WINDOW MATERIAL AND FABRICATION ISSUES AND PLANS

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University of Mississippi – Oxford

Absorber Review
Neutrino Factory and Muon Collider Collaboration
~~Comitium WH2SE — Beauty Parlor WH12NW~~
Fermi National Accelerator Laboratory
Batavia, Illinois
21–22 February 2003

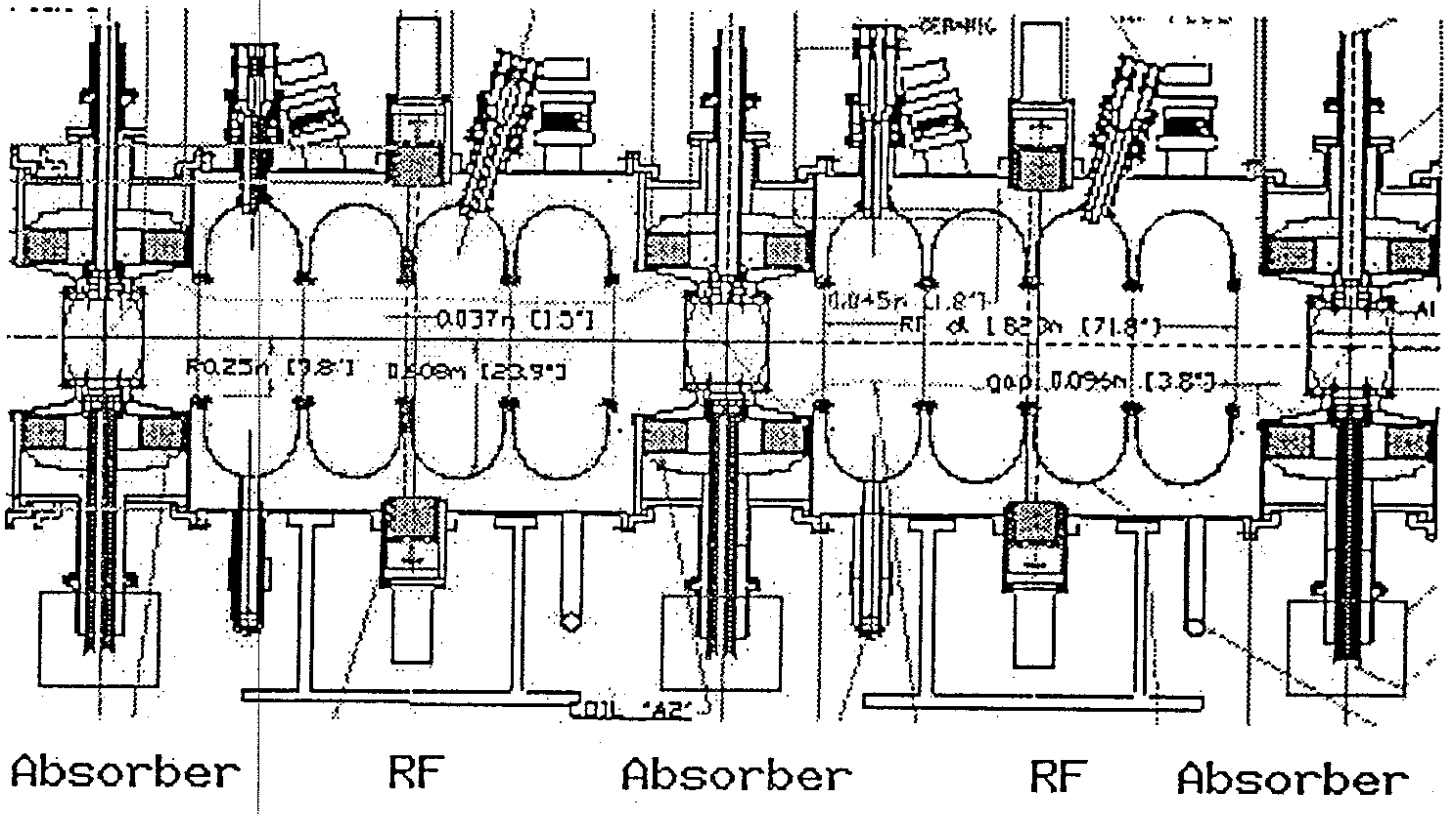
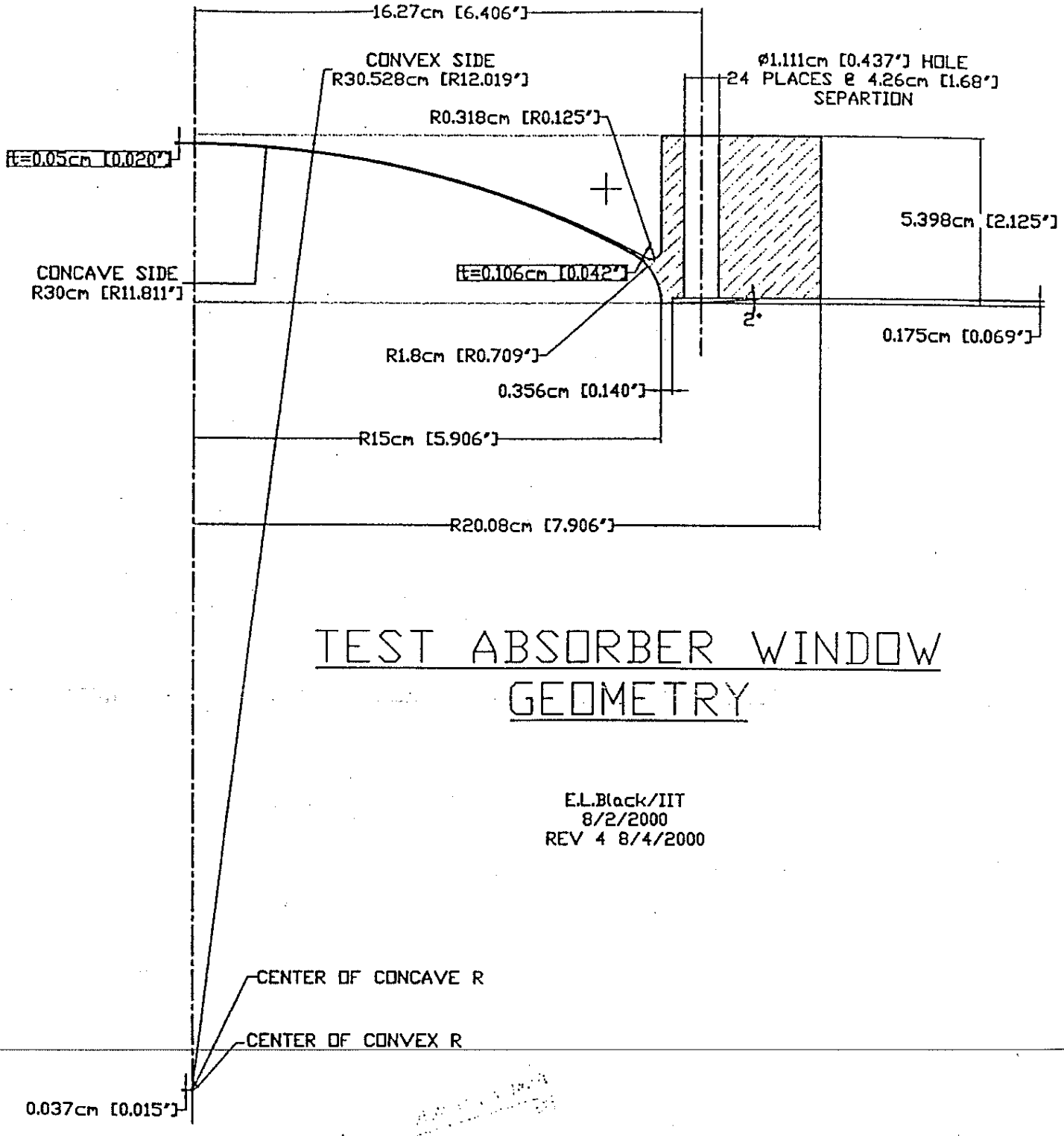


Fig. 1. SFOFO cooling channel design. A 5.5 m long section is shown, consisting of two 200 MHz four-cell cavities interleaved with three liquid hydrogen absorbers.

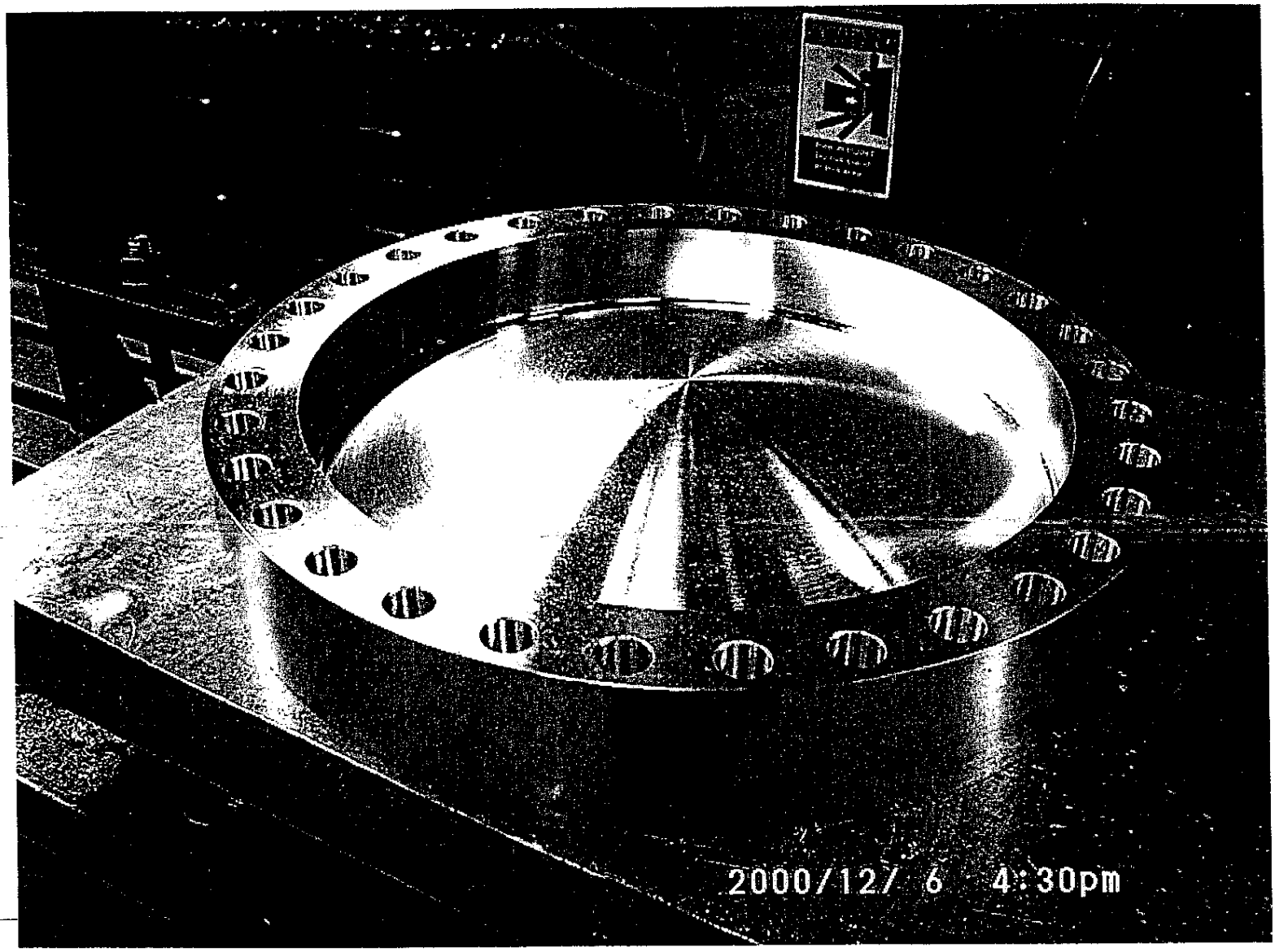
$$\frac{d\epsilon_n}{ds} = -\frac{1}{\beta^2}\frac{dE_\mu}{ds}\frac{\epsilon_n}{E_\mu} + \frac{1}{\beta^3}\frac{\beta_\perp (0.014\,\mathrm{GeV})^2}{2E_\mu m_\mu L_R},$$

where s is the path length, E_μ the muon energy, L_R the radiation length of the absorber medium, $\beta = v/c$, and $\beta_\perp$ is the betatron function of the beam (where the size of the beam is given by $\sigma_x = \sigma_y = \sqrt{\epsilon_n \beta_\perp / \beta\gamma}$).



TEST ABSORBER WINDOW GEOMETRY

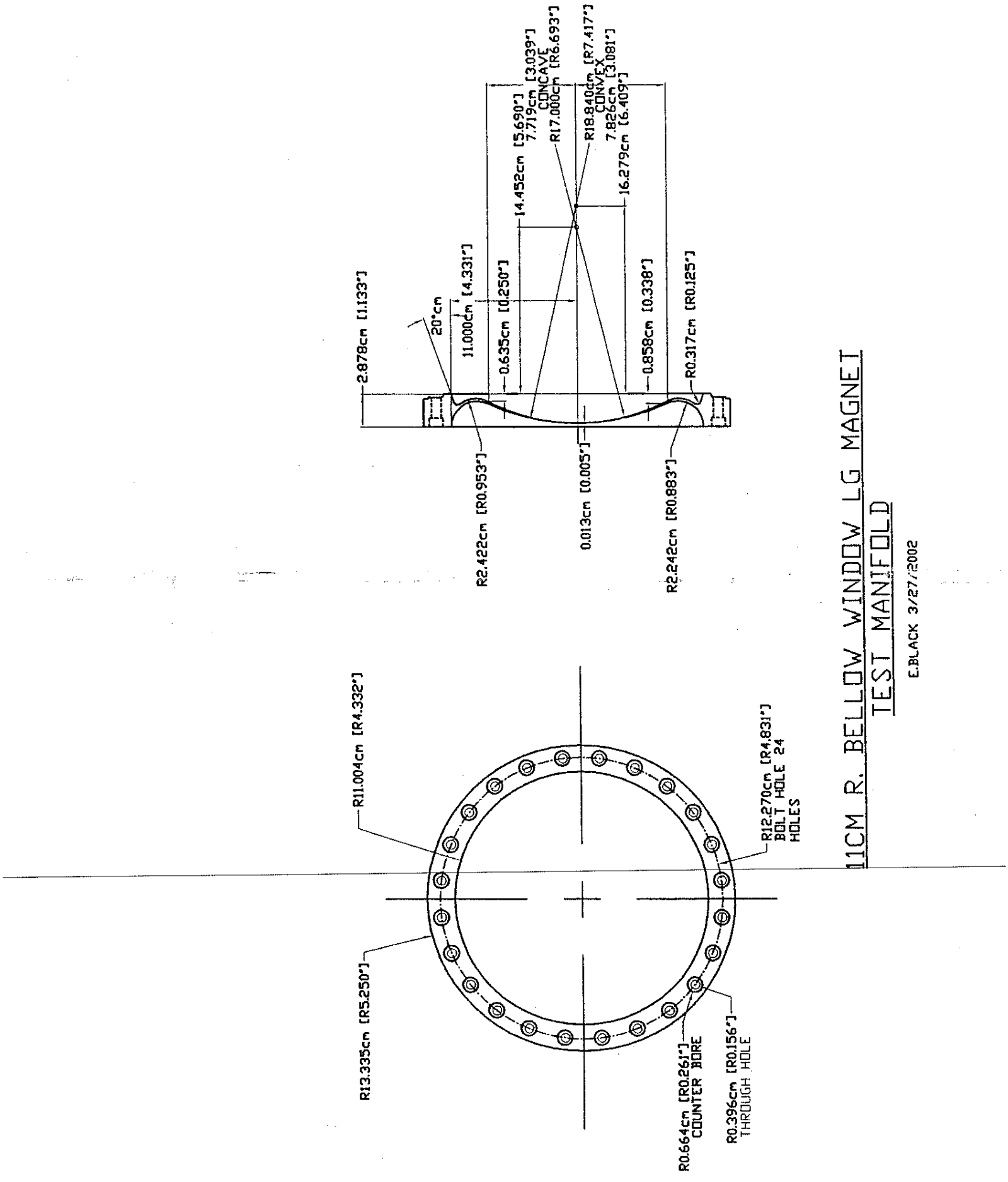
E.L.Black/IIT
8/2/2000
REV 4 8/4/2000

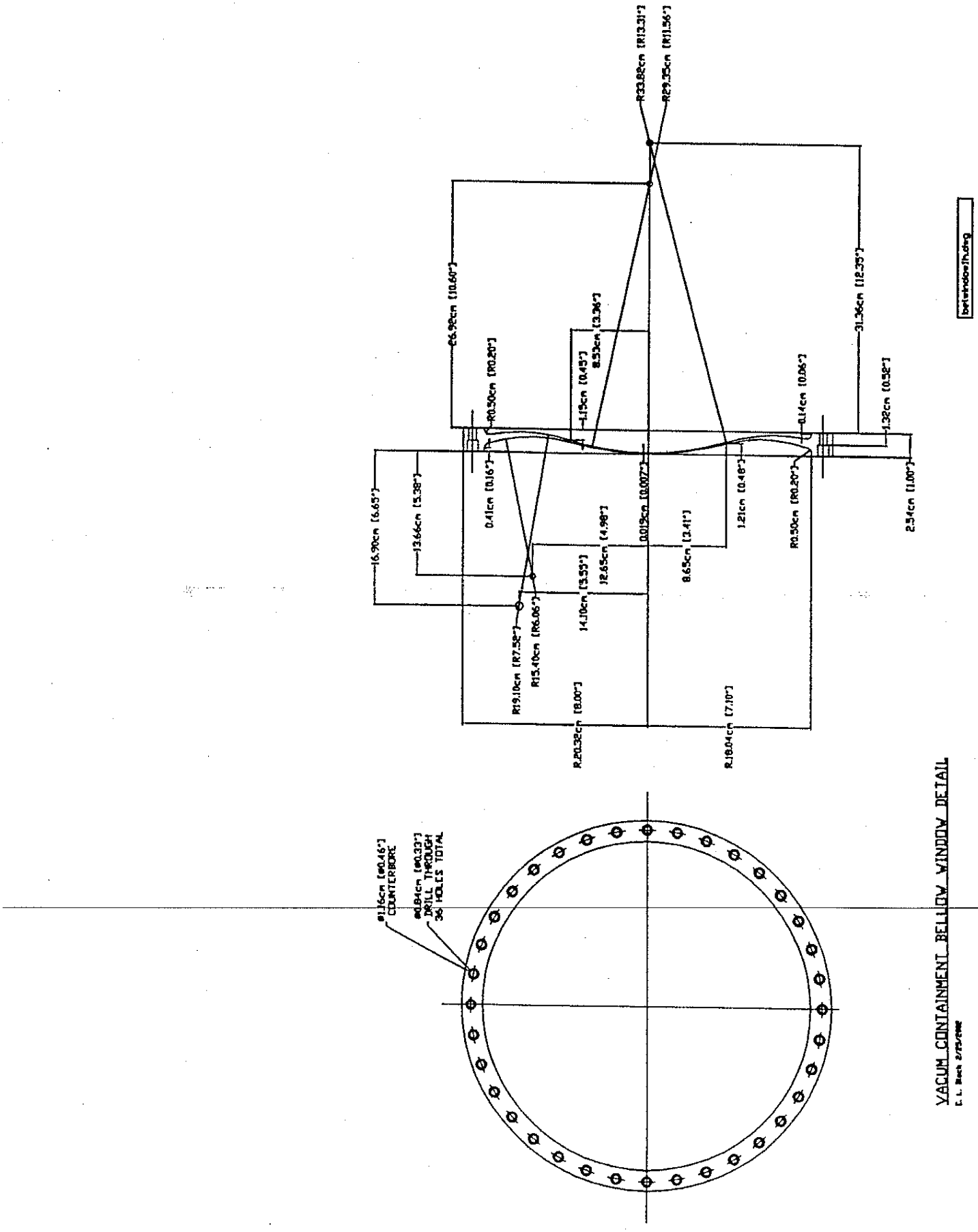

2000/12/ 6 4:30pm

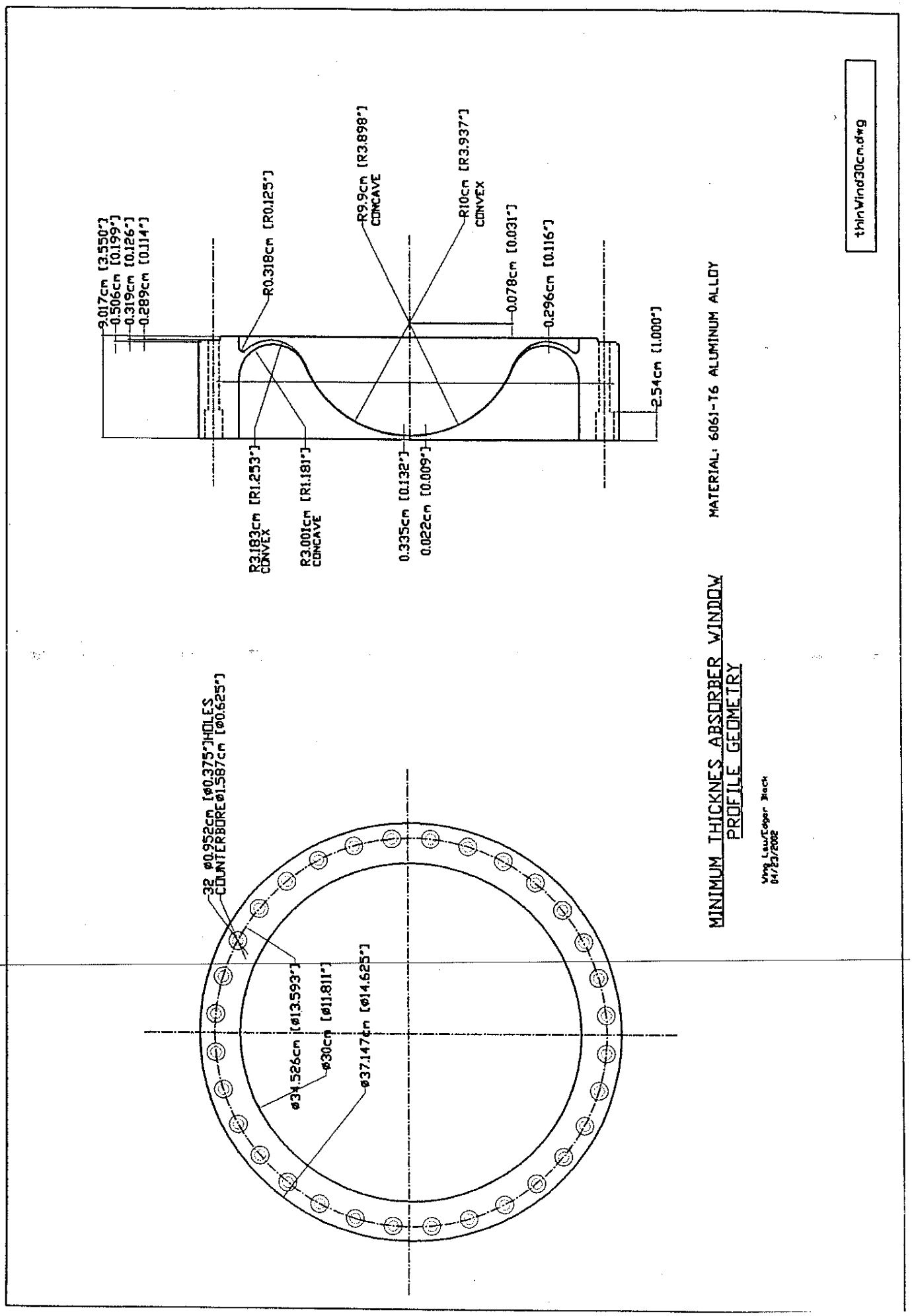
Summary of burst pressures and thicknesses

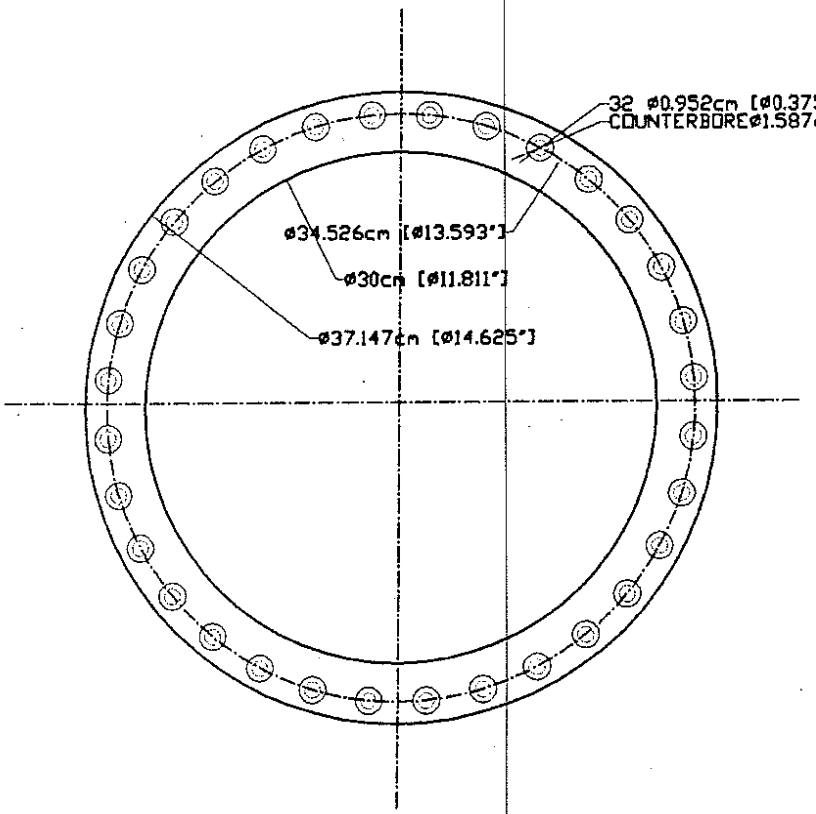
Window number	Temperature	Measured burst pressure (psi)	FEA burst pressure (psi) design thickness=127um	Photogrammetry thickness(u
1	room	43.5	na	na

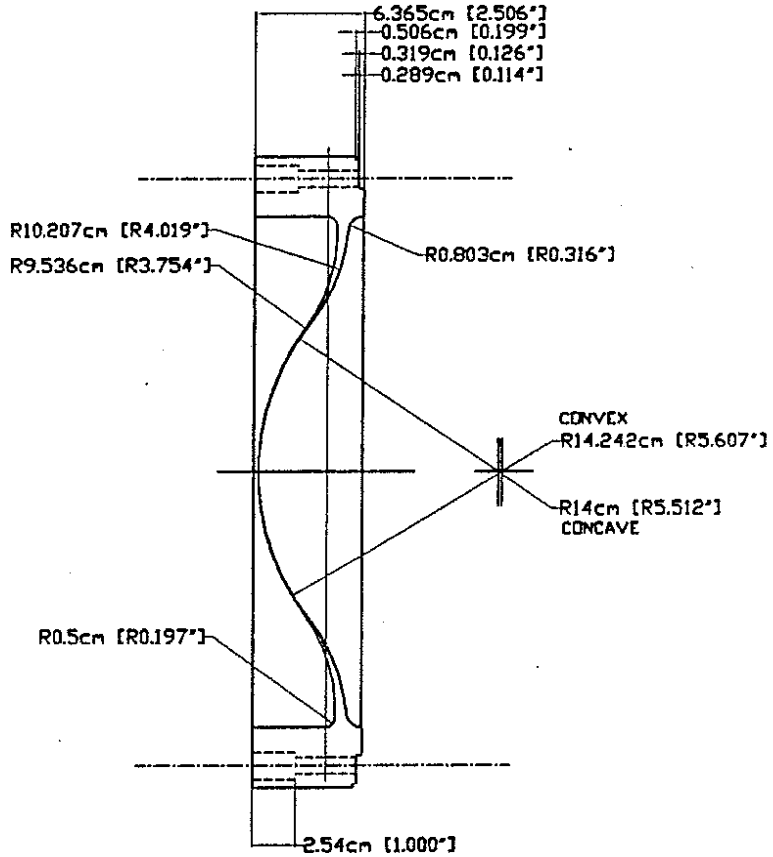
Window number	Temperature	Measured burst pressure (psi)	FEA burst pressure (psi) design thickness=330um	Photogrammetry thickness(u
2	room	119	117	na
3	room	120	117	na
4	LN	151	156	331.6


11CM R. BELLOW WINDOW LG MAGNET
TEST MANIFOLD
E.BLACK 3/27/2002
2.878cm [1.133"]
20°cm
11.000cm [4.331"]
0.635cm [0.250"]
14.452cm [5.690"]
7.719cm [3.039"]
CONCAVE
R17.000cm [R6.693"]
R18.840cm [R7.417"]
CONVEX
7.826cm [3.081"]
16.279cm [6.409"]
0.858cm [0.338"]
R0.317cm [R0.125"]
R2.422cm [R0.953"]
0.013cm [0.005"]
R2.242cm [R0.883"]
R11.004cm [R4.332"]
R12.270cm [R4.831"]
BOLT HOLE 24
HOLES
R13.335cm [R5.250"]
R0.664cm [R0.261"]
COUNTER BORE
R0.396cm [R0.156"]
THROUGH HOLE


R33.82cm [R13.31"]
R29.35cm [R11.56"]
16.98cm [6.68"]
31.36cm [12.35"]
R0.50cm [R0.20"]
1.15cm [0.45"]
8.53cm [3.36"]
0.14cm [0.06"]
1.32cm [0.52"]
0.41cm [0.16"]
0.019cm [0.007"]
1.21cm [0.48"]
R0.50cm [R0.20"]
2.54cm [1.00"]
16.90cm [6.65"]
13.64cm [5.38"]
12.65cm [4.98"]
8.65cm [3.41"]
14.10cm [5.55"]
R19.10cm [R7.52"]
R15.40cm [R6.06"]
R20.32cm [8.00"]
R18.04cm [7.10"]
ø1.16cm [ø0.46"] COUNTERBORE
ø0.84cm [ø0.33"] DRILL THROUGH 36 HOLES TOTAL
bellwindow1h.dwg
VACUM CONTAINMENT BELLOW WINDOW DETAIL


thinWind30cm.dwg
MINIMUM THICKNES ABSORBER WINDOW
PROFILE GEOMETRY
Ying Lau/Roger Stock
04/23/2002
MATERIAL: 6061-T6 ALUMINUM ALLOY
9.017cm [3.550"]
0.506cm [0.199"]
0.319cm [0.126"]
0.289cm [0.114"]
R0.318cm [R0.125"]
R9.9cm [R3.898"]
CONCAVE
R10cm [R3.937"]
CONVEX
0.078cm [0.031"]
0.296cm [0.116"]
2.54cm [1.000"]
R3.183cm [R1.253"]
CONVEX
R3.001cm [R1.181"]
CONCAVE
0.335cm [0.132"]
0.022cm [0.009"]
32 ø0.952cm [ø0.375"]HOLES
COUNTERBORE ø1.587cm [ø0.625"]
ø34.526cm [ø13.593"]
ø30cm [ø11.811"]
ø37.147cm [ø14.625"]





MINIMUM THICKNESS ABSORBER WINDOW PROFILE GEOMETRY

MATERIAL: 6061-T6 ALUMINUM ALLOY

Ying Lau/Edgar Black
04/23/2002

thinWind1130cm.dwg

A MODERN AIRCRAFT ALUMINUM ALLOY

Aluminum Alloy Name	Composition % by weight	Density g/cc	Yield Strength ksi 300K	Tensile Strength ksi 300K	Tensile Strength ksi 20K	Radiation Length cm
6061-T6	1.0Mg .6Si .3Cu .2Cr	2.70	40	45	68	8.86
2090-T81	2.7Cu 2.2Li .12Zr	2.59	74	82	120	9.18

Alloying Element Name	Z	A	Density	Radiation_Length(cm)
Lithium	3	6.94	0.534	155.
Magnesium	12	24.30	1.74	14.4
Aluminum	13	26.98	2.70	8.89
Silicon	14	28.08	2.33	9.36
Chromium	24	51.99	7.19	2.08
Copper	29	63.55	8.96	1.43
Zirconium	40	91.22	6.53	1.56

2195 Al-Li

McCOOK METALS

McCook Metals L.L.C.
4900 First Avenue
McCook, IL 60525-3294
Phone 1.800.462.9838
Outside U.S. 708.485.90
Fax 1.800.338.9180 or
708.387.8182
www.mccookmetals.con

2195 Low Density / High Strength Aluminum-Lithium Alloy

TECHNICAL DATA

Product Availability[1]

Thickness Range	Up to 2.0 inches	(50 mm)
Widths	Up to 132 inches	(3.4 m)
Lengths	Up to 550 inches	(13.9 m)

[1]Plate sizes are subject to inquiry. Extrusion and Forging billets are also available.

Mechanical Properties[2]

	U.S. Customary Units	Metric Units
Ultimate Strength		
L	87 ksi	600 MPa
LT	86 ksi	593 MPa
ST	85 ksi	586 MPa
Yield Strength		
L	84 ksi	579 MPa
LT	81 ksi	558 MPa
ST	74 ksi	510 MPa
Elongation		
L	10%	10%
LT	8%	8%
ST	4%	4%
Fracture Toughness		
L-T	24 ksi ^in	27 MPa ^ m
T-L	23 ksi ^ in	26 MPa ^ m
S-L	20 ksi ^ in	22 MPa ^ m
Tensile Elastic Modulus		
L	11 Msi	76 GPa
Density	0.0975 lbs/inch^3	(2.71 g/cm^3)
Stress Corrosion	≥45 ksi for 10 days per ASTM G47	

[2]Material available to applicable customer specifications. Data reflects typical 1.5-Inch 2195-T8XX Plate data.

2195 Al-Li

McCook Metals Aircraft/Aerospace Alloys

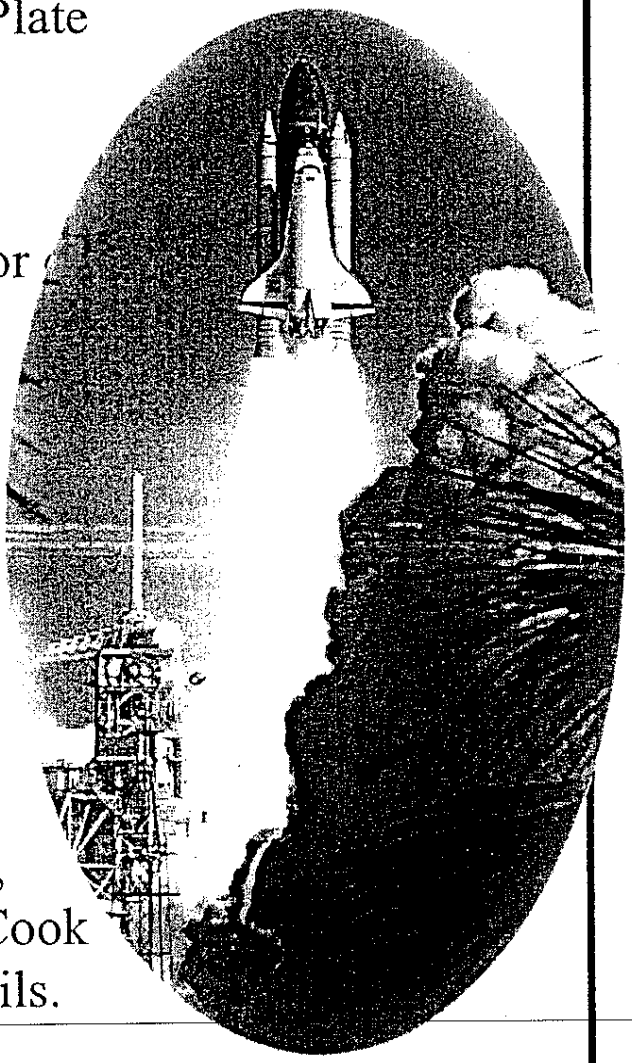
McCOOK METAL

For applications that require high strength and low-density, specify McCook Metals 2195 Al-Li Plate

McCook Metals L.L.C.
4900 First Avenue
McCook, IL 60525-329
Phone 1.800.462.9838
Outside U.S. 708.485.9(
Fax 1.800.338.9180 or
708.387.8182
www.mccookmetals.co

2195 Al-Li

McCook Metals Al-Li 2195 Plate is an Al-Cu-Li-Mg-Ag alloy designed to provide a unique combination of high strength, low-density and weldability for aerospace structures.



2195 has been successfully used on cryogenic tank applications - Saving over 7000 lbs (3100 kg) on the Space Shuttle External Tank

2195 is available as extrusion billet, forging stock, and thin plate. Ask your McCook Metals representative for details.

For more information on McCook Metals 2195 plate, contact your local McCook Metals Sales Representative, or call toll free
1.800.452.9838 ❖ Outside U.S. 708.485.9000

McCook Metals L.L.C.

We're doing things today, that have never been done before.

Does it outgas?

UHV grade 6061-T6 Aluminum does not outgas
1.0% Mg .6% Si 0.3% Cu 0.2% Cr
is used for high vacuum
see
CERN Courier, page 51, November 1999
http://www.caburn-mdc.co.uk
http://www.caburnuhv.com/atlas.htm
Alkaline cleaning suggested

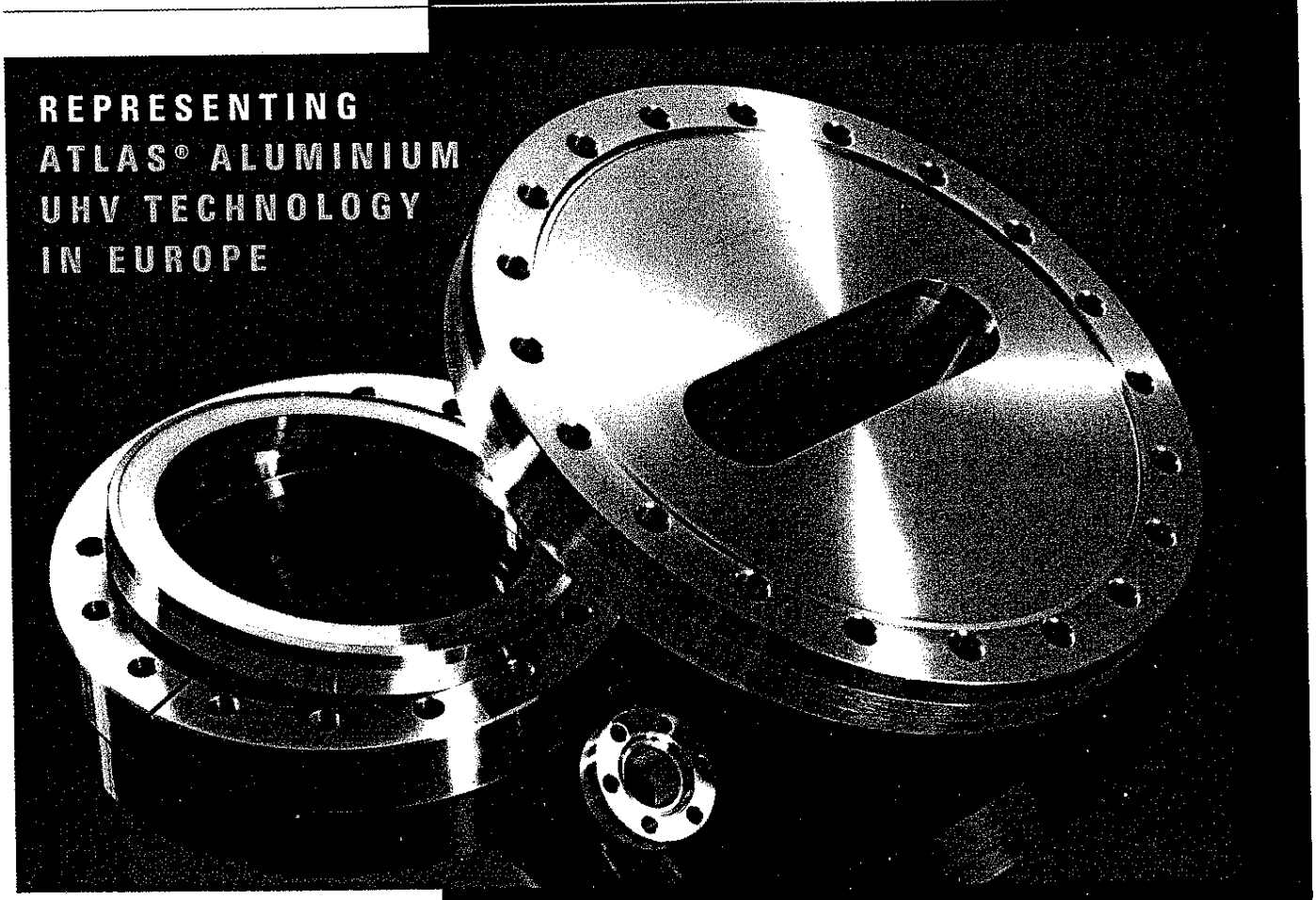
7075-T6 Aluminum alloy with zinc does outgas
http://www.caburnuhv.com/nextgenerationvacuum.pdf
"zinc has a high vapor pressure at low temperature"

Lithium Aluminum Alloy 2195 might outgas
2% Lithium

Check with a
Residual Gas Analyzer
(e.g. Stanford Research Systems RGA300)
http://www.srsys.com/html/body_rga.html

NEW PRODUCTS FROM CABURN-MDC

AL UHV TECHNOLOGY

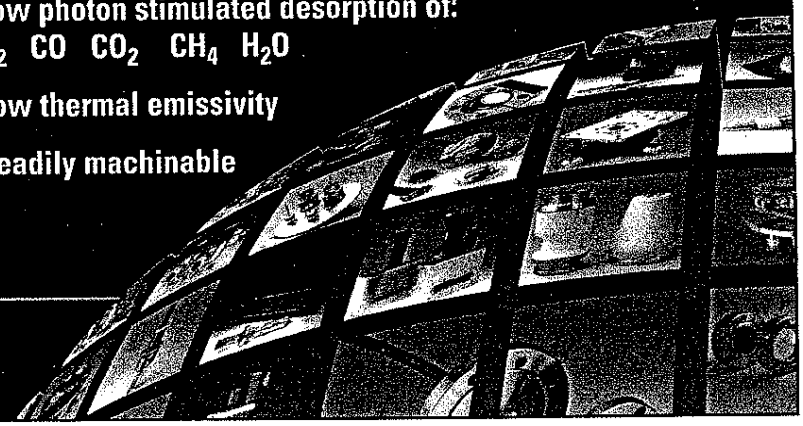


ALUMINIUM UHV TECHNOLOGY

Introducing the Atlas Flange™, the aluminium flange with a conventional stainless steel Conflat® knife edge.

Now you can utilise the dynamic physical properties of aluminium vacuum chambers and components

- 5½ times the thermal conductivity and 24 times the thermal diffusivity of stainless steel
- Ultimate vapour pressures in the order of 10^{-13} mbar
- Non-magnetic
- Low Z, low residual radioactivity, short half life
- Low photon stimulated desorption of: H_2 CO CO_2 CH_4 H_2O
- Low thermal emissivity
- Readily machinable



CABURN-MDC THE VACUUM COMPONENTS COMPANY™

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WELDING COMMON 6061-T6 ALUMINUM

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Electron Beam Welding (LEP L3 Magnet Coils)

WELDING LITHIUM ALUMINUM ALLOY

http://www.msfc.nasa.gov/NEWSROOM/background/facts/Friction_Stir_Welding.PDF
Space Shuttle External Tank
originally used Aluminum 2219
Reynolds Al-Li 2195 now used saved 3400 kilograms

--> Friction stir welded liquid hydrogen and oxygen tanks <--

Note: If the thin window is heated too much it will have to
be heat treated to regain its strength.

WINDOW FABRICATION

One 125 micron central thickness window has been tested at 44 psi

One 330 micron central thickness window has been tested to 120 psi

We need a factor of four safety margin

Four more 330 micron central thickness windows have been fabricated

The key to thin windows is a precision machined backing plate

Mississippi now has a new 27" swing NC lathe

PLANS

Fabricate smaller windows that will fit in the available superconducting soleinoid.

Obtain samples of Lithium Aluminum alloys and test their machining charcteristics