Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number: MD-ENG-101 Date: 1/26/06

Project Internal Reference:

Project: DECAM

Title: Multi CCD Vacuum Test Vessel – Flat Vacuum Window

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Key Words: Multi – CCD Test Vessel

Abstract Summary: The Multi – CCD Test Vessel is a vacuum vessel with a large optical window. Optical vacuum windows do not apply to FESHM-**5033.1,** however the window analysis is still provided using the Brookhaven ES&H manual (Standards-Based Management System) engineering guidelines.

Applicable Codes:
Brookhaven: GUIDE FOR GLASS AND PLASTIC WINDOW DESIGN FOR PRESSURE VESSELS

Introduction

The Multi-CCD test vessel is used to test up to 6 CCDs at one time. The test vessel is a full scale prototype of the real Camera Vessel which will contain 70 CCDs. A desired vacuum pressure of 10e-6 Torr is required in the vessel to prevent water vapor from condensing onto the CCDs during operation. Optical tests are performed on the CCDs through an optical window that is described by drawing #4900.123-MB-436084-C. The window is held in a cell that is described by drawing #4900.121-MD-436163. The vessel has a positive pressure relief as described in MD-ENG-099.

Optical windows do not apply to FESHM Chapter 5033 Vacuum Window Safety. However, Brookhaven's Standards-Based Management System provides engineering guideline titled: GUIDE FOR GLASS AND PLASTIC WINDOW DESIGN FOR PRESSURE VESSELS.

Design:

Allowable Material Stress:
Due to possible stress concentrations and the brittleness of the material, the maximum allowable stress is a factor of 10 times less than the yield strength of the material. The window is constructed of Corning Industrial Grade Fused Silica with a manufacturing allowable tensile stress of 7250 psi, a Young's modulus of 10.5e6 psi, and a Poisson's ratio of 0.16. Reducing the yield strength by a factor of 10 gives a maximum allowable stress of 725 psi. For long term applications, the Brookhaven document further reduces the allowable stress to 680 psi.

*Ref. H0607_Fused_Silica_Industrial_Grade_ProductSheet.pdf

Calculating the Window Stress and Deflection:
The window deflection is much smaller than 0.50 times the window thickness so the window is considered to be simply supported and thick plate theory is used. The design of the window mount shall be such that the window is not significantly constrained against thermal motions or motions under loading. The diameter of the window is taken to be the O-Ring diameter.

Using Appendix A of the Brookhaven document:
Stress = K1* Pressure * (diameter /thickness)^2
K1 = 0.296
Stress = 0.296 * 14.7 psid * (19.955 inch / 1.614 inch)^2
Stress = 644 psi

644 psi is less than the maximum allowable design stress of 680 psi

Using Appendix A of the Brookhaven document:
Deflection at the center of the window
= K3 * Pressure * diameter^4 / (modulus * thickness^3)
K3 = 0.051
Deflection = 0.051 * 14.7 psi * 19.955^4 / (10.5e6 psi * 1.614 inch^3)
Deflection = 0.0026 inch = 66 microns

Deflection is less than 0.5 times the window thickness so thick plate theory is satisfied.

EXHIBIT A –Modified for Optical Window

Vacuum Window Engineering Note
(per Fermilab ES&H Manual Chapter 5033.1) –Modified for Optical Window

Vacuum Window Number: N/A

Purpose of vacuum vessel and vacuum window	Decam Multi-CCD Test Vessel	
Internal MAWP	14.7 PSI	
External MAWP	14.7 PSI	
Working Temperature Range	50 °F	100 °F

1. Design Verification: Provide design calculations in the Note Appendix.

2. Fabrication: Is this vacuum window fabricated in house? [ ] Yes [X] No
If "Yes", Attach the written fabrication procedure in the Note Appendix.

3. Inspection: Attach inspection reports and Travelers in the Note Appendix. Include date(s) of manufacture.

4. Testing: Attach failure and acceptance testing procedure and results in the Note Appendix. Include dates of testing

   Acceptance Testing performed using normal operational vacuum conditions. The Mechanical Engineer will be present during assembly and initial pump down of the vessel and window.

5. System Venting Verification:

   Is the relieving system of the vacuum vessel to which this vacuum window is attached sufficiently sized such that if the vessel is pressurized, the maximum differential pressure across the window cannot exceed the design differential pressure of the vacuum window?
   [X] Yes [ ] No

   MD-ENG-099

6. Operating Procedure Section:

   Is an operating procedure necessary for the safe operation of this vessel? [ ] Yes [X] No

If "Yes", the operating procedure must be attached to the Note Appendix

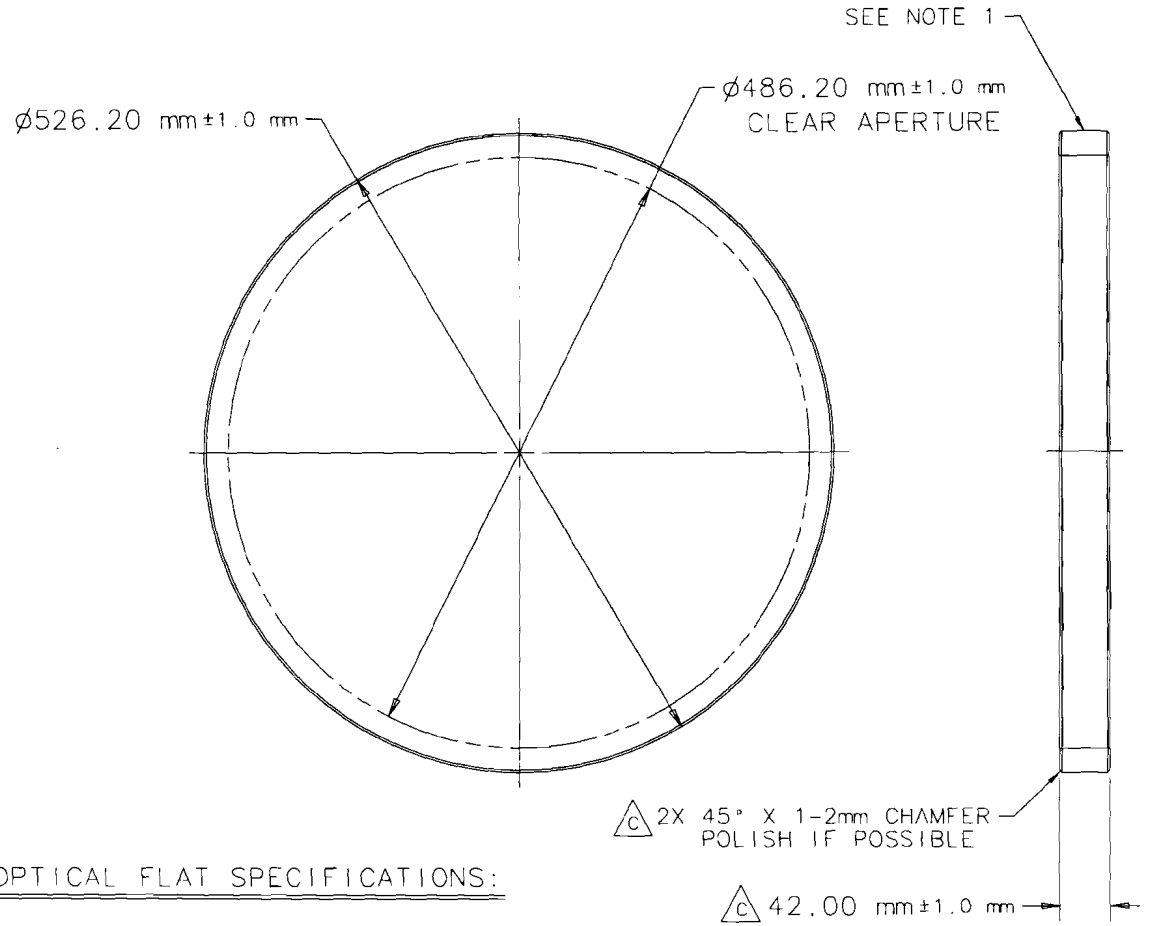
7. Hazard Analysis: Is the safety factor on this vacuum window less than 2.0? [ ] Yes [X] No

If "Yes", a hazard analysis must be prepared and attached to the Note Appendix

8. Degradation from Exposure: Will the integrity of the window be compromised over time by exposure to radiation or cyclic stress? [ ] Yes [X] No

If "Yes", include in the technical appendix any requirements for recording exposure, as well as a change-out schedule.

REV	DESCRIPTION	DRAWN / APPROVED	DATE / DATE
A	1/4 WAVE SURFACE FLATNESS SPEC. ADDED	GRIMM	5-APR-2005
		CEASE	5-APR-2005
B	100 MICRON TOTAL WEDGE WAS 20 MICRONS 120/80 SCRATCH/DIG WAS 60/40 1 WAVE SUFACE FLATNESS WAS 1/4	GRIMM	28-APR-2005
		CEASE	28-APR-2005
C	ADDED 1-2mm CHAMFERS ADDED NOTE 1 ADDED DOCUMENT & REPORT TO OPTICAL SPECIFICATIONS PARALLELISM OF 42' WAS 50' 60/40 SCRATCH/DIG WAS 120/80 RIPPLE FINISH SPEC. ADDED	GRIMM	13-JUL-2005
		CEASE	18-JUL-2005



NOTES:

C 1) GROUND SURFACES #400 GRIT OR FINER.

OPTICAL FLAT SPECIFICATIONS:

B C PARALLELISM OF <42'(100 MICRONS TOTAL WEDGE)

B C SURFACE FINISH OF 60/40 SCRATCH/DIG

A B 1 WAVE SURFACE FLATNESS - BOTH SIDES

C RIPPLE SURFACE FINISH 1nm rms

C DOCUMENT AND REPORT FINAL FIGURES OF FLATNESS AND WEDGE.

UNLESS OTHERWISE SPECIFIED			ORIGINATOR	H. CEASE	31-MAR-2005
.XX	.XXX	ANGLES	DRAWN	C. GRIMM	31-MAR-2005
± **	± **	± **	CHECKED	CEASE/GRIMM	01-APR-2005
1. BREAK ALL SHARP EDGES ** MAX. 2. DO NOT SCALE DRAWING. 3. DIMENSIONS BASED UPON ASME Y14.5M-1994 4. MAX. ALL MACH. SURFACES ** √ 5. DRAWING UNITS: U.S. INCH			APPROVED	H. CEASE	01-APR-2005
			USED ON		
			MATERIAL	BK7 - FUSED SILICA OR EQUIV.	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

CTIO BLANCO DECAM
FULL-SCALE CAMERA TEST MODEL
C5 FLAT OPTICAL LENS

SCALE	DRAWING NUMBER	SHEET	REV
QUARTER	4900.123-MB-436084	1 OF 1	C

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