High Pressure, Small Diameter Hot Tap

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Motivation

- Los Alamos National Laboratory (LANL) works with complex and hazardous systems that need to be accessed while the system is live
- LANL needs to maintain the internal pressure of the system, prevent contamination of the system, and protect the users of the device
- Hot tapping is common at large diameters (like in oil pipelines), but is difficult at tiny diameters

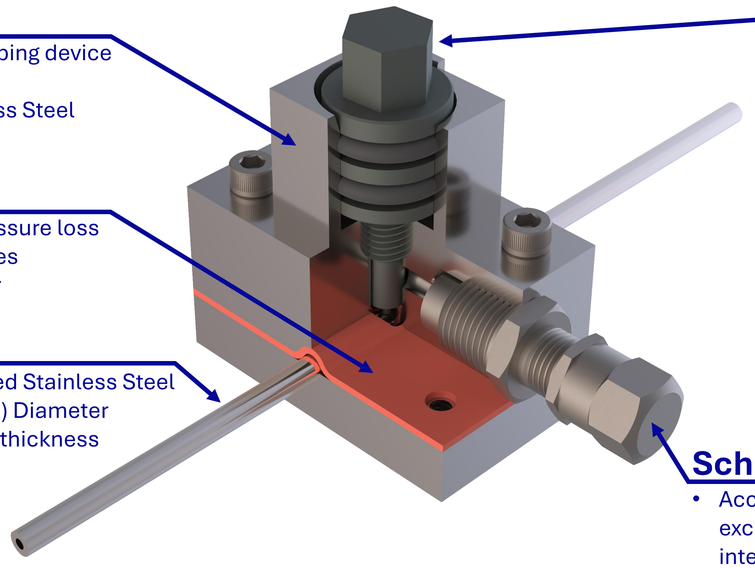
Specifications

Hot Tap

- ✓ System shall retain 95% of initial pressure over 10 minutes
- ✓ System should provide a valved means of accessing the internal environment
- ✓ Tubing should retain structural integrity during and after the cut

Testing

- ✓ Pressurize tube to a target pressure of 80 psig
- ✓ Post tapping, pressure gauges must experience the same pressure drop within 10 psig to detect blockages
- ✓ Access window no larger than 14”x 8” to simulate field of application

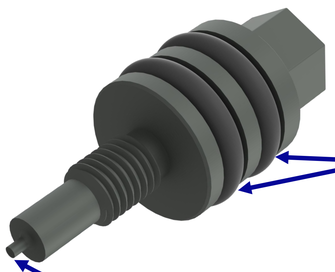


Saddle
- Mounts tapping device to tubing
- 303 Stainless Steel

Gasket
- Prevent pressure loss through sides
- SBR Rubber

Tube
- 304 Annealed Stainless Steel
- 1/8” (0.125”) Diameter
- 0.035” Wall thickness

Punch
- Creates a hole by pressing the punch tip into the tubing
- Hardened A2 Tool Steel, done in house to 60 HRC
- Initially made manually, shortened manufacturing time by using CNC Lathe



O-Rings
- Prevent pressure loss through threaded shaft inside the saddle
- 3/32” Aflas® Rubber

Schrader Valve
- Access valve for exchange of gas from internal cavity
- 1/8” NPT standard fitting

Tip
- 0.045” Diameter
- Flat headed punch
- 0.020” Fillet to minimize stress concentration

Testing Timeline

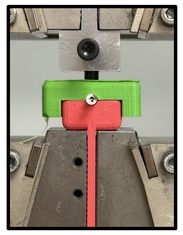
Punching Feasibility Test



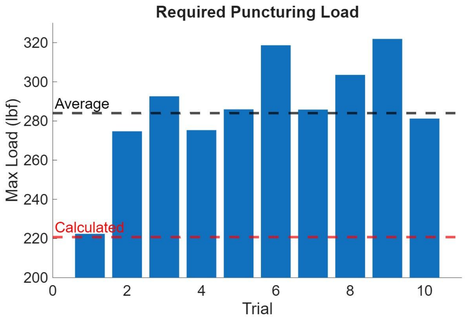
Conical Punch Tip
Crushed tubing as diameter increased



Flat Head Punch Tip
Tip diameter < I.D. of tube, punctured tubing

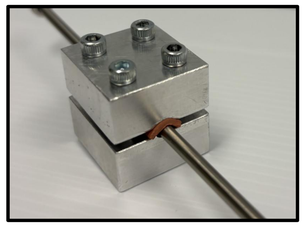


UTM Test Fixture

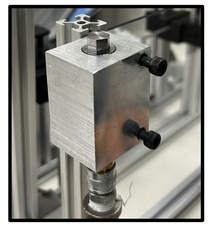


Key Findings: On first trial, 220 lb load is required to puncture, which aligns with our predicted values

Isolated Sealing Tests



Gasket Test Fixture
Isolate leak rate through gasket & Test materials and shapes

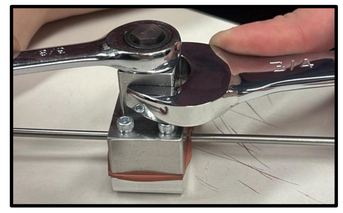


O-ring Test Fixture
Isolate leak rate through O-rings

Test	Gasket Material	Shape	Δt (min)	ΔP (psi)
1	SBR	▭	10	<1
2	Aramid/Buna-N	□	0	Instant Failure
3	SBR	□	10	0
4	SBR	□□	10	0

Key Findings:
- ✓ Retained 99.85% of initial pressure over 10 minutes (~0.12 psi/10 min combined leak rate)
- ✓ Double & single sided gasket both effectively seal saddle
- ✓ Two O-Rings effectively seal punch interface

First Prototype



Results:
- X Combined systems test was unsuccessful in puncturing tube
- X Bottom gasket caused extra deformation of tubing
- X Punch tip broke due to torsional stress



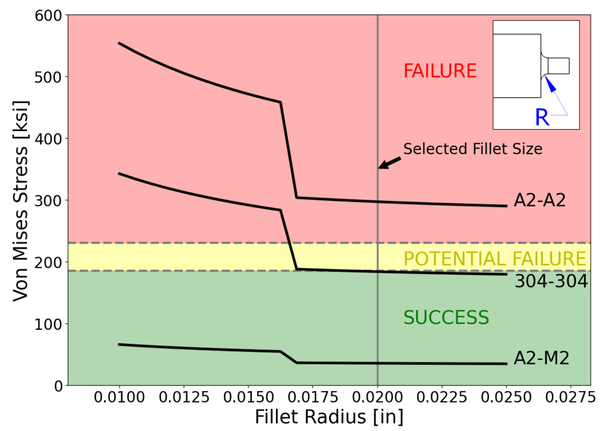
Deformed Tube



Failed Punch

Punch Tip Failure

Reduction in Stress due to Fillet addition at the Tip



- *Theoretical:* Calculated how stress concentrations at the tip vary with fillet radii
- *Fatigue Testing:* Repeated puncturing of tubing using the same punch

Key Findings:
- ✓ With fillet radii > 0.018”, little reduction in stress: 0.020” fillet was chosen

Final Prototype Testing



Successfully Punctured Tube

Results:
- ✓ Punctured the tubing 20 times per punch
- ✓ Successfully released pressure though Schrader valve
- ✓ Retained 98.75% of system pressure over 10 minutes, mostly due to filling the volume in saddle

Next Steps

- Design with a focus to operate with hazardous materials
- Consider longevity of materials for indefinite sealing
- Miniaturize further to reduce obstruction on system
- Redesign clamping to make application simpler

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