9^{th} Neutrino Beams and Instrumentation Workshop

Fermilab on September 23^{rd}-26^{th}

LBNE Removable Decay Pipe Window

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TOPICS:

- Energy Deposition, Temperature, Stresses and Strains
- Seal Technology Investigations
- Remote Seal Clamping Alternatives
- Additional Considerations

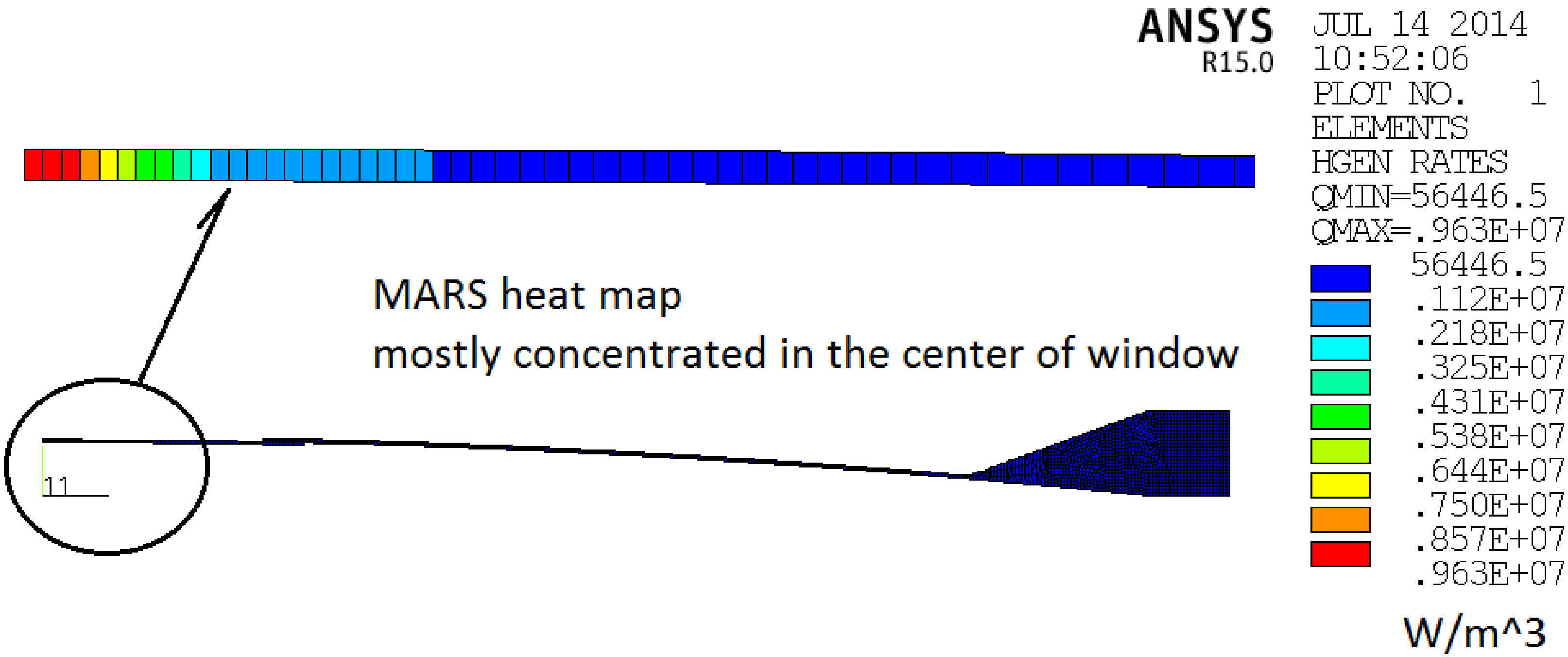
ENERGY DEPOSITION, TEMPERATURE, STRESSES AND STRAINS

- Energy Deposition calculated using MARS by Dianne Reitzner
- Energy deposition used to calculated an internal energy generation term used in ANSYS
- ANSYS used by Ang Lee to calculate temperatures, resulting thermal stresses.
- Considering normal beam condition & accident conditions at 120, 80 and 60 GeV :

ENERGY DEPOSITION, TEMPERATURE, STRESSES AND STRAINS

- Multiple cases considered:
    - 120 GeV beam with 1.2 and 2.4 MW
    - 80 GeV beam with 1.07 and 2.14 MW
    - 60 GeV beam with 1.03 and 2.06 MW
    - All cases run for:
        - Beam hitting target, centered on window
        - Beam missing target, centered on target (an accident condition)
        - Beam missing target, hitting window off centered (an accident condition)

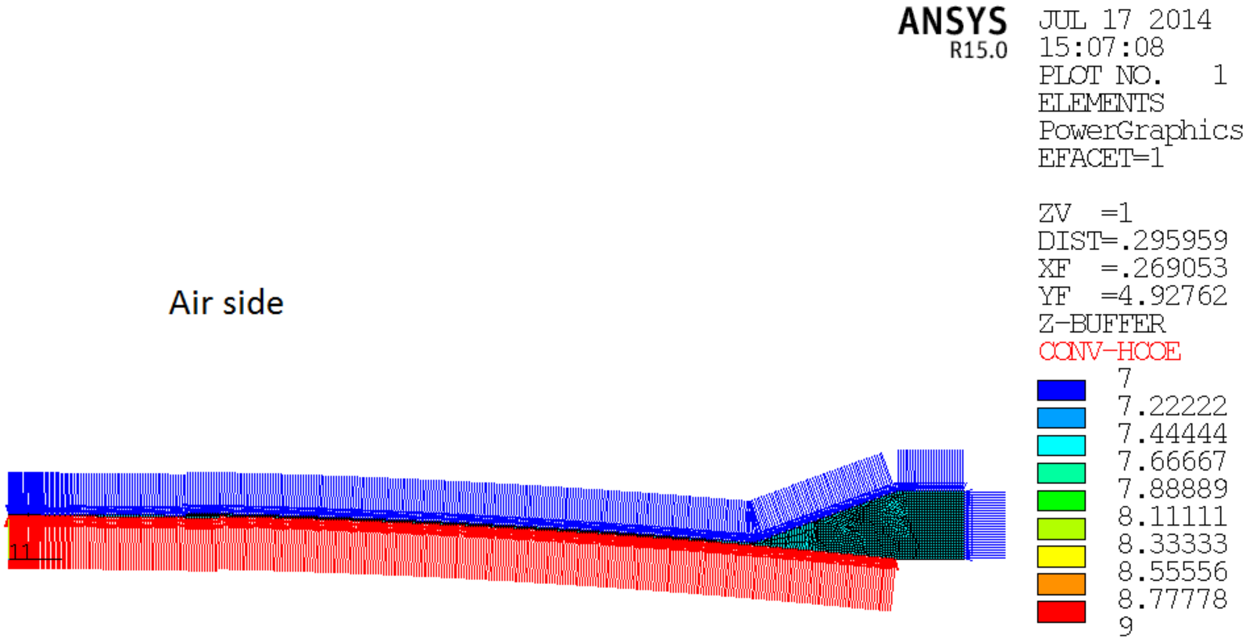
INTERNAL ENERGY GENERATION FOR ONE CASE (DIANNE AND ANG'S WORK):



BOUNDARY CONDITIONS

Air Side, convection with h = 7 W/m^2-K, Air temperature at 30 C

Helium Side, convection with h = 9 W/m^2-K, Helium temperature at 52 C



PURPOSE OF FEA WORK:

Evaluate window lifetime as a function of:

- Beam spot size
- Convection boundary conditions
- Chilled fluid at window perimeter boundary condition

Ang Lee's Temperature Result (@120 Gev) by increasing the convection film coefficient, h_c:

	hc_air side (W/m^2*K)	The center of the window_ Be alloy section				flange	
		Tave(Steady state)_C	Tmax_C	Tmin_C	ΔT _C	Tmax_C	ΔT _C
120 Gev 2.4 MW	7	85	87.75	84.25	3.5	115	0
120Gev 2.4 MW	14	68	70.69	67.27	3.42	86.8	0
80 Gev_ 2.14 MW	***7***	***79***	***80.6***	***78.73***	***1.87***	***105***	***0***
80 Gev 2.14 MW	***14***	***64.05***	***65.4***	***63.53***	***1.87***	***80.4***	***0***

Note:
a) Increase the convective hc_air side from 7 to 14 W/m^2*K, the temperature goes down ~15 C in the center and ~25C at the flange. The ΔT is about the same. The similarity is observed for 120 GeV case

SEAL PERFORMANCE REQUIREMENTS:

0.3 bar (5 psig) helium

Permissible leakage rate: 0.01 liters per minute (200 cubic feet per year)
(this leakage rate specification is pretty arbitrary)

Significant Prompt radiation exposure

Significant post-running activation

Seal Investigations:

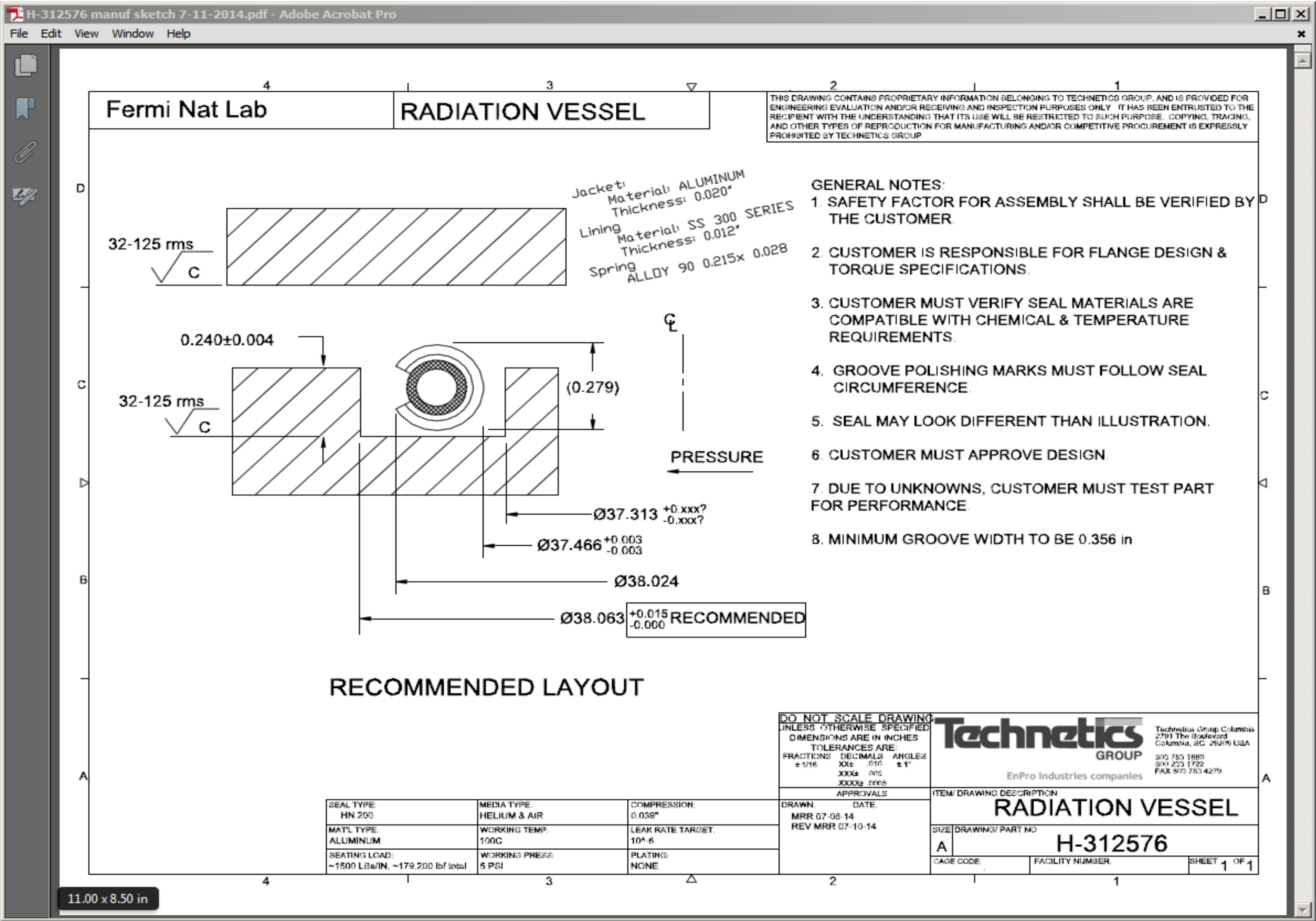
To be further investigated:

- Commercial Products:
  - Helicoflex (spring energized alumium “C” Seal)
  - Parker ESI (spring energized alumium “C” Seal)
- Peanut Seal as used on the 15’ bubble chamber (an inflatable metal seal).

Eliminated from Further Consideration:

- Elastomer O-rings
- Lead Gasket
- Indium wire
- Mercury Amalgam
- Cast Materials
- Conflat gaskets

HELICOFLEX SEAL ORDERED FOR TESTING:



Seal Leakage Test Vessel

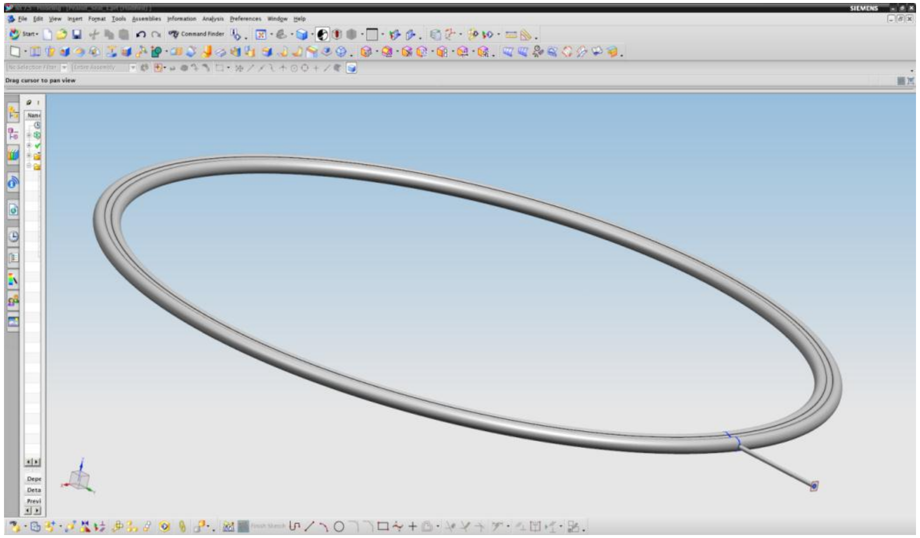
Can test ~ 1 meter diameter seals.

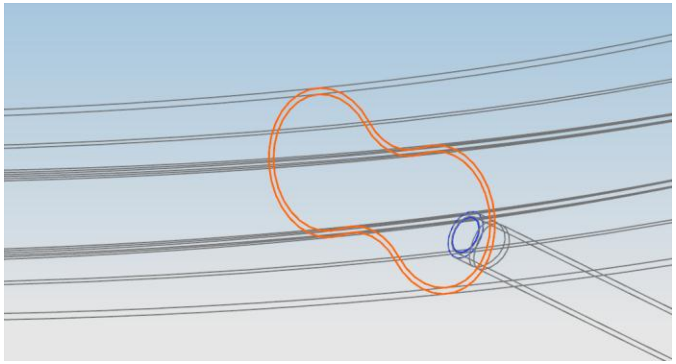
Externally applied sealing force (hydraulically actuated with load cells)

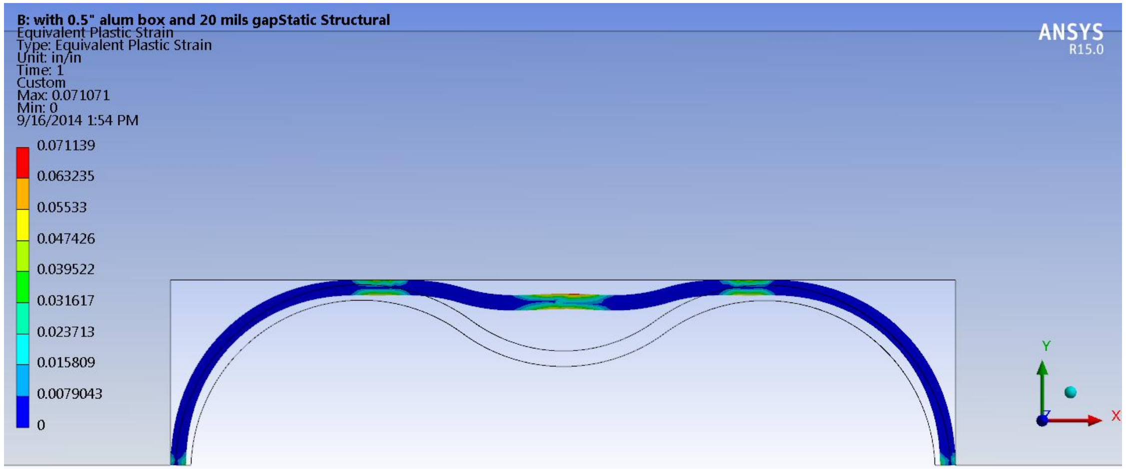
Internally pressurized with helium (or other inert gas) to 5 psig

Measure leak rate down to 0.02 scfh (200 cu ft/year or 10 cc/min)

PEANUT SEAL:






B: with 0.5" alum box and 20 mils gapStatic Structural
Equivalent Plastic Strain
Type: Equivalent Plastic Strain
Unit: in/in
Time: 1
Custom
Max: 0.071071
Min: 0
9/16/2014 1:54 PM
0.071139
0.063235
0.05533
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ANSYS
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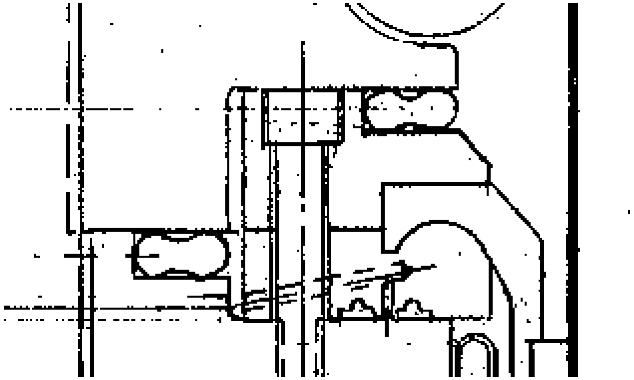
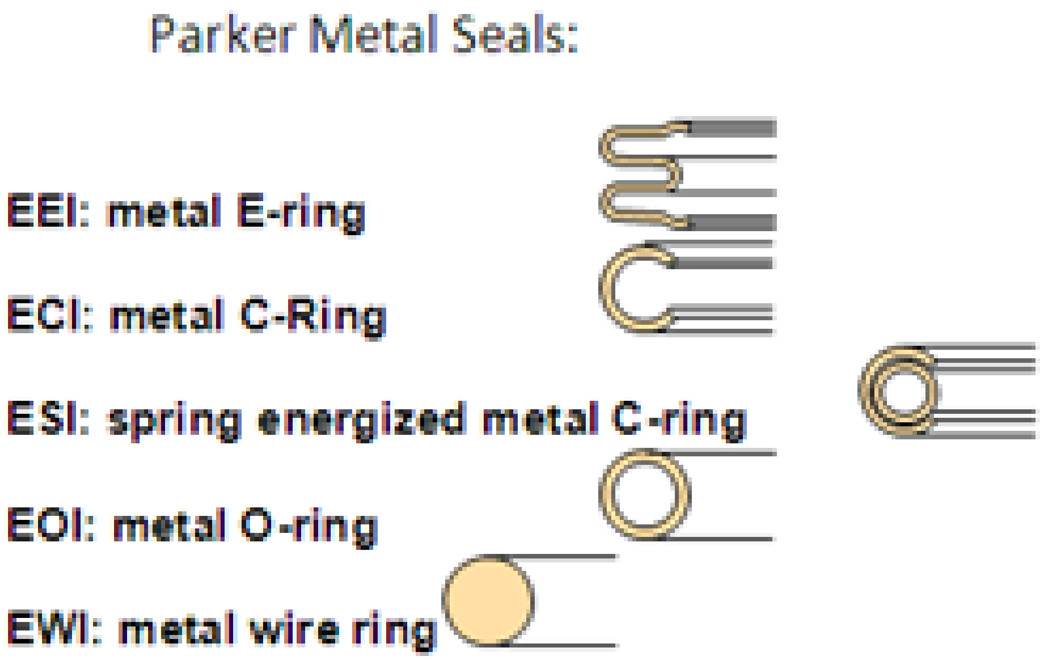


COMMERCIALLY AVAILABLE SEALS:



EnPro Industries (the manufacture of Helicoflex) also offers a similar set of metal seals.

CLOSURE MECHANISMS:

Wedge system

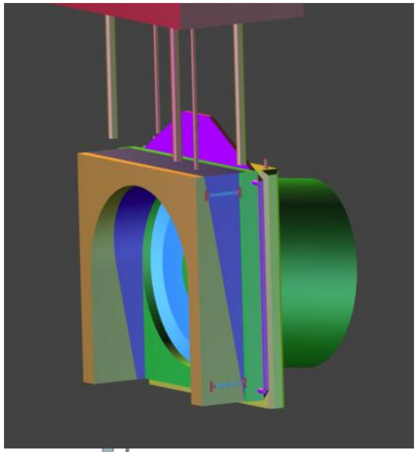
- Initial design conceived by Kris Anderson and Glenn Waver.

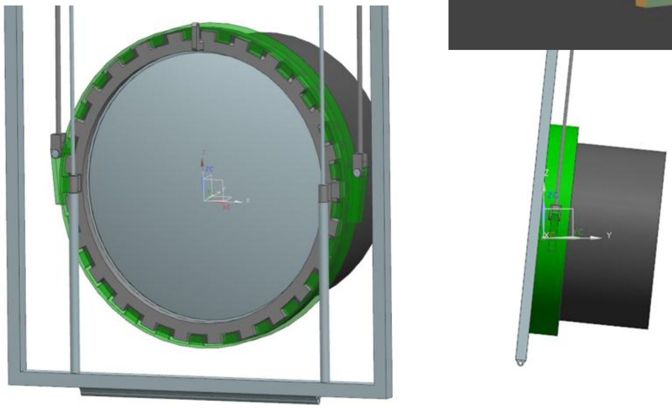
Autoclave Closure Flange

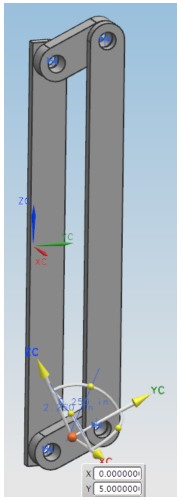
- Standard industry detail used for 'quick-opening' vessel ends.

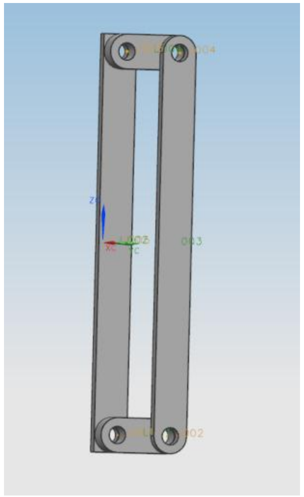
4 – bar (parallelogram) linkage

- Commonly used mechanism for applying high seal loads to large vacuum gate valves

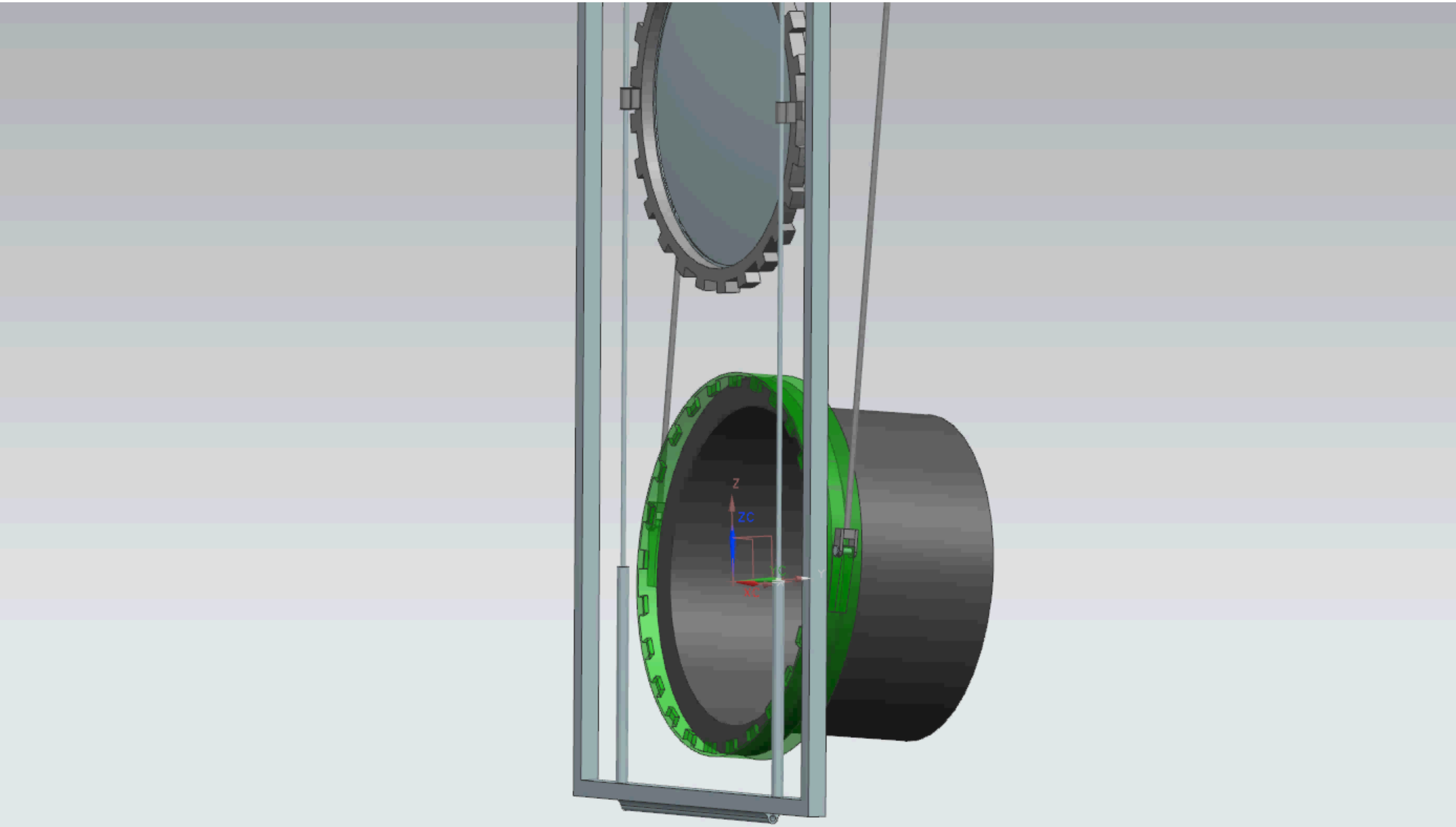








All seal loading mechanism will be driven from the top through about 2 meters of shielding material


Z
ZC
YC
XC

ADDITIONAL CONSIDERATIONS:

Helium Vessel will be slightly pressurized above atmospheric pressure.

- Do we allow the helium to escape?
  - A loss of 2500 cu meters of helium gas
- Do we recover the helium, fill the decay pipe with CO_2, then change the window?
  - Takes time to setup, perform, and re-fill the decay pipe
- Do we include a temporary helium seal to isolate the decay pipe from the window change mechanism?
  - Significant design time, perhaps additional time for a window change

Include forced convection on helium side of window as part of the module?