SS Helium Vessels

Status Report -4 Oct 2011

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Introduction and Motivation

- SS helium vessels – an alternate concept to the existing Titanium helium vessels.

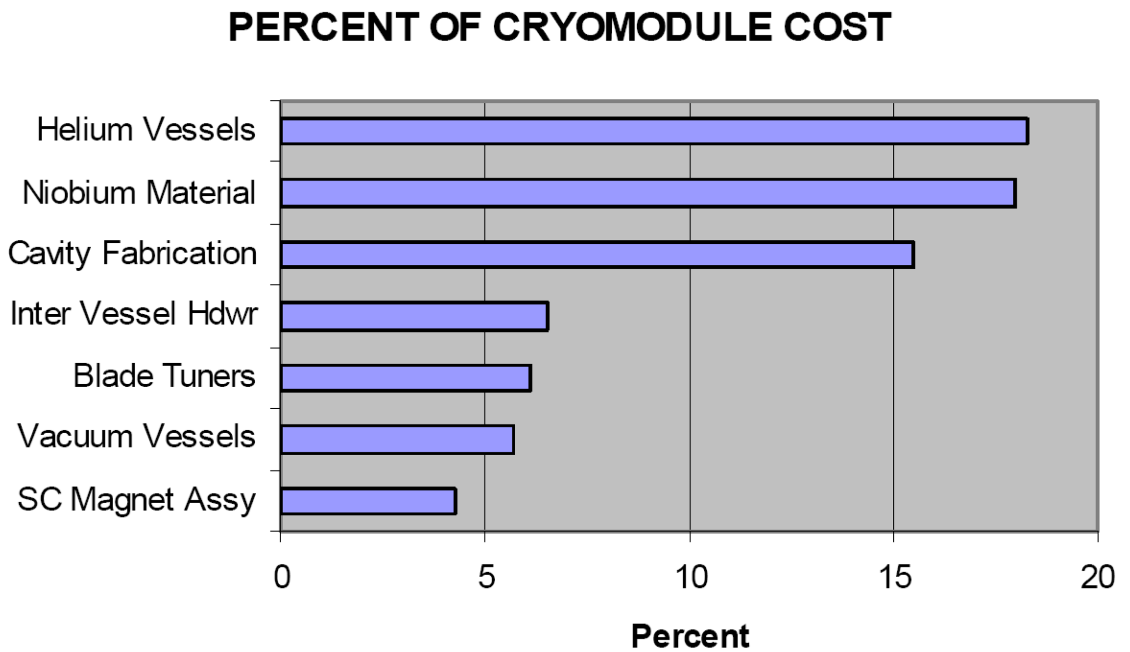


Figure 3: Cost Drivers for ILC Cryomodules

Courtesy of AES

Introduction and Motivation (contd.)

Table-3: Unit Cost Summary for Helium Vessel Fabrication

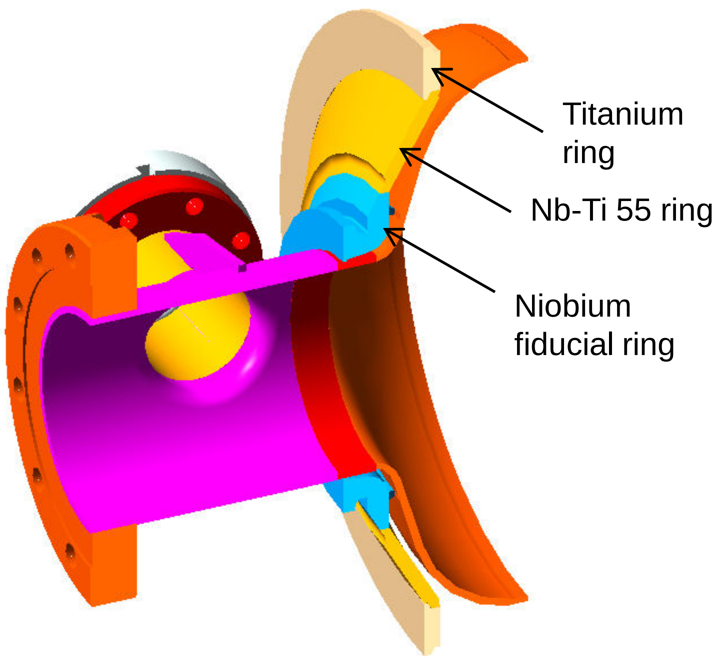
He Vessel Mat'l.	Titanium		316L SS	
Production Quantities	**6000**	**18000**	**6000**	**18000**
Titanium Fabrication	$24,400	$23,316	$19,660	$18,826
Joseph Oat	$41,779	$39,415	$28,690	$27,302
Unit Average Cost	**$33,090**	**$31,366**	**$24,175**	**$23,064**
Average Cost Savings / Unit			**-$8,915**	**-$8,302**

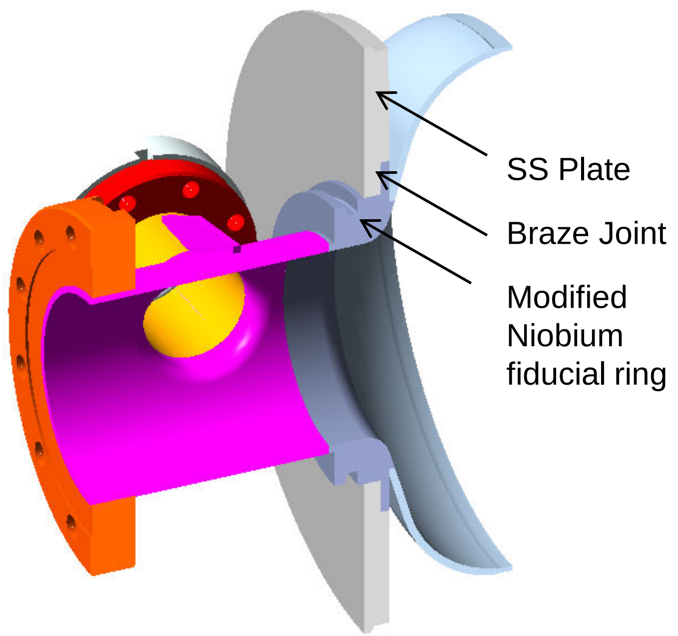
Courtesy of AES

- SS costs less compared to Titanium grade 2.
- Titanium vessels require glove box welding – expensive and cumbersome.

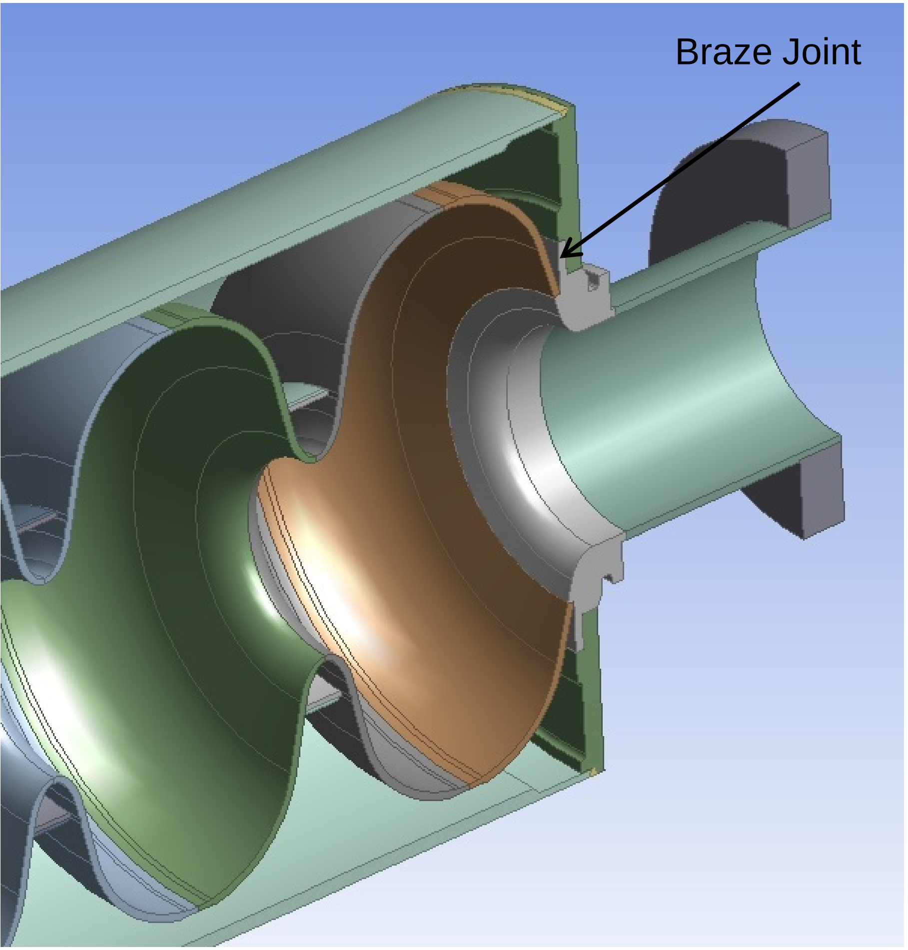
Need for a Transition Joint

- Titanium vessels – transition made from niobium fiducial rings to Nb-Ti flange followed by another transition from Nb-Ti to Ti rings which are then welded to the titanium shells.
- SS vessels – transition made from niobium fiducial rings to SS end plates via a braze joint which gets directly welded to the vessel shell.





Braze Joint Design



- Braze joint designed between modified niobium fiducial ring and SS end plate.
- Braze Type : Vacuum Furnace Brazing
- Braze Fillers: 50 Au-50 Cu, 35 Au-65 Cu and OFHC copper
- Braze procedures drawn from copper to stainless steel brazing experience.

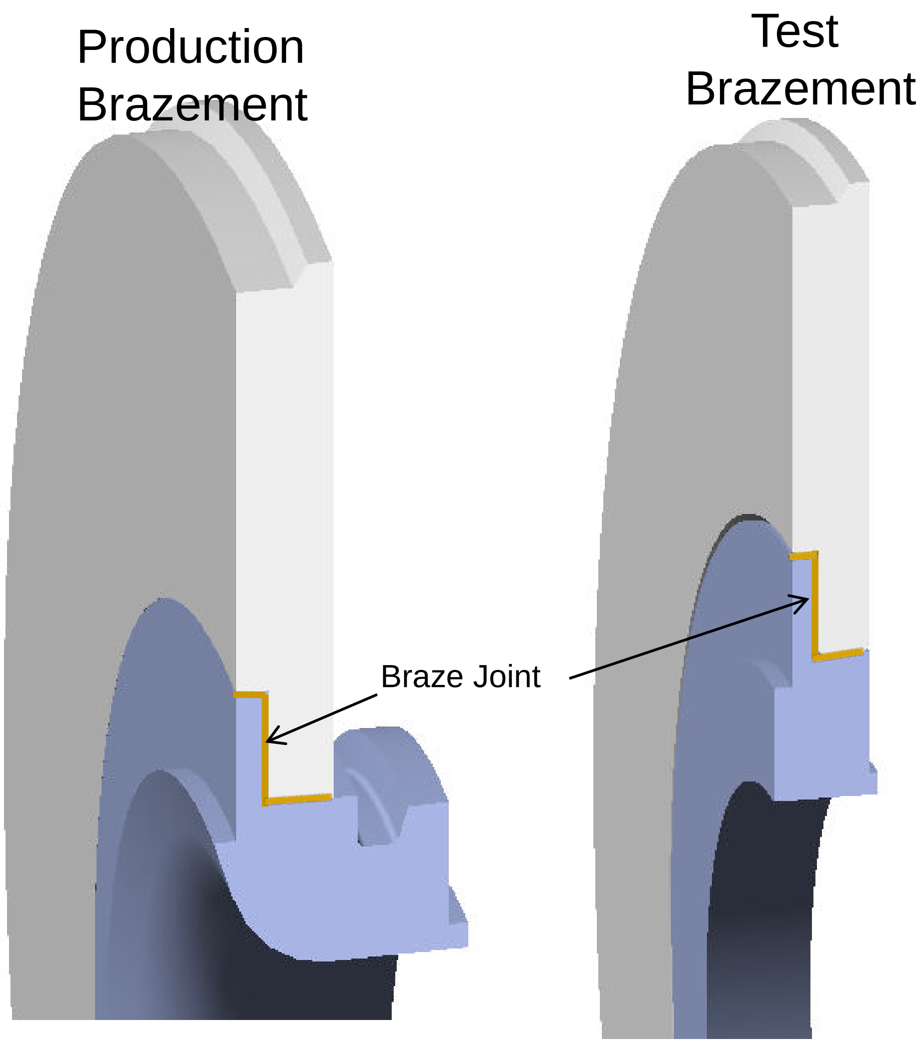
Braze Joint Design (Contd.)

✓ 50 Au / 50 Cu
970 °C liquidus
✓ 35 Au / 65 Cu
1010 °C liquidus
X 100 OFHC Cu
1085 °C liquidus

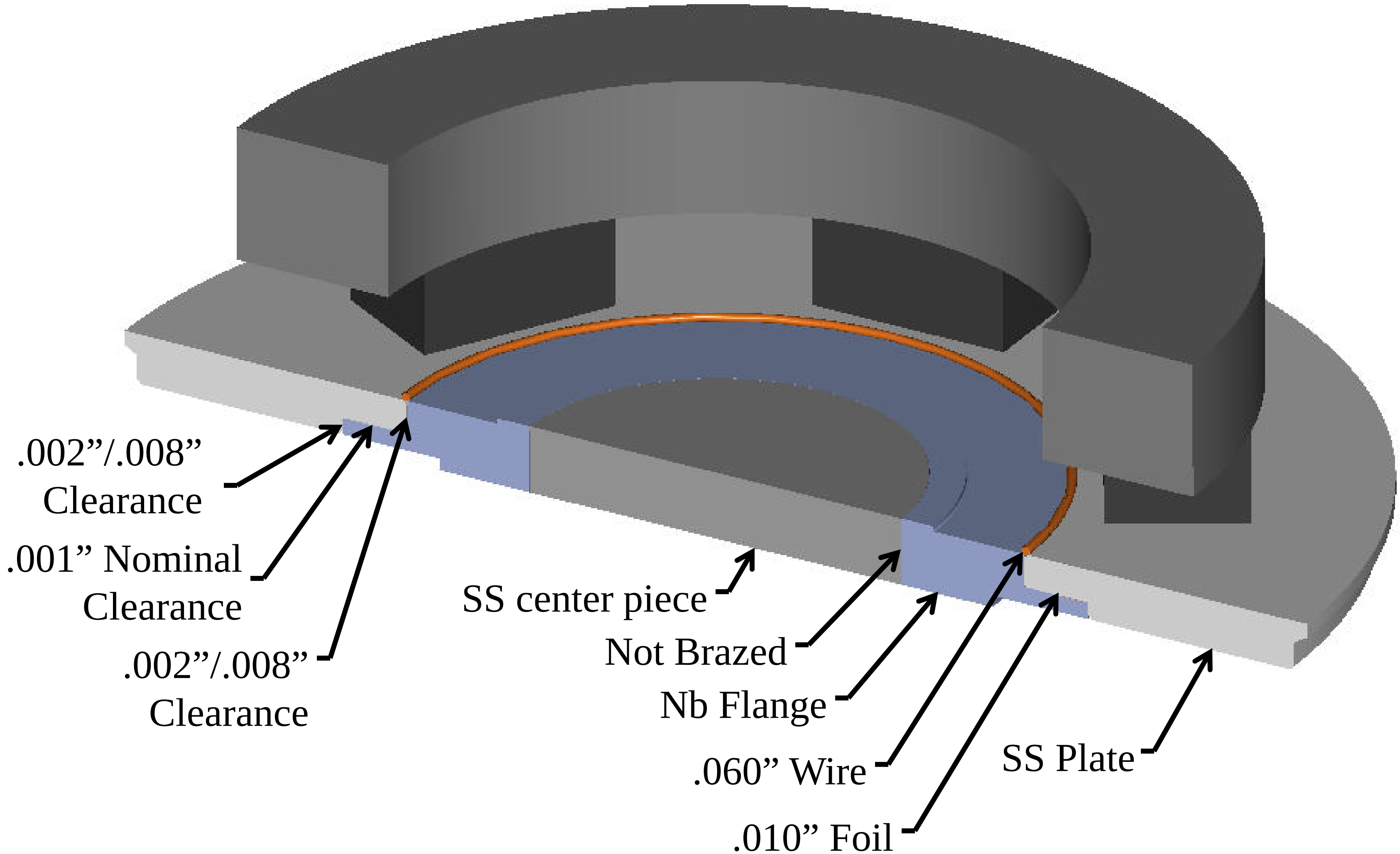
Jlab Design

Braze alloy

- 50/50 Au/Cu (Premabraze 402)
- liquidus 969°C/solidus 954°C
- Not affected by subsequent BCP
- ~0.015 thick foil and .060 wire



Braze Set up – Issue of CTE



Quality of Brazed Joint – strength issues

- Principal mechanism of brazing – capillary action
- The quality and strength of a braze joint depends mostly on the joint design.
- A properly designed joint will have a optimum clearance usually between .001” - .0015”.
- The joint should provide a capillary flow path for the braze material, i.e. the sharp corners should be avoided and turned into fillets.
- Joints with wider surface area (contact region) stronger.

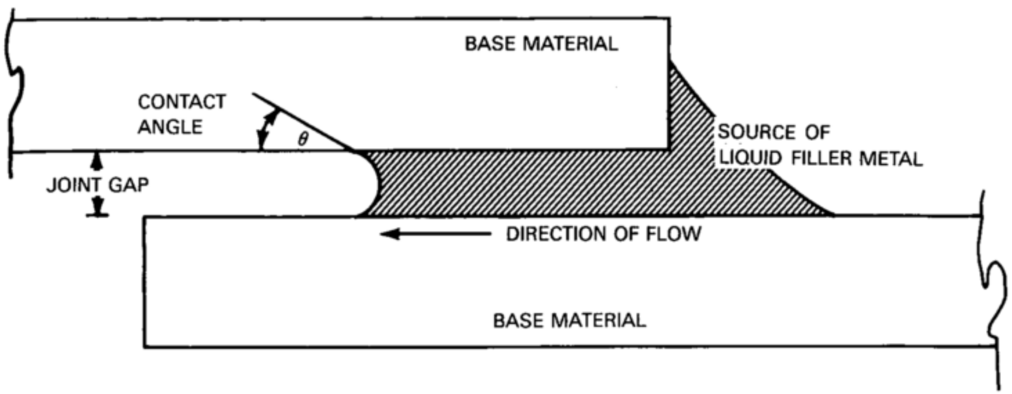


Figure 1.2 — Schematic Representation of a Braze Joint

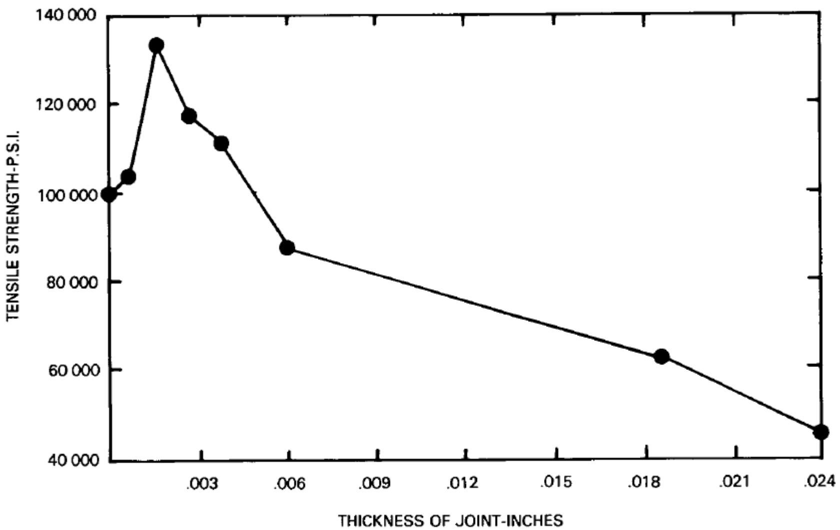
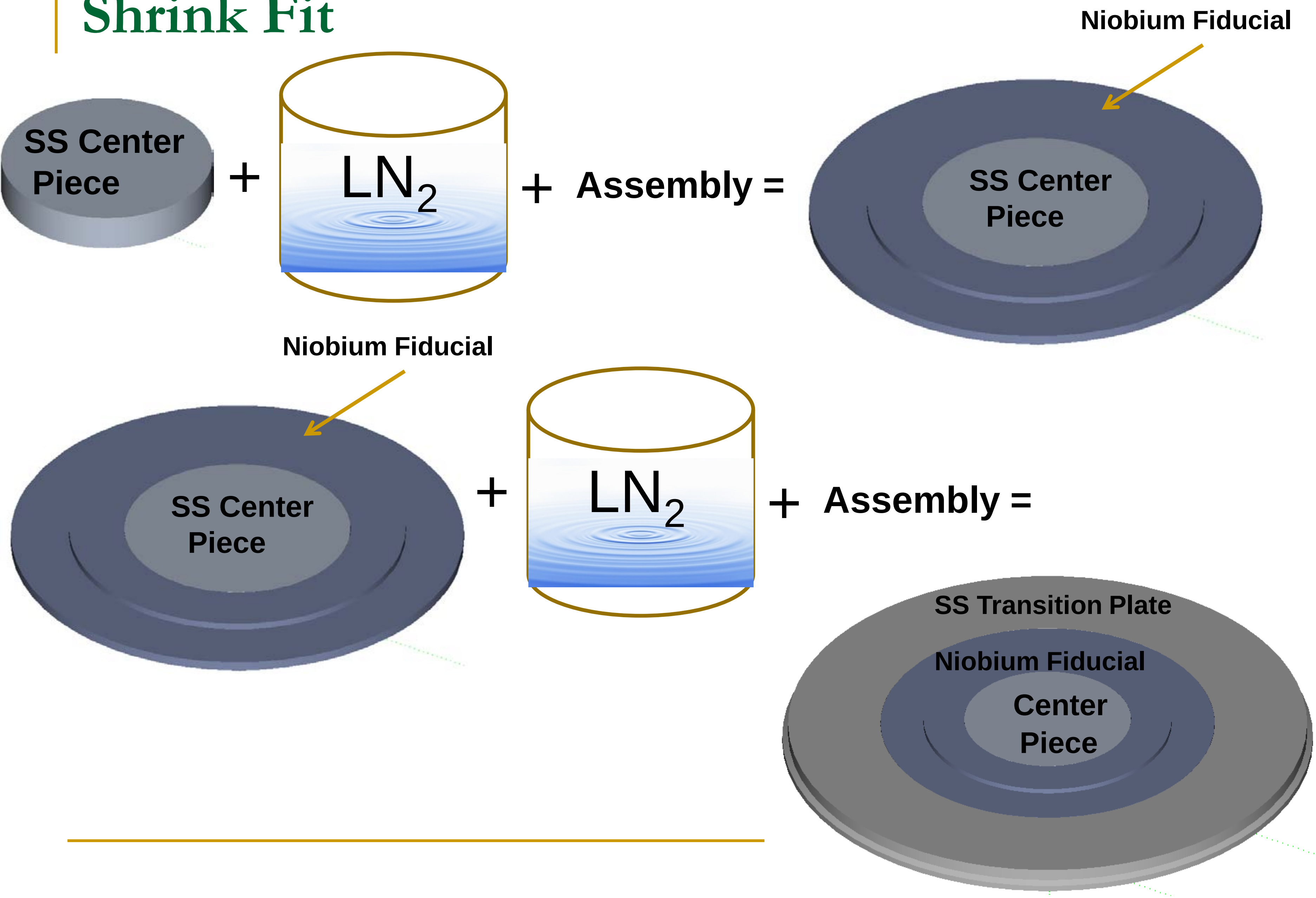


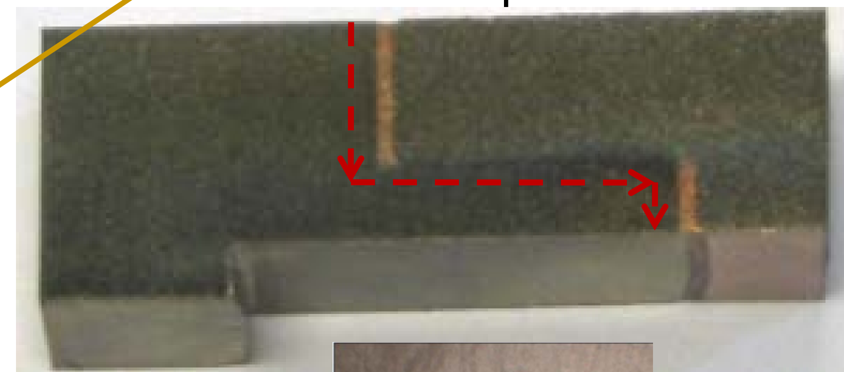
Figure 1.5 — Relationship of Tensile Strength to Joint Clearance of Stainless Steel Brazed with BAg-1a Filler Metal (From Work of Leach and Edelson as Described by Bredzs)

Shrink Fit



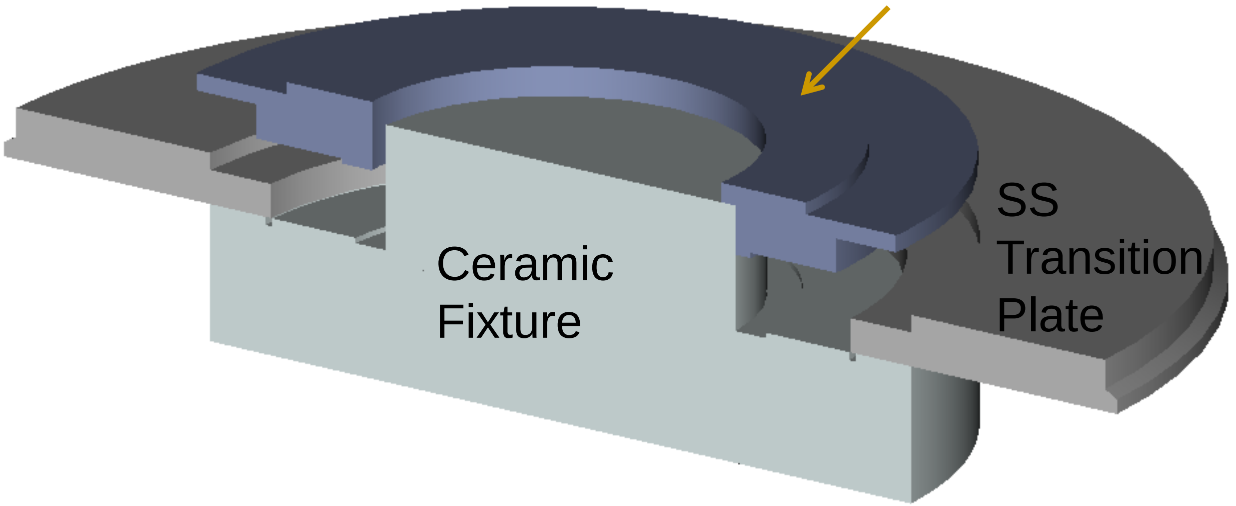
Niobium Fiducial
SS Center Piece
+
LN2
+ Assembly =
SS Center Piece
Niobium Fiducial
SS Center Piece
+
LN2
+ Assembly =
SS Transition Plate
Niobium Fiducial
Center Piece

Results



- Able to achieve full brazements
- Good flow characteristics
- Finished braze material width ~1mm

Expansion Fit

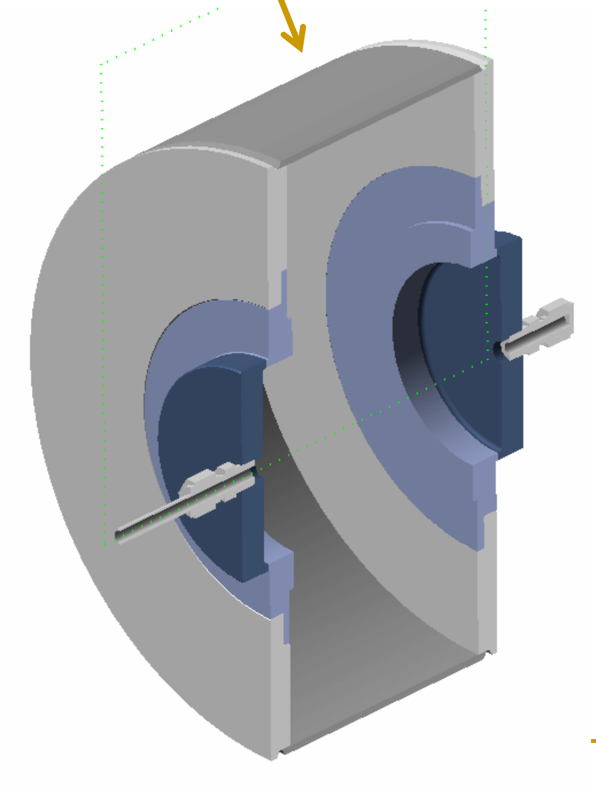


Advantage: Allows for closer fit tolerances and consequentially higher strength joints.

Results Pending …………………..

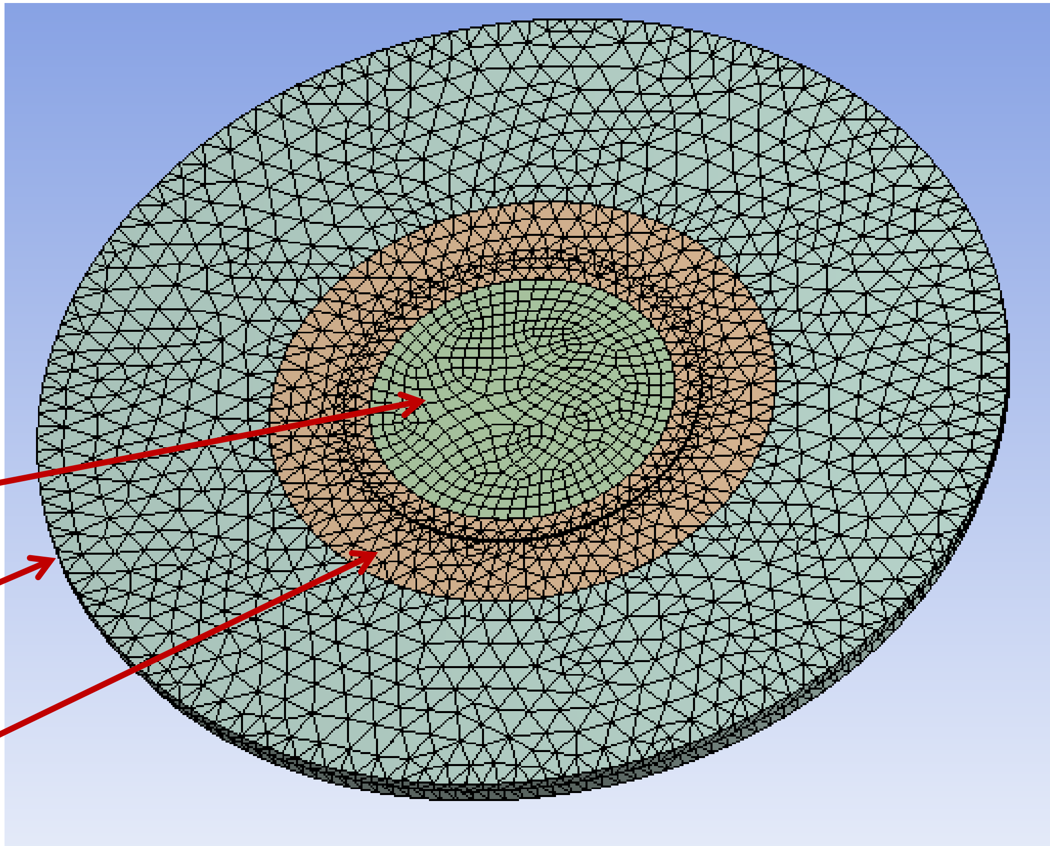
Braze Qualification

- Cold shock tests - **done**
- Section Tests - **done**
- ASTM samples pull tests
- Pressure tests of brazements

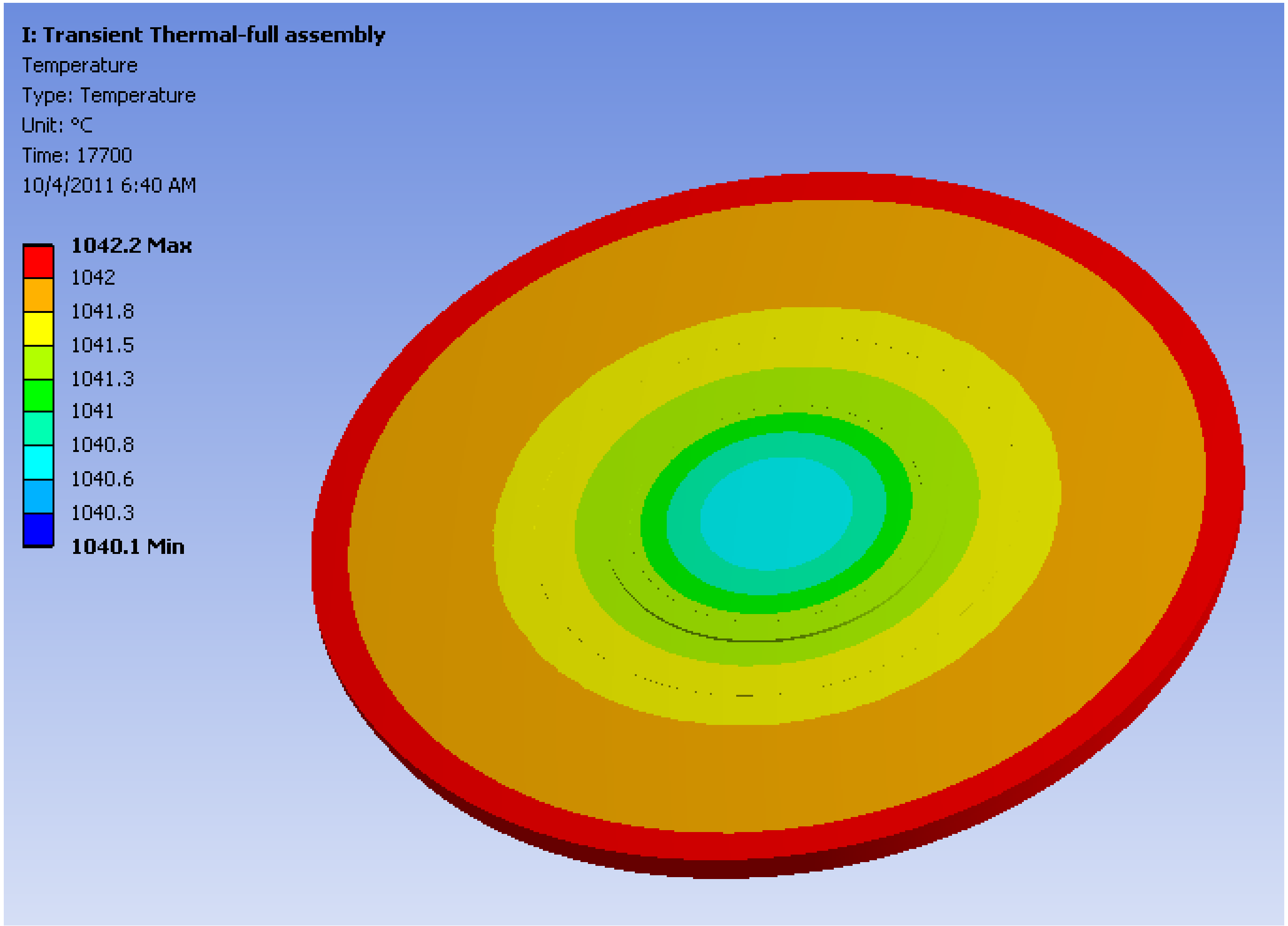


Braze Procedure Qualification - FEA

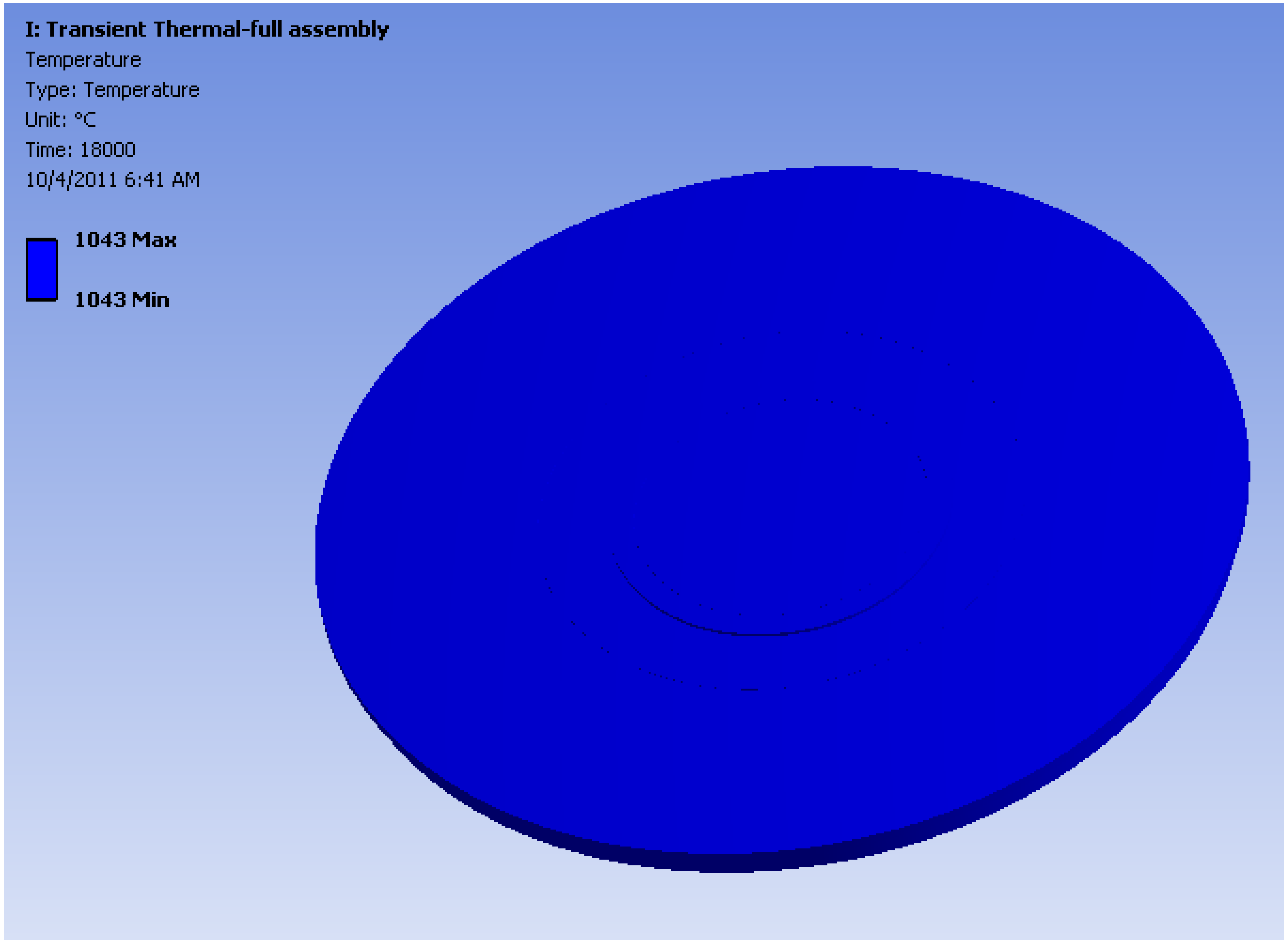
Ramp Rate (min)	Temp (ºC)	Hold time (min)
50	200	10
250	970	10
35	1043	10



Braze Procedure Qualification – FEA (contd.)

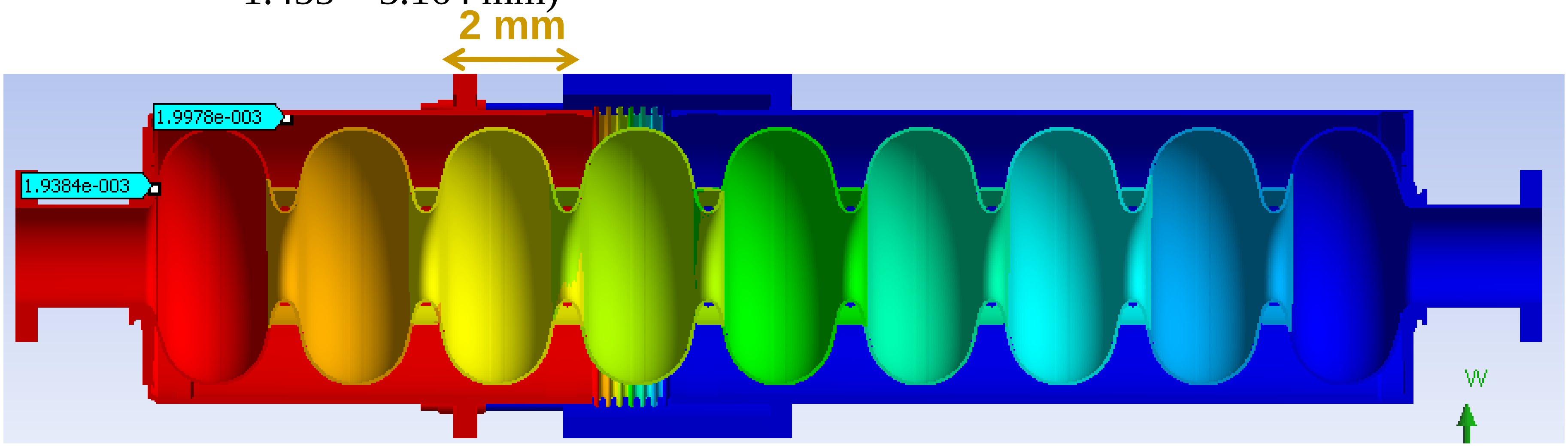


Braze Procedure Qualification – FEA (contd.)



Application of SS Vessel Technology

- Compensating for thermal expansion:
  - Niobium cavity change in length ~ 1.455 mm at 4K (0.143 % of length 1017.4992 mm)
  - SS helium vessel change in length ~ 3.164 mm at 4K (0.306 % of length 1034.1205 mm)
  - Extend cavity by 1.709 mm using a fixture attached to the ends with tuner at neutral position at room temperature.
  - When vessel is cooled down to 4K the cavity would shorten a total of (1.709 + 1.455 = 3.164 mm)



Cause and Effect

- SS vessels require a new bellows design - **done !**
- The incorporation of new bellows and the procedure for CTE compensation combined with the fact the cavity is made of non-code material calls for an invoking of ASME Section VIII Division 2 – Design by Analysis (Finite Element Methods) – **In progress ……**
- Loads to be considered for FEA
  - Tuner extension for CTE compensation and cavity tuning
  - RT Pressure P = 2 bar (30 psi)
  - Cold pressure P = 4.4 bar (65 psi)
  - Hydrostatic load – liquid helium head
  - Gravity