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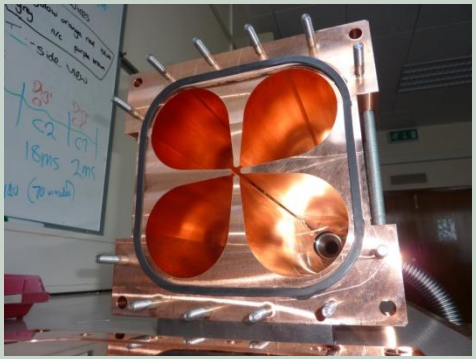
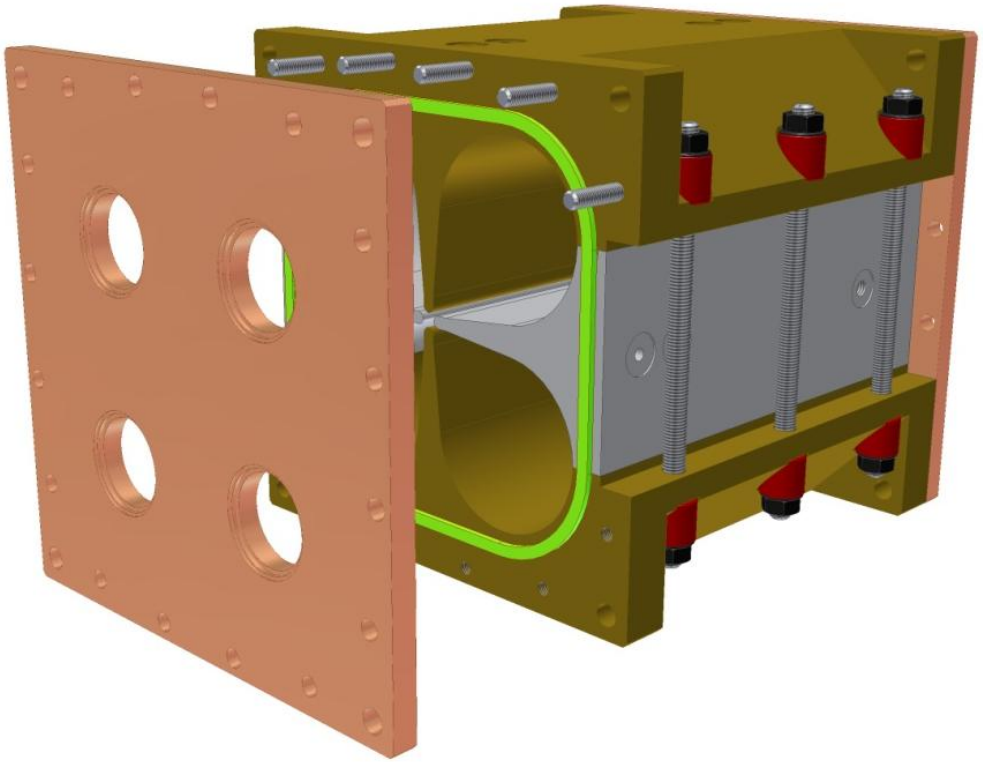
3D ‘O’ Ring Vacuum Tests – PART I

13th April 2011

by Peter Savage & Ian Clark



3D ‘O’ ring test



Why are we doing this?

A full scale (transversely) model of the seal as could be used for the full RFQ.

It is one quarter the length but sealing along the length is not considered the challenge.

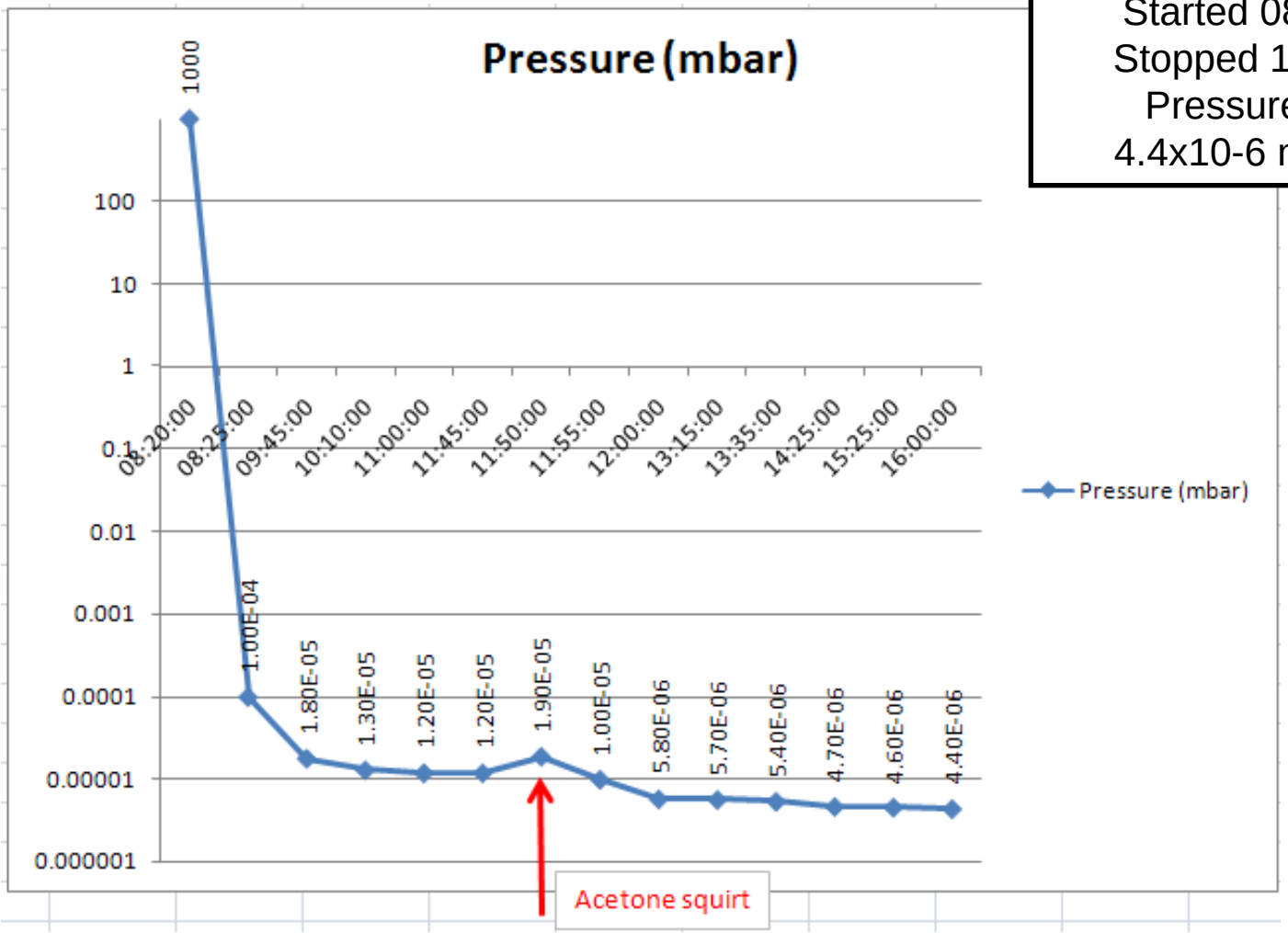
To learn from before using for the real RFQ.

Test # 1

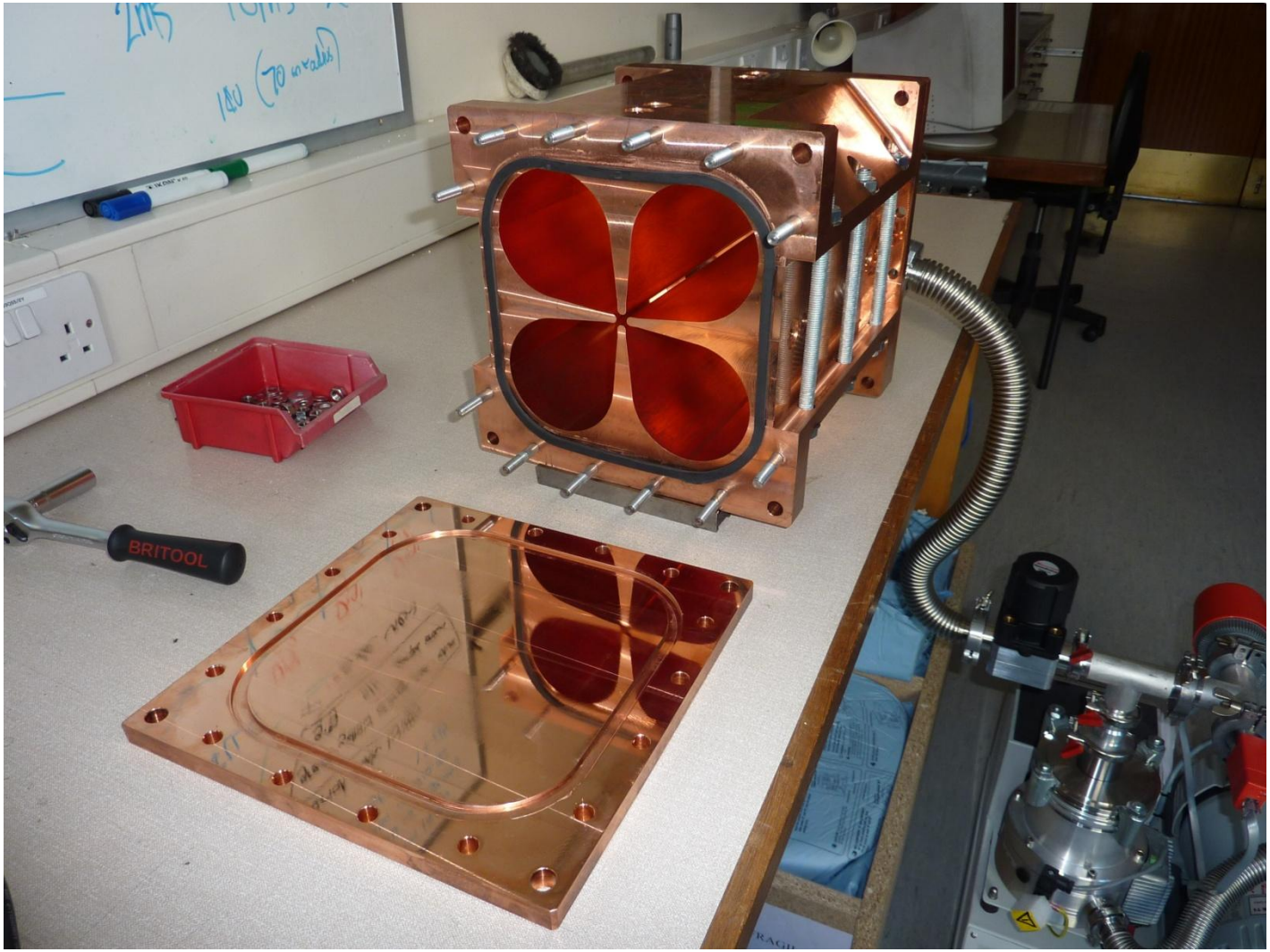
- 3D ‘O’ ring build #1
- Cyanoacrylate (Superglue)
- End plates did not pull down flush
- Suspect trapped ‘O’ ring
- Decided to pump anyhow.

Vacuum test #1

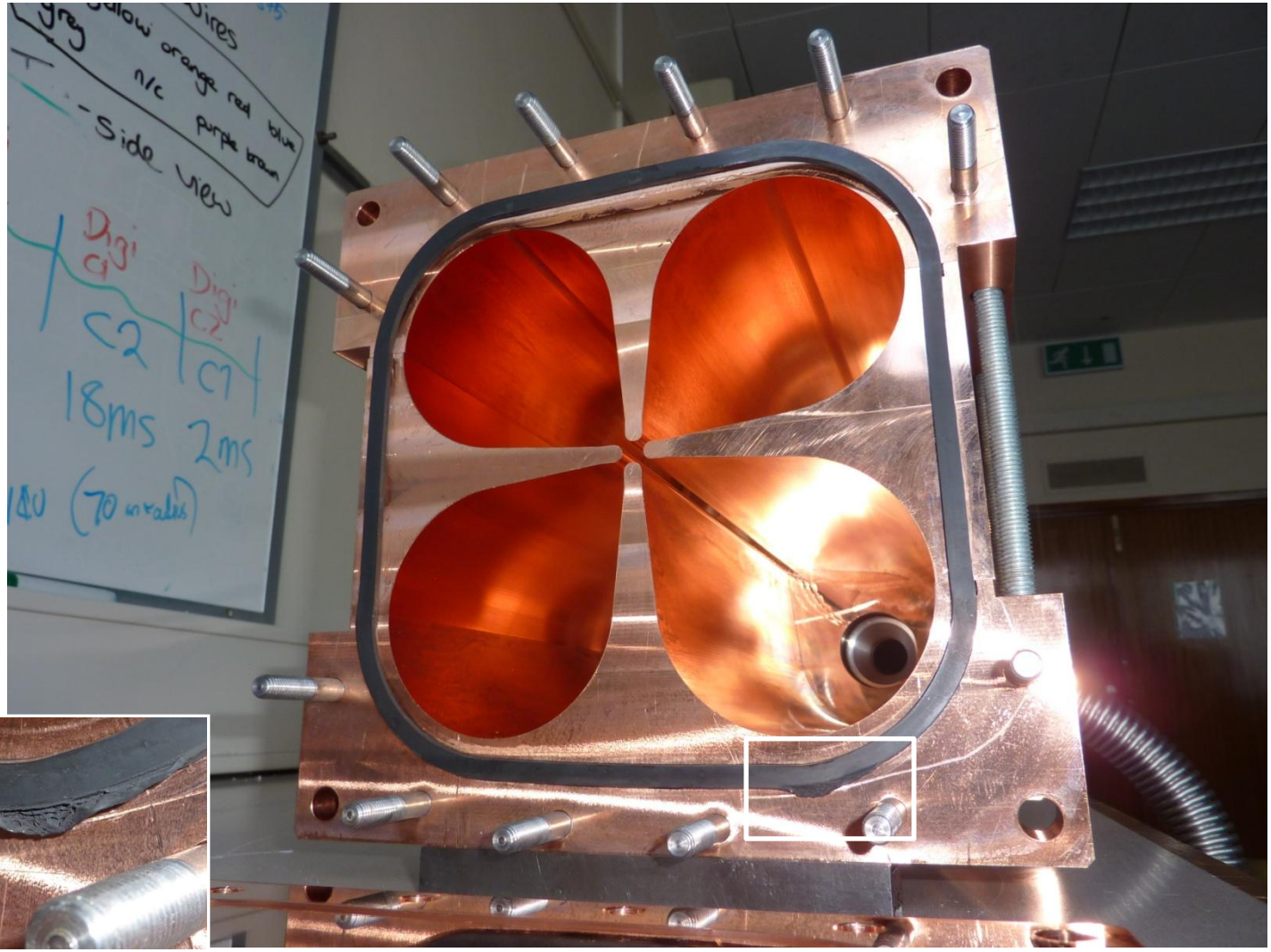
Started 08:20
Stopped 16:00
Pressure =
4.4x10-6 mbar



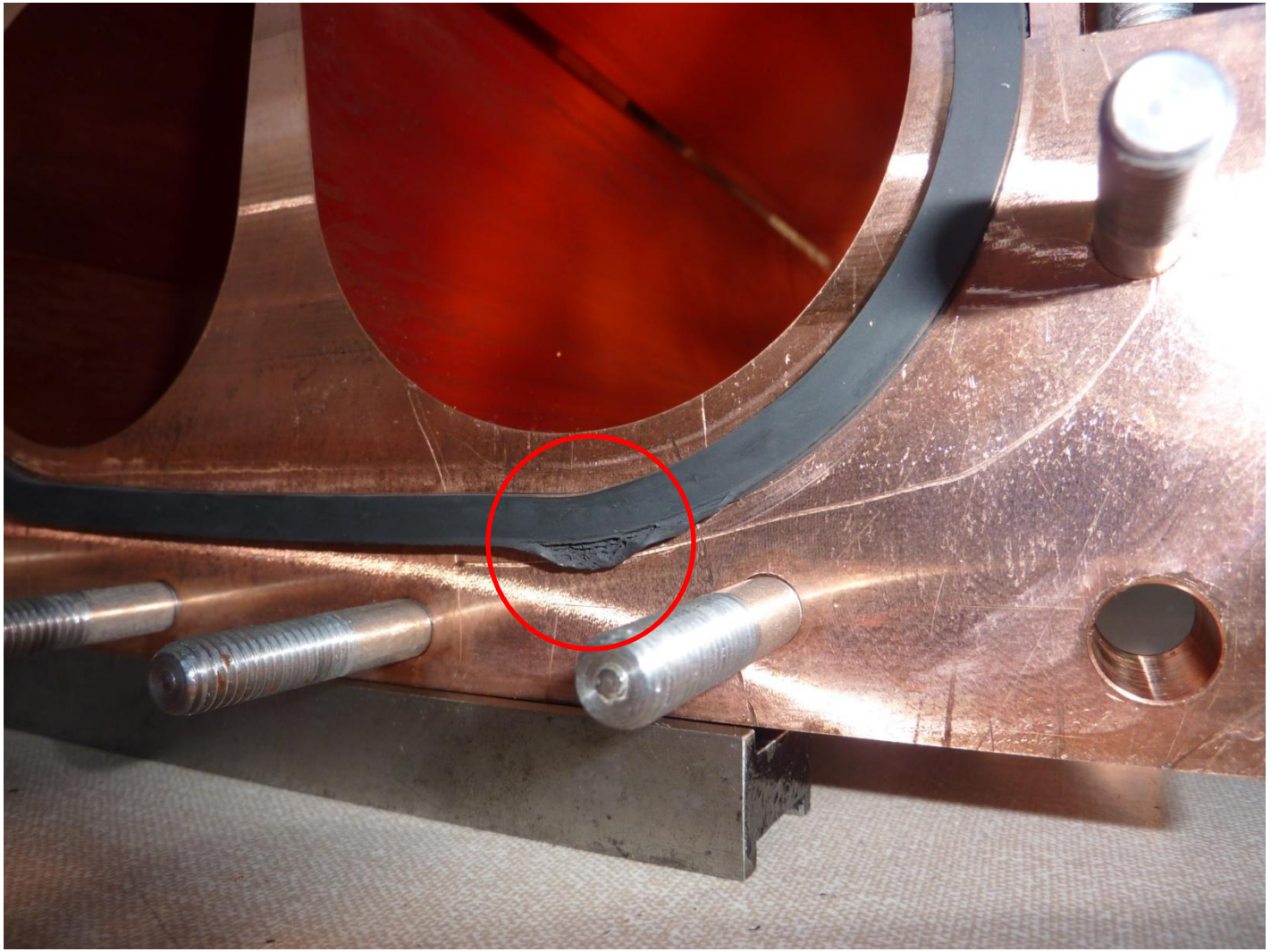
Dismantling



Damage to end seal revealed



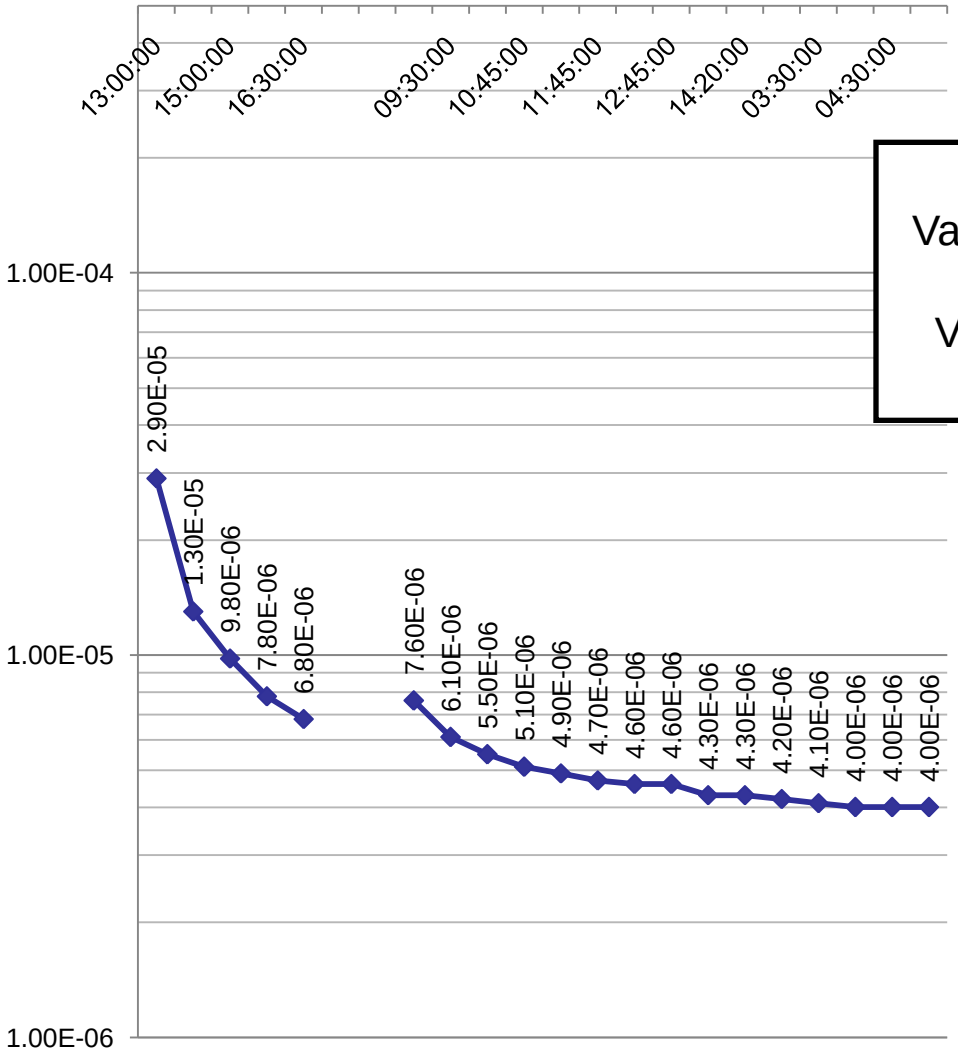
Oops



Test # 2

- 3D ‘O’ ring build #2
- Re-assemble
- Re-test

TEST #2 Pressure (mbar)



Test duration:
Vacuum pump on one afternoon
Off overnight, valve closed
Vacuum pump on one full day
Pressure = 4.0x10-6 mbar

Problems encountered....

Tricky to rest minor vanes in position i.e. they move about on the O ring – will design alignment blocks for full RFQ. Also, for full RFQ we won't want to rest vane tips on one another.

Need provision for lifting when full RFQ. Not a problem manually at this ¼ weight.

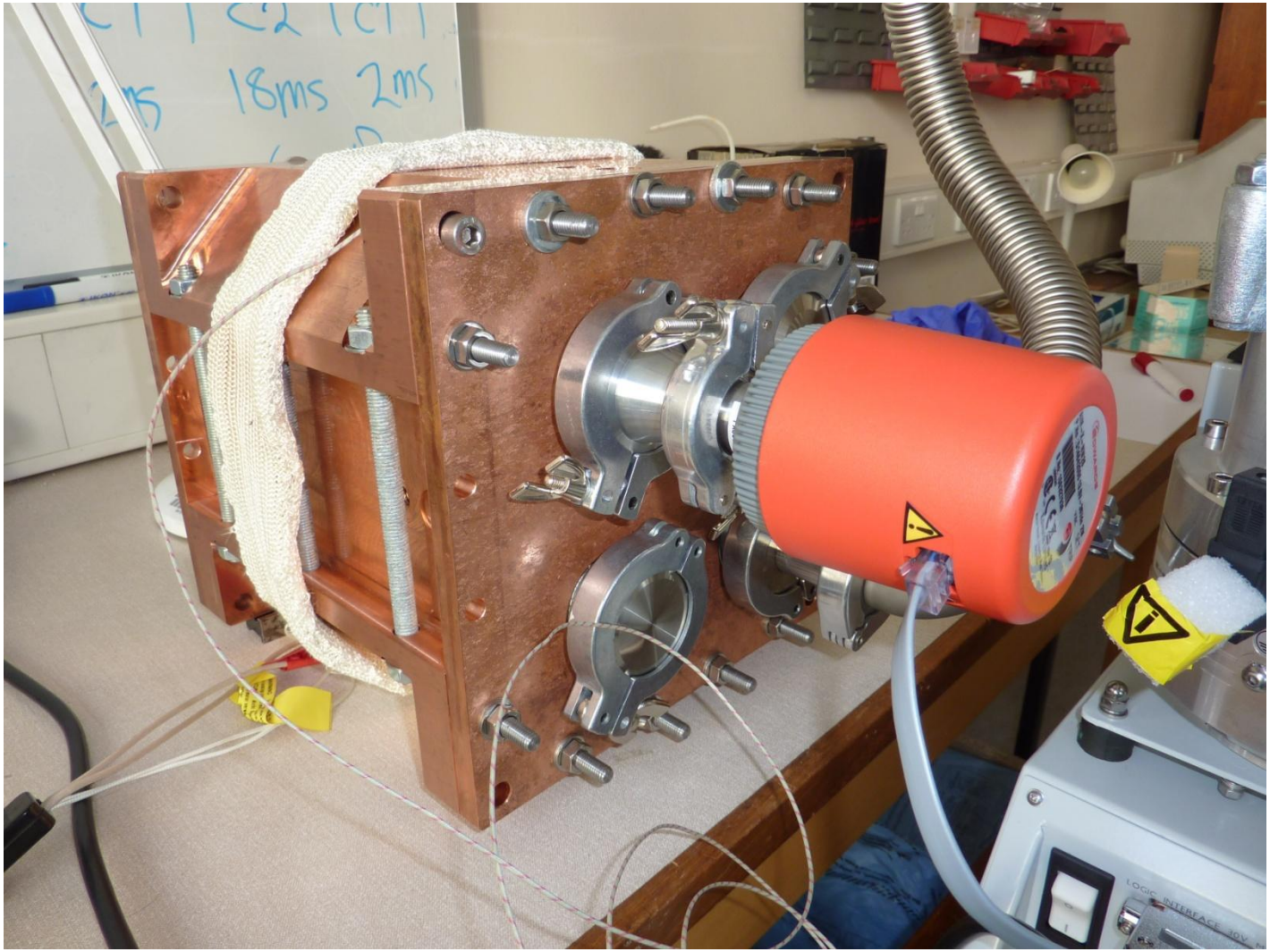
Test # 3

- 3D ‘O’ ring build #2

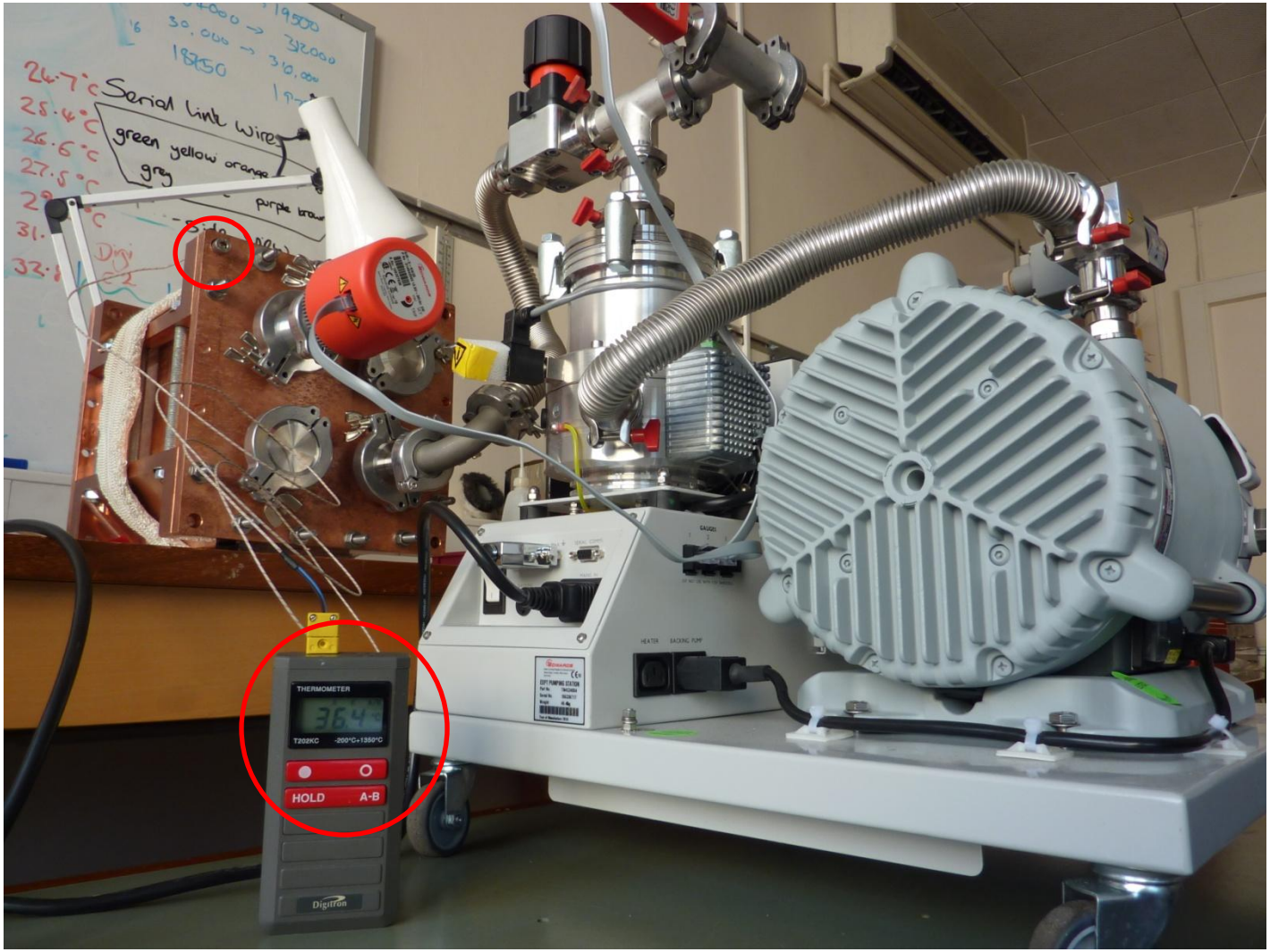
- Connect vacuum gauge directly to RFQ model. Previous gauge position (close to the pump) was not reading RFQ model pressure.

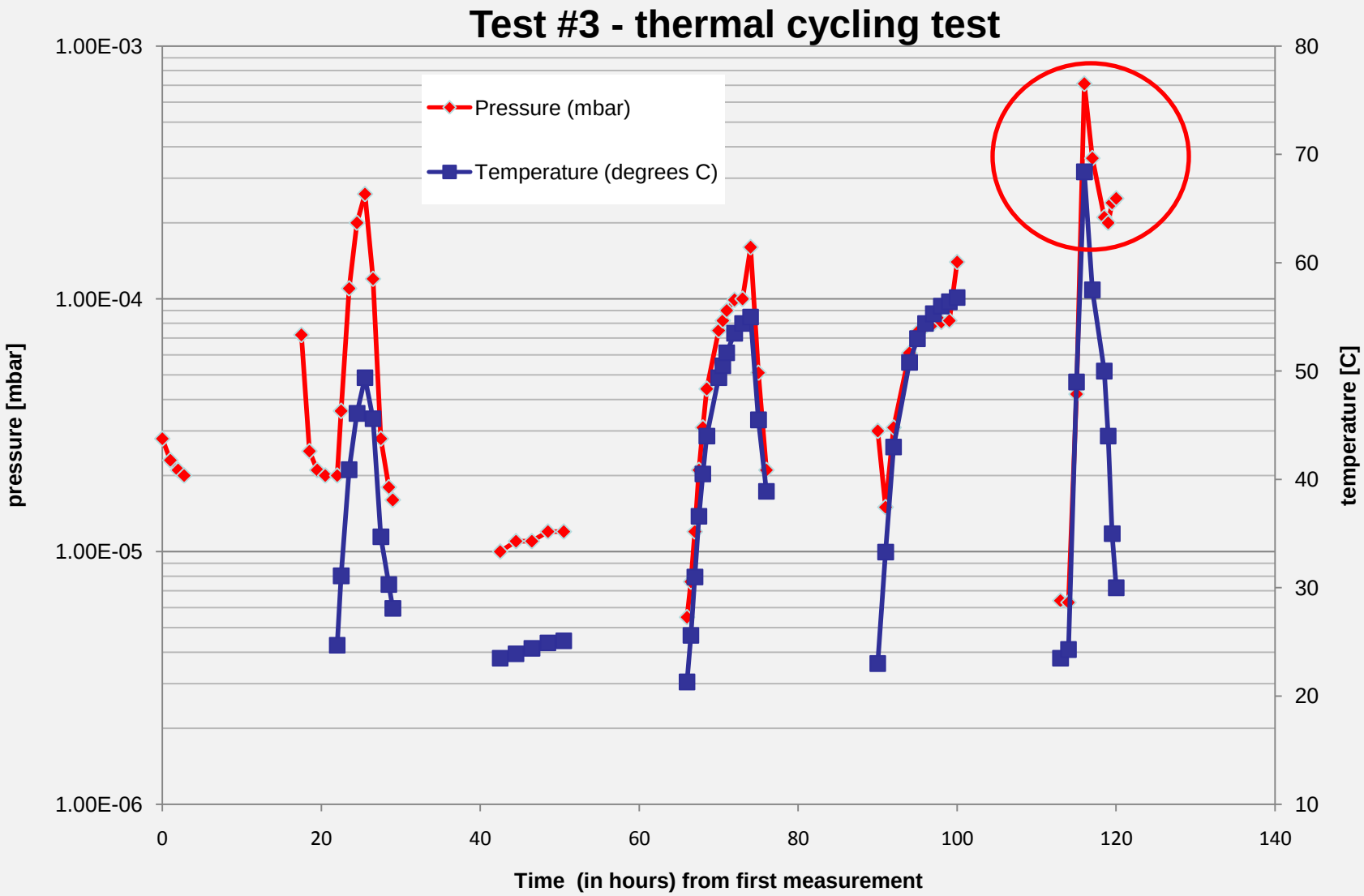
- Apply heat

Showing new position of vacuum gauge



Heating tape and thermocouple attached




Test #3 - thermal cycling test
Pressure (mbar)
Temperature (degrees C)
pressure [mbar]
temperature [C]
1.00E-03
1.00E-04
1.00E-05
1.00E-06
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
Time (in hours) from first measurement

Conclusions

Regular superglue makes an excellent bond for Viton O rings

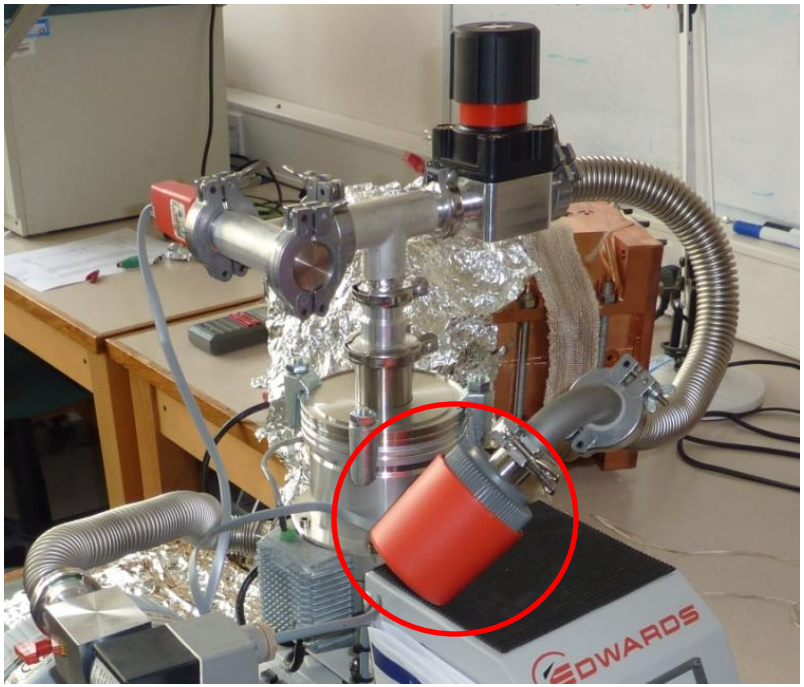
But when baking out may be required it is of limited use with a melting temperature of just 82^0C

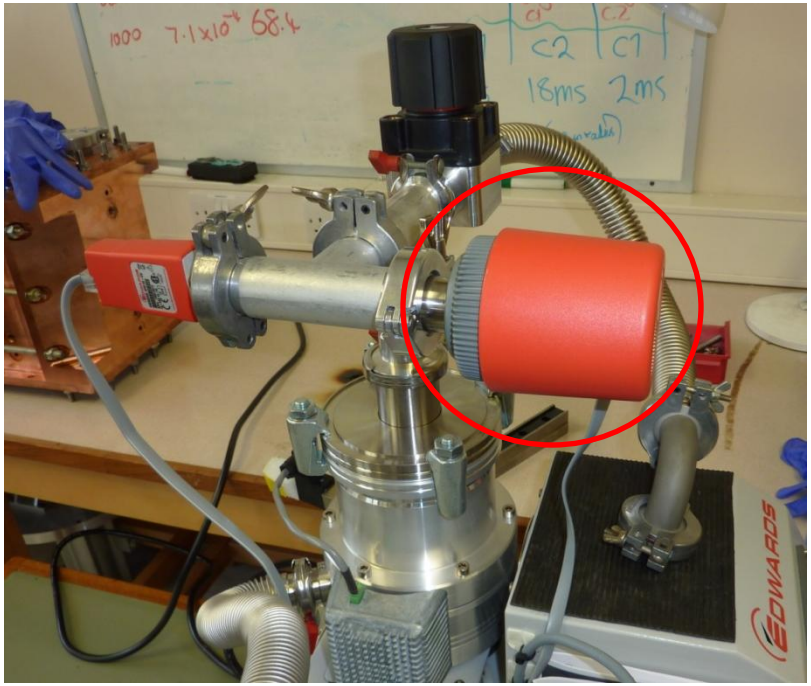
Plan to use Viton based adhesive that can withstand high temperatures.

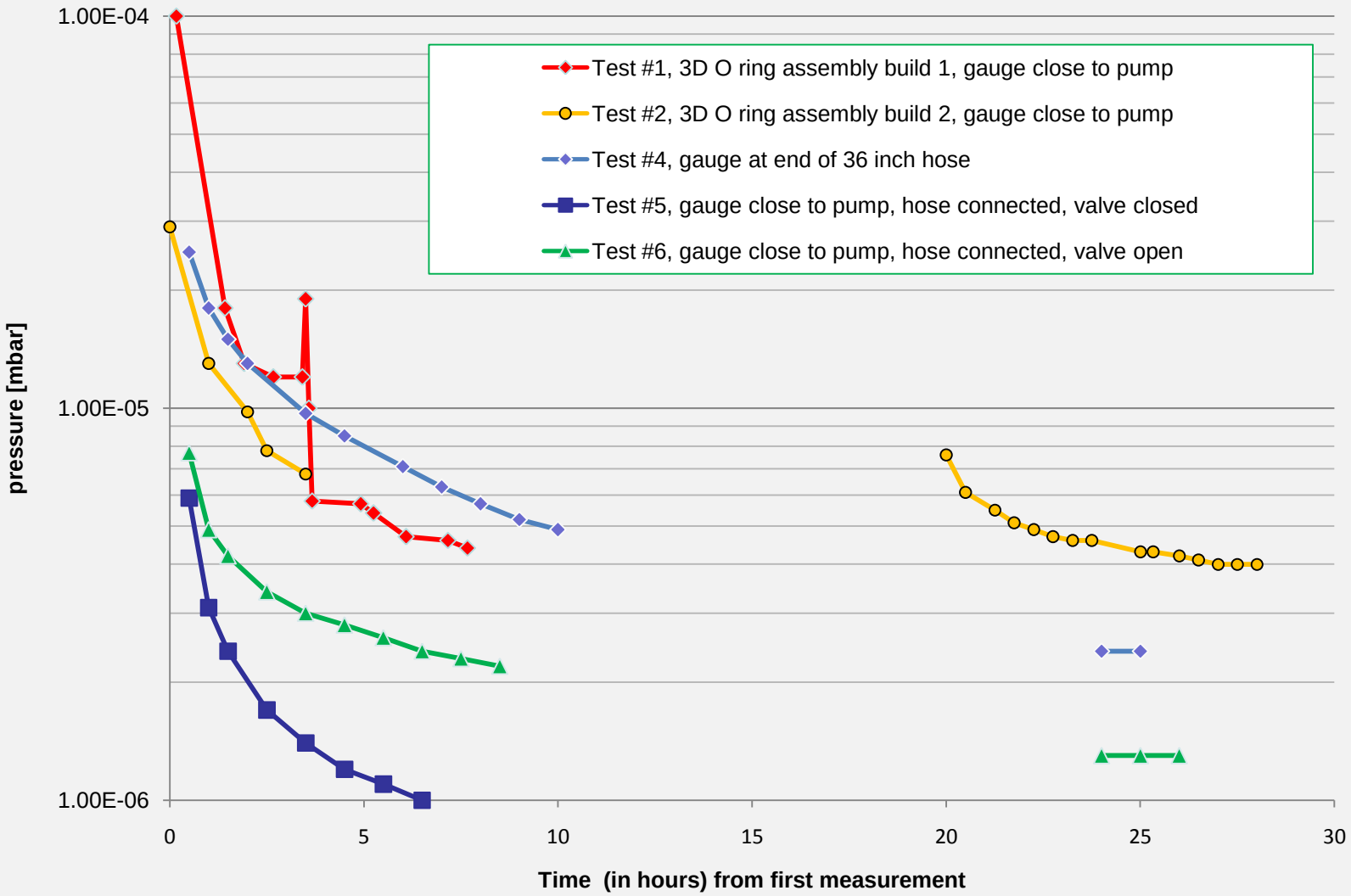
In the meantime plan to measure the performance of the vacuum pumping station alone to allow comparison to performance of the RFQ model.

Measuring the performance of the pumping station alone.

- **Test #4** - Vacuum gauge connected directly to end of vacuum hose.
- **Test #5** – Vacuum gauge close to pump.
- **Test # 6** - Vacuum gauge close to pump, hose connected, valve open






1.00E-04
1.00E-05
1.00E-06
pressure [mbar]
0
5
10
15
20
25
30
Time (in hours) from first measurement
Test #1, 3D O ring assembly build 1, gauge close to pump
Test #2, 3D O ring assembly build 2, gauge close to pump
Test #4, gauge at end of 36 inch hose
Test #5, gauge close to pump, hose connected, valve closed
Test #6, gauge close to pump, hose connected, valve open

Effective pumping speed

$1/S = 1/Sp + 1/C$

Where:

S = Effective pumping speed [litres/sec]
Sp = Speed of the pump [litres/sec]
C = Conductance [litres/sec]

$C = 78\ (D)^3/L$

Where:

D = I.D. of path in inches
L = length of path in inches

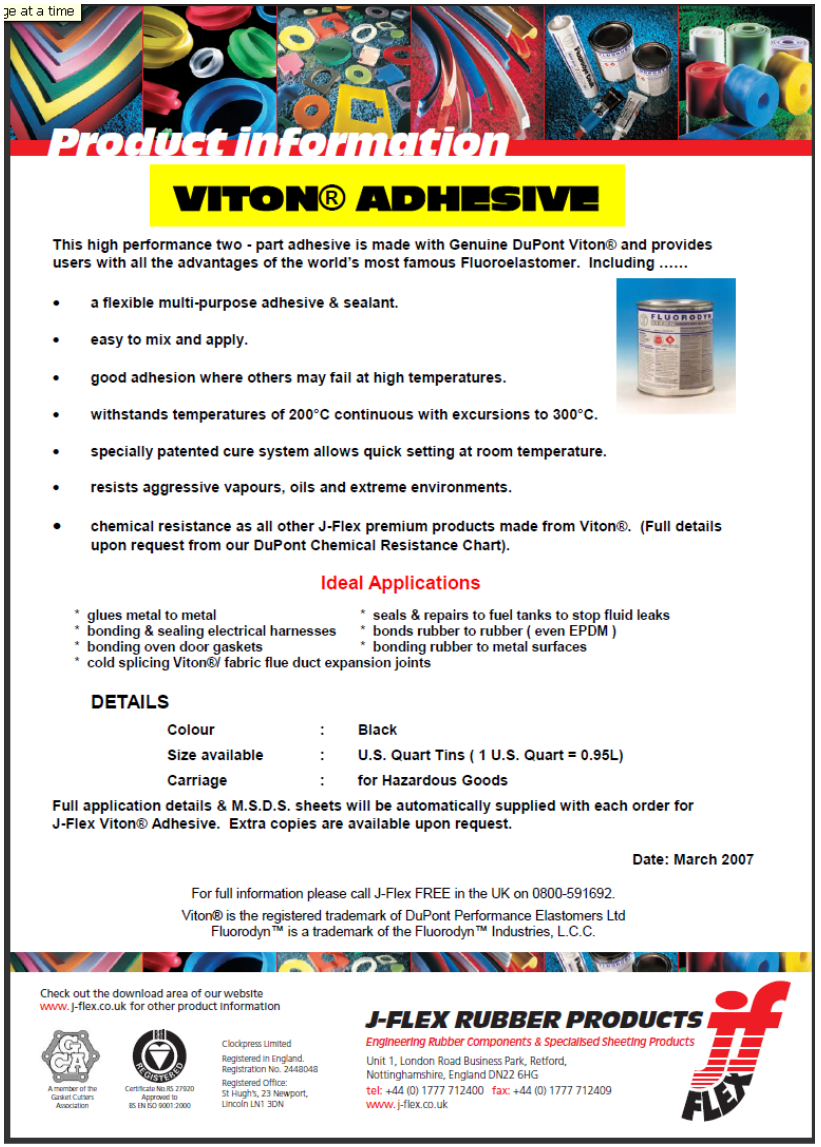
So for our setup with an I.D. of 1.5” and a length of 36”: **C = 7.3 litres/sec**

Giving an effective pumping speed (at end of hose) of: **S= 7 litres/sec**

Very poor!

Test # 7

- Viton bonded sealing ring
- Very difficult to use. Weak (easily peeled) bond, indefinite cure time at room temperature. Quick cure at stepped elevated temperatures but still weak)
- Conclusion – several weeks of experiments show it's not practical.



ge at a time

Product information

VITON® ADHESIVE

This high performance two - part adhesive is made with Genuine DuPont Viton® and provides users with all the advantages of the world's most famous Fluoroelastomer. Including .....

- a flexible multi-purpose adhesive & sealant.
- easy to mix and apply.
- good adhesion where others may fail at high temperatures.
- withstands temperatures of 200°C continuous with excursions to 300°C.
- specially patented cure system allows quick setting at room temperature.
- resists aggressive vapours, oils and extreme environments.
- chemical resistance as all other J-Flex premium products made from Viton®. (Full details upon request from our DuPont Chemical Resistance Chart).

Ideal Applications

* glues metal to metal
* bonding & sealing electrical harnesses
* bonding oven door gaskets
* cold splicing Viton®/ fabric flue duct expansion joints
* seals & repairs to fuel tanks to stop fluid leaks
* bonds rubber to rubber (even EPDM)
* bonding rubber to metal surfaces

DETAILS

Colour	:	Black
Size available	:	U.S. Quart Tins (1 U.S. Quart = 0.95L)
Carriage	:	for Hazardous Goods

Full application details & M.S.D.S. sheets will be automatically supplied with each order for J-Flex Viton® Adhesive. Extra copies are available upon request.

Date: March 2007

For full information please call J-Flex FREE in the UK on 0800-591692.

Viton® is the registered trademark of DuPont Performance Elastomers Ltd
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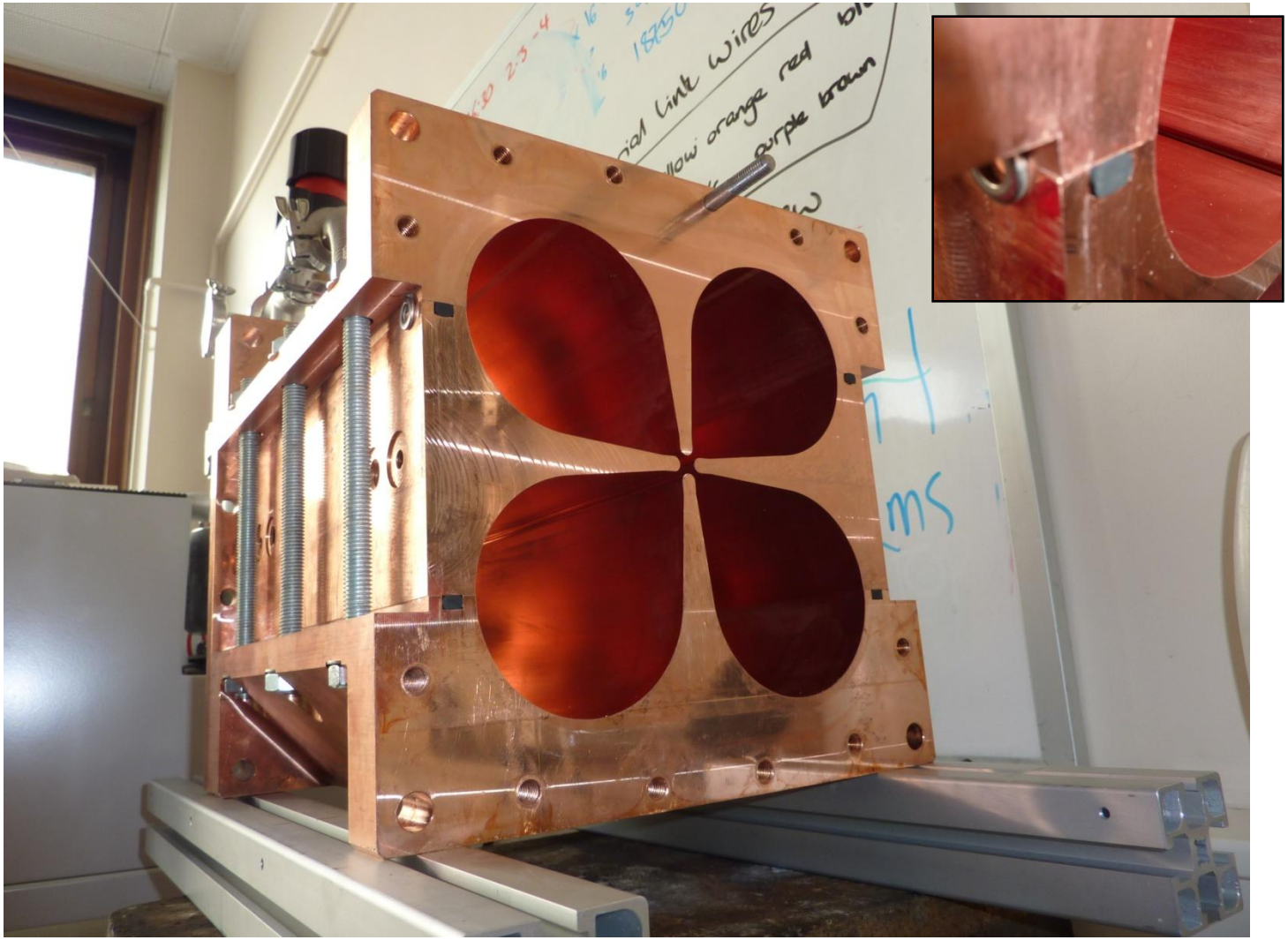
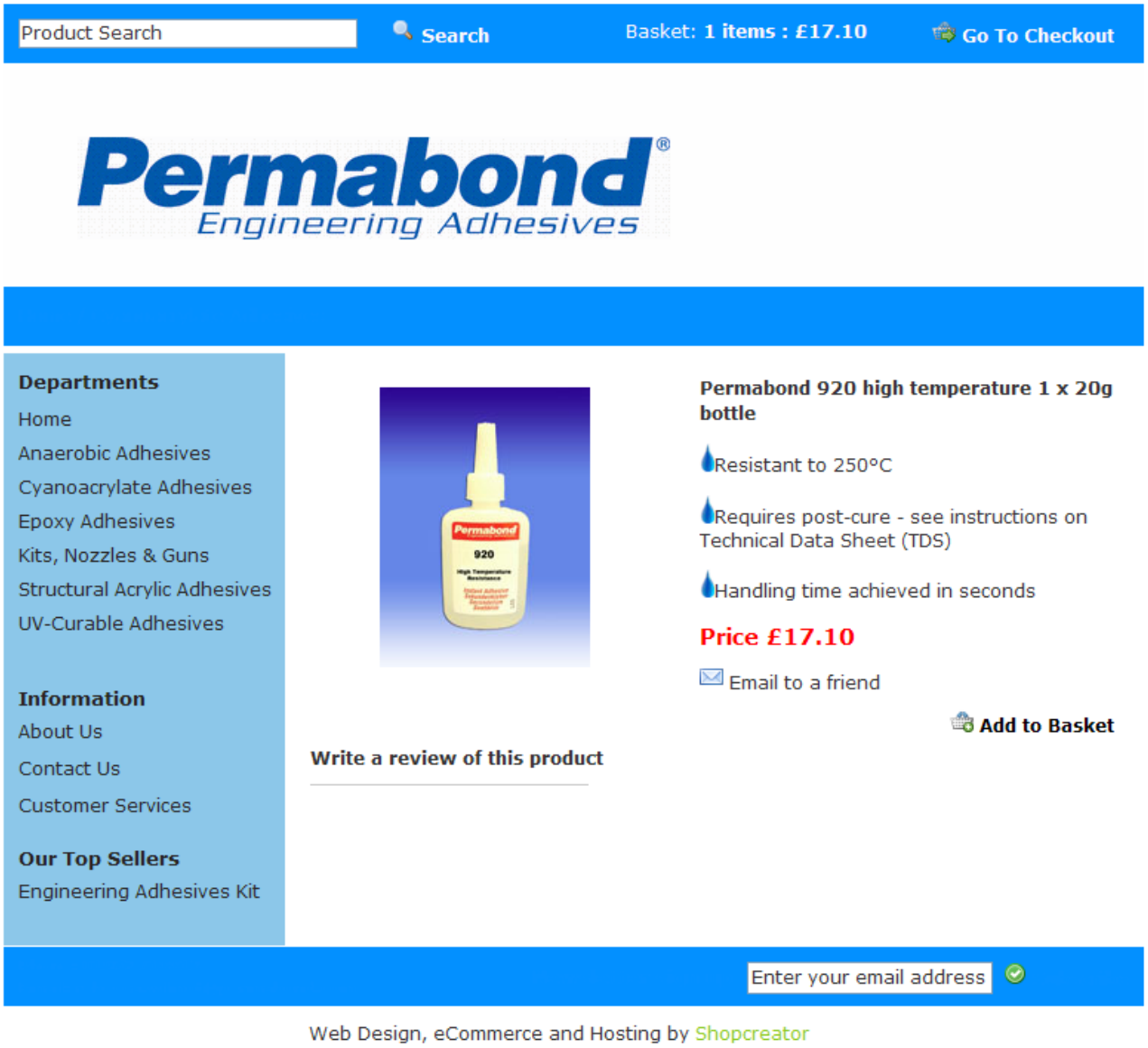
Removing the end flange revealed the failed bond





Test # 8

High temperature cyanoacrylate – Permabond 920

Nearly instant (initial) cure.

Inexpensive.

On order.

Conclusions

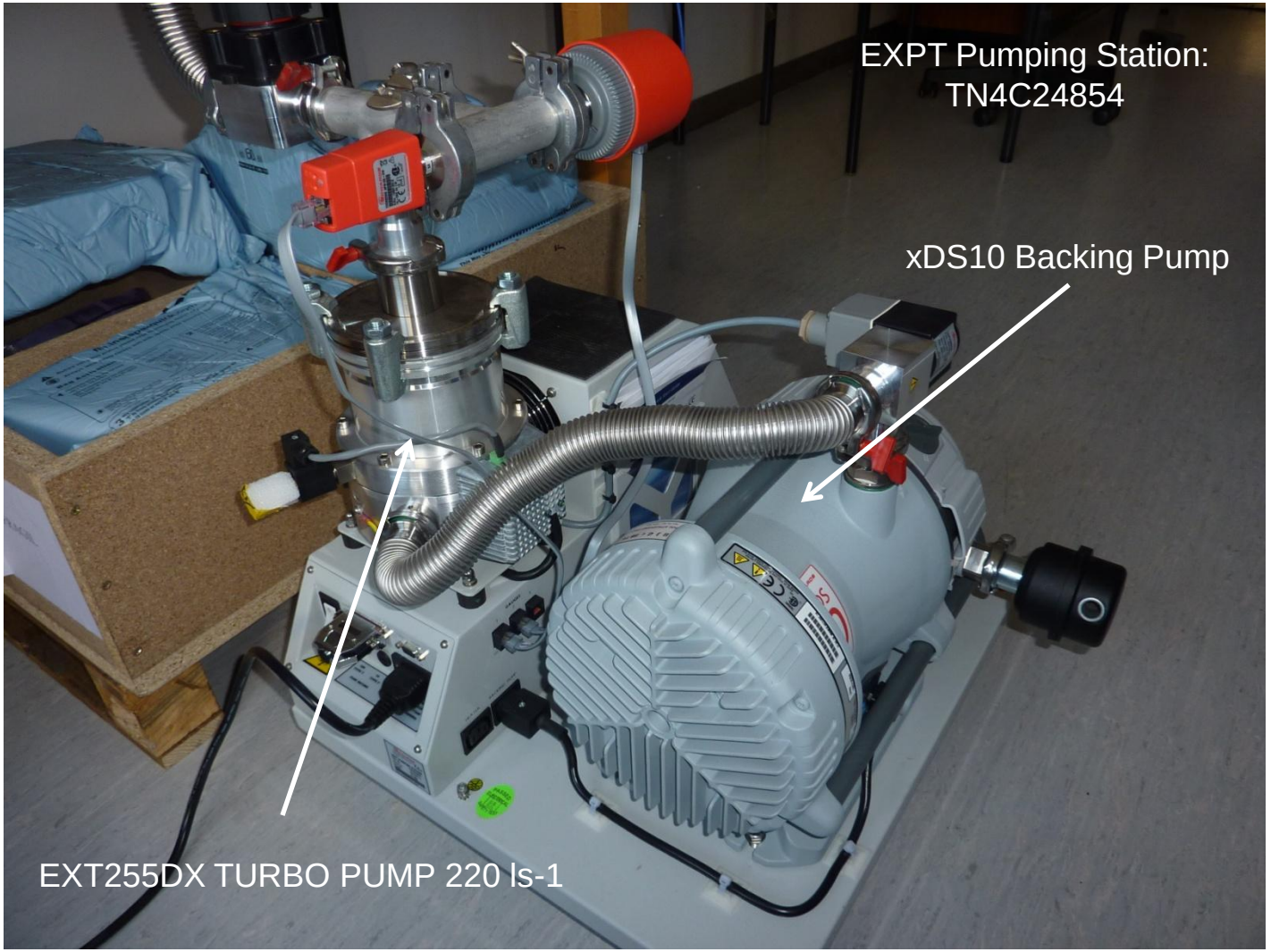
Principle of 3D O ring is good. Have seen pressures in the high 10^{-6}s but would like to see low 10^{-6}s.

Need to find adhesive that is practical and can withstand temperatures that may be used for bake-out. Hoped that Permabond 920 is the answer.

If all else fails will have to consider vulcanising. Have not tried because jig is approx. £1000

Appendix

Pumping station (borrowed from RAL)



Pumping station gauges

Gauge 1
Model: APG 100-XM
(**A**ctive **P**irani **G**auge)
Range: 1 x 10^{-3} to 1000 mbar
Operating temp: 5 – 60^{0}C

Gauge 2
Model: AIM-X-NW25
(**A**ctive **I**nverted **M**agnetron Gauge)
Range: 1 x 10^{-9} to 1 x 10^{-2} mbar
Operating temp: 5 – 60^{0}C

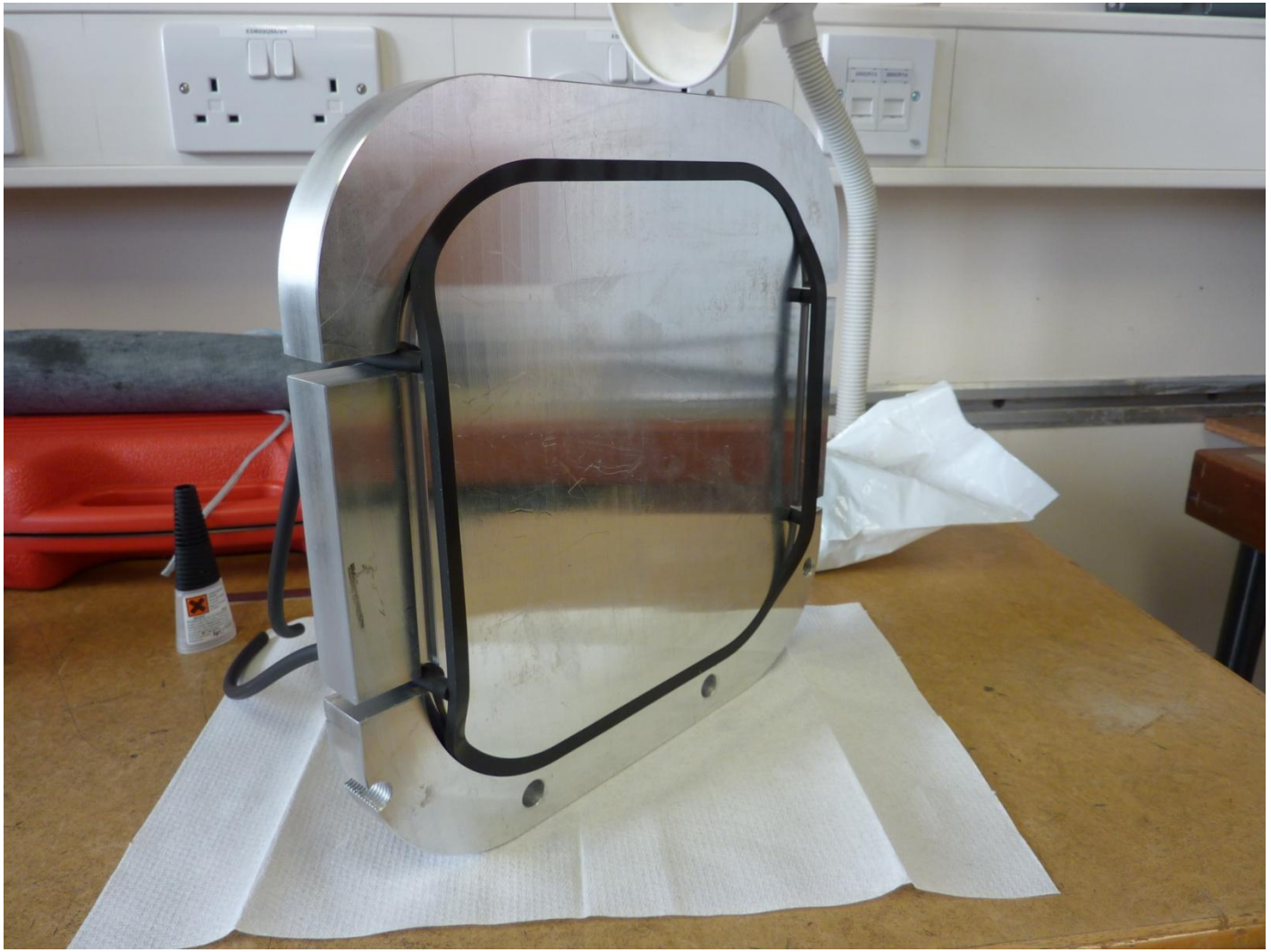
How is the 3D ‘O’ ring made?

I keep calling it an ‘O’ ring but of course the end (transverse) rings are rectangular

3D seal bonding jig

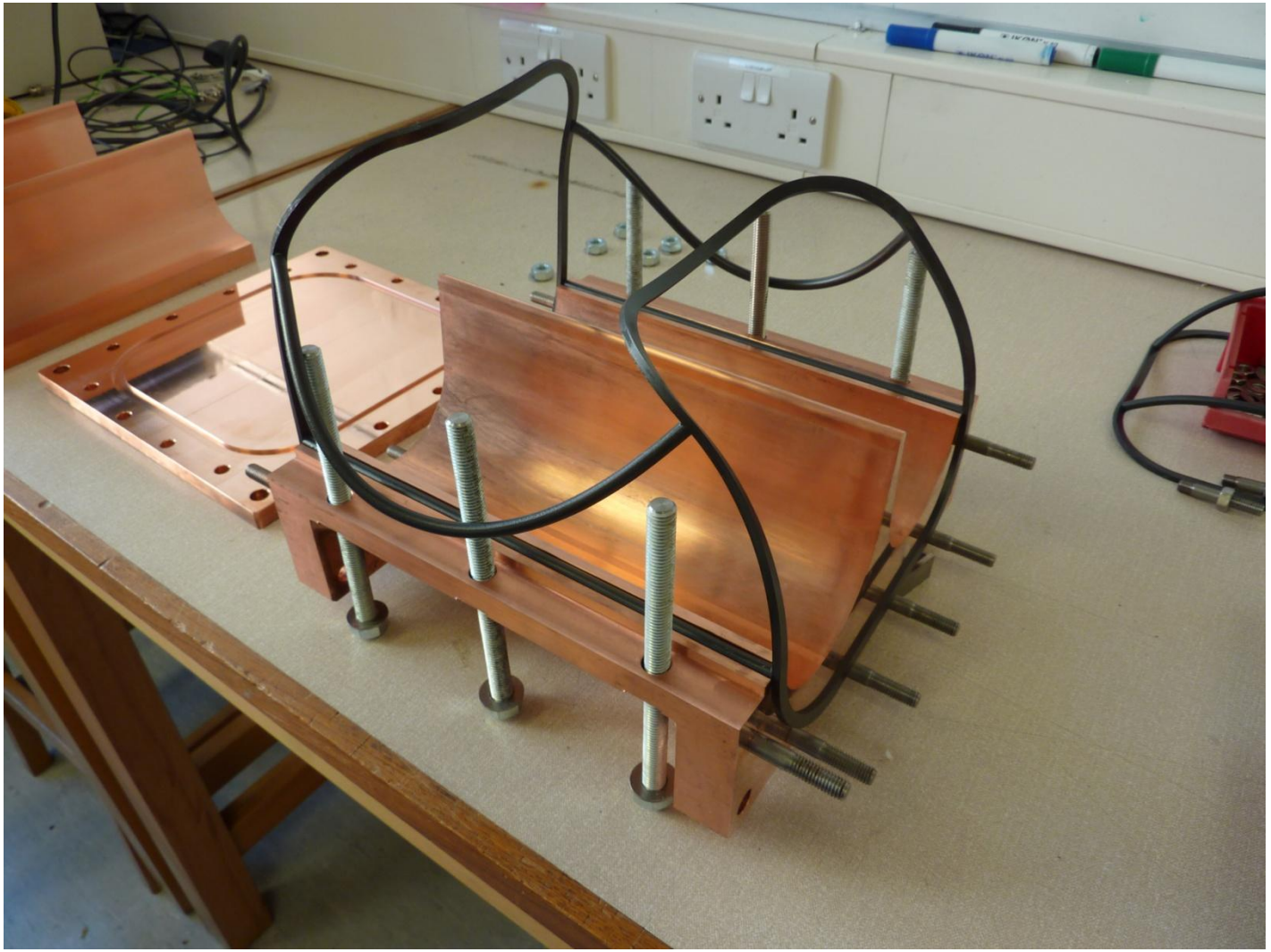
4 lengths of O ring bonded to 1 flat end ring

Pushing bonded seal out of jig

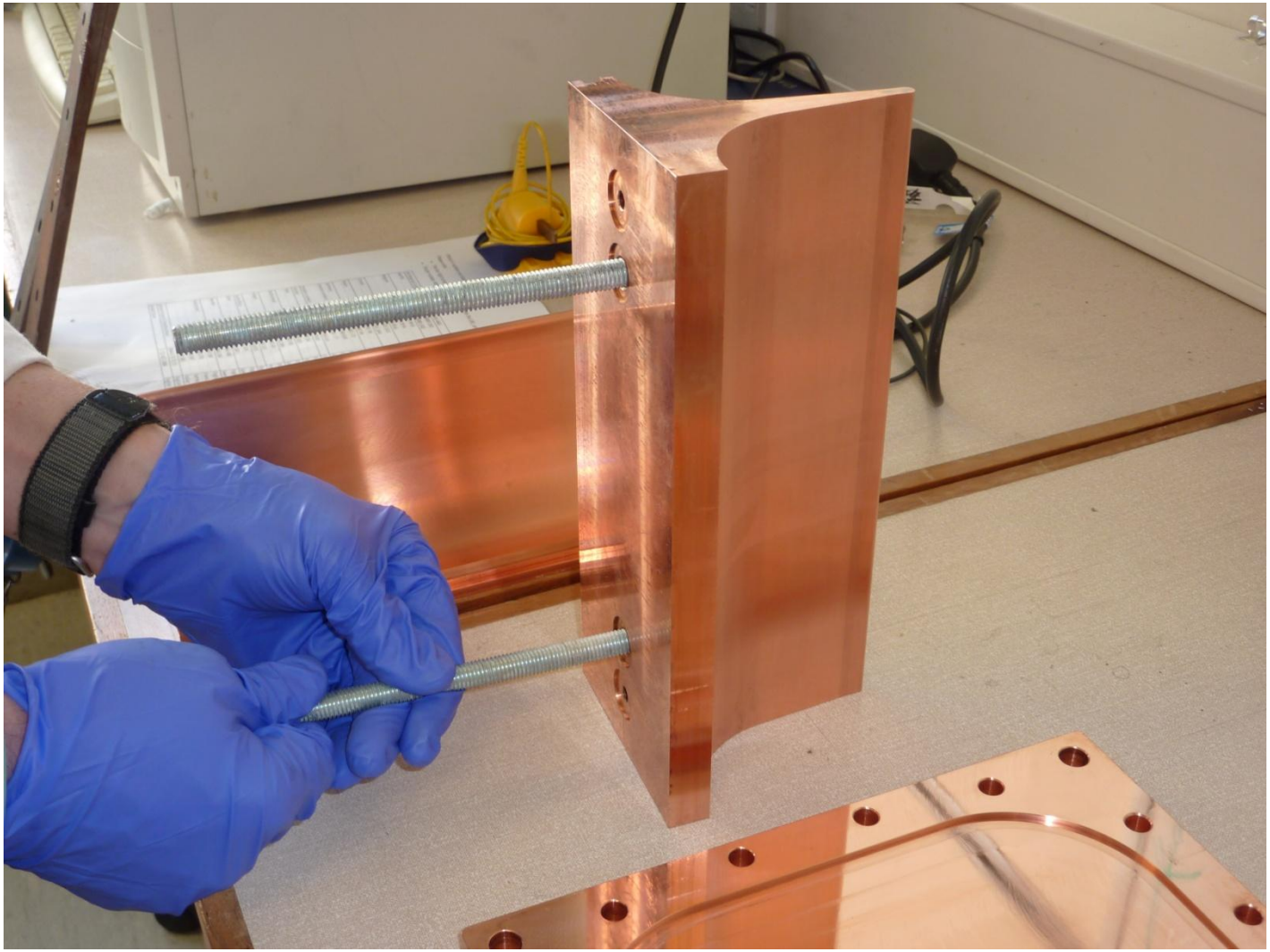


Bonding the other end....

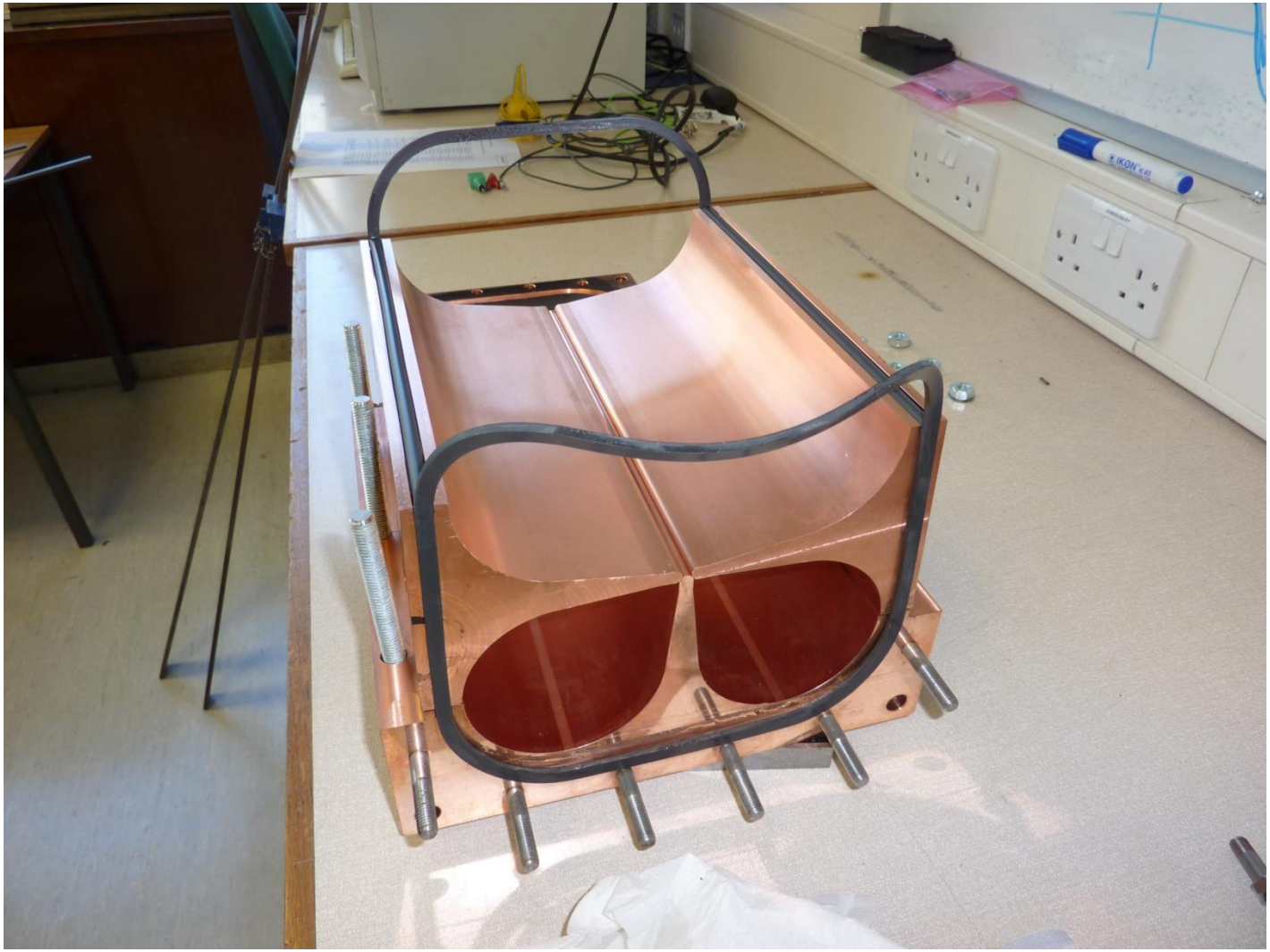
Laying seal into grooves of major vane



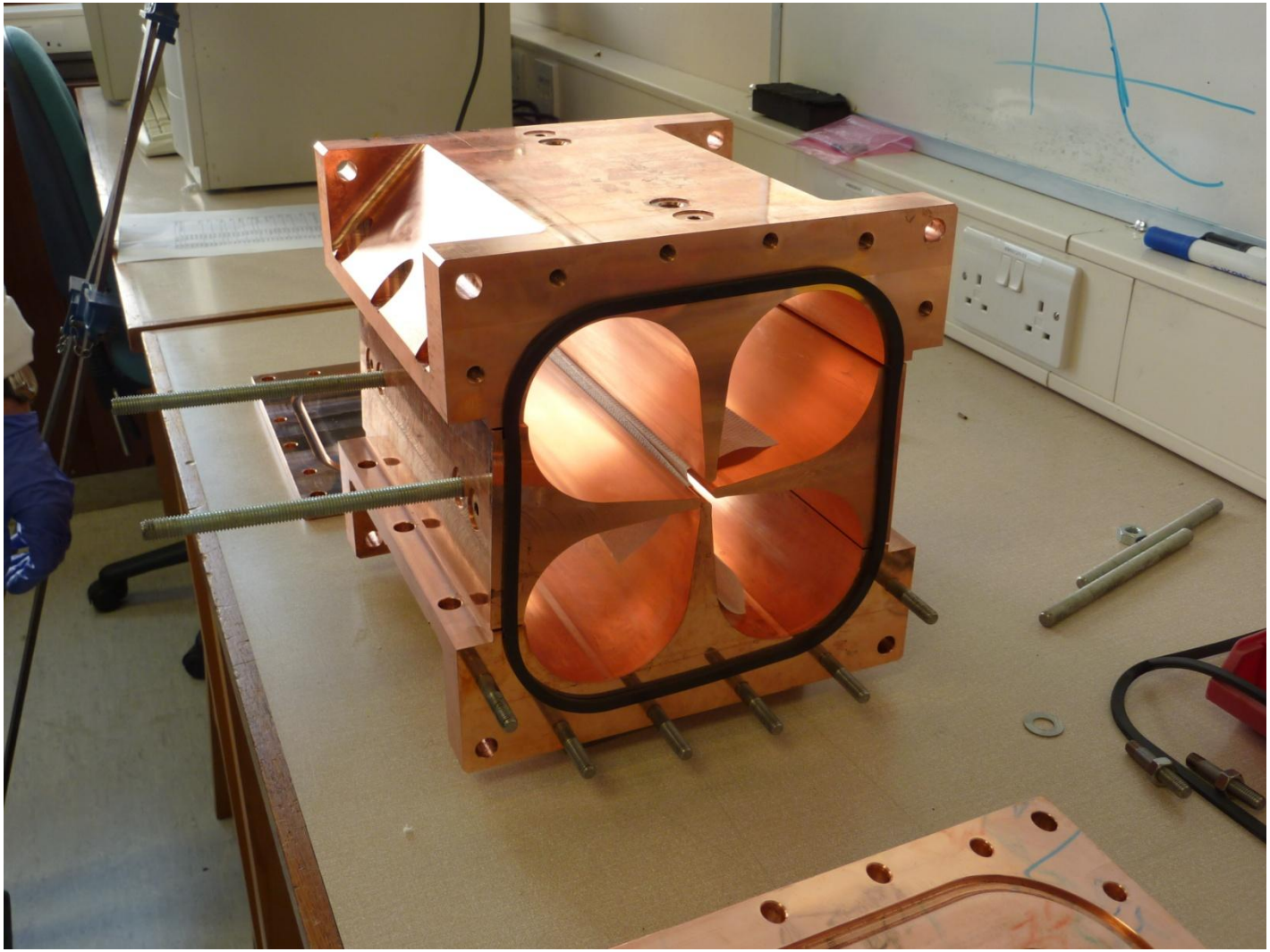
Minor vane being readied for lifting



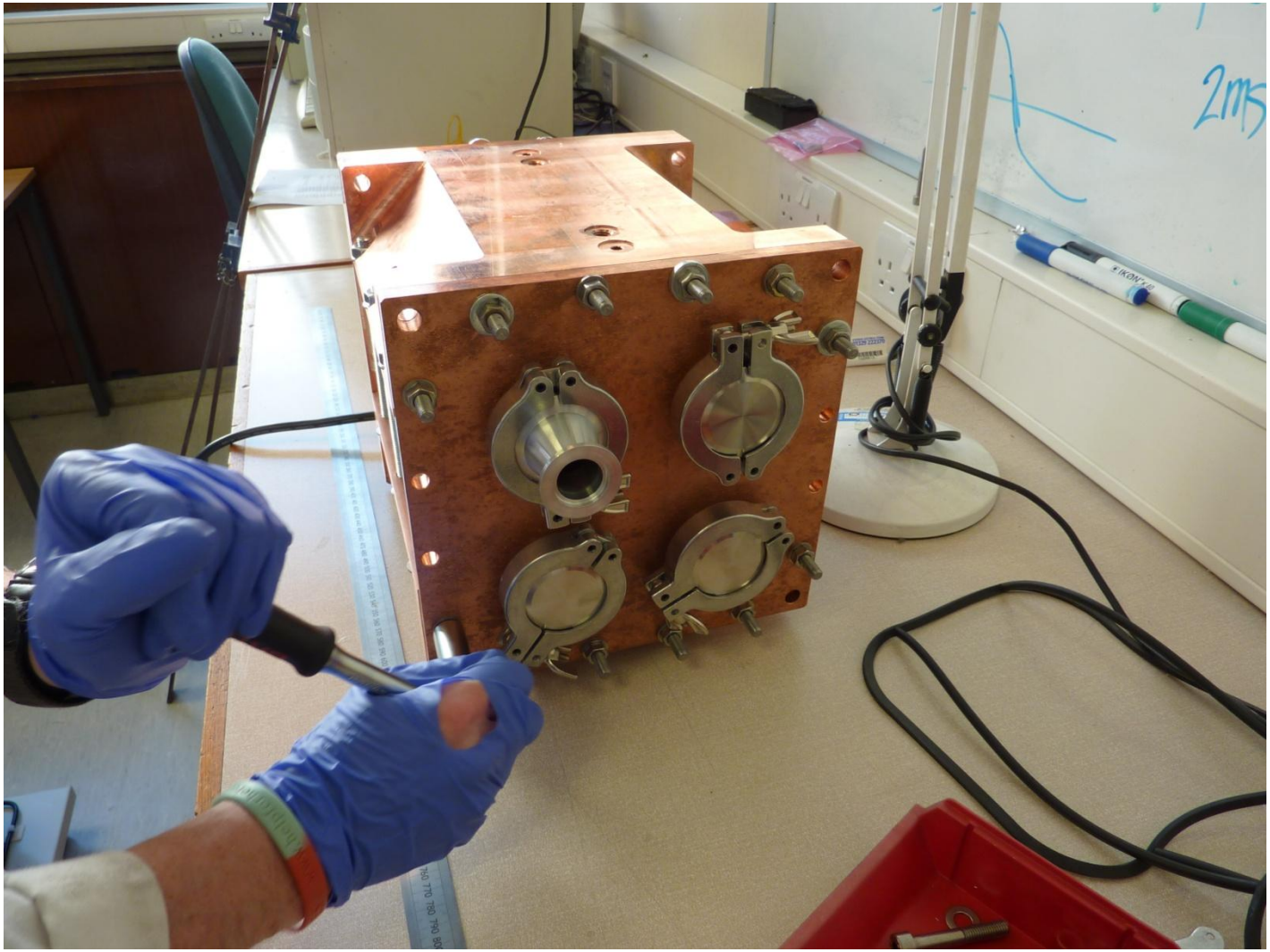
Minor vanes resting in position



Four vanes resting in position



Bolts being tightened



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Permabond 920 high temperature 1 x 20g bottle

- Resistant to 250°C
- Requires post-cure - see instructions on Technical Data Sheet (TDS)
- Handling time achieved in seconds

Price £17.10

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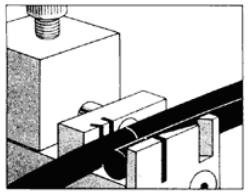
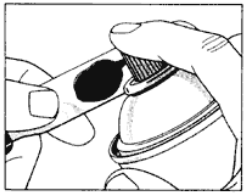
Why are we not vulcanising?

YOU CAN MAKE AN O-RING!

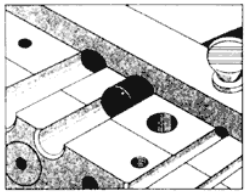
Four easy steps to fabricate an O-Ring to the exact size you need



Measure length of cord and mark with marking instrument supplied, leaving 1/2" excess at end of cord. Place ends in cutting guide.



Cut cord and apply bonding liquid: Insert clean razor blade supplied into cutting guide slot and apply firm pressure downward. Remove cord, keeping cut surfaces clean. Spray small amount of bonding liquid onto spatula provided, dip ends into liquid and allow to dry (until dull).



Set cord into mold: Insert first end of cord half way into mold and lock with screw clamp. Pull to test if cord is firmly locked. Place other end of cord into mold and apply light pressure, forcing both ends together. Lock with screw clamp, being sure to align ends accurately

Vulcanize and cool: After placing top of mold in position, slide mold onto heating element. Set heater to high and leave die on for 12 minutes, then set to low for 5 minutes. Turn off heater and quench die in cooling pan. When cool, remove locks and mold top. Pull out new O-Ring and resume production.

http://www.epm.com/vulcan_oringkit.htm

Model 01104
Vulcanizing Liquid

.... Because a heated mould is required which requires time and money