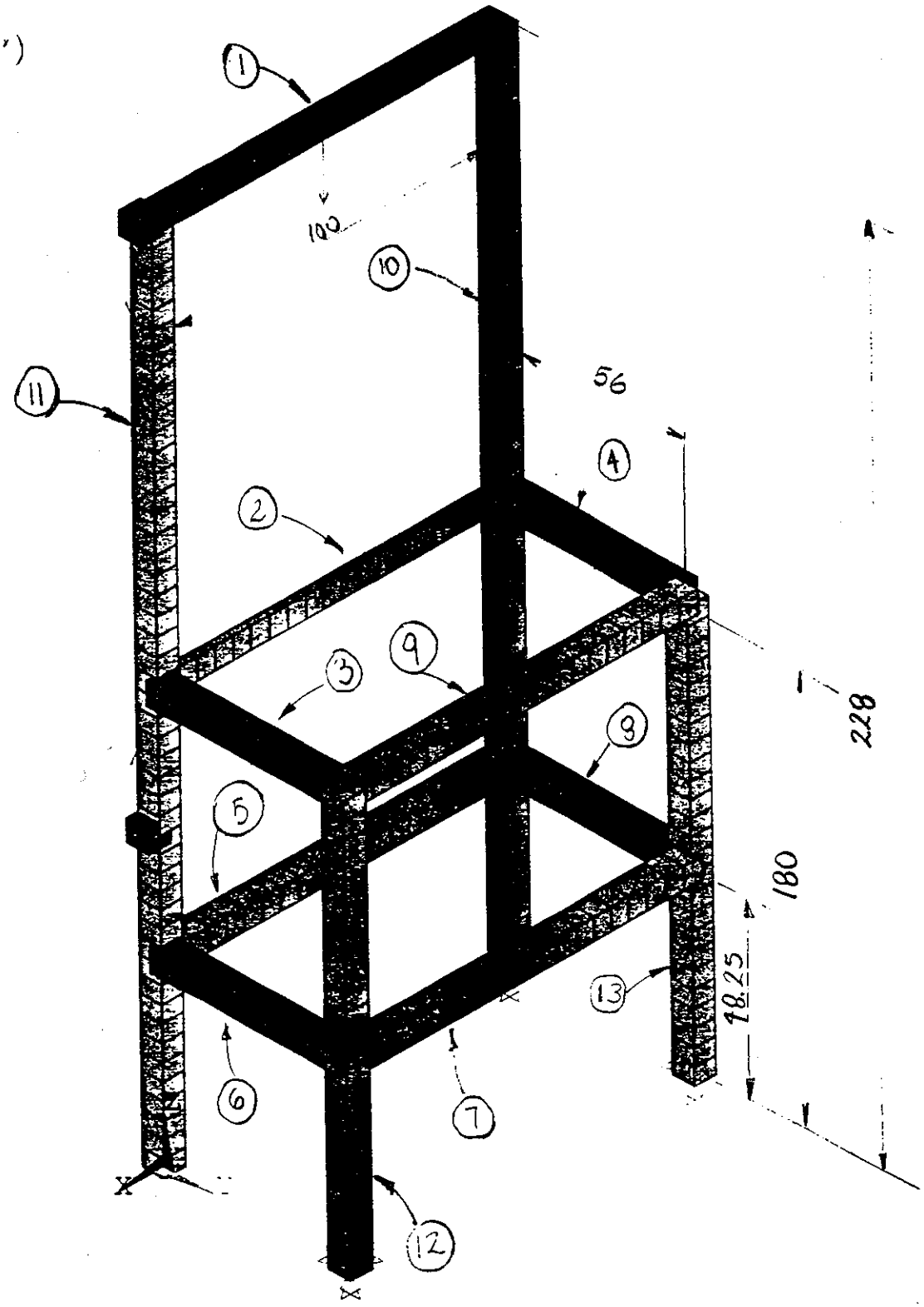
SEE MEMBER IDENTIFICATION NEXT PAGE

MEMBERS IDENTIFICATION

① : 2 x (6" x 2' x 1/4")

② : 6" x 2' x 1/4"

OTHERS : 6" x 6" x 1/4"

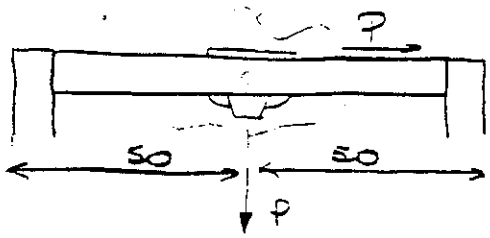


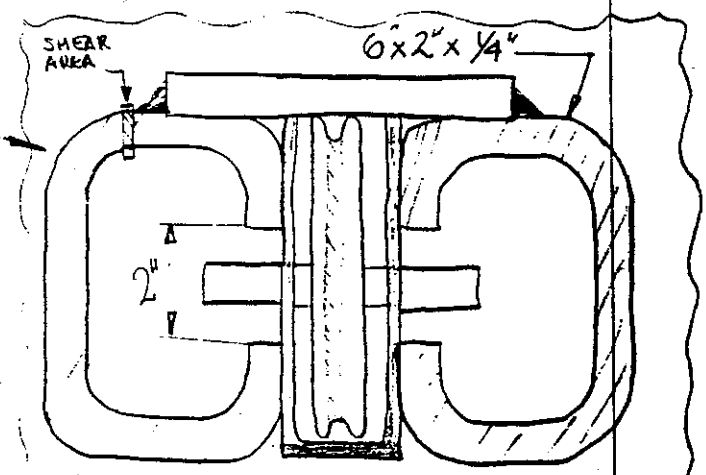
6 x 6 x 1/4 →	112 ft x 19.02 lb/ft	=	2130 lb
6 x 2 x 1/4 →	25 ft x 12.21 lb/ft	=	310 lb
	TOTAL	=	2,440 lb

2 x 228
2 x 180
3 x 10
4 x 56

MEMBER (1) (2 x [6" x 2" x 1/4])

Ø) LOADING





P = 3,700 lb
(SEE BENDING ALLOWABLE STRESSES & WEIGHTS)

↳ THERE IS INSIGNIFICANT TORSION ON THE TUBING.

PROPERTIES: $A = 3.09\ in^2$
$I_x = 13.63\ in^4$
$I_y = 1.86\ in^4$
$r_x = 2.10\ in$
$r_y = 0.78\ in$

1) BENDING (ASSUMING SIMPLY SUPPORTED)

$$M_{MAX} = \frac{(3{,}700)(100)}{4} = 92{,}500\ lb\cdot in$$

$$f_{bx} = \frac{92{,}500}{\underbrace{2}_{2\ TUBES} \times \frac{(13.63)}{3}} \Rightarrow f_{bx} = 10{,}180\ psi$$

$$f_{bx} = 10.2\ ksi \ll 30.4\ ksi \Rightarrow OK.$$

2) COMPRESSION

TAKING $F_y = 46$ ksi, $E = 29{,}000$ ksi, $l = 50"$, $r_y = 0.78$ in,

K (Tb. C-C2; p. 5-135) $= 1.0 \Rightarrow Kl/r = 64 < C_c = 111.6$

$\Rightarrow$ (E2-1): $F_a = 20.7$ ksi ADDING 10% OF LATERAL LOAD:

$$f_a = \frac{(3{,}700 + 1{,}000)}{\underbrace{2}_{2\ TUBES} \cdot (3.09)} \Rightarrow f_a = 761\ psi \Rightarrow f_a = 0.8\ ksi < F_a \Rightarrow \underline{\underline{OK}}$$

3) COMBINED

$$\frac{f_a}{F_a} = \frac{0.8}{20.7} \Rightarrow \frac{f_a}{F_a} = 0.04 \Rightarrow$$ H1-3; CONSIDERING $f_{by} = 10\%$ OF f_{bx}
↳ DUE TO OSCILATIONS OF THE SHIELD

$$\frac{f_a}{F_a} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = 0.04 + \frac{10.2}{30.4} + \frac{(0.1)10.2}{30.4} = 0.41 < 1.0 \Rightarrow \underline{\underline{OK}}$$

NOTE. MAX. DEFLECTION $= \dfrac{(3{,}700/2) \times (100)^3}{48 \cdot (2.9 \times 10^7) \times (13.63)} \Rightarrow \Delta_{MAX} = 0.098"$ (2.5 mm)

MEMBER ①

CONCENTRATED LOADS

1) SHEAR (F4, p 5-49)

$h/t_w = \frac{[6-(2\times 1/4)]}{1/4} = 22$

$\frac{380}{\sqrt{F_y}} = \frac{380}{6.78} = 56$

$h/t_w < 380/\sqrt{F_y} \Rightarrow F_v = 0.4F_y$

$F_v = 0.4 \cdot 46 \Rightarrow F_v = 18.4$ ksi

$f_v = \frac{(3{,}700/2)}{(1/4 \times 6)} = 1{,}240$ psi ≈ 1.3 ksi $<< 18.4$ ksi

↳ AREA MARKED ON SKETCH OF PREVIOUS PAGE.

2) BUCKLING OF THE SIDE WALLS

TAKING: $F_y = 46$ ksi, $E = 29{,}000$ ksi, $l = 6''$, $r = 0.072$ in

K (To C-C21) (ECCENTRICALLY LOADED) p. E-135) = 2.0, $Kl/r = 186.2$ $C_c = 111.6 \Rightarrow$

(E2-1): $F_a = 5.4$ ksi

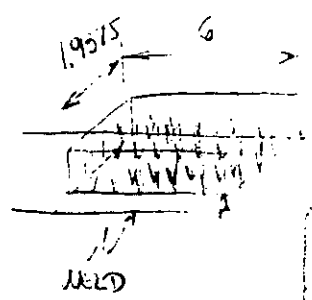
$f_a = \frac{(3{,}700/2)}{1 \cdot (6 \times 1/4)} = 1{,}233$ psi ; $f_a = 1.2$ ksi < 5.4 ksi $= F_a$

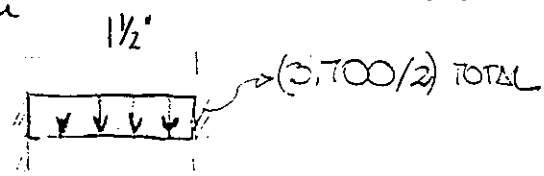
↳ LENGTH OF TOP PLATE OF LEAD BLOCK

↳ CONSIDERING ONLY OUTSIDE WALL

$\Rightarrow$ OK

3) BENDING





$M_{max} = \frac{wl^2}{12} = \frac{(3{,}700/2)(1\frac{1}{2})}{12} = 231$ lb-in

$f_b = \frac{231}{\frac{6(1/4)^2}{6}} \Rightarrow f_b = 3{,}700$ psi

CONSERVATIVE

$f_b = 3.7$ ksi < 30.4 ksi $= F_b \Rightarrow$ OK

MEMBERS (3) & (4) (6" x 6" x 1/4")

Ø) LOADING

A4.3 => P = 1.1 (DC WEIGHT) = 1.1 (500) => P = 550 lb

I) BENDING

$$M_{MAX} = \frac{(550/2)\cdot(56)}{4} = 3{,}850 \text{ lb-in}$$

$$f_{bx} = \frac{3{,}850}{10.1} = 381 \text{ psi} = 0.4 \text{ ksi} << 30.4 \text{ ksi} \Rightarrow \underline{OK}$$

NOTE: MAX. DEFLECTION = $\frac{(550/2)\cdot(56)^3}{48(29\times10^7)\cdot(30.3)}$ = 0.001" (0.03 mm)

MEMBER (2) (6 x 2" x 1/4")

Ø) LOADING

LATERAL BRACING => 10% OF LOAD = 1000 lb

I) COMPRESSION

WITH $F_y = 46$ ksi, $E = 29{,}000$ psi $\ell = 100"$, $r = 0.802$ in,
$K = 1.0$, $K\ell/r = 124.7$, $C_c = 111.6$ => (E 2-2) $F_a = 9.6$ ksi
$A = 3.59$ in² => $P = (9.6)(3.59)$ => $P_{max} = 34$ kips
34 kips >> kip => OK

MEMBERS (6) TO (9) (6" x 6" x 1/4")

SAME ANALYSIS AS FOR MEMBER (2) ABOVE, EXCEPT $F_a = 23.7$ ksi,
$A = 5.59$ in² => $P = (23.7)(5.59)$ => $P_{max} = 132$ kips >> 1 kip
=> OK.

MEMBER (5) (6" x 6" x 1/4)

Ø) LOADING

THIS MEMBER IS GOING TO BE BENT SIMILARLY TO MEMBER (1).

1) BENDING.

$$M_{max} = \frac{(3{,}700)(100)}{4} = 92{,}500 \text{ lb-in}$$

$$f_{bx} = \frac{92{,}500}{10.1} = 9{,}158 \text{ psi} \Rightarrow f_{bx} = 9.2 \text{ ksi} < 30.4 \text{ ksi}$$

OK

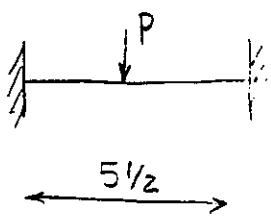
NOTES.

1) FOR COMPRESSION, SEE MEMBER (6) TO (9).

2) AS THE SHIELD PLATE RESTS OVER THIS MEMBER, A COLUMN WILL BE ADDED AT THE CENTER OF THIS BEAM TO REDUCE STRESSES TO A MINIMUM. AS THE SIZE OF THIS COLUMN IS GOING TO BE 6x6x1/4", THE SIZING OF MEMBERS (10) TO (13) WILL SUFICE

2) CONCENTRATED LOAD.

1) BENDING



$$M_{MAX} = \frac{P\ell}{8} = \frac{3{,}700 \times 5.5}{8} = 2{,}545 \text{ lb-in}$$

THE AREA OF THE PLATE THAT IS IN CONTACT WITH THIS MEMBER IS 22" x 1" SO:

$$f_b = \frac{2{,}545}{\frac{(22)(1/4)^2}{6}} \Rightarrow f_b = 11{,}100 \text{ psi}$$

$$f_b = 11.1 \text{ ksi} < 30.4 \text{ ksi} = F_b \Rightarrow \text{OK}$$

2) SHEAR. $f_v = \frac{3{,}700}{(1/4)\,22} = 673 \text{ psi} \Rightarrow f_v = 0.7 \text{ ksi} < 18.4 \text{ ksi} \Rightarrow$ OK

3) BUCKLING.

$$f_a = \frac{(3{,}700)/2}{(22 \times 1/4)} = 336 \text{ psi} \Rightarrow f_a = 0.3 \text{ ksi} < 5.4 \text{ ksi} = F_a \Rightarrow \text{OK}$$

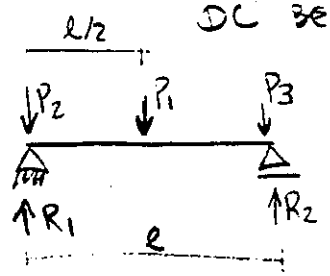
2 WALLS

SEE MEMBER (1)

MEMBERS (10) & (11)

Ø) LOADING

LOADS: MAXIMUM COMPRESSIVE : 4,620 lb (P_2)
LATERAL FORCE : 1,000 lb (P_L)
BENDING FORCE : 3,700 lb (P_1)
DC BENDING FORCE : 275 lb (P_D)



$$R_1 = \frac{P_1}{2} + P_2 = \frac{3{,}700}{2} + 1{,}320 = \underline{3{,}170\ lb}$$

$$R_2 = \frac{P_1}{2} + P_3 = \frac{3{,}700}{2} + 4{,}620 = \underline{6{,}470\ lb}$$

IT WILL BE ASSUMED THAT THE MOMENTS ON THE BEAMS ARE GOING TO BE TRANSFERED TO THE COLUMNS.

1) BENDING

FROM MEMBER (1) · $M_x = \frac{P_2 l}{8} = \frac{(3{,}700)\ 100}{8} = 46{,}250$ lb-in

FROM MEMBERS (3) & (4) $M_y = \frac{P_3 l}{8} = \frac{(550/2).(56)}{8} = 1{,}925$ lb-in

$f_{bx} = \frac{46{,}250}{10.1} = 4{,}580$ psi < 30.4 ksi

$f_{by} = \frac{1{,}925}{10.1} = 191$ psi $\ll 30.4$ ksi

FROM LATERAL LOAD (CONSERVATIVELY) $M = \frac{1{,}000\ (131.175)}{4} = 32{,}940$ lb-in

$f_{bL} = \frac{32{,}940}{10.1} = 3{,}260$ psi < 30.4 ksi

f_{bL} CAN BE ADDED TO f_{bx} OR f_{by}:

$$\frac{\sum f_b}{F_b} = \frac{4.6 + 0.2 + 3.3}{30.4} = \frac{3.1}{30.4} = 0.27$$

NOTE: MEMBERS (12) & (13) WILL BE <u>OK</u> IF (10) & (11) ARE <u>OK</u>.

MEMBERS (10) & (11)

2) COMPRESSION

CONSERVATIVELY; IT WILL BE ASSUMED $K = 2.0$, $KL = 22'$

FROM p.3-42, $6 \times 6 \times 1/4$, $KL = 22'$ => $P = 65$ kips

WITH $F_y = 46$ ksi, $E = 29{,}000$ ksi, $\ell = 11'$, $r = 2.33$ in,

$K = 2.0$, $K\ell/r = 113.3$ & $C_c = 111.6$ =>

E2-2: $F_a = 11.6$ ksi

$$f_a = \frac{R_2 + (D/2)}{A} \quad \frac{6470 + (550/2)}{5.59} = 1{,}207 \text{ psi} = 1.2 \text{ ksi} < 11.6 \text{ ksi} \Rightarrow \underline{OK}$$

3) COMBINED

$$\frac{f_a}{F_a} = \frac{1.2}{11.6} = 0.10 < 0.15 \Rightarrow H1\text{-}3$$

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} = 0.10 + 0.23 = 0.33 < 1.0 \Rightarrow \underline{OK}$$

A ANSYS F.E.A. (BY ANG LEE) CONFIRMS THE LOW LEVEL OF STRESSES PRESENT, AS CAN BE SEEN AS FOLLOWS.

NOTE: THE NEXT PAGE SHOWS THE MAXIMUM VALUES (FORCES, MOMENTS, DEFLECTION, AND STRESS)

From: Ang Lee
To: R.Silva
Subject: Calculation result for the case with 10% horizontal load
Date: March 15, 1995

Here is the calculation result for the case with 10% horizontal load (-X direction):

Maximum Stress : 17,000 psi
Maximum deflection: 0.716"

Maximum moment:

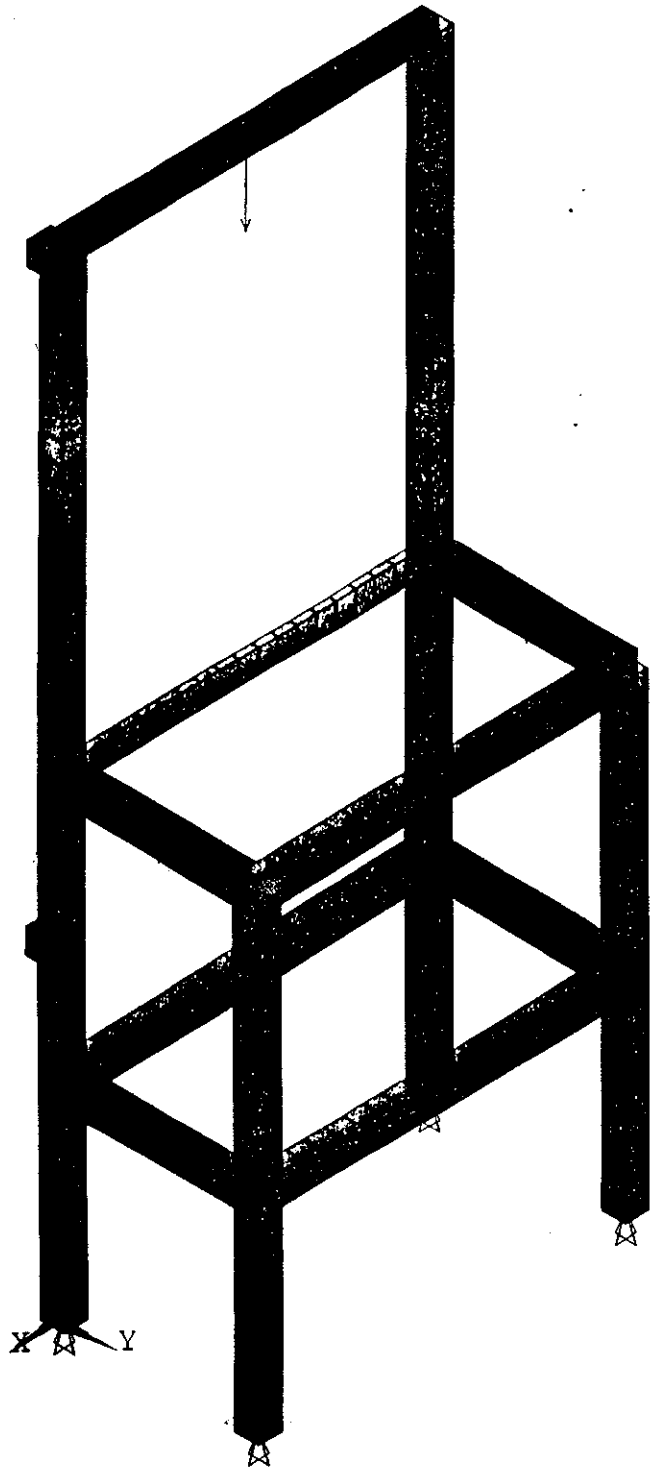
Mx=23,834 lbf-in
My=0.11e6 lbf-in
Mz=54,822 lbf-in

Maximum Force:

Fx=4,118 lbf
Fy=1,065 lbf
Fz=2,175 lbf

Note: X-Y-Z direction is based on the element coordinate

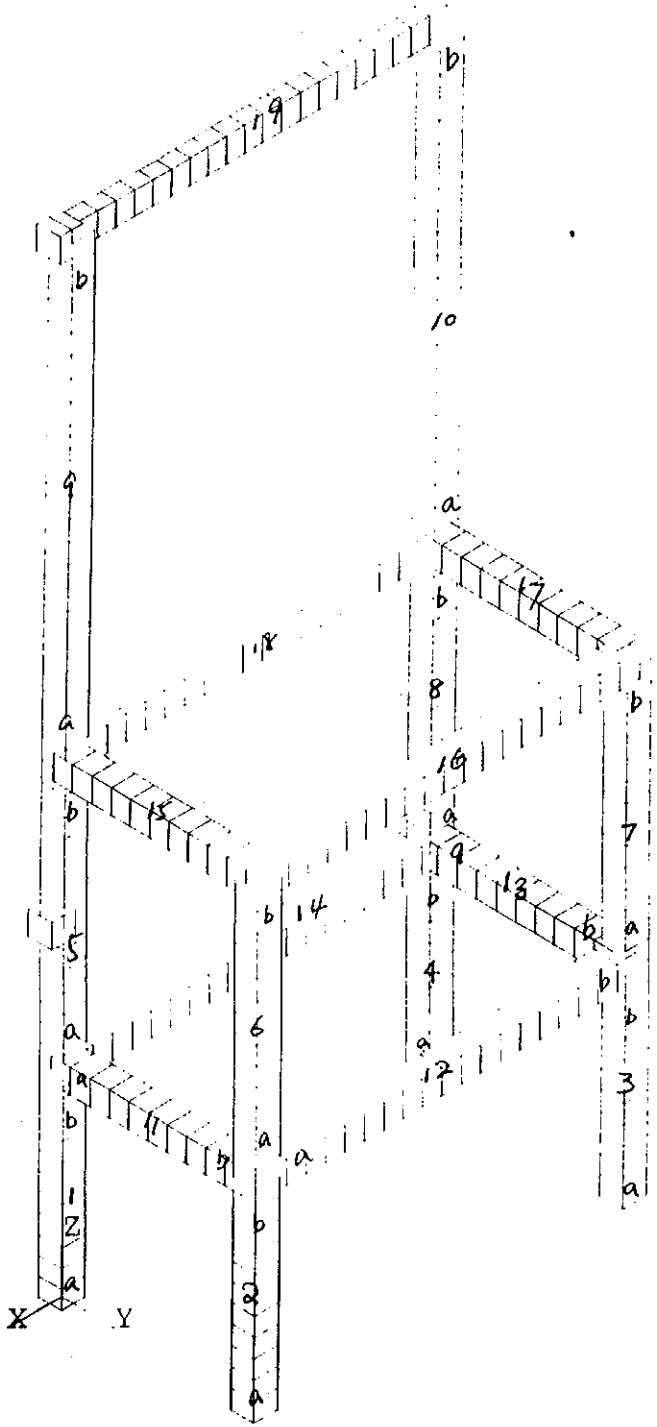
1



ANSYS 5.0 A
MAR 10 1995
13:41:13
PLOT NO. 1
ELEMENTS
TYPE NUM
U
F
M

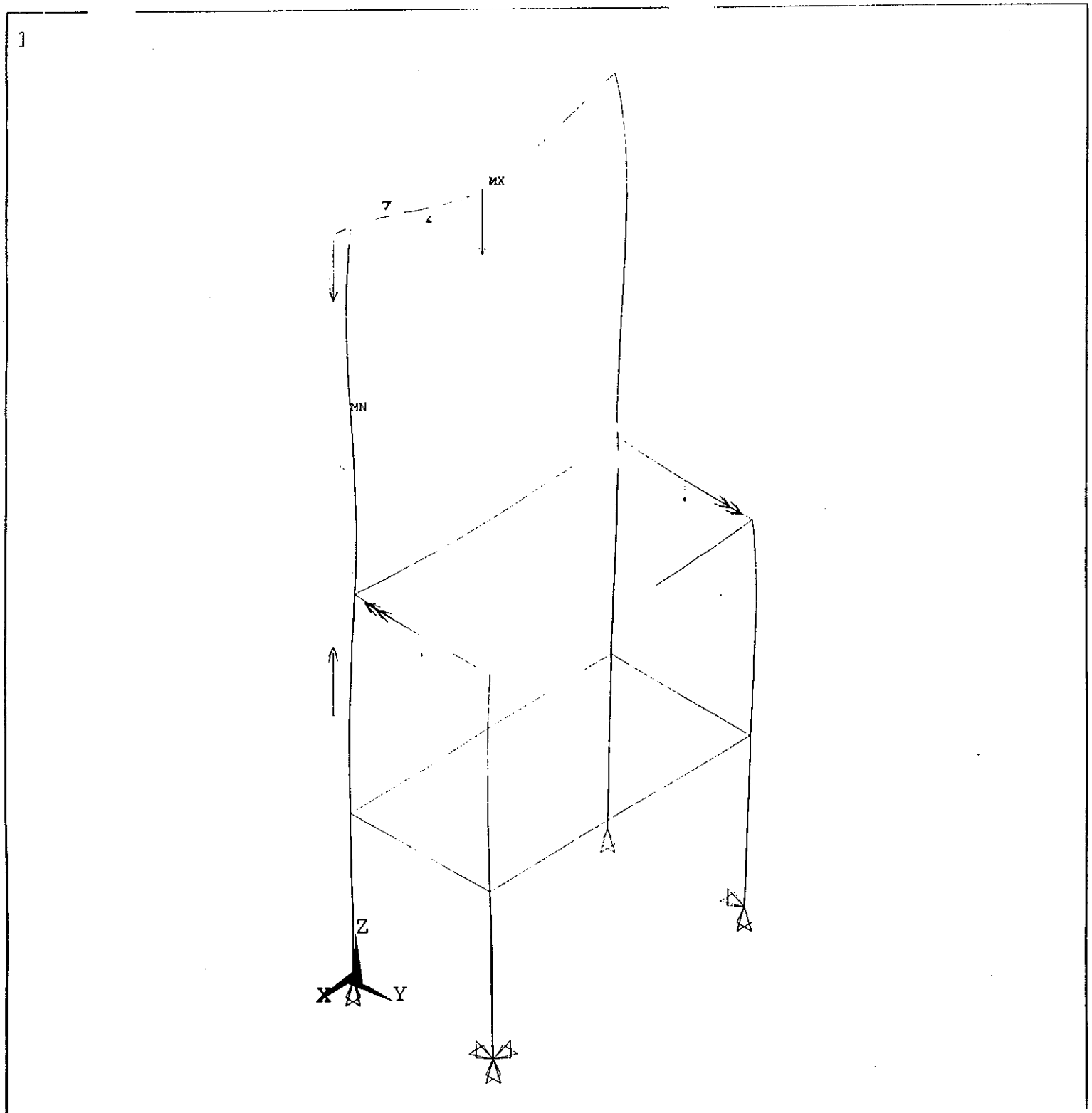
XV =1
YV =1
ZV =1
DIST=137.191
XF =-44
YF =25
ZF =115.25
VUP =Z
CENTROID HIDDEN

1



ANSYS 5.0 A
MAR 13 1995
16:05:50
PLOT NO. 1
ELEMENTS
TYPE NUM

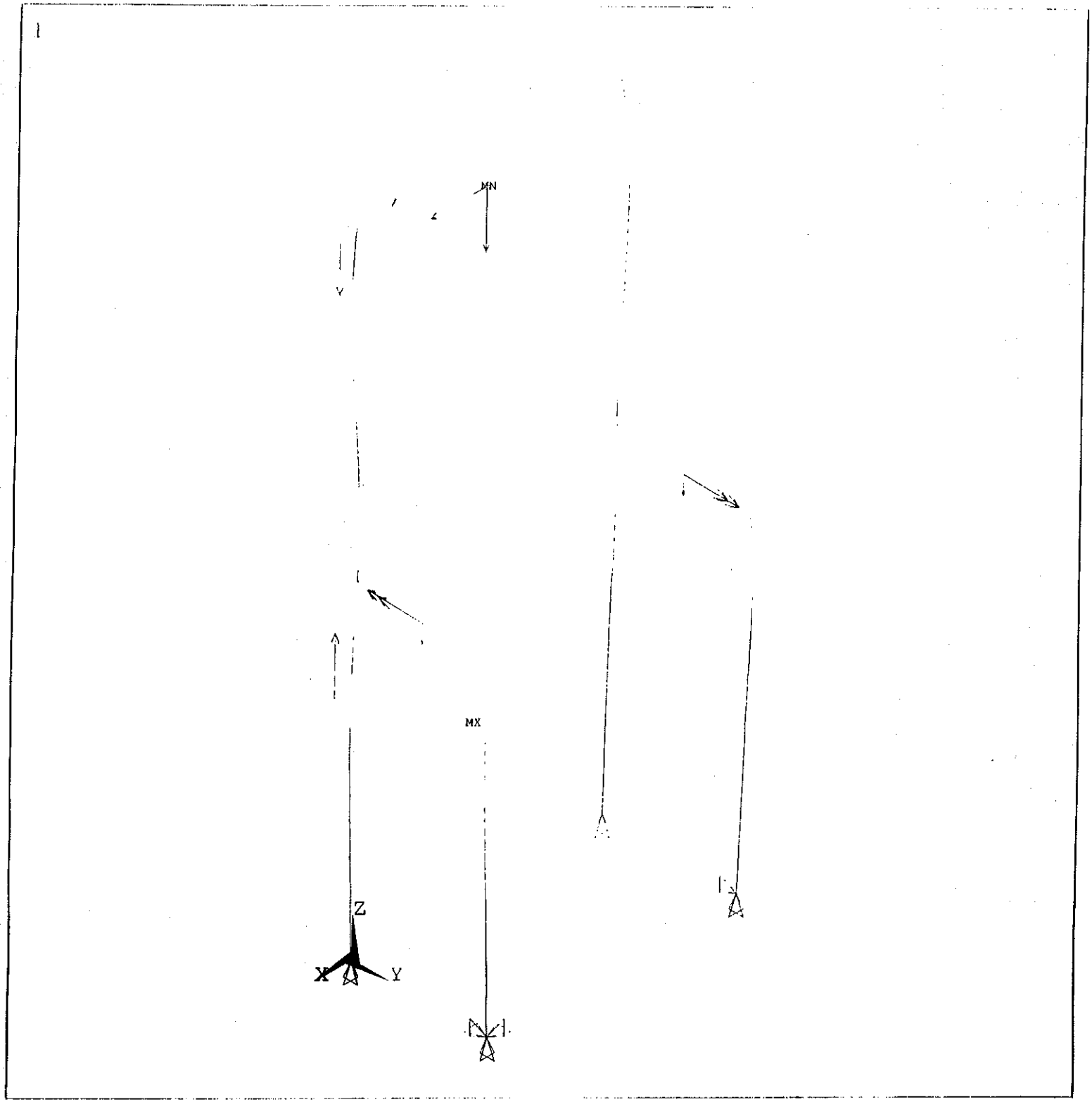
XV =1
YV =1
ZV =1
DIST=137.191
XF =-44
YF =25
ZF =115.25
VUP =Z
PRECISE HIDDEN



ANSYS 5.0
MAR 10 1995
13:43:17
PLOT NO. 1
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SMAX1 (NOAVG)
DMX =0.021383
SMN =-447.043
SMX =3152

M

-447.043
-47.198
352.647
752.492
1152
1552
1952
2352
2752
3152



ANSYS 5.0 A
MAR 10 1995
13:44:02
PLOT NO. 1
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SMIN2 (NOAVG)
DMX =0.021383
SMN =-3570
SMX =29.687

M

-3570
-3170
-2770
-2370
-1970
-1570
-1170
-770.16
-370.236
29.687

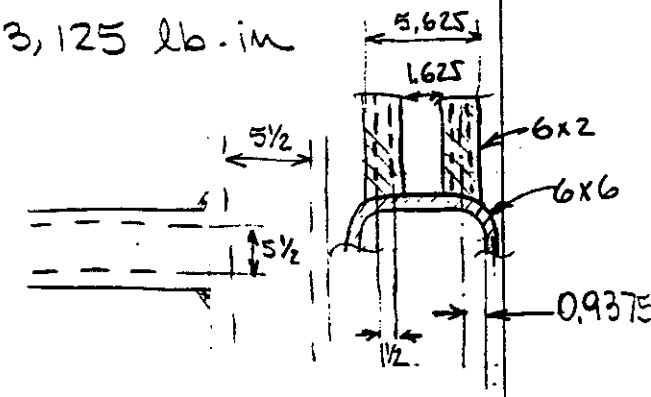
MEMBERS (10) x (11)

CONCENTRATED LOADS

JOINT (1) TO (10): 2 x (6" x 2" x 1/4") CONNECTED TO 1 x (6 x 6 x 1/4)

$$M = \frac{(P\ell/8)}{2} = \frac{3{,}700 \cdot 100}{16} = 23{,}125 \text{ lb-in}$$

← 2 TUBES



$$F = \frac{M}{a} = \frac{23{,}125}{(5.5)} \Rightarrow F = 4{,}205 \text{ lb}$$

$$P = \frac{(1{,}000 + 3{,}700)}{2} = 2{,}350$$

← 2 TUBES

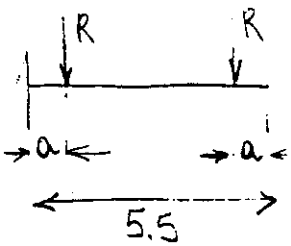
$$R = 4{,}205 + 2{,}350\left[\frac{1.5}{2(1.5+5.5)}\right] \Rightarrow \underline{R = 4{,}460 \text{ lb}}$$

SHEAR

$$f_v = \frac{4{,}460}{2 \times (1/4)} \Rightarrow f_v = 8.9 \text{ ksi} < 18.4 \text{ ksi} \Rightarrow \underline{\underline{OK}}$$

SEE MEMBER (1)

BENDING



BY SUPERPOSITION (*):

$$M_{MAX} = \frac{Na^2}{\ell} = \frac{(4{,}460)(0.9375)^2}{5.5} \Rightarrow$$

$$M_{MAX} = 715 \text{ lb-in}$$

$$S = \frac{5.5 \cdot (1/4)^2}{6} = 0.0573 \text{ in}^3 \Rightarrow f_b = \frac{715}{0.0573} \Rightarrow f_b = 12{,}480 \text{ psi}$$

CONSERVATIVE

$$\Rightarrow f_b = 12.5 \text{ ksi} < 30.4 \text{ ksi} \Rightarrow \underline{\underline{OK}}$$

(*) SEE ROARK & YOUNG, 6th ed, CHAP. 7, Tb. 3, CASE 1d, p. 101:

$$M_{MAX} = -\frac{Wa}{\ell^2}(\ell-a)^2 - \frac{Wa^2}{\ell^2}(\ell-a) + a\left[\frac{W}{\ell^3}(\ell-a)^2(\ell+2a) + \frac{Wa^2}{\ell^3}(3\ell-2a)\right] = \frac{Wa^2}{\ell}$$

SIDE WALLS STABILITY

$$f_a = \frac{2(4460)}{2(6 \times 1/4)} = 2,980 \text{ psi} \Rightarrow f_a = 2.9 \text{ ksi} < 5.4 \text{ ksi} = F_a \Rightarrow \underline{\underline{OK}}$$

SEE MEMBER (1)

LEAD BLOCK BRACKET

THE BRACKET IS MADE OF ASTM A36, $F_y = 36$ ksi

TO B5.1, TO BE COMPACT $b/t \leq 95/\sqrt{F_y/k_c}$

$h/t < 70 \Rightarrow k_c = 1$ ($h < 35''$)

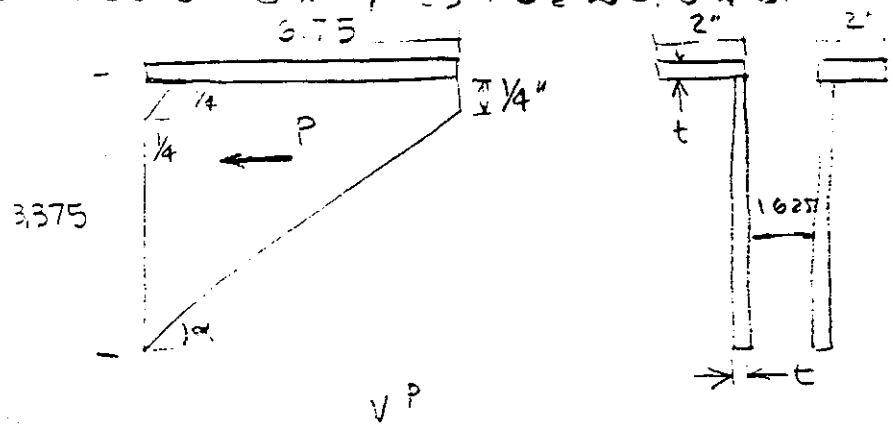
$\Rightarrow b/t \leq 95\sqrt{36} \Rightarrow b/t \leq 570 \Rightarrow$ OK ($b < 285''$)

SO THE PLATES ARE COMPACT

F3.1, p.5-48, $L_{c\,max} = \frac{1950b}{F_y}$, $b_{min} = 2'' \Rightarrow$

$L_{c\,max} = \frac{1950 \times 2}{36} = 108.3$ ft $\Rightarrow$ OK

SO: $F_b = 0.66 \times F_y \Rightarrow F_b = 23.8$ ksi

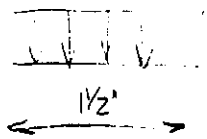


$R = P\sqrt{2} = 3{,}700\sqrt{2}$

$\Rightarrow R = 5{,}235$ lb

$t = 1/2''$

TOP PLATE



BENDING: $M = \frac{wl^2}{2} = \frac{(3{,}700/2) \times (1\frac{1}{2})}{2} = 1{,}390$ lb·in

$S = \frac{bh^2}{6} = \frac{(6.75)(1/2)^2}{6} = 0.281$ in³

$f_b = \frac{M}{S} = \frac{1{,}390}{0.281} \Rightarrow f_b = 4{,}935$ psi

$f_b = 4.9$ ksi < 23.8 ksi $= F_b \Rightarrow$ OK

COMPRESSION: $\frac{3{,}700/2}{(6.75)(1/2)} = 550$ psi $\Rightarrow$ VERY SMALL $\Rightarrow$ OK

TRIANGULAR PLATE

DUE TO THE COMPLEX LOADING APPLIED TO THE PLATE, A ANSYS F.E.A WAS DONE (SEE PAGES ATTACHED). THUS:

$\sigma_{SI} = 10.3$ ksi

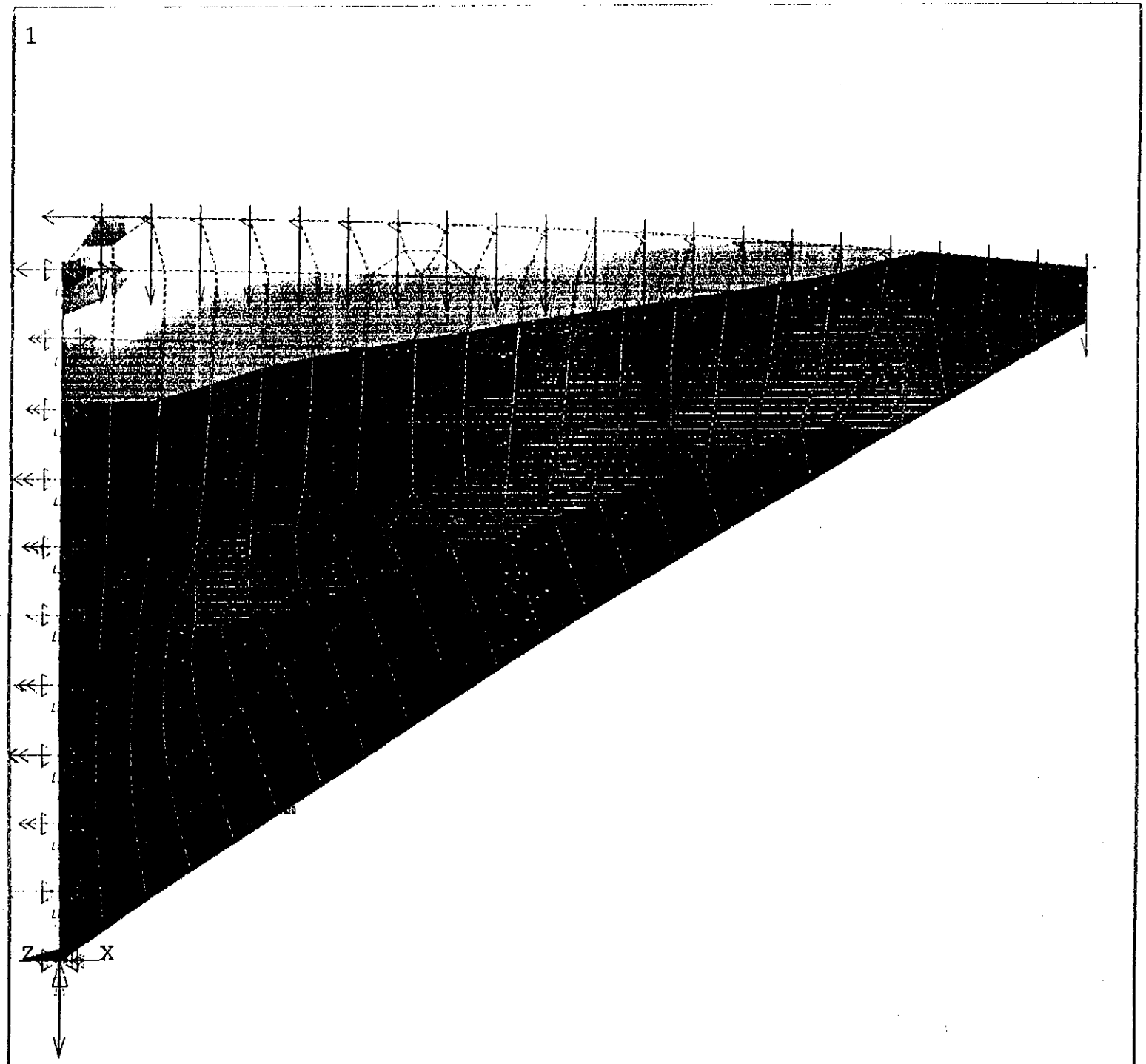
$\sigma_{COMP} = 3.4$ ksi

$\sigma_{SI} < F_b \Rightarrow$ OK

TO VERIFY STABILITY, IT WAS ASSUMED (CONSERVATIVELY):
$F_y = 36$ ksi, $E = 29{,}000$ ksi, $\ell = 8''$, $r = 0.144$ in,
K (Tb C-21, p. 5-135) $= 2.0$, $K\ell/r = 111.1$ $C_c = 126.1$
(ECCENTRICALLY LOADED)

(E2-1) $F_a = 11.5$ ksi

$\sigma_{COMP} < F_a \Rightarrow$ OK

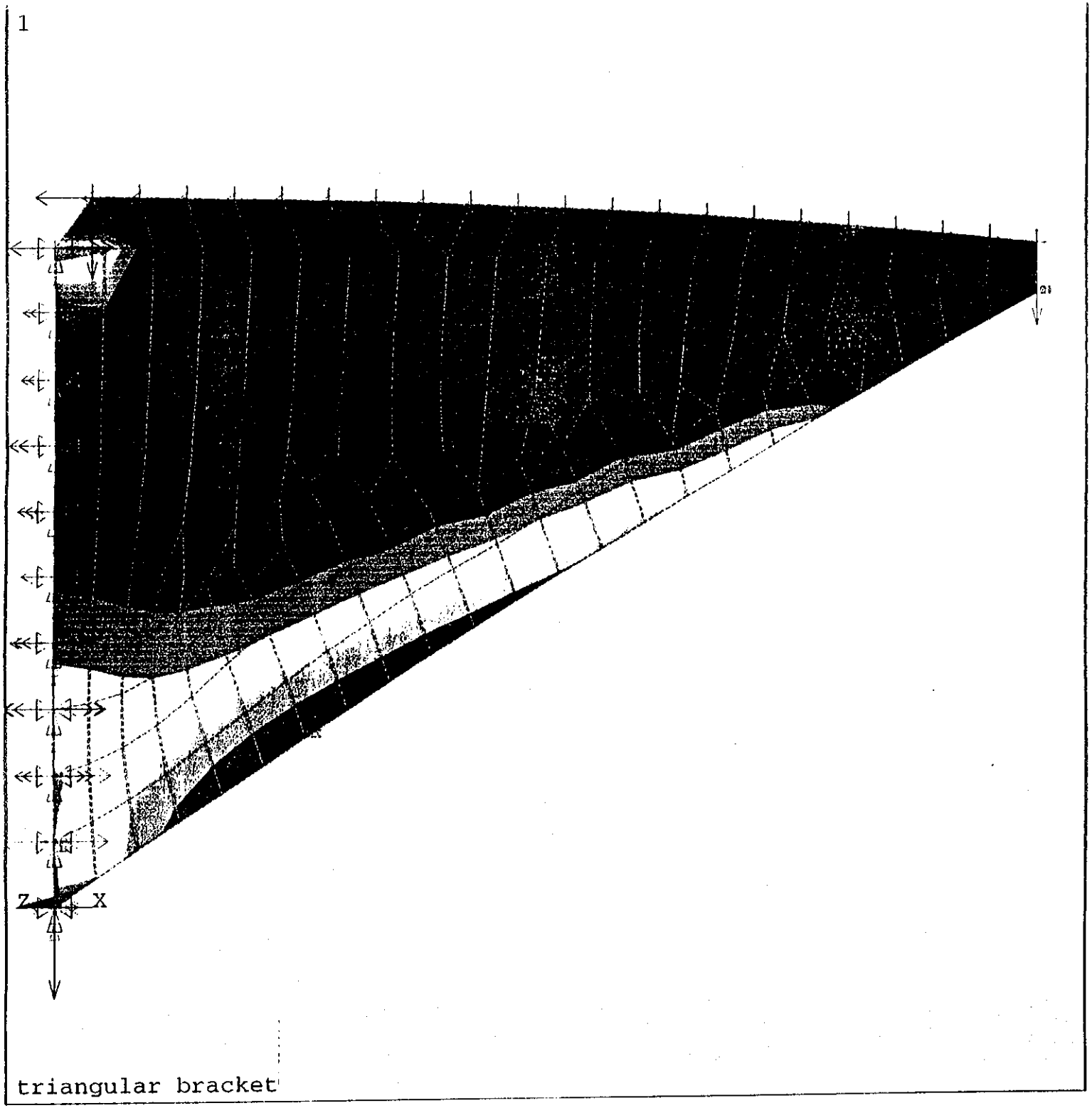


ANSYS 5.0 A
APR 7 1995
12:14:02
PLOT NO. 1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SX (AVG)
TOP
RSYS=0
DMX =0.006083
SMN =-8433
SMX =9070
U

F
NFOR
NMOM
RFOR
RMOM
ACEL

-8433
-6488
-4543
-2598
-653.465
1291
3236
5181
7126
9070

triangu r bracket



ANSYS 5.0 A
APR 7 1995
13:56:48
PLOT NO. 2
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SINT (AVG)
TOP
DMX =0.006083
SMN =1866
SMX =10289
U

F
NFOR
NMOM
RFOR
RMOM
ACEL

1866
2802
3738
4674
5610
6545
7481
8417
9353
10289

```
c****** File     : bracket
c****** Analysis: bracket

/prep7
/tit,triangular_bracket

acel,0,-1,0          ****** y acel (g): F=ma, F=lbf &  m=lb => a=1!

c****** constants
E=29e6                 ****** Steel: E=29000ksi
n=0.3                  ****** Steel: nu=0.3
t=1/2                  ****** thickness
d=0.283                ****** 0.284 lb/cuin
a=3.375                ****** height
b=6.75                 ****** length
c=0.25                 ****** lip
d=0.25                 ****** corner clearence
l1=3700                ****** load 1
l2=3700                ****** load 2

c****** Element
et,1,63
mp,ex,1,E
mp,nuxy,1,nu
mp,dens,1,d
r,1,t

c****** X-Y Keypoints
k,1,0,0,0
k,2,b,(a-c),0
k,3,b,a,0
k,4,d,a,0
k,5,0,(a-d),0
a,1,2,5
a,2,3,4,5

c****** Size of elements
esize,(b*0.05)

c****** Area to mesh
type,1
mat,1
real,1
amesh,all

c****** Constrains
nsel,s,loc,x,0
d,all,all,0

c****** Loading
nsel,s,loc,y,a
f,all,fy,-(l1/21)
c****** nsel,r,loc,x,(b/2)
f,all,fx,-(l2/21)

c****** Select all
allsel,all

c****** Save model files
save
```

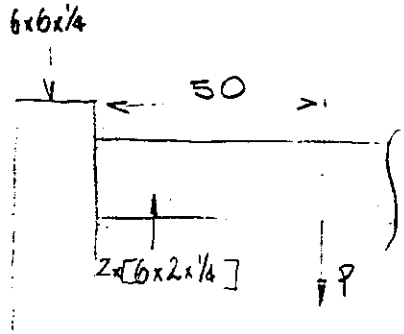
WELDS

THE WELDS WILL BE FILLET, ALL ARROUND. ACTUALLY, MOST VERTICAL WELDS ARE PARTIAL PENETRATION GROOVE WELDS. IF JOINT 1 TO 10 IS OK, ALL OTHER WELDS ON TUBES ARE OK

JOINT 1 TO 10 (DESIGN ACCORDING TO MSD EN-1.1.9.a)

Ø) ALLOWABLE STRESSES: $0.3 F_u = 0.3 \times 58 = 17.4$ ksi
BASE METAL SHEAR = 18.4 ksi (SEE MEMBER 1)

SO $F_w = 17.4$ ksi



ASSUMING:

- LOAD EVENLY DISTRIBUTED BETWEEN 2 TUBES
- RIGIDLY CONNECTED (FULL MOMENT CONNECTION)

1) SHEAR

$$F_s = \frac{3{,}700}{2.2} = 925 \text{ lb}$$

2 TUBES, 2 SIDES

2) BENDING

$$M = \frac{(Pl/8)}{2} = \frac{(3{,}700)(100)}{2.8} \Rightarrow M = 23{,}125 \text{ lb-in.}$$

3) PROPERTIES

WELD LENGTH: 15.15

INERCIA MOMENT 63.88 in⁴/in ; c = 3" (c.G.)

4) STRESSES

TRYING 1/8" (MINIMUM RECOMMENDED SIZE FOR 1/4" THICK PLATE)

SO: THROAT = 0.088"

$A = (15.15)(0.088) = 1.339 \text{ in}^2 \Rightarrow f_v = (0.925)/1.339 = 0.69$ ksi

$I_x = 63.88 \times (0.088) = 5.65 \text{ in}^4 \Rightarrow f_b = (23.125) \cdot 3/5.65 = 12.29$ ksi

$R = \sqrt{f_v^2 + f_b^2} \Rightarrow R = 12.31$ ksi < 17.4 ksi $\Rightarrow$ OK

SO: 1/8" FILLET WELD IS OK.

LEAD BLOCK BRACKET WELDS

Ø) ALLOWABLE STRESSES: $0.3F_u = 0.3(58) = 17.4$ ksi
$0.4F_y = 0.4(36) = 14.4$ ksi

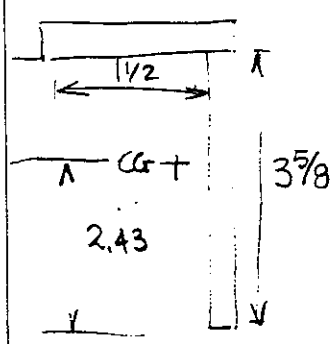
SO $F_W = 14.4$ ksi

1) SHEAR

$F_S = \frac{3700}{2} = 1{,}850$ lb.

2) BENDING

$M = \frac{(P\ell/8)}{2} = \frac{(3{,}700 \times 4'/8)}{2} \Rightarrow M = 925$ lb-in.



3) PROPERTIES:

WELD LENGTH = 10 1/4"

INERTIA MOMENT : 2.172 in⁴/in

$c = 2.43$"

4) STRESSES:

TRYING 3/16" (MINIMUM RECOMMENDED FOR 1/2")

THROAT = 0.354"

$A = (10.25)(0.354) = 3.661 \text{ in}^2 \Rightarrow f_v = 0.5$ ksi

$I_x = (0.354)(2.172) = 0.769 \text{ in}^4 \Rightarrow f_b = 2.9$ ksi

$R = \sqrt{f_v^2 + f_b^2} \Rightarrow R = 3.0$ ksi < 14.4 ksi $\Rightarrow$ OK

SO 3/16 FILLET WELD IS OK.

ANCHOR BOLTS

HILTI. HSL-R M8/20 → Concrete strenght: 2000 psi ⇒

ALLOWABLE LOADS: { Tension : 1,280 lb
Shear : 1,920 lb

MAXIMUM TOTAL SHEAR: 655 lb ⇒ OK

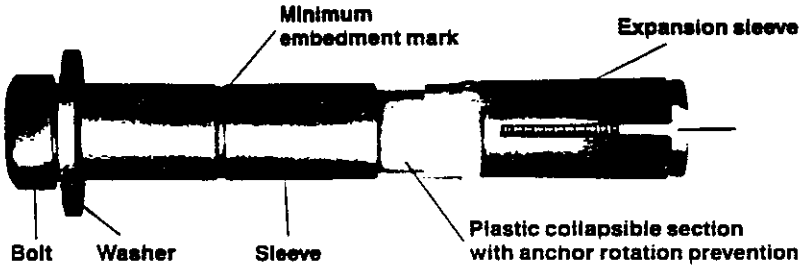
NUMBER OF ANCHOR BOLTS: 10.

HSL Metric Heavy-Duty Expansion Anchor

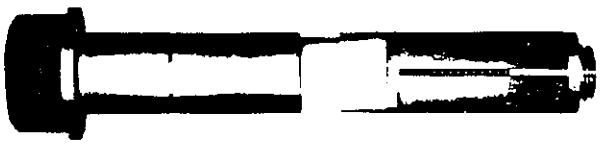
Reliable heavy-duty anchor for heavy/dynamic loads

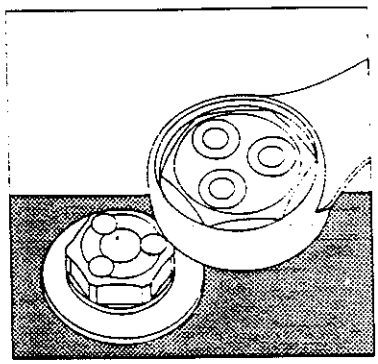
Product Details

Hilti HSL Heavy-Duty Anchor



Hilti HSLB Heavy-Duty Anchor with Torque Cap

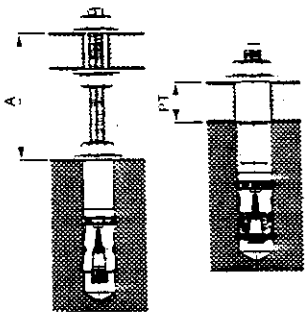




Red setting indicator

Three accurately sized shear pins are provided in the red indicator cap. On applying the required tightening torque with an ordinary wrench, the red indicator cap shears off. The green seal on the bolt head which appears indicates that the anchor has been tightened properly.

Hilti HSLG Heavy-Duty Anchor with Threaded Rod



The thickness fastened, PT, and the stand-off, A, can be varied. (Extra-long versions are available through specials.)

Advantages

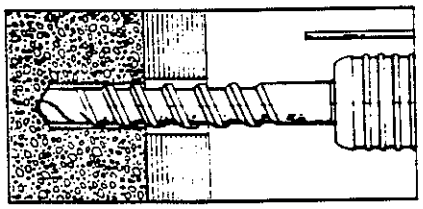
- High Loading Capacity
- Force Controlled Expansion
- Reliable Pull-Down of Part Fastened
- Suitable for Dynamic Loading
- Suitable for Tension Zone
- No Rotation When Tightening Bolt or Nut

Bolt/Rod Material

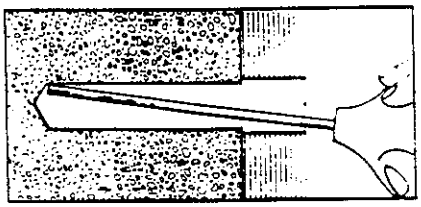
HSL-R/HSLG-R:	Stainless Steel Type 316	HSLB/HSL/HSLG:	Steel to min. UTS of 116 ksi
	UTS min. of 101.5 ksi		Yield of 92.8 ksi
	Yield of 65.25 ksi		Zinc plated to min. 5 μm

HSL Metric Heavy-Duty Expansion Anchor continued

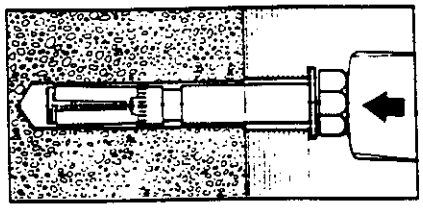
HSL Metric Installation Instructions



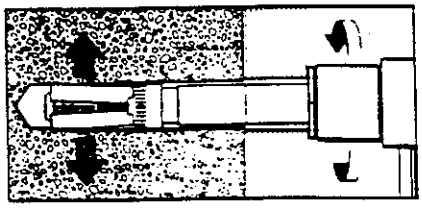
1. Drill a hole with the prescribed Hilti metric bit. Note: the HSL can be installed in a bottomless hole.



2. Clean the hole using a blow-out bulb or compressed air.



3. Using a hammer, tap the preassembled anchor through the object being anchored into the hole. The anchor should be seated firmly against the base plate. Note: do not expand the anchor by hand before tapping it into the hole.



4. Tighten bolt or nut to the specified torque, using a torque wrench.

Note: When using an HSLB anchor no torque wrench is required. The torque cap shears off at the specified torque value.

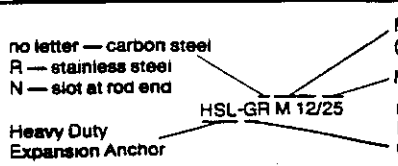
HSL Metric-Ultimate Loads

Anchor Diameter	Embedment Depth (mm)	Ultimate Loads (lbs.)									
		Concrete Strength (psi)									
		2000		3000		4000		5000		6000	
		Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear
M 8	65	4460	6700	5165	7520	5870	8345	6545	8610	7220	8880
M 10	75	6070	11745	7285	12480	8500	13220	9700	13960	10900	14700
M 12	80	7880	16245	9560	17570	11240	18900	12920	20390	14600	21875
M 16	105	14700	28135	17450	30890	20205	33640	22960	36390	25710	39140
M 20	130	20600	33000	23050	39010	25500	45020	27975	48110	30450	51195
M 24	155	23500	48000	28945	55310	34390	62615	39835	68790	45280	74965

HSL Metric-Allowable Working Loads

Anchor Diameter	Embedment Depth (mm)	Allowable Loads (lbs.)									
		Concrete Strength (psi)									
		2000		3000		4000		5000		6000	
		Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear
M 8	65	1280	1920	1480	2155	1680	2390	1875	2470	2070	2545
M 10	75	1740	3365	2090	3580	2435	3790	2780	4000	3125	4215
M 12	80	2260	4655	2740	5040	3220	5420	3700	5845	4185	6270
M 16	105	4215	8065	5000	8855	5790	9645	6580	10430	7370	11220
M 20	130	5905	9460	6610	11180	7310	12905	8020	13790	8730	14675
M 24	155	6735	13760	8300	15855	9860	17950	11420	19720	12980	21490

Note: Definition of nomenclature —



Example: HSL-GR M 12/25
This is a stud HSL anchor. The anchor material is type 316 Stainless Steel. The thread size is 12 mm and this anchor can attach up to a 25 mm thick plate.

	Fermilab **Research Division** **Mechanical Support Department**	Engineering Note # MSD EN -1.1.1.9.a Date: March/29/1995

Title	S.M.A.W. - Fillet Weld Sizing Criterion

Author(s)	Rafael Silva, Ang Lee and Don Mitchell
Reviewer	Zhijing Tang
Key Words	Fillet, Weld
Abstract/ Summary	Conservative criterion for sizing shielded metal arc fillet welds.

1. This is a conservative criterion for structural shielded metal arc fillet welds: if the resulting analysis is too conservative, or if different sizes are required for any other reason, you may consult the proper codes and/or use F.E.A. Welds are sized conservatively and according to AISC/ASD, 9th ed. It should only be applied in conjunction with sound engineering analysis and judgment. It should not be used for pressure vessels, lifting devices, or anything else not covered by the AISC code.

2. The allowable stress is the smallest of:

- 0.3 Fu of base metal (see Comm. J, J2.4, p. 5-164 and 5-165);
- 0.4 Fy of base metal, if $h/tw \leq 380/\sqrt{Fy}$, otherwise see F4, p. 5-49 for allowable shear stress.

3. Limitations:

T	m	M
$T \leq 1/4$	1/8	t
$1/4 < T \leq 1/2$	3/16	t - 1/16
$1/2 < T \leq 3/4$	1/4	t - 1/16
$3/4 < T$	5/16	t - 1/16

Where:

T = Material thickness of thicker part joined (in)
t = Material thickness of thinner part joined (in)
m = Minimum leg size of single-pass fillet weld (in)
M = Maximum leg size of single-pass fillet weld (in)

4. Pick a fillet weld size (in 1/16" increments) and select the proper length.

5. The effective length is taken from the shorter edge of the fillet weld.

6. The throat is the leg size times 0.707.

7. The effective area (except in holes and slots) is the throat times the effective length.

8. Check the strength of the fillet weld. The resultant stress R from the combination of shear (Rsx, Rsy), tension (Rtx, Rty), and the components derived from eccentric loads, has to be smaller than the allowable stress calculated in item **2** above.

9. If eccentric loads are present, use the vector analysis (see "Alternative Method 1 - Elastic", p. 4-72).

- Calculate the inertia moments per width of the weld (in^4/in) as if the center lines of the welds were relying on their inner edges. Then multiply by the throat (in) to obtain the inertia moment (in^4).

- When the load is in the same plane of the weld group, calculate the moment M, determine the centroid x_{cg}, y_{cg}, and the polar moment of inertia of the fillet weld in relation to its centroid Ip. Then:

  $Rmx = (M.x_{cg}) / Ip \quad \& \quad Rmy = (M.y_{cg}) / Ip$

  $$R = \sqrt{(Rmx + Rtx + Rsx)^2 + (Rmy + Rty + Rsy)^2}$$

- When the load is not in the same plane of the weld group, calculate the moments (Mx, My, Mz), determine the centroid (x_{cg}, y_{cg}, z_{cg}), and the moments of inertia of the fillet weld in relation to its centroid (Ix, Iy, Iz). Then:

  $Rmx = (Mx.x_{cg}) / Ix, \quad Rmy = (My.y_{cg}) / Iy \quad \& \quad Rmy = (Mz.z_{cg}) / Iz$

  $$R = \sqrt{(Rmx + Rtx + Rsx)^2 + (Rmy + Rty + Rsy)^2 + (Rmz + Rtz + Rsz)^2}$$

Fermilab

To : Joel Misek Chair, KTeV Mechanical Safety Committee

From: Ron Currier

Subj: KTeV Vacuum Window Safety Shield (VWSS)

Joel,

This note is a follow up to our phone conversation of 2-3-93. A few words of explanation first. The (VWSS) is a large plate which is positioned over the 1.8m thin vacuum window when personnel are in the enclosure. It is intended that the (VWSS) prevent accidental rupturing of the window and slow down the rush of air if the window were to rupture.

We are trying to understand the operational requirements of the (VWSS) and turn to your committee for guidance. We have an existing large volume vacuum system and 1.2m thin window, which has a (VWSS) as part of E-799 which operated in m-center. This (VWSS) is being handled procedurally where the first person entering the enclosure would manually position the shield over the window. An alternative plan would have the (VWSS) become part of the interlock system, where if a key were removed from the keytree, the shield would automatically cover the window.

The operational requirements will determine, to a large extent, the parameters and how this equipment is designed.Would you consider reviewing this very important question?

Thanks,
Ron

cc: D.Jensen
R.Ford
T.J.Sarlina
D.Pushka
A.Stefanik