MECHANICAL SUPPORT DEPARTMENT
ENGINEERING NOTE

NUMBER: MSD EN-5.0

DATE: 26 May 1995

TITLE: KTEV 1.8 meter Vacuum Window Testing Procedure for vacuum and hydrostatic tests and test results

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REVIEWED BY: KTEV Mechanical Safety Review Panel, Joel Misek, Chairman

DATE REVIEWED: March 21, 1994

KEY WORDS: KTEV Vacuum Window structural components, Stress Analysis Vacuum test, Hydraulic test

ABSTRACT/SUMMARY:

This documentation contains an enginering analysis for some of the structural elements used during the testing. It also shows results of the vacuum, hydrostatic and impact tests. Three out of the four hydrostatic tests yielded an effective safety factor of 2 for the tested window assembly.

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KTeV 1.8 m VACUUM WINDOW

PART A

1.8 m VACUUM WINDOW TESTING PROCEDURE FOR VACUUM AND HYDROSTATIC TESTS

ANDREW SZYMULANSKI
RD / MSD
MARCH 8.94

JB

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KTEV
E-832

1.8 m VACUUM WINDOW TESTING PROCEDURE FOR VACUUM AND HYDROSTATIC TESTS.

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9220.832.MD-285394

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KTEV- 1.8m VACUUM WINDOW BOLT PATTERN
SKETCH 2

KTEV- 1.8m VACUUM WINDOW
RIGGING ARRANGEMENT
FOR AN AIR BLEEDING OPERATION

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12. MATERIAL SAFETY DATA SHEETS:

a) KEVLAR

b) MYLAR

4B

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March 8,1994

KTeV 1.8m Vacuum Window
Overview of Test Procedure

This test is required to provide a suitable, safe, non metallic vacuum window for the KTeV experiment, which is running during the next fixed target run. To determine if the design of this window meets all of the parameters of the experiment and the KTeV ES&H Review Committee,the following set of tests were devised. The first test, initial pump down, proves that the window design works. The puncture test will give us an idea how the window will fail, if a hole were to develop (material failure), or was accidentally penetrated. The initial pump down and puncture test will require a single pressure test permit. The hydrostatic test is intended to give us an idea of the safety factor of the window and will require a separate pressure test permit. The long duration creep test will give us information on how the window survives or fails over a long period of time. If there are <u>any</u> deviations from expected results during any test, the tests will be stopped until the deviation can be understood then explained in writing to the KTeV ES&H Review Committee, exactly what happened, why, and how it will affect the rest of the test program. Interesting phases of the test should be put on video tape.Present at the beginning of each phase of the tests should be a representative of the ES&H Dept , the KTeV experiment, the KTeV ES&H Review Committee, Don Carpenter and Andrew Szymulanski.

Safety considerations:

A) During the vacuum test, no one will be allowed within 10 feet of the test vessel. This is to be assured by roping off the test area, appropriate signs, (keep-out test in progress), and supervisory vigilance.

B) Safety glasses and safety shoes are requirements of anyone working at MAB. Test observers will be required to wear safety glasses at all times.

C) Hearing protection will be required of all personnel in the building during the initial pump down, subsequent pump downs and during the puncture test only.

1) Make a kevlar and aluminized mylar, sandwiched window, and assemble with flanges etc. as specified on Dwg.# MD-285394 and attached information. Inform Andrew when starting, so the KTeV ES&H Review Committee and the experiment can be notified.

2) Set up for vacuum test as shown on Dwg.#MD-285391 and schematic attached. Arrange for surveyors.

2a) Prepare for pump down by clearing the test area and setting up as specified in A) above.Check for eye and hearing protection and display pressure test permit.

2b) Pump down test chamber to a minimum of 29" Mercury(Hg) and remotely measure and record the deflection of the window every 2 hours.The remote measuring is to be accomplished by using optical surveying instruments looking at the scale mounted in the center of the thin window as shown on page 7B. Shut down overnight and bleed up to atmosphere. Pump down again in the AM recording the deflection every 2 hours. Shut down overnight and bleed up to atmosphere. Pump down again in the AM to 29" Hg then shut down and bleed up to atmosphere.

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3) Using the same window, prepare for puncture test. Follow the design data of sketch 1'.

3a) Prepare for pump down and puncture test by clearing the test area and setting up as specified in A) above.Check for eye and hearing protection and display pressure test permit.

3b) Set up puncture device as shown on attached sketch, start pumping down test chamber. At 29" of Hg.

3c) After double checking all of the appropriate safety precautions, remotely release spear to puncture window.

4) Assuming the first window worked, make a second window and proceed to Hydraulic test. Notify surveyors.

5) Set up for hydrostatic test inside the MAB shop per schematic attached. Assemble test chamber and place 2 legs on a 4 x 4 to elevate bleed valve (as shown on attached sketch).Make sure to display pressure test permit.

5a) Fill test chamber with water (make sure bleed valve is open.) After filled, lift chamber with crane using appropriate slings and rigging techniques. Remove 4 x 4s from under legs.(as shown on attached sketch)

5b) Prepare for hydrostatic test by clearing the test area and setting up as specified in A) above.Check for eye protection.

5c) Pressurize test chamber, as shown in subsection 3, using a hydrostatic tester pump, to 15psig then carefully measure the window deflection. Continue to add pressure and remotely measure deflection at 5psig increments, to destruction of window or 45psig whichever comes first. (failure expected at 31psig to 38psig)

5d) Clean up mess, then disassemble window flanges and check window, o-ring, and aluminum ring for irregularities.

6) Using information learned from the fabrication of the first windows, make another window for the long duration, 6 month, creep test.

6a) Find an area in the shop, out of the normal traffic pattern, away from people and well protected from casual contact to set up the test chamber and new window.

6b) Prepare for pump down and long duration creep test by clearing the test area and setting up as specified in A) above.

6c) For the duration of the test, maintain the area to the same degree of security and safety as originally set up.

6d) Test chamber and window are to be under vacuum, with vacuum pump running, 24 hours a day 7 days a week.

6e) Bleed up to atmosphere once per month, over the weekend only.

6f) Record the pressure level in a log at the start and the finish of each working day for the duration of the test. It's not <u>necessary</u> to use a strip chart recorder.

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6g) It is possible that the window will creep,or move, or maybe even stretch, over a period of time. The result would be an increase in deflection. If the measured deflection is ever greater than the original by 1/4" notify Andrew.

6h) Remotely measure and record the deflection of the window each day for the first week.

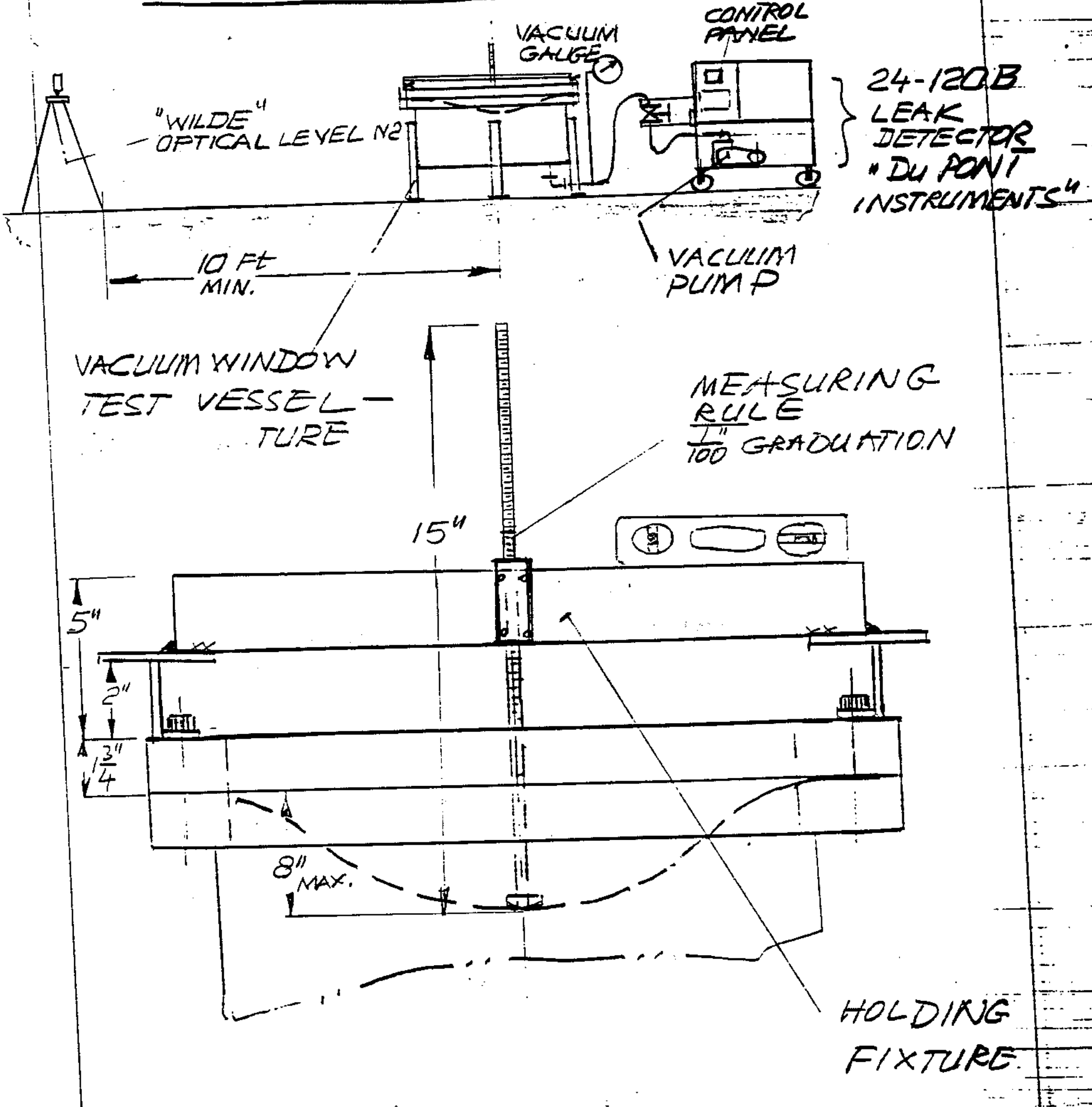
6j) If a measurable change is not indicated during the first week then measure and record the deflection of the window at the end of the first and last day of the second week.

6k) If a measurable change is not indicated at the end of the second week then measure and record the deflection of the window at the end of first day of each week for the duration of the test.

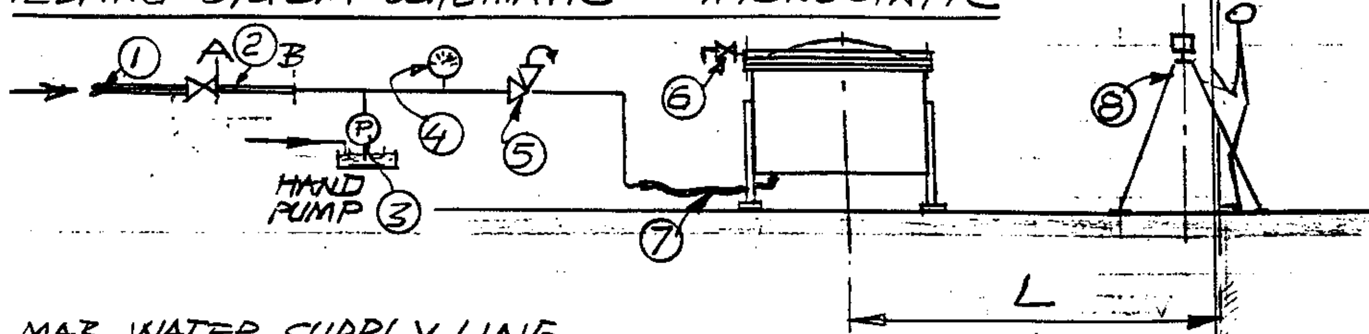
6m) The duration of the test is expected to be 6 months.

6n) If any peculiarities or problems are encountered, call Andrew @ x4870.

2. TESTING SYSTEM SCHEMATIC - VACUUM



3. TESTING SYSTEM SCHEMATIC – HYDROSTATIC



1. MAB. WATER SUPPLY LINE
   MAX. PRESSURE 65 [psi]
2. WATER FLOW CAPACITY CONTROL
   SECTION "A – B" $\frac{1}{8}$" SCH 40 PIPE
   INSIDE DIA : 0.269"
3. HAND PUMP
4. PRESSURE GAUGE
   "WEISS" 0 TO 100 psi
5. RELIEF VALVE (WATER)
   SET PRESSURE 40 psiG
   CAPACITY 18 GAL/min
   @ 10% OVERPRESSURE
   TELEDYNE-FARRIS TYPE 1850, 1"/1$\frac{1}{2}$"
6. BLEED VALVE
7. FLEXIBLE HOSE
   $\frac{1}{4}$", 400 psi RATING
8. WILDE OPTICAL
   LEVEL N2

DIMENSION "L" HAS TO BE LARGER OR EQUAL 10 Ft FOR VACUUM TEST BUT MAY BE CLOSER THAN 10 FOR HYDROSTATIC TEST.

- DETERMINE THE FLOW RATE IN $\frac{1}{8}$" PIPE, SECTION "A–B" (ITEM 2).

GIVEN DATA: MAX. PRESSURE IN THE M.A.B. SUPPLY LINE = 65 [psiG]

INSIDE DIA OF THE "A-B" SECTION
$d = 0.269"$

ASSUMED NO FRICTION IN THE PIPE.

$p = 65 psi = 150$ Ft of H_2O
FROM BERNOULIS EQUATION:

$$\frac{v^2}{2g} = 150$$

v – WATER VELOCITY IN THE PIPE
g – GRAVITY ACCELERATION

$v = \sqrt{150(2)\,32.2}$
$v = 98.28$ Ft/sec

FLOW CAPACITY:
$Q = A \cdot v$
$A = \frac{\pi d^2}{4} = 0.00039 \left[Ft^2\right]$
$Q = 0.0383 \left[\frac{Ft^3}{sec}\right] = 17.2$ GPM

4. PRESSURE TESTING PERMIT – OUTLINE FOR VACUUM TEST

Fermilab

Date__________

EXHIBIT B

Pressure Testing Permit* – OUTLINE

Type of Test: VACUUM ~~[ ] Hydrostatic~~ ~~[ ] Pneumatic~~

Test Pressure: 14.7 psig NEGATIVE Maximum Allowable Working Pressure: 45 psig

Items to be Tested

1.8 m KTEV VACUUM WINDOW

REF. DWG. 9220.832. MD-285394

Location of Test M.A.B. Date and Time ~

Hazards Involved RUPTURE OF THE WINDOW COMPONENTS, WHAT MAY GENERATE ABNORMAL SOUND LEVEL. OTHER HAZARDS RELATE TO TYPICAL INDUSTRIAL INSTALLATION

Safety Precautions Taken

SEE SUBSECTION 1 OF THIS ELABORATION

Special Conditions or Requirements TESTING PROCEDURE HAS TO BE CONSISTENT WITH: " KTEV 1.8m VACUUM WINDOW OVERVIEW OF TEST PROCED

Test Coordinator ANDREW SZYMULANSKI Dept/Date __________

Division/Section Safety Officer __________ Dept/Date __________

Division/Section Head __________ Dept/Date __________

Results __________

Witness __________ Dept/Date __________
(Safety Officer or Designee)

WI
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* Must be signed by division/section safety officer and division/section head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

5. PRESSURE TESTING PERMIT – OUTLINE FOR HYDROSTATIC TEST 12. 10B

Fermilab

Date ____________

EXHIBIT B

Pressure Testing Permit* — OUTLINE

Type of Test: [✓] Hydrostatic [ ] Pneumatic

Test Pressure: 45 psig Maximum Allowable Working Pressure: 45 psig

Items to be Tested 1.8m VACUUM WINDOW REF. DWG. 9220.832.MD-285394

Location of Test M.A.B. Date and Time ~

Hazards Involved FAILURE OF THE TESTED COMPONENTS; FLYING DEBRIS

Safety Precautions Taken SEE SUBSECTION 1 OF THIS ELABORATION

Special Conditions or Requirements TESTING PROCEDURE HAS TO BE CONSISTENT WITH: "KTEV 1.8m VACUUM WINDOW OVERVIEW OF TEST PROCEDURE"

Test Coordinator ANDREW SZYMULANSKI Dept/Date ____________

Division/Section Safety Officer ____________ Dept/Date ____________

Division/Section Head ____________ Dept/Date ____________

Results ____________

Witness ____________ Dept/Date ____________
(Safety Officer or Designee)

WILL BE FILLED OUT AT THE TESTING DATE

* Must be signed by division/section safety officer and division/section head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

FERMILAB **ENGINEERING NOTE**

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SUBJECT	NAME
1.8 m VACUUM WINDOW — WINDOW ASSEMBLY HOLDING FIXTURE (SPREADER BEAM CAPACITY ANALYSIS)	ANDREW SZYMULANSKI
	DATE: NOV. 23, 93 — REVISION DATE: —
	CHECKED BY: [signature] 12/22/93

6.

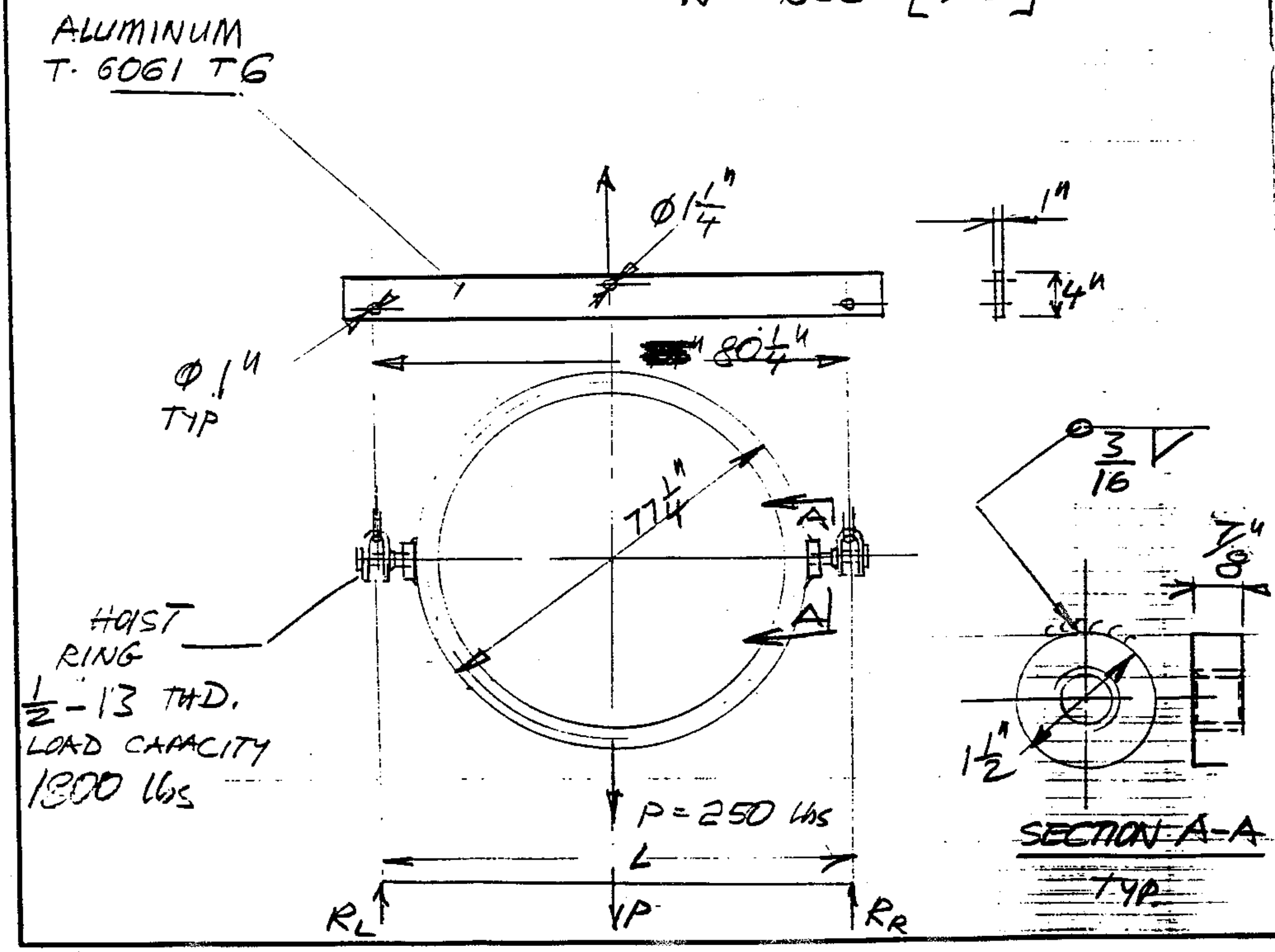
THE FOLLOWING COMPRISE DESIGN CRITERIA AND STRENGTH ANALYSIS FOR ALUMINUM SPREADED BEAM, WHICH WILL BE USED DURING ASSEMBLY PROCESS OF THE 1.8m VACUUM WINDOW.

GIVEN DATA :

a) 1.8m VACUUM WINDOW TEST FIXTURE
1.8m WINDOW ASSEMBLY
DWG. 9220.832.MD-285394 REV.A

b) WEIGHT OF THE WINDOW ASSEMBLY

$$W = 600 \ [lbs]$$



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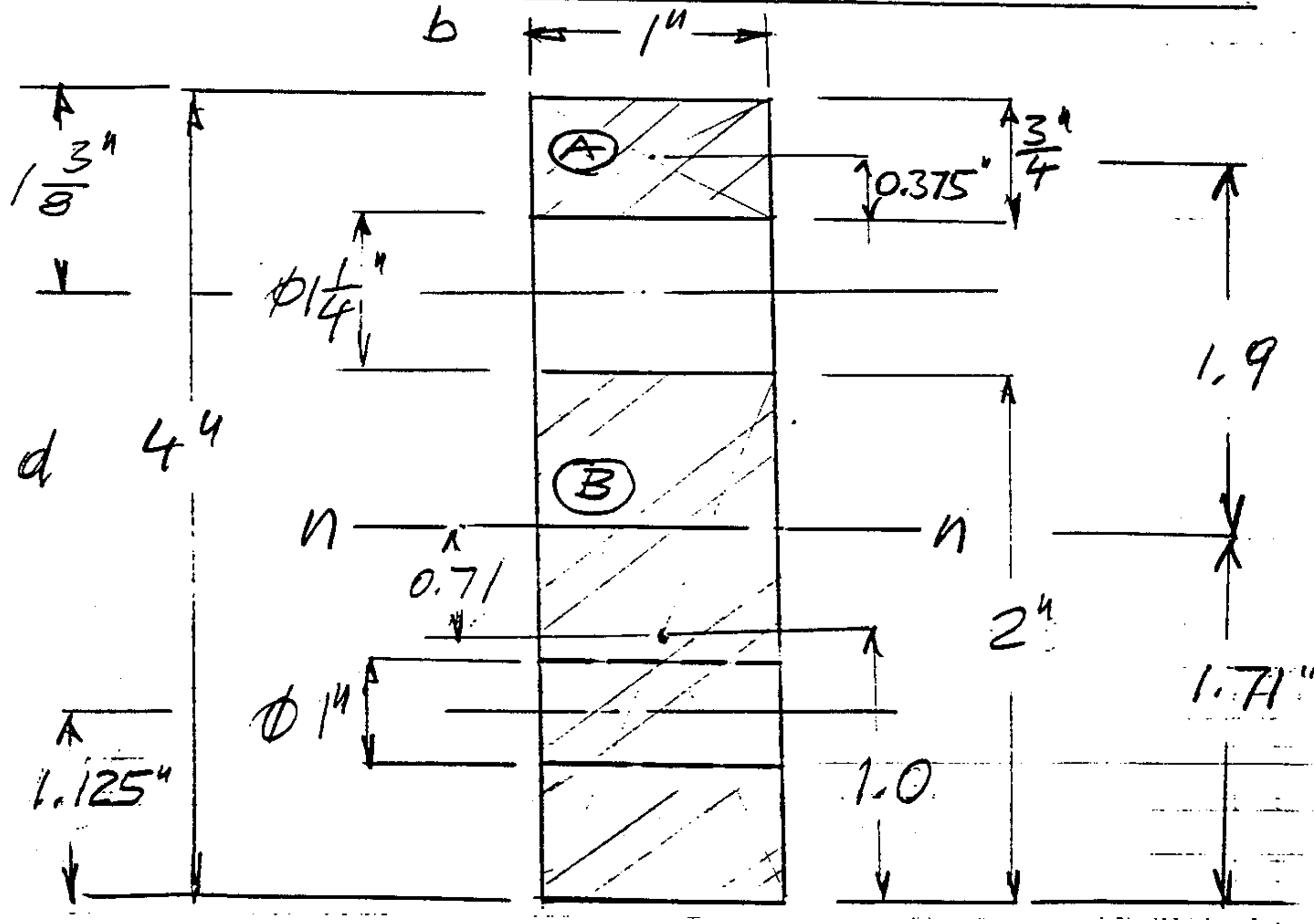
MAX $M = \frac{1}{4} PL = \frac{1}{4}(600.)79$

$M_{max} = \underline{11850}$ [lbin]

IT IS INTENDED TO USE READY AVAILABLE ALUMINUM FLAT 4" x 1" CROSS SECTION. BASEING ON THE 1" THICKNES 1¼ AND 1" HOLES WILL BE USED ACCORDINGLY, FOR SHACLES.

CROSS SECTION OF THE BEAM AND OPNGS. LOCATION



DETERMINE THE MOMENT OF INERTIA OF THE CROSS SECTION AT THE CENTER OF THE BEAM.

FIGURE	SIZE	DISTANCE y	$A = b \cdot d$	$M = Ay$	$\bar{I}_y = My$	$I_g = \frac{bd^3}{12}$
A	1 × 0.75	3,625	0.75	2.71	9.85	0.035
B	1 × 2	1	2	2	2	0,66
TOTAL			2,75	4,71	11.85	0.69

$$n = \frac{\sum M}{\sum A} = \frac{4.71}{2.75} = \underline{1,71}$$

$$I_n = I_y + I_g - \frac{M^2}{A}$$

$$I_n = 11,85 + 0,69 - \frac{(4,71)^2}{2.75}$$

$$I_n = 11.85 + 0,69 - 8.06$$

$$I_n = 4,47 \; [in^4]$$

SECTION MODULUS

$$S_M = \frac{4,47}{2,29} = \underline{1,95} \; [in^3]$$

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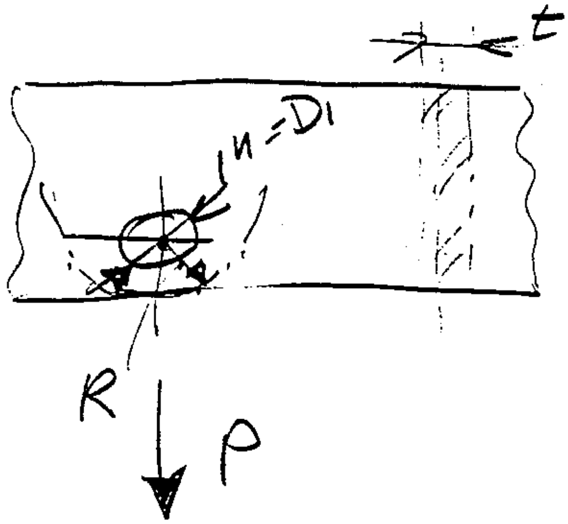
CHECKING THE STRESS IN THE BOTTOM PART OF THE BEAM



$D_1 = 1"$

$R = 1.125"$

$t = 1"$

$S = \frac{42000}{4}$

$S = 10,500$ [psi]

$$P = t\left[2S\left(R - \frac{D_1}{2}\right)\right]$$ REF. [1]

$$P = 1\left[2(10500)\left(1.125 - \frac{1}{2}\right)\right]$$

$$P = \underline{13,125} \text{ [lbs]}$$

UPPER PART OF THE BEAM

$D_1 = 1.25"$

$R = 1.375"$

$t = 1$

$S = 10500$

$$P = 1\left[2(10500)\left(1.375 - \frac{1.25}{2}\right)\right]$$

$$P = \underline{15,750} \text{ [lbs]}$$

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FIND THE CORRESPONDING MAX. LOAD AT THE CTR. OF THE BEAM

$$\tilde{\sigma} = \frac{M}{S_m}$$

$$10500 = \frac{\frac{PL}{4}}{1,95}$$

$$4(1.95)\,10500 = P \cdot L$$

$$P = \frac{81900}{79}$$

$$P = 1036 \quad [lbs]$$

SELECTED CAPACITY OF THE BEAM :

600 [lbs]

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LOAD CAPACITY 600 lbs

PRESSURE VESSEL HANDBOOK
BY: E. F MEGYESSY

LIFTING ATTACHMENTS (cont.)

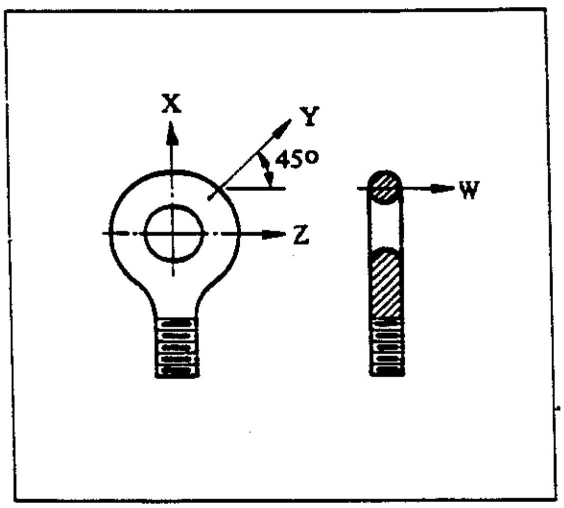
RECOMMENDED MATERIAL: A 515-70, A 302 or equivalent. The thickness and length of the lifting lug shall be determined by calculation.*

WELD: When fillet welds are used, it is recommended that throat areas be at least 50 per cent greater than the cross sectional area of the lug.

To design the lugs the entire load should be assumed to act on one lug.

All possible directions of loading should be considered (during shipment, storage, erection, handling.) When two or more lugs are used for multileg sling, the angle between each leg of the sling and the horizontal should be assumed to be 30 degrees.

EYE - BOLT



Threaded fasteners smaller than 5/8" diameter should not be used for lifting because of the danger of overtorquing during assembly.

Commercial eyebolts are supplied with a rated breaking strength in the X direction.

For loadings other than along the axis of the eyebolt, the following ratings are recommended. These are expressed as percentage of the rating in the axial direction.

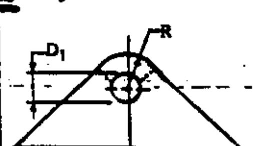
X = 100% Y = 33%
Z = 20% W = 10%

EXAMPLE:

An eyebolt of 1 in. diameter which is good for 4960 lb. load in tension (direction x) can carry only 4960 x 0.33 = 1637 lb. load if it acts in direction y.

The above dimensions and recommendations are taken from C. V. Moore: Designing Lifting Attachments, Machine Design, March 18, 1963.

REF. *Assuming shear load only thru the minimum section, the required thickness may be calculated by the formula:



$$t = \frac{P}{2S\,(R - D_1/2)}$$

where t = required thickness of lug, in.
P = load, lbs.
S = allowable shear stress, psi.

See page 440 for design of weld and length of lug.

SPREADER BAR

I.D. No 62 COLOR OF BAR: ALUMINUM

LOAD CAPACITY PAINTED ON BAR 600 ~~TONS.~~ [lbs]

DATE CAP. & I.D. No PAINTED ON BAR DEC. 23. 93

DATE OF LAST LOAD TEST. DEC. 23. 93

TEST LOAD WEIGHT 750 [~~TONS~~] lbs

TEST LOAD % 125

STRESS CALCULATIONS:

DONE BY ANDREW SZYMULANSKI

DATE DEC. 23. 93

REMARKS: ENG. NOTE No 62

DWG. NO. PAGE 5 (11A)

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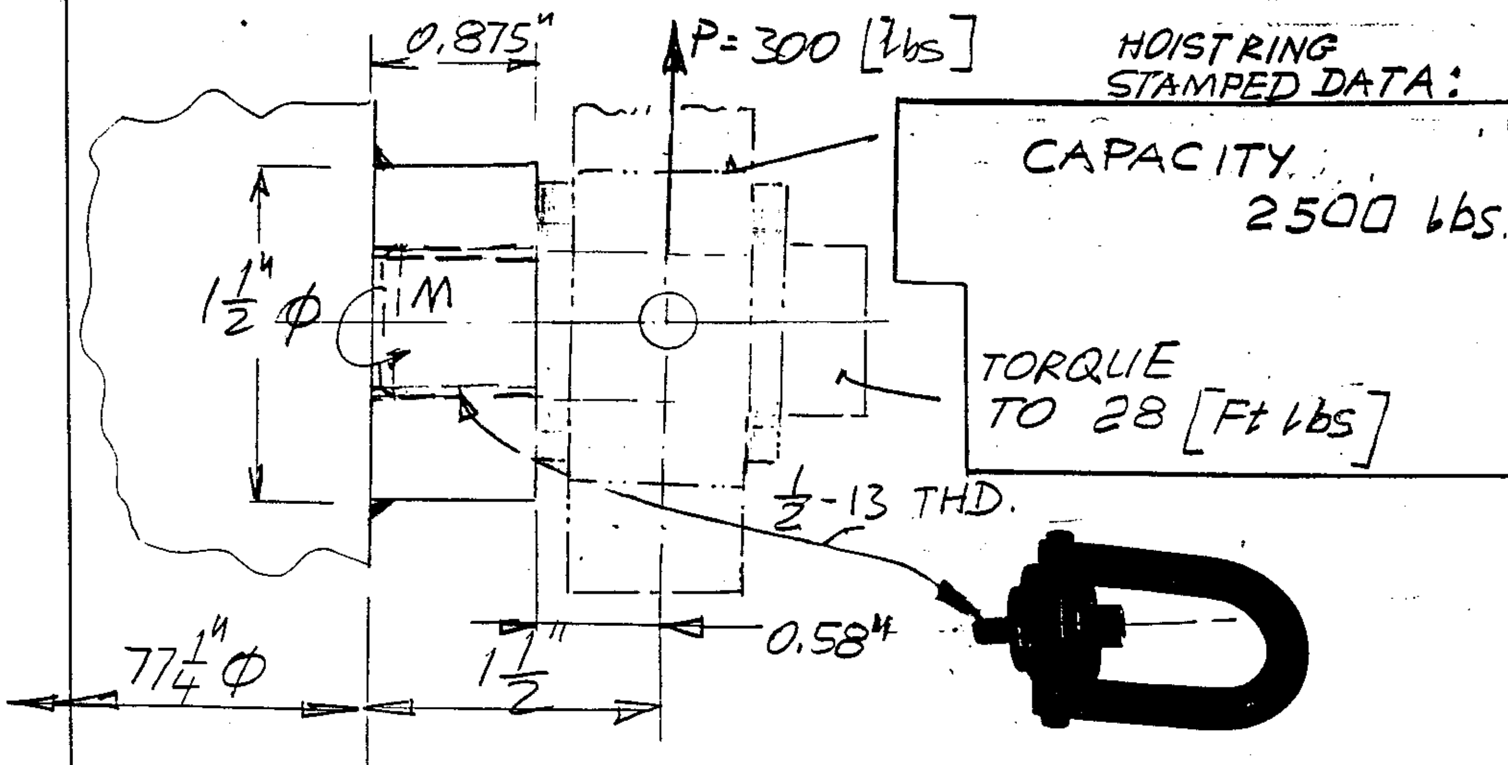
7. DETERMINING THE BENDING STRESS IN THE FASTENERS OF A HOIST RINGS AND STRESS IN THE WELDS THAT ATTACH THE THREADED BOSS TO THE FLANGE.



BENDING MOMENT: $M = P \times (1.5) = 450$ [lb in]

MOMENT OF INERTIA OF THE THREADED BOSS.

$$I = \frac{\pi}{64}\left(D^4 - d^4\right)$$

$$I = \frac{\pi}{64}\left(1.5^4 - 0.5^4\right)$$

$$I = 0.245 \; [in^4]$$

BENDING STRESS IN THE BOSS

$$\sigma = \frac{M \cdot C}{I} = \frac{450\,(0.75)}{0.245}$$

$$\sigma = 1377.5 \; [psi]$$

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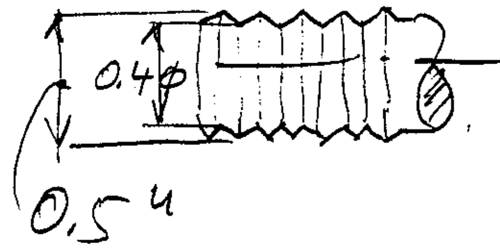
MOMENT OF INERTIA OF THE THREADED FASTENER (HOIST RING)

$$I = \frac{\pi d^4}{64} = \frac{\pi (0.4)^4}{64}$$



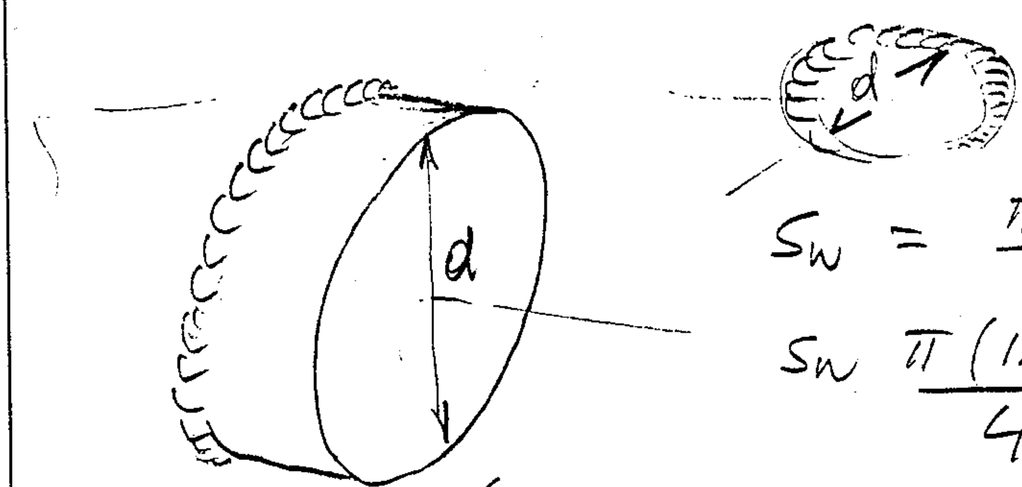
$$I = 0.00125 \, [in^4]$$

BENDING STRESS IN THE FASTENER

$$\sigma = \frac{M_1 \cdot C}{I} = \frac{(0.58 \times 300)(0.2)}{0.00125} = 27{,}840^{*} \, [psi]$$

* THIS IS A ROUGH CHECK TO VERIFY MANUFACTURER RATING DATA OF THE HOIST RING.

FIND PROPERTIES OF WELD, TREATING IT AS A LINE



$$S_W = \frac{\pi d^2}{4} \quad [REF.$$

$$S_W \; \frac{\pi (1.5)^2}{4} = 1.76 \; [$$

(SEE ATTACHED REFERENCE INFORMATIO ON FOLLOWING PAGES; 21B, 22B, 23B.

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$$A_W = \pi d = \pi(1.5) = 4.71 \; [in]$$

BENDING FORCE ON WELD:

$$f_b = \frac{M}{S_W} = \frac{450}{1.76}$$

$$f_b = 255.7 \qquad [lbs/in]$$

VERTICAL SHEAR ON THE WELD

$$f_v = \frac{V}{A_W} = \frac{P}{A_W} = \frac{300}{4.71} = 63.7 \; [lbs/in]$$

ACTUAL RESULTANT FORCE ON THE WELD:

$$f_r = \sqrt{f_b^2 + f_v^2}$$

$$f_r = 263.5 \qquad [lbs/in]$$

FIND THE SIZE OF A FILLET WELD:

$$\omega = \frac{\text{ACTUAL FORCE}}{\text{ALLOWABLE FORCE}}$$

$$= \frac{263.5}{9600} = 0.027''$$

WE ARE USING $\frac{3}{16}$ △

REF[2] (3) FOLLOWING PAGES 21-23

TABLE 2 - MINIMUM WELD SIZES FOR THICK PLATES (AWS)

THICKNESS OF THICKER PLATE JOINED t	MINIMUM LEG SIZE OF FILLET WELD ω
to 1/2" incl.	3/16"
over 1/2" thru 3/4"	1/4"
over 3/4" thru 1 1/2"	5/16"
over 1 1/2" thru 2 1/4"	3/8"
over 2 1/4" thru 6"	1/2"
over 6"	5/8"

Minimum leg size need not exceed thickness of the thinner plate.

Table 1 gives the leg size of fillet welds for various plate thicknesses, based on formulas #1 and #2. Values have been adjusted where necessary to comply with AWS-recommended minimums for thick plates (Table 2).

For rigidity designs, the fillet weld may be reduced by using intermittent welds.

Thick Plates

The American Welding Society recognizes that thick plates offer greater restraint, and produce a faster cooling rate for the welds. As a result they recommend the minimum fillet weld sizes in Table 2 for various plate thicknesses, based on the thicker plate.

This table is predicated on the theory that the required minimum weld size will provide sufficient welding heat input into the plate to give the desired slow rate of cooling.

This is not a complete answer to this problem; for example, a plate thicker than 6" would require a minimum weld size of ⅝", yet in actual practice this would be made in several passes. Each pass would be equivalent to about a 5/16" fillet, and have the heat input of approximately a 5/16" weld which may not be sufficient unless the plates are preheated.

A partial solution to this problem would be the following: Since the first pass of the joint is the most critical, it should be made with low-hydrogen electrodes and a rather slow travel speed. Resulting superior weld physicals, weld contour, and maximum heat input provide a good strong root bead.

3. TYPES OF WELDS

a. Primary welds transfer the entire load at the particular point where they are located. If the weld fails, the member fails. The weld must have the same property as the member at this point. In brief, the weld becomes the member at this point.

b. Secondary welds simply hold the parts together, thus forming the member. In most cases, the forces on these welds are low.

c. Parallel welds have forces applied parallel to their axis. In the case of fillet welds, the throat is stressed only in shear. For an equal-legged fillet, the maximum shear stress occurs on the 45° throat.

d. Transverse welds have forces applied transversely or at right angles to their axis. In the case of fillet welds, the throat is stressed in both shear and normal (in tension or compression). For an equal-legged fillet weld, the maximum shear stress occurs on the 67½° throat, and the maximum normal stress occurs on the 22½° throat.

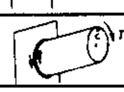
4. SIMPLE TENSILE, COMPRESSIVE OR SHEAR LOADS ON WELDS

For a simple tensile, compressive or shear load, the given load is divided by the length of the weld to arrive at the applied unit force, lbs per linear inch of weld. From this force, the proper leg size of fillet weld or throat of groove weld may be found.

5. BENDING OR TWISTING LOADS ON WELDS

The problem here is to determine the properties of the welded connection in order to check the stress in the weld without first knowing its leg size. Some design texts suggest assuming a certain weld-leg size and then calculating the stress in the weld to see if it is overstressed or understressed. If the result is too far off, then the weld-leg size is readjusted.

TABLE 3 - DETERMINING FORCE ON WELD

Type of Loading		standard design formula stress lbs/in^2	treating the weld as a line force lbs/in
	PRIMARY WELDS transmit entire load at this point		
	tension or compression	$\sigma = \frac{P}{A}$	$f = \frac{P}{A_w}$
	vertical shear	$\sigma = \frac{V}{A}$	$f = \frac{V}{A_w}$
	bending	$\sigma = \frac{M}{S}$	$f = \frac{M}{S_w}$
	twisting	$\tau = \frac{T\,c}{J}$	$f = \frac{T\,c}{J_w}$
	SECONDARY WELDS hold section together - low stress		
	horizontal shear	$\tau = \frac{V\,a\,y}{I\,t}$	$f = \frac{V\,a\,y}{I\,n}$
	torsional horizontal shear	$\tau = \frac{T}{2At}$	$f = \frac{T}{2A}$

A = area contained within median line.
(*) applies to closed tubular section only.

This has the following disadvantages:

1. Some decision must be made as to what throat section is going to be used to determine the property of the weld. Usually some objection can be raised to any throat section chosen.

2. The resulting stresses must be combined and, for several types of loading, this can be rather complicated.

In contrast, the following is a simple method to determine the correct amount of welding required for adequate strength. This is a method in which the weld is treated as a line, having no area, but a definite length and outline. This method has the following advantages:

1. It is not necessary to consider throat areas because only a line is considered.

2. Properties of the welded connection are easily found from a table without knowing weld-leg size.

3. Forces are considered on a unit length of weld instead of stresses, thus eliminating the knotty problem of combining stresses.

4. It is true that the stress distribution within a fillet weld is complex, due to eccentricity of the applied force, shape of the fillet, notch effect of the root, etc.; however, these same conditions exist in the actual fillet welds tested and have been recorded as a unit force per unit length of weld.

6. DETERMINING FORCE ON WELD

Visualize the welded connection as a single line, having the same outline as the connection, but no cross-sectional area. Notice, Figure 1, that the area (A_w) of the welded connection now becomes just the length of the weld.

Instead of trying to determine the stress on the weld (this cannot be done unless the weld size is known), the problem becomes a much simpler one of determining the force on the weld.

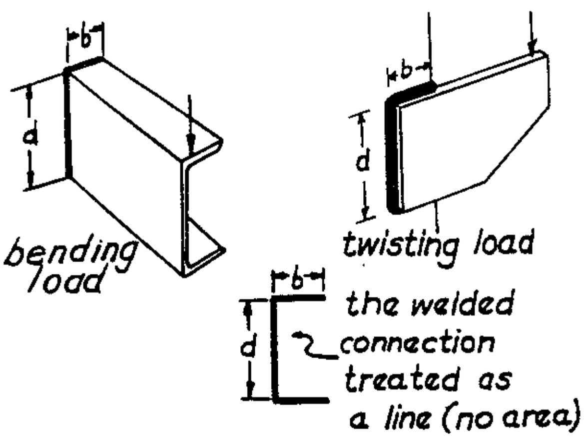
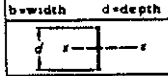
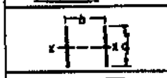
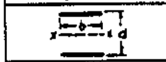
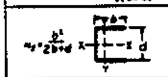
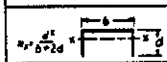
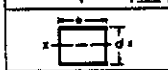
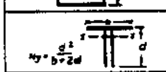
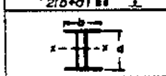
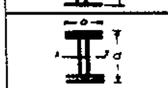
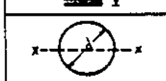
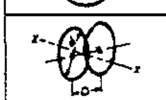


Fig. 1 Treating weld as a line.

TABLE 4 - PROPERTIES OF WELD TREATED AS LINE

Outline of Welded Joint b=width d=depth	Bending (about horizontal axis x-x)	Twisting
	$S_w = \frac{d^2}{6}$ in.^{2}	$J_w = \frac{d^3}{12}$ in.^{3}
	$S_w = \frac{d^2}{3}$	$J_w = \frac{d(3b^2+d^2)}{6}$
	$S_w = bd$	$J_w = \frac{b^3+3bd^2}{6}$
	$S_w = \frac{4bd+d^2}{6} = \frac{d^2(4b+d)}{6(2b+d)}$ top bottom	$J_w = \frac{(b+d)^4-6b^2d^2}{12(b+d)}$
	$S_w = bd + \frac{d^2}{6}$	$J_w = \frac{(2b+d)^3}{12} - \frac{b^2(b+d)^2}{(2b+d)}$
	$S_w = \frac{2bd+d^2}{3} = \frac{d^2(2b+d)}{3(b+d)}$ top bottom	$J_w = \frac{(b+2d)^3}{12} - \frac{d^2(b+d)^2}{(b+2d)}$
	$S_w = bd + \frac{d^2}{3}$	$J_w = \frac{(b+d)^3}{6}$
	$S_w = \frac{2bd+d^2}{3} = \frac{d^2(2b+d)}{3(b+d)}$ top bottom	$J_w = \frac{(b+2d)^3}{12} - \frac{d^2(b+d)^2}{(b+2d)}$
	$S_w = \frac{4bd+d^2}{3} = \frac{4bd^2+d^3}{6b+3d}$ top bottom	$J_w = \frac{d^3(4b+d)}{6(b+d)} + \frac{b^3}{6}$
	$S_w = bd + \frac{d^2}{3}$	$J_w = \frac{b^3+3bd^2+d^3}{6}$
	$S_w = 2bd + \frac{d^2}{3}$	$J_w = \frac{2b^3+6bd^2+d^3}{6}$
	$S_w = \frac{\pi d^2}{4}$	$J_w = \frac{\pi d^3}{4}$
	$I_w = \frac{\pi d}{2}\left(D^2 + \frac{d^2}{2}\right)$ $S_w = \frac{I_w}{c}$ where $c = \frac{\sqrt{D^2+d^2}}{2}$	

By inserting the property of the welded connection treated as a line into the standard design formula used for that particular type of load (see Table 3), the force on the weld may be found in terms of lbs per linear inch of weld.

Example: Bending

Standard design formula (bending stress)	Same formula used for weld (treating weld as a line)
$\sigma = \frac{M}{S} = \frac{lbs}{in.^2}$ stress	$f = \frac{M}{S_w} = \frac{lbs}{in.}$ force

Normally the use of these standard design formulas results in a unit stress, psi; however, when the weld is treated as a line, these formulas result in a force on the weld, lbs per linear inch.

For secondary welds, the weld is not treated as a line, but standard design formulas are used to find the force on the weld, lbs per linear inch.

In problems involving bending or twisting loads Table 4 is used to determine properties of the weld

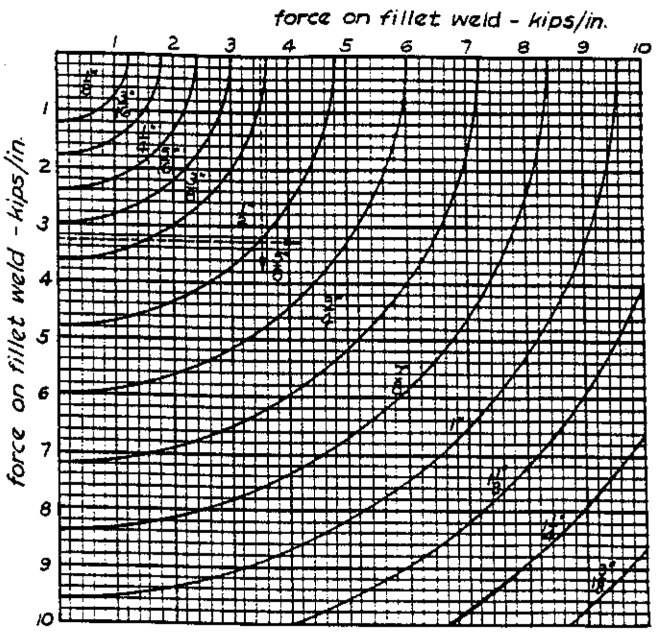


Fig. 2 Fillet weld leg size for combined forces.

treated as a line. It contains the section modulus (S_w), for bending, and polar moment of inertia (J_w), for twisting, of some 13 typical welded connections with the weld treated as a line.

For any given connection. two dimensions are needed. width (b) and depth (d).

Section modulus (S_w) is used for welds subject to bending loads, and polar moment of inertia (J_w) for twisting loads.

Section moduli (S_w) from these formulas are for maximum force at the top as well as the bottom portions of the welded connections. For the unsymmetrical connections shown in this table, maximum bending force is at the bottom.

If there is more than one force applied to the weld, these are found and combined. All forces which are combined (vectorially added) must occur at the same position in the welded joint.

Determining Weld Size by Using Allowables

Weld size is obtained by dividing the resulting force on the weld found above, by the allowable strength of the particular type of weld used (fillet or groove), obtained from Table 5 (steady loads) or Table 6 (fatigue loads).

For a joint which has only a transverse load applied to the weld (either fillet or groove weld), the allowable transverse load may be used from the table. If part of the load is applied parallel (even if there are transverse loads in addition), the allowable parallel load which is lower must be used.

If there are two forces at right angles to each other. the resultant is equal to the square root of the sum of the squares of these two forces.

$$f_r = \sqrt{f_1^2 + f_2^2} \quad \text{......(3)}$$

If there are three forces, each at right angles to each other, the resultant is equal to the square root of the sum of the squares of the three forces.

$$f_r = \sqrt{f_1^2 + f_2^2 + f_3^2} \quad \text{......(4)}$$

The chart in Figure 2 can be used for E60 welds to combine two forces and indicate the proper fillet-weld leg size.

TABLE 5 - ALLOWABLE STEADY LOADS (lbs/linear in. of weld)

Fillet Weld (For 1" weld leg)	Groove weld (for 1" weld thickness)	Partial Penetration ** Groove weld* (For 1" weld thickness)
	Parallel Load	
E60 or SAW - 1 weld 9600 (AWS)	$\tau = .40\ \sigma_y$ of base metal (shear) (AWS)	E60 or SAW - 1 weld 13,600 (AISC)
E70 or SAW - 2 weld 11,200 (AWS)		E70 or SAW - 2 weld 15,800 (AISC)
	Transverse Load	
E60 or SAW - 1 weld 11,200	$\tau = .60\ \sigma_y$ of base metal (tension) (AWS)	E60 or SAW - 1 weld 13,600 (AISC)
E70 or SAW - 2 weld 13,100		E70 or SAW - 2 weld 15,800 (AISC)

*For bevel joint, deduct first 1/8" for effective throat, if done by manual electrode.

**

tension transverse to axis of weld or shear – use table

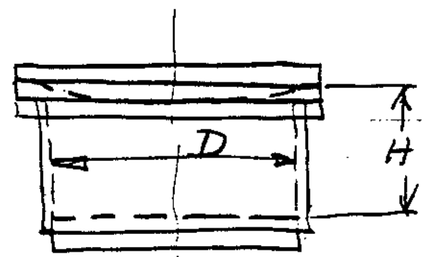
for tension parallel to axis of weld or compression – weld same as plate

(RT)

8. DETERMINE AN APPROXIMATE AIR IMPACT DISCHARGE, DURING UNCONTROLLED RUPTURE OF THE KEVLAR FABRIC AT FULL VACUUM CASE.

VOLUME OF THE VACUUM SPACE.

$$V = \frac{\pi D^2}{4} \cdot H$$



$$V = \frac{\pi (5.91)^2}{4} 1.12$$

$$V = \underline{30.72} \left[Ft^3\right]$$

D = 5.91 Ft
H = 1.12 Ft

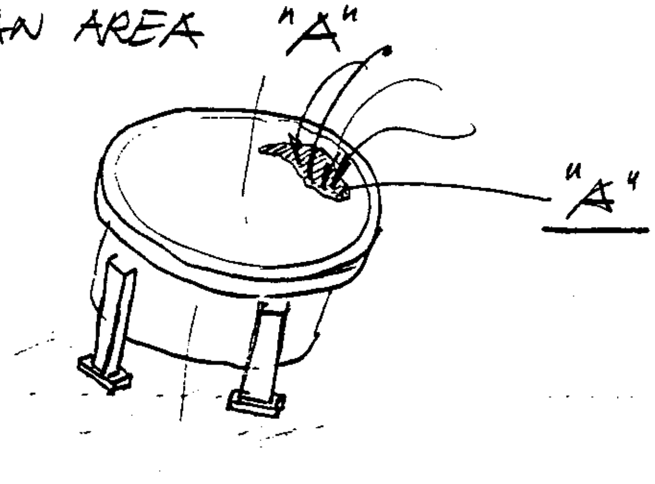
EQUIVALENT OF STORED ENERGY IN THE VOLUME "V" AT $p = 14.7$ psi

$$E = p \cdot V$$

$$E = 14.7(144)(30.72) \quad \frac{lbs}{Ft^2} Ft^3 \left[lbs\ Ft\right]$$

$$E = \underline{65,028.}$$

THIS POTENTIAL ENERGY OF THE AIR ABOVE THE KEVLAR WINDOW, WILL CONVERT TO KINETIC ENERGY OF AIR MOLECULES FLOWING THROUGH A RUPTURE OF AN AREA "A"



$E = E_K$

$E_K = \frac{m \cdot v^2}{2}$

FROM CONTINUITY FLOW:

$Q = A \cdot v$

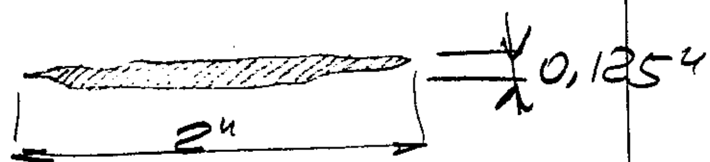
WHERE

v - VELOCITY OF AIR AT RUPTURE "A"

A - RUPTURE AREA

$E_K = \frac{m \left(\frac{Q}{A} \right)^2}{2}$

ASSUMED "A":



$A = \underline{0,0017}\ Ft^2$

$E_K = \frac{m Q^2}{2 A^2}$

m - MASS OF THE AIR

$m = \frac{0.08 (30.72)}{32.2}$

0.08 - SPECIFIC WEIGHT OF AIR $\left[\frac{lbs}{Ft^3} \right]$

$m = \underline{0.076}\ \left[\frac{lbs\ sec^2}{Ft} \right]$

$E_K = \frac{0.076\ Q^2}{2\ (0.0017)^2}$

$65028 = \frac{0.076\ Q^2}{2 (0.0017)^2}$

$$Q^2 = 4.94$$

$$Q = 2.22 \left[\frac{Ft^3}{sec}\right]$$

(R3)

$$Q' = 2.22\,(0.08)$$

$$Q' = \underline{0.17} \left[\frac{lbs}{sec}\right]$$

THIS IS A MARGINAL IMPACT ON THE FIXTURE ASSEMBLY WHICH WEIGHT IS 4250 [lbs].

27-B1
29

Fermilab

Draft Revision March 4, 1994

E-832
K-Tev 1.8 Meter Window Assembly Procedure

SEE APPENDIX 5 FOR A FINAL VERSION

Written by Dave Erickson
January 15, 1994

DRAFT

Materials, Equipment, and References

- Drawing 9220.832.MD-285394 ... Window Assembly
- Drawing 922.0832.MD-285391 ... Vessel Assembly
- Aluminum spreader bar (I.D. 62 600 lb. capacity)
- .250 Diameter Urethane O-ring stock
- .250 Diameter 1100 Series Aluminum wire stock
- .005 X 72" DuPont Mylar Sheet (Aluminized coating) MSDS#12407
- Woven Kevlar MSDS# 12406
- Hysol epoxy ... 826 resin (MSDS# 07625)and 308 Hardener (MSDS# 06160)
- RTV 157 (gray) MSDS#04471
- Utility knife and razor blades
- Surgical knife and blades
- Wooden tongue depressors
- Oxy-Acet unit with standard regulators, hoses and tips.

- Nederman electrostatic filter for exhausting fumes when burning Kevlar and Mylar. Flexible extension hose for the output side of the filter unit.
- 600 ft/lb. torque wrench
- Removable wooden flange periphery work surface
- Removable aluminum cover to protect assembly when not worked on
- Nylon blocks to elevate upstream flange from Test Vessel
- 2 inch wide green tape stock # 1365-0980
- Curved surgical scissors
- Kevlar scissors
- Test Vessel is used as an assembly table when making window
- Eye protection (Maybe particle mask)
- ES&H requirements/recommendations

Preparatory Work

First and foremost, care must be taken to ensure a clean and accident free environment.

1100 Aluminum Alloy O-ring

One 1100 aluminum alloy o-ring (.250 diameter) must be made for window. Determine the correct length of the 1100 aluminum rod needed for o-ring grove by fitting the rod into the appropriate o-ring groove in the flange. Determine the correct groove by consulting the assembly print (MD-285394). Cut the rod to the correct length and weld the two ends together. File and sand the o-ring weld until it blends with the parent material diameter. There should not be any scratches or nicks in the o-ring. Hand polish the o-ring using a Scotchbrite pad. Store ring in a safe place until needed.

Urethane O-ring

One o-ring (.250 diameter) is needed for window flange. Determine the length of urethane o-ring chord material by fitting material in the correct o-ring groove (again consult assembly print for correct grove). Cut the o-ring material to length and join the ends using the conventional heat method. Trim excess material carefully with razor blade to blend with rest of chord. Clean thoroughly and store in a safe place until needed.

.005 Mylar (Polyester metallized film)

Unroll and inspect mylar to be sure there are no scratches, nicks or other defects. Cut two pieces of mylar approximately six inches larger than flange. This will ensure the mylar sheet is large enough to be pulled taut over the flange and then taped to the work table/shelf. Orientation of the metallized surface is critical. It should be the atmospheric side of the window. Double check the assembly drawing.

Kevlar

Unroll and discard the outer layer of kevlar if signs of degradation are obvious. Inspect the kevlar material to be sure that are no cuts, punctures or strands that have been pulled in the woven material. Cut the kevlar so it is six inches larger in diameter than the flange. This will ensure the kevlar sheet is large enough to be pulled taut over the flange and then taped to the outrigger.

Epoxy

The epoxy should not be prepared until it is going to be used. A one to one mixing ration is used. Mix 75 ml. of hardener to 75 ml. of 826 resin. Mix thoroughly and put into a squeeze bottle. This mixture will fully cure in 24 hours.

Wooden Outrigger Platform (Flange work table)

The wooden outriggers (table) are made of 3/4" thick plywood. Special brackets that support the plywood were used to align 8 nuts which were welded to the flange (9220.832.MD-285389) equally spaced around flange diameter. The nuts where welded in a position that made approximately 12 inches larger than the diameter of the window flange. This will aid in taping of mylar and kevlar during assembly. The outrigger is made to be removable for further assembly or to make a new window. Nuts will remain on flange indefinitely.

Assembly Procedure

(most of this procedure requires two people)

1. Screw 1/2" - 13 swivel eye bolts into special removable pick points of upstream flange MD-285389. Using crane and spreader bar, place the flange (o-ring side up) onto the equally spaced nylon standoffs which have been placed on test vessel flange.

2. Attach wooden outrigger platform to upstream flange (MD-285389).

3. Center one piece of .005 mylar (aluminized side down) over the flange and onto the outrigger platform. Tape the mylar to the outrigger platform as needed allowing the mylar to sag 1/4 inch in the middle of the flange. Use straight edge to measure sag.

4. Lay the Kevlar over the mylar, making sure it is smoothed out evenly on the mylar. Tape kevlar down onto outrigger platform all the way around. Check with a straight edge to ensure 1/4 inch sag.

5. Place and then tape the second piece of mylar (aluminized side up) on top of the kevlar so it conforms to the first piece of mylar and kevlar, maintaining the 1/4 inch sag in the middle of the flange. Again tape down mylar as needed to platform.

6. Using crane and spreader bar, lift downstream flange (MD-285390) over upstream flange (MD-285389) with the o-ring facing down. Lower it carefully until it is almost touching flange (MD-285389). Shine a flashlight up through four holes 90 degrees apart in flange. When the holes are lined up between both flanges, lower flange (MD-285390) onto upstream flange (MD-285389).

7. Make timing marks on the top flange (MD-285390), the window, and the bottom flange (MD-285389). These marks will be used to align the flanges and the window later on.

8. Locate the four holes 90 degrees apart which will become the bolt hole clearance holes. Use torch to carefully burn the window material from the inside of the bolt clearance holes. **You must use the electrostatic filter when burning any kevlar and mylar!** *Extreme care must be taken to avoid snagging or pulling a strand of kevlar.

9. The electrostatic filter must be exhausted outside of the assembly building. After the four clearance holes have been burned out, temporarily place bolts through the holes in the assembly. Tighten the bolts down to 80 foot/pounds. This will hold flanges while burning the window material out of the remaining holes. **Remember to use the electrostatic filter exhaust.**

10 Using torch set, burn the material out of the remaining bolt holes. Be sure to remove all kevlar strands from the holes. If they are not removed, the strands may catch on the bolts when they are screwed in.

11. When all the bolt holes are open, remove the four bolts which were temporarily placed in the holes.

12. Using the crane carefully lift the top flange (MD-285390) off the lower flange (MD-285389), making sure the window material does not stick to the flange while it is removed. Use tongue depressors to separate material from flange. Flip flange over 180 degrees so o-ring is facing up. Place flange in work area so that aluminum o-ring can be installed.

13. Carefully peel the top sheet of mylar away from the kevlar by feeding wooden tongue depressors between the two materials in the areas where the holes have been burned away. Once again, care must be taken to ensure that the kevlar strands are not pulled. After the mylar is completely separated from the kevlar, place the mylar in a safe place until it is needed again.

14 The orange o-ring must be inserted into the o-ring groove of the upstream flange (MD-285389). Coat lightly the orange o-ring with vacuum silicone grease. From under the flange (between the test vessel flange and nylon standoffs) carefully squeeze the o-ring between the mylar and the flange until it snaps into the o-ring groove of the flange (MD-285389).

15. When the orange o-ring is in place, it will create a small impression on the surface of the kevlar. Use a felt tip marker to accentuate this ridge around the kevlar. This marker line will act as a guide for applying the epoxy.

16. Working on the downstream flange (MD-285390), which was previously removed from the upstream flange (MD-285389), apply spots of RTV silicone in the bottom of the aluminum o-ring groove. Insert the aluminum o-ring into the flange o-ring groove. Allow the RTV to set up, which usually takes about three hours. The RTV will hold the aluminum o-ring in place when the flange is picked up, flipped over and put back onto the upstream flange (MD-285389).

17. While the RTV is setting up, mix the epoxy and apply a bead of epoxy to the marker line on the kevlar. Use a wooden tongue depressor to work the epoxy into the kevlar. The epoxy will soak into the kevlar and spread out about 3/4 of an inch.

18. Carefully place the mylar which was removed in Step 13, back on the top of the kevlar, lining up the timing marks.

19. Using the crane and the spreader bar lift and turn over the downstream flange (MD-285390) with the aluminum o-ring. Slowly lower the flange with the aluminum o-ring facing down, lining up the timing marks on the upper flange the window and the

lower flange. Use bolt holes as a guide when lowering flange. Lower the flange completely so it is sitting on flange (MD-285389).

20. Screw bolts through top flange (MD-28390) into lower flange (MD-285389) and torque bolts using bolt tighten sequence provided on the print.

21. After curing the epoxy for 24 hours, the excess window material on the outside of the flanges can be cut away with a scissors using the outside edge of the flanges as a guide. The remaining material can be burned away with a torch. Remember to use the smoke eater when burning the material.

22. Remove the outrigger platform from the assembly.

23. Before leak checking the window assembly, the mylar window on the vacuum side must be cut out (it was used as an assembly aid). You must carefully flip the assembly over 180 degrees. Extreme care must be taken when cutting this mylar window out because the mylar is laying next to the kevlar. With the vacuum side up, lift the center of the mylar with a piece of tape which has been stuck on the surface in the middle of the mylar window. When the mylar has been lifted away from the kevlar, carefully cut a small slit using a hooked surgical knife. Using the slit to access the mylar, carefully use blunt nose scissors to cut around the mylar window to with in an inch or an inch and one half of the inner wall of the flange. Remove mylar cutout and dispose of.

24. The assembly is now ready for vacuum testing. See comments before continuing.

COMMENTS :

This procedure was derived from previous kevlar-mylar window assembly procedures. Reference : E-773/731 12 inch and 30 inch and 48 inch diameter windows. Drawings: #9220.731-MD-202185 and 9220.731-MD-202178. This procedure is still in draft form pending Safety Review Committee approval.

The vacuum, hydrostatic, and puncture tests that follow the completion of the window assembly fall under a procedure written by Andrew Szymulanski. He is coordinating this with the Safety Review Committee. The ordered tests shall not be executed until A. Szymulanski has the Safety Review Committee approval to do so.

* The RD/ES&H section (Bill Nicholson) is reviewing personnel hazards having to do with the burning of the kevlar and mylar. However, the accepted and applicable procedure is to exhaust the output side of the fume collecting apparatus (electrostatic filter) to the outside of the assembly building. Extending the exhaust through a door or window with a flexible exhaust extension is acceptable.

10. REQUIRED TORQUE AND BOLTING SEQUENCE

A SERIES OF TESTS HAS BEEN PERFORMED, TO FIND THE RIGHT CLAMPING FORCE FOR THE KEVLAR / MYLAR SANDWICH. THE TORQUE VALUE WHICH YIELDED THE MAX. PULL OUT FORCE FOR THE CLAMPED MATERIAL WAS 250 Ft lbs.

THIS VALUE TRANSLATES TO 45970 [psi] TENSILE STRENGTH IN THE BOLT. THE MAX. STRENGTH OF THE BOLT IS 153000 [psi]

10.1 TIGHTENING THE BOLTS.

SKETCH NO 2 SHOWS THE WINDOW ASSEMBLY BOLT ARRANGEMENT.

10.1.1 START WITH BOLT NO 1 POSITION (1a) AND TIGHTEN THE FIRST (4) BOLTS TO <u>25 Ft lbs</u> AS FOLLOW:

1a, 1b, 1c, 1d

10.1.2 CONTINUE WITH THE NEXT (4) BOLTS IN THE SAME MANNER, FOLLOWING THE ARROW DIRECTION.

10.1.3 CONTINUE OTHER (4) AS ABOVE UNTIL ALL ARE TIGHTENED.

10.1.4 INCREASE THE TORQUE TO <u>50</u> [Ft lbs] AND CONTINUE AS IN: 4.1.1
4.1.2
4.1.3

10.1.5 INCREASE TORQUE VALUES

TO: 100 [Ft lbs]
150 -"-
200 -"-
250 -"-

FOLLOWING THE STEPS OF

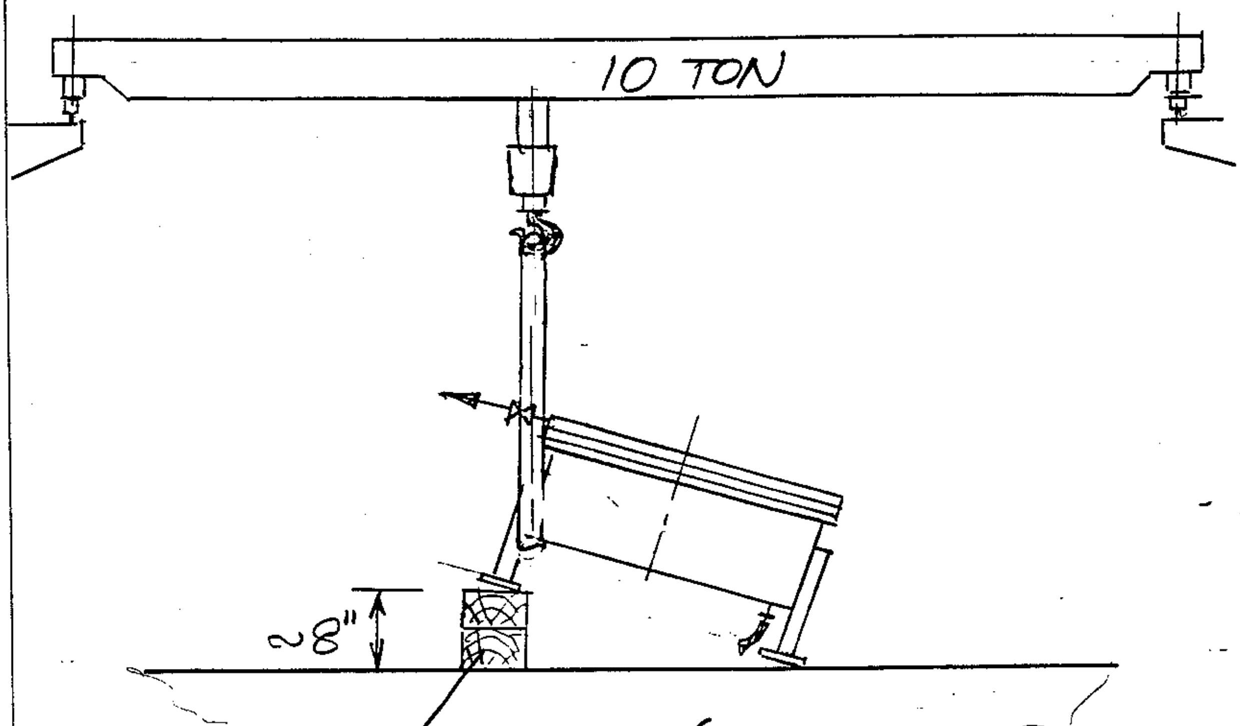
4.1.1
4.1.2
4.1.3

FOR EACH TORQUE VALUE.

10.2 PLACE THE WINDOW ASSEMBLY ON THE VESSEL FLANGE, AND INSTALL THE BOLTS (POS 2.) AND NUTS (POS. 3) WITH SPRING WASHERS.

TIGHTEN ALL (60) BOLTS IN THE SAME WAY AS DESCRIBED FOR POS. 1 BOLTS,

RIGGING ARRANGEMENT FOR AN AIR BLEEDING OPERATION.



72" LG. - (4" × 4" NOMINAL) 2 PCS.

CRANE WILL STAY ATTACHED AND LOCKED OFF DURING THE BLEEDING OPERATION

SKETCH 3

APPENDIX

SELECTING THE RELIEF VALVE :

MANUFACTURER: TELEDYNE FARRIS ENG.
CATALOG : 189 C

VALVE TYPE NUMBER : 1850

INLET MNPT 1"

OUTLET FNPT 1½"

MAX. SET PRESSURE RATING : 300 psiG

CAPACITY OF THE VALVE @ 25% OVERPRESSURE AND SET PRESSURE OF 40 psiG
(SEE CAPACITIES TABLE ON PAGE 6 OF "FARRIS" CAT. 189 C)

CAPACITY = 30 GAL/min

CAPACITY @ 10% OVERPRESSURE :

CAP.(@10%) = 30 × 0.6 = 18 GAL./min

SET PRESSURE + 10% OVERPRESSURE = MAX. PRESSURE INSIDE THE VESSEL

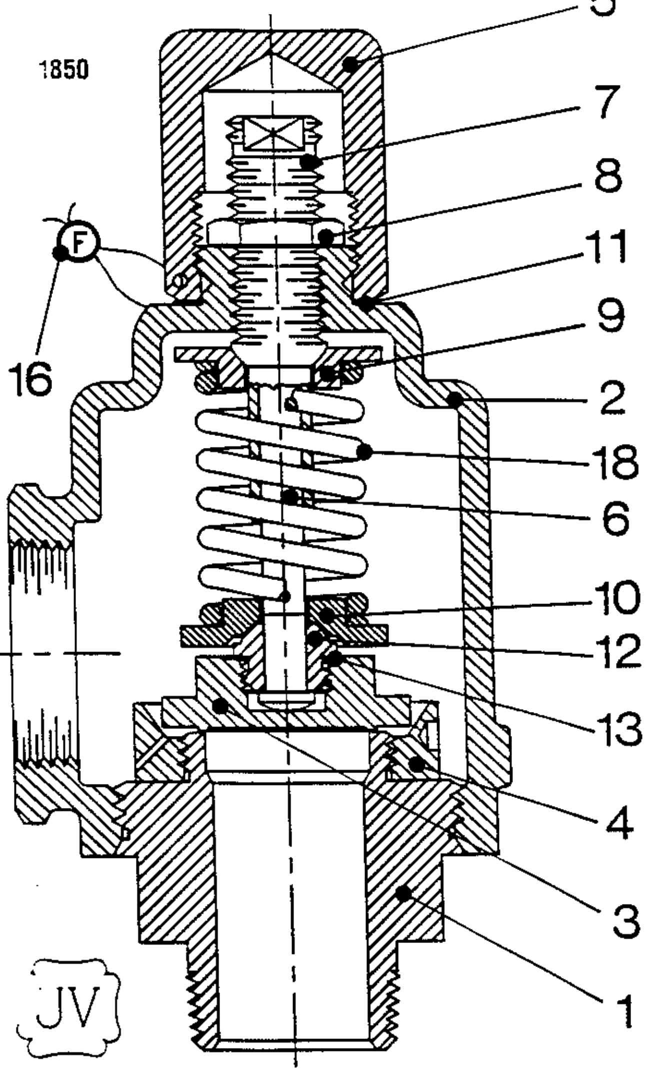
40 + 4 = 44

44 < 45

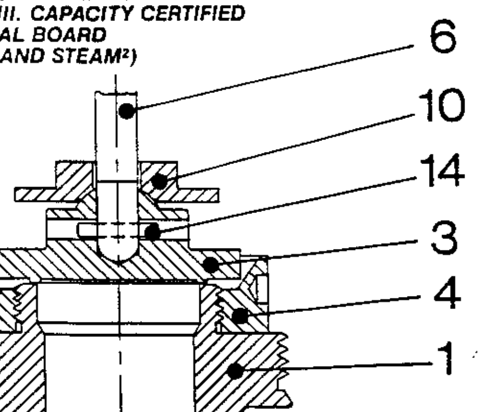
WHERE 45 PERTAINS TO MAX. ALLOWABLE PRESSURE INSIDE THE VESSEL.

SERIES 1850, 1855 & 1856M PRESSURE RELIEF VALVES

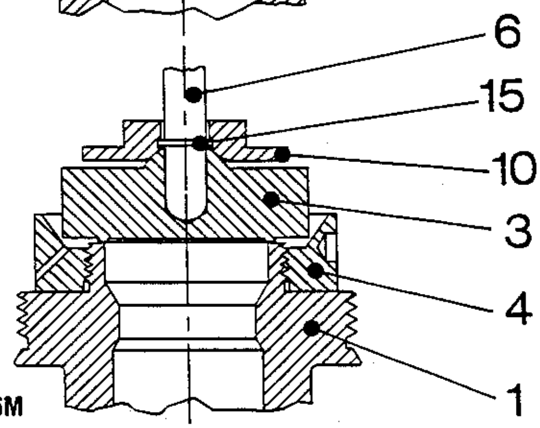
1850



BUILT IN CONFORMANCE TO ASME CODE SECTION VIII. CAPACITY CERTIFIED BY NATIONAL BOARD (AIR, GAS, AND STEAM²)



1855



1856M

BILL OF MATERIALS

Farris

Item No.	Part Name	Material: 1850, 1850H, 1852, 1852H	Material: 1850/S4, 1850H/S4, 1852/S4 1852H/S4	Material: 1855	Material: 1856M
1	Body	SA-479 Type 316 St. St. Or SA-351, Gr. CF8M St. St.	SA-479 Type 316 St. St. Or SA-351, Gr. CF8M St. St.	ASTM B16 H.H. Brass Or ASTM B62 Bronze	ASTM B16 H.H. Brass Or ASTM B62 Bronze
2	Bonnet	SA-216 Gr. WCB Carb. St.	SA-351 Gr. CF8M St. St.	ASTM A126 Cl.B Cast Iron	ASTM B62 Bronze
3	Disc	316 St. St.	316 St. St.	Brass	Brass
4	Blow Down Ring	St. St.	316 St. St.	Brass	Brass
5	Cap	Carbon St.	316 St. St.	Iron	Bronze
6	Stem	St. St.	316 St. St.	St. St.	Brass
7	Spring Adj. Screw	St. St.	316 St. St.	Brass	Brass
8	Jam Nut	St. St.	316 St. St.	Brass	Brass
9	Spring Button (Upper)	Carbon St. Rust Proofed	316 St. St.	Carbon St. Rust Proofed	St. St.
10	Spring Button (Lower)	Carbon St. Rust Proofed	316 St. St.	Carbon St. Rust Proofed	St. St.
11	Cap Gasket	Flexible Graphite	316 St. St.	Flexible Graphite	Flexible Graphite
12	Stem Retainer	St. St.	316 St. St.	—	—
13	Lockwasher	St. St.	316 St. St.	—	—
14	Groov-Pin	—	—	St. St.	—
15	Retaining Ring	—	—	—	St. St.
16	Wire Seal	Stainless Steel Wire/Lead Seal			
17	Nameplate (not shown)	Stainless Steel			
18	Spring	See Selection Table			
NOTE 1	Lap Joint Stub End (Inlet)	SA-403, Gr. WP316 St. St.	SA-403 Gr. WP316 St. St.	NOT AVAILABLE	
	Lap Joint Stub End (Outlet)	SA-234 Carbon St.	SA-403 Gr. WP316 St. St.		
	Lap Joint Flange (Inlet)	SA-181 or SA-105 Carb. St.	SA-182 Gr. F316 St. St.		
	Lap Joint Flange (Outlet)	SA-181 or SA-105 Carb. St.	SA-182 Gr. F316 St. St.		

Notes:

1. Applicable to the F1850 Series (flanged).
2. Also suitable for liquid service where ASME Code certification is not required.
3. The 1856M(C) open lever and packed lever constructions use a stem retainer design similar to internals shown for the 1850 Series.
4. All open lever types are provided with an untapped hole in bonnet for drainage of condensate.
5. Series 1850 (¾") and 1850H (1") supplied with body gasket in the same materials as the cap gasket.

GENERAL NOTES
ALL SERIES

1. Available with the following cap constructions:

Cap Construction	Add As Suffix To Type Number
Open Lever	-OL
Packed Lever	-PKD
Test Gag	W/TG

2. Available with "O" Ring Seat Pressure Seal option (not illustrated) – add "R" to type number.
   Examples: 1850R
   1856MR-PKD
   Choice of elastomers includes Buna N, Viton, silicone, ethylene propylene and Kalrez.
3. Test lever required for air, steam and hot water (above 140°F) service.

SELECTION TABLE

Farris

SCREWED VALVES

SERIES 1850/1850H

MNPT INLET x FNPT OUTLET

Type Number	Maximum Set Pressure, PSIG — Inlet ¾ / Outlet 1	Inlet 1 / Outlet 1½	Inlet 1½ / Outlet 2	Inlet 2 / Outlet 3	Inlet 3 / Outlet 4	Inlet Temp. Range °F	Max. Back Press. PSIG	Materials: Body/Bonnet	Materials: Spring
1850	300	300	300	300	300	−20 to 400	50	316 St. St./ Carbon St.	Carbon Steel, Rust Proofed
1850H	—	800	—	—	—				
1852	300	300	300	300	300	400 to 750			High Temp. Alloy (Note 2)
1852H	—	800	—	—	—				
1850/S4	300	300	300	300	300	−400 to 400	50	316 St. St./ 316 St. St.	316 St. St.
1850H/S4	—	800	—	—	—				
1852/S4	300	300	300	300	300	401 to 750			High Temp. Alloy (Note 3)
1852H/S4	—	800	—	—	—				

Notes:
1. For ½" x 1" size see 1890 Series in Catalog 488C.
2. Above 400°F High Temperature Alloy Steel, Plated or High Temperature Stainless Alloy is required.
3. Above 400°F in S4 Types, High Temperature Alloy Steel, Nickel Plated or High Temperature Stainless Alloy is required.

SERIES 1855/1856M

MNPT INLET x FNPT OUTLET

Type Number	Max. Set Pressure, PSIG — Inlet ¾ / Outlet 1¼	1 / 1¼	1 / 1½	1½ / 2	1½ / 2½	2 / 2½	2 / 3	2½ / 3	2½ / 4	3 / 4	Inlet Temp. Range °F	Max. Back Press. PSIG	Materials: Body/Bonnet	Materials: Spring
1855	250	—	250	—	250	—	250	—	250	250	−20 to 400	50	Brass or Bronze/ Cast Iron	Carbon Steel, Rust Proofed
1856MC	—	—	—	—	—	—	—	250	—	250	−20 to 400		Brass or Bronze/ Bronze	
1856M	—	300	—	200	—	250	—	250	—	250	−400 to 400			316 St. St.

Note:
For ½" x ¾" and ¾" x ¾" sizes see 1895/1896M Series in Catalog 488C.

APPENDIX 1 PAGE 42

CAPACITY SELECTION

Farris

TO USE THE CAPACITY TABLES, LOCATE THE TYPE NUMBER AND VALVE SIZE. REFER TO THE CORRECT COLUMN IN THE APPLICABLE FLUID TABLE.

Series	Valve Size						
1850	3/4 x 1	1 x 1½	—	1½ x 2	2 x 3	3 x 4	—
1850H	1 x 1½	—	—	—	—	—	—
1855	3/4 x 1¼	1 x 1½	—	1½ x 2½	2 x 3	2½ x 4	3 x 4
1856M	1 x 1¼	—	1½ x 2	2 x 2½	2½ x 3	3 x 4	—
Column	A	B	C	D	E	F	G

CAPACITIES

Farris

ASME PRESSURE VESSEL CODE (UV) 90% RATING

AIR

10% OVERPRESSURE

Capacities in Standard Cubic Feet Per Minute at 60°F.

Set Pressure (PSIG)	A	B	C	D	E	F	G
1# Incr.	3	5	9	13	20	35	50
5# Incr.	16	27	44	63	101	175	252
10# Incr.	32	54	88	126	202	350	504
15	94	161	261	376	602	1041	1499
20	108	185	301	433	694	1200	1728
40	169	289	468	674	1080	1868	2691
60	232	397	644	927	1485	2568	3700
80	295	505	819	1180	1889	3268	4708
100	358	613	995	1433	2294	3968	5717
120	421	722	1170	1685	2699	4668	6725
140	485	830	1346	1938	3104	5368	7734
160	548	938	1521	2191	3508	6068	8742
180	611	1046	1697	2444	3913	6768	9751
200	674	1154	1873	2696	4318	7468	10759
220	737	1263	2048	2949	4723	8168	11768
240	800	1371	2224	3202	5127	8868	12777
250	832	1425	2311	3328	5330	9218	13281
260	864	1479	2399	3455	5532		
280	927	1587	2575	3707	5937		
300	990	1695	2750	3960	6342		
400	1306						
500	1622						
600	1938						
700	2254						
800	2570						

STEAM

10% OVERPRESSURE

Capacities in Pounds Per Hour at Saturation Temperature

Set Pressure (PSIG)	A	B	C	D	E	F	G
1# Incr.	9	15	25	36	57	98	142
5# Incr.	44	76	123	178	284	492	708
10# Incr.	89	152	247	355	569	983	1417
15	264	452	733	1056	1690	2923	4212
20	304	521	845	1217	1949	3370	4856
40	474	811	1316	1895	3034	5248	7561
60	651	1115	1809	2605	4171	7215	10394
80	829	1419	2302	3315	5308	9182	13228
100	1006	1723	2795	4025	6446	11148	16062
120	1184	2027	3288	4735	7583	13115	18895
140	1361	2331	3782	5446	8720	15082	21729
160	1539	2635	4275	6156	9857	17049	24562
180	1716	2939	4768	6866	10994	19016	27396
200	1894	3243	5261	7576	12131	20983	30230
220	2072	3547	5754	8286	13269	22949	33063
240	2249	3851	6247	8996	14406	24916	35897
250	2338	4003	6494	9351	14974	25900	37314
260	2427	4155	6741	9706	15543		
280	2604	4459	7234	10417	16680		
300	2782	4763	7727	11127	17817		
400	3669						
500	4557						
600	5445						
700	6332						
800	7220						

Notes:

1. Capacities for Air and Steam at 30 PSIG and below are based on 3 PSI overpressure.
2. Incremental capacities: determine the capacity at any set pressure by adding or subtracting the correct incremental value to any capacity listed.
3. Set pressure limit of the 1855 Series is 250 psig as shown by the Grey colored line. Set pressure limit of the 1850 Series is 300 psig as shown by the Brown colored line. Maximum set pressure Series 1850H is 800 psig. For 1856M Series pressure limits, consult the selection table.

CAPACITY SELECTION

TO USE THE CAPACITY TABLES, LOCATE THE TYPE NUMBER AND VALVE SIZE. REFER TO THE CORRECT COLUMN IN THE APPLICABLE FLUID TABLE.

Series	Valve Size						
1850	¾ x 1	1 x 1½	—	1½ x 2	2 x 3	3 x 4	—
1850H	1 x 1½	—	—	—	—	—	—
1855	¾ x 1¼	1 x 1½	—	1½ x 2½	2 x 3	2½ x 4	3 x 4
1856M	1 x 1¼	—	1½ x 2	2 x 2½	2½ x 3	3 x 4	—
Column	A	B	C	D	E	F	G

CAPACITIES

NON-CODE 90% RATING

WATER

25% OVERPRESSURE

Capacities in U.S. Gallons Per Minute at 70°F (See Note 1)

Set Pressure (PSIG)	A	B	C	D	E	F	G
15	10	18	26	40	71	111	162
20	11	20	29	45	81	126	183
40	17	30	43	67	119	186	270
60	21	36	53	82	146	227	331
80	24	42	61	95	168	263	382
100	27	47	68	106	188	294	427
120	29	52	74	116	206	322	468
140	32	56	80	125	222	347	505
160	34	60	86	134	238	371	540
180	36	63	91	142	252	394	573
200	38	67	96	150	266	415	604
220	40	70	101	157	279	436	633
240	41	73	105	164	291	455	661
250	42	74	107	168	297	464	675
260	43	76	110	171	303		
280	45	79	114	177	314		
300	46	81	118	184	325		
400	53						
500	60						
600	65						
700	71						
800	75						

Notes:

1. To determine capacity at 10% overpressure multiply the capacity at 25% overpressure by 0.6.
2. Set pressure limit of the 1855 Series is 250 psig as shown by the Grey colored line.
   Set pressure limit of the 1850 Series is 300 psig as shown by the Brown colored line.
   Maximum set pressure Series 1850H is 800 psig. For 1856M Series pressure limits, consult the selection table.

Farris

EFFECTIVE ORIFICE AREAS

(SQ. IN.)

Inlet Size	1850		1850H		1855		1856M	
	Liquids Only	Vapors Gases & Steam	Liquids Only	Vapors Gases & Steam	Liquids Only	Vapors Gases & Steam	Liquids Only	Vapors Gases & Steam
¾	0.098	0.163	—	—	0.098	0.163	—	—
1	0.173	0.280	0.098	0.163	0.173	0.280	0.098	0.163
1½	0.390	0.653	—	—	0.390	0.653	0.250	0.452
2	0.691	1.048	—	—	0.691	1.048	0.390	0.653
2½	—	—	—	—	1.080	1.811	0.691	1.048
3	1.080	1.811	—	—	1.570	2.617	1.080	1.811

Note:
For sizing purposes, the coefficients of discharge K_d are 0.953 for air, gas and vapor, 0.64 for liquids.

kevlar
1.

Du Pont Material Safety Data Sheet

MATERIAL IDENTIFICATION

NAME : KEVLAR* ARAMID FIBER - DU PONT

TRADE NAMES / SYNONYMS :
KEVLAR Aramid Yarn
KEVLAR Aramid Staple
KEVLAR Aramid Pulp
KEVLAR Aramid Floc
KEVLAR Aramid Fabric

DU PONT REGISTRY NUMBER : DP5-73-6
TSCA INVENTORY STATUS : Reported/Included
MANUFACTURER/DISTRIBUTOR: E. I. du Pont de Nemours & Co. (Inc.)
1007 Market Street
Wilmington, DE 19898
Date Prepared: 07/26/89
Preparer: E. A. Merriman
1-800-453-8527
TRANSPORTATION EMERGENCY PHONE : CHEMTREC: 1-800-424-9300
MEDICAL EMERGENCY PHONE : 1-800-441-3637

COMPONENTS

Material		CAS Number	%
Poly(terephthaloylchloride-p-'phenylene diamine):		26125-61-1	>89
Water, absorbed (pulp shipped as wetlap contains up to 35%-50%)	:	7732-18-5	< or =7
Sodium sulfate : in KEVLAR pulp	:	7757-82-6	<0.1
: in other forms	:		<2
Finish	:	None	<2
Wax overlay, in addition to above, on yarn types-960, 978 only	:	8474-43-4	<10

PHYSICAL DATA

Melting Point : Does not melt.
Solubility in Water : Insoluble in water.
Odor : Odorless.
Color : Gold.
Specific Gravity : 1.44
Form : Solid - continuous multi-filament yarns, staple, cut floc, pulp fabric.
% Volatiles : < 9%, water and finish. (<50% water, <.5% finish in wetlap)

kevlar
4
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(HEALTH HAZARD INFORMATION - CONTINUED)

Safety Precautions

Avoid breathing fibers or dust. Follow good industrial hygiene practices for ventilation and clean-up; in particular avoid the use of air jets to blow off equipment; use vacuum cleaners with high efficiency particulate air (HEPA) filters instead.

Do not handle moving threadlines of KEVLAR*, as entanglement with a high strength fiber can severely cut or even sever fingers.

FIRST AID

INHALATION: If large amounts of fibers are inhaled, remove to fresh air. If breathing is difficult, give oxygen, and call a physician

SKIN CONTACT: If fibers irritate the skin, wash with soap and water.

OTECTION INFORMATION

Generally Applicable Control Measures and Procedures

If the fibers or parts made from the fibers are cut or otherwise mechanically worked, dusts and fibers may be generated. Use engineering controls where technically feasible such as isolation, enclosures, exhaust ventilation, wetting, and dust collection systems wherever necessary to control airborne respirable fiber exposures below applicable limits.

Loose fitting clothing that is routinely washed is recommended to reduce build up of fibers at chafing points.

Laser cutting of fabric of KEVLAR or of laminates containing KEVLAR or machining that produces smoke should be well exhausted or ventilated to remove fumes from the workplace.

Water jet cutting of fabric or composites of KEVLAR produces fibrils in the cutting waste. If dried, this waste can become a source of airborne respirable fibers. Rinse or wipe waste from work surfaces and parts.

Personal Protective Equipment

EYE/FACE PROTECTION
When cutting or mechanically working this product, wear safety glasses or coverall goggles.

RESPIRATORS
When cutting or mechanically working this product wear NIOSH/MSHA approved respiratory protection if there is potential for airborne exposures in excess of applicable limits, or if there is potential for irritation of the nasal passages to occur due to the mechanical action of the fibers.

Kevlar
3.
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(HEALTH HAZARD INFORMATION CONTINUED)

ANIMAL DATA (CONTINUED):

respirable content) showed mild fibrosis at concentrations of 25 fibers per cubic centimeter and lung tumors (cystic keratinizing squamous cell carcinomas) in some rats in the group exposed to respirable fibers at concentrations of 100 fibers per cubic centimeter. This is a unique type of tumor not found in humans and may be indicative of a nonspecific biological response to the respirable material rather than an indication of KEVLAR® toxicity. No lung tumors and no fibrosis were seen in animals exposed to 2.5 respirable fibers per cubic centimeter for two years. At no concentrations were fibers found to have migrated beyond the lungs and associated lymph system. Abdominal cavity tumors have been observed in two studies where rats were administered KEVLAR by intra-cavity injection. For additional details, see References.

HUMAN DATA.

Skin sensitization has not been observed in human skin tests. The mechanical action of the fibers may cause slight skin irritation at clothing binding points and mild irritation of the eyes and nasal passages. Overexposure to the respirable fibers by inhalation may cause mild and temporary upper respiratory irritation with discomfort or cough. Based on animal testing, prolonged and repeated exposure to excessive concentrations may cause permanent lung injury.

Workplace exposure measurements: Measured levels of airborne respirable fibrils from handling and processing KEVLAR pulp and filament yarn are typically 0.3 fibrils/cc, or less, 8-Hour Time Weighted Average (TWA). The normally low airborne dust levels result from the inherent tendenc, KEVLAR fibrils to clump together - they have high surface static charges and their branched shapes readily interlock. Staple spinning operations, with their high potential for fiber abrasion can produce levels of 1-3 fibrils/cc unless air handling is well designed and maintained. In all processing of KEVLAR, the use of compressed air to clean equipment can temporarily increase the airborne fibril concentrations markedly. Equipment should be vacuumed or wiped instead.

Carcinogenicity

None of the components in this material is listed by IARC, NTP, OSHA, or ACGIH as a carcinogen. Se Animal Data discussed above.

Exposure Limits for KEVLAR ARAMID FIBER - DU PONT

AEL * (Du Pont)	:	2 respirable fibers/cc (8-Hr. TWA)
TLV ** (ACGIH)	:	None established.
PEL (OSHA)	:	None established.

* AEL is Du Pont's Acceptable Exposure Limit.
** TLV is a registered trademark of the American Congress of Governmental Industrial Hygienists

Other Applicable Exposure Limits:
Exposure Limits for KEVLAR DUST

AEL * (Du Pont)	:	5 mg/m3, Total Dust
TLV ** (ACGIH)	:	None Established.
PEL (OSHA)	:	None Established

Particulates Not Otherwise Regulated

PEL (OSHA)	:	15 mg/m3, Total Dust 5 mg/m3, Respirable Dust

Kevlar
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DISPOSAL INFORMATION

Spill, Leak, or Release

Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean up. Wash, shovel or sweep up and place in solid waste containers. Clean up dusts and fibers with high efficiency particulate air (HEPA) filtered vacuum equipment.

Waste Disposal

KEVLAR® is not a hazardous waste as defined by regulations implementing the Resource Conservation and Recovery Act (RCRA). In general, KEVLAR waste materials may be discarded in accordance with the State and Local regulations governing the disposal of other common or non-RCRA regulated waste materials.

SHIPPING INFORMATION

DOT
Proper Shipping Name : None, non-regulated

STORAGE CONDITIONS

KEVLAR dry pulp should be stored with 4 - 8% absorbed moisture to control static charge.

Storage:
- Boxes of yarn
- Bales of staple
- Bags of pulp
- Rolls of wetlap
- Rolls of fabric

ADDITIONAL INFORMATION AND REFERENCES

This MSDS is provided to comply with provisions of the Hazard Communication Standard (29 CFR 1910.1200).

Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III: KEVLAR contains no toxic chemicals as regulated under section 313 Emergency Planning and Community Right-to-Know Act (EPCRA) of SARA Title III and 40 CFR part 372. KEVLAR is not regulated as hazardous waste under CERCLA and is not subject to the Superfund tax.
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): KEVLAR contains none of the substances known to the State of California to cause cancer or reproductive toxicity.
Pennsylvania and New Jersey Right-to-Know Laws: KEVLAR is not subject to provisions of the Pennsylvania and New Jersey Right-to-Know laws.

References:

Lee, K.P., et al, Toxicology and Applied Pharmacology, 71 (1983), 243-253.
Lee, K.P., et al., Fundamental and Applied Toxicology, 11 (1988), 1-20.
Vu, V.T., Health Hazard Assessment of Non-Asbestos Fibers (Final Draft), Office of Toxic Substances, U.S. Environmental Protection Agency, (May, 1988), 19-21, 152-164.

Mylar
-50-

MATERIAL SAFETY DATA SHEET

SCHARR INDUSTRIES
40 EAST NEWBERRY ROAD
BLOOMFIELD, CT 06002

Date revised: 2/9/94

SCHARR 24 HR. # (203)243-0343

SECTION I - PRODUCT IDENTIFICATION

TRADE NAME: 500 gauge Polyester film metallized (Mylar)
CHEMICAL FAMILY: Polyethylene Terephthalate
FORMULA: N/A
PRIMARY PRODUCT USE: Film industry related products

SECTION II - HAZARDOUS COMPONENTS

INGREDIENT	CAS #	% (BY WT.)	PEL	TLV

THIS PRODUCT IS NOT REGULATED UNDER THE OSHA HAZARD COMMUNICATION STANDARD, 29CFR1910.1200 OR SARA TITLE III

SECTION III - PHYSICAL PROPERTIES

MELTING POINT °F : N/A
SOLUBILITY IN WATER : INSOLUBLE
ODOR : NONE
PERCENT VOLATILE WT. : 0.8
APPEARANCE : METALLIC FILM
STATE : SOLID

SECTION IV - FIRE & EXPLOSION INFORMATION

FLASH PT. °F : +700°F

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may form toxic materials: carbon monoxide & carbon dioxide, carbon compounds.

SPECIAL PRECAUTIONS: Toxic gases may be released during fire. Use positive-pressure, self-contained breathing apparatus and full protective clothing. Handling of this material may cause generation of electrostatic charges and sparking. Use electrical grounding equipment to minimize charge buildup. Avoid dusting. Dust levels can buildup to explosive levels.

EXTINGUISHING MEDIA: Foam or carbon dioxide or dry chemical or Water spray.

SECTION V - HEALTH HAZARD DATA

PERMISSIBLE EXPOSURE LEVEL: NOT DETERMINED
THRESHOLD LIMIT VALUE: NOT DETERMINED

EFFECT OF ACUTE OVEREXPOSURE:

EYES - No specific information. May cause irritation by mechanical contact.
SKIN - No specific information.
BREATHING - No specific information.
Swallowing - No specific information.

FIRST AID:

If exposed to fumes from over heating or combustion, move to fresh air. Consult a physician if symptoms persist.

Wash skin with soap and plenty of water.

Flush eyes with water. Consult a physician if symptoms persist.

If molten polymer contacts skin, cool rapidly with cold water. Do not attempt to pe polymer from skin. Obtain medical attention for thermal burn.

CHRONIC EFFECTS: None are known.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: None are known.

SECTION VI - REACTIVITY DATA

HAZARDOUS POLYMERIZATION: Cannot occur

STABILITY: Stable

INCOMPATIBILITY: Avoid contact with: strong oxidizing agents.

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:

SPILL OR LEAK PROCEDURES: Pick up film to avoid a slipping hazard.

WASTE DISPOSAL: Dispose of in accordance with all Local, State and Federal Regulations.

SECTION VIII - PROTECTIVE EQUIPMENT TO BE USED

RESPIRATORY PROTECTION: Not required.

VENTILATION: Normal ventilation except at temperatures above 235°C where local ventilation may be required.

EYE PROTECTION: Safety goggles or glasses in compliance with OSHA regulations and good industrial safety practices.

OTHER PROTECTIVE EQUIPMENT: None required

SPECIAL PRECAUTIONS: Use good hygiene practices, wash hands after handling, use good housekeeping practices, keep work area clean.

KTeV 1.8m VACUUM WINDOW

PART B

VACUUM AND HYDROSTATIC TESTS

TESTS DOCUMENTATION DATA.

-55

March 21, 1994

TO: R. Dixon - Research Division Head

FROM: J. Misek and W. Smart - KTeV ES&H/QA Review Committee J. Misek / W. Smart

SUBJECT: KTeV 1.8 m Vacuum Window Test Procedure Review Report - Recommendation to Proceed

Pursuant to the Committee charter, a summary report of the compliance status for the KTeV Window Test program - WBS 3.1 is provided. Mechanical aspects were the primary focus of this review, though per the WBS List, electrical and conventional safety aspects were also to be included. The Committee has no electrical or conventional safety concerns for this testing program.

Committee members J. Misek, R. Bossert, E. Haggard, P. Hurh, and W. Smart have reviewed documentation received from KTeV Engineering Staff outlining the testing program and conclude that sound engineering practices have been employed. In addition, the Committee made an inspection walkthru of the test area and viewed the equipment setup. This walkthru was made on 3/2/94 and no deficiencies were noted.

The window testing program does not require adherence to any specific standards set forth in Fermilab's ES&H Manual. The *KTeV E-832 1.8 m Vacuum Window Testing Procedure for Vacuum and Hydrostatic Tests* dated 3/8/94 is made part of this report. See attachment. Please note that the KTeV Engineering Staff and this Committee have agreed that they will observe the Fermilab Pressure Testing Permit formalism (Fermilab ES&H Manual 5034) with one permit to cover all vacuum testing and a second permit to cover the hydrostatic tests.

In making its recommendation to proceed with window testing in accordance with the attached documentation, the Committee would like to include as part of the documentation file W. Smart's calculations and discussion on the vessel movement from window failure.

Please note that the draft version dated March 4, 1994 of the *Window Assembly Procedure* is the current version. A change in the assembly procedure document does not require formal Committee action.

We recommend that you approve this testing program for the KTeV 1.8 m Vacuum Window.

I hereby approve the window testing program for the 1.8 m vacuum window subject to the conditions outlined above.

Roger L. Dixon
3-22-94

cc:
-without attachments-
W. Smart
P. Hurh
R. Bossert
E. Haggard
A. Szymulanski
D. Pushka

Fermilab

Date MARCH 22. 94

EXHIBIT B

Pressure Testing Permit*

Type of Test: VACUUM ~~[ ] Hydrostatic~~ ~~[ ] Pneumatic~~

Test Pressure: 14.7 NEGATIVE psig Maximum Allowable Working Pressure: 45 psig

Items to be Tested 1.8 m KTEV VACUUM WINDOW REF. DWG. 9220.832. MD-285394

Location of Test M.A.B. Date and Time MARCH 28.94 9AM

Hazards Involved RUPTURE OF THE WINDOW COMPONENTS, WHAT MAY GENERATE ABNORMAL SOUND LEVEL. OTHER HAZARDS RELATE TO TYPICAL INDUSTRIAL INSTALLATION WO[RK]

Safety Precautions Taken SEE SUBSECTION 1 OF THIS ELABORATION

Special Conditions or Requirements TESTING PROCEDURE HAS TO BE CONSISTENT WITH: "KTEV 1.8M VACUUM WINDOW OVERVIEW OF TEST PROCEDURE

Test Coordinator ANDREW SZYMULANSKI Dept/Date

Division/Section Safety Officer [signature] for D. Sarlin Dept/Date RD/ES&H 3-22-94

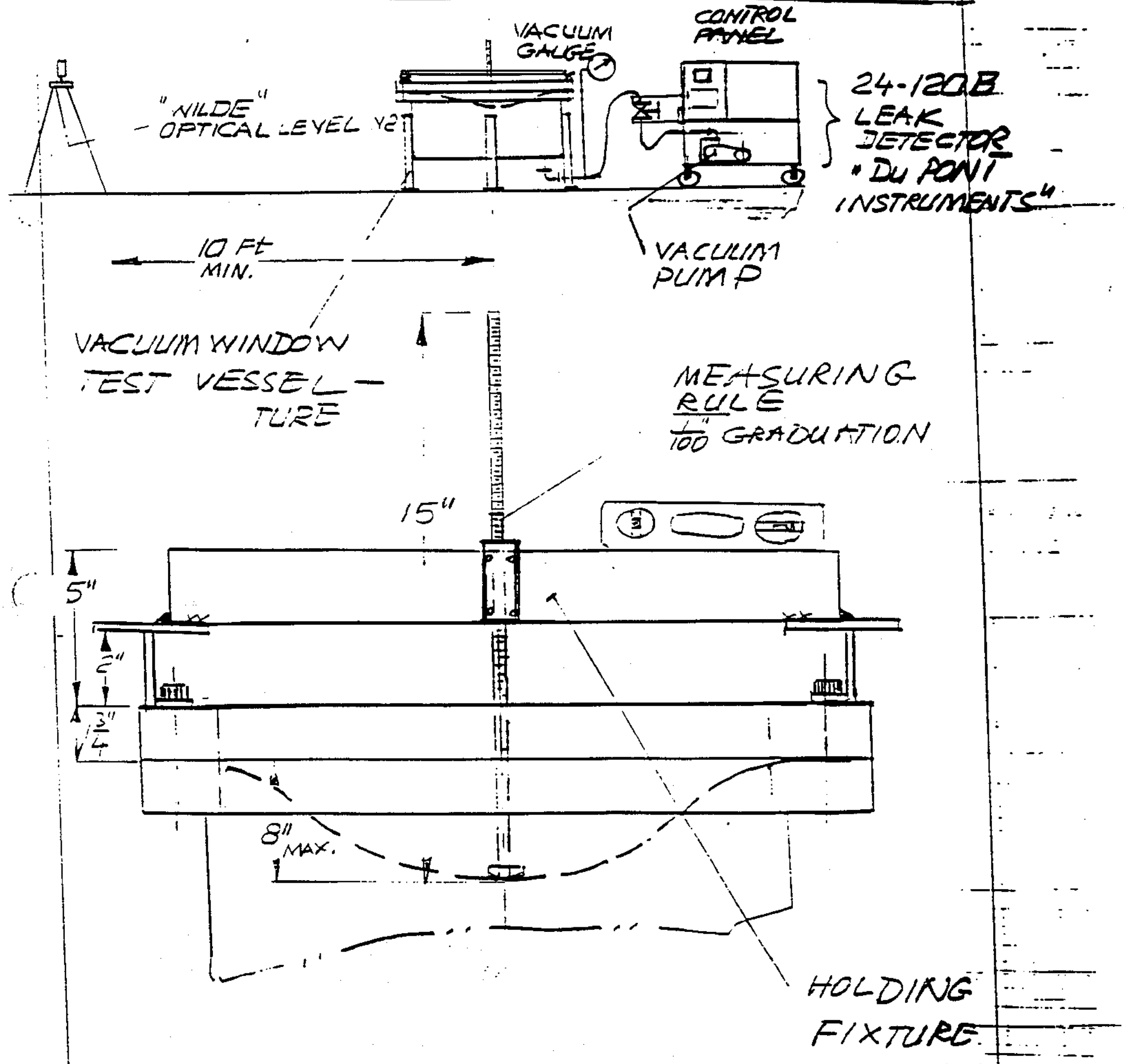
Division/Section Head [signature] Dept/Date RDO 3/23/94

Results

Witness __________ Dept/Date __________
(Safety Officer or Designee)

* Must be signed by division/section safety officer and division/section head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

2. TESTING SYSTEM SCHEMATIC - VACUUM



4B' 59.

R.Currier
A.Szymulanski
March 8,1994

KTeV 1.8m Vacuum Window
Overview of Test Procedure

This test is required to provide a suitable, safe, non metallic vacuum window for the KTeV experiment, which is running during the next fixed target run. To determine if the design of this window meets all of the parameters of the experiment and the KTeV ES&H Review Committee,the following set of tests were devised. The first test, initial pump down, proves that the window design works. The puncture test will give us an idea how the window will fail, if a hole were to develop (material failure), or was accidentally penetrated. The initial pump down and puncture test will require a single pressure test permit. The hydrostatic test is intended to give us an idea of the safety factor of the window and will require a separate pressure test permit. The long duration creep test will give us information on how the window survives or fails over a long period of time. If there are any deviations from expected results during any test, the tests will be stopped until the deviation can be understood then explained in writing to the KTeV ES&H Review Committee, exactly what happened, why, and how it will affect the rest of the test program. Interesting phases of the test should be put on video tape.Present at the beginning of each phase of the tests should be a representative of the ES&H Dept , the KTeV experiment, the KTeV ES&H Review Committee, Don Carpenter and Andrew Szymulanski.

Safety considerations:

A) During the vacuum test, no one will be allowed within 10 feet of the test vessel. This is to be assured by roping off the test area, appropriate signs, (keep-out test in progress), and supervisory vigilance.

B) Safety glasses and safety shoes are requirements of anyone working at MAB. Test observers will be required to wear safety glasses at all times.

C) Hearing protection will be required of all personnel in the building during the initial pump down, subsequent pump downs and during the puncture test only.

1) Make a kevlar and aluminized mylar, sandwiched window, and assemble with flanges etc. as specified on Dwg.# MD-285394 and attached information. Inform Andrew when starting, so the KTeV ES&H Review Committee and the experiment can be notified.

2) Set up for vacuum test as shown on Dwg.#MD-285391 and schematic attached. Arrange for surveyors.

2a) Prepare for pump down by clearing the test area and setting up as specified in A) above.Check for eye and hearing protection and display pressure test permit.

2b) Pump down test chamber to a minimum of 29" Mercury(Hg) and remotely measure and record the deflection of the window every 2 hours.The remote measuring is to be accomplished by using optical surveying instruments looking at the scale mounted in the center of the thin window as shown on page 7B. Shut down overnight and bleed up to atmosphere. Pump down again in the AM recording the deflection every 2 hours. Shut down overnight and bleed up to atmosphere. Pump down again in the AM to 29" Hg then shut down and bleed up to atmosphere.

R.Currier
A.Szymulanski
March 8,1994

3) Using the same window, prepare for puncture test. Follow the design data of sketch 1'.

3a) Prepare for pump down and puncture test by clearing the test area and setting up as specified in A) above.Check for eye and hearing protection and display pressure test permit.

3b) Set up puncture device as shown on attached sketch, start pumping down test chamber. At 29" of Hg.

3c) After double checking all of the appropriate safety precautions, remotely release spear to puncture window.

4) Assuming the first window worked, make a second window and proceed to Hydraulic test. Notify surveyors.

5) Set up for hydrostatic test inside the MAB shop per schematic attached. Assemble test chamber and place 2 legs on a 4 x 4 to elevate bleed valve (as shown on attached sketch).Make sure to display pressure test permit.

5a) Fill test chamber with water (make sure bleed valve is open.) After filled, lift chamber with crane using appropriate slings and rigging techniques. Remove 4 x 4s from under legs.(as shown on attached sketch)

5b) Prepare for hydrostatic test by clearing the test area and setting up as specified in A) above.Check for eye protection.

5c) Pressurize test chamber, as shown in subsection 3, using a ~~hydrostatic water pump~~ BLDG. SUPPLY WATER, to 15psig then carefully measure the window deflection. Continue to add pressure and remotely measure deflection at 5psig increments, to destruction of window or ~~45~~ 40psig whichever comes first. (failure expected at 31psig to 38psig)

5d) Clean up mess. then disassemble window flanges and check window, o-ring, and aluminum ring for irregularities.

6) Using information learned from the fabrication of the first windows, make another window for the long duration, 6 month, creep test.

6a) Find an area in the shop, out of the normal traffic pattern, away from people and well protected from casual contact to set up the test chamber and new window.

6b) Prepare for pump down and long duration creep test by clearing the test area and setting up as specified in A) above.

6c) For the duration of the test, maintain the area to the same degree of security and safety as originally set up.

6d) Test chamber and window are to be under vacuum, with vacuum pump running, 24 hours a day 7 days a week.

6e) Bleed up to atmosphere once per month, over the weekend only.

6f) Record the pressure level in a log at the start and the finish of each working day for the duration of the test. It's not necessary to use a strip chart recorder.

6g) It is possible that the window will creep,or move, or maybe even stretch, over a period of time. The result would be an increase in deflection. If the measured deflection is ever greater than the original by 1/4" notify Andrew.

6h) Remotely measure and record the deflection of the window each day for the first week.

6j) If a measurable change is not indicated during the first week then measure and record the deflection of the window at the end of the first and last day of the second week.

6k) If a measurable change is not indicated at the end of the second week then measure and record the deflection of the window at the end of first day of each week for the duration of the test.

6m) The duration of the test is expected to be 6 months.

6n) If any peculiarities or problems are encountered, call Andrew @ x4870.

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Ktev 1.8 m Kevlar Window #1 Vacuum/Deflection Test

Vacuum Control	:	Jim Humbert
Surveyor	:	Glenda Adkins
Observers	:	Don Carpenter
	:	Andrew Szymulanski
	:	Joe Misek
	:	Dave Erickson
Recorder	:	Pat Richards
Safety	:	Martha HEFLIN
	:	Jennifer HESS

Ktev 1.8 m Kevlar Window #1 Vacuum/Deflection Test

Date : 3/28/94

Time	T-2 Reading (Inches)	N3 Reading (Inches)	Bench Reading (Inches)	Pressure (Torr)	Pressure In. Hg.
9:00 AM	4.5	14.621	4.253		Atmosphere
9:26 AM				580.000	-8
9:27 AM				415.000	-15
9:28 AM				320.000	-20
9:29 AM				240.000	
9:30 AM				135.000	-28
9:31 AM				60.000	-30
9:32 AM				27.000	-30
9:33 AM				9.550	-30
9:34 AM				4.120	-30
9:35 AM				1.800	-30
9:36 AM				0.978	-30
9:37 AM				0.670	-30
9:38 AM				0.597	-30
9:39 AM				0.520	-30
9:40 AM	10.695(?)			0.460	-30
9:41 AM				0.430	-30
9:42 AM				0.408	-30
9:43 AM				0.390	-30
9:44 AM				0.380	-30
9:45 AM				0.366	-30
10:00 AM	10.662				
10:15 AM				0.247	-30
10:45 AM				0.204	-30
11:00 AM	10.742				
11:15 AM				0.182	-30
11:45 AM				0.168	-30
12:00 PM	10.756				
1:00 PM	10.795			0.140	-30
2:00 PM	10.809			0.128	-30
3:00 PM				0.115	-30
3:30 PM	10.817				
4:00 PM	10.827			0.107	-30
4:30 PM				0.104	-30
4:31 PM				0.240	Vacuum Pump Isolated

* Rate of rise 4:30 PM, 3-28-94 to 0800, 3-29-94 = 0.67 T/hr.
(Δ Time = 15.5 hr.)
(Δ Pressure = 10.396 T)

Ktev 1.8 m Kevlar Window #1 Vacuum/Deflection Test

Date : 3/29/94

Time	T-2 Reading (Inches)	N3 Reading (Inches)	Bench Reading (Inches)	Pressure (Torr)	Pressure In. Hg.
8:00 AM		17.704	3.764	11.500	
9:00 AM		17.704			
9:17 AM				755.000	
9:18 AM				625.000	8
9:19 AM				530.000	12
9:20 AM				435.000	16
9:21 AM				325.000	20
9:22 AM				225.000	24
9:23 AM				130.000	28
9:24 AM				49.000	30
9:25 AM				17.600	30
9:26 AM				6.400	30
9:27 AM				2.330	30
9:28 AM				1.030	30
9:29 AM				0.573	30
9:30 AM		17.661		0.405	30
10:15 AM				0.132	30
10:30 AM		17.707			
11:00 AM				0.106	30
11:30 AM		17.722			
11:45 AM				0.093	30
1:00 PM		17.734		0.083	30
2:00 PM				0.078	30
3:00 PM				0.073	30
3:30 PM		17.744			
4:00 PM				0.069	30
4:30 PM		17.749		0.067	30
4:30 PM				0.162	Vacuum Pump Isolated

* Rate of rise 4:30 PM, 3-29-94 to 0800, 3-30-94 = 0.66 T/hr.
(Δ Time = 15.5 hr.)
(Δ Pressure = 10.233 T)

Ktev 1.8 m Kevlar Window #1 Vacuum/Deflection Test

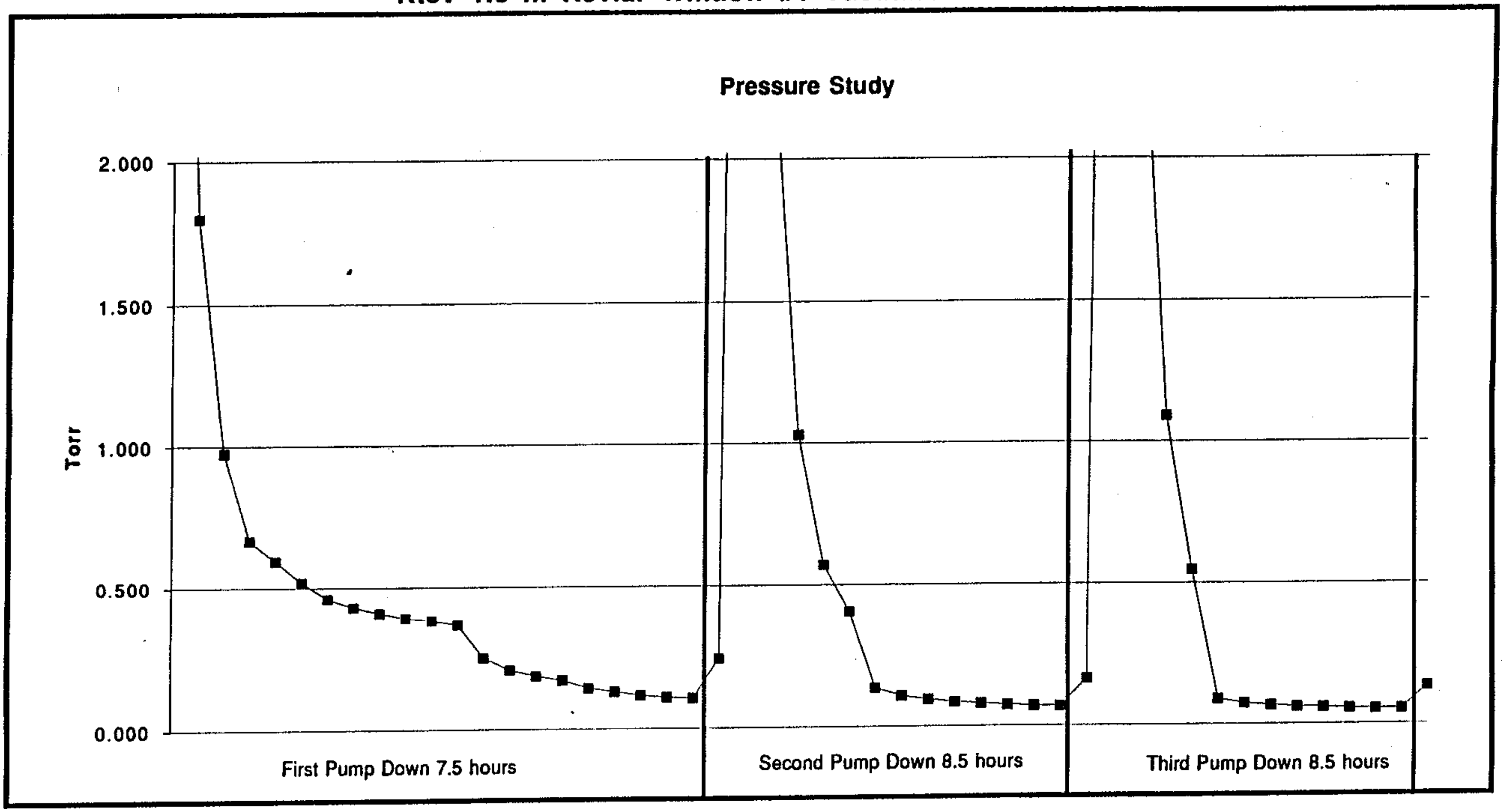
Date : 3/30/94

Time	T-2 Reading (Inches)	N3 Reading (Inches)	Bench Reading (Inches)	Pressure (Torr)	Pressure In. Hg.
8:00 AM		17.778	3.773	10.300	Vacuum Off
8:40 AM		15.846			Atmosphere
8:45 AM				760.000	
8:46 AM				620.000	
8:47 AM				470.000	
8:48 AM				385.000	
8:49 AM				300.000	
8:50 AM				220.000	
8:51 AM				120.000	
8:52 AM				53.000	
8:53 AM				20.400	
8:54 AM				7.500	
8:55 AM				2.600	
8:56 AM				1.090	
8:57 AM				0.550	
9:00 AM		17.724			
9:02 AM		17.736			
10:00 AM				0.088	
11:00 AM		17.778		0.073	
12:00 PM				0.066	
1:00 PM				0.061	
1:05 PM		17.783			
2:00 PM				0.058	
3:00 PM		17.787		0.055	
4:00 PM				0.053	
4:30 PM				0.053	
4:30 PM		17.791	3.774	0.131	Vacuum Pump Isolated

Time	T-2 Reading (Inches)	N3 Reading (Inches)	Bench Reading (Inches)	Pressure (Torr)	Pressure In. Hg.
8:15 AM		17.798	3.772	9.600	
9:13 AM		16.196	3.772		

* Rate of rise 4:30 PM, 3-30-94 to 0800, 3-31-94 = 0.612 T/hr.
(Δ Time = 15.5 hr.)
(Δ Pressure = 9.547 T)

Ktev 1.8 m Kevlar Window #1 Vacuum/Deflection Test



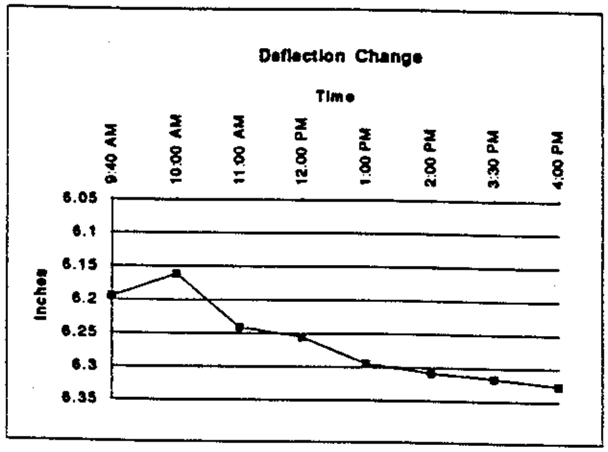
Ktev 1.8 m Kevlar Window #1 Vacuum/Deflection Test

67.

March 28, 1994 First Pump Down
Scale Readings in Inches of Deflection

Time	Readings
9:00 AM	4.5
9:40 AM	10.695
10:00 AM	10.662
11:00 AM	10.742
12:00 PM	10.756
1:00 PM	10.795
2:00 PM	10.809
3:30 PM	10.817
4:00 PM	10.827

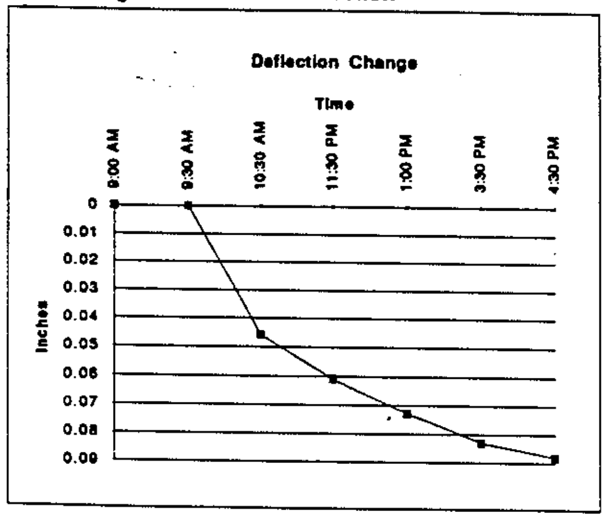
Time	Change in Inches
9:00 AM	
9:40 AM	6.195
10:00 AM	6.162
11:00 AM	6.242
12:00 PM	6.256
1:00 PM	6.295
2:00 PM	6.309
3:30 PM	6.317
4:00 PM	6.327



March 29, 1994 Second Pump Down
Scale Readings in Inches of Deflection

Time	Readings
8:00 AM	17.704
9:00 AM	17.704
9:30 AM	17.661
10:30 AM	17.707
11:30 PM	17.722
1:00 PM	17.734
3:30 PM	17.744
4:30 PM	17.749

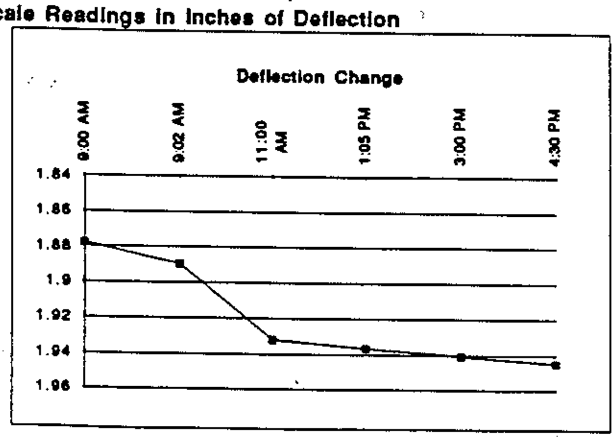
Time	Change in Inches
8:00 AM	
9:00 AM	0
9:30 AM	0
10:30 AM	0.046
11:30 PM	0.061
1:00 PM	0.073
3:30 PM	0.083
4:30 PM	0.088



March 30, 1994 Third Pump Down
Scale Readings in Inches of Deflection

Time	Reading
8:00 AM	17.778
8:40 AM	15.846
9:00 AM	17.724
9:02 AM	17.736
11:00 AM	17.778
1:05 PM	17.783
3:00 PM	17.787
4:30 PM	17.791

Time	Inches
9:00 AM	1.878
9:02 AM	1.89
11:00 AM	1.932
1:05 PM	1.937
3:00 PM	1.941
4:30 PM	1.945



TESTS :
(4) AUGUST 23. 94
(3) AUGUST 1. 94
(2) JULY 18. 94
(1) JUN 27. 94

Fermilab

Date JUN. 27, 94

EXHIBIT B

Pressure Testing Permit*

STEEL VESSEL 45psi
WINDOW ASSEMBLY 40

Type of Test: [✓] Hydrostatic [ ] ~~Pneumatic~~

Test Pressure: 40 psig Maximum Allowable ~~Working Pressure:~~ 45 ~~psig~~

Items to be Tested 1.8m VACUUM WINDOW
REF. DWG. 9220.832.MD-285394

Location of Test M.A.B. Date and Time

Hazards Involved FAILURE OF THE TESTED COMPONENTS; FLYING DEBRIS

Safety Precautions Taken
SEE SUBSECTION 1 OF:
KTEV E-832 1.8m VACUUM WINDOW TESTING PROCEDURE

Special Conditions or Requirements TESTING PROCEDURE HAS TO BE CONSIST. WITH : "KTEV 1.8m VACUUM WINDOW OVERVIEW OF TEST PROCEDURE"

Test Coordinator ANDREW SZYMULANSKI Dept/Date

Division/Section Safety Officer [signature] Dept/Date 23 June 94

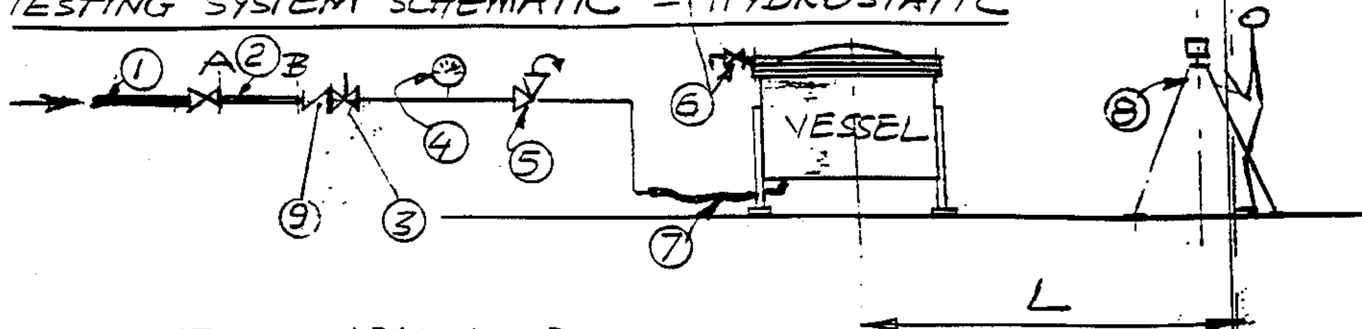
Division/Section Head [signature] Dept/Date 6/23/94

Results

Witness Dept/Date
(Safety Officer or Designee)

* Must be signed by division/section safety officer and division/section head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

3. TESTING SYSTEM SCHEMATIC – HYDROSTATIC



1. MAB. WATER SUPPLY LINE
   MAX. PRESSURE 65 [psi]
2. WATER FLOW CAPACITY CONTROL
   SECTION "A – B" 1/8" SCH 40 PIPE
   INSIDE DIA : 0.269"
3. METERING VALVE 1/4" NPT
   PARKER: 1/4-4M-V4LN-3
4. PRESSURE GAUGE
   "WEISS" 0 TO 100 psi
5. RELIEF VALVE (WATER)
   SET PRESSURE 40 psiG
   CAPACITY 18 GAL/min
   @ 10% OVERPRESSURE
   TELEDYNE-FARRIS TYPE 1850, 1"/1 1/2"
6. BLEED VALVE
7. FLEXIBLE HOSE
   1/4", 400 psi RATING
8. WILDE OPTICAL LEVEL N2
9. CHECK VALVE
   3/8" NPT

DIMENSION "L" HAS TO BE LARGER OR EQUAL 10 Ft FOR VACUUM TEST BUT MAY BE CLOSER THAN 10 FOR HYDROSTATIC TEST.

- DETERMINE THE FLOW RATE IN 1/8" PIPE, SECTION "A–B" (ITEM 2).

GIVEN DATA: MAX. PRESSURE IN THE M.A.B. SUPPLY LINE = 65 [psiG]

INSIDE DIA OF THE "A–B" SECTION $d = 0.269"$

ASSUMED NO FRICTION IN THE PIPE.

$p = 65\,psi = 150\ Ft\ of\ H_2O$

FROM BERNOULIS EQUATION:

$$\frac{v^2}{2g} = 150$$

v – WATER VELOCITY IN THE PIPE
g – GRAVITY ACCELERATION

$$v = \sqrt{150(2)\,32.2}$$

$$v = 98.28\ Ft/sec$$

FLOW CAPACITY:

$$Q = A \cdot v$$

$$A = \frac{\pi d^2}{4} = 0.00039\,[Ft^2]$$

$$Q = 0.0383\,\left[\frac{Ft^3}{sec}\right] = 17.2\ GAM$$

1.8m KTEV WINDOW HYDROSTATIC TEST

PARKER - METERING VALVE / TYPE:

1/4 - 4M - V4LN - B

Needle valve
orifice 0.176"

IN LINE C_v 0.4

ΔP psid	10	50	100	MPA
GPM	1.27	2.8	4.0	

Hydro Test #1 on 1.8 m. Kevlar Window

Date 6/27/94

Raw Data

Time	Scale reading	Pressure	Change
10:07 AM	13.748	0.0 lbs.	
10:51 AM	10.832	5.0 lbs.	2.916
10:55 AM	9.735	10.0 lbs.	1.097
10:59 AM	8.978	14.7 lbs.	0.757
11:01 AM	8.846	16.0 lbs.	0.132
11:04 AM	8.635	18.0 lbs.	0.211
11:08 AM	8.413	20.0 lbs.	0.222
11:09 AM	8.386		0.027
11:10 AM	8.227	22.0 lbs.	0.159
11:12 AM	8.052	24.0 lbs.	0.175
11:13 AM	7.892	26.0 lbs	0.160
	Failed before read	28.0 lbs.	

5.856

Flange Reading	14.668
Flange Width	1.75
Total reading	16.418

Teflon foot= 0.335

Total Distance with Teflon Foot
14.083
11.167
10.070
9.313
9.181
8.970
8.748
8.721
8.562
8.387
8.227

Total change from o lbs. pressure to 26.0 lbs pressure was 5.856 inches.

*All readings and measurements taken in inches.

Second Hydro Test on 1.8 m. Kevlar Window

Date 7/18/94

Raw Data

Flange Reading	Time	Scale reading	Pressure	Change
14.188	10:30 AM	13.265	0	0.000
14.185	10:43 AM	10.460	5	2.805
14.181	10:49 AM	9.217	10	1.243
14.179	10:51 AM	8.483	14.7	0.734
14.178	10:56 AM	8.317	16	0.166
14.176	11:02 AM	8.093	18	0.224
14.174	11:08 AM	7.874	20	0.219
14.174	11:15 AM	7.678	22	0.196
14.171	11:27 AM	7.483	24	0.195
14.171	11:38 AM	7.309	26	0.174
	11:50 AM	7.139	28	0.170
14.188	approx. 11:50:10	7.089	*	0.050

* Reading just after Kevlar Broke

Flange Reading	14.188
Flange Width	1.75
Total reading	15.938

Teflon foot= 0.335

Pressure	Total Distance with Teflon Foot
0	2.338
5	5.143
10	6.386
14.7	7.120
16	7.286
18	7.510
20	7.729
22	7.925
24	8.120
26	8.294
28	8.464

Total change from o lbs. pressure to 28.0 lbs pressure was 6.126 inches.

R.L. Smith

* All readings and measurements taken in inches.

Third Hydro Test on 1.8 m. Kevlar Window

Date 8/1/94

Scale Readings			Time	Scale Reading	Pressure	Change
A	B	C				
14.219	14.195	14.210	10:31 AM	13.139	0 PSIG	0.000
14.207	14.200	14.203	10:55 AM	10.049	5 PSIG	3.090
14.199	14.206	14.205	11:10 AM	9.038	10 PSIG	1.011
14.191	14.206	14.207	11:13 AM	8.319	14.7 PSIG	0.719
14.190	14.212	14.210	11:18 AM	8.153	16 PSIG	0.166
14.187	14.214	14.210	11:23 AM	7.935	18 PSIG	0.218
14.186	14.215	14.210	11:28 AM	7.759	20 PSIG	0.176
14.184	14.218	14.212	11:34 AM	7.591	22 PSIG	0.168
14.181	14.218	14.212	11:45 AM	7.415	24 PSIG	0.176
* 14.207	14.191	14.196	11:49 AM	7.364	2 PSIG	0.051

* Kevlar failed, but Mylar held.

Average Flange Reading 14.208
Flange Width 1.75 Teflon foot= 0.335
Total reading 15.958

Pressure Reading	Total Distance with Teflon Foot
0 PSIG	2.358
5 PSIG	5.574
10 PSIG	6.586
14.7 PSIG	7.304
16 PSIG	7.470
18 PSIG	7.688
20 PSIG	7.864
22 PSIG	8.032
24 PSIG	8.208
* 2 PSIG	8.259

* Kevlar failed, but Mylar held.

Total change from 0 lbs. pressure to 24.0 lbs pressure was 5.775

G.K. Adkins

* All readings and measurements taken in inches.

Fourth Hydro Test on 1.8 m. Kevlar Window

Date 8/23/94

Scale Readings			Time	Scale Reading	Pressure	Change
A	B	C				
14.168	14.154	14.188	1:25 PM	13.543	0	0.000
14.170	14.159	14.180	1:49 PM	10.316	5	3.227
14.173	14.161	14.169	1:55 PM	9.158	10	1.158
14.174	14.163	14.161	2:04 PM	8.399	14.7	0.759
14.174	14.165	14.158	2:07 PM	8.223	16	0.176
14.175	14.165	14.155	2:10 PM	7.992	18	0.231
14.176	14.167	14.152	2:12 PM	7.807	20	0.185
14.176	14.167	14.149	2:16 PM	7.616	22	0.191
14.177	14.168	14.147	2:20 PM	7.43	24	0.186
14.175	14.169	14.143	2:27 PM	7.249	26	0.181
14.179	14.168	14.141	2:34 PM	7.085	28	0.164

Average Flange Reading 14.17
Flange Width 1.75 Teflon foot= 0.335
Total reading 15.92

Pressure Reading	Total Distance with Teflon Foot
0	0.000
5	3.562
10	1.493
15	1.094
16	0.511
18	0.566
20	0.520
22	0.526
24	0.521
26	0.516
28	0.499

Total change from 0 lbs. pressure to 28.0 lbs pressure was 6.458

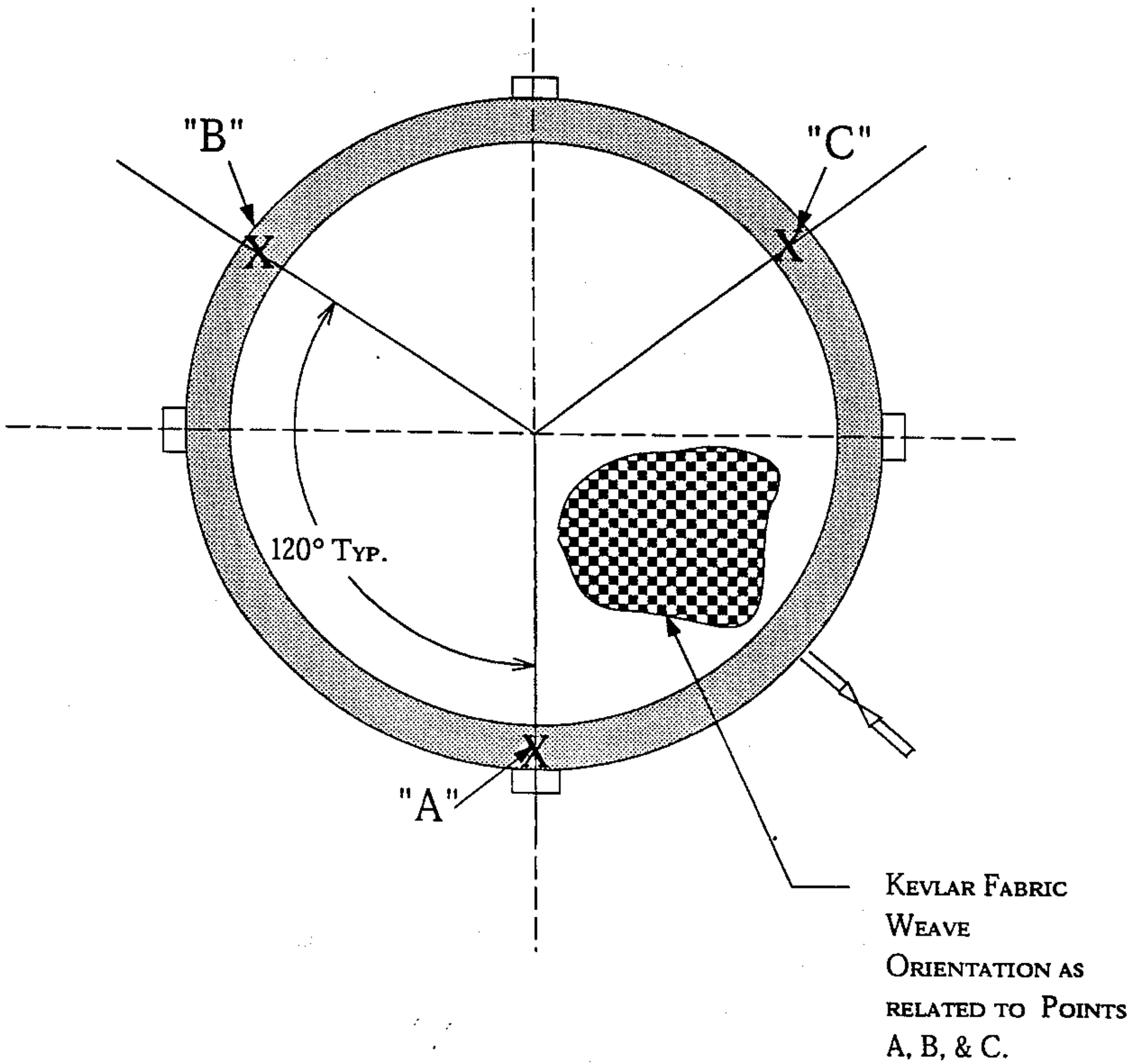
C Bradford
Revised: 8/29/94

* All readings and measurements taken in inches.

FOURTH HYDRO TEST KTEV VACUUM WINDOW

AUGUST 25, 1994

1 KEVLAR ORENTATION
2. DEFLECTION OF THE FLANGE.



KTeV 1.8m VACUUM WINDOW

PART C

1,8 m VACUUM WINDOW
VACUUM PUNCTURE TEST

-78

Fermilab

Date APRIL 18, 94

EXHIBIT B

Pressure Testing Permit*

VACUUM PUNCTURE TEST.

Type of Test: [ ] Hydrostatic [ ] Pneumatic

Test Pressure: 14.7 NEGATIVE psig Maximum Allowable Working Pressure: 45 psig

Items to be Tested 1.8m VACUUM WINDOW

SEE. DWG. 9220.232.MD-285394

10

Location of Test M.A.B. Date and Time APRIL 21. 94

Hazards Involved RUPTURE OF THE WINDOW COMPONENTS ← We... hear...

WHAT MAY GENERATE ABNORMAL SOUND LEVEL. RD ES&H to measure level.

OTHER HAZARDS RELATED TO TYPICAL INDUSTRIAL INSTALLATION

Safety Precautions Taken

SEE. SUBSECTION 1 OF "1.8m VACUUM WINDOW TESTING PROCEDURE FOR VACUUM AND HYDROSTATIC TESTS

Special Conditions or Requirements TESTING PROCEDURE HAS TO BE CONS... WITH: "KTEV 1.8m VACUUM WINDOW OVERVIEW OF TEST PROCEDURE" – PUNCTURE TEST.

Test Coordinator ANDREW SZYMULANSKI Dept/Date

Division/Section Safety Officer [signature] Dept/Date 18 April 94

Division/Section Head [signature] Dept/Date 4/19/94

Results

SEE: "RESULTS OF 1.8m VACUUM WINDOW PUNCTURE TEST"

Witness __________ Dept/Date __________

(Safety Officer or Designee)

*Must be signed by division/section safety officer and division/section head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

RESULTS OF THE 1.8m VACUUM
WINDOW PUNCTURE TEST

a) THE WINDOW MYLAR / KEVLAR SANDWICH WAS PUNCTURED BY AN ARROW, CAUSING SUDDEN RUPTURE OF THE COMPOSITE MATERIALS, AS PICTURED ON THE PHOTOGRAPH "FNAL 94-485-1"
THE ARROW WAS DESIGNED IN A WAY TO CREATE A FULL PENETRATION INTO MYLAR / KEVLAR COMPOSITION.
THE FIXTURE TO WHICH THE WINDOW WAS BOLTED, WAS NO ANCHORED TO THE FLOOR.
SLIGHT DISLOCATION OF THE FIXTURE WAS NOTICED, AFTER IMPACT.

b) KTeV VACUUM WINDOW ENGINEERING NOTE "WBS #'S 1.1.1.4 TO 1.1.1.9
ENGINEERING ANALYSIS REPORT (EAR) # 121
FAILURE ANALYSIS FOR 1.8m VACUUM WINDOW
KTeV By Ang Lee
DISCUSSES THE THEORETICAL ASPECTS OF THE TEST