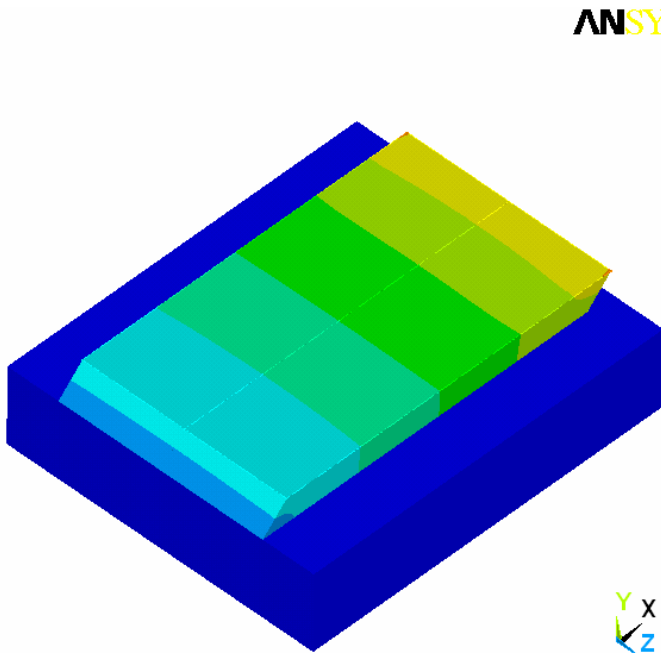


Weld Study Continued

9-24-07

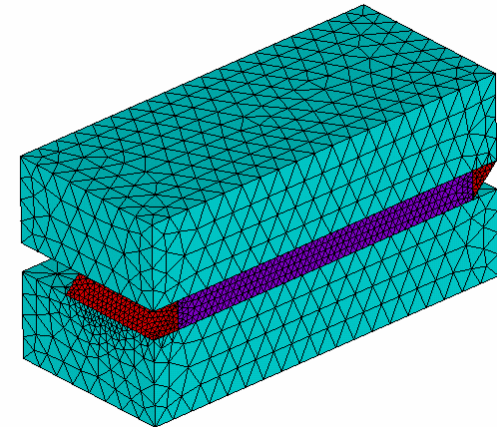
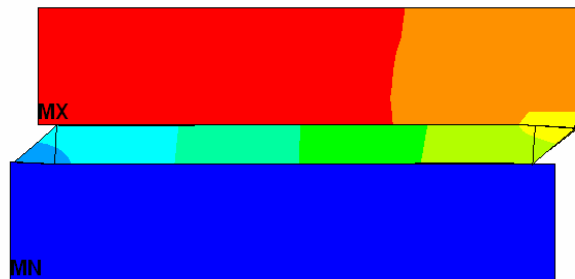
Filet weld on both sides

Deflection (top flange removed)



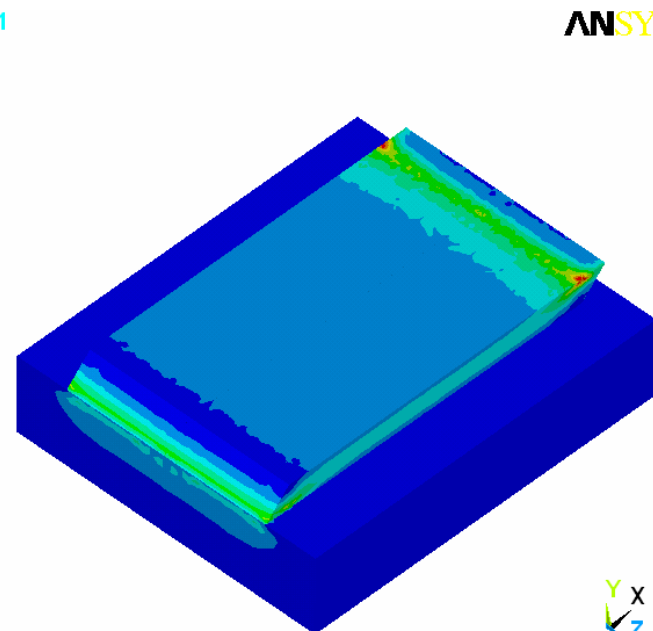
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 TIME=1
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 AVRES=Mat
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 SMX =.004053

Blue	0
Light Blue	.450E-03
Cyan	.901E-03
Green	.001351
Light Green	.001801
Yellow-Green	.002251
Yellow	.002702
Orange	.003152
Red-Orange	.003602
Red	.004053



Stress Intensity (top flange removed)

1



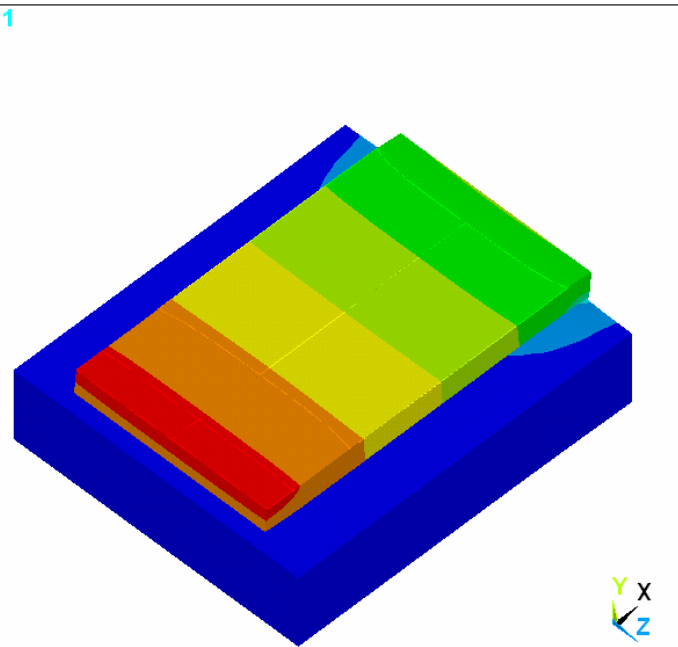
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Light Green	14725
Yellow-Green	18405
Yellow	22085
Orange	25765
Red-Orange	29445
Red	33125

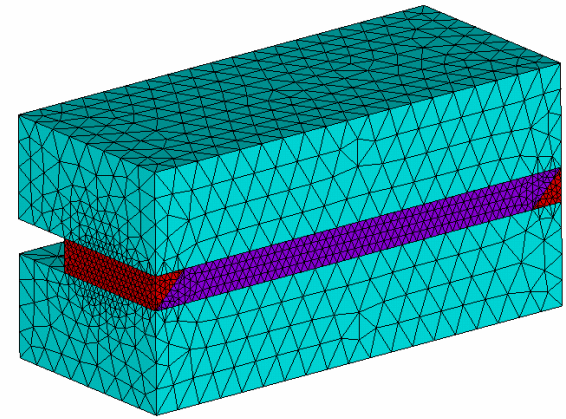
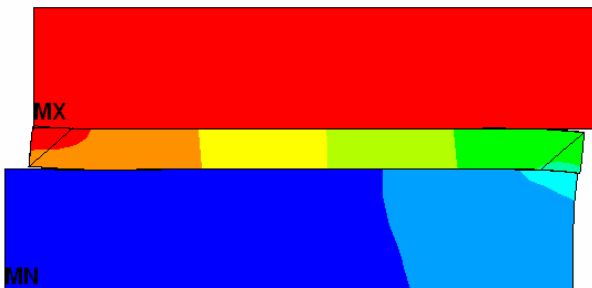


Filet weld on both sides with chamfer

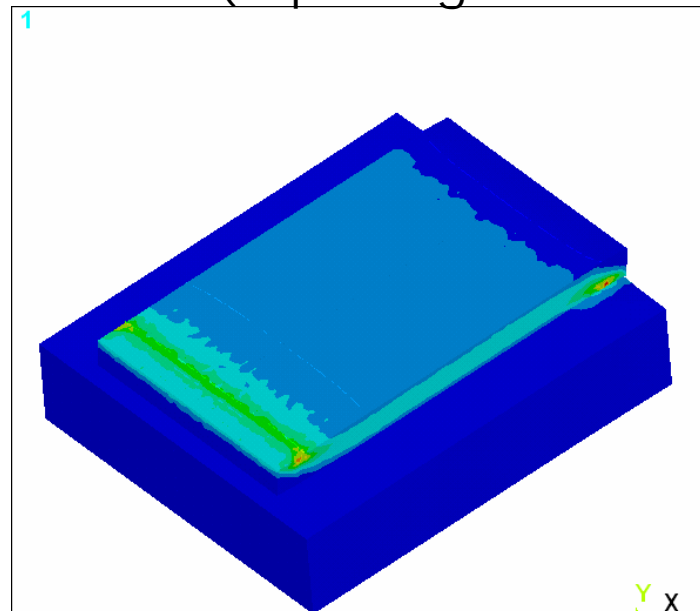
Deflection (top flange removed)



ANSYS 11.0
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 SUB =1
 TIME=1
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 USUM (AVG)
 RSYS=0
 PowerGraphics
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 SMX =.004244
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 .943E-03
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 .001886
 .002358
 .00283
 .003301
 .003773
 .004244



Stress Intensity (top flange removed)

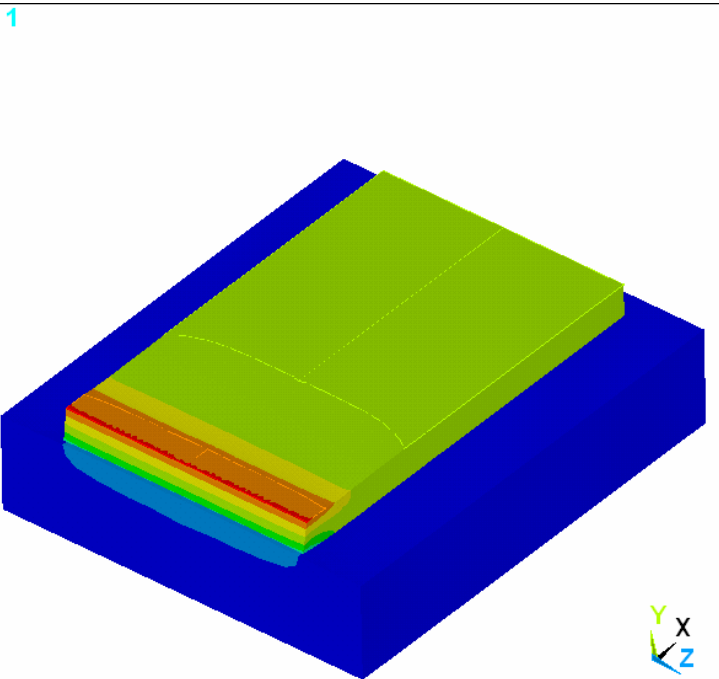


ANSYS 11.0
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 TIME=1
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 10.05
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 12886
 16105
 19324
 22543
 25762
 28981



Plug weld in front

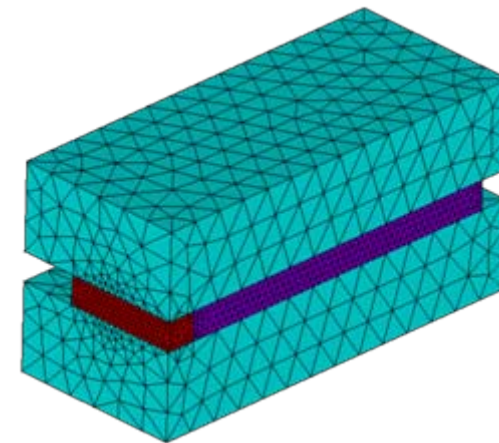
Deflection (top flange removed)



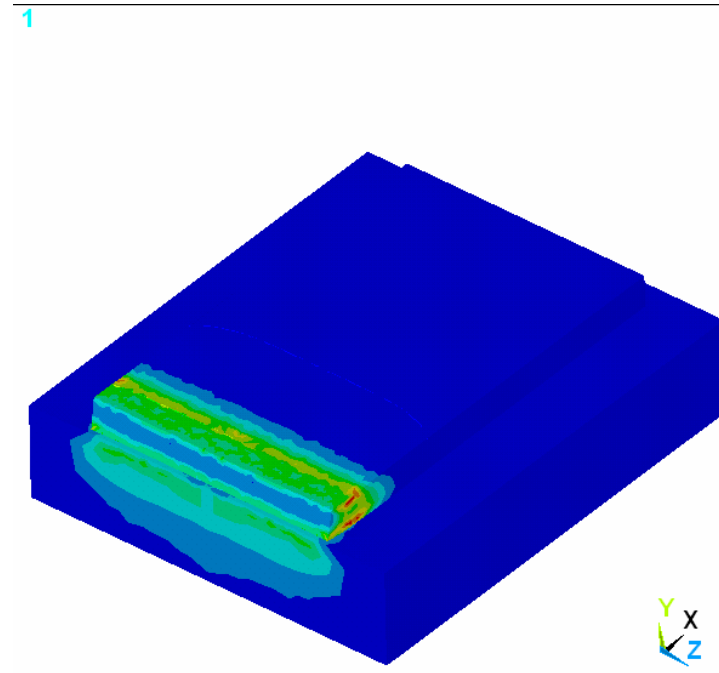
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 SUB =1
 TIME=1
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 USUM (AVG)
 RSYS=0
 PowerGraphics
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 AVRES=Mat
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 SMX =.001601

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.178E-03
.356E-03
.534E-03
.712E-03
.889E-03
.001067
.001245
.001423
.001601

simple weld analysis



Stress Intensity (top flange removed)

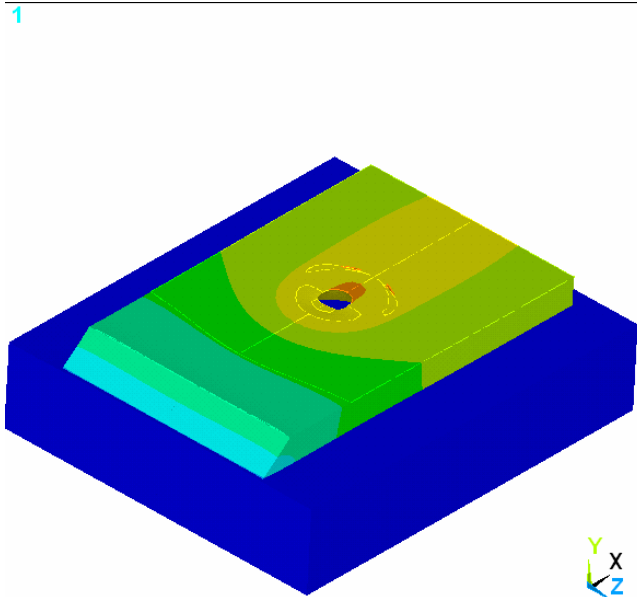


ANSYS 11.0
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 SMN =.145575
 SMX =20793

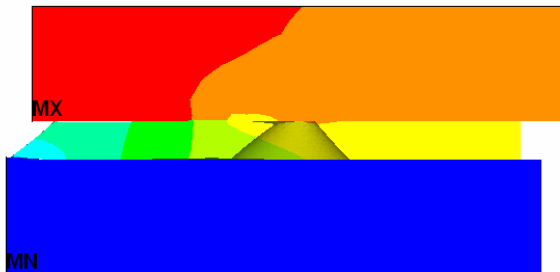
.145575
2310
4621
6931
9241
11552
13862
16172
18482
20793

1.5" hole with 0.5" fillet

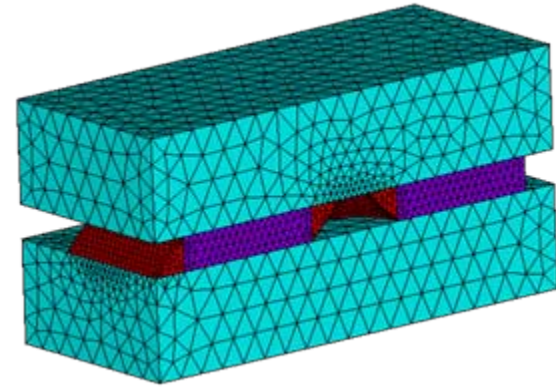
Deflection (top flange removed)



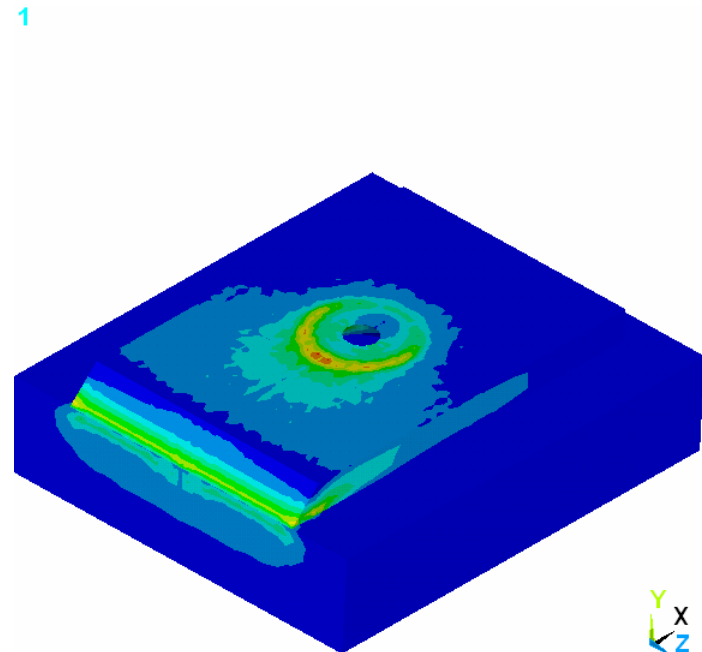
simple weld analysis



ANSYS 11.0
 NODAL SOLUTION
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 SUB =1
 TIME=1
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 USUM (AVG)
 RSYS=0
 PowerGraphics
 EFACET=1
 AVRES=Mat
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 .606E-03
 .909E-03
 .001212
 .001515
 .001819
 .002122
 .002425
 .002728



Stress Intensity
 (top flange removed)

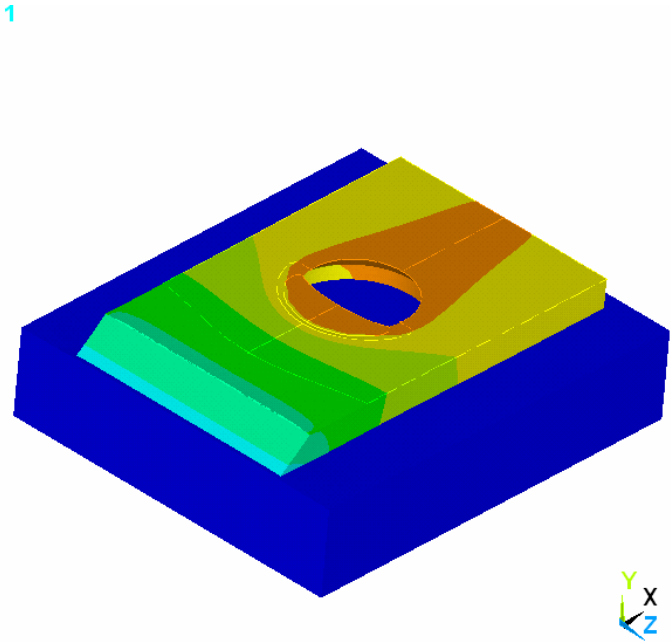


simple weld analysis

ANSYS 11.0
 AVG ELEMENT
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 SUB =1
 TIME=1
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 SMN =1.468
 SMX =27026
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 6007
 9010
 12013
 15015
 18018
 21021
 24024
 27026

2.25" hole with 0.25" fillet

Deflection (top flange removed)

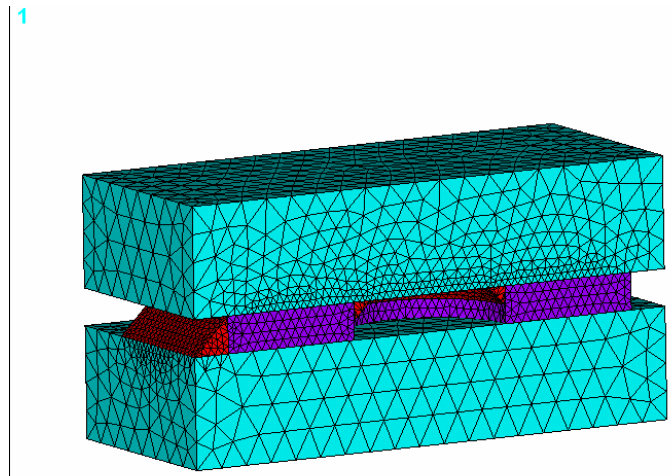


```

ANSYS 11.0
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SUB =1
TIME=1
/EXPANDED
USUM (AVG)
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PowerGraphics
EFACET=1
AVRES=Mat
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Blue	.290E-03
Light Blue	.580E-03
Cyan	.871E-03
Green	.001161
Light Green	.001451
Yellow-Green	.001741
Yellow	.002032
Orange	.002322
Red	.002612



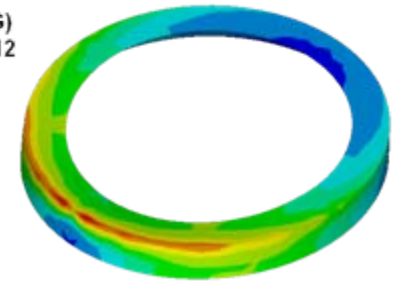
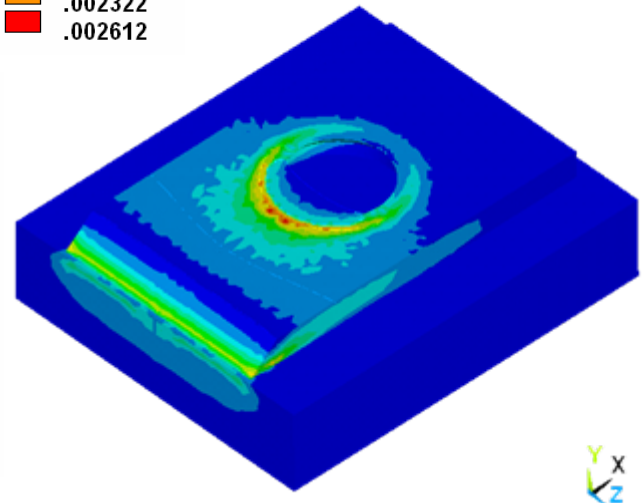
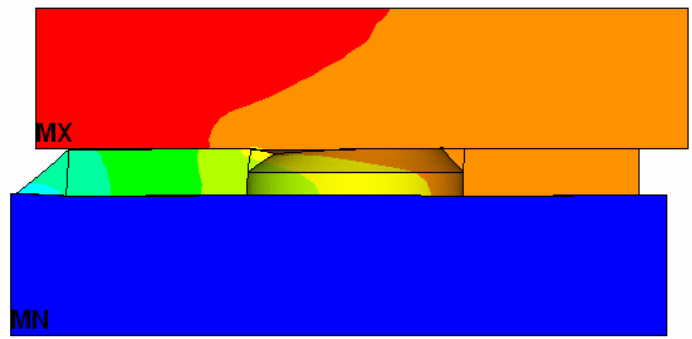
Stress Intensity (top flange removed)

```

ANSYS 11.0
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/EXPANDED
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SMX =27011

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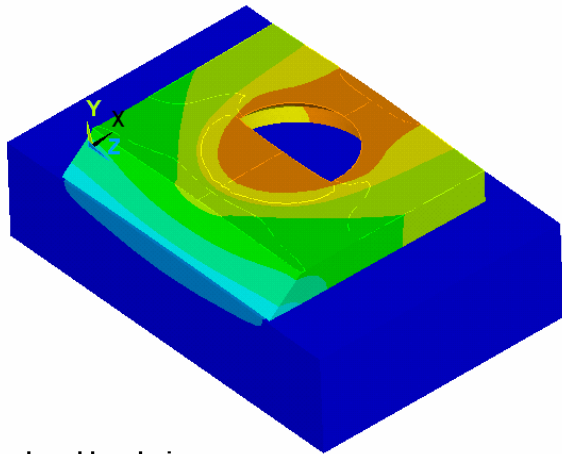
Blue	1.395
Light Blue	3002
Cyan	6004
Green	9005
Light Green	12006
Yellow-Green	15007
Yellow	18008
Orange	21009
Red-Orange	24010
Red	27011



weld

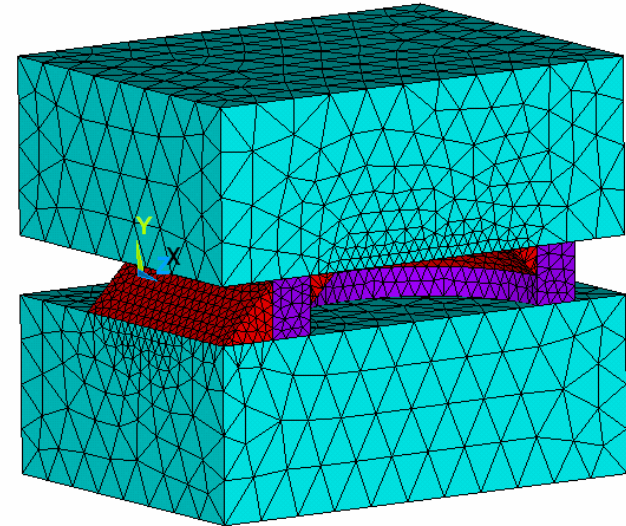
Shorter shim with 2.25" hole and 0.25" NCSX NATIONAL COMPACT STELLARATOR EXPERIMENT

1 weld



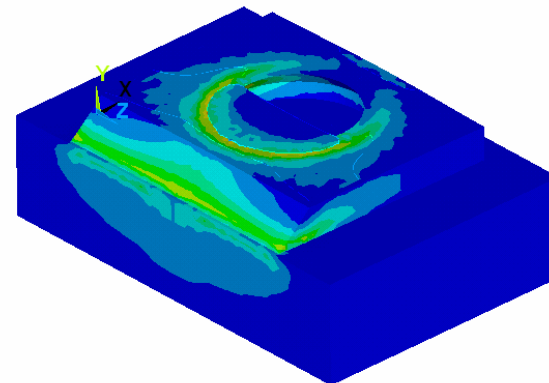
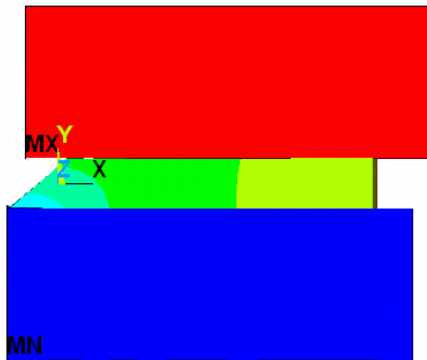
simple weld analysis

ANSYS NODAL SOLUTI
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 SUB =1
 TIME=1
 /EXPANDED
 USUM (AVG)
 RSYS=0
 PowerGraphics
 EFACET=1
 AVRES=Mat
 DMX =.001843
 SMX =.001843
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 .205E-03
 .410E-03
 .614E-03
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 .001024
 .001229
 .001434
 .001638
 .001843



1

ANSYS AVG ELEMENT
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 TIME=1
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 SINT (AVG)
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 19552
 22811
 26069
 29327



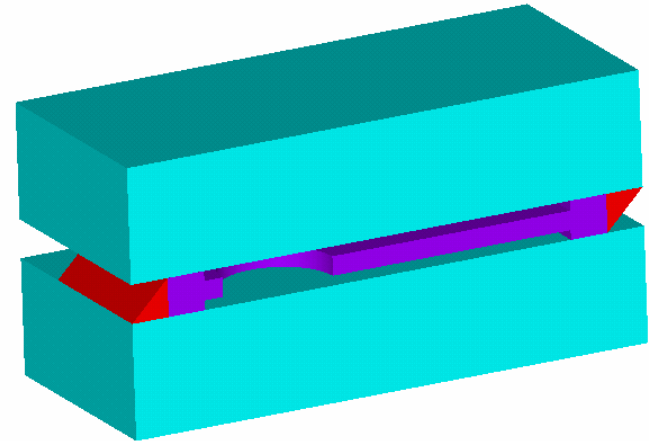
simple weld analysis

Undercut with loose hockey puck, filleted ends

1

```

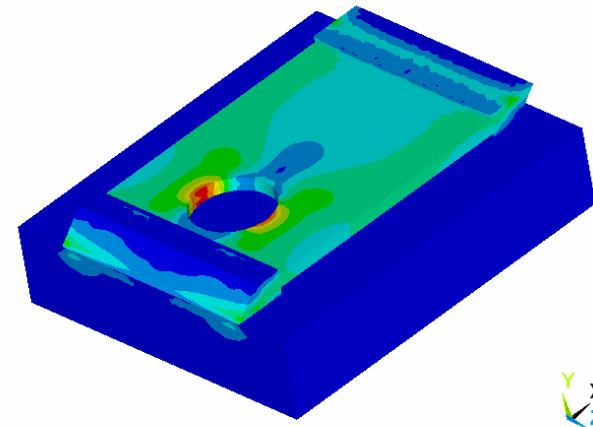
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NODAL SOLUTIC
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SUB =1
TIME=1
/EXPANDED
USUM (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
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■ .004287
■ .005002
■ .005717
■ .006431
    
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1

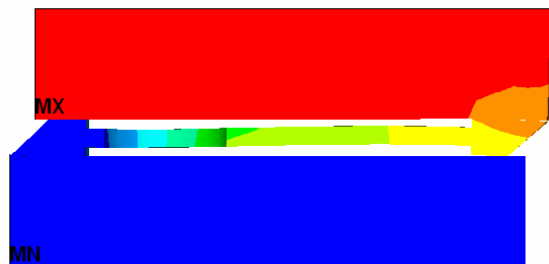
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■ 12493
■ 18737
■ 24980
■ 31223
■ 37467
■ 43710
■ 49954
■ 56197
    
```



simple weld analysis

simple weld analysis



Table

Weld Case	Deflection (mils)	Max Stress Intensity (ksi)	X stress (ksi)	XY shear (ksi)
New Fillet welds	4	33	29	13
New fillets with chamfer	4.2	29	-24	11
End fillet weld + (1.5" hole, 0.5" fillet weld)	2.7	27	24	10
End fillet weld + (2.25" hole, 0.5" fillet weld)	2.5	21	20	10
End fillet weld + (2.25" hole, 0.25" fillet weld)	2.6	27	26	10
End fillet weld + (2.25" hole, 0.25" fillet weld) Shim length = 3 in.	1.8	29	22	10
Loose Hockey Puck in 1.5" hole, Fillet welds both ends	4.5	32 (33 shim)	24	12
Loose Hockey Puck in 1.5" hole, Fillet welds both ends (1/8" undercut	6.4	32 (56 shim)	27	14
Previous weld baseline (end plug)	1.6	21	20	9
0.5" studs on 2.5" centers with Stycast [experiment + analysis] 2006 baseline	5	14	15 (bending)	16

Shim length except where noted is 6 inches

- Going to a smaller weld will no longer pass the 31.5 ksi requirement everywhere. We are already there with the 0.5" (0.35" throat weld). (see table).
- It is true that in some instances we can use less weld since the shear force is not uniform.
- Shear tearout of hockey puck is not clear, typically, an edge distance of $1.5 \times \text{Diameter of pin}$ is required. If imposed, the puck would no longer be in the ideal compression load path position.
- Undercutting the shim along with a hole increases the deflection through the shim quite significantly.
- When clamped, a shim (with a hole in it moves up 0.046" when unclamped after welding one side. The same shim will distort 0.5 inches if unclamped. If we tack the front of the shim down, we can chisel the weld after the top coil has been lowered into place. This removes the need for a compression limiter (IMO).
- Finally, it is my opinion that the difficulties of distortion seen in experiments, potential damage to the coils and an unclear design path after many iterations is prohibitive enough to warrant using the backup plan (the now infamous pin-cushion). ORNL will proceed with design.

- No Weld Distortion.
- Single Piece shim(s), (no limiters)
- Carries shear effectively, shown by experiment.
- Easy to use “break off studs”
- Assembly sequence straight forward. No need to pull coils apart.
- Can be disassembled. (spray pins with mold release, worked well in experiment fixture)

Still need.

Epoxy injection system – finalize placement of O-rings/seals, may not be needed if using smaller discrete shims.

Possibly could use filler materials in stycast to provide additional bearing strength.

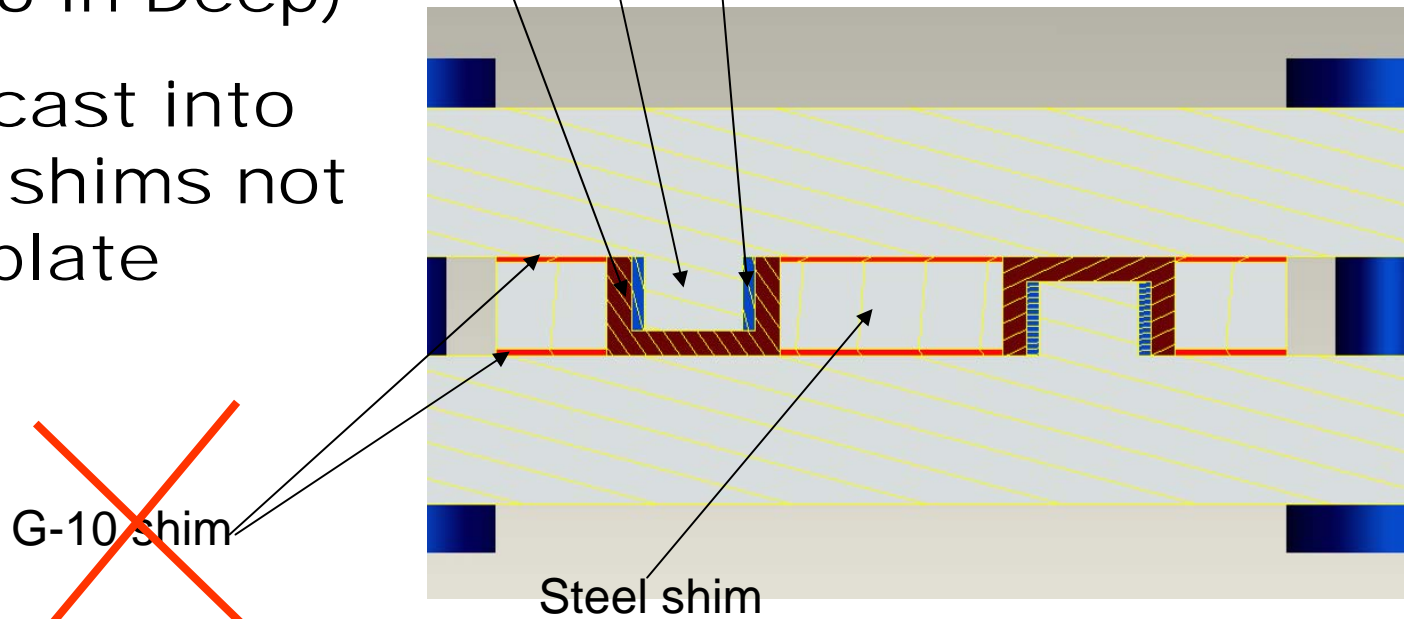
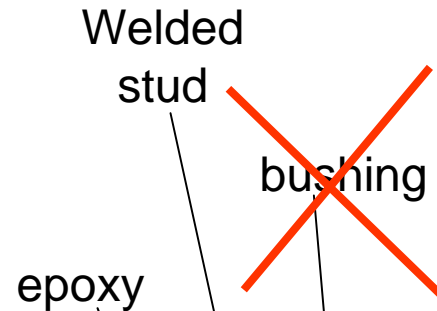
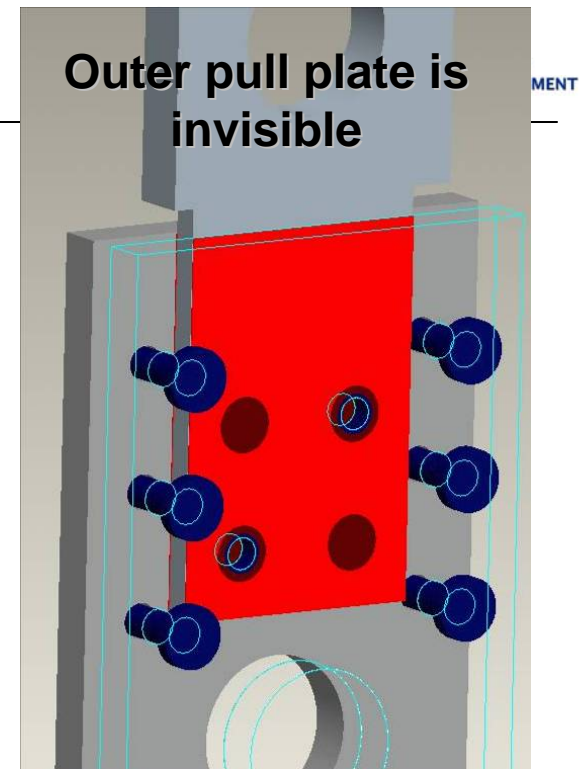
Fixture

CHANGES (Sept 07)

No electrical requirement- no bushings - or g10 shims

Keep shim layout (4 in wide X 6 in Deep)

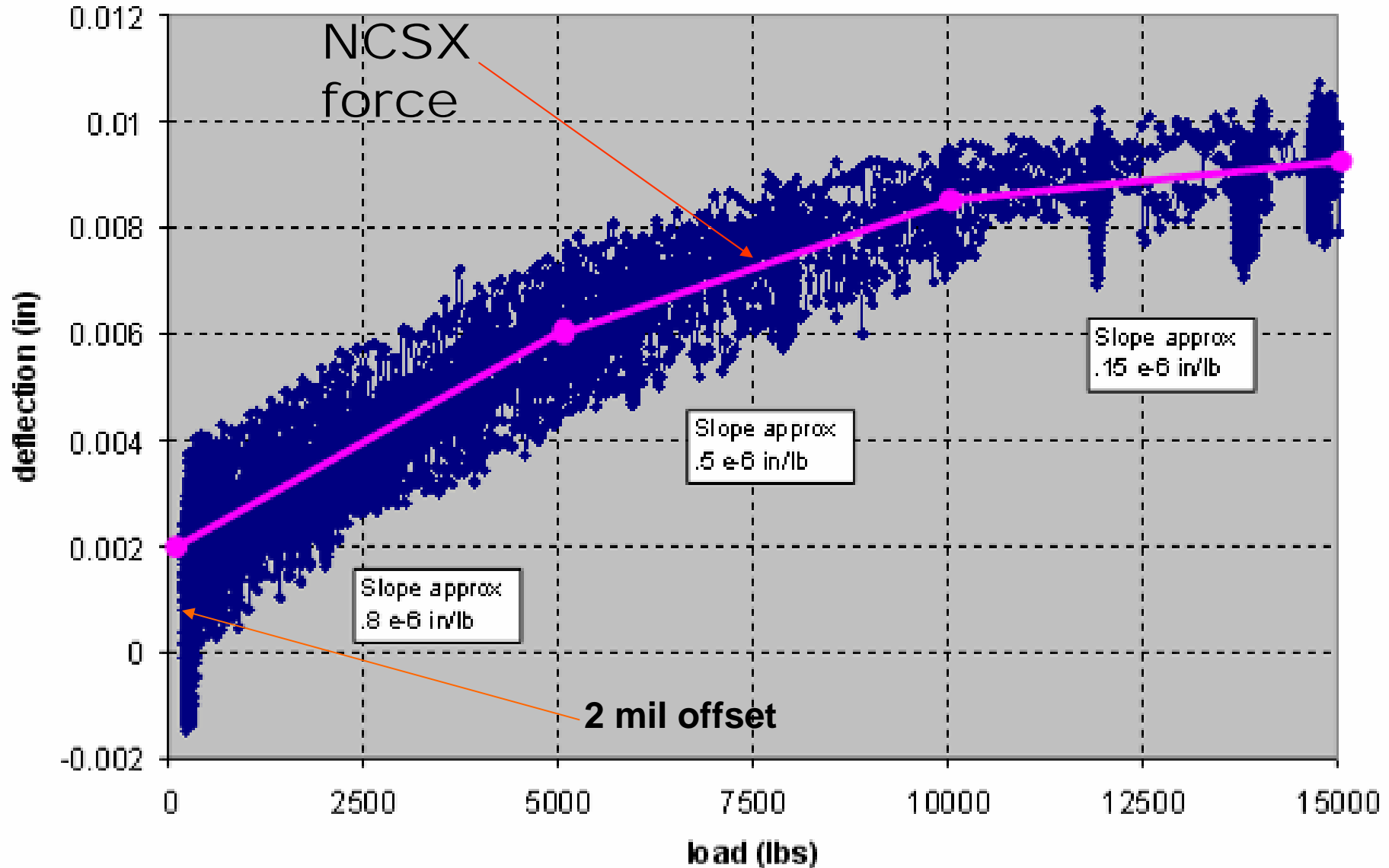
Inject Stycast into individual shims not an entire plate



- The four half inch studs were welded on at the MDL laboratory onto the two pull plates. The pins had very little tilt to them and were fairly normal to the plates.
- The weld bead was then ground off and the studs were cut back to 3/8" long. *****
- This procedure can be performed at PPPL in the same manner as was done at MDL.
- All other parts of the fixture (excluding the studs), were machined at a local machine shop.
- ***** Knock off studs makes this exercise very easy, even I could do it. A fixture could be made, and will be made at MDL to remove the fillet splatter, or it may be ok to remain id shim is chamfered at holes.

Testing was conducted at double NCSX expected shear force.

Deflection vs Load for one armed bandit

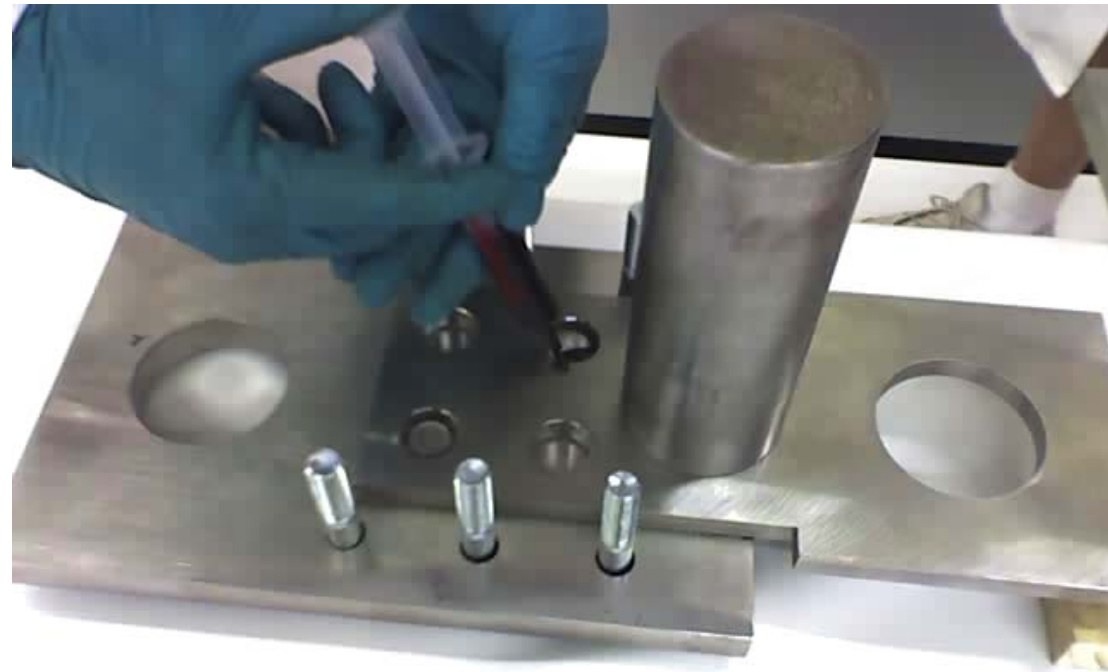


Sample Preparation (Insertion of the Stycast FIRST TIME)



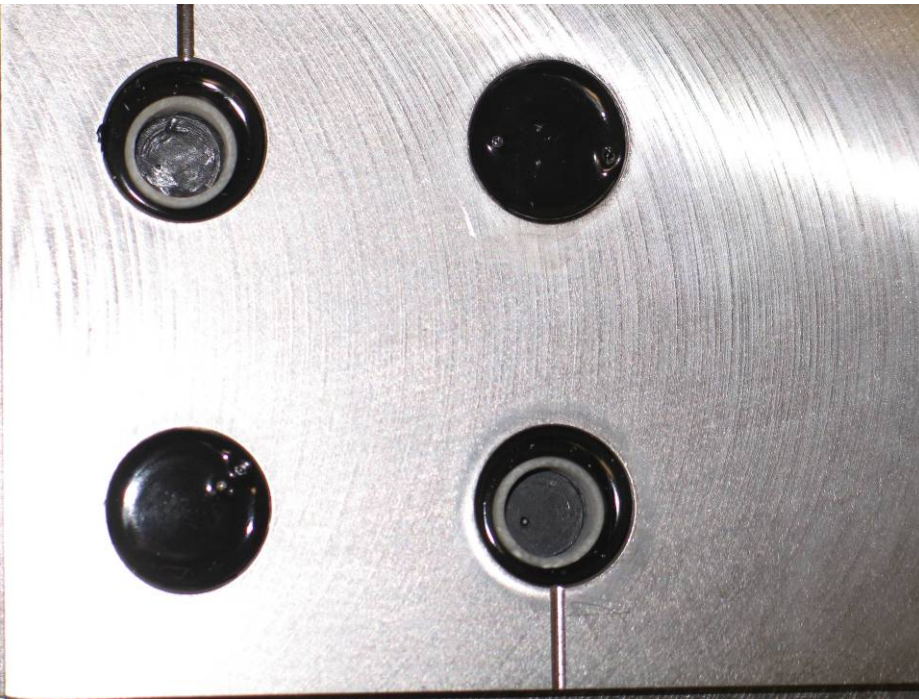
Mixed Stycast 2850
with catalyst 23LV

Extracted using
Walgreens syringe



Stycast was inserted from the top filling all four
holes in this orientation

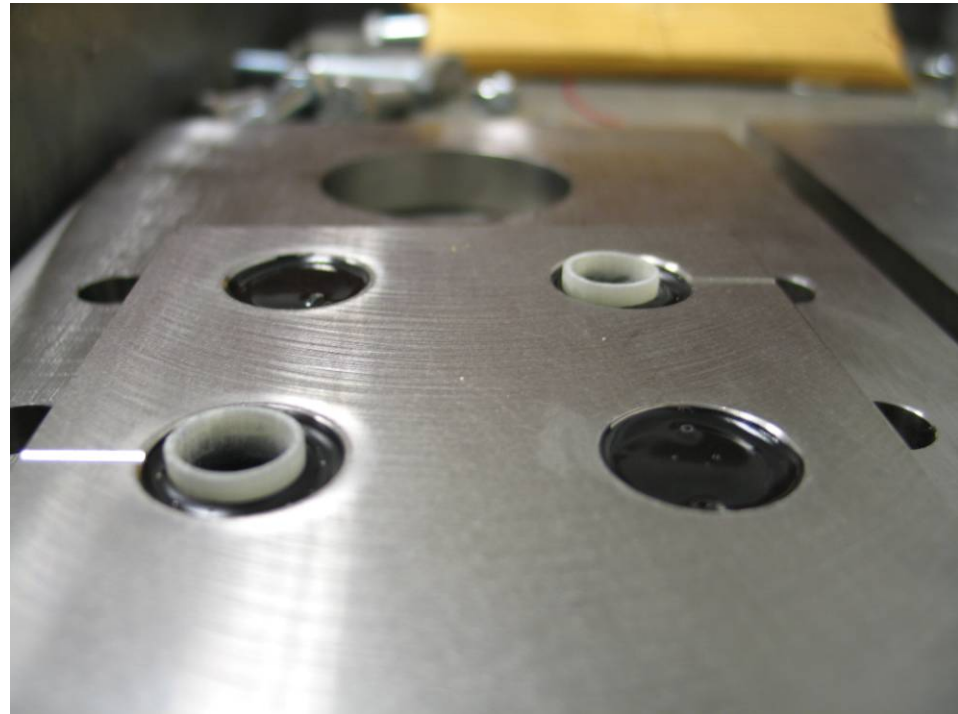
Pictures of Stycast and bushings



Top View:

Bushing are not concentric

No cracking is seen.

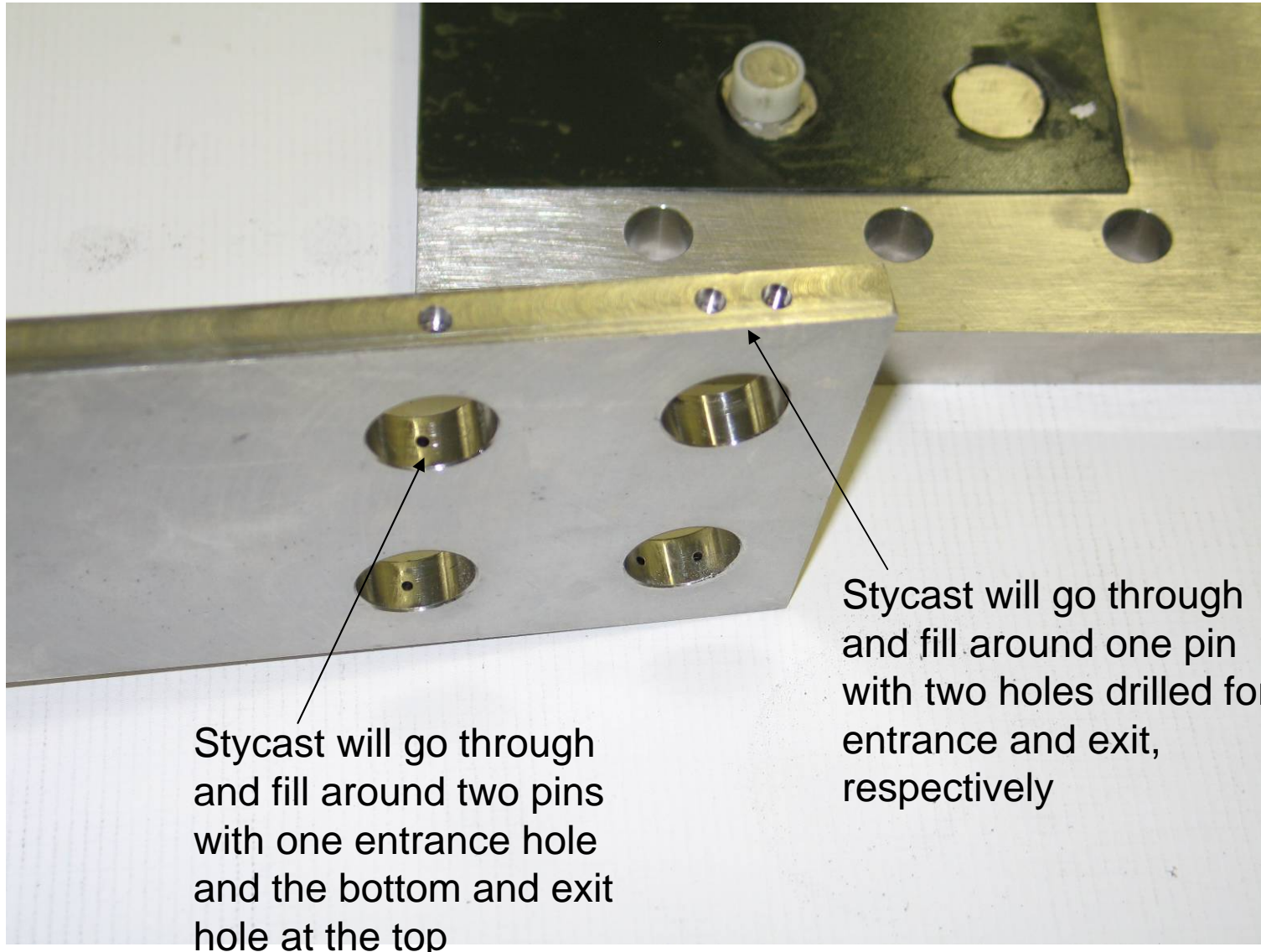


ISO view:

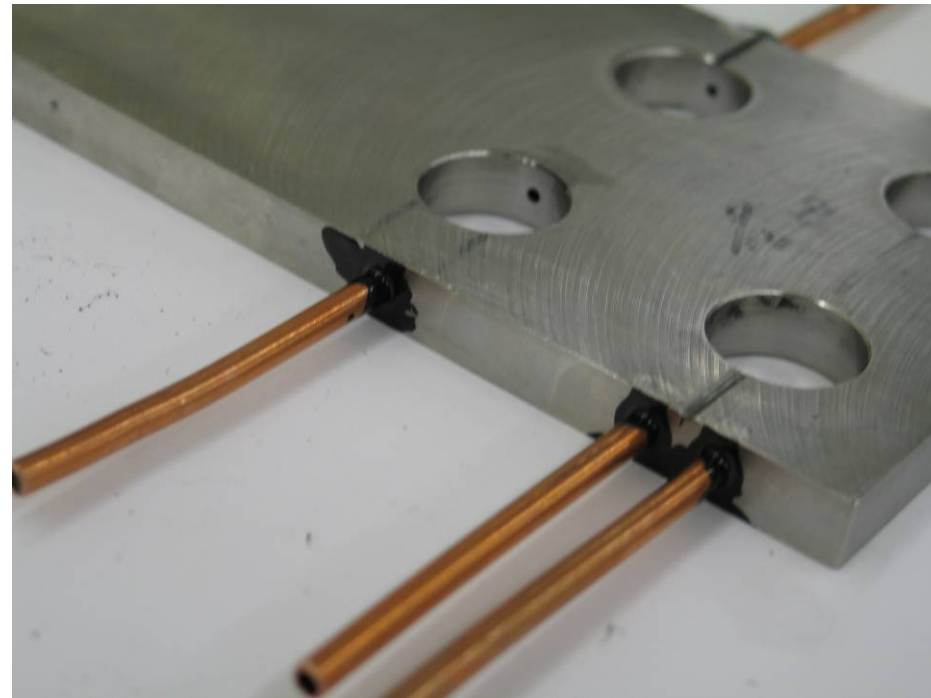
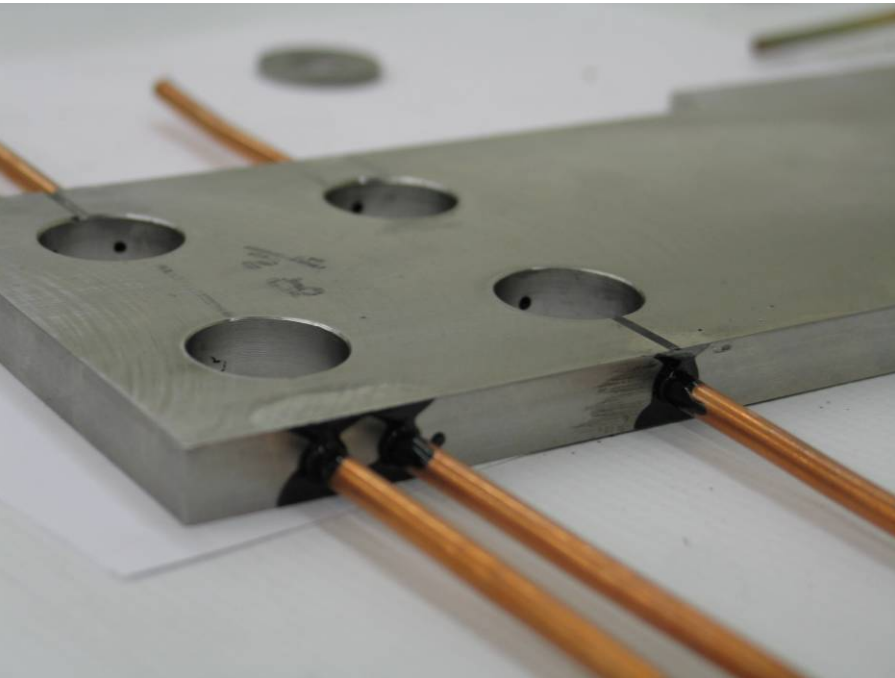
Large gaps 1/8" are seen in the level of the stycast compared to the sst shim,

Even though results were good with incomplete fill, a new insertion technique was tried.

1. Approx 3/32 hole drilled in plate, holes are counterbored for copper tubing

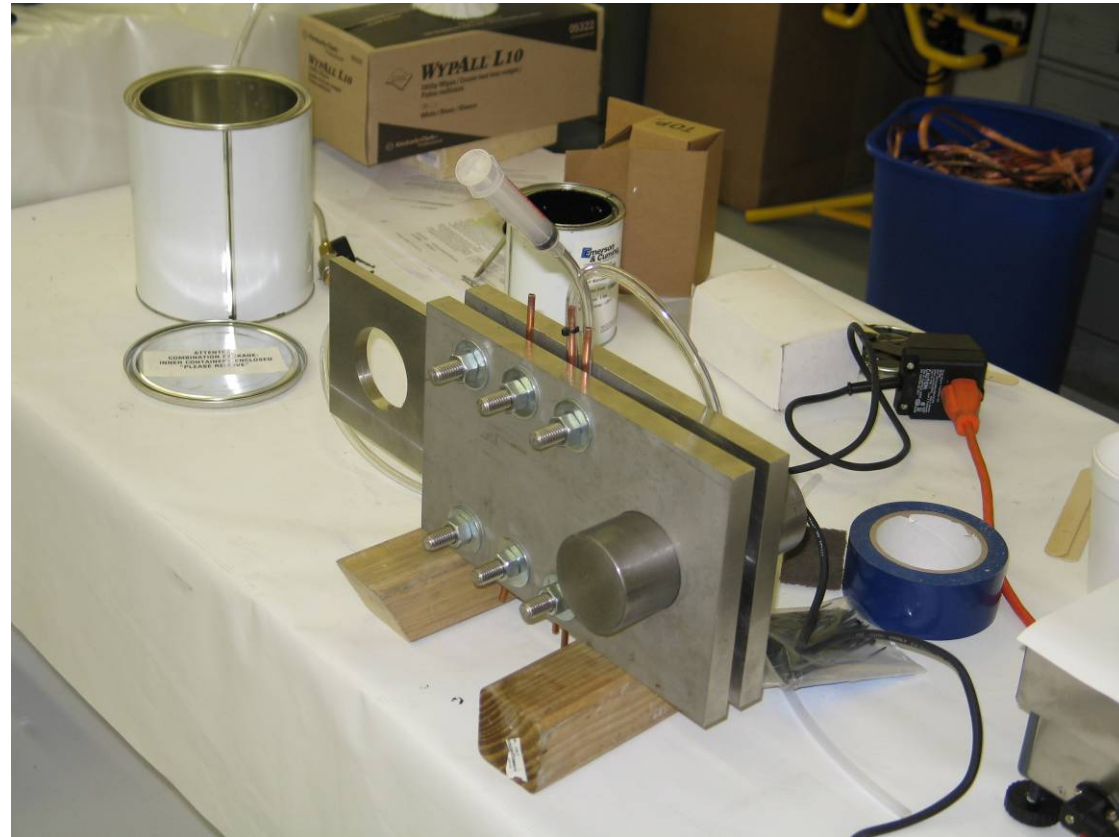
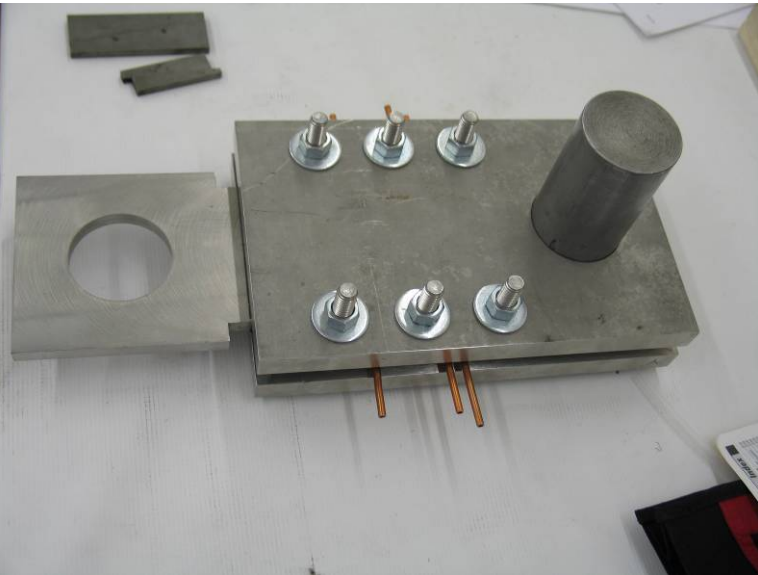


2. Copper tubing glued in with stycast **NCSX** NATIONAL COMPACT STELLARATOR EXPERIMENT



Small Zerc-like Fittings may be used in the real coil, but stycast works just fine.

3. Sample was carefully installed aligning pins in the middle of the holes.

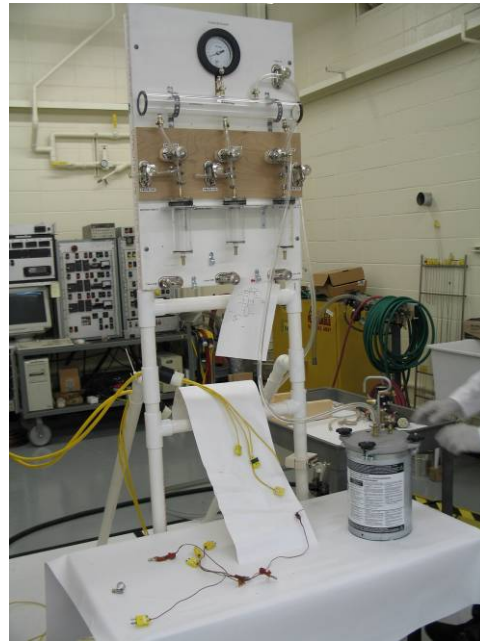


Sample is then turned on its side for stycast insertion, standard plastic tubing is used. For delivery, a hypodermic syringe is used.

4. To prevent bubbles in stycast, sample is mixed, stirred then placed in a hard vacuum for 3 minutes



Paint pot used as vacuum chamber

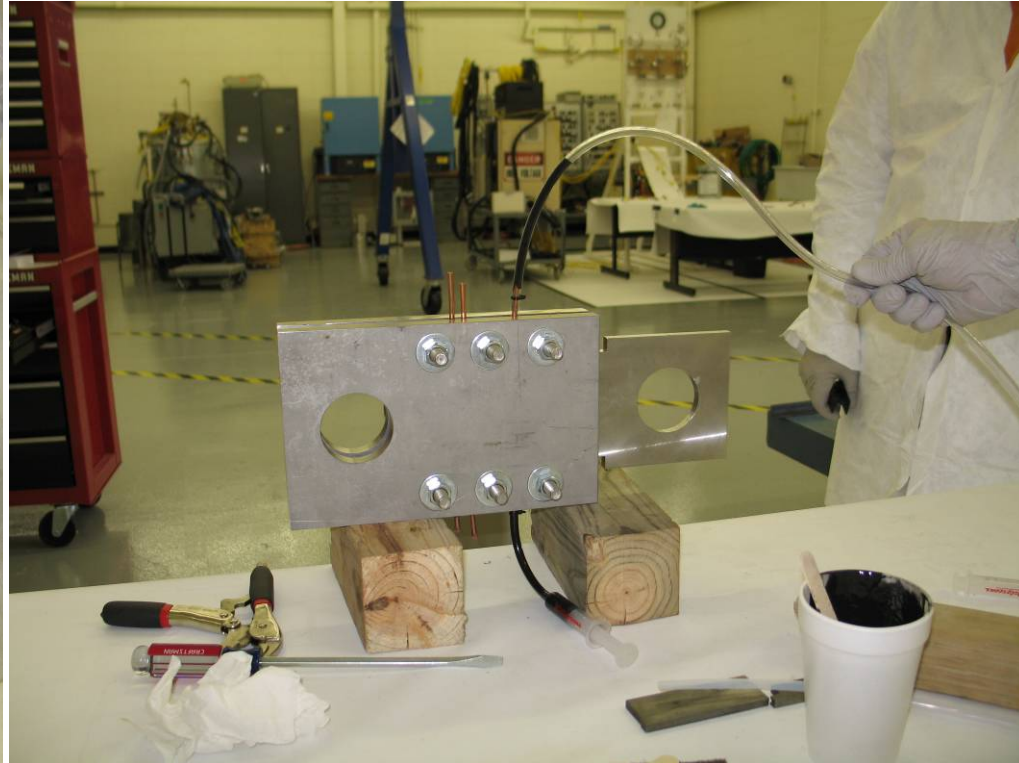
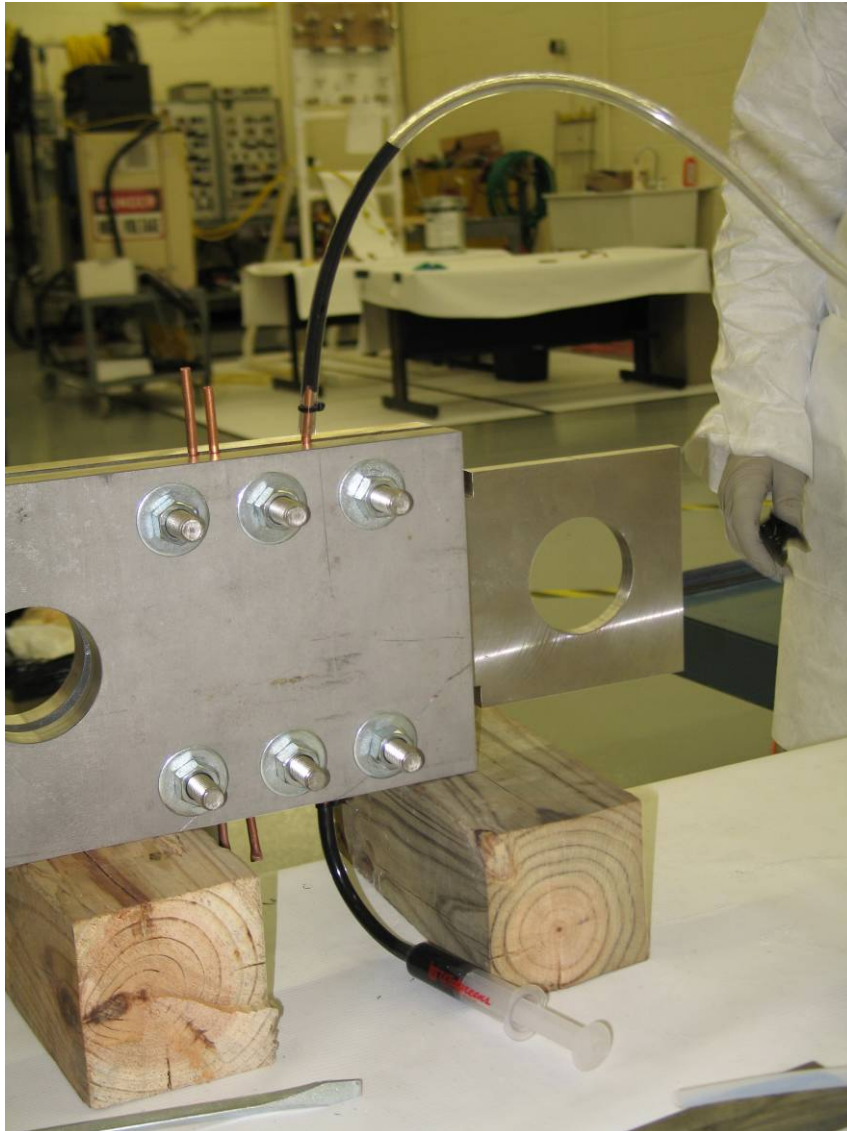


Vacuum system and gage (used for QPS racetrack coils)

Stycast after vacuum deairing, notice that it foamed up the sides.

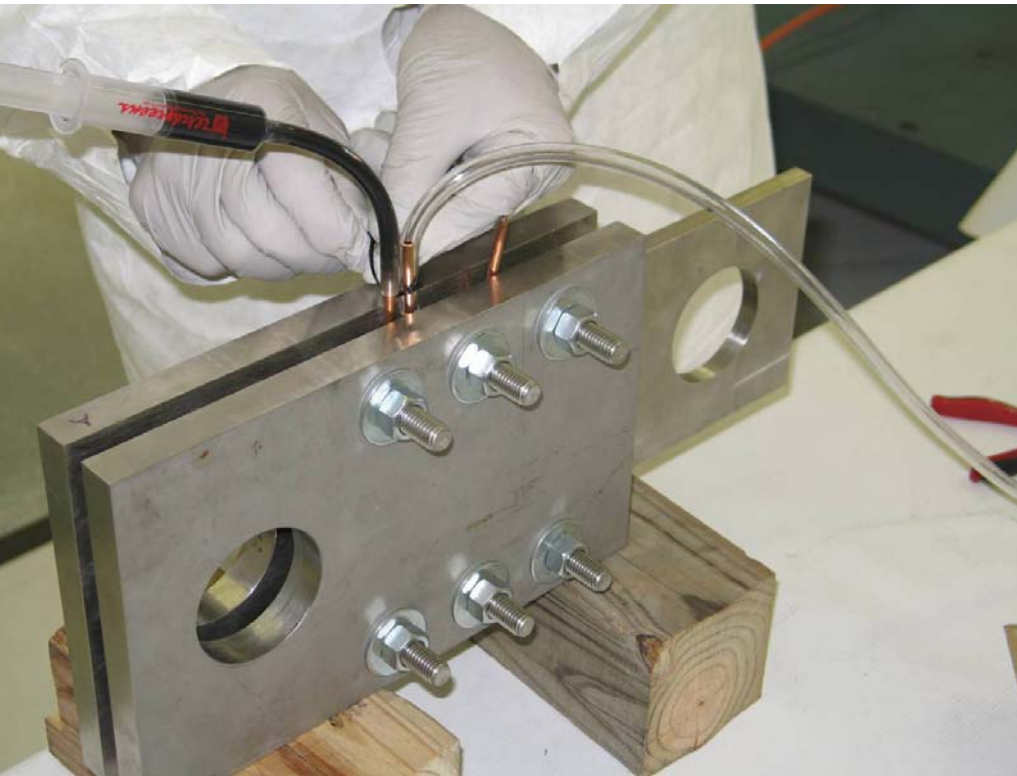


5. Injection of stycast (Vertically)



The stycast was pushed using the syringe from the bottom until it expelled from the top. It flowed with very little resistance at first but became slightly harder once the bottom hole was filled. There was no visible seepage from the sides and no visible air in the line. A vacuum was applied to the top line after stycast was observed coming out of the top. This was followed by further pushing with the syringe. No air bubbles were seen.

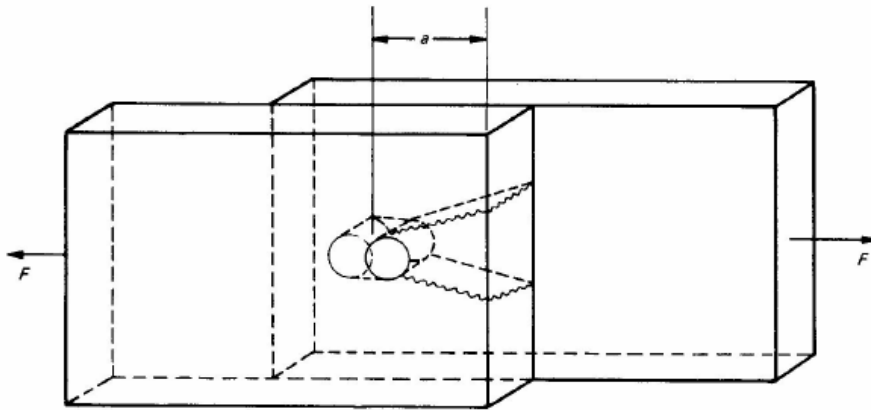
6. The other two holes showed similar results with no air bubbles in the line.



The results for this test and setup were marginally better than the first setup, roughly (0.5 mils).

Upon inspection, (pictures in lab camera), fill was not perfect (some pockets) but much better than the first attempt, improvement from approx 80% fill to 95% fill.

Shear Tear Out at Edge of Plate



Stress Formula

$$\tau_t = \frac{F}{2at}$$

Prevention

This type of failure is normally controlled by specifying minimum edge distances. An edge distance greater than 1.5d is commonly used.

Deutschman, Fig. 16-8