NCSX Vacuum Vessel Joint Design

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PPPL
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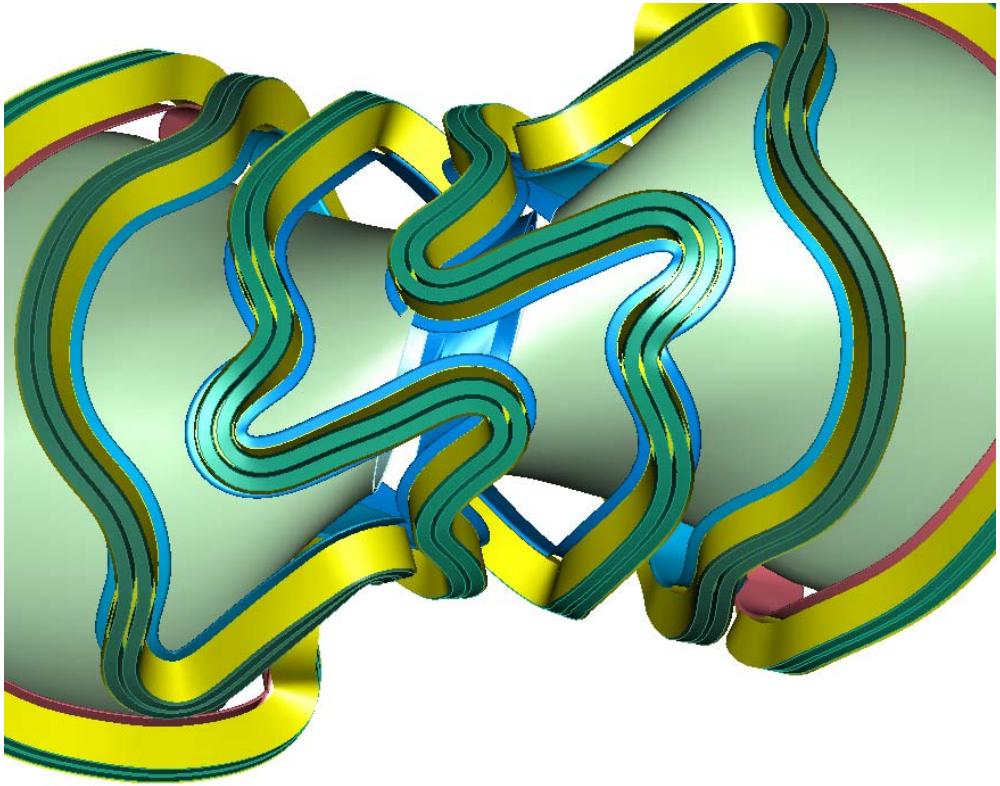
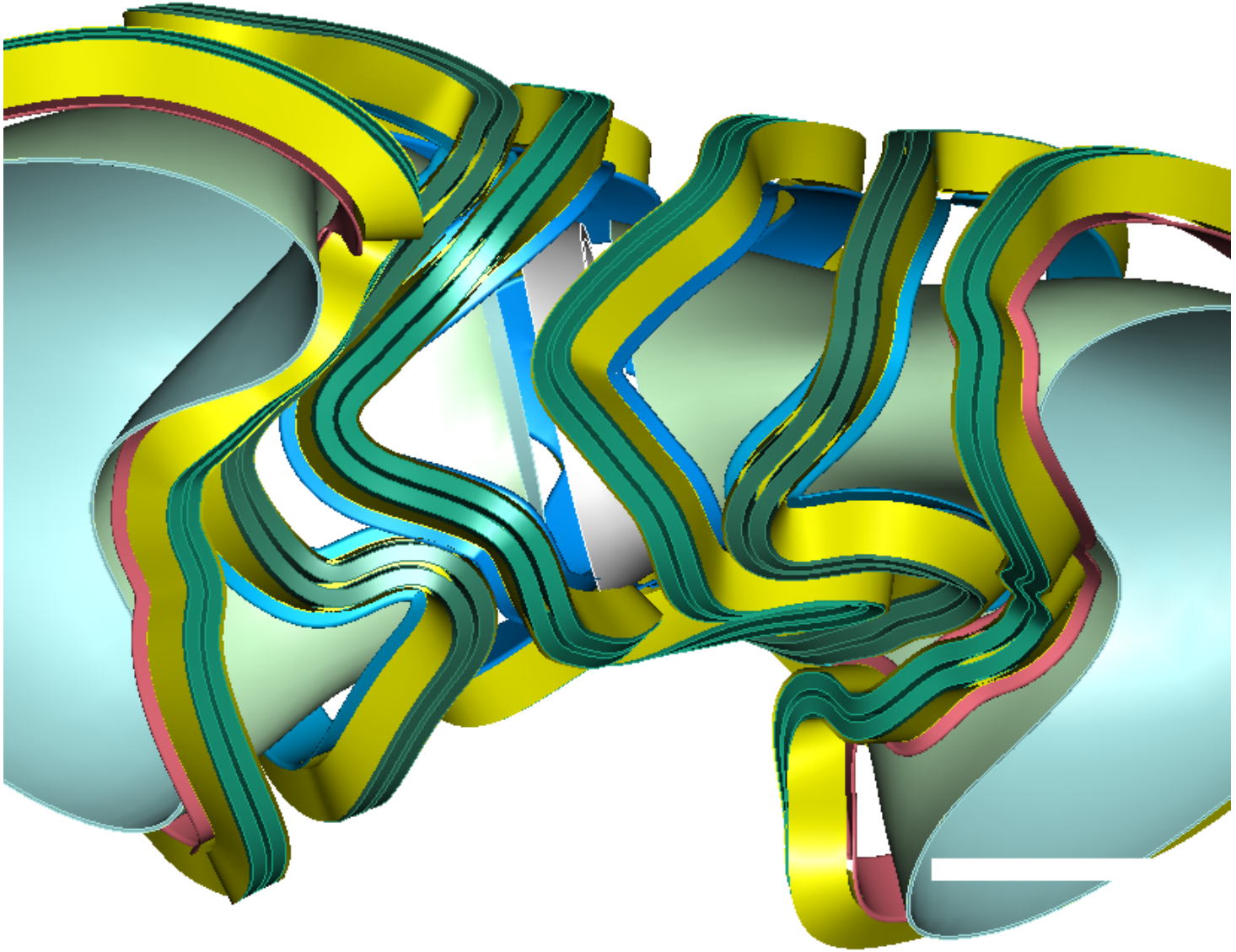
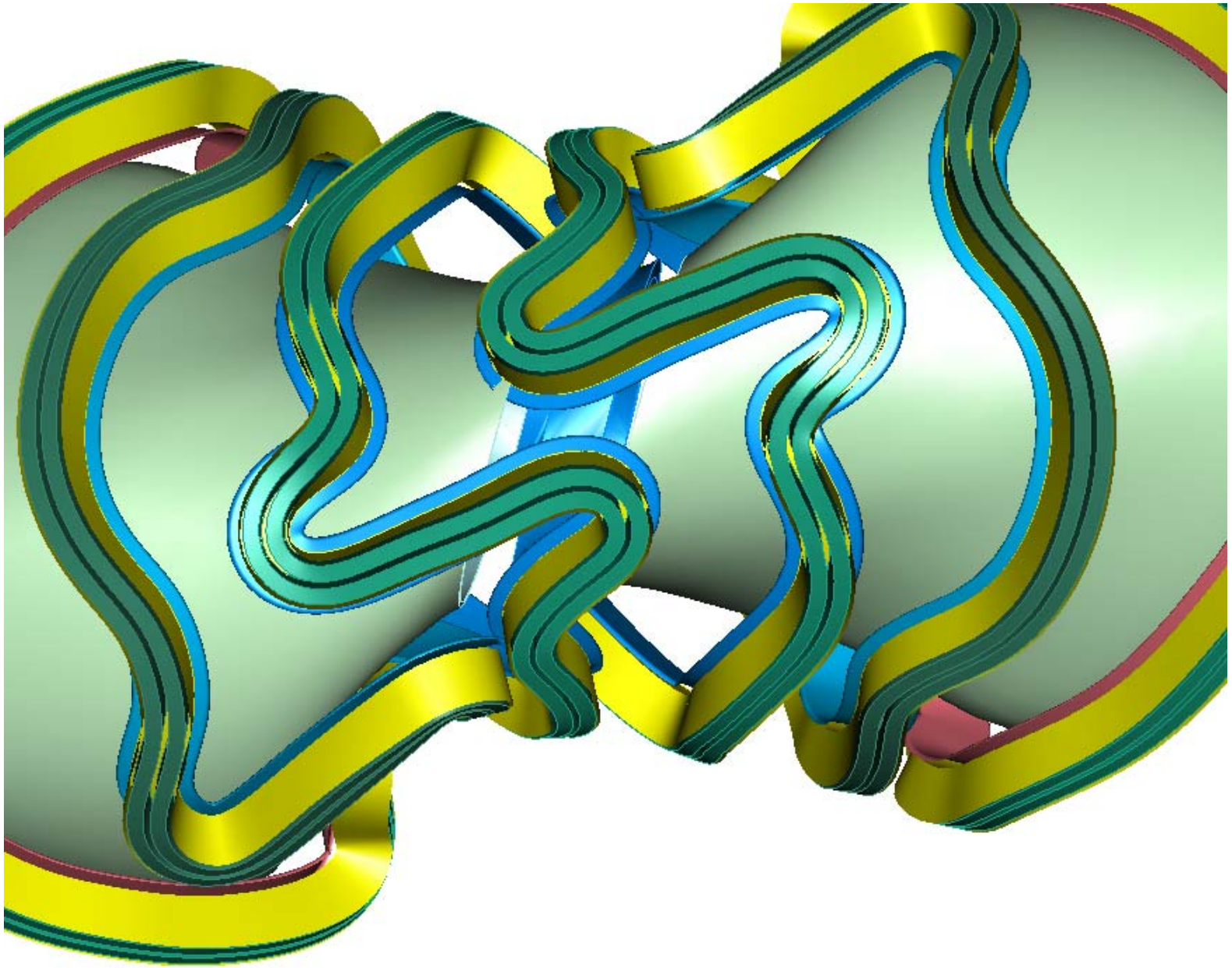


THE CHALLENGE

- Provide a removable joint to connect the three vessel segments.
- At first a straight cut was proposed but the coils dip into the plane of the vessel such that the face would collide with the drooping coil edge as they were brought together.
- This resulted in the angled joint concept which moves the vessel joint ahead of the drooping coil and precludes the interference.





CRITERIA

- Provide a vacuum tight assembly of vacuum vessel segments.
- Provide for tolerance differences between segments.
- Provide a machinable section to allow for poloidal variances.
- Capable of disassembly and reassembly even if rework is necessary.

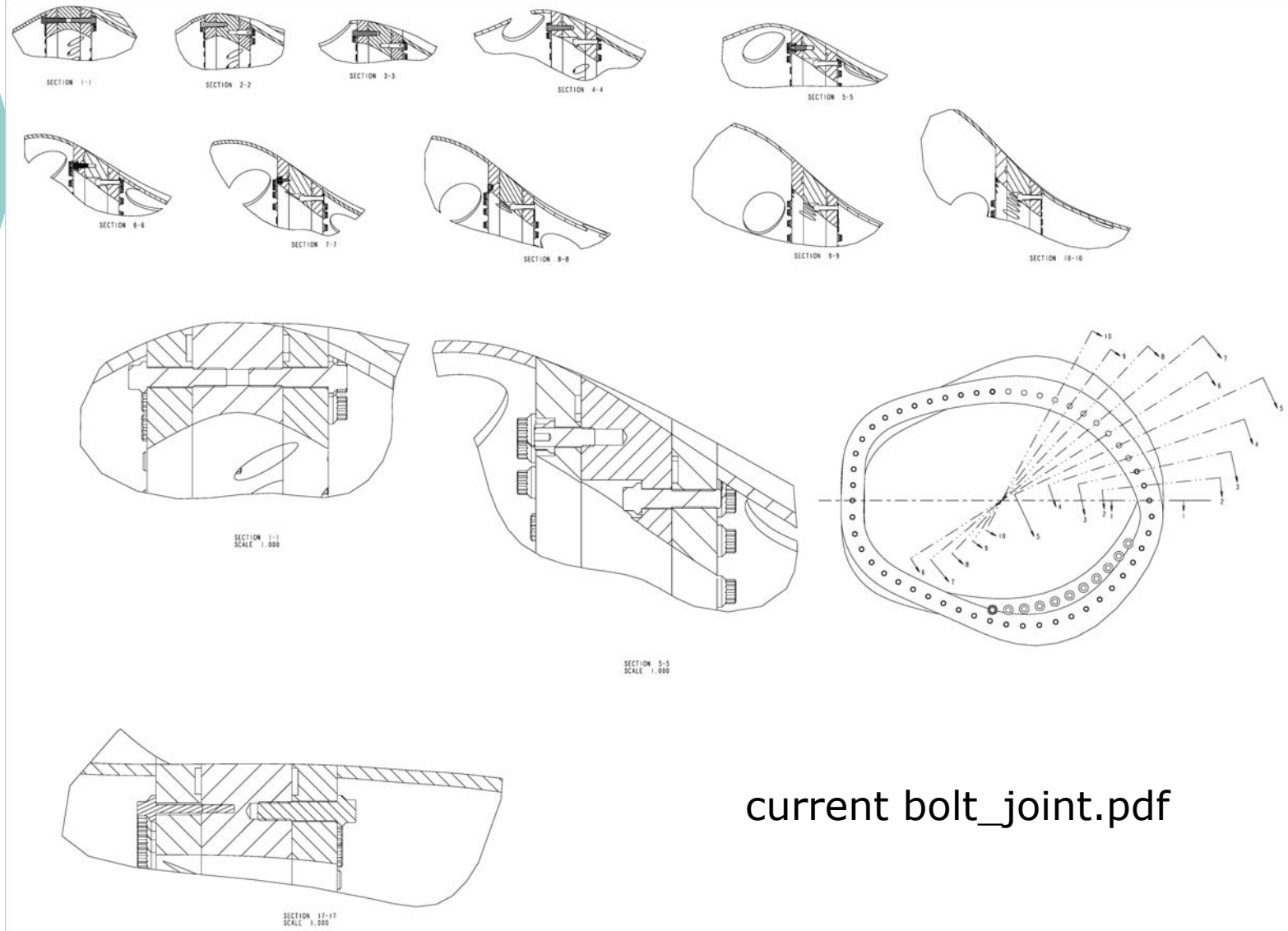
CONCEPT OVERVIEWS

Configuration	PROS	CONS
Straight bolted	[1] Easy fit up [2] Symmetrical	[1] Interference with modular coils during assembly THIS IS NOT AN OPTION – IT DOES NOT WORK
Angled bolted CURRENT DESIGN	[1] Cure coil interference at top. [2] Provide machinable shim to accommodate potential fit-up problems. [3] Easily dissassembled	[1] Create problem at bottom [2] Adds double seal
Angled Welded	[1] Easy fit up – not clear [2] Symmetrical [3] Simple single joint [4] Compatible with groove for diamond wire cutting.	[1] Structural welding introduces risk of distortion during assembly [2] Difficult access for welding [3] Special features required for backing weld & leak checking?
Hybrid – Bolted with inside welded seal plate	[1] Drop in bolts cure clearance problem [2] simple seal weld	[1] difficult disassembly [2] cannot service bolts

CURRENT BOLTED JOINT

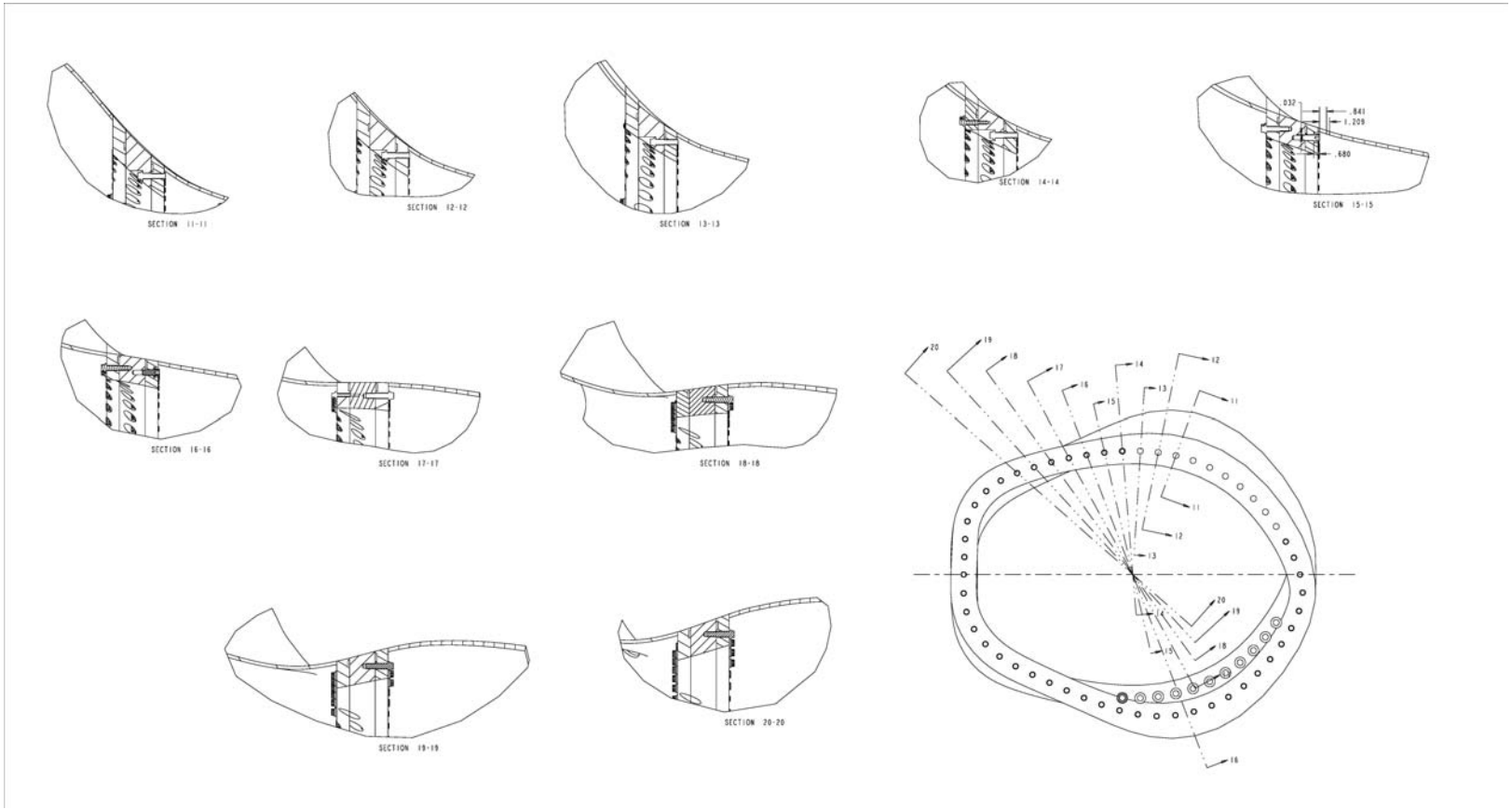
- HIGHLY COMPLEX
  - Two shaped flanges and a machinable spacer
  - Eccentric bolt loading of flanges
  - Detail required for each bolt location
  - Some bolts have hard interference with vessel wall

CURRENT BOLTED JOINT – COMPLEX DRAWING



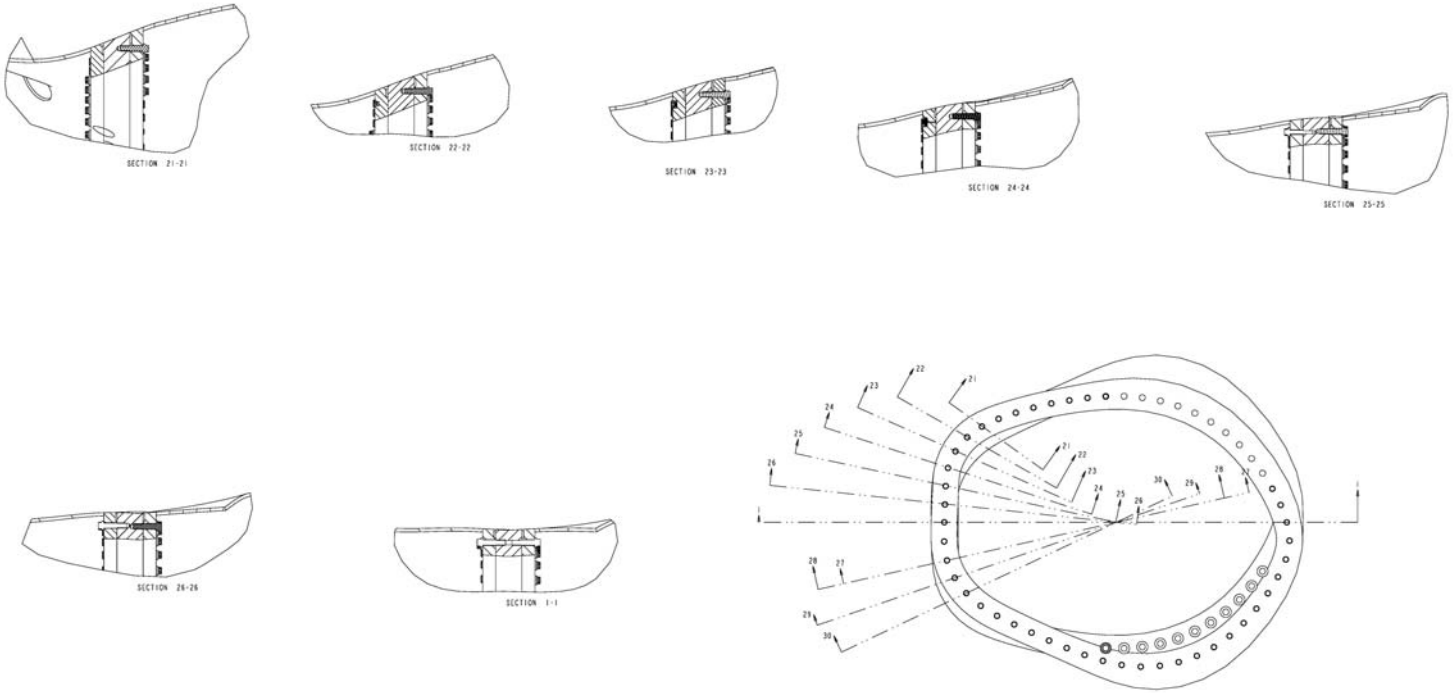
current bolt_joint.pdf

CURRENT BOLTED JOINT – COMPLEX DRAWING



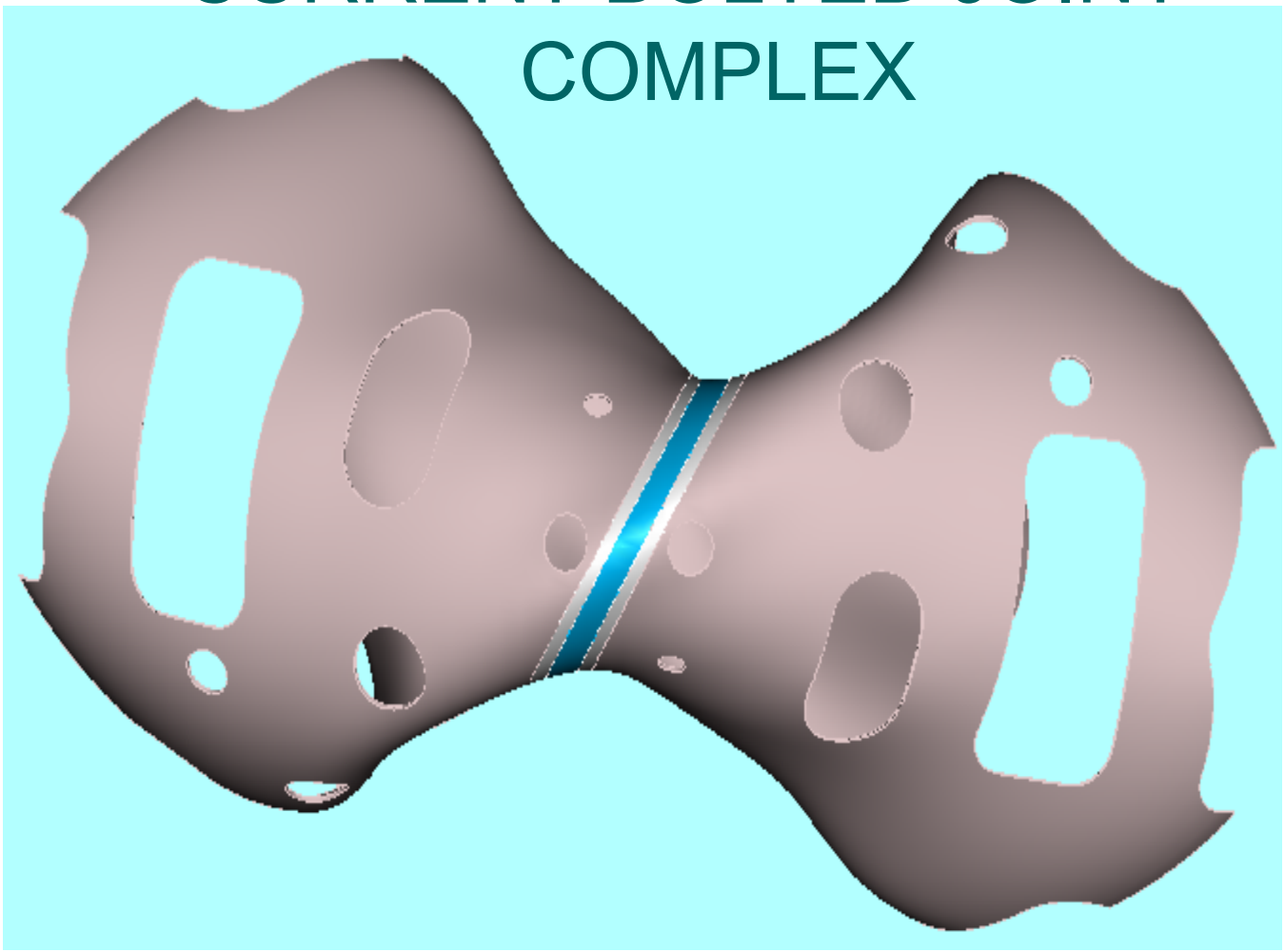
current bolt_joint.pdf

CURRENT BOLTED JOINT – COMPLEX DRAWING



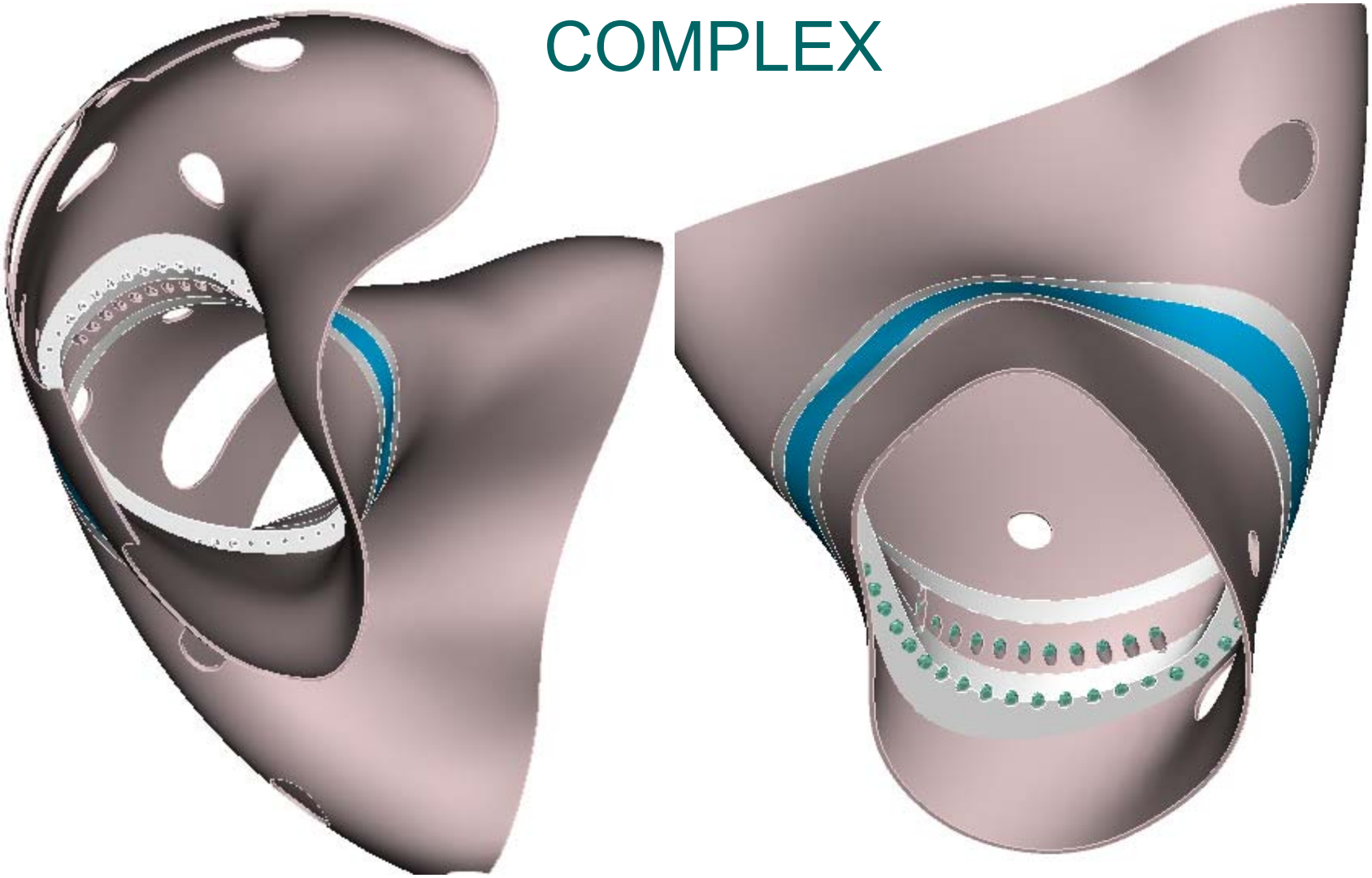
current bolt_joint.pdf

CURRENT BOLTED JOINT – COMPLEX



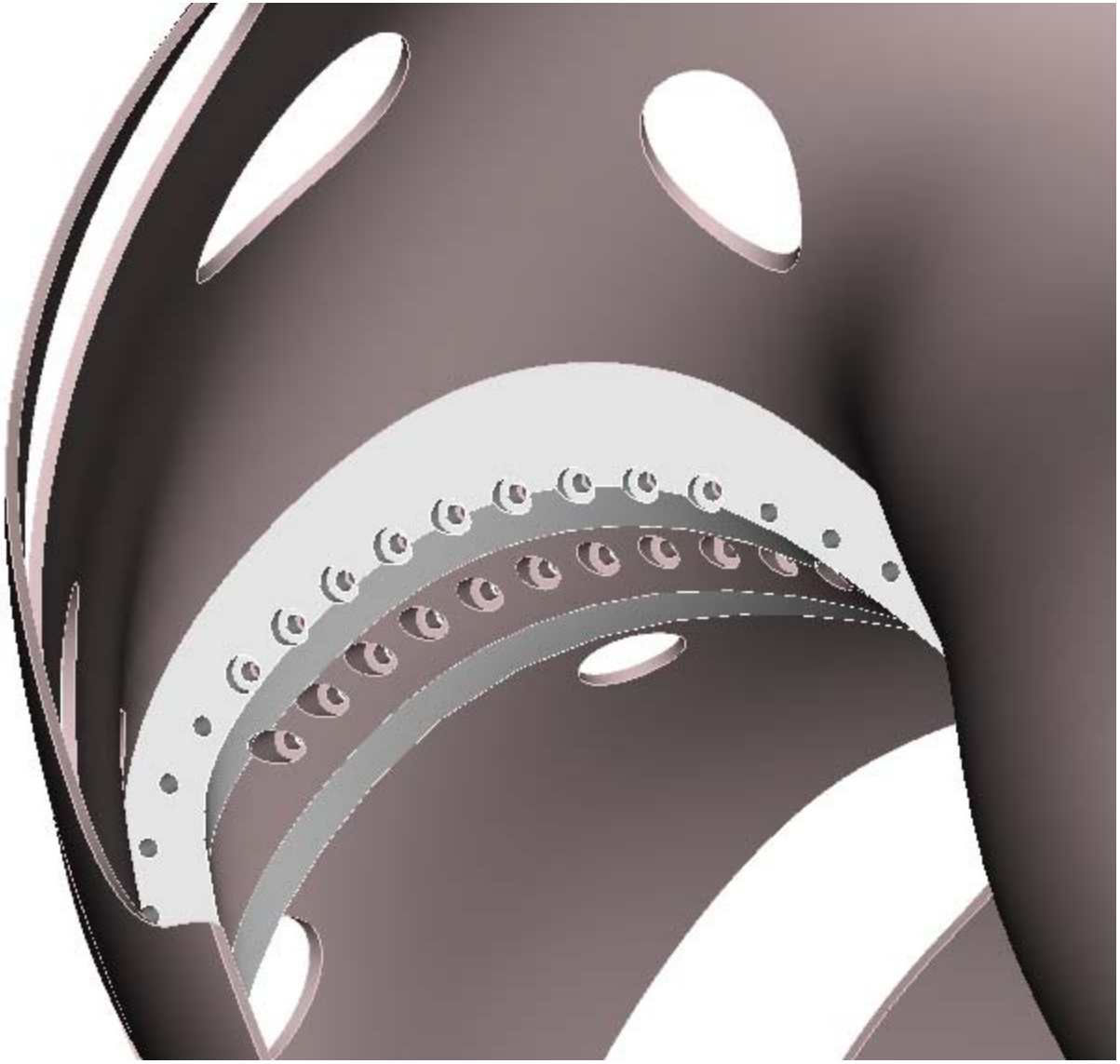
Current bolt_joint.ppt

CURRENT BOLTED JOINT – COMPLEX



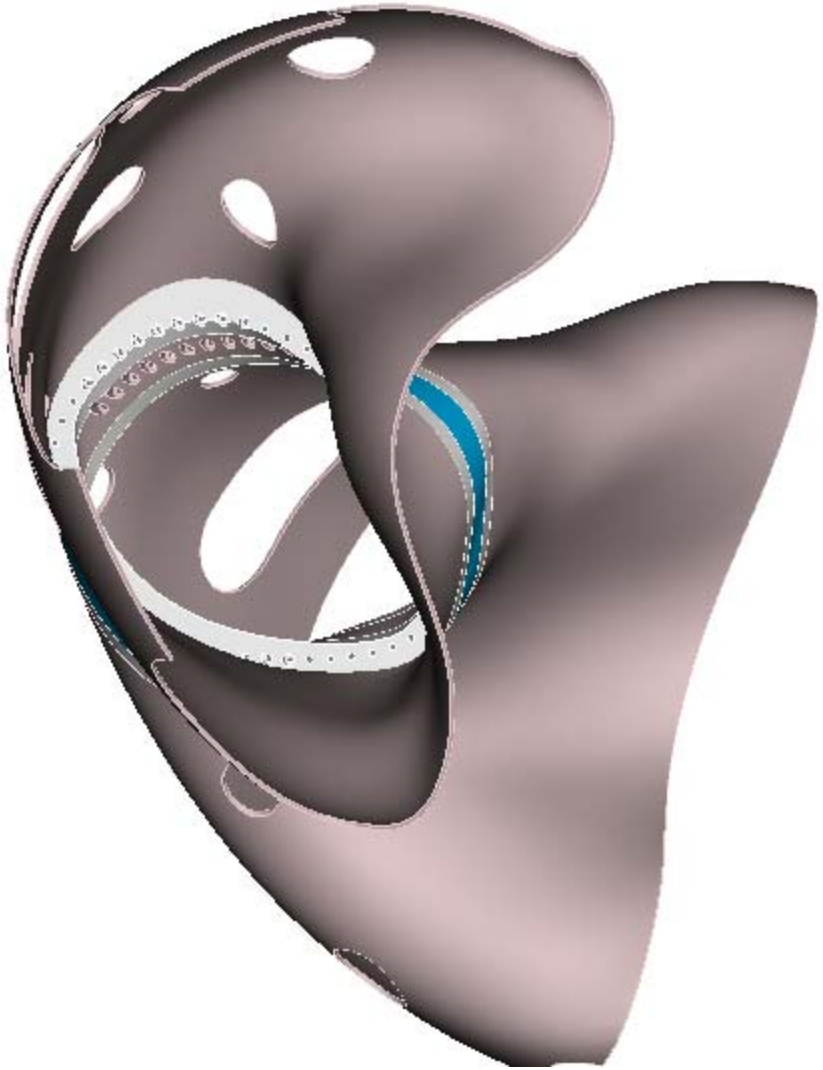
Current bolt_joint.ppt

CURRENT BOLTED JOINT – COMPLEX



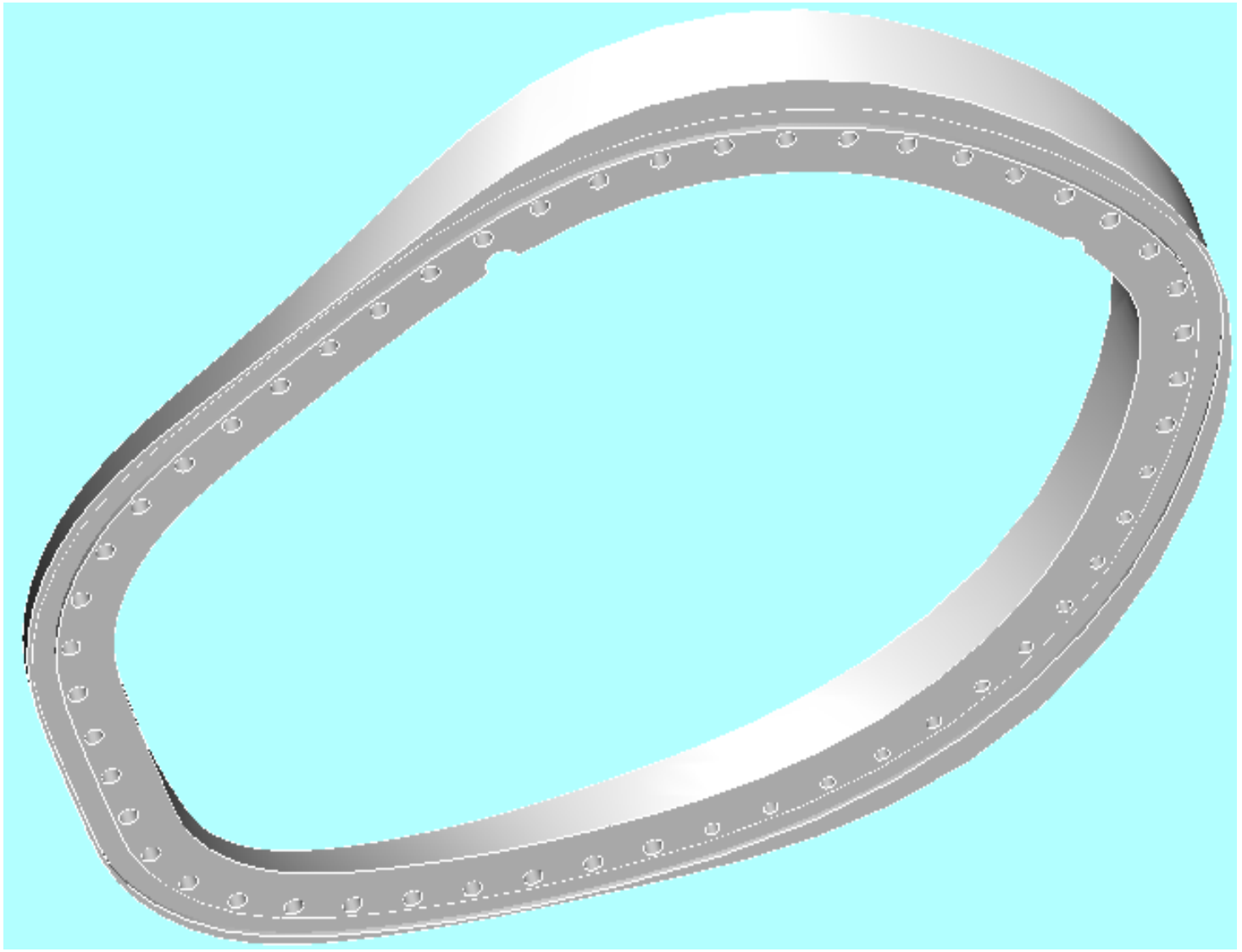
Current bolt_ves_close.ppt

CURRENT BOLTED JOINT – MANY COMPLEX PIECES



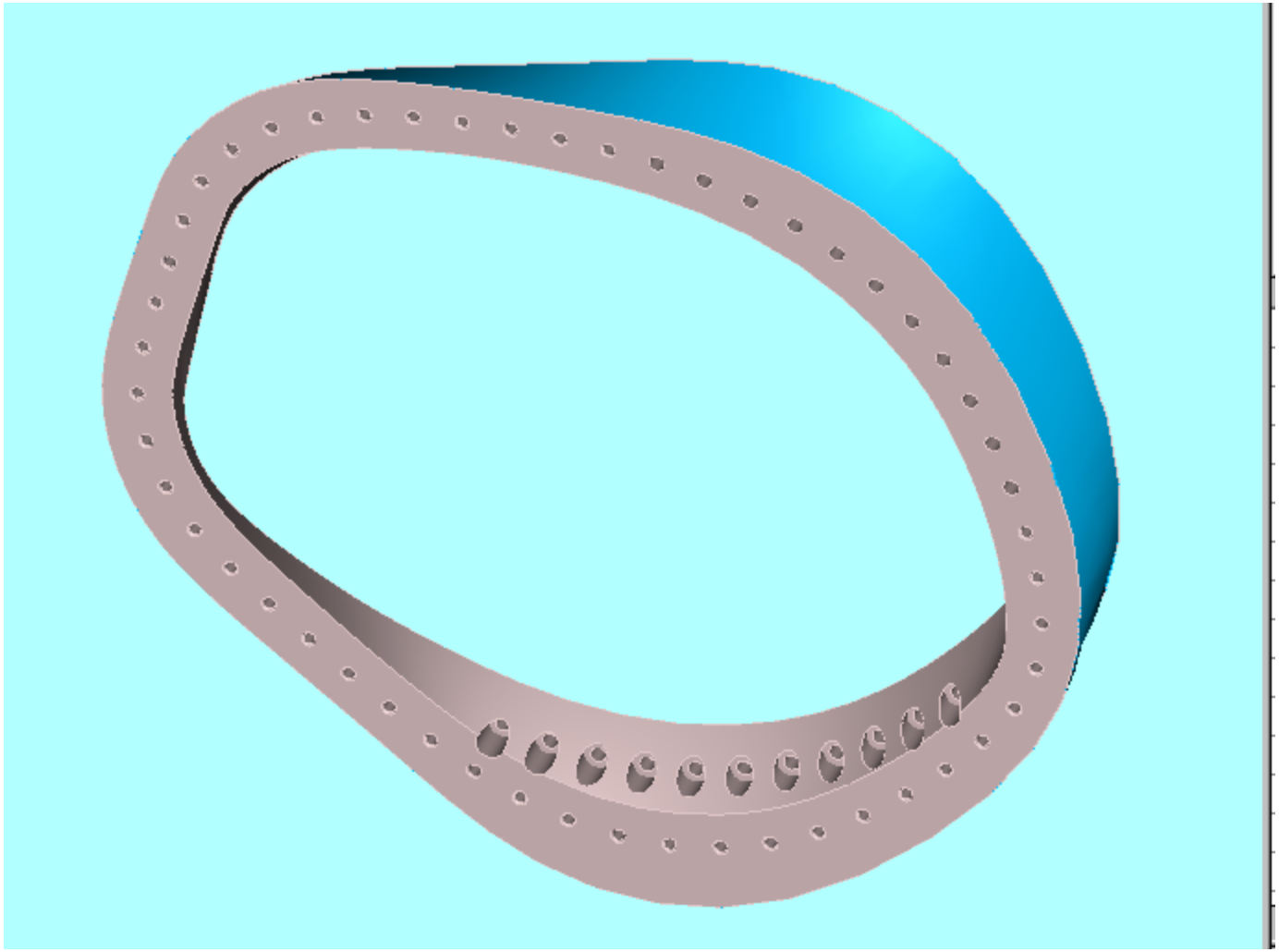
Current bolt_ves_far.ppt

CURRENT BOLTED JOINT – MANY COMPLEX PIECES



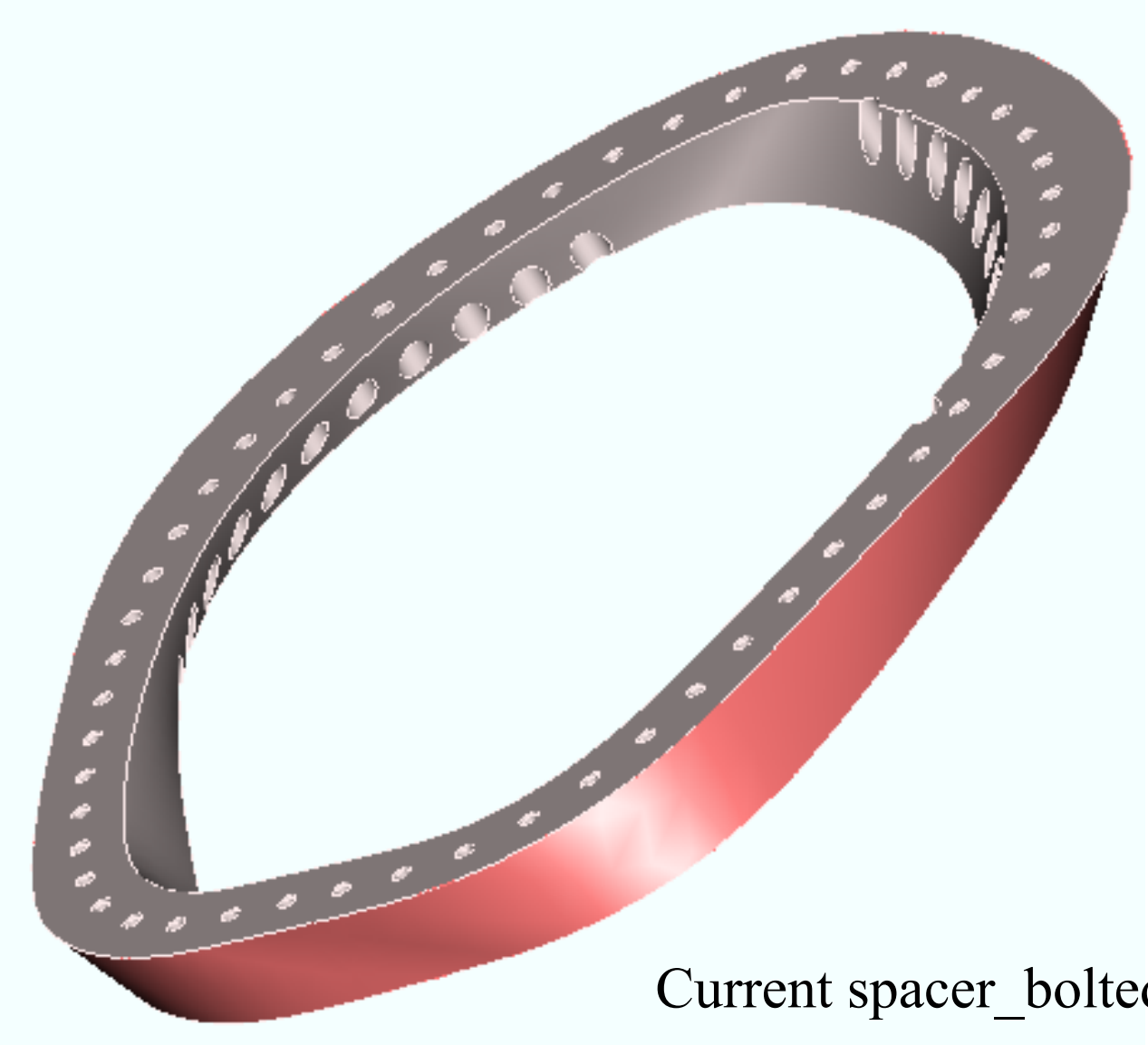
Current flange_bolted.ppt

CURRENT BOLTED JOINT – MANY COMPLEX PIECES



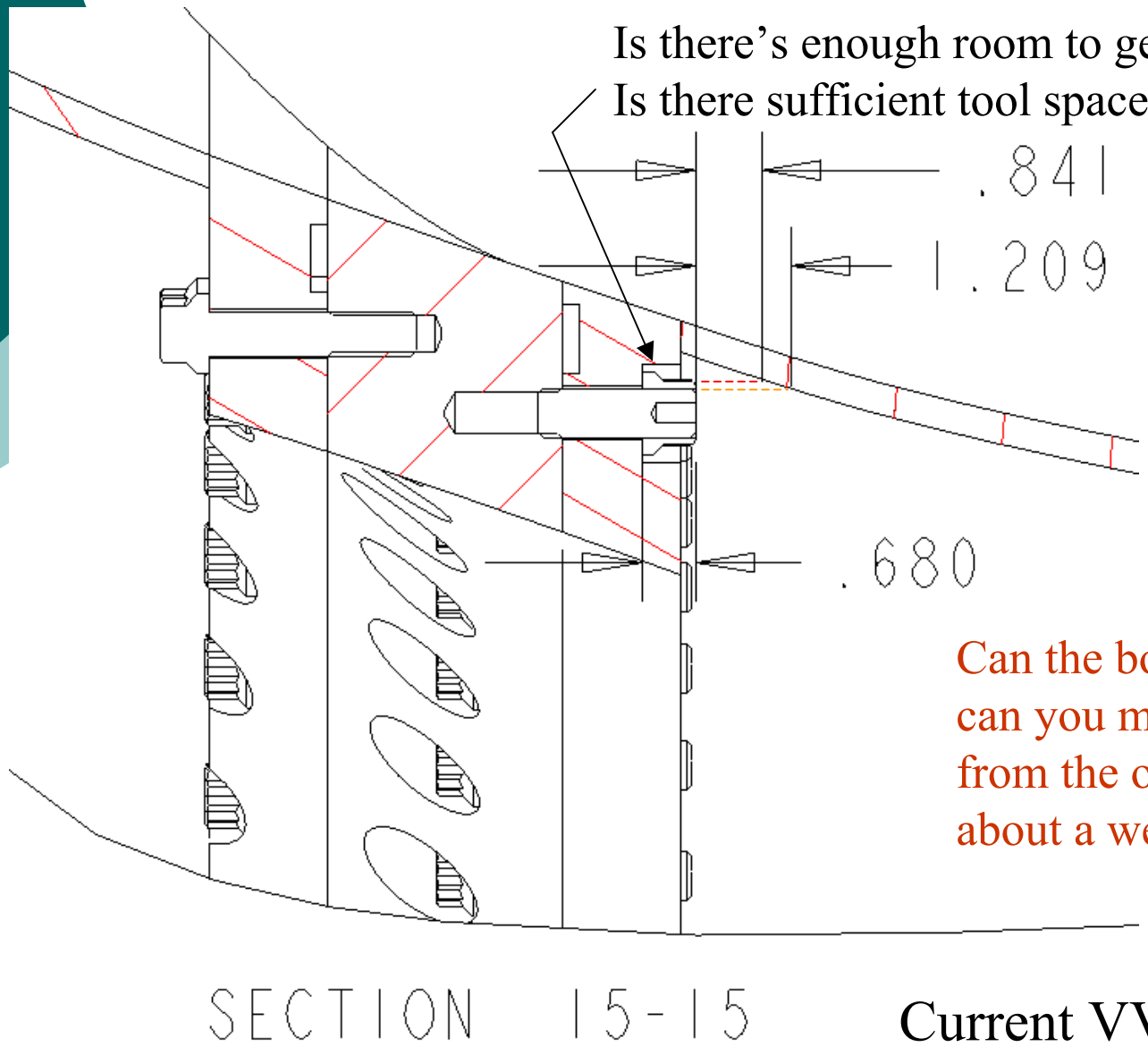
Current ring_bolted.ppt

CURRENT BOLTED JOINT – MANY COMPLEX PIECES



Current spacer_bolted.ppt

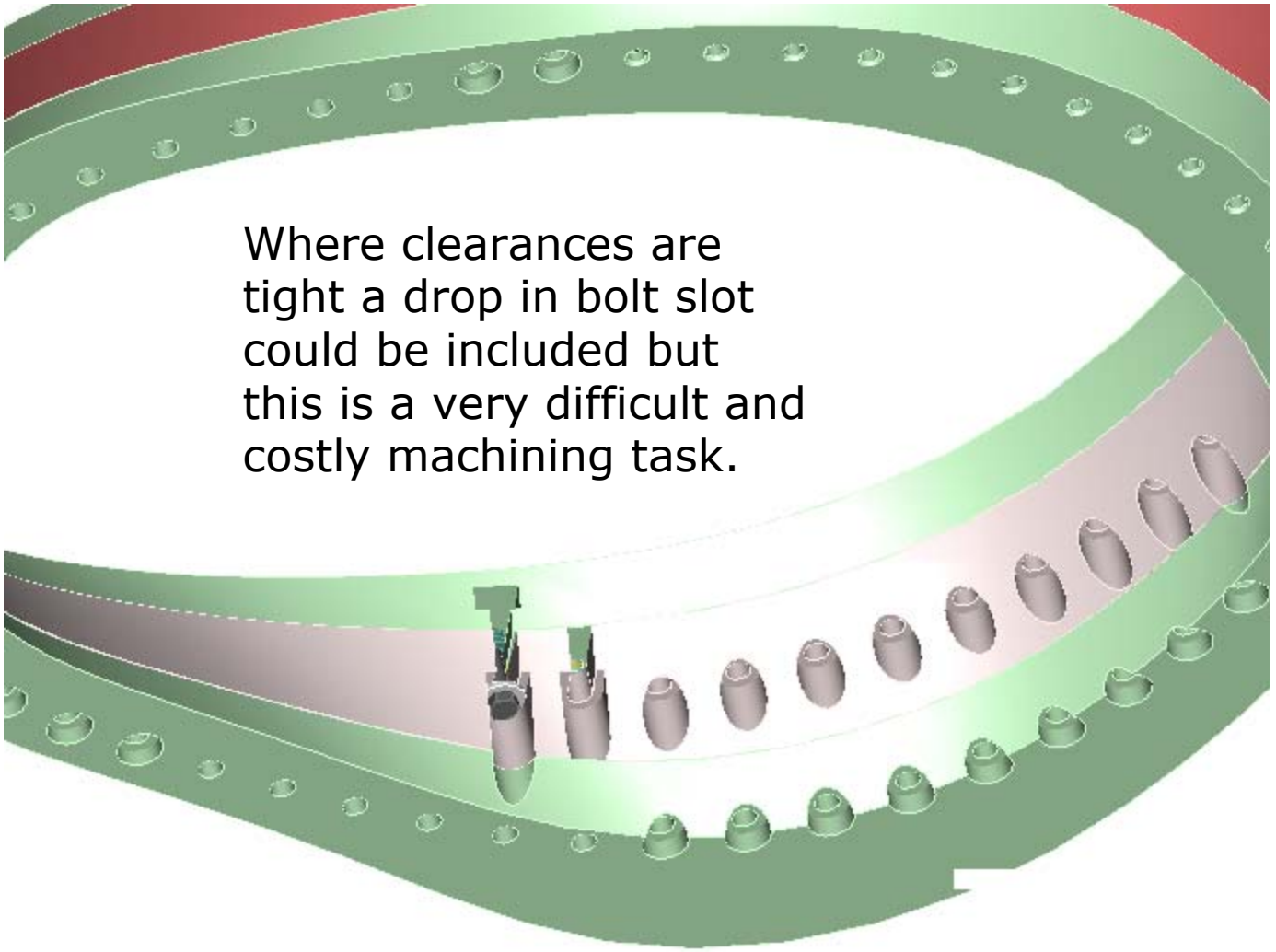
CURRENT BOLTED JOINT – MANY QUESTION



Can the bolt be lowered or can you make the hole from the other side? How about a welded joint?

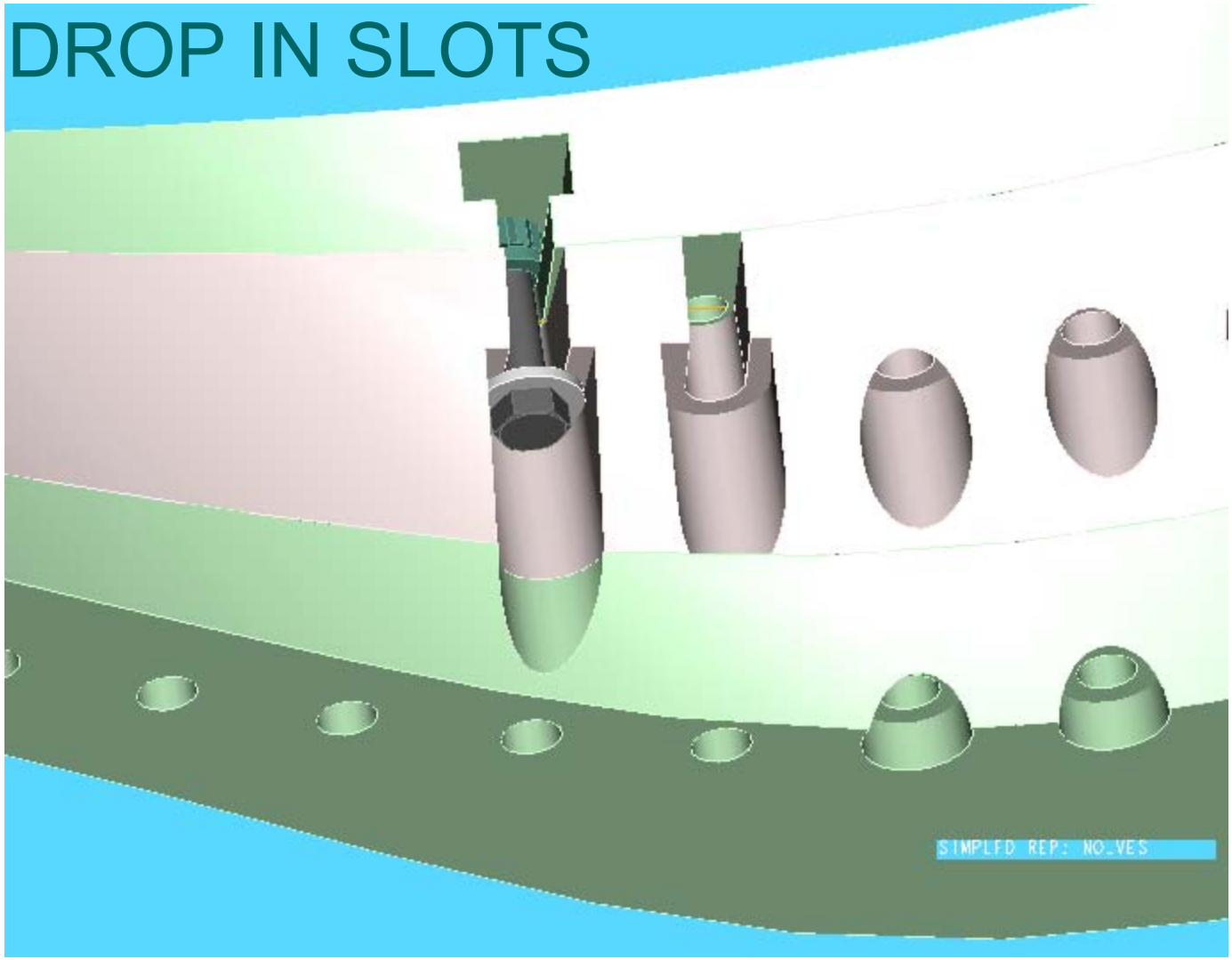
Current VV flange seal.ppt

CURRENT BOLTED JOINT WITH DROP IN SLOTS



Drop in bolt_half_far.ppt

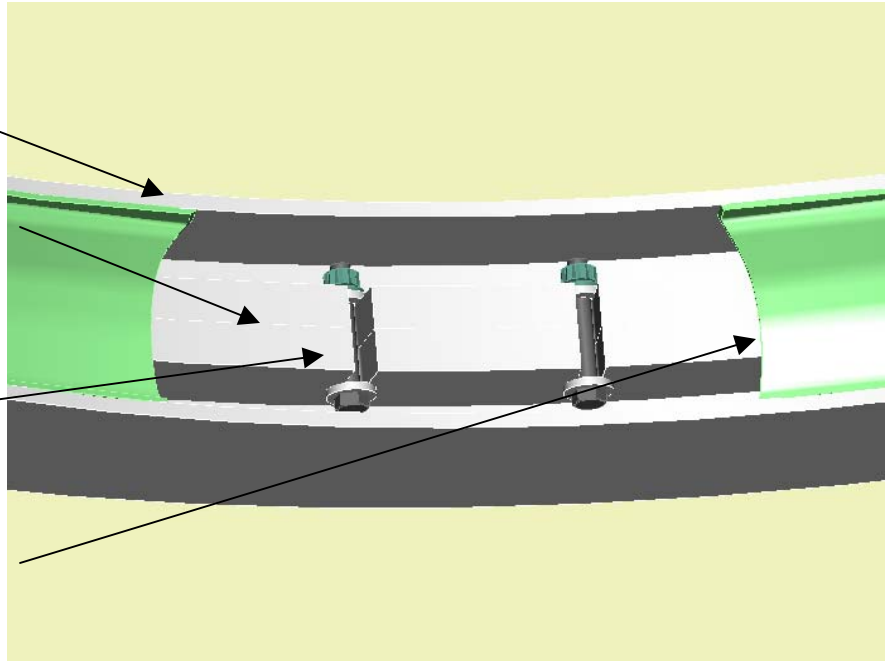
CURRENT BOLTED JOINT WITH DROP IN SLOTS



Drop in bolt_half_zoom.ppt

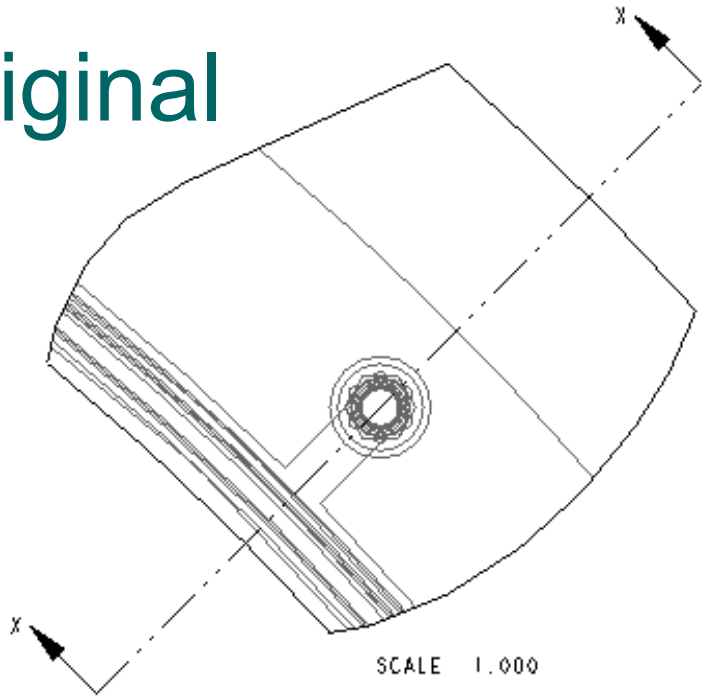
HYBRID JOINT

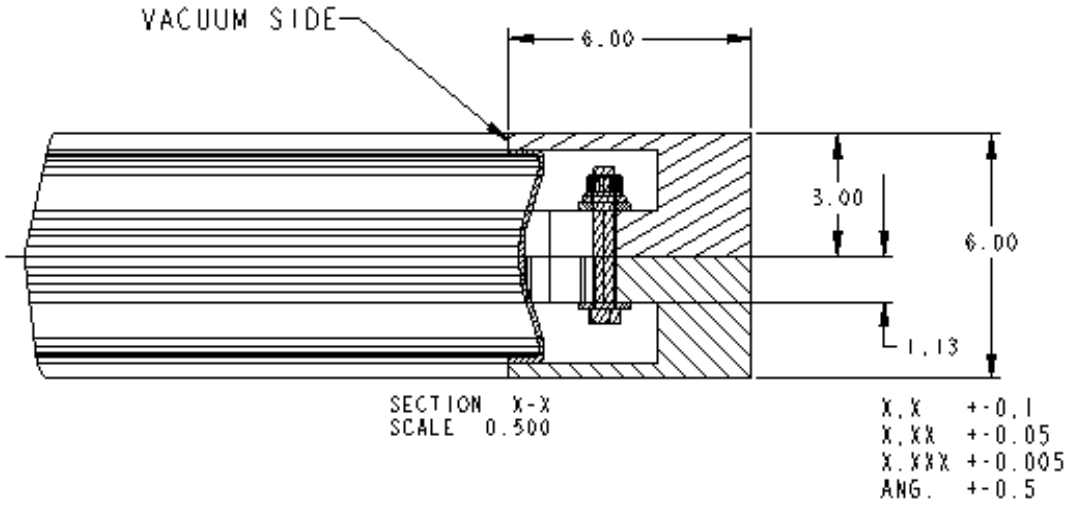
- Flanges welded to vessel segments
- Machinable spacer
- Drop-in bolts where necessary
- Thin seal cap seal welded over bolts on inside



HYBRID Original

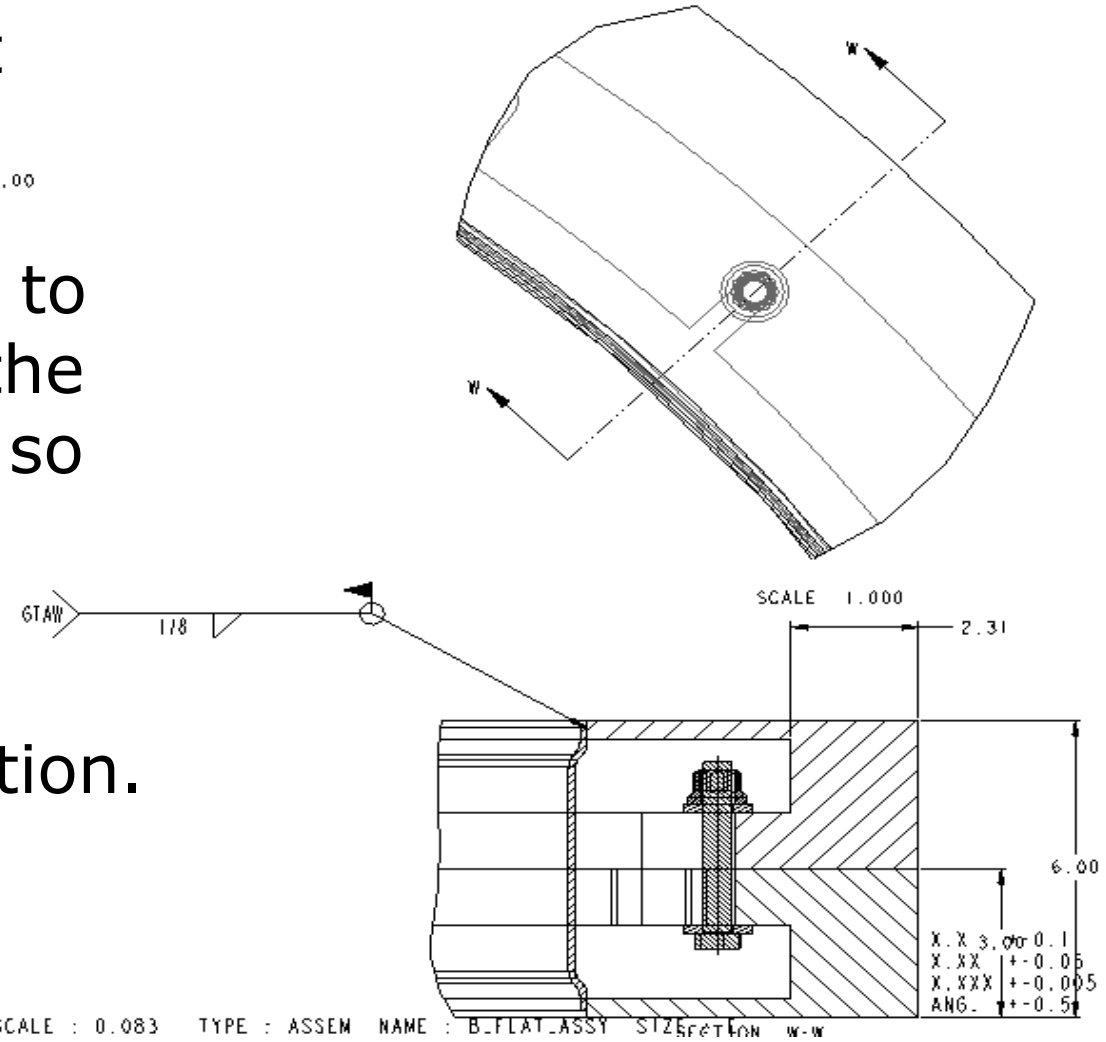
- Cannot slide seal plate into place





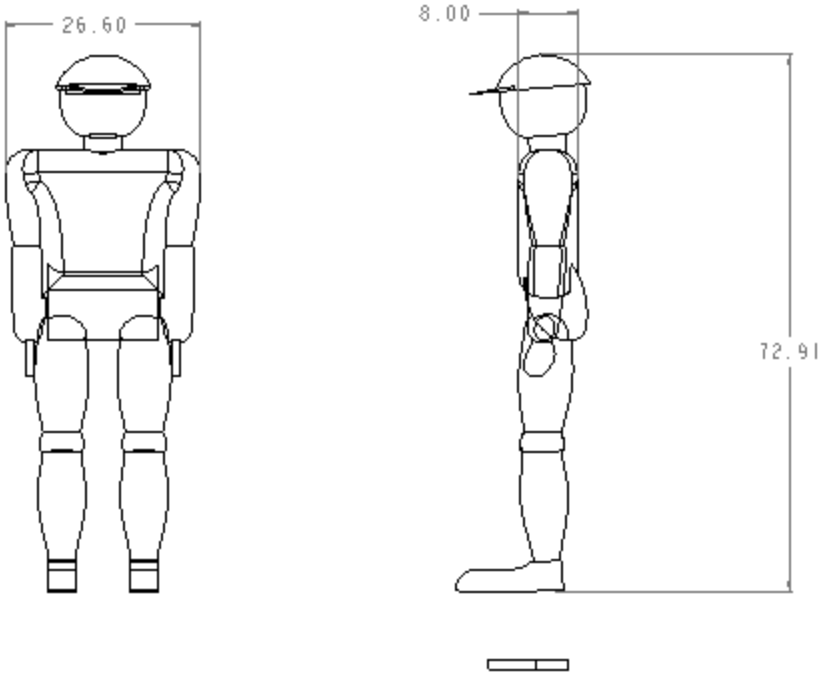
HYBRID Convex

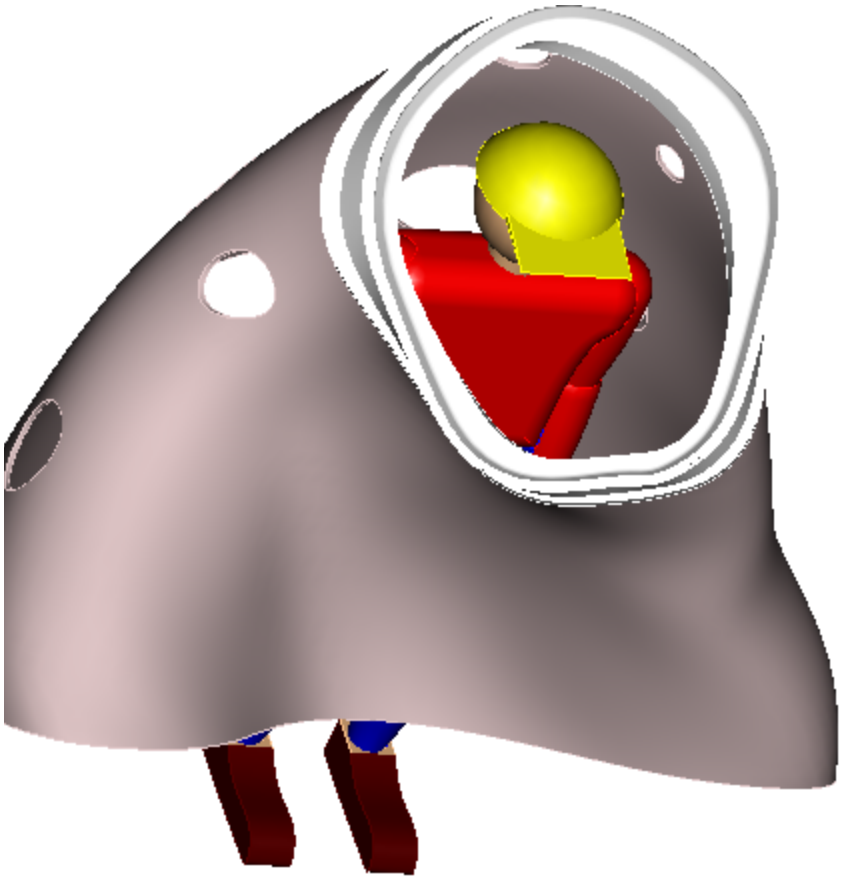
- Better but twist still makes it necessary to segment the seal plate so original is viable assuming segmentation.



ACCESSIBILITY

This is a 6’ tall 230 lb guy. Space is limited but welding from the inside is possible.



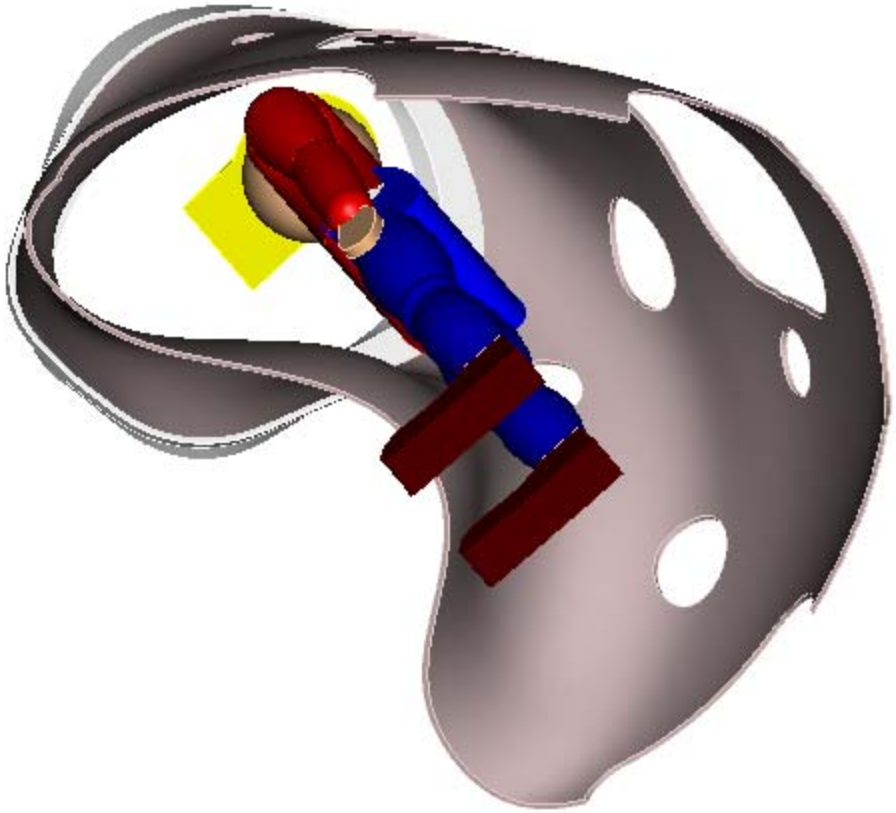


Husky man_deep_ves.ppt

ACCESSIBILITY

Another view

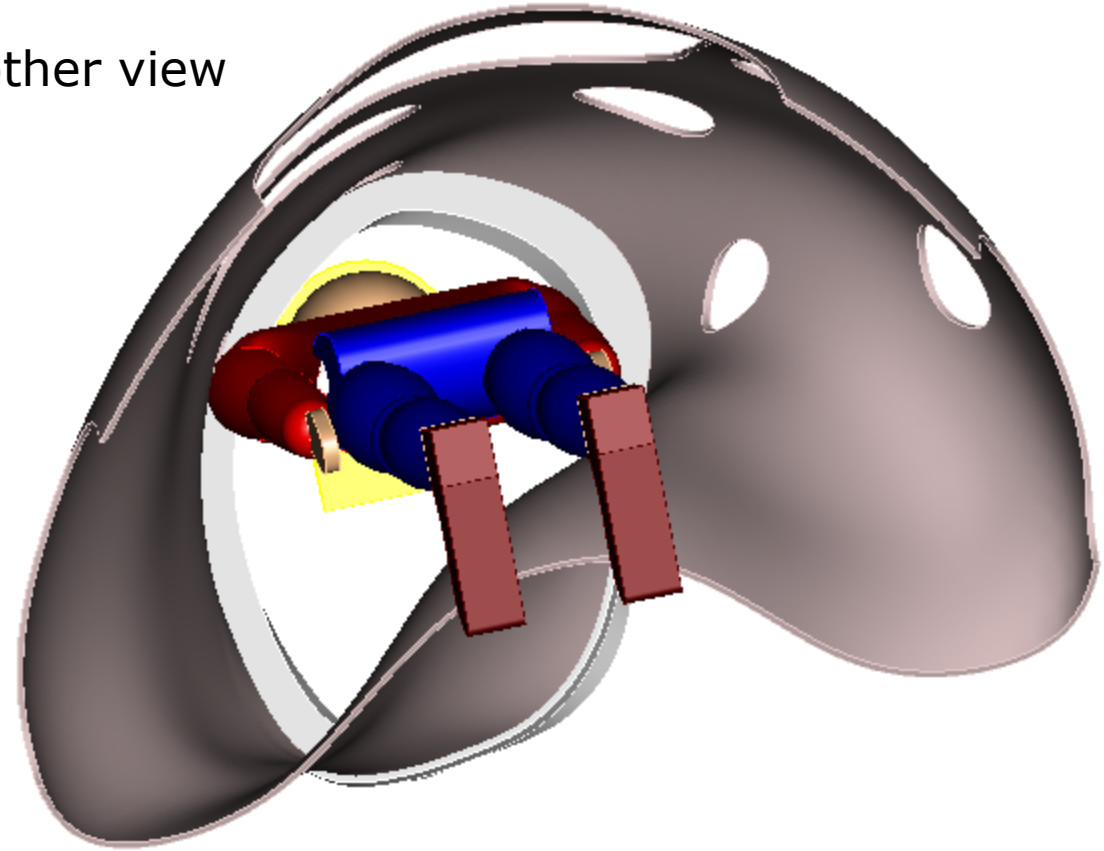
He would probably creep in from the NB port shown to the right.



Husky man_deep_feet.ppt

ACCESSIBILITY

Another view

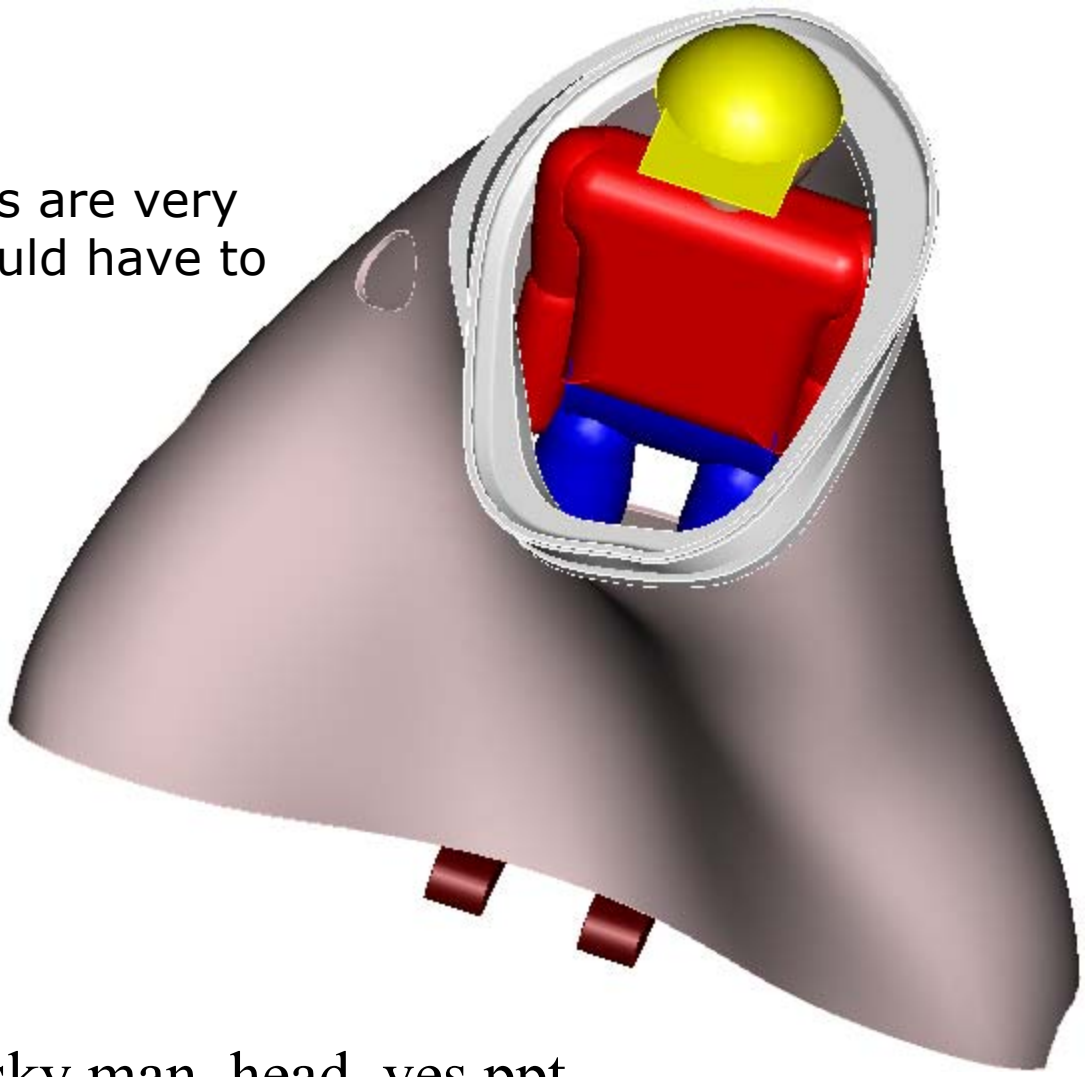


Husky man_feet_ves.ppt

ACCESSIBILITY

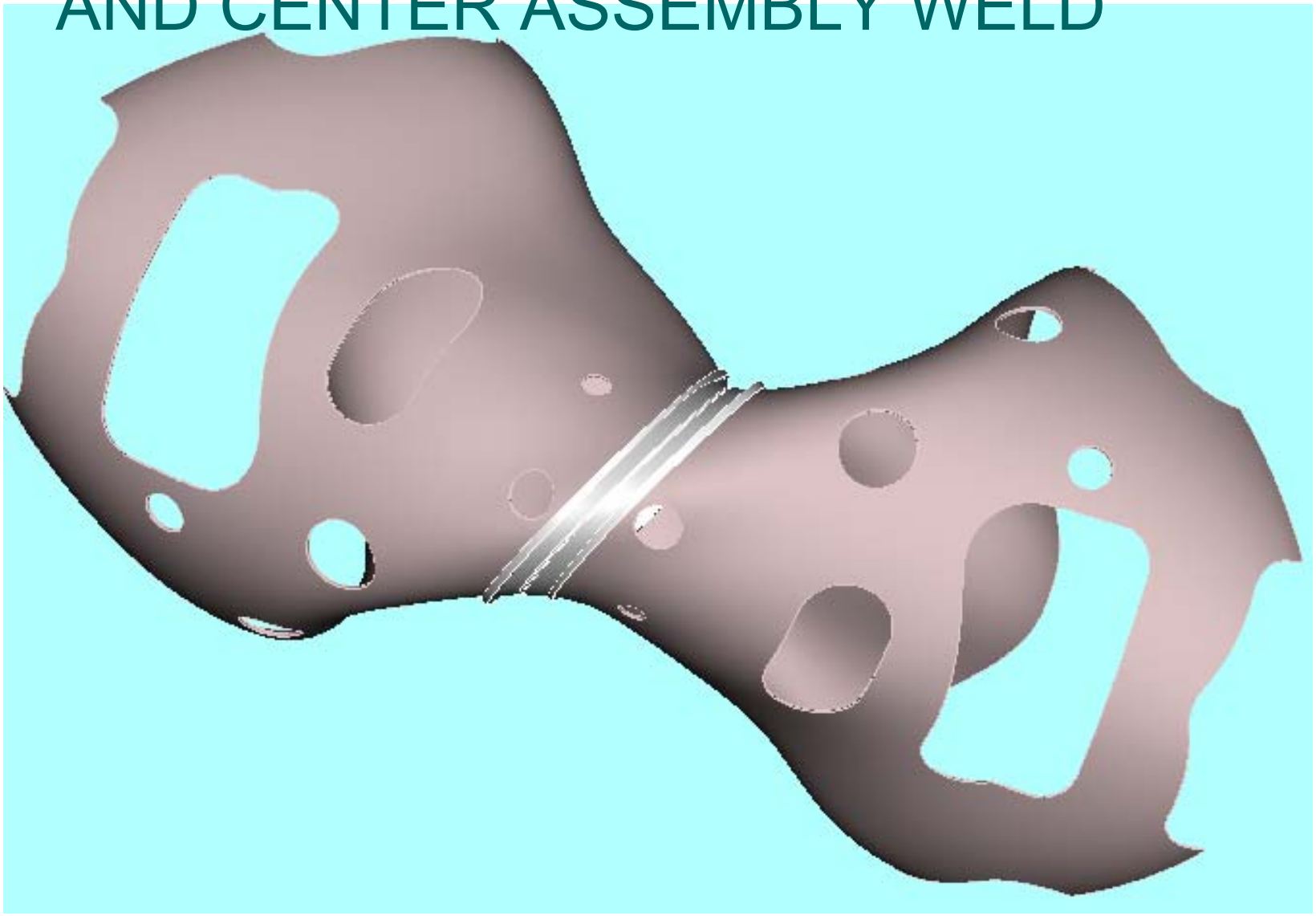
Another view

Certain positions are very tight and he would have to reach forward.



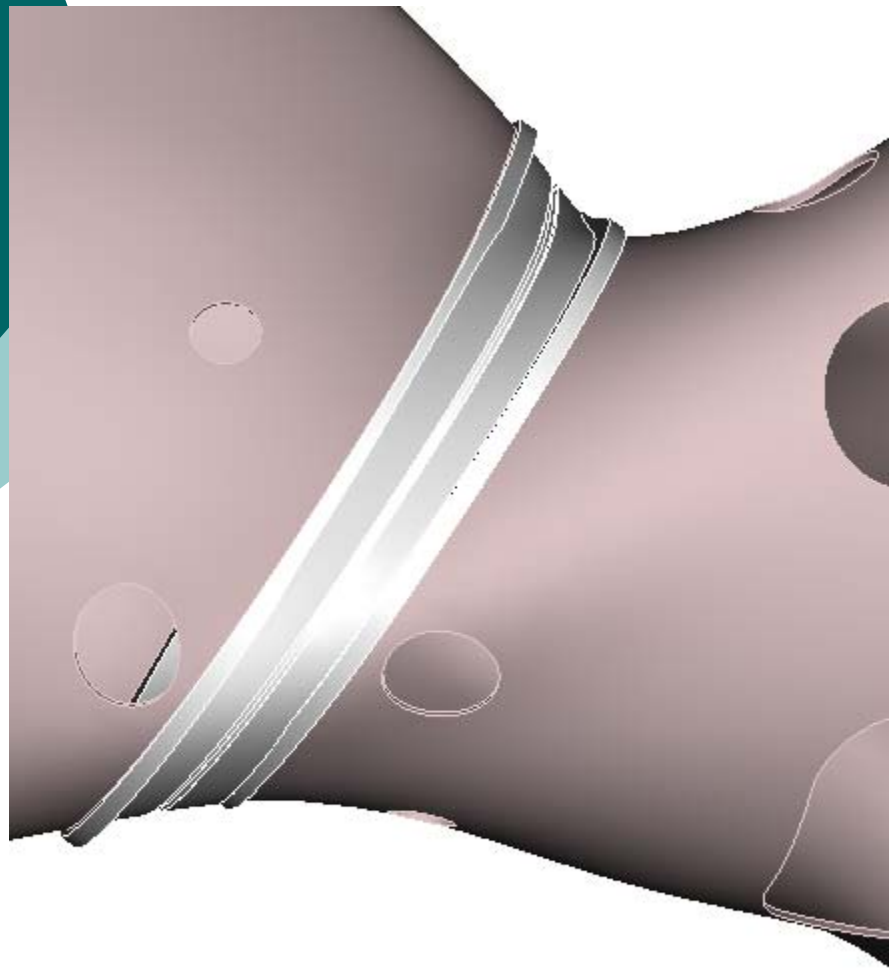
Husky man_head_ves.ppt

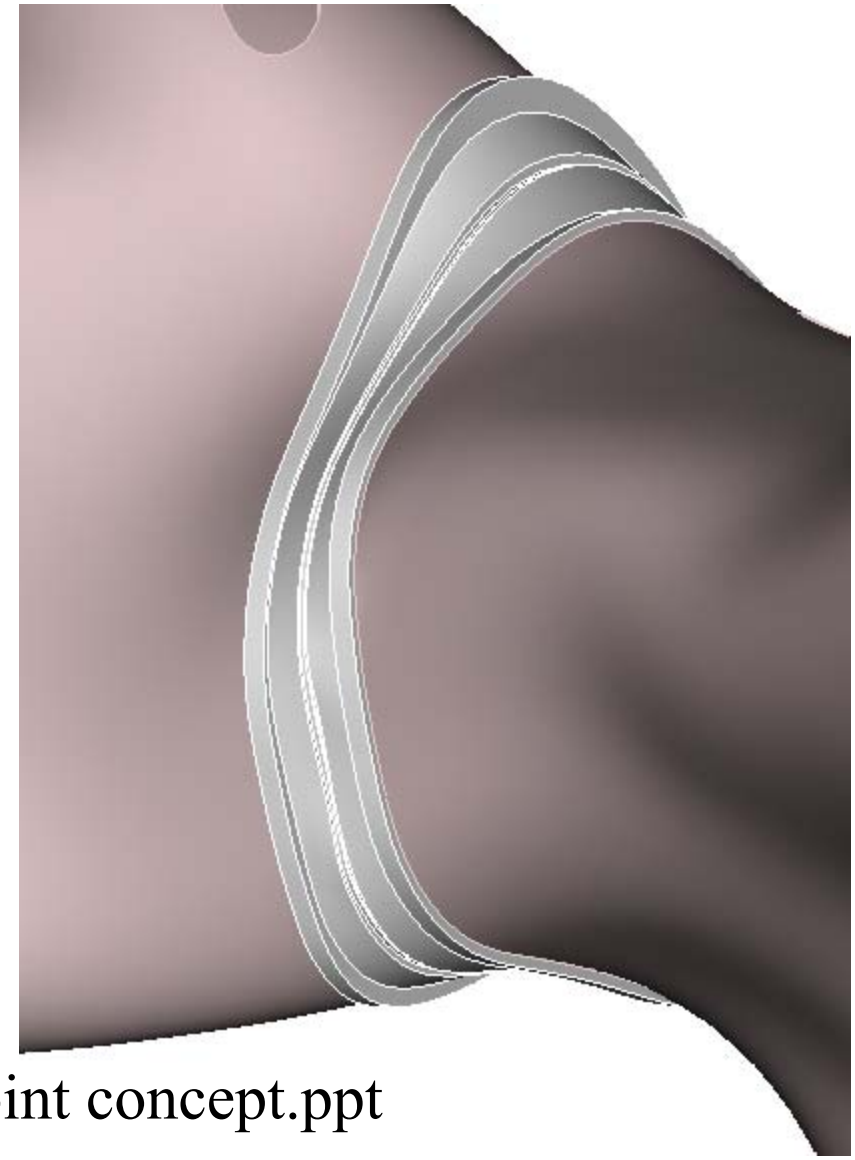
WELDED JOINT WITH 2 FACTORY WELDS AND CENTER ASSEMBLY WELD



Tom’s weld_joint.ppt

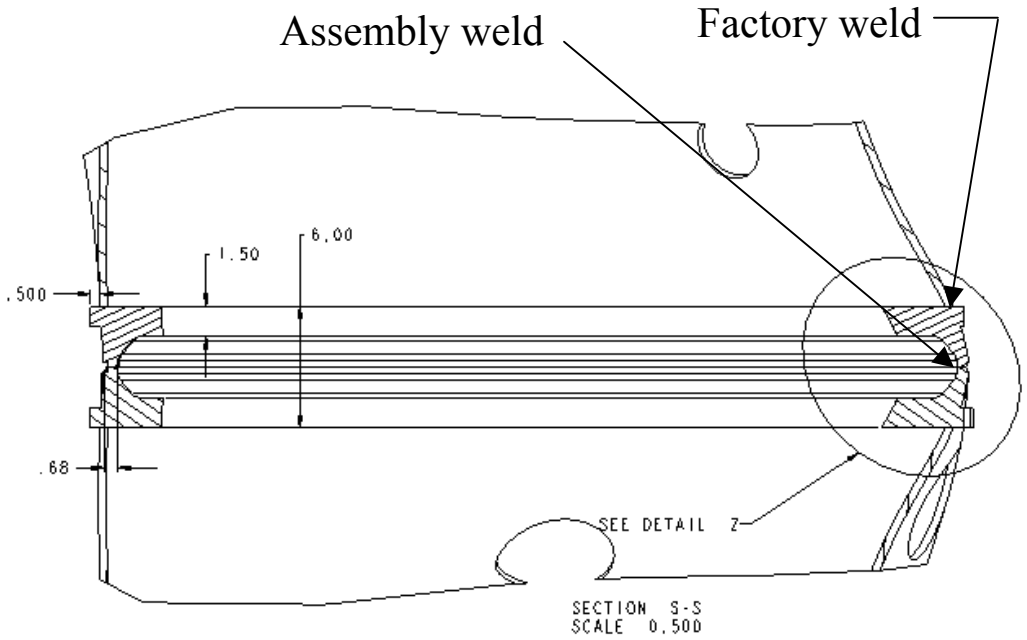
WELDED JOINT WITH 2 FACTORY WELDS AND CENTER ASSEMBLY WELD

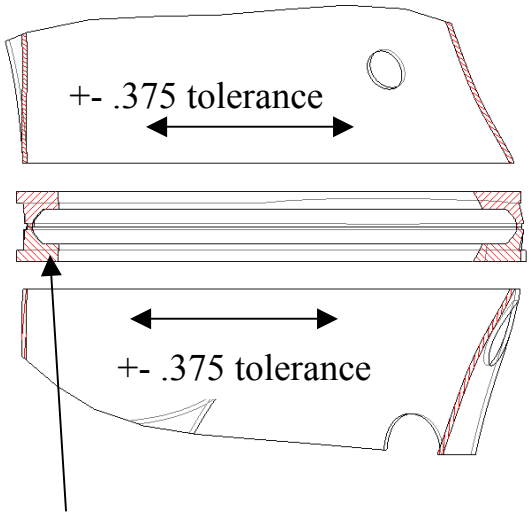




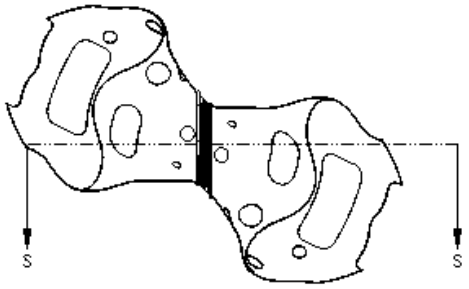
Tom’s Welded VV joint concept.ppt

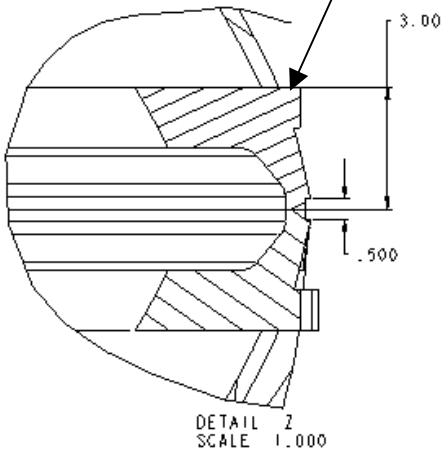
WELDED JOINT WITH 2 FACTORY WELDS AND CENTER ASSEMBLY WELD





Allow a machined end flange to take care of VV shell tolerances

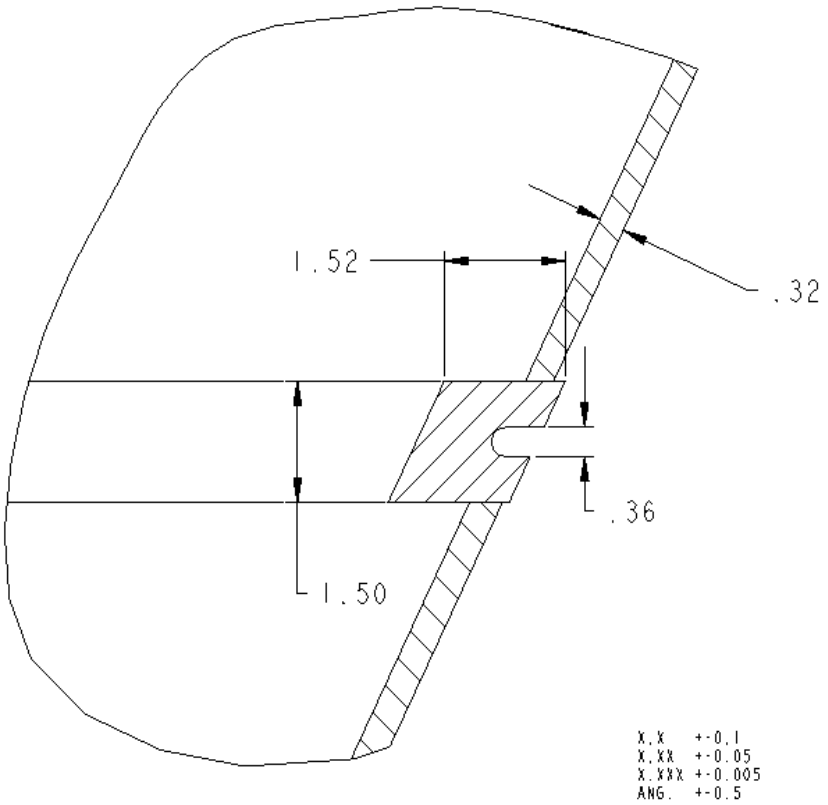




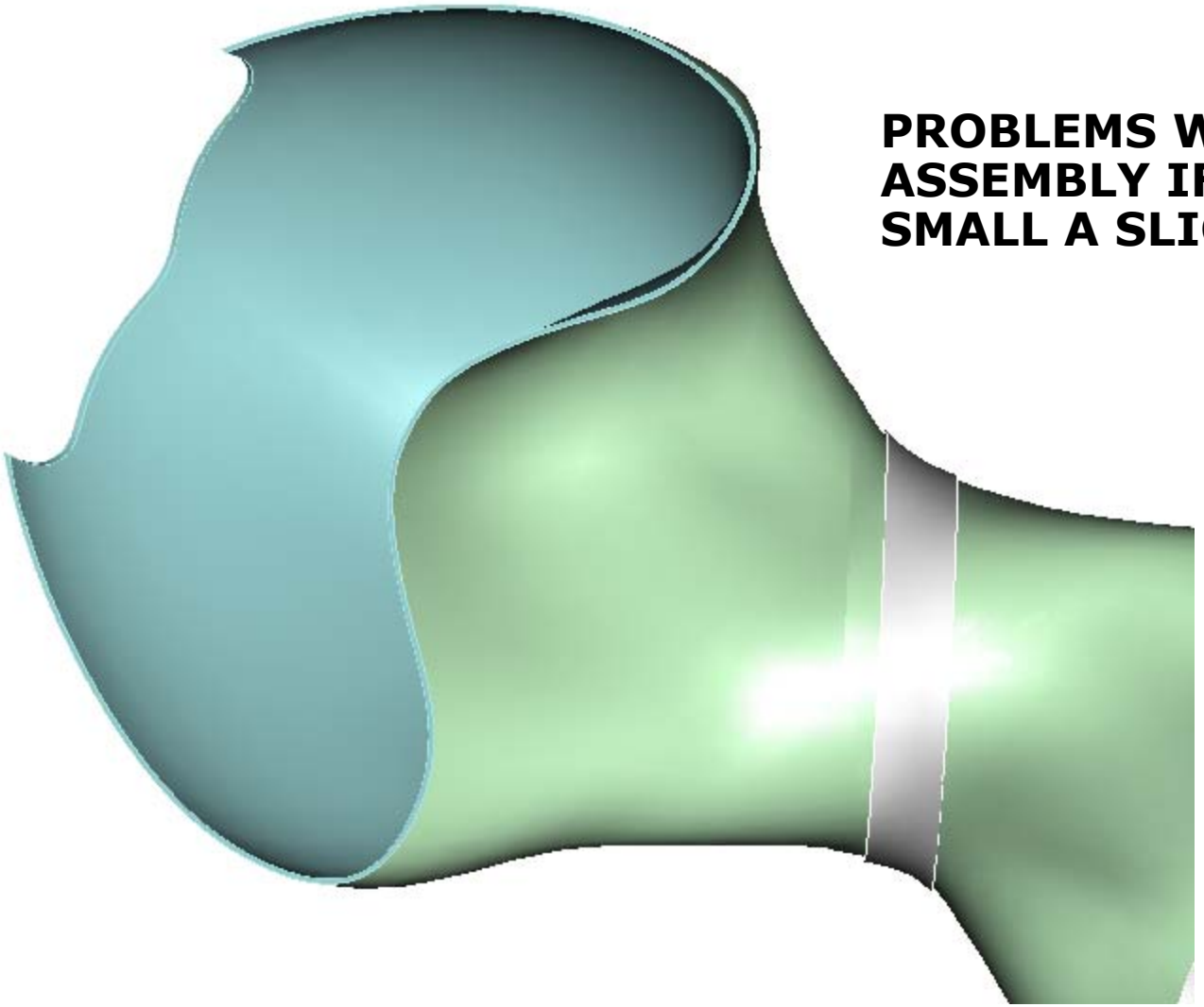
Tom's Welded VV joint concept.ppt

ONE PIECE WELDED SPACER

- Pre cast 3 spacers ready for machining. (Spacers can lay flat on mill.)
- Make a template of the vessel segment faces.
- Bring segments together without coils.
- Measure/make a template of the required spacer.
- Machine spacers including diamond wire cut groove



ONE PIECE WELDED SPACER

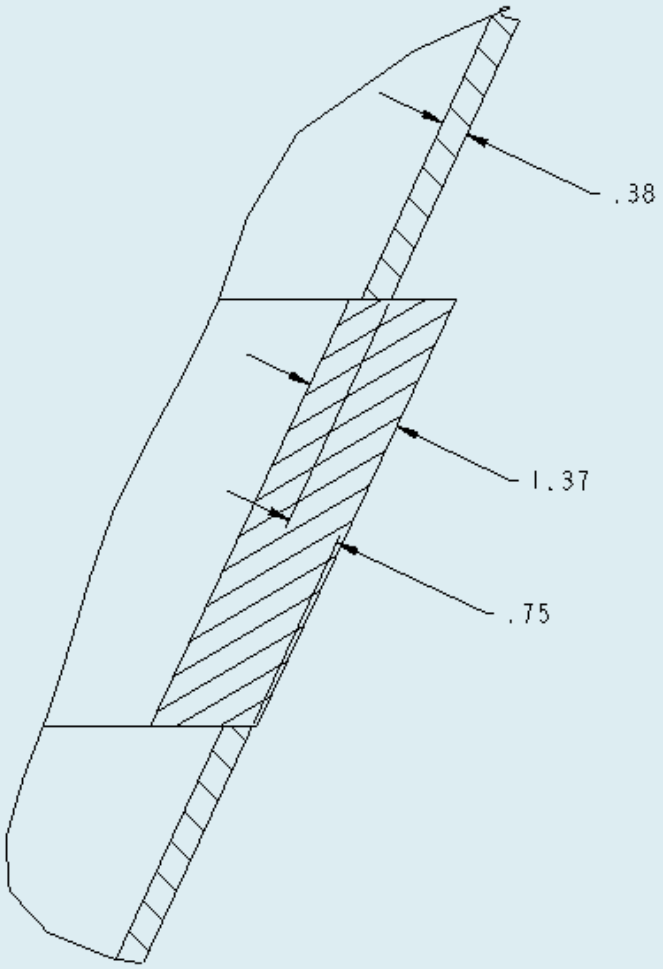


PROBLEMS WITH ASSEMBLY IF TOO SMALL A SLICE.

ONE PIECE WELDED SPACER

- Pre cast 3 spacers ready for machining. (Spacers can lay flat on mill.)
- Make a template of the vessel segment faces.
- Bring segments together without coils.
- Measure/make a template of the required spacer.
- Machine spacers.
  - Two diamond wire grooves for disassembly.
- Dangle in place
- Weld

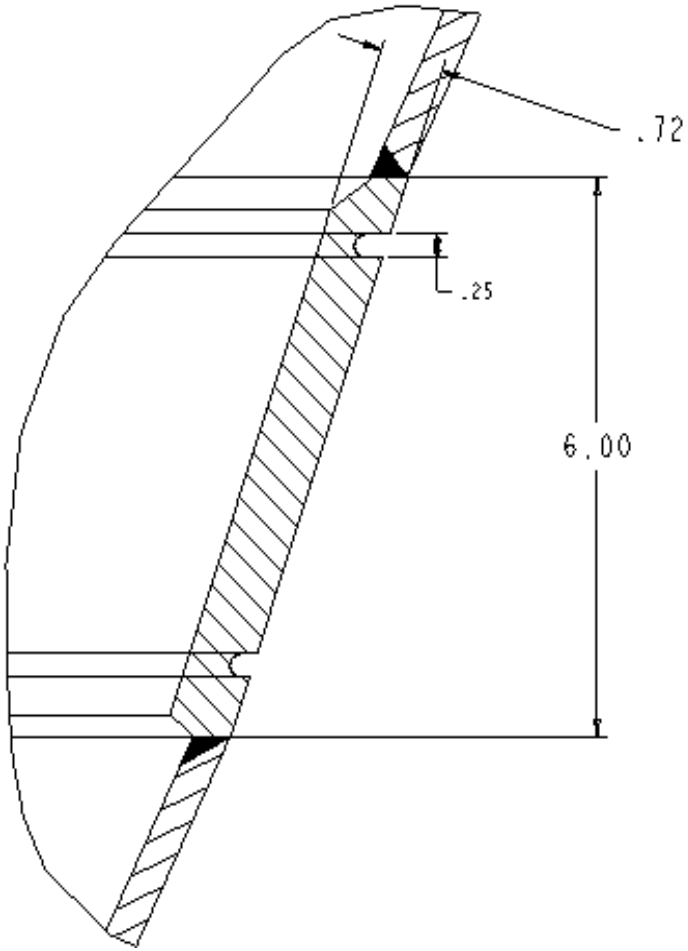
Precast spacer before machining showing maximum potential tolerance



WELDED SPACER

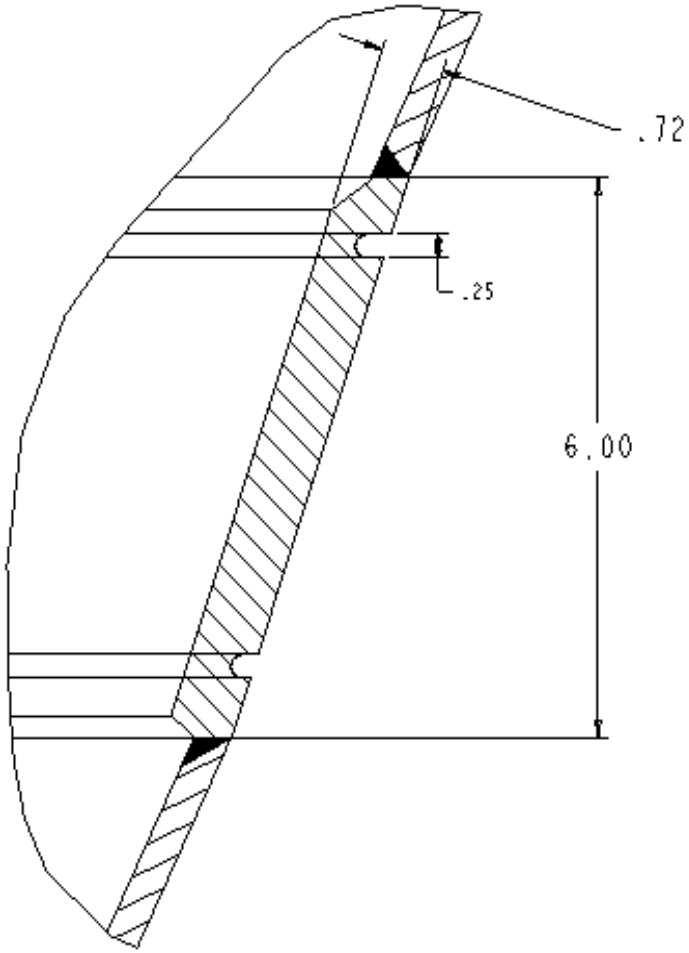
- Worst case tolerance condition shown
  - Ask if tighter tolerance is reasonable between matching segment faces
- Machined on the outside
  - minimize interference with coil
  - Diamond wire groove added
- Machined on the inside
  - Minimize vessel intrusion
  - Tapered relief for weld access

- **Drawback** –
  - One shot at fitup
  - Weld might distort piece



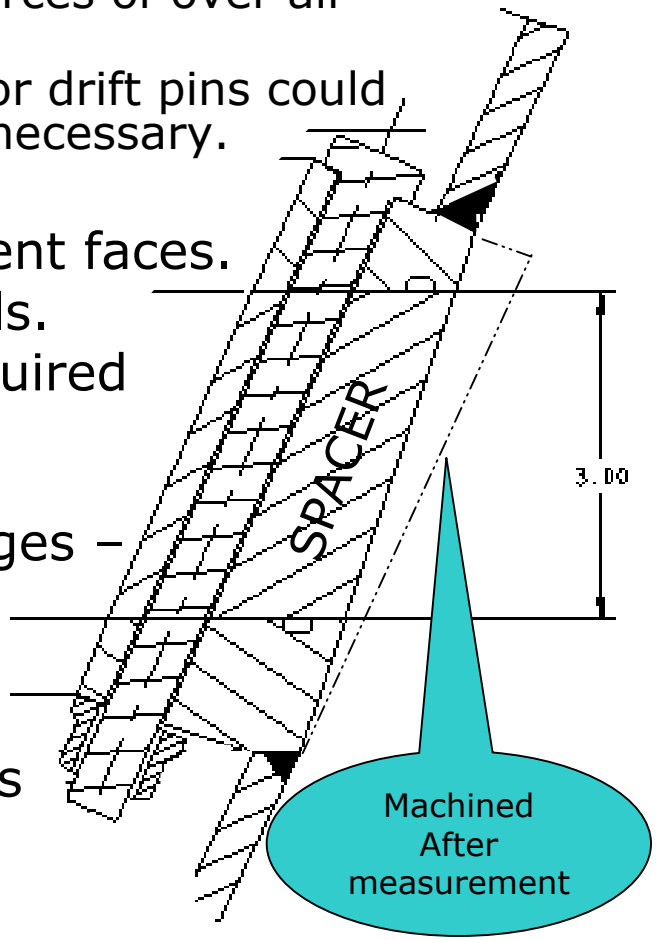
WELDED SPACER

- COMMENTS?



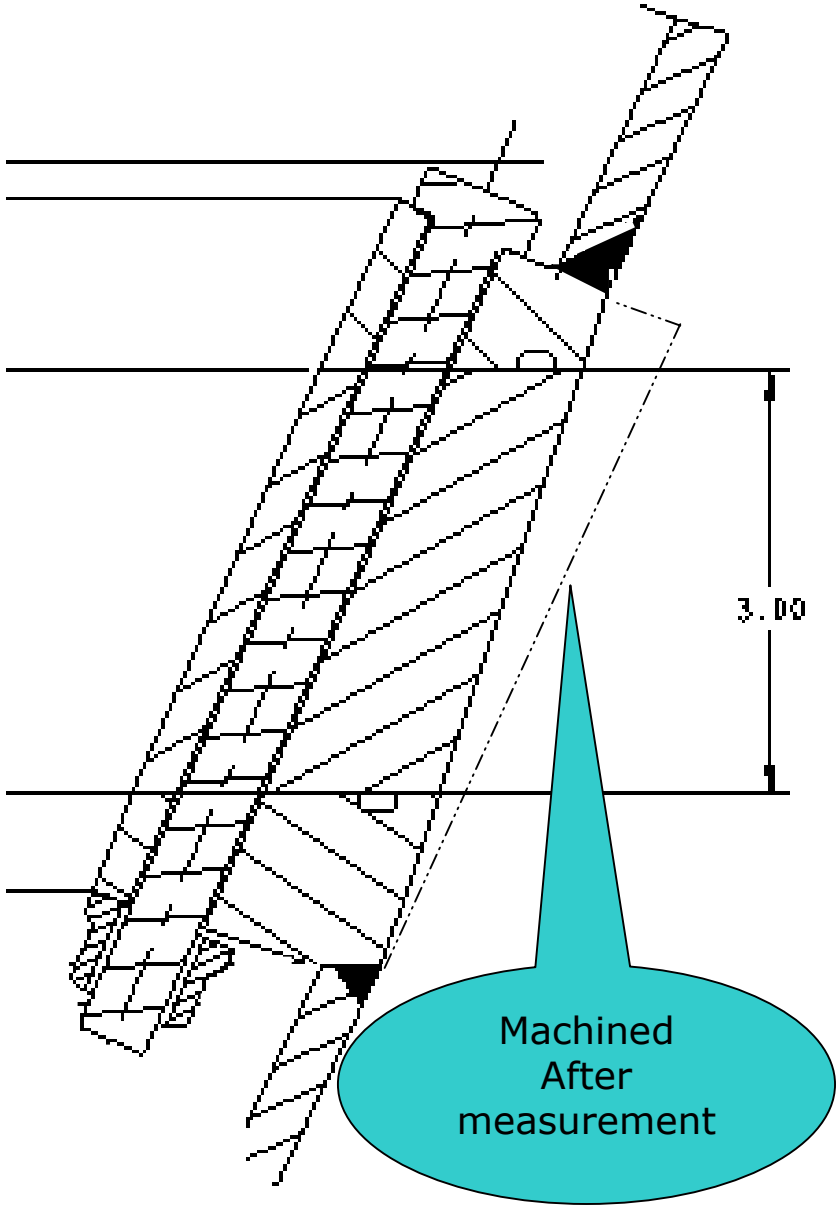
CONFORMING BOLTED JOINT

- Bolts are parallel to vessel surface:
  - Local axial friction should overbear any radial forces.
  - Opposite sides counter react radial forces of over all body.
  - A few close tolerance shoulder bolts or drift pins could be used to handle any shear force if necessary.
- Pre-assembled flanges with spacers.
- Make a template of the vessel segment faces.
- Bring segments together without coils.
- Measure/make a template of the required spacer.
- Machine spacer.
- With vessel assembled, weld on flanges –
  - Allows full pen from the outside.
- Unbolt joint
- Dangle spacers
- Reassemble vessel with modular coils



CONFORMING BOLTED JOINT

- COMMENTS?



SUMMARY

- CURRENT BOLTED JOINT
  - Too complex, many questions
- CURRENT BOLTED JOINT WITH DROP IN SLOTS
  - Still complex, even more complicated fabrication
- HYBRID
  - Easier fabrication, seal plate covers bolts
- WELDED JOINT WITH CENTER ASSEMBLY WELD
  - Need wider slice
- WELDED JOINT WITH SIMPLE SPACER
  - One shot at fitup, weld might distort piece
- CONFORMING BOLTED JOINT
  - Best potential