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Refabrication Capability Development, HFEF System and Instrumentation

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Advanced Fuels Campaign

Refabrication Capability Development, HFEF System and Instrumentation

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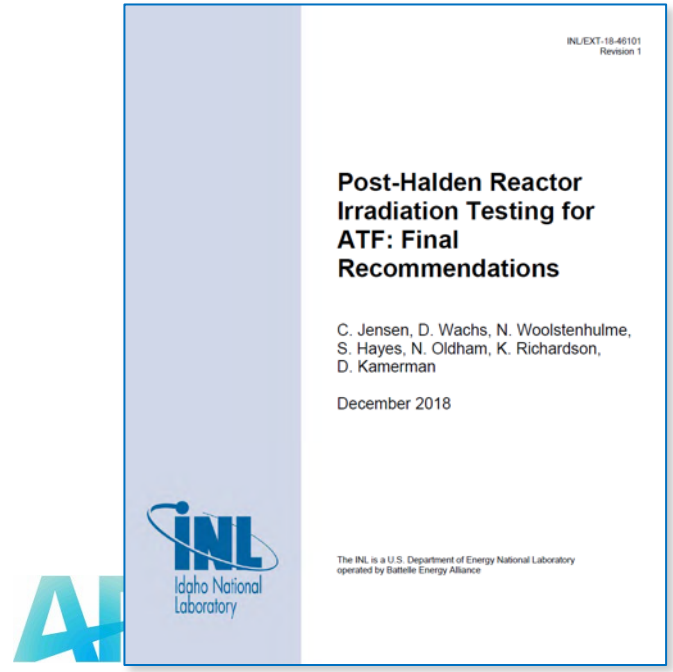
Halden Gap Assessment/Recommendations to Support ATF

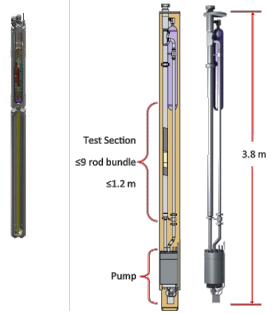


RECOMMENDATIONS

1. Accelerate LOCA Testing Capability at TREAT

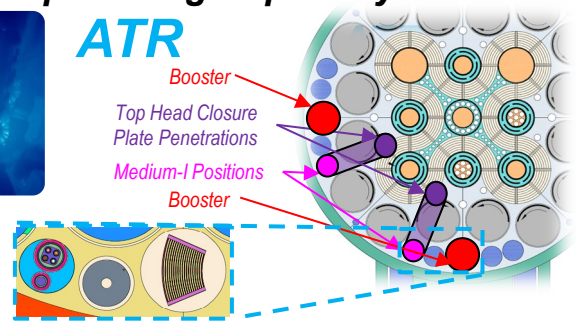
TREAT

Devices for prototypic LWR design basis accident conditions



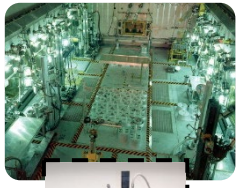
2. Expand Water Loop Capacity with Ramp Testing Capability at ATR

ATR

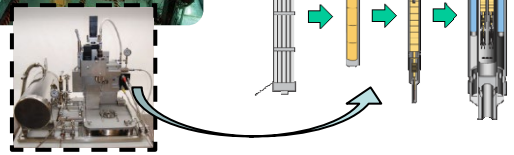


Prototypic environments for operational transient experiments to failure and BWR conditions

3. Establish Refabrication/ Instrumentation Capability



MFC HFEF/FSRB



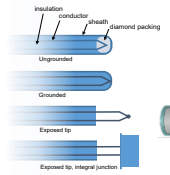
Refabrication and reinstrumentation of fuel irradiated in nuclear power plants

4. Deploy Reliable Advanced In-Pile Instrumentation

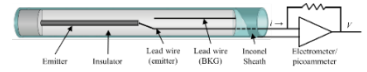
LVDT's transducers

HTTL

Thermocouples



SPND's



Dedicated instrumentation development with specific focus on in-pile test reactor deployment

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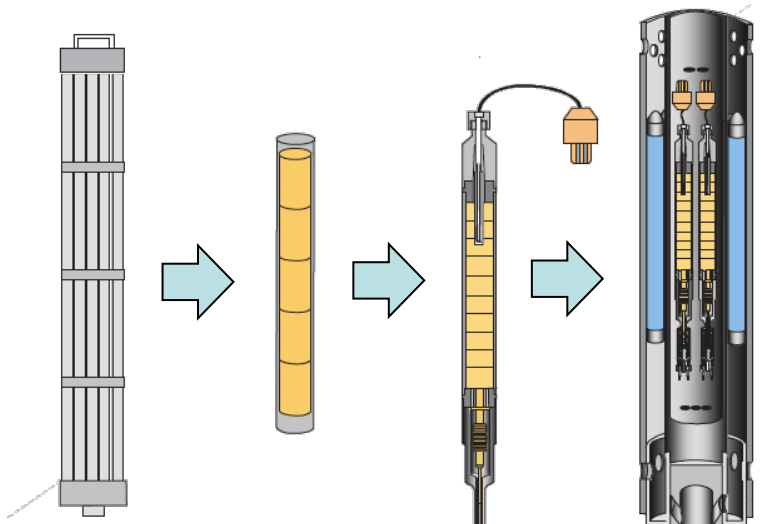
Refabrication is a Key Enabling Technology to Bridge Irradiations in Different Reactors

- **Fuel Rod Refabrication, Reinstrumentation, and Continued Irradiation**
  - Access the state of the fuel at any point in its life cycle
  - Used in test facilities around the world for decades – extended to reinstrumentation developed by RISO facility, Denmark; optimized by Halden facility



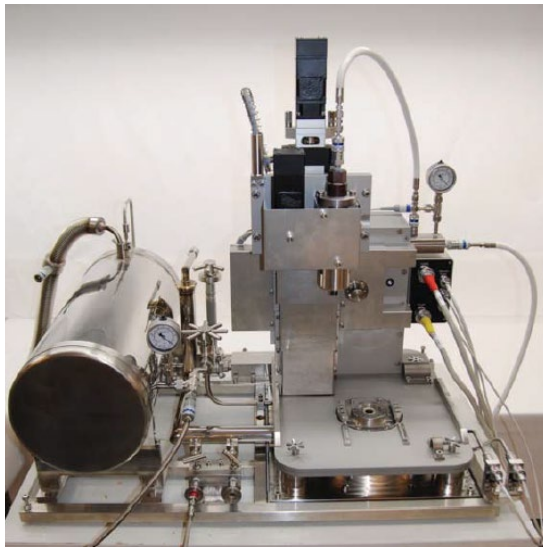
Fuel assembly irradiation in a commercial LWR or test reactor (ATR)

Fuel Segment from Rod

Re-fabricated/ Re-instrumented segment

Experiment in ATR or TREAT or SATS

Halden re-instrumentation equipment



Preserve state of fuel using cryo system – drill fuel to defuel cladding and instrument insertion and attachment

France (CEA) has developed a "dry" drilling alternative to the Halden "cryo" drilling technique. Limited available information.

- **Required for enough source material to generate licensing data by use of commercial irradiated materials**

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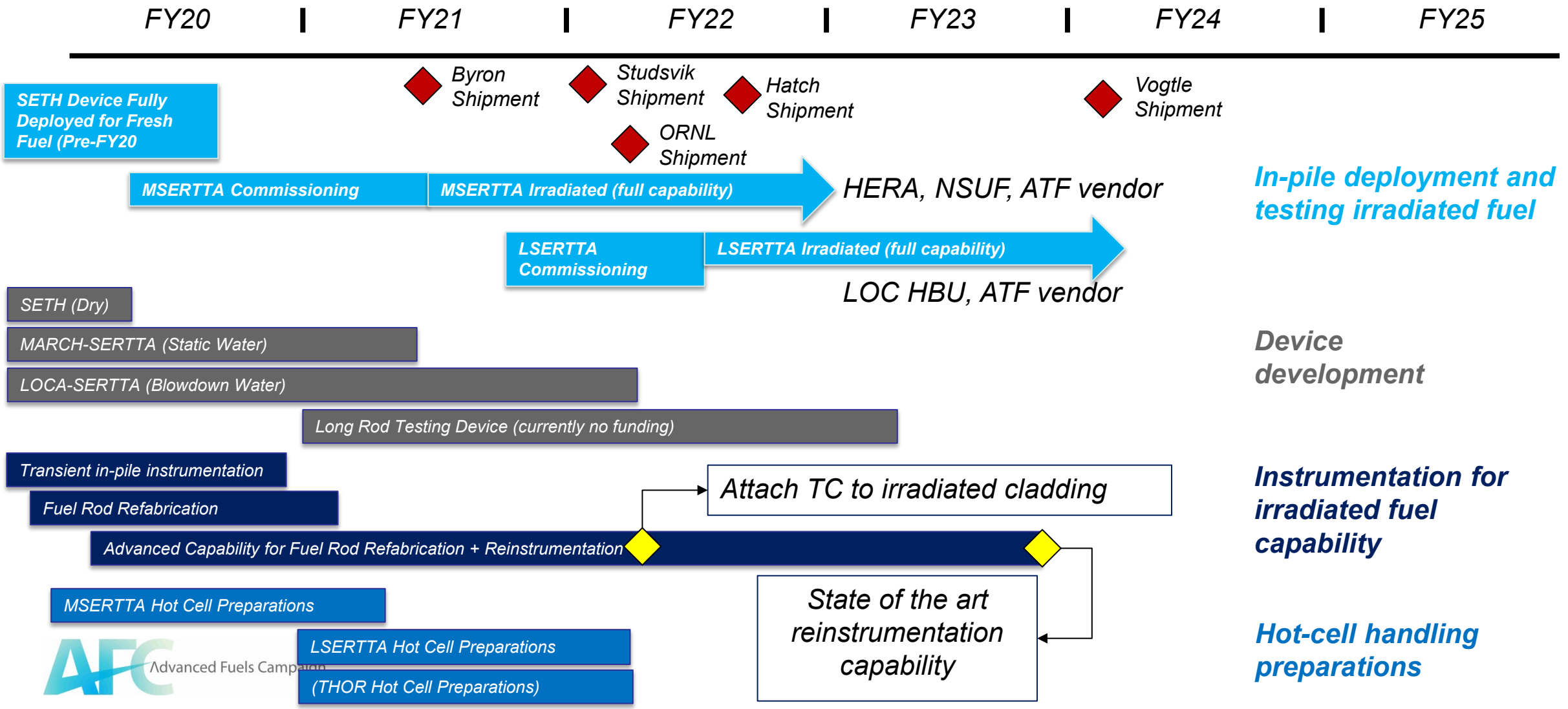
Current Outlook for Testing Irradiated Fuel



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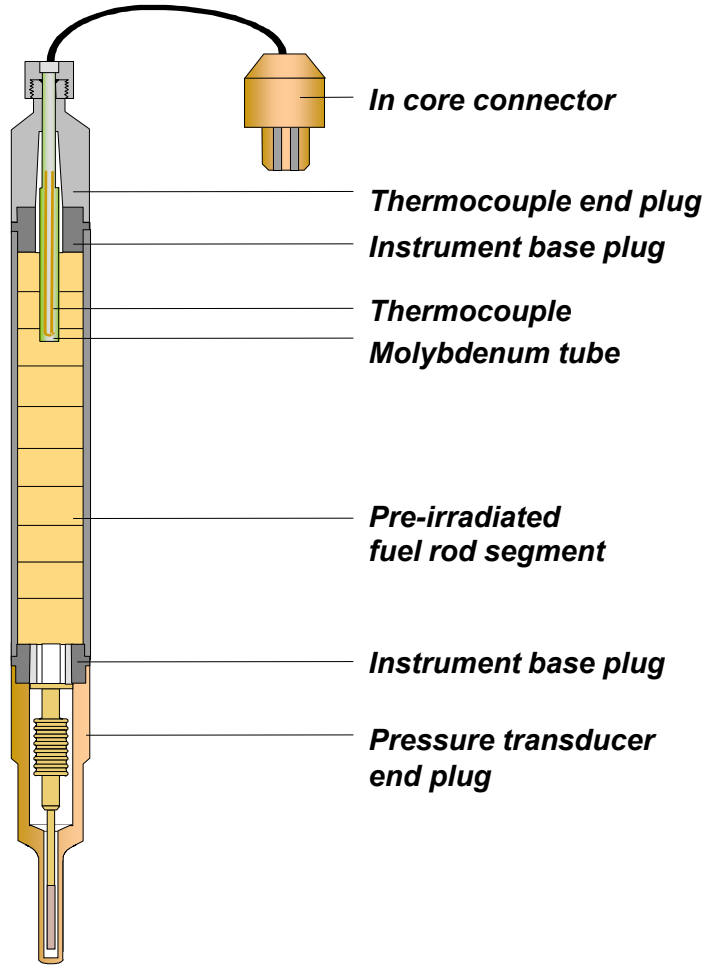
Refabrication and Reinstrumentation Process

- Inspection of fuel rod (includes neutron radiography)
- Fuel rod cut to length
- De-fuelling of fuel rod ends
- Oxide layer removed from cladding ends
- End plugs welded to fuel rod (pressure transducer and thermocouple base plugs)
- Fuel rod filled with liquid CO_2 and frozen with liquid N_2
- Drilling of centre hole (vacuum process)
- Assembly of Mo-tube
- Fuel rod dried at 300 °C for 72 hours (vacuum)
- Second part of pressure transducer end plug welded to fuel rod
- Second part of thermocouple end plug welded to fuel rod
- Measurement of fuel rod free-volume and gas flow properties
- Surface TC attachment (welding)
- Fuel rod evacuated, filled with He and seal welded
- He leak-test of fuel rod
- Check-out / testing of fuel rod instrumentation
- Final inspection of fuel rod

Baseline Refabrication
Advanced Reinstrumentation



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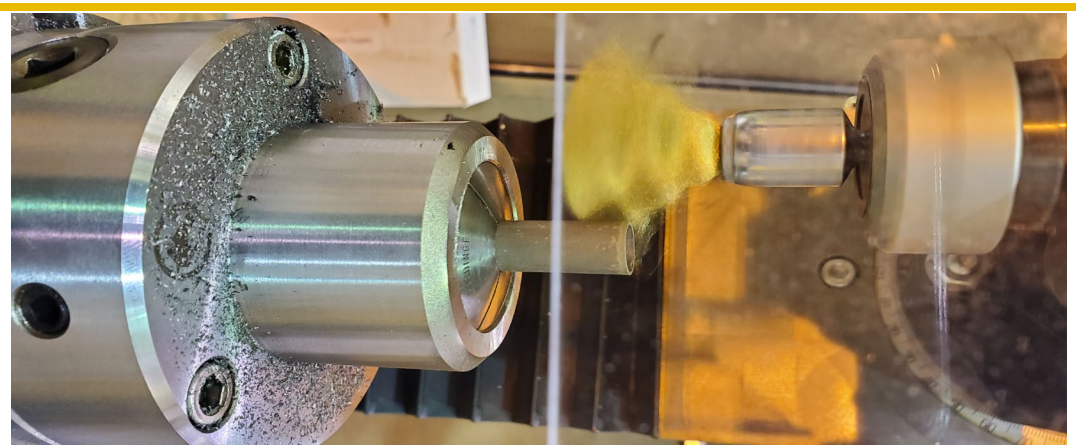
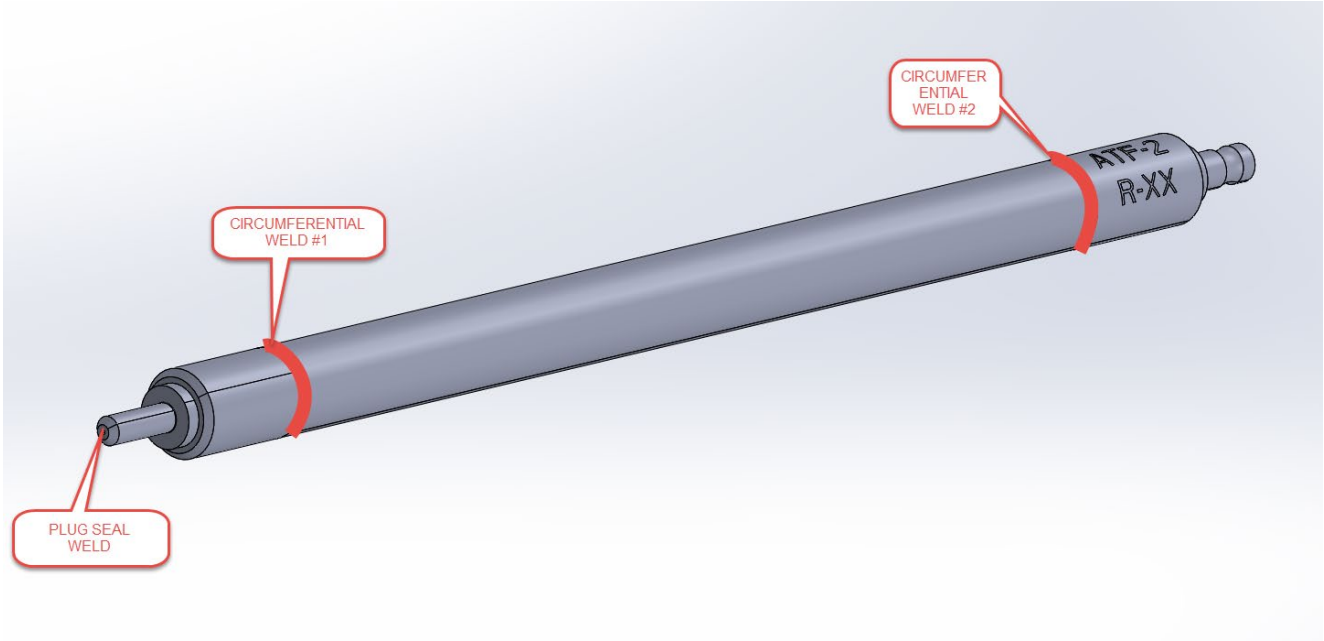
ATF-2 STYLE Rodlet Welds and Removing Oxide Layer for Welding

- **Three Welds Needed for ATF-2 Style Rodlets**
  - Two circumferential welds for rodlet end caps
  - One plug seal weld after pressurizing the Rodlet





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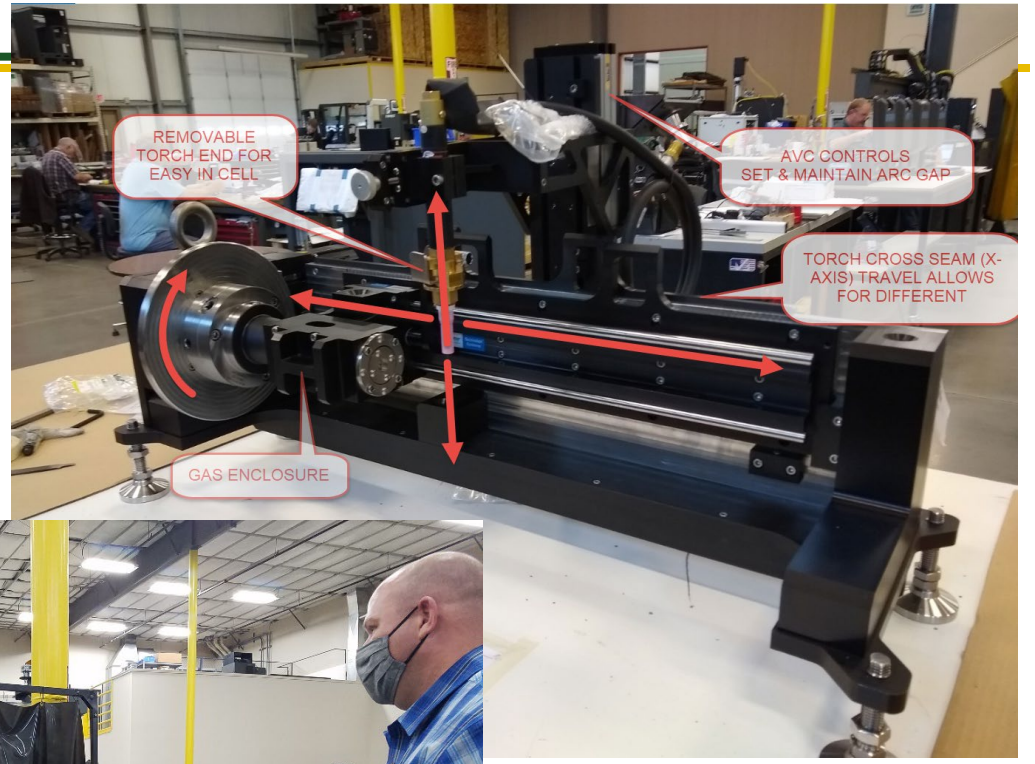
Rodlet End Welding System (REWS)

End Cap Welding Fixture

- Programable Automated Voltage Control (AVC)
- Programable Cross Seam Position (X-AXIS)
- Programable Rotary Control
- Gas enclosure for added process gas coverage
- Tooling accommodates ATF-2 style rodlets
- Open concept for easier operation and future adaptability



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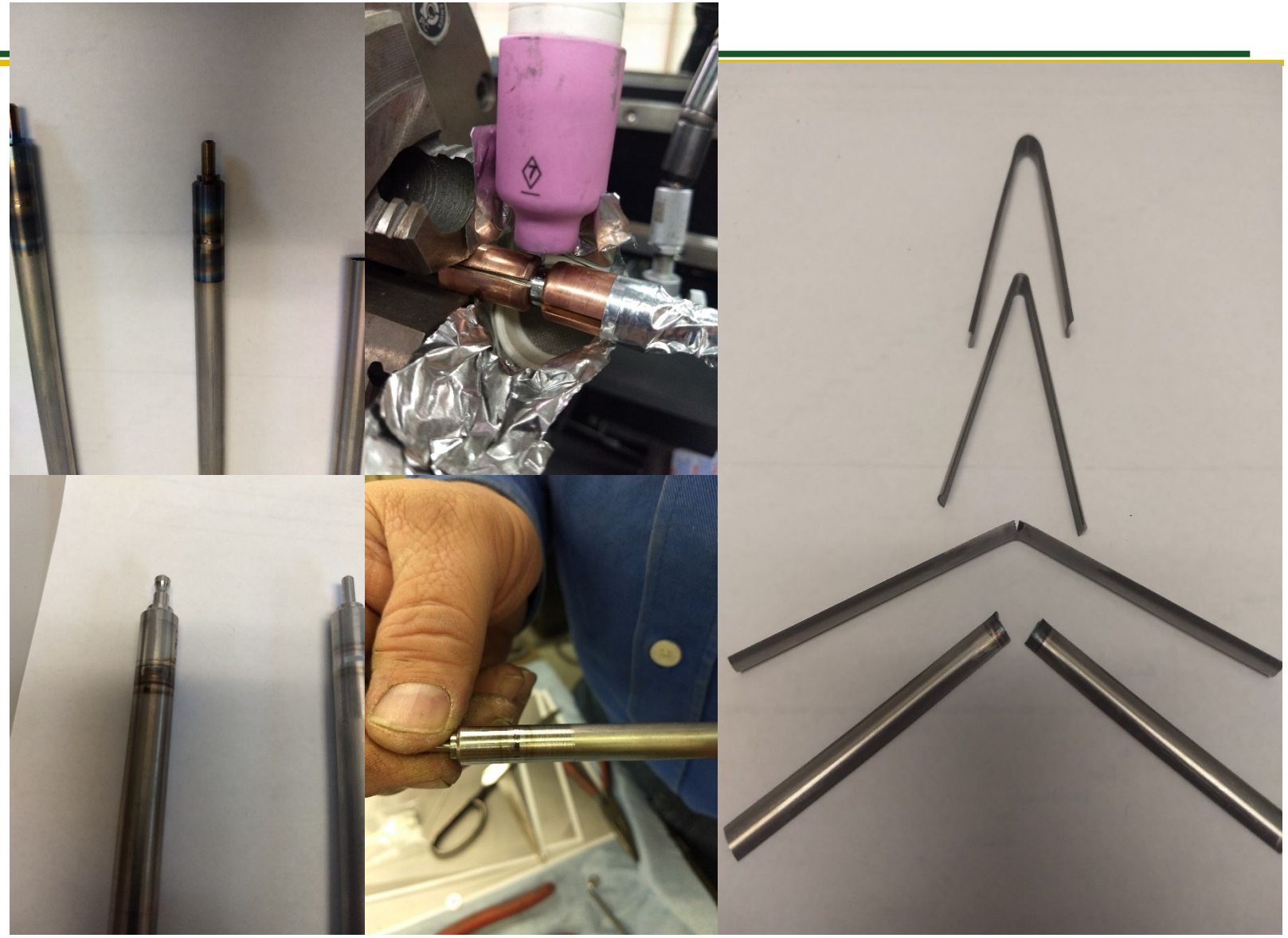
Gas Coverage & Welding Trials

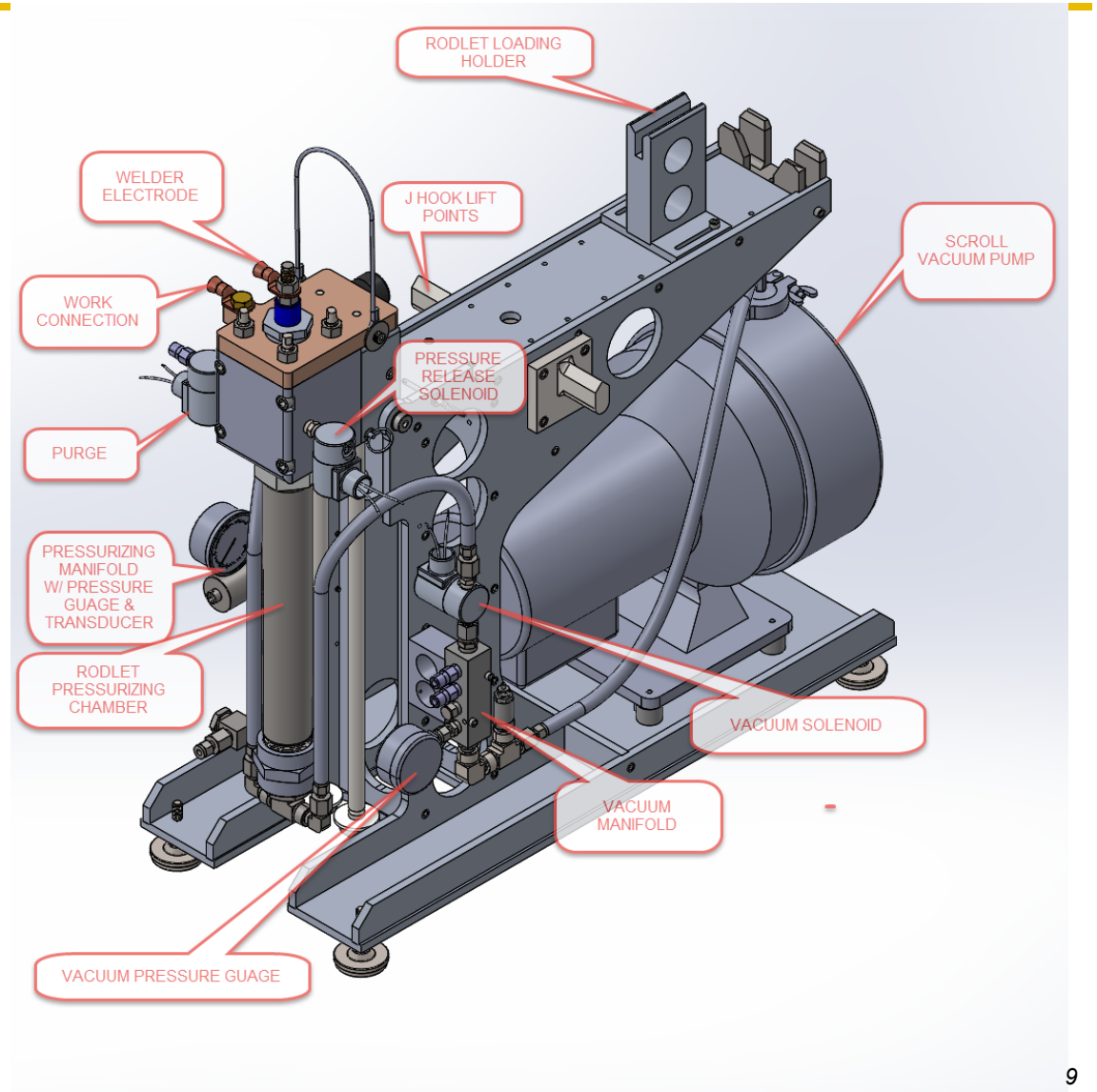
- Weld test showed localized shield gas was not sufficient
- Initially no heat sink or enclosure
- Added heat sink and enclosure
- Altered gas flow
- Two out four bent without breaking
- Those that broke did not have full penetration
- With shield gas, backing gas, weld program and tungsten alterations we can improve welds.



In Cell Weld Under Pressure System (ICWUPS)

Rodlet Pressurizing and Seal Weld Fixture

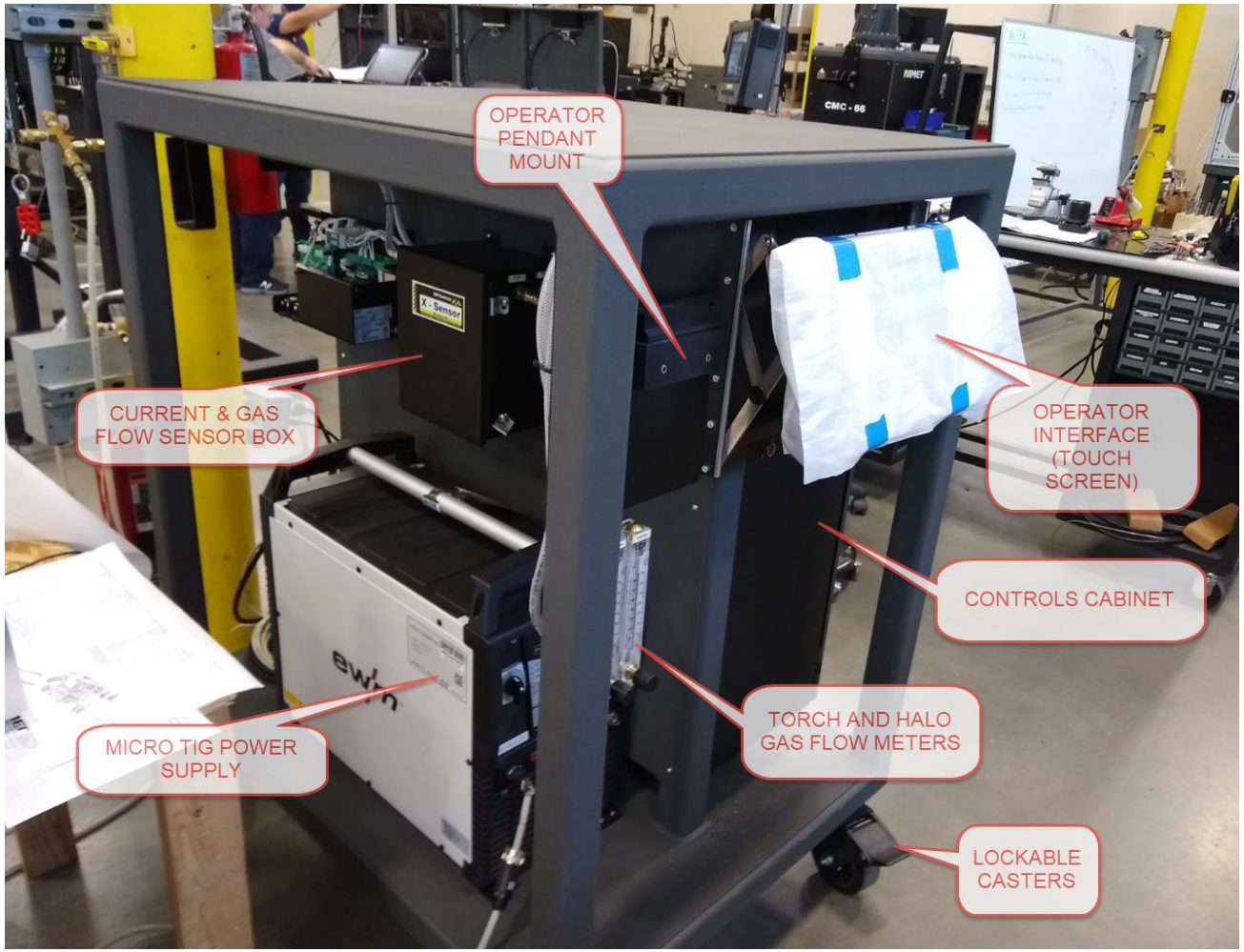
- Currently being Machined
- Utilizes same weld control as the REWS welding fixture
- Utilizes a PLC controller for vacuum a pressurization sequences
- Scroll pump for rodlet gas evacuation
- Capability of pressurizing to 2250 psi



REWS & ICWUPS Weld Controller

Weld Controller

- AMET X-PRO controller
- Controls welding power supply, and motion axis through upslope, main, & downslope segments
- Data acquisition tracking of voltage current and motion axis
- Micro TIG power supply for low current arc initiation, and welding
- Programmable AVC controller



Weld Systems Future Work

- Complete fabrication and factory acceptance, deliver to INL for testing
- Using mockup parts, weld parameters will be developed and weld testing will be performed
- Testing for in-cell maintainability will be performed
- In cell feed through needs to be machined and assembled
- Electrical noise testing with assembled feed through
- Feed through needs to be installed
- Testing for future application welding

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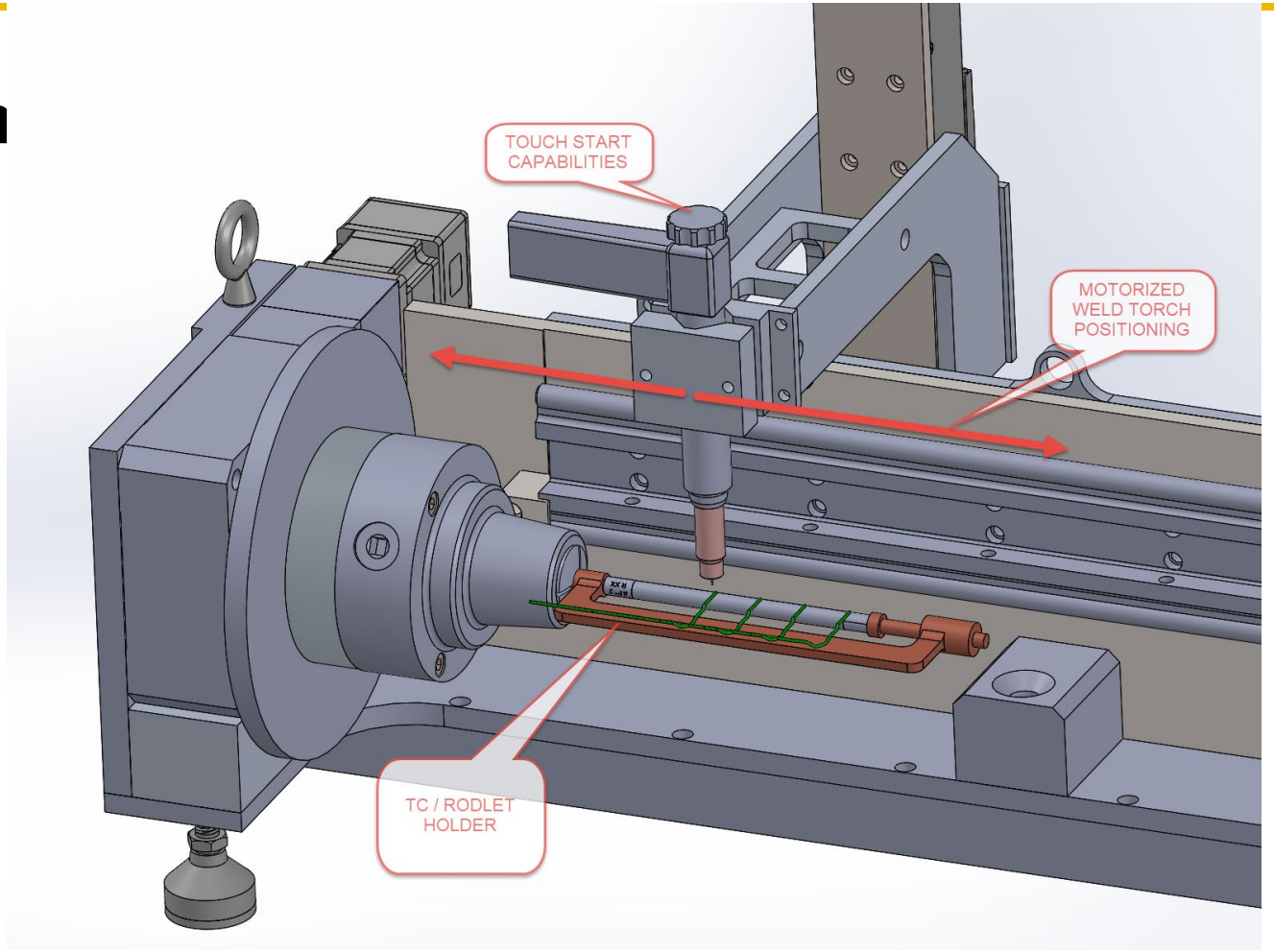
Intermediate Steps for Advanced Re-instrumentation to also support Near Term Needs

- **Evaluate options to perform surface TC attachment (welding)**
  - Different TC types (sheathed, bare-wire) and configurations
  - Evaluate options for near term deployment without TESB
- **Investigate options to perform instrumented endcap welding**
  - Leverage Halden designs of endcaps, and design/fabricate instrumented endcaps compatible with experiments
    - *TCs, LVDTs, Bellows, Pyrometers, etc.*
  - Develop endcap welding that preserves the critical features of embedded instruments
  - Evaluate options for near term deployment without TESB
- **Develop fuel pellet drilling process for fresh and irradiated fuels**
  - Both fresh and irradiated fuel experiments expected to require centerline temperature measurement in the near future.
  - Halden “cryo” system available to use to develop methodology on surrogate materials; thanks to I2!
  - Develop “dry” (aka CEA method) which could be deployed more quickly than “cryo” method, and could make use of existing equipment.
- **Considerations**
  - Timing of TESB availability
  - Speed and complexity of deployment in existing facilities

Instrumentation Welding

- **Adapting and testing with new equipment**
  - TC welding
    - *bare and sheathed,*
    - *integral junctions*
    - *Modeling of TC connections*
  - Other rodlet designs



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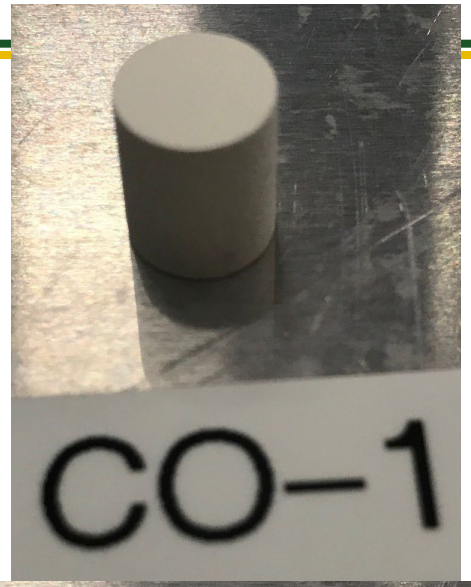
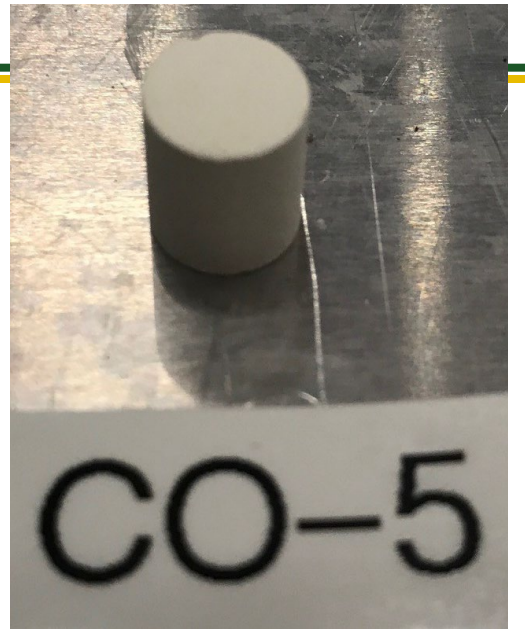
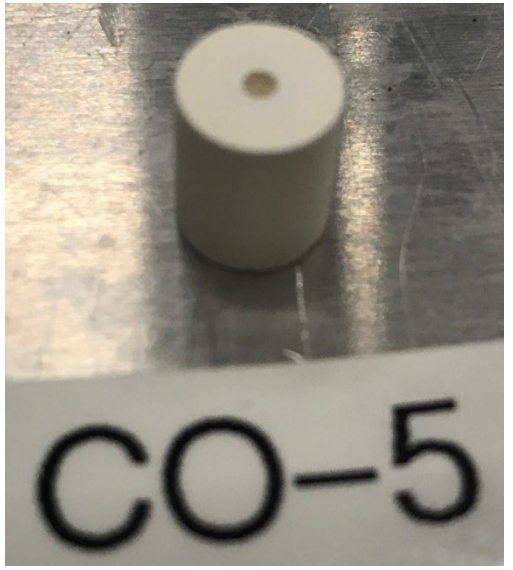
Dry Pellet Drilling Trials and Pellet Cracking

- Dry drilling has potential for near term implementation using existing equipment.
- Pre-cracking pellets provides source for next phase of drilling development







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Title That Explains Impact

- Bullet points explaining the approach, results, and future directions
- Presentations limited to 15 minutes plus 5 minutes Q&A
- Include contact information
- No embedded movies please

Caption should explain how image relates

- ReBekah will upload, share and advance slides during the meeting
- Slides are due to ReBekah (cc Phyllis and Kate) on December 1.
- Presentations need to be approved for public release should be cleared for public release prior to send them to ReBekah.