VACUUM EXCELLENCE DEFINED

AVS Meeting
January 25, 2012

Vacuum Chambers:
The Atmosphere of Excellence

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Some Facts about GNB

Some Facts

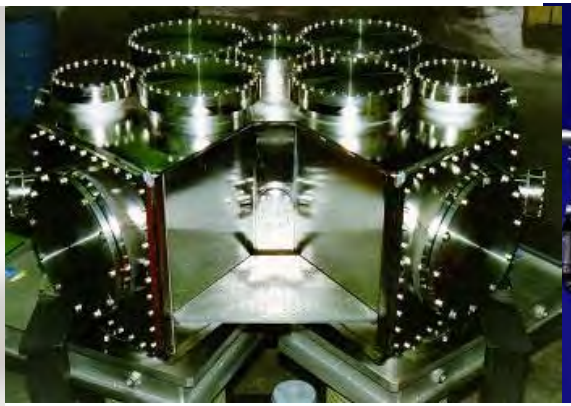
- Founded in 1968 by Gary N. Burnett
- Located in Elk Grove, CA (South of Sacramento)
- 60 Employees (7 Design Engineers)
- 62,500 Sq Ft. Facility
- Focused on Vacuum Chambers and Valves
- ISO 2000 – 9001 Certified

Focus: Large Manufacturing

Vacuum Valves

4” to over 100”

Vacuum Chambers



9 ft Diameter x 16 ft Long

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Vacuum Chambers Are Exciting

How Could a Metal Box be Exciting?

- New tools make it fun to design chambers
- Welding is faster and tighter than ever
- Unique advantages of combining or separating parts
- UHV is bigger and cheaper
- Fit and finish for any budget

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Revolutionary Design Tools

Finite Element Analysis

- FEA tools make analyzing complex shapes possible
  - Lighter weight chambers
  - Increased rigidity
  - Reduced costs
  - Heat transfer, deflection and stress are primary calculations

Stress Analysis Example

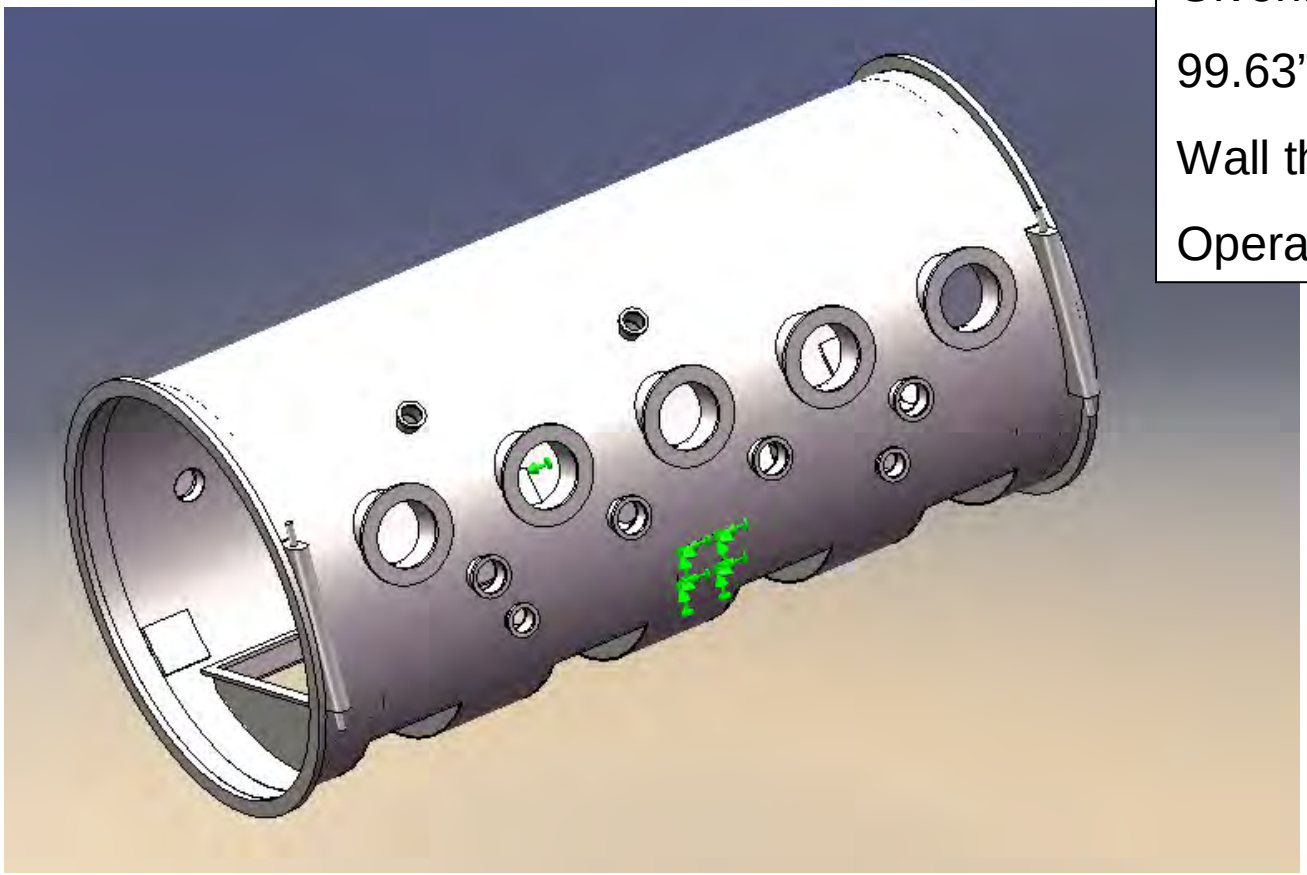
Complex Shapes can be Difficult to Analyze

Given: 304 sst

99.63” OD x 206.25” L

Wall thickness 3/8”

Operating temp 200F



Minimizing Deflection is the Key to Great Vacuum Chambers

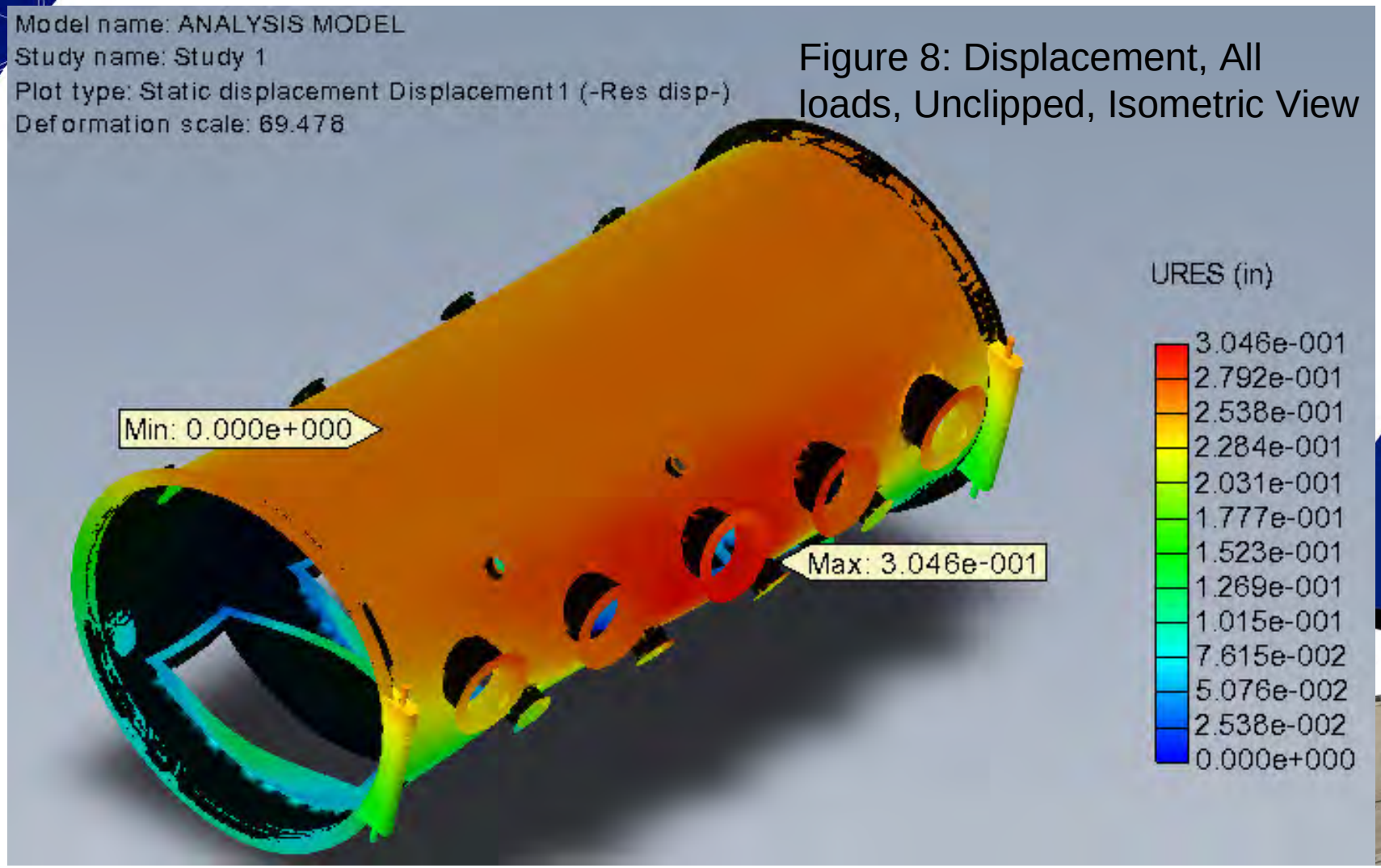


Figure 8: Displacement, All loads, Unclipped, Isometric View

Secondly, We Analyze Stress at Elevated Temperatures

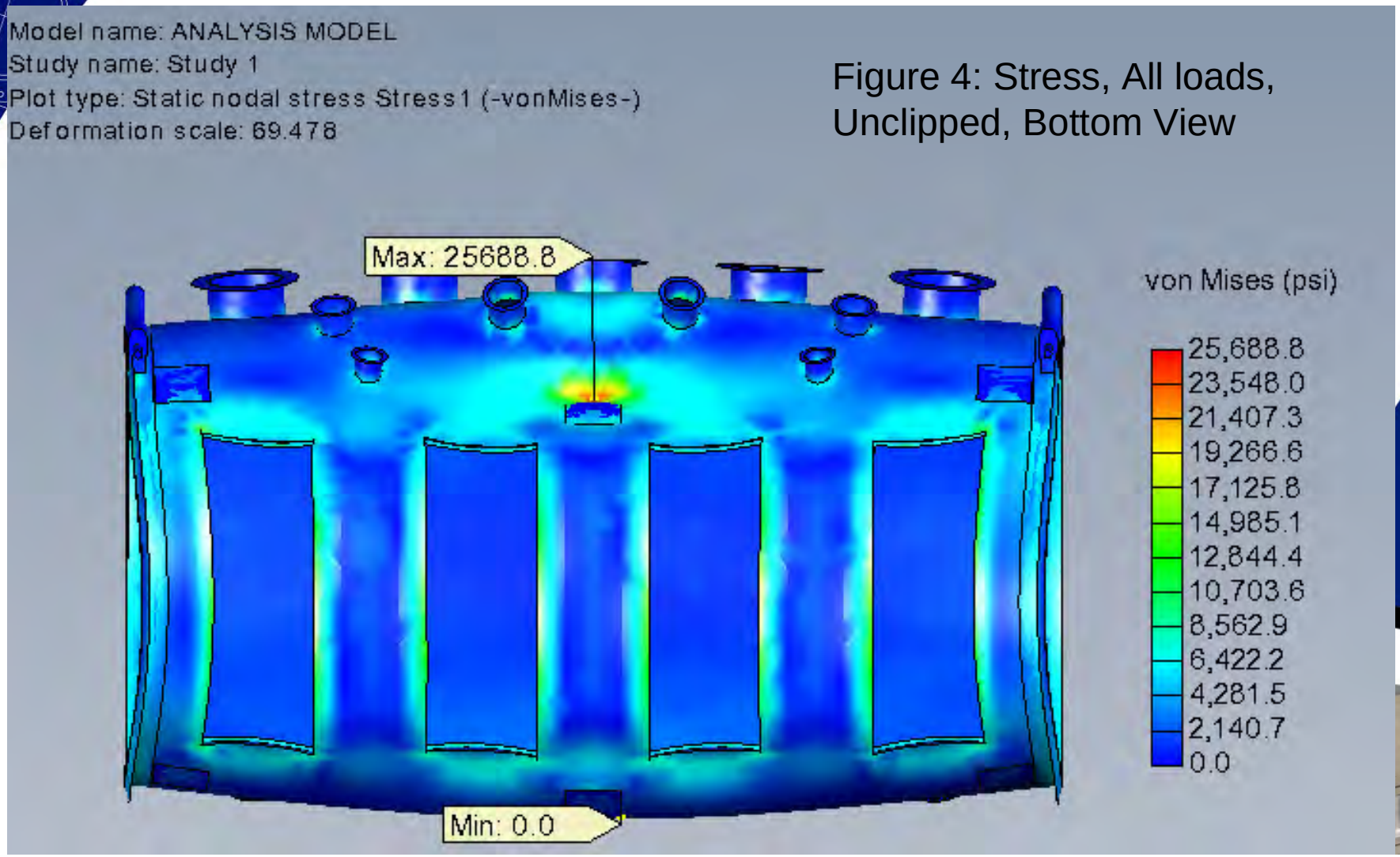


Figure 4: Stress, All loads, Unclipped, Bottom View

Factor of Safety was 1.17

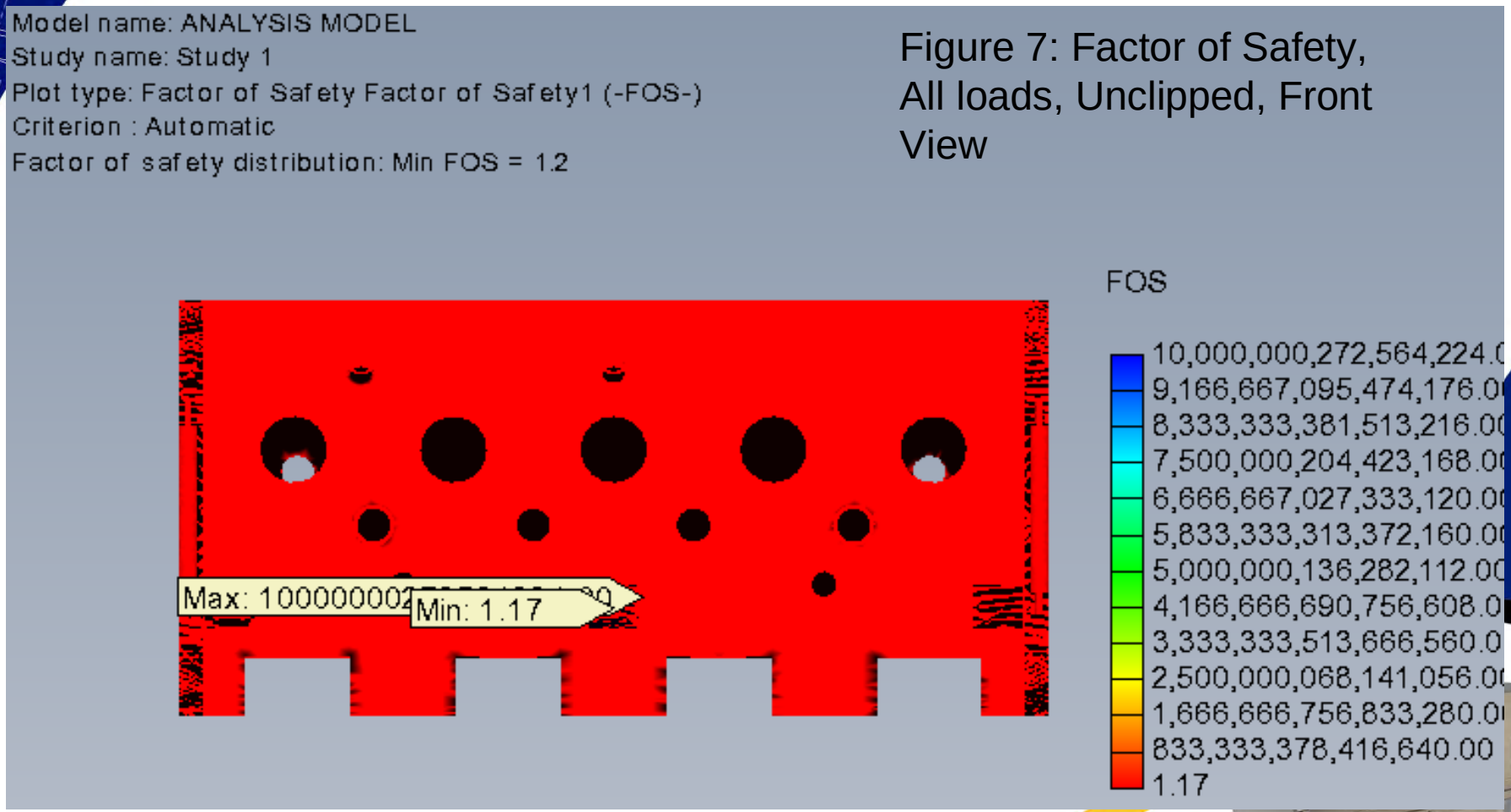


Figure 7: Factor of Safety, All loads, Unclipped, Front View

Risks and Benefits of FEA Tools

Benefits

- Ability to analyze complex shapes
- Fast process
- Temperature is included

Risks

- Incorrect restraints and assumptions
- Over confidence in numbers by inexperienced users
- Fabrications are not as exact as models

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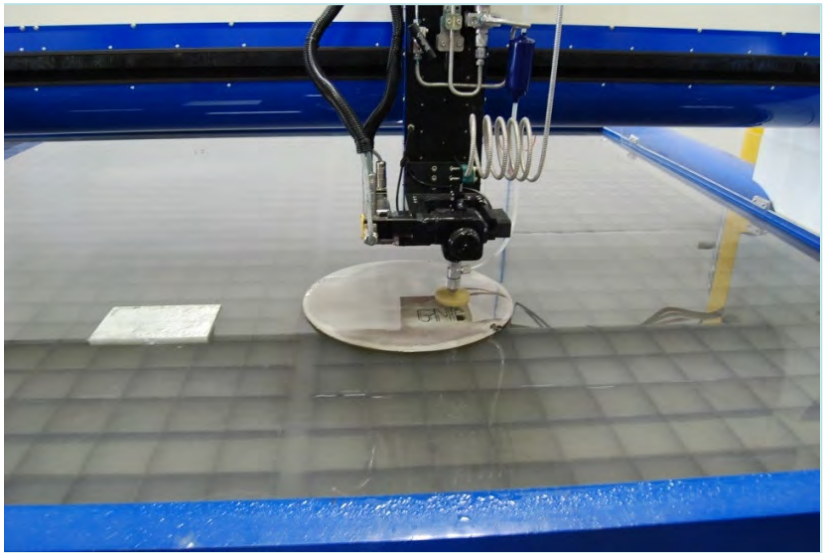
Waterjet Cutting

Waterjet

- 5-axis Waterjet can be used to prepare edges for welding
- No heat involved, there will be no thermal stress in the material and the cut will be oxide free



CAM Systems

- In conjunction with waterjet cutting have revolutionized chamber manufacturing
  - No machining on most parts
  - 5-axis cutting
- Reduced paper

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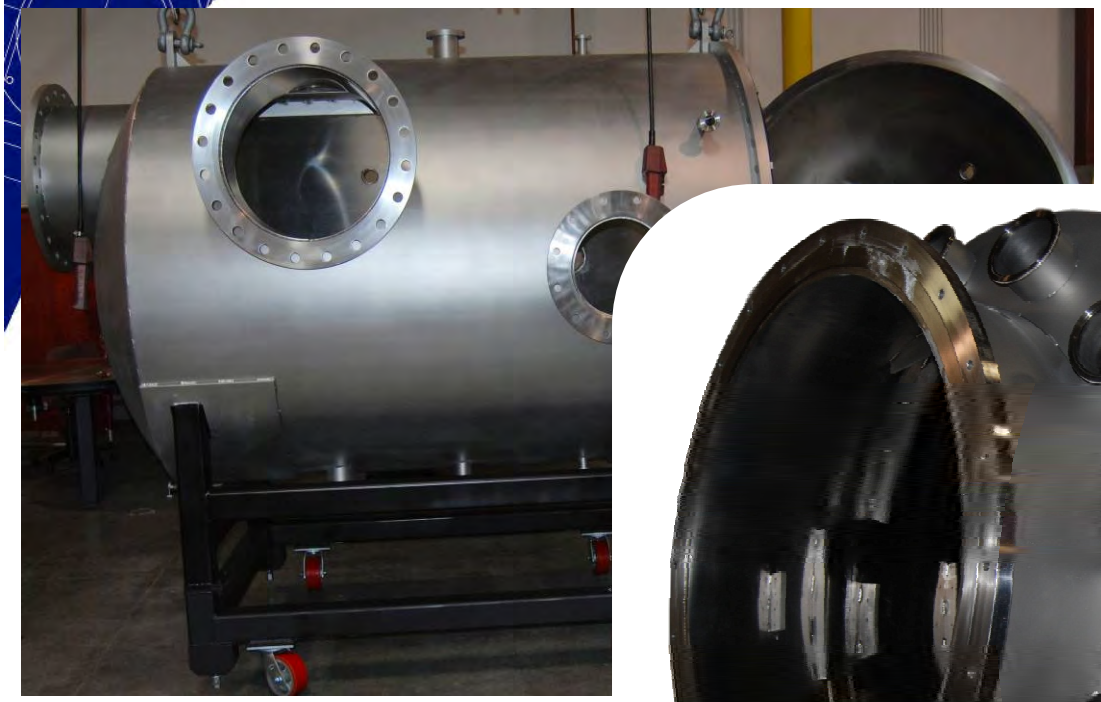
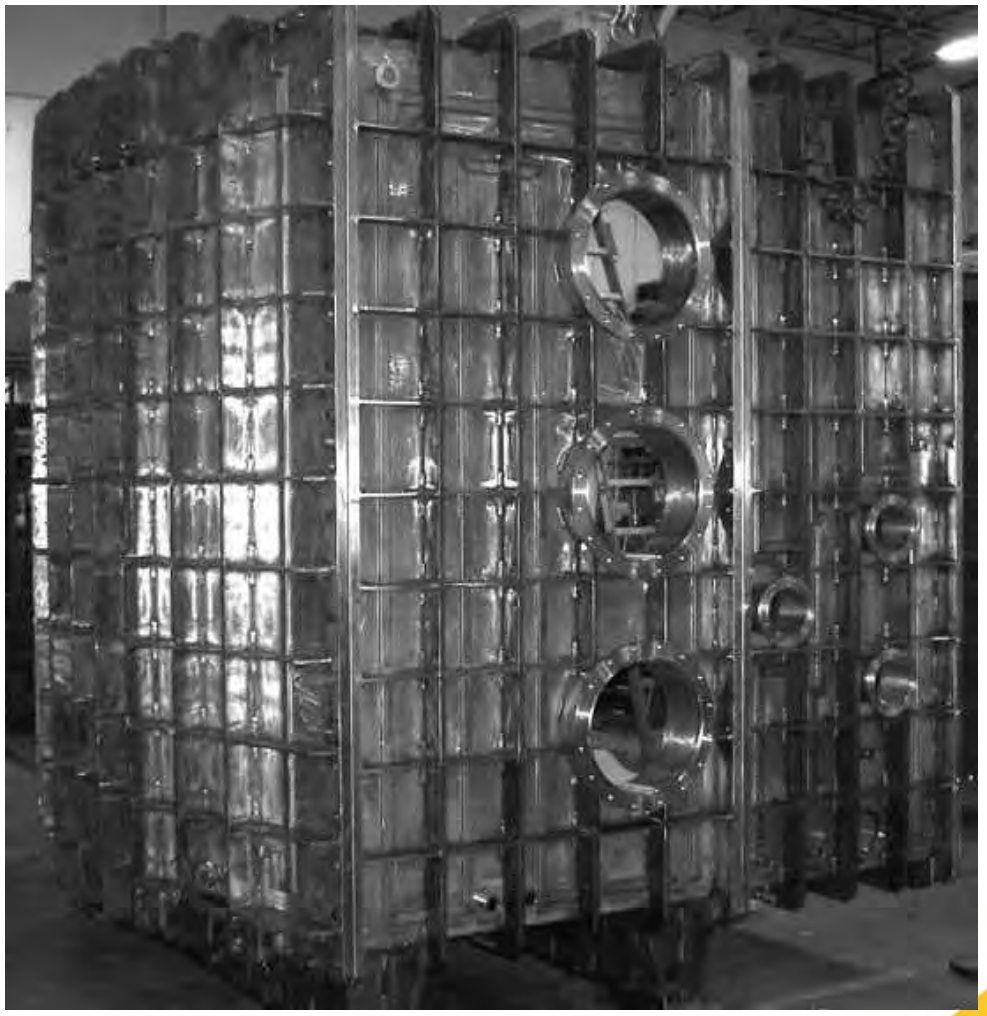
5-axis Waterjet Cutting Makes Port Fitting Simple

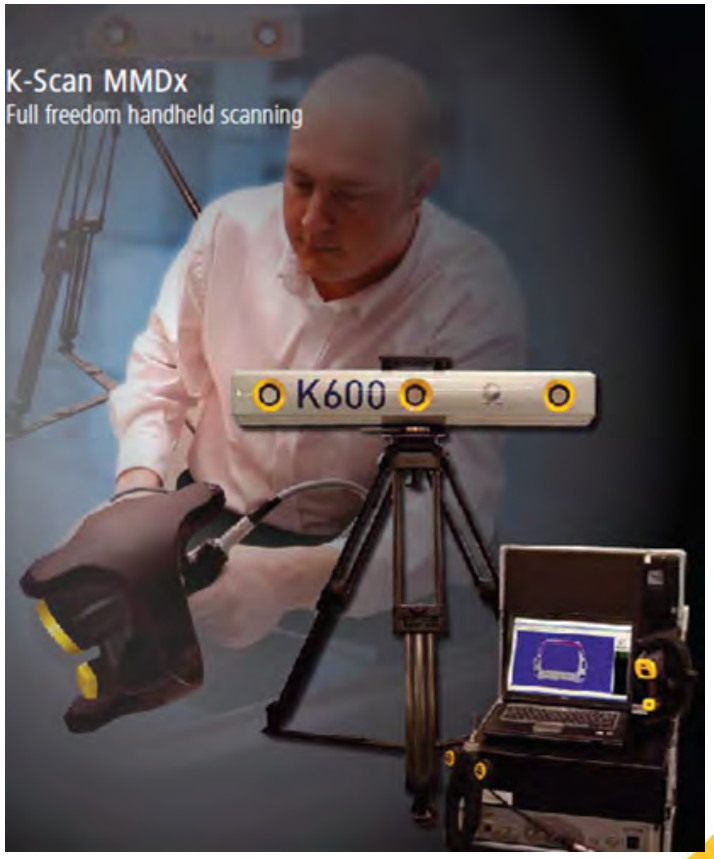


Welding Layouts are Done by CNC Programming



Measurement Goes to the Work Piece

Inspection Arms



Laser Scanners

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With Inspection at the Part During Welding no Post Weld Machining is Required

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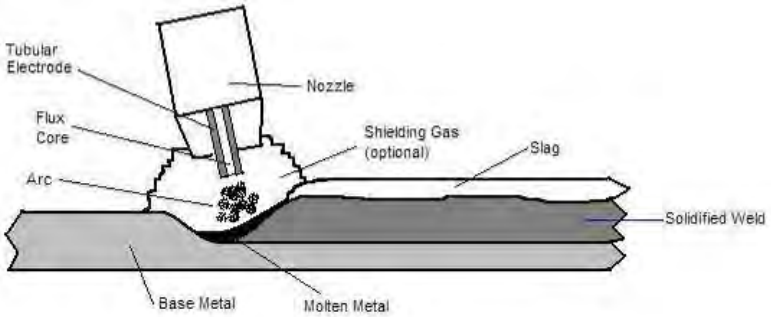
Welding

Welding Processes for Vacuum Chambers

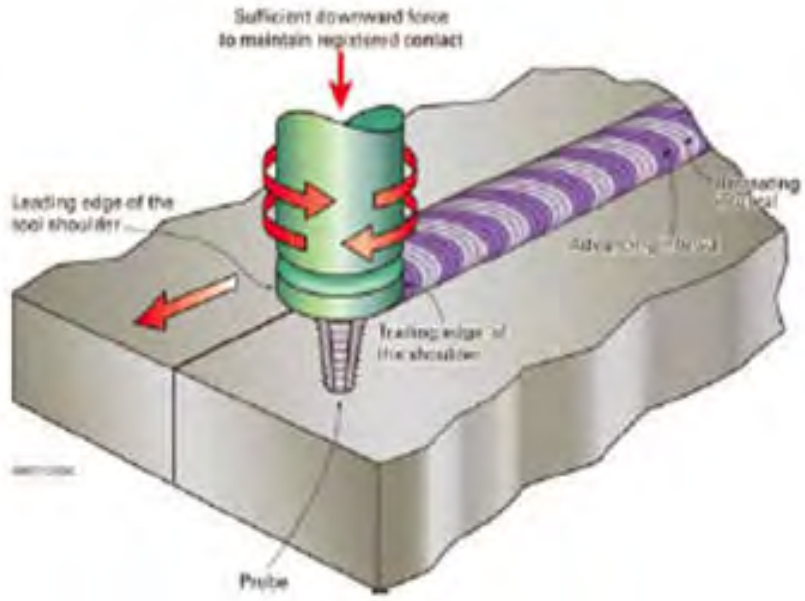
- TIG (Tungsten Inert Gas)
  - Standard process for critical vacuum welds
- MIG (Metal Inert Gas)
  - Standard process for structural welds
- Dual Shield MIG



Welding Processes for Vacuum Chambers

- Electron Beam Welding
  - Deep penetration
  - Small heat impact zone

- Friction Stir Welding
  - For Aluminum

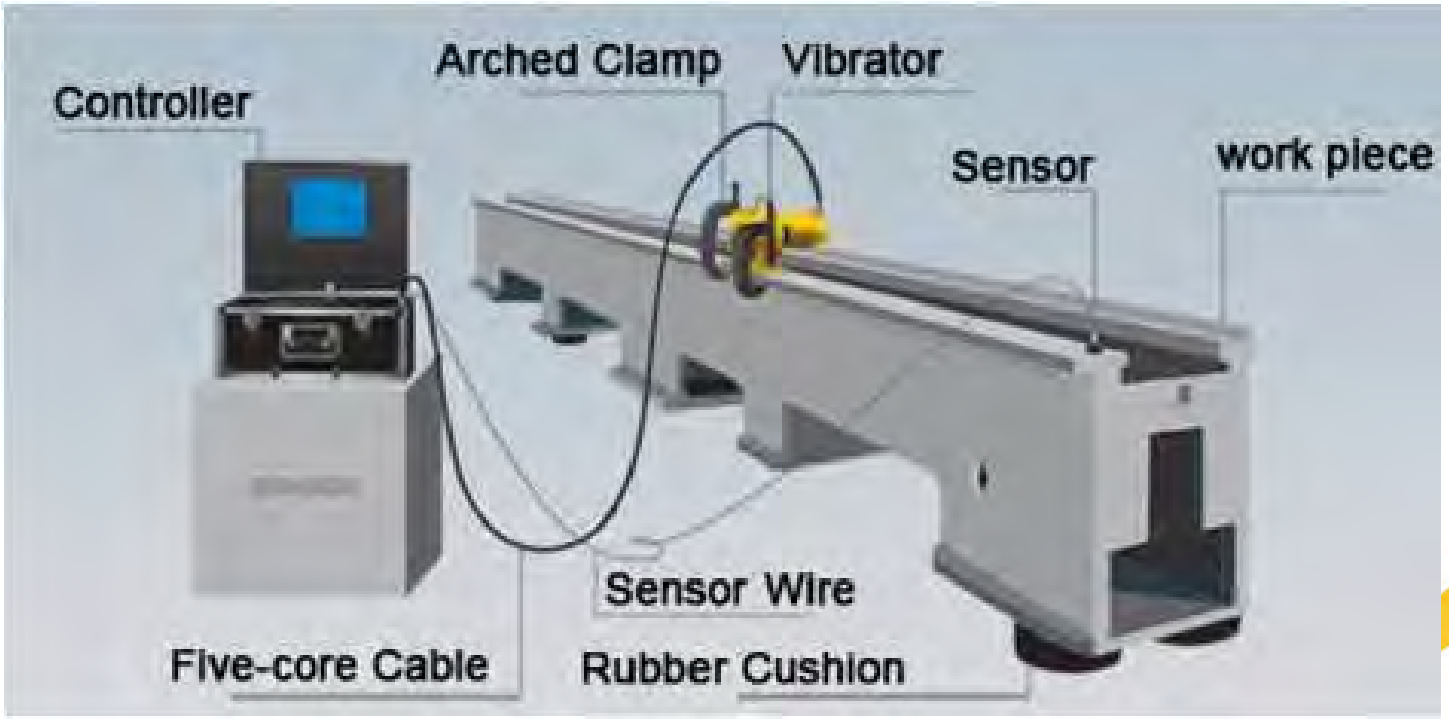


Stress Relieving

- The benefits of stress relieving after/ during welding are:
  - Less stress in material
  - Less deformations of chamber during and following machining operations
  - Better quality of welding seam if vibratory stress relieving is done during welding

Vibratory Stress Relieving

- Alternative to thermal stress relieving for very large structures
- Vibrations 60% to 100% of resonance frequency are implemented into work piece



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Integration of Components Into a Vacuum Chamber

Benefits of Integration

- The traditional layout of a system has components flanged onto a chamber.
- The benefit is higher flexibility.
- Integrating valves, baffles and other components into a chamber can save costs and most of the time will reduce the size of the system.

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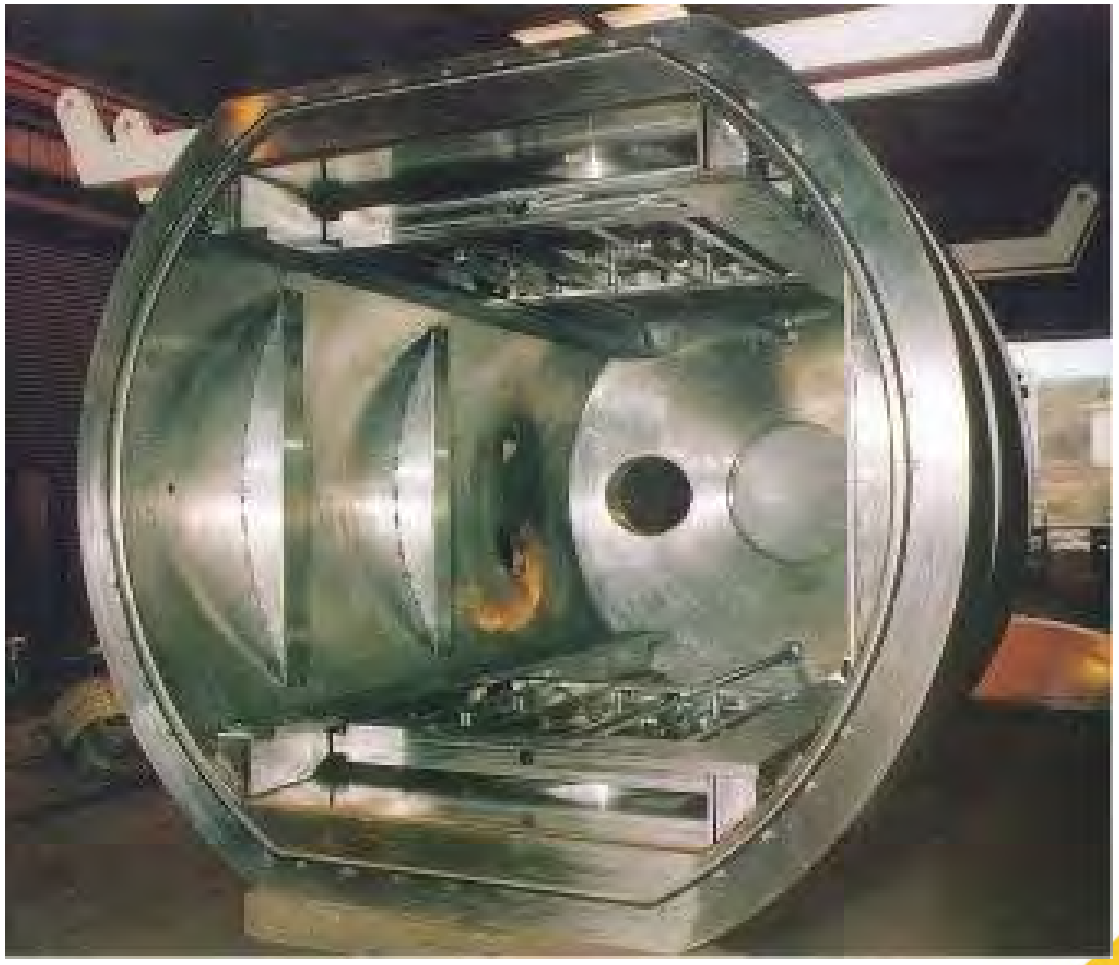
Chamber with Gate Valves

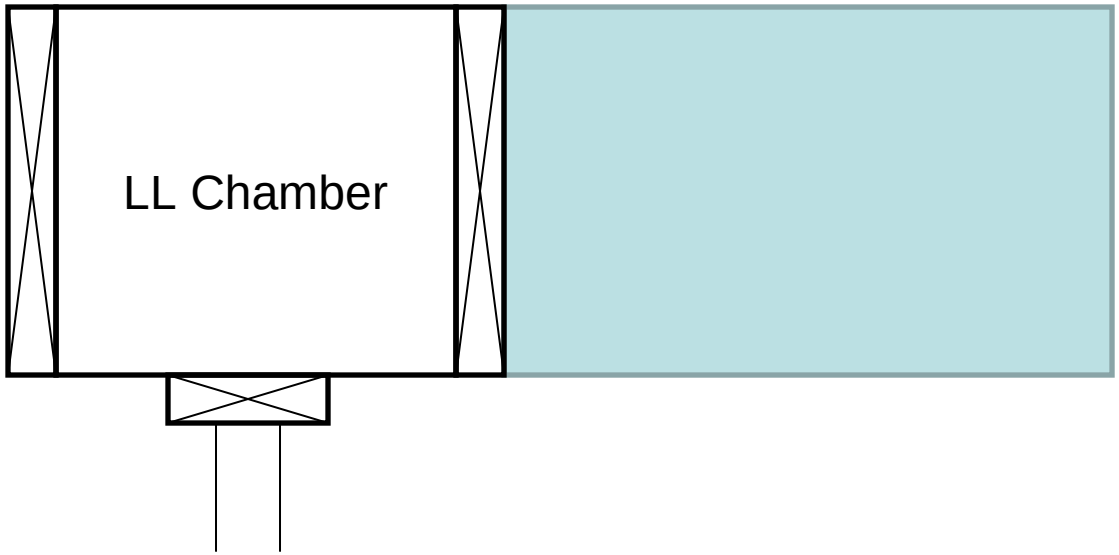


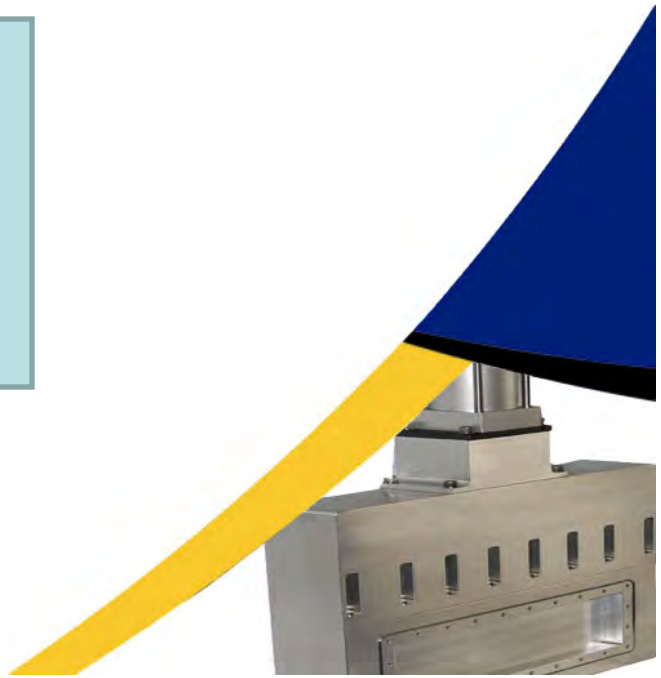
Chamber with Curved Gate

- GNB Engineered Chamber measuring 1.5m in diameter.
- Includes a 170˚ custom valve that seals with differential pressure in either direction.

Load Lock Module

- Door, LL chamber and transfer valves can be combined into one compact package.





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UHV is Bigger & Less Expensive

Typical UHV Seals

- Wire seal flanges
- Conflat flanges
- Garlock Helicoflex
- Ferrofluidic seal

Two Challenges

- Larger flanges
- Reduced costs

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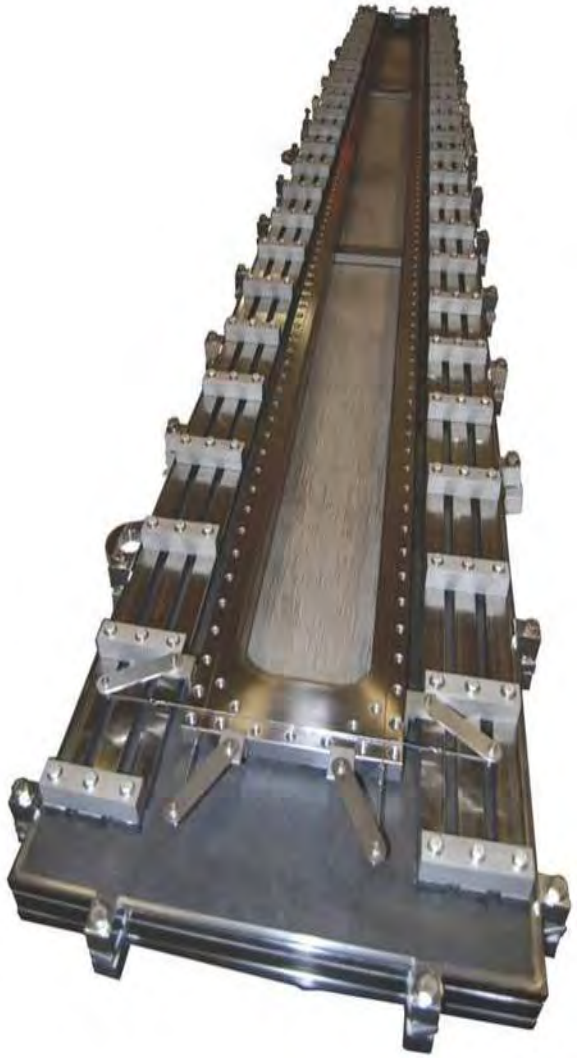
4 Meter Long All-metal Seal



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Surface Preparation and Cleaning

Correct Material Selection

Approximate outgassing rates to use for choosing vacuum materials or calculating gas loads

(All rates are for 1 hour of pumping)

Vacuum Material	Outgassing Rate *(torr liter/sec/cm^2)*
Stainless Steel	6×10^{-9}
Aluminum	7×10^{-9}
Mild Steel	5×10^{-6}
Brass	4×10^{-6}
High Density Ceramic	3×10^{-9}
Pyrex	8×10^{-9}

Vacuum Material	Outgassing Rate *(torr liter/sec/linear cm)*
Viton (Unbaked)	8×10^{-7}
Viton (Baked)	4×10^{-8}

If some elements are not permitted in a chamber, keep them away!

- Mild Steel
  - No mild steel fixtures, carbide cutting tools
- Tungsten
  - No TIG welding

Cleaning Processes

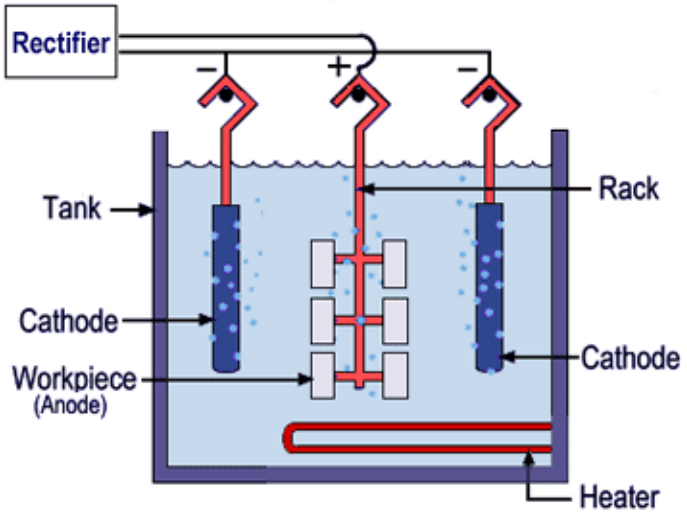
- Depends on desired vacuum level and process
  - High pressure wash
  - Wash with DI water
  - Alcohol wipe down
  - Ultrasonic chemical clean
  - Passivation and electro-polishing
  - Bake out

Passivation

- According to ASTM A380, passivation is "the removal of exogenous iron or iron compounds from the surface of stainless steel”
- Will avoid corrosion especially in 300 series stainless
- Typically done with acids followed by a water (or DI water) rinse

Electro-polishing

- Deburrs
- Smoothes
- Brightens
- Passivates
- Redefines oxide layer
- Removes surface contaminants



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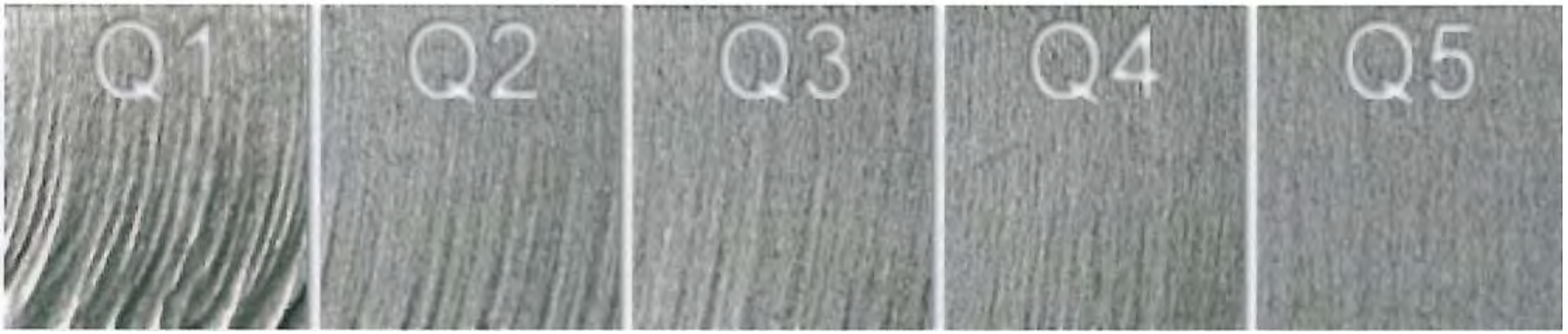
Cost Effective Surface Finishes

5 Main Reasons for Selecting a Surface Finish

- Aesthetics
- Gas load
- Fit up
- Elimination of trapped volumes
- Ease of cleaning

The cost can be large and many companies over specify!

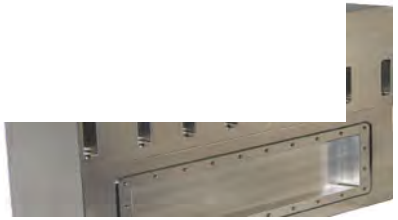
Waterjet Cutting has Dramatically Changed Chamber Manufacturing



Waterjet edges are specified by “Q” codes.
The better the finish, the slower the cut.

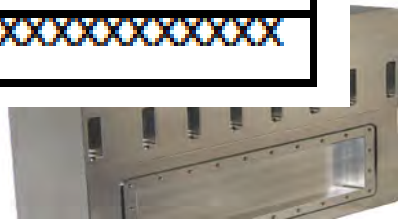
15 Common Surface Finishes

- Number 0 finish is hot rolled annealed (also known as mill-scale)
- Number 1 finish is hot rolled
- Number 2D finish is cold rolled
- Number 2B finish, cold rolled bright finish
- Number 2BA is bright annealed finish, nearly a mirror
- Number 3 grained, sanded in a uniform direction with 80-100 grit
- Number 4 grained, sanded in a uniform direction with 150 grit
- Number 6 finish is plate sanded with a rotating abrasive cloth; “Satin Blend” is an example
- Number 7 finish is buffed, highly reflective, some fine scratches
- Number 8 finish is a true blemish-free mirror finish
- Bead blasted
- Blanchard ground
- Machined all over
- Electro-polished
- A lapped finish



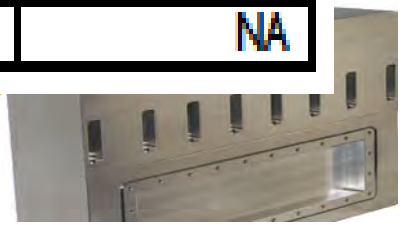
Surface Roughness for Typical Chamber Processes

	Roughness Height Ra (µ inch)									
Process	2000	1000	500	250	125	63	32	16	8	4
Flame Cutting	---------XXXX--------									
Waterjet	----------XXXX----------									
Sawing	----------XXXXXX----------									
EDM	---------XXXXXXXXXX--------									
Milling	----------XXXXX----------									
Turning	----------XXXXX----------									
Laser	---------XXXXXXXXX----------									
Grinding	---------XXXXXXXXXXXXXXXXXXX----------									
#4 Grained	---XXX---									
Electro-Polish	----XXXXXXXX----------									
Lapping	----XXXXXXXXXXX									



To Eliminate the Conversion Confusion

Ra (µ inch)	RMS (µ inch)	Ra (µ meter)	RMS (µ meter)	Grit Finish
4	4.5	0.10	0.11	Mirror
8	9.0	0.20	0.23	400
16	18	0.41	0.46	240
32	36	0.81	0.91	180
63	71	1.60	1.80	120
125	141	3.18	3.57	36
250	281	6.35	7.14	NA
500	560	12.7	14.3	NA
1000	1125	25.4	28.6	NA
2000	2250	50.8	57.2	NA



Misconceptions

- Shiny surfaces are always better
  - Electro-polishing and graining, particularly, introduces contaminants into the metal.
- Electro-polishing is required for UHV
  - The greatest reduction in gas load occurs between a mill-scale and brushed mill-scale finish. It is difficult to find a difference in gas load between a #4 grained finish and an electro-polished finish.

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Thank You!

Questions?

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