Fermilab

SDC SOLENOID DESIGN NOTE #188

TITLE: Progress of Isogrid Vacuum Vessel (including inspection and shipping plan)

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DATE: Dec. 9, 1992

This design note is one of a series which represents the proceedings of the SDC solenoid subgroup meeting held in Japan on December 8-11, 1992. The plan and purpose of the meeting was to:

- Look at the prototype coil winding and honeycomb vessel R&D in Japan
- **Reports of technical progress from each group**
- Plan and schedule for the prototype magnet assembly and test
- Discussions on design of the SDC solenoid power supply
- Discussions on cryogenic design for the SDC solenoid
- Discussions on responsibilities for the cryogenics fabrication
- Response to the report of the DOE review sub-committee
- Publications and presentations of the technical progress

SDC Solenoid Subgroup Meeting in Japan

Progress of Isogrid Vacuum Vessel
(including inspection and shipping plan)

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R. Kephart (Felmilab)

Dec. 9, 1992

SDC Solenoid
Outer Vacuum Shell R&D

Purpose:

The SDC solenoid is required to be thin in terms of radiation lengths. If this shell were made with conventional techniques (e.g. Welded shell of solid aluminum) then it would be a major contributor to the overall thickness of the coil in terms of radiation lengths. (.3 λ_r) For this reason the SDC magnet group began a program to develop an improved technique to fabricate this shell.

Outer Vacuum Shell Specifications:

outer radius	2.05 m
total length	8.72 m
High Reliability	metallic - welded
Radiation tolerant	> 6 megarads (10 yrs @ 10^{34} cm^{-2} s^{-1})
Safe - predictable	built to ASME/CGA codes

Option 2) ISO grid Shell

Characteristics of Aluminum ISO grid construction

- A lattice of intersecting ribs forming an array of equilateral triangles.
- Isotropic (no directions of instability or weakness)
- Efficient use of material for either compression and/or bending
  - Lightweight
  - Proven analysis techniques
  - Can be optimized for wide range of loading intensities
  - Readily reinforced for concentrated loads and cutouts
  - Regular pattern of nodes provides attach points for other structures
- Easily fabricated from solid Al plate with NC machine tools yielding a very reliable material of known costs.
- LARGE Experience base in US Aerospace industry

Plan:

The outer vacuum shell thickness for a solid shell is determined by elastic stability criterion for a cylindrical shell under external pressure.

The SDC magnet group evaluated various fabrication techniques intended to achieve the equivalent stiffness of a solid plate but with much less material.

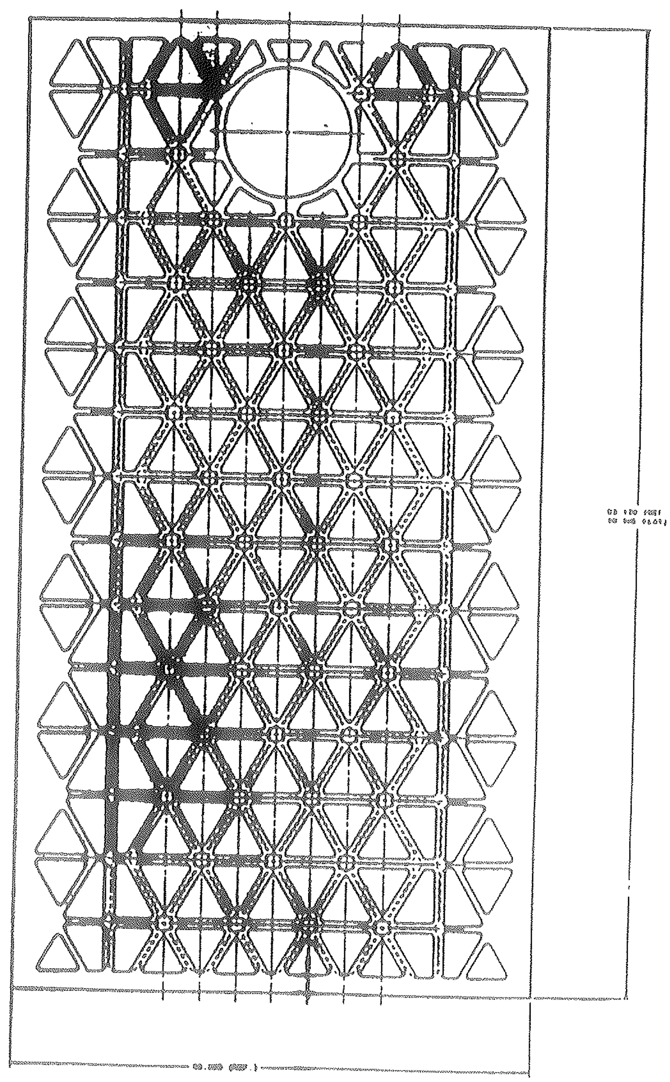
We chose to pursue R&D on two techniques that we judged most likely to lead to a practical shell that would meet the requirements of SDC:

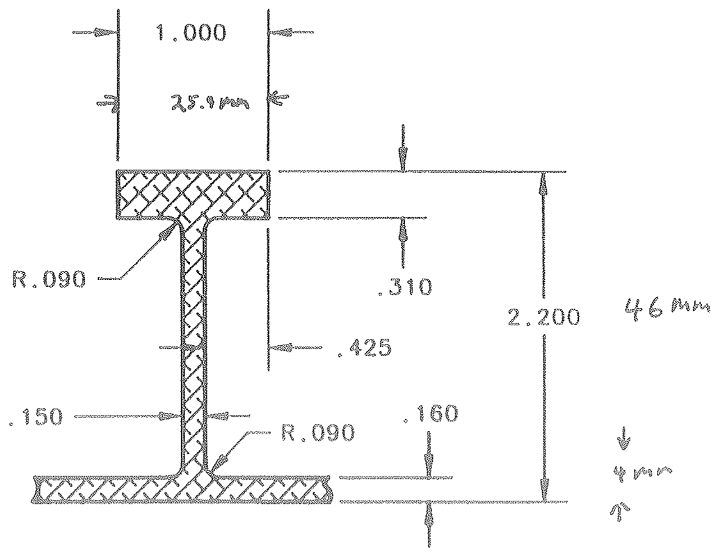
1) Brazed Aluminum Honeycomb

2) Aluminum ISO grid

R&D is in progress at this time on both techniques. I will discuss our progress and plans: for ISOGRID R+D +

Prototype STATUS





NOTE:

1. NODE SPACING IS 7.092 IN
2. EFFECTIVE THICKNESS IS 0.407 IN.
3. MATERIAL-ALUM. 5083-H321

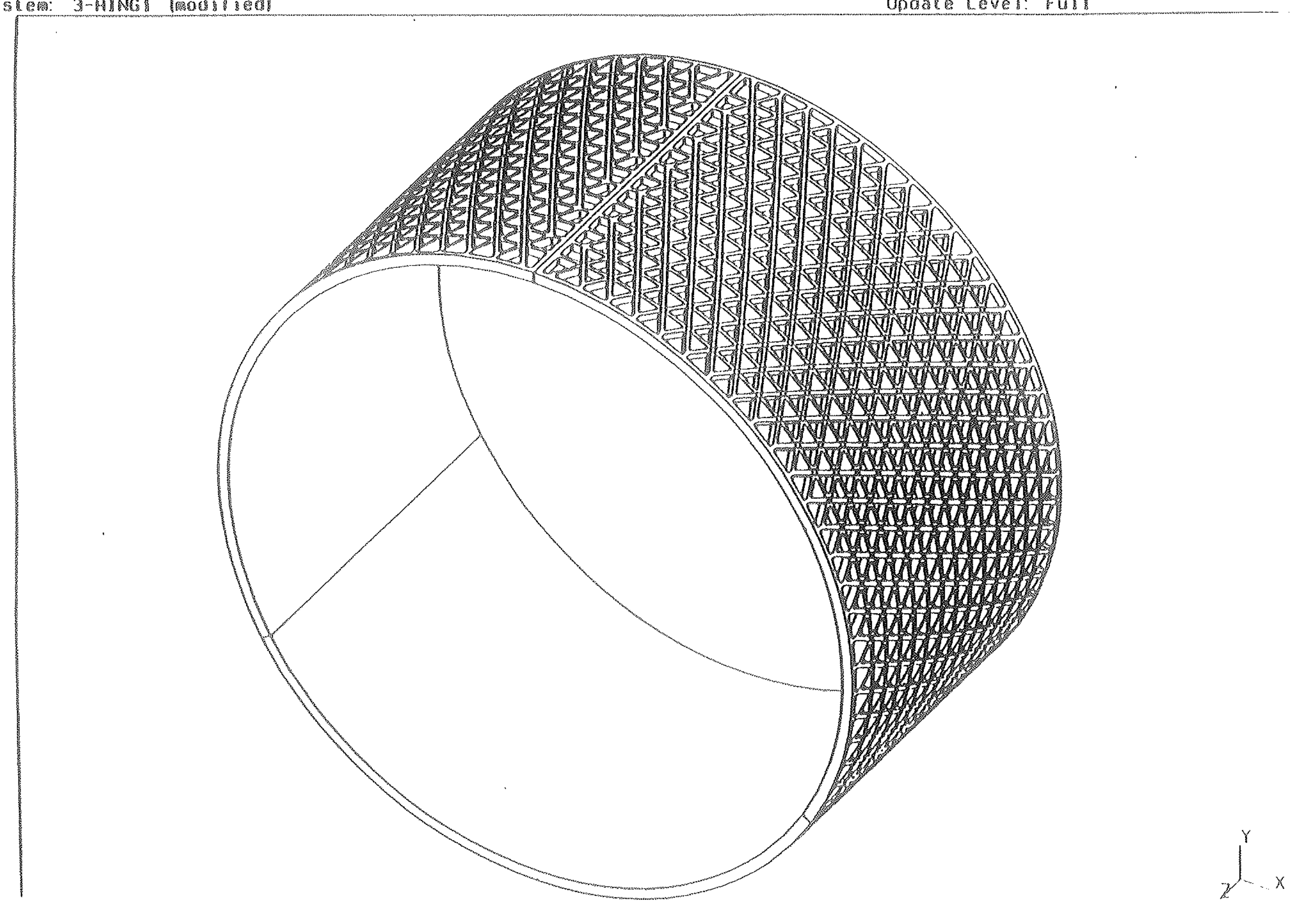
SUPERCONDUCTING SOLENOID
OUTER VACUUM SHELL
ISOGRID TYPICAL RIB CROSS SECTION

4/16/92

SDRC I-DEAS VI: Solid_Modeling 14-NOV-91 11:59

Database: isogrid tank
View : No stored View
Task: Assembly
System: 3-RING1 (modified)

Units
Display : No stored O
Bin: 1-MAIN
Update Level: Full

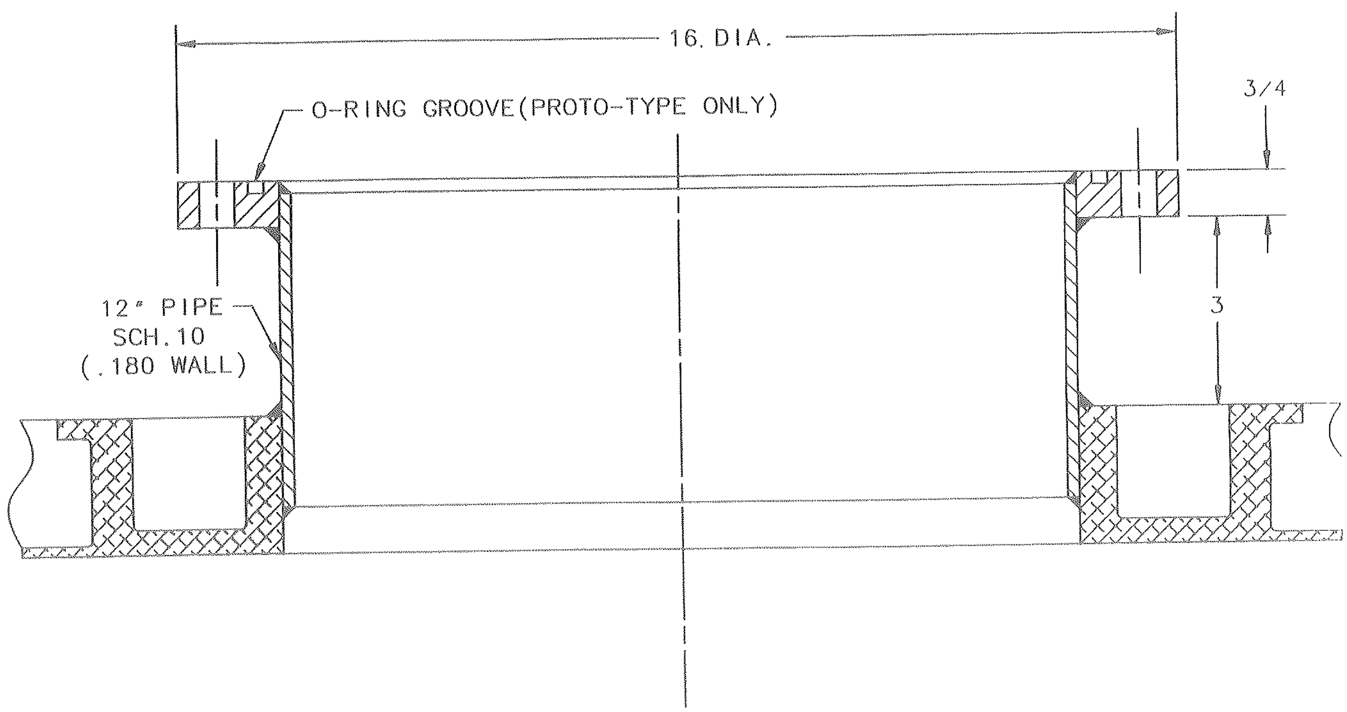


ISO grid Vacuum Shell Design Specifications

ISO grid Outer Vacuum Shell

Aluminum alloy	5083
Total thickness	46 mm
Skin thickness	4.0 mm
Skin layers	single
Node configuration	triangle
Effective thickness	11 mm (Al)
Weight reduction ratio	1/2.5
Radiation thickness	0.12 Xo

- We have Now fabricated a large Test plate. (50" x 90") of The required Thickness for SDC. (DIAL Machine, Rockford Ill.)
- Successfully brake-formed it To desired radius of curvature. (AMRO, CALIF)
- STARTED on ProtoType shell



SUPERCONDUCTING SOLENOID

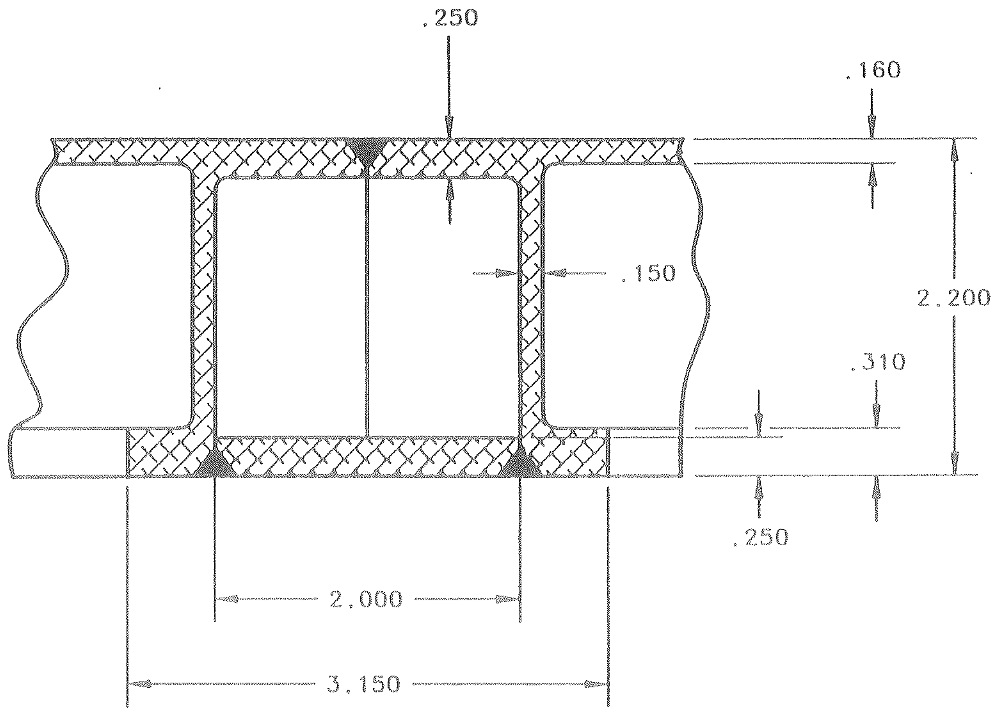
OUTER VACUUM SHELL

ISOGRID(CHIMNEY PENETRATION)

Progress with Welding Aluminum ISO grid Panels

- Weld samples of Panel to Panel joints have been made using 2219-T351 material. (5083 soon)
- No detectable leaks
- Possible to leak check main welded joints before cryostat assembly (probably true with Honeycomb also)
- Deformation at joint is very small (large Stiffness)

Conclusion: Welding ISO grid panels seems also to have few problems



SUPERCONDUCTING SOLENOID
OUTER VACUUM SHELL
ISOGRID PANEL TO PANEL WELD DETAIL

STATUS OF ISOGRID R&D AND PROTOTYPE SHELL

DEC 3, 1992

- **Engineering design of Isogrid shell is complete for both full sized magnet and prototype.**

- Isogrid R&D was successful on a large 50" x 90 " test plate.

  Material was 5083-H321 Aluminum

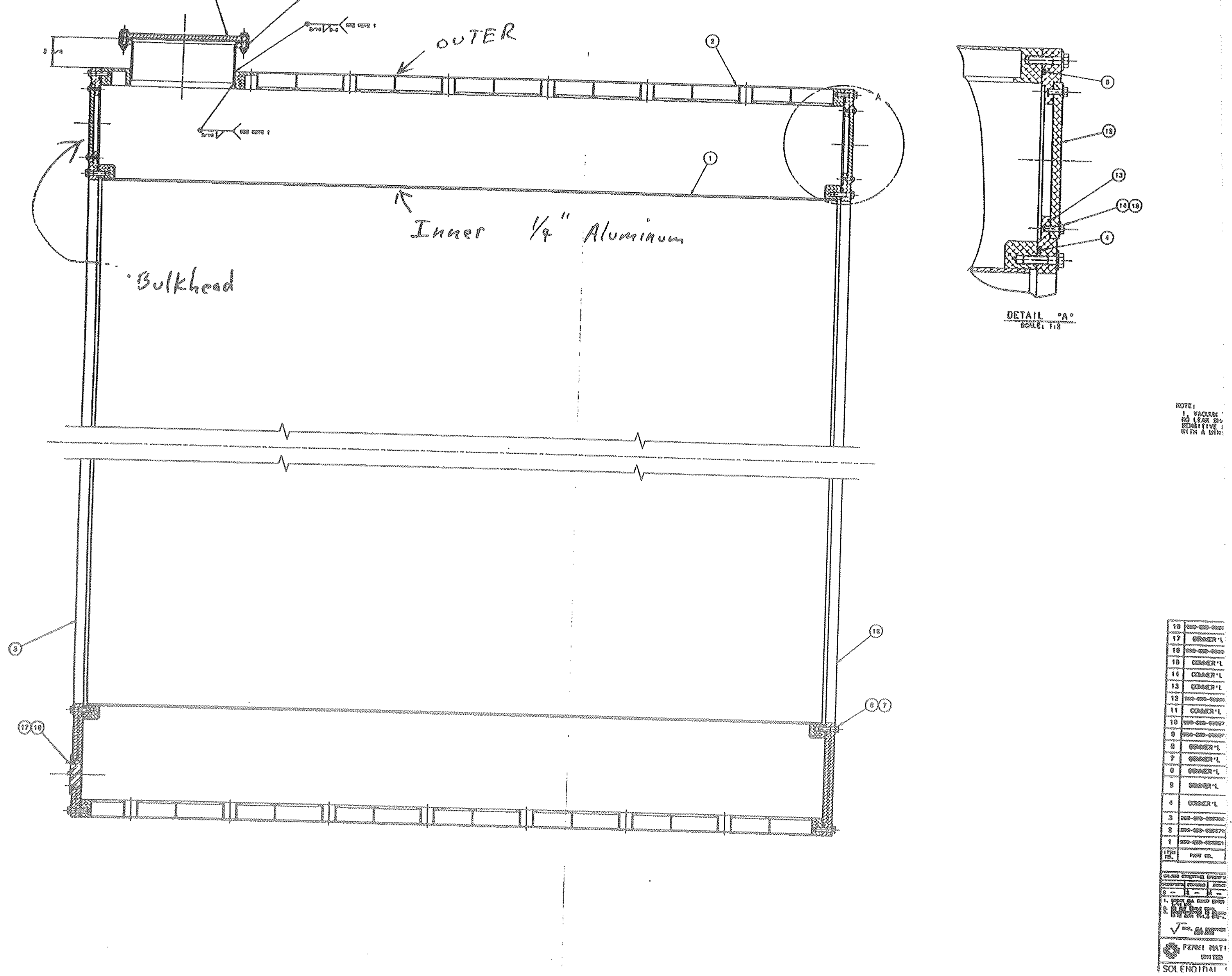
  Successful test of weld joints

  Break formed to the desired curvature

- **Somewhat less efficient than Honeycomb (11 mm vs 7 mm t_{eff}) but very robust reliable material.**

- **SDC Magnet Working Group decided to fabricate the Outer Vacuum Shell for the Prototype using Isogrid**

STATUS of Isogrid Vacuum vessel for Prototype



NOTE:

1. VACUUM TEST:
NO LEAK SHALL BE DETECTABLE ON THE MOST SENSITIVE SCALE OF A HELIUM LEAK DETECTOR WITH A MINIMUM SENSITIVITY OF 10-[illegible] ATM CC/SEC.

10^{-9}

Prototype Shell Status

Outer Vacuum Vessel

Isogrid Panel	All three 2.5 M x 5 M panels for prototype are machined at Camarillo Dynamics. Inspection complete and within tolerances.
Isogrid Forming	All three panels have been formed to 2004-mm radius (1000 T press at AMRO)
Isogrid Welding Fixture	The fixture for the welding of the panels into a shell is 80 % complete and should be finished 12-7-92

Inner Vacuum Vessel

The inner vacuum vessel cylinder has been formed to the required 1700-mm radius and the end flanges have been positioned and welded.

The fixture required to hold the vessel round during final machining is complete and installed. This fixture will remain in place during shipment to Japan. Final machining should be complete by 12-7-92

Annular Bulkheads

The Bulkhead material has been received by AMRO Manufacturing and is sawcut for welding of the segments

Machining will start this week.

DATE: 12/01/92

AMRO FABRICATING CORPORATION

1456 CHICO AVENUE , SOUTH EL MONTE CA 91733-2990

TEL (818) 579-2200 FAX (818) 579-2249

ATTENTION : MR. CHARLES GROZIS

REF : PURCHASE ORDER NO. B40610

SUBJECT : MILESTONE STATUS REPORT

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INNER VACUUM SHELL

PROCESS	10/2	10/5	10/6	10/7	10/9	11/13	12/7
MACHINE RINGS	▲	▲					
RE-ROLL INNER SHELL		▲	▲				
WELD RING TO SHELL				▲	▲		
FINAL MACH. ASSY						▲	△

DATE: 12/01/92

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SUBJECT : MILESTONE STATUS REPORT

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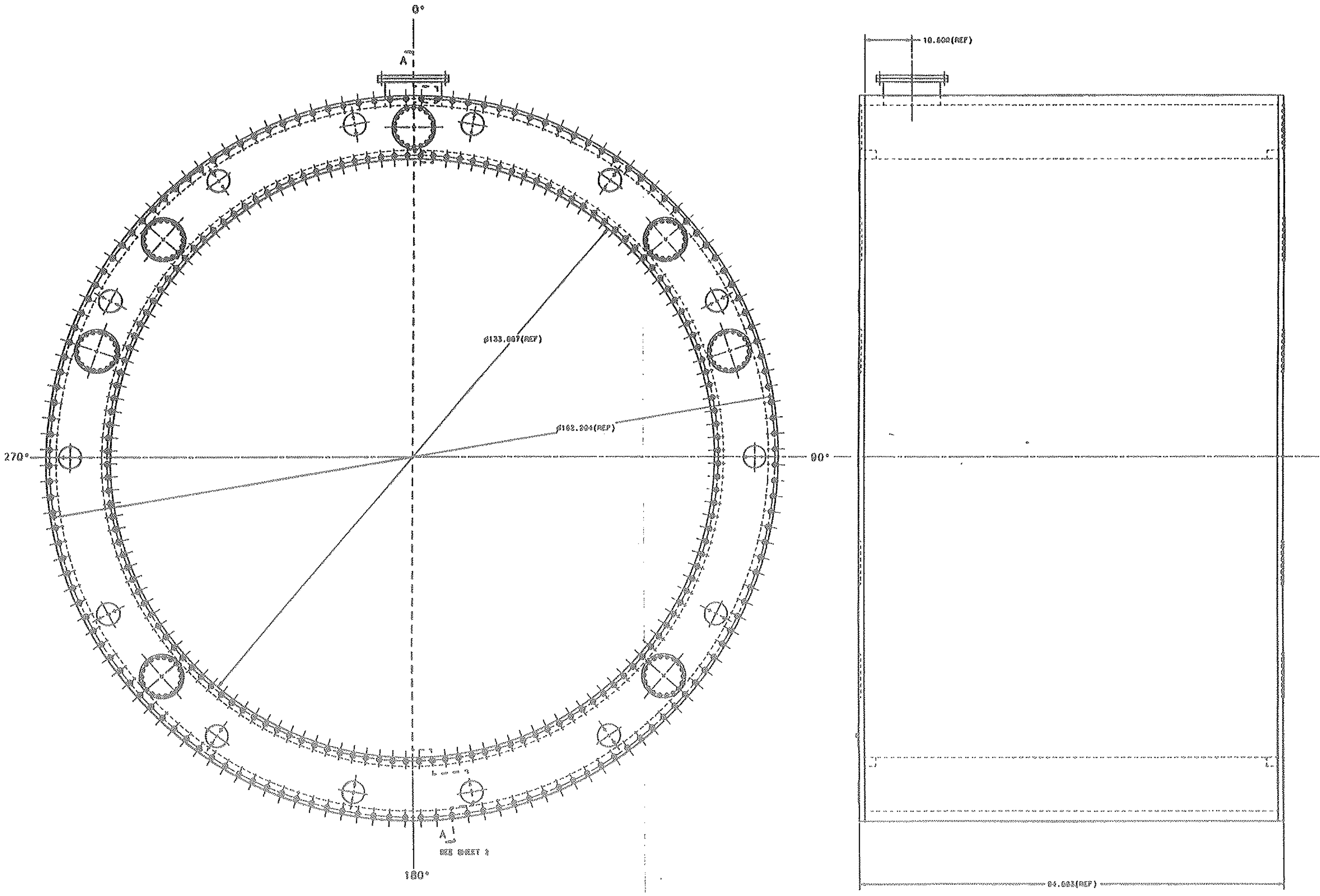
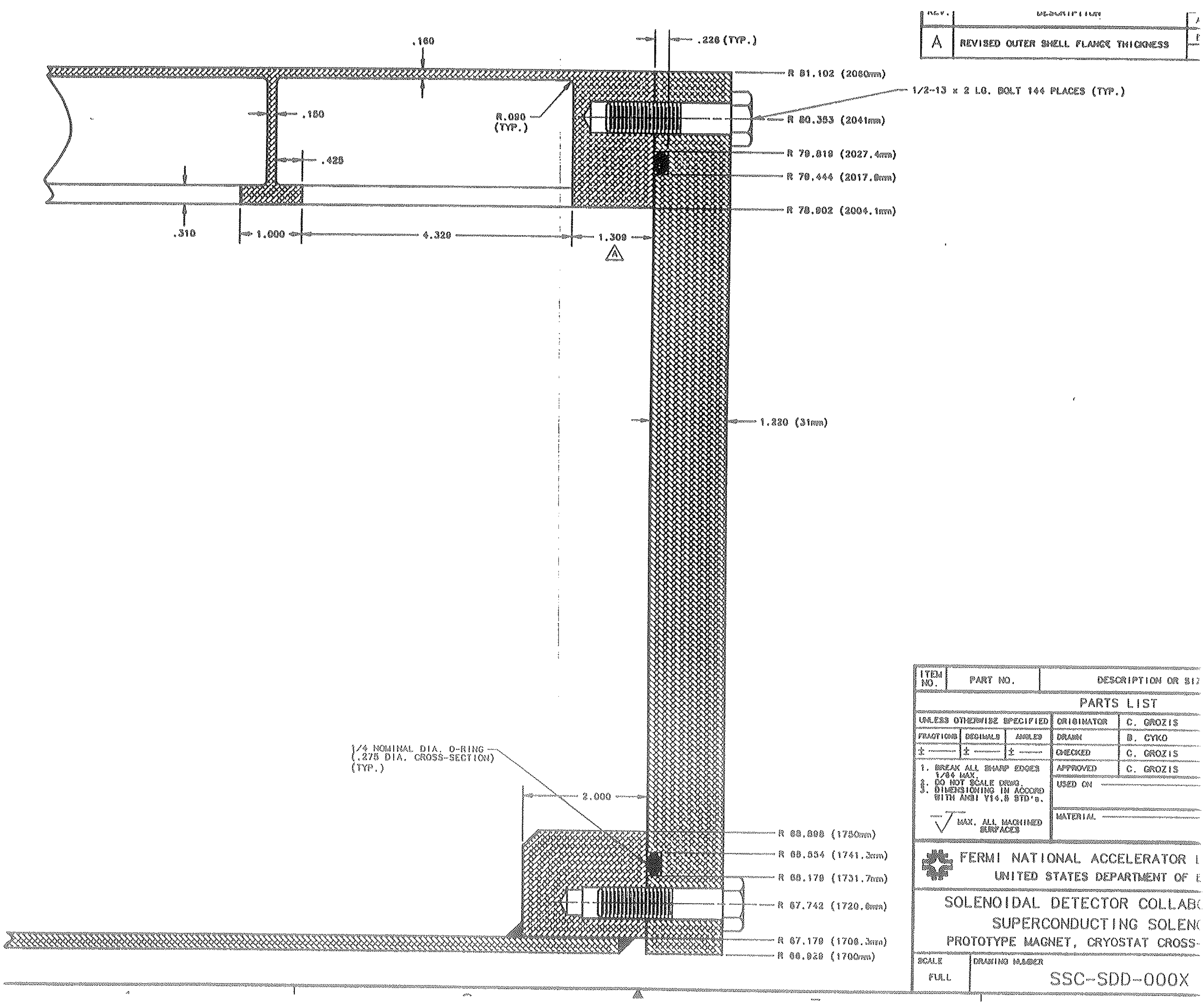
BULK HEAD

PROCESS	11/10	11/20	12/7	12/9	12/23	1/17/93
RECEIVE MATERIAL	▲					
SAW-CUT	▲	▲				
PREP / WELD		▲	△			
FINAL MACHINE			△			△



Bulkhead for Prototype Vessel



Bulkhead for Prototype Vessel

DATED: 12/01/92

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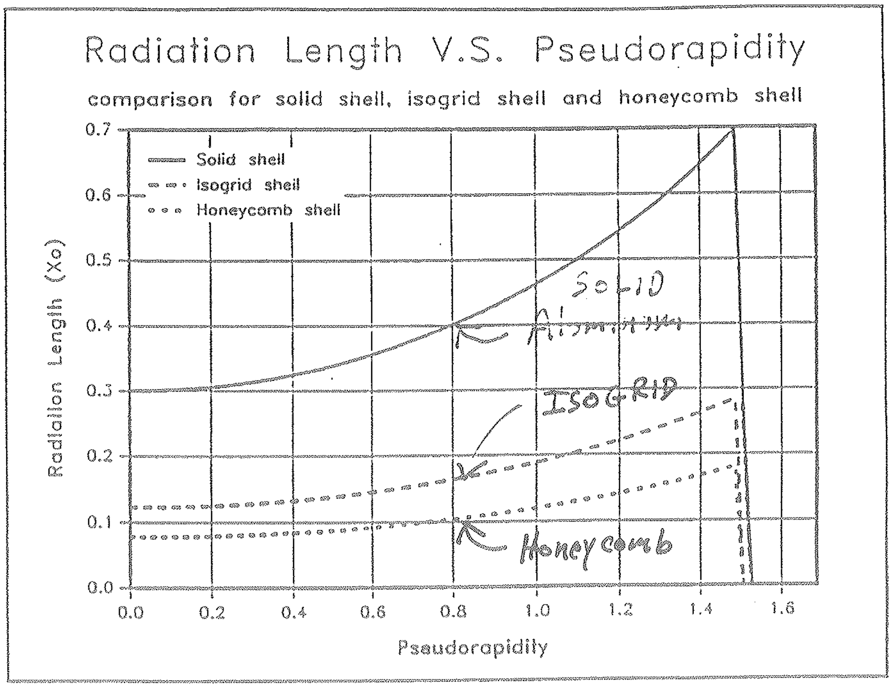
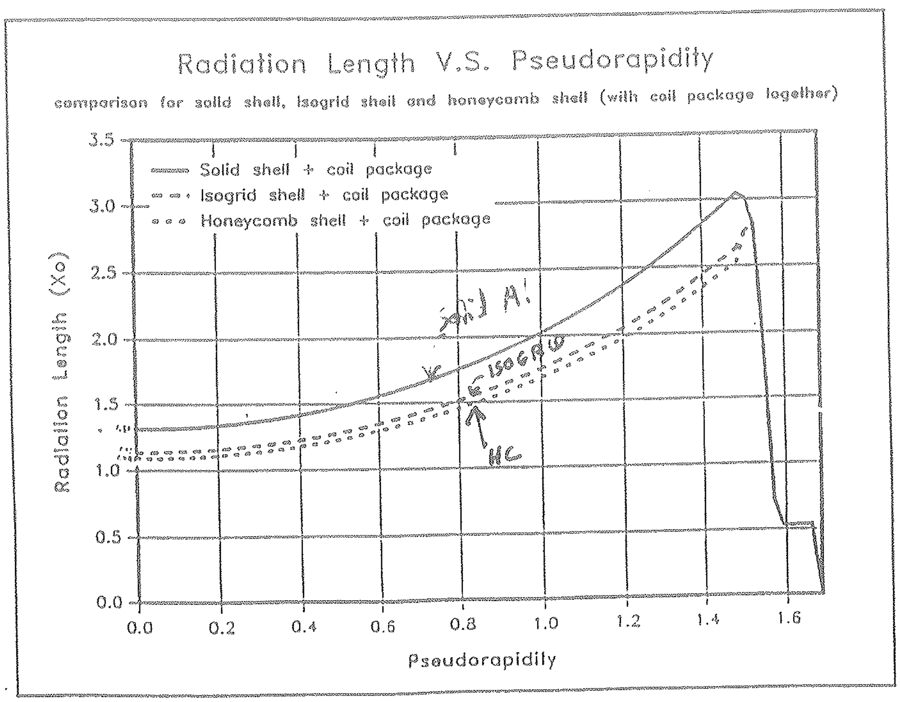
OUTER SHELL & ASSEMBLY

PROCESS	10/6	10/19	11/19	12/08	12/10	12/16	12/17	1/20	2/11	2/13	2/21	2/26
FORM	▲		▲									
MACH. WELD PREP		▲		△								
WELD					△	△						
FINAL MACHINE							△	△				
CLEAN & ASSY								△	△			
HELIUM LEAK										△	△	
PACKAGE & SHIP											△	△

Expected Performance of SDC Vacuum Shell
(Effective Thickness vs pseudo-rapidity)





.onclude:

Either choice looks feasible. Either is better Than Solid shell

(END)