COUPLED RING COOLING LOOP DESIGN AND PROTOTYPING FOR THE ATLAS PIXEL INNER SYSTEM

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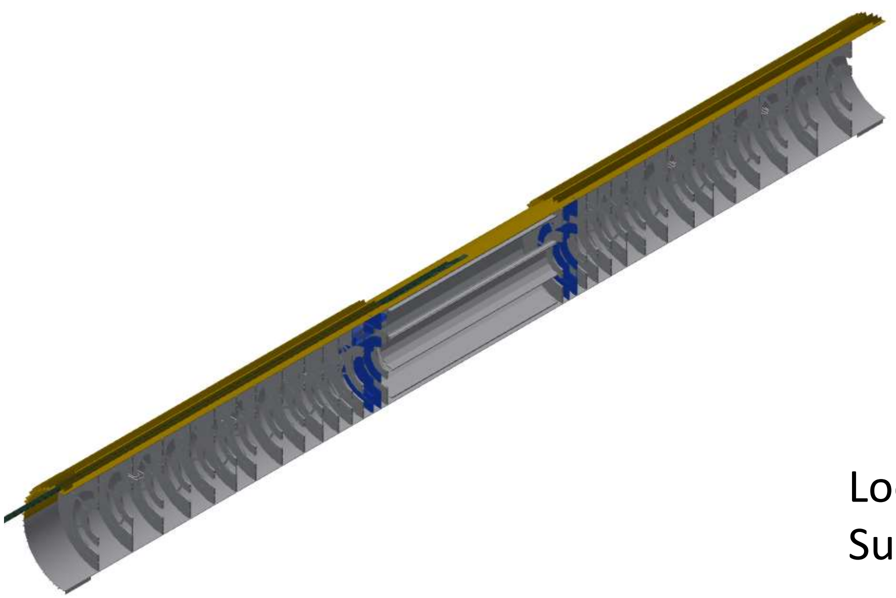
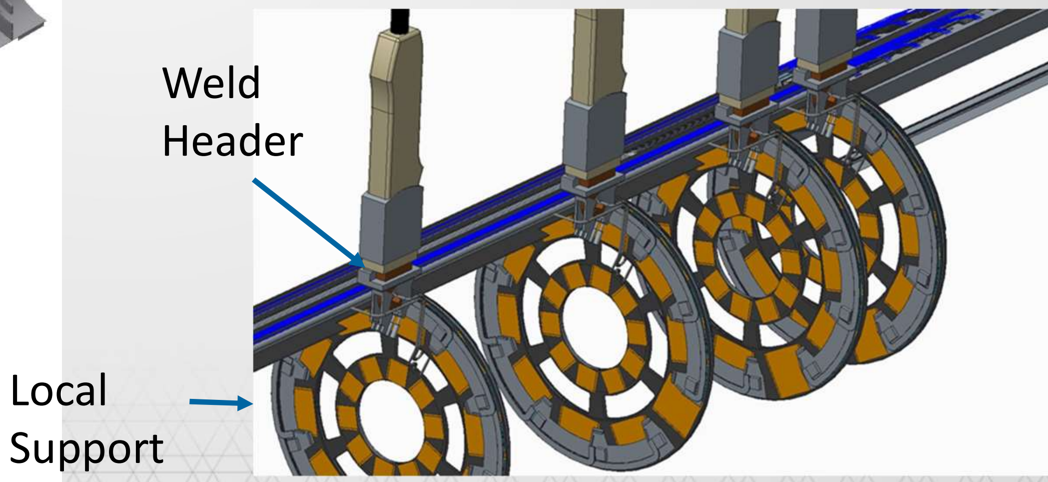
OUTLINE

- Background
- Coupled ring cooling loop
- Thin titanium tube socket welding
- Summary

BACKGROUND

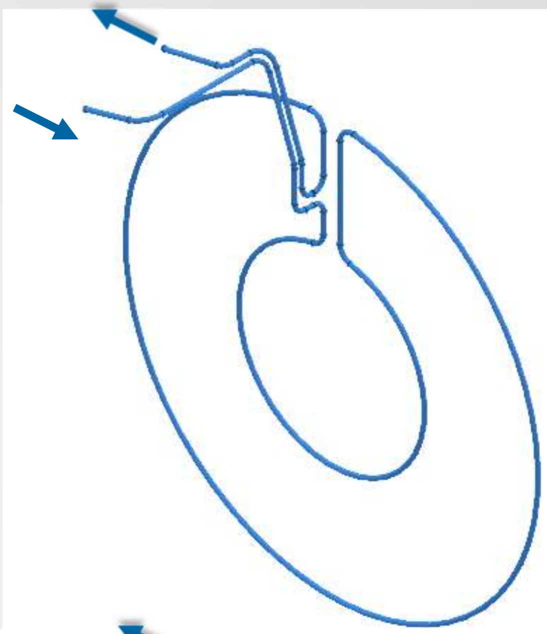
- Argonne is responsible for the evaporators and manifolds for the inner system
- As part of these, we are responsible for the connections of the tubes and electrical breaks
- Total 32 tubes and 128 welds

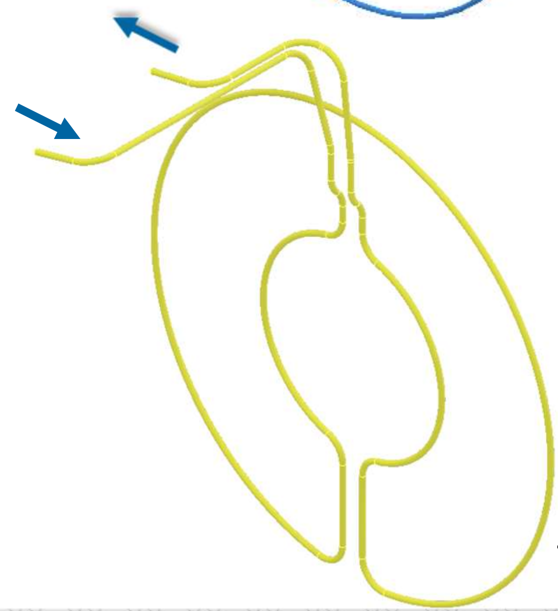




COUPLED RING COOLING LOOP DESIGN

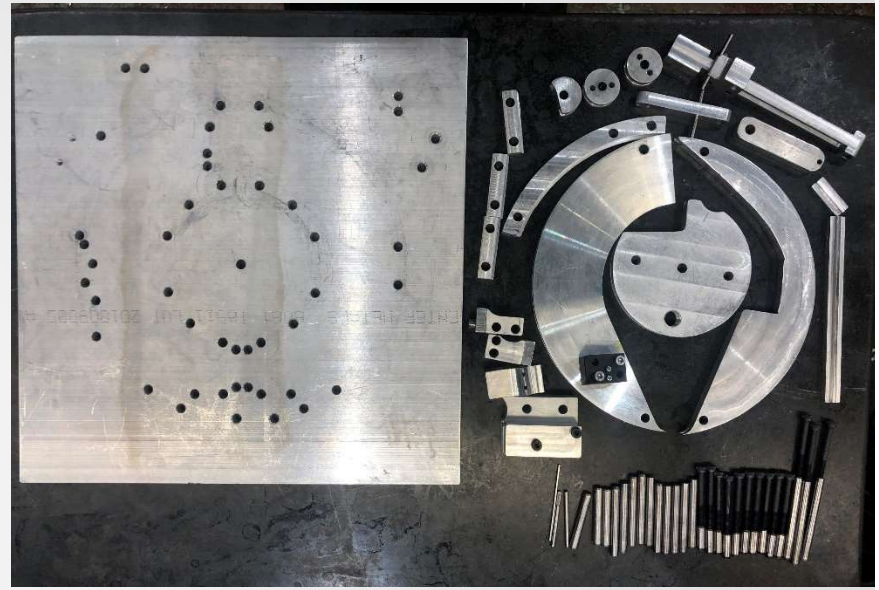
- Design constraints:
  - Maintain minimum bending radius of 10mm for 2.5mm OD thin wall titanium tube
  - Max Z space available in the tightest position is around 19mm
- Initial design (in blue) uses a u bend
  - Violates the design constraint
- Current design (in yellow) use 2 45 degree bends





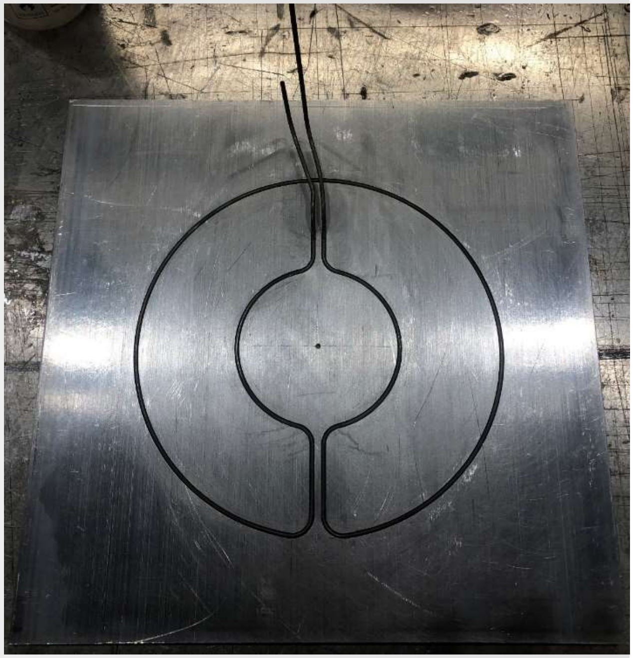
COUPLED RING COOLING LOOP BENDING

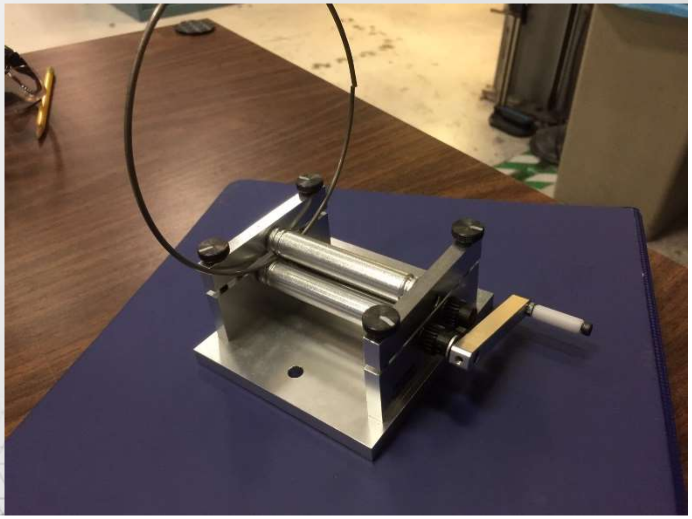
- Designed manual bending fixture
  - Maintain the proper length of the tube after each bending
  - Over bend the tube for the straight section to compensate the spring back effect
  - For inner and out ring radius, it took many iterations to find out the right over bend radius



FITTING INTO GROVE

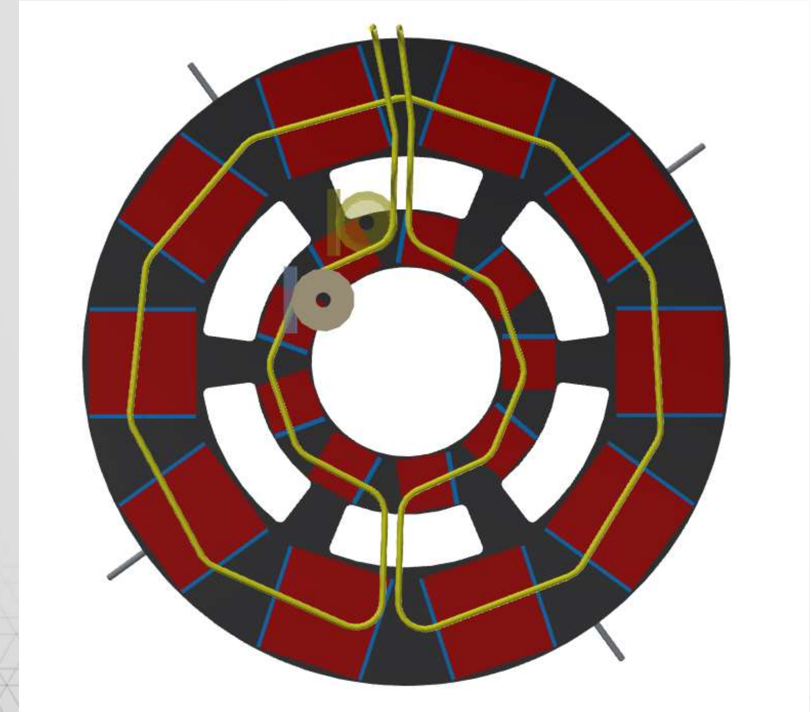
- Responsibility
  - ANL bend the tube
  - LBL machined the foam and fit the tube
- Challenge
  - The tolerance of the machined groove easy to achieve +/-0.15mm
  - Tolerance of manual bending hard to achieve even +/-0.25 mm
  - This will create tight spot at some corners
  - The composite foam is rigid, fragile, and easy to break with little force. Foam is the part of structure support for the local support
- Solution
  - Make a Al witness plate to ensure all the geometry is correct. (also as shipping fixture)
  - Over machine the groove +0.15 mm





TUBE BENDING FUTURE WORK

- Design a segmented ring for easy fabrication
  - Thermal performance?
- Use CNC wire bender



PENSA LABS

WELD MOTIVATION

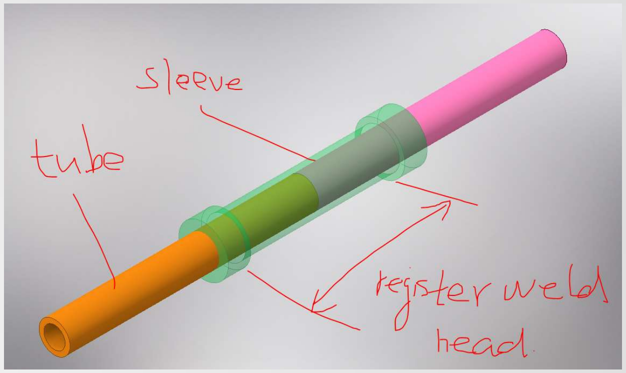
- Require completely leak free system
  - All connections by welding
- Weld titanium tubes with OD 2.5mm/ID 2.2mm using commercial available welding system
- Swagelok orbital welding system is inexpensive and capable to weld tube down to 3mm tubes of varieties of materials, but it is hard to reliably weld thin wall tube with thickness of 200 um or less.
- Two concepts tested
  - Sleeve weld
    - is not very successful since it required very high precision on alignment
  - Socket weld
    - Current focus

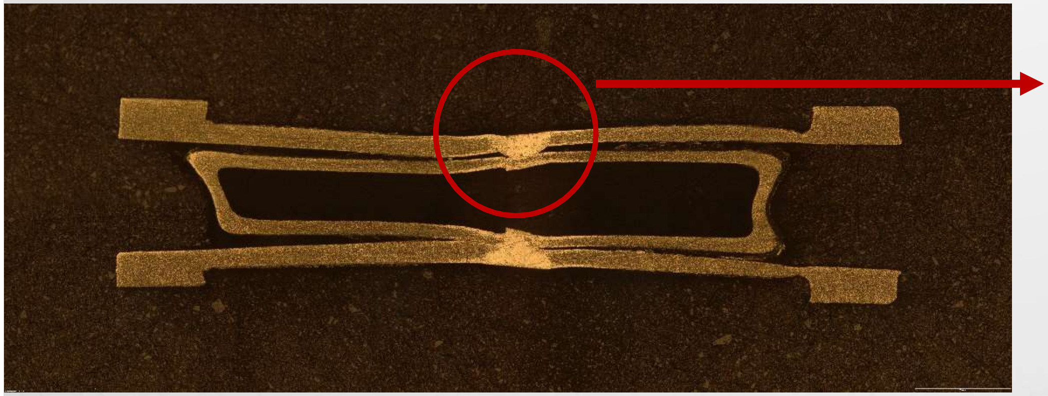
SLEEVE WELD STATUS

- Tubes meet at the center of sleeve
- Steps on sleeve match weld head

- Machine sleeve out of titanium rod
- ID of sleeve is about 25 um bigger than OD of tube to enable tight fit
- Properly cleaned before welding

- Hard to align properly every time, repeatability is problem



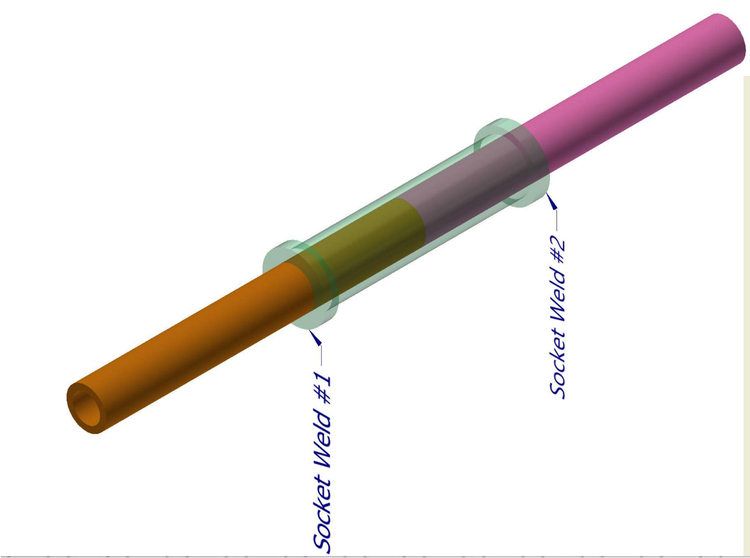


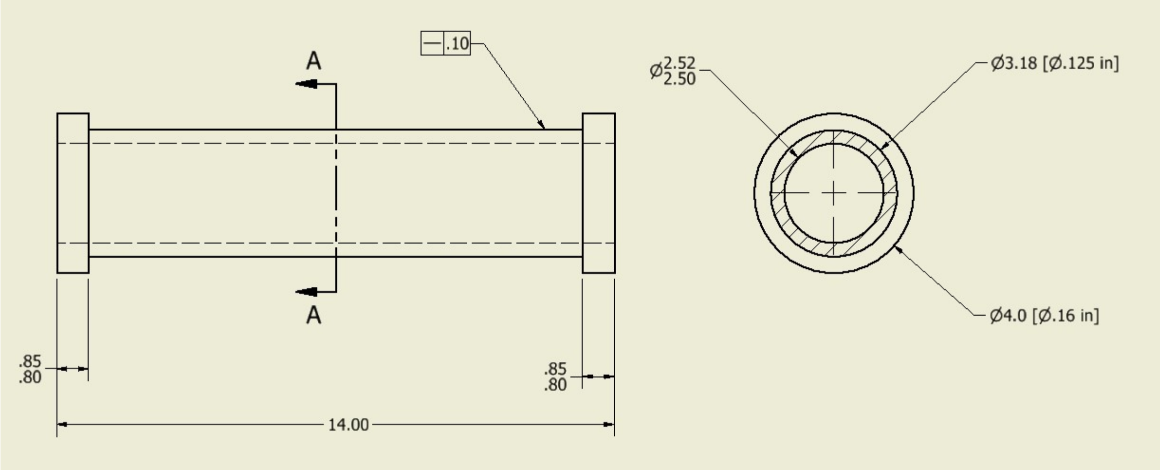
2mm

0.2mm

SOCKET WELD DESIGN

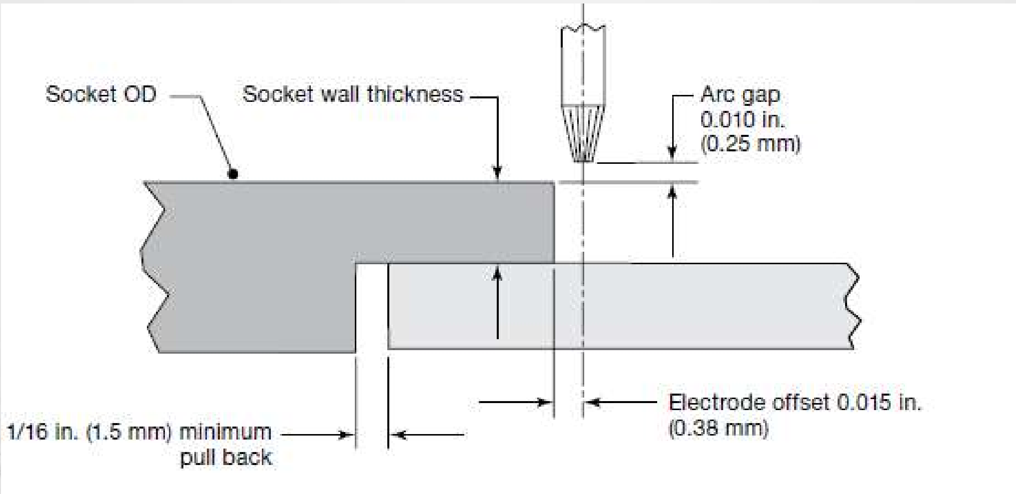
- Weld happens at two ends of the sleeve instead of middle
- Precision requirement is much lower compare to sleeve weld, including end preparation, alignment
- Diameter of Ends are 4mm, to form large melt pool since the minimal power of Swagelok weld power supply is relatively large





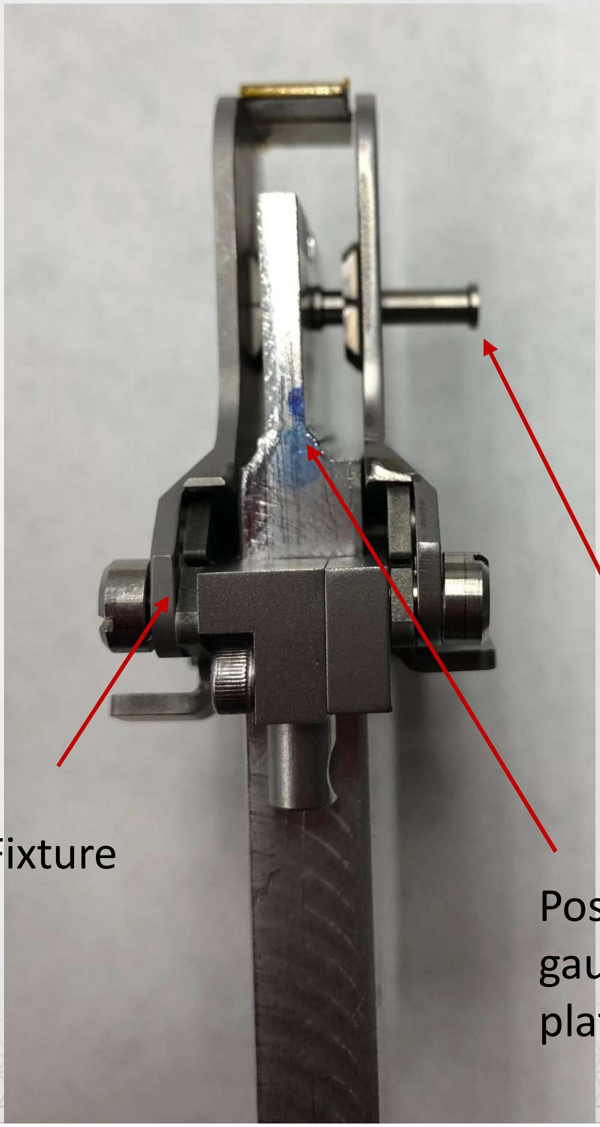
SOCKET WELD TECHNIQUE

- All socket welds use a single-pass technique
- The arc gap is 0.010 in. (0.25 mm) from the socket OD, and the offset is 0.015 in. (0.38 mm) from the socket face
- Start all socket welds between the 11 and 12 o'clock positions to assist the formation of a weld pool



SOCKET WELD FIXTURE

- Insert Position gauge plate into weld fixture
- Insert sleeve to butt the position gauge plate
- Clamp the sleeve into the weld fixture
- Remove position gauge plate
- Insert tube from left



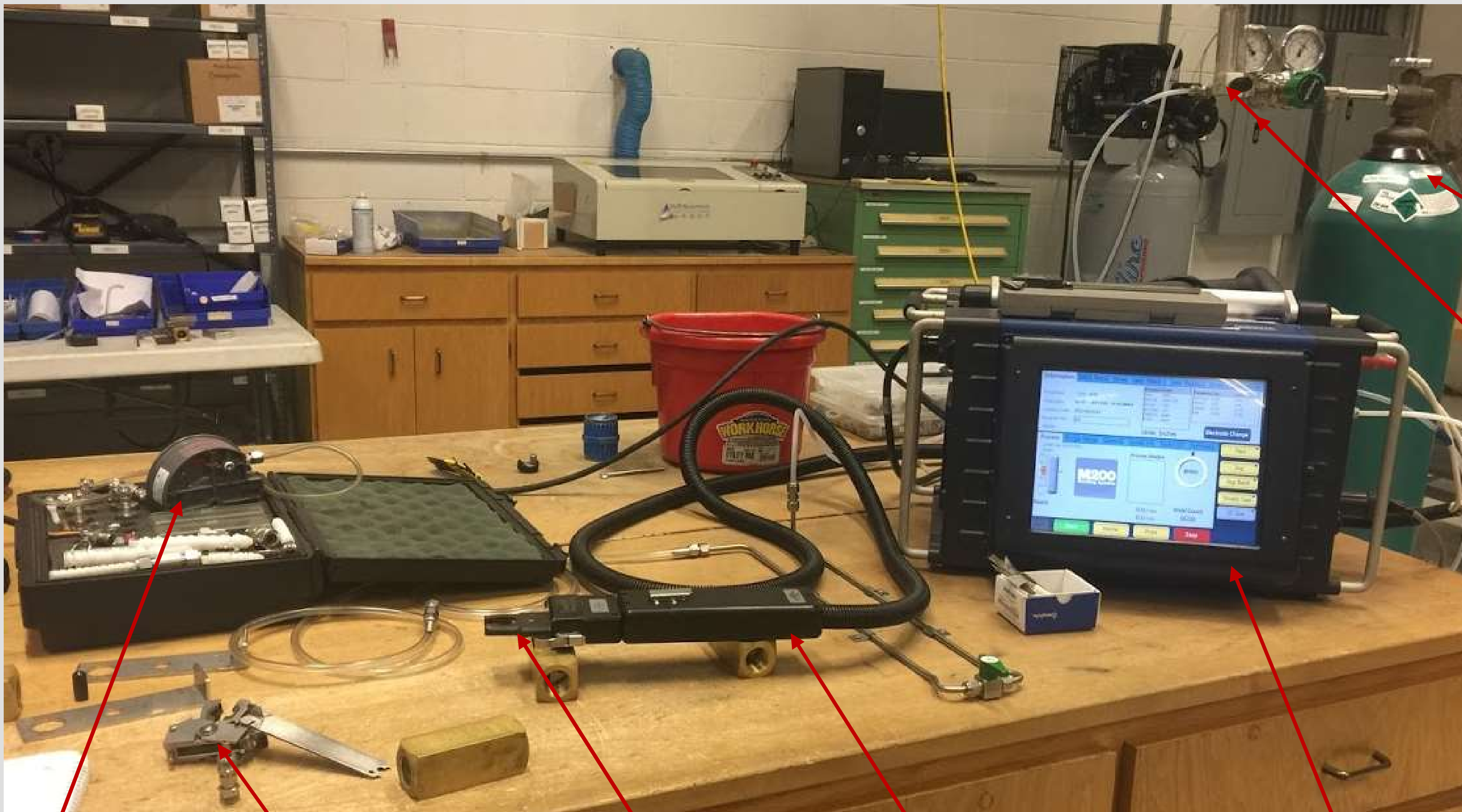
Sleeve

Weld Fixture

Position gauge plate

Tube 1

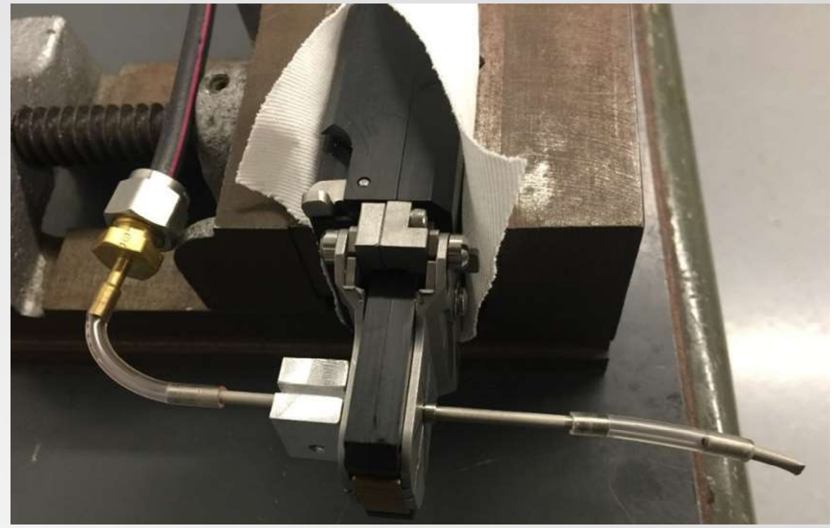
SWAGELOK ORBITAL WELDING SYSTEM SETUP

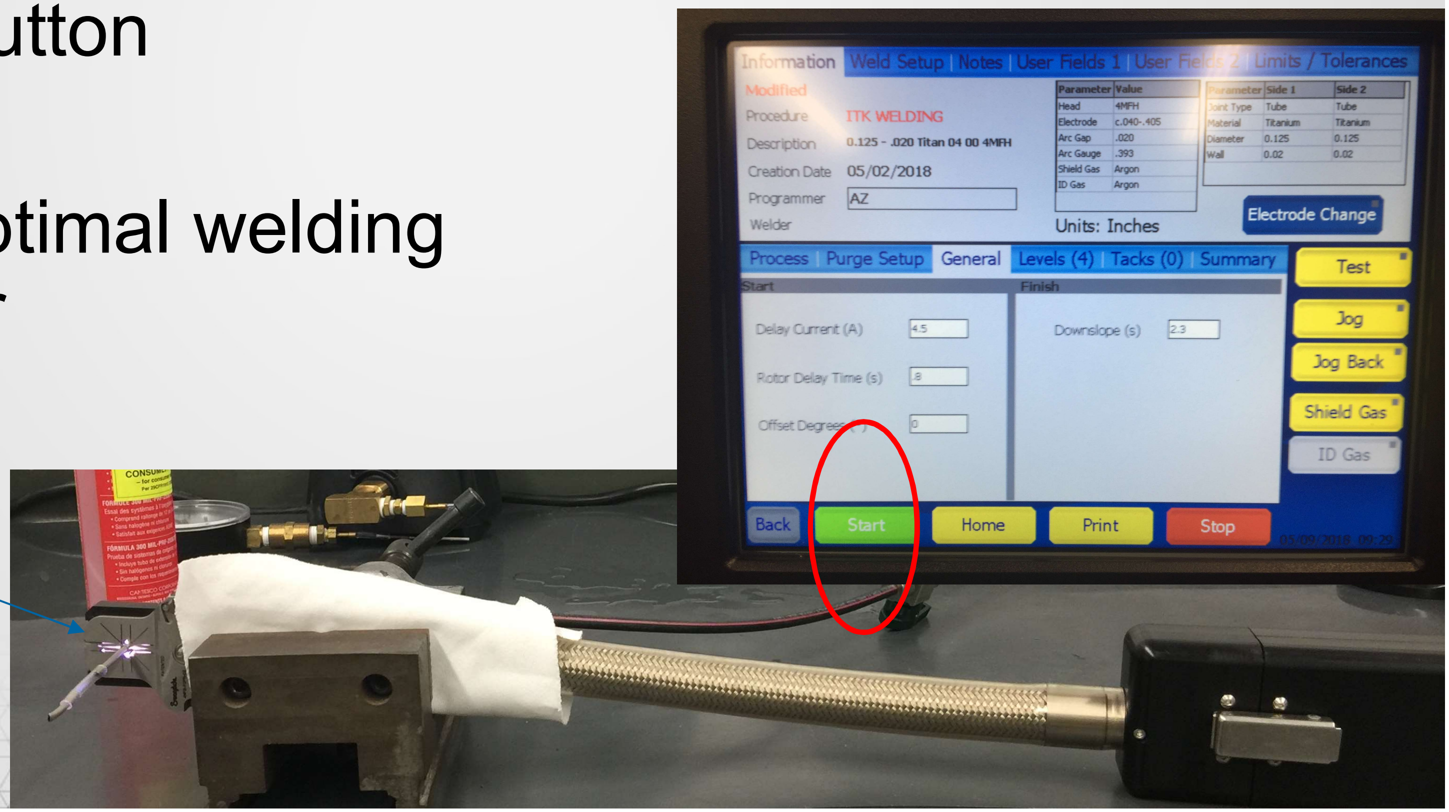


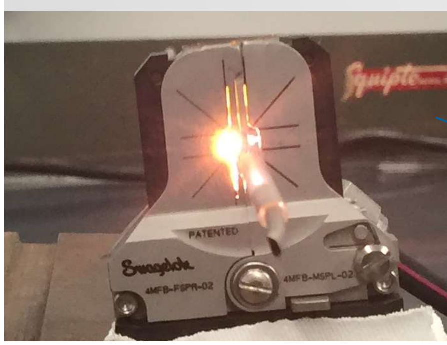
WELDING

- Connect tubes to purge gas
- Insert fixture to the flexible drive and the motor module
- Hit start button

- Finding optimal welding parameter

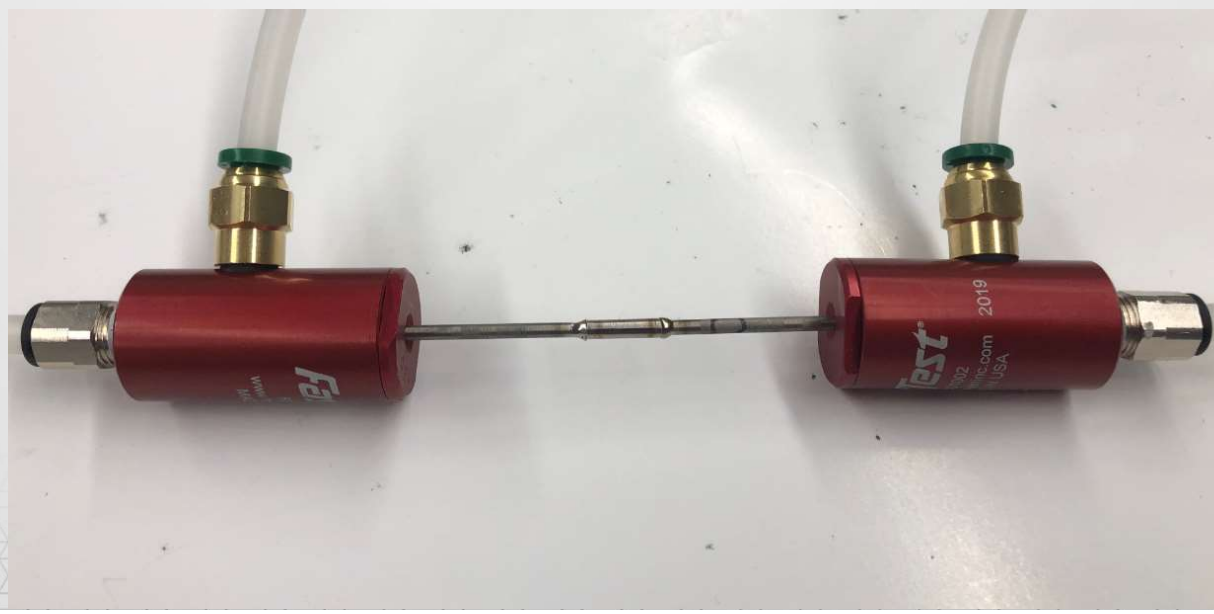






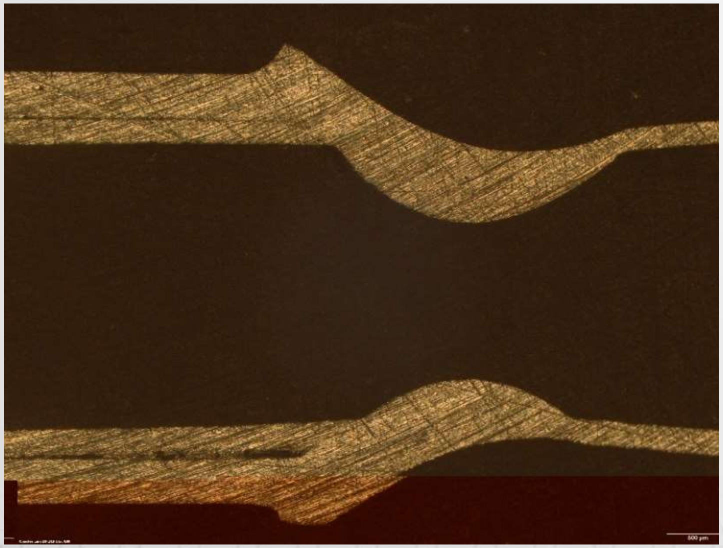
QUICK LEAK TEST

- Fasttest FE Series
  - Automated External Sealing from Vacuum to 500 psi (34 Bar)
  - Pneumatic Operation Seals Outside to Tubes and Threaded Pipes
  - Seals Over Tubes and Threaded Pipes Sizes 0.030" to 5.040" OD

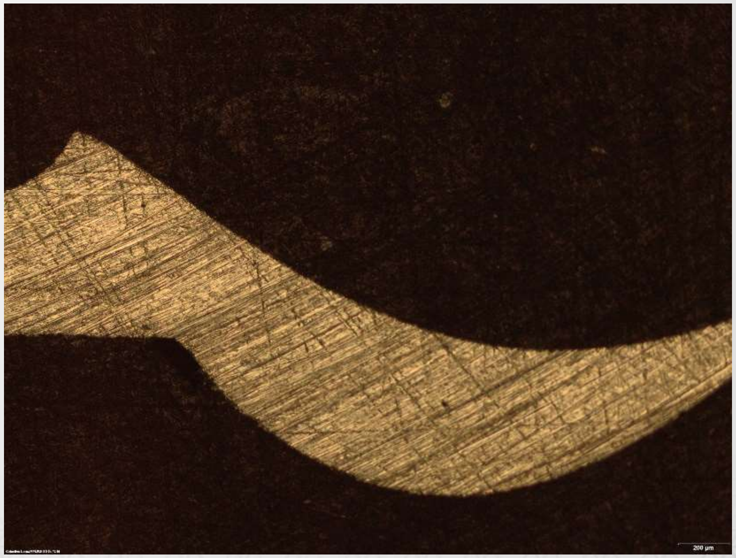


WELD INSPECTION

- Visual inspection
- Use gauge pins to measure the inner diameter of the weld - 1mm diameter reduction
- Micrography



0.5mm scale



0.2mm scale

WELD FUTURE WORK

- Optimize the welding parameters based on metallurgic test, especially the purge gas
- Estimate the reliability by doing ~100 welds
- Apply NASA qualification method and get qualification

SUMMARY

- Complex geometry of cooling loop can be precisely fabricated and fit into precision groove of the composite foam
- Socket weld of the thin tube using commercial available orbital welding system is feasibleS
  - Welding parameters have to be tuned to get good and repeatable weld

BACKUP

- Our equipment
  - Swagelok
    - M200 Weld power supply
    - The Series 4 micro flexible weld head and its Motor Module
    - Micro Weld Head Fixtures: SWS-4MFB-02
    - Purge gas kits
  - Fasttest FE Series