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Annular Core Research Reactor

ACRR Operational Challenges

SAND # TBD

TRTR Conference 2020

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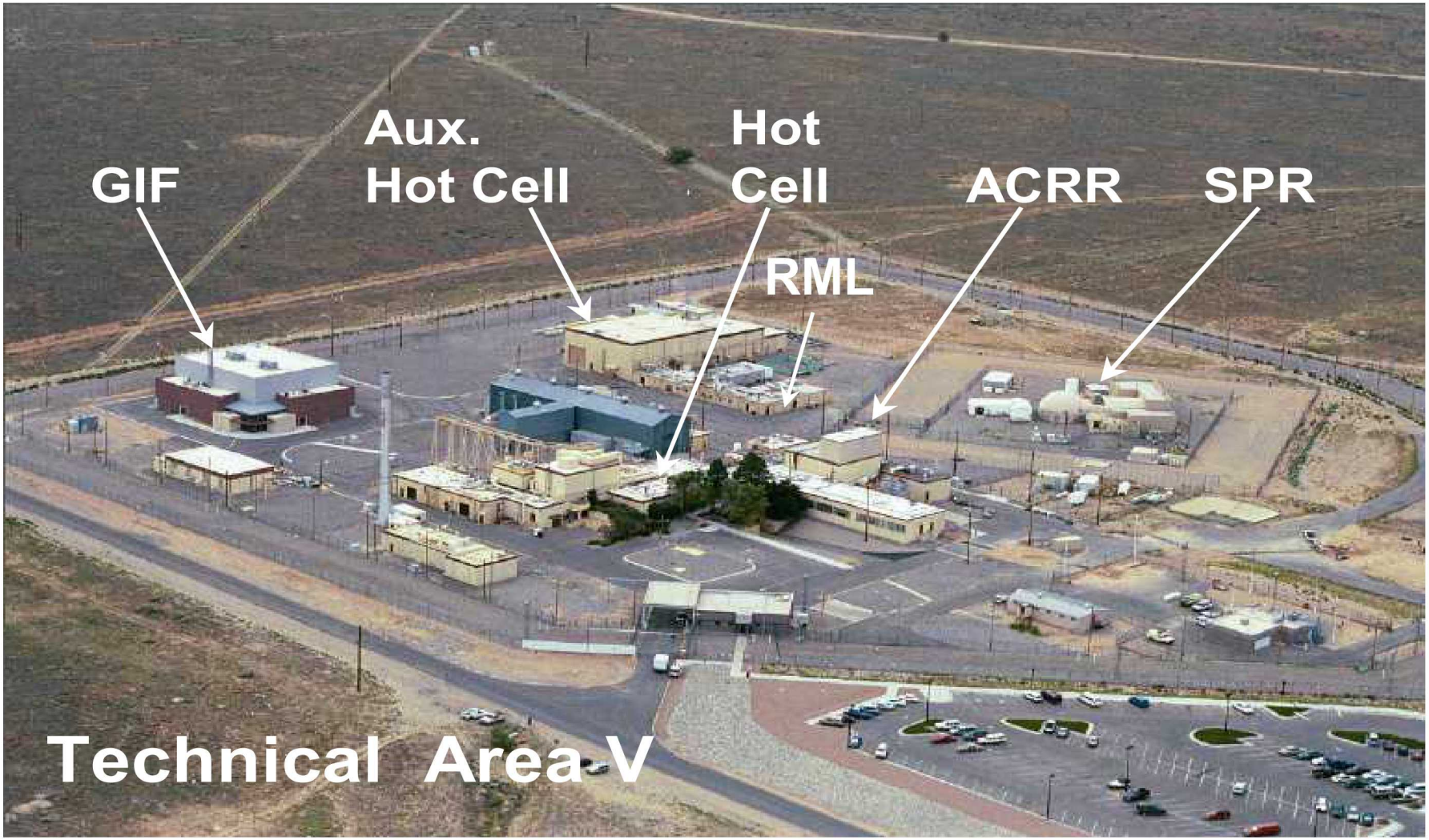
Abstract

The Annular Core Research Reactor (ACRR) has been in a prolonged maintenance mode since September of 2019 due to equipment failures and operational errors. This has caused a significant reduction in normal operations and has resulted in a transition to a recovery mode to fix deficient conditions. Normally ~300-400 operations are performed a year, and now it has been reduced to ~30 operations. In addition, many staffing changes have occurred (five new operators in training, a new manager, two new reactor supervisors), which has caused additional workload for the existing staff. The challenges in returning ACRR to an operational state will be discussed in further detail herein.

The initiating event for many of the recent issues at ACRR has been aging equipment. A nickel plate rigging failure and a loose bolt on a Safety Rod (SR1) connecting rod led to further investigations and identification of more deficient conditions. Equipment failures and operational errors while implementing recovery actions caused additional work to be performed. Repair of the loose bolt on SR1 resulted in identification of a cladding breach. Search for foreign material led to identification of a suspect fuel element #134. During staging activities to remove fuel element #134, the fuel element transfer container (15-element rack) failed during testing. Additional Foreign Material Exclusion (FME) concerns (dropped bolts, loose bolts and washers on the safety plate, and legacy FME) have caused significant recovery and retrieval work. There have been accomplishments to address FME including successful deployment of a Foreign Object Search and Retrieval (FOSAR) Crawler to remove legacy foreign material on the pool floor.

There have been many lessons learned in the areas of FME controls, aging equipment, infrequently performed tasks, inexperience with new staffing, and distractions due to multiple concurrent events. The coronavirus (COVID-19) added additional complexity to performing maintenance to fix the deficient conditions. The number of people who could perform work was limited from COVID-19. Communication with masks was more difficult and planning meetings were held via Skype. Future work at ACRR includes development of advanced fuel inspection techniques. This includes building a test rig to hold the fuel and testing to include: visual inspections, ultrasonic testing, Go/No-Go fit testing, and hermeticity testing. Visual inspection criteria will examine for scratches, dents, corrosion, and weld integrity.

SNL TECHNICAL AREA V (TA-V)



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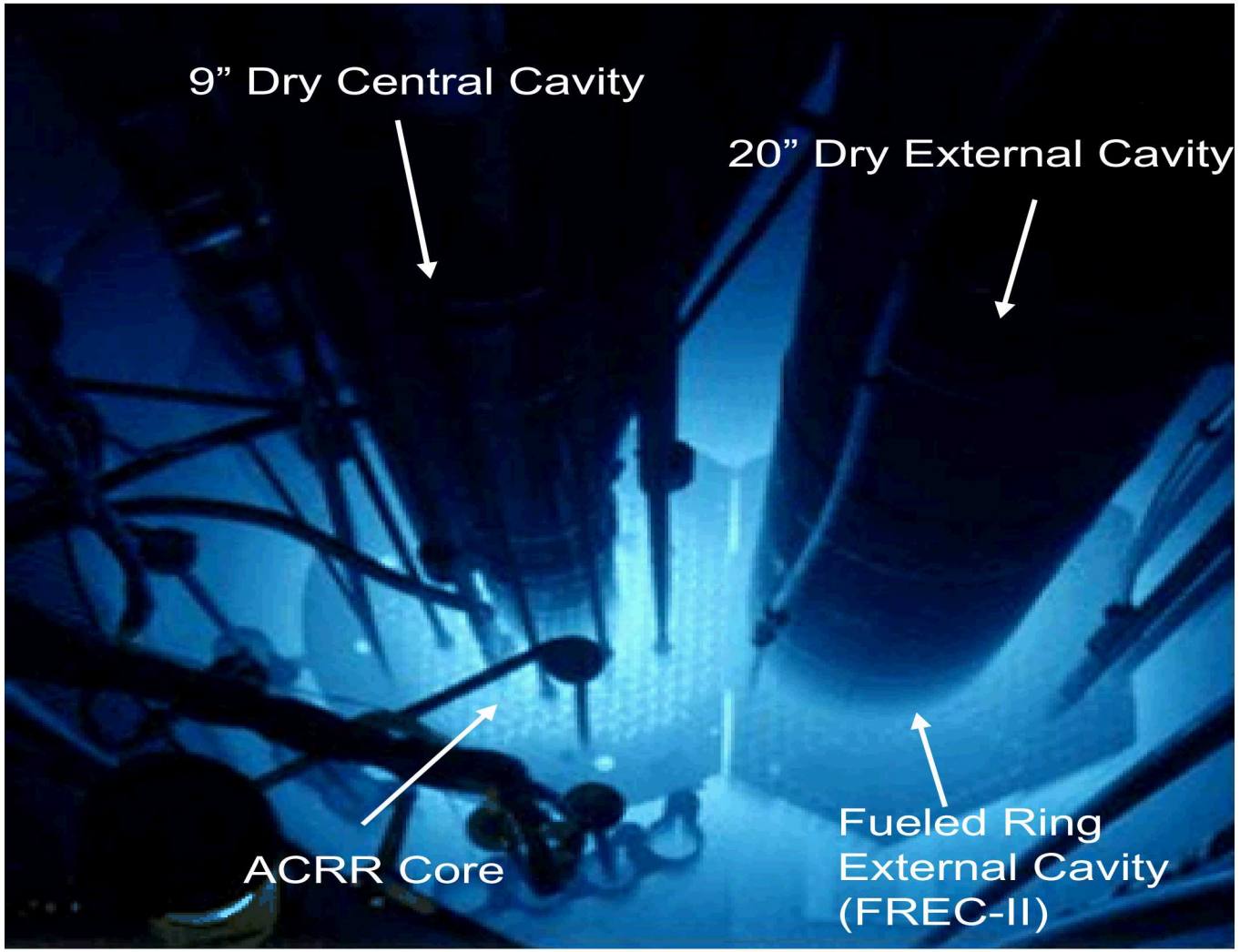
ACRR Current Configuration



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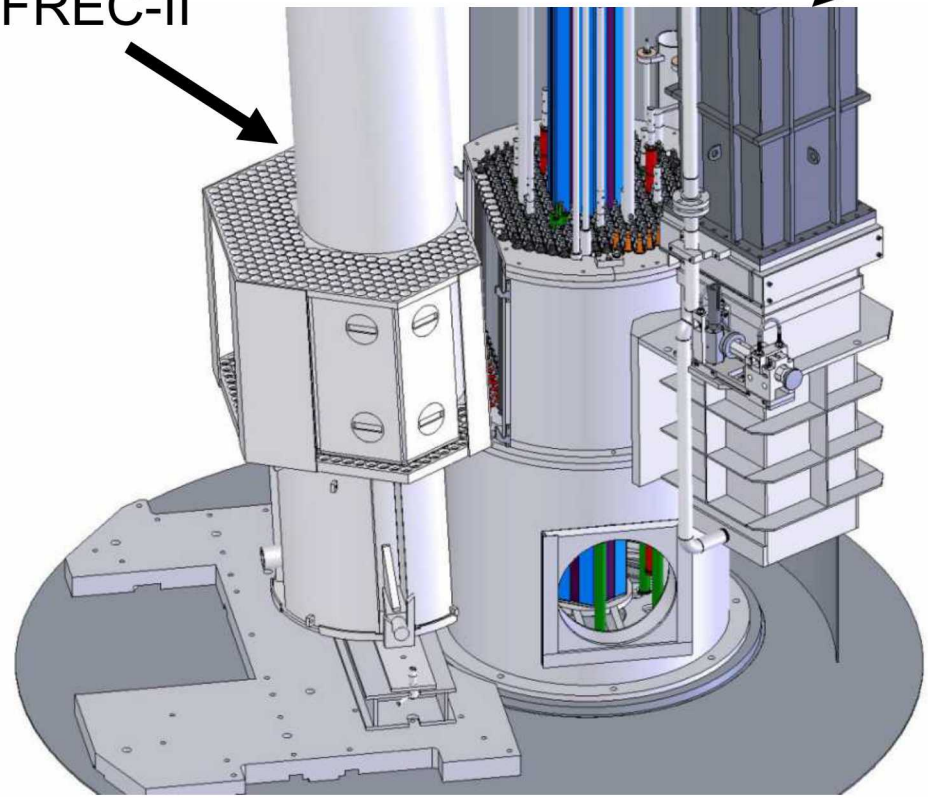
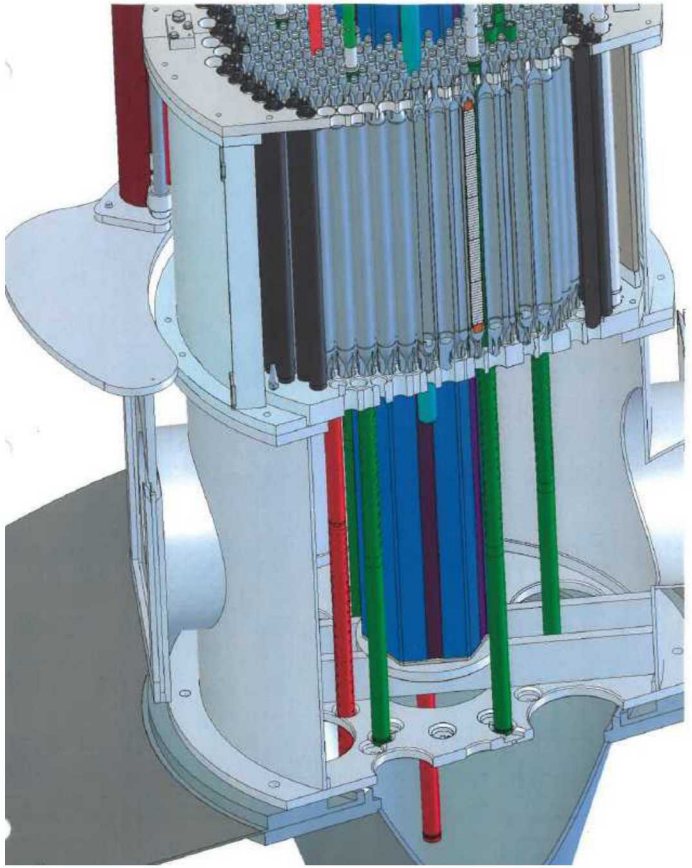
ACRR 3D View

Neutron Radiography Tube (NRT)

FREC-II





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Diversity and Status of Operator Qualifications

Operators	Navy Rx	Commercial Rx	University Rx	DOE Rx	BS	MS	PE
1 (RS)	x		x	x	x	x	x
2 (RS)	x			x	x		x
3 (RS)				x			
4 (RS)	x			x	x		
5 (RO)			x	x	x		
6 (RO)		x	x	x	x		
7 (ROIT)			x	x	x		
8 (ROIT)		x	x	x	x	x	x
9 (ROIT)	x			x	x		

Timeline of Events

Sept 2019	• Nickel plate rigging failure • Shutdown from normal operations for ~1 month
Nov 2019	• Loose bolt on SR1 connecting rod • Reactor began prolonged maintenance outage
Dec 2019	• Cladding breach found on SR1
Jan 2020	• Removal of SR1 from the core and into storage • During search for missing nut and washer ~16 elements were inspected, which lead to identification of suspect Fuel Element #134 • Foreign material found under control/safety rods
Feb 2020	• Bolt dropped onto core grid and later fell to the safety plate during maintenance activities • 15-element transfer rack failure
Mar 2020	• SR1 replacement installed

Timeline of Events (cont.)

Apr 2020
- Control Rod 5 (CR5) removal and replacement due to suspect dent
- Bolt from dust cap fell into pool and was recovered
- Returned to programmatic operations for a limited set of authorized experiments under Justification for Continued Operation (JCO)

Jun 2020
- Removal of 15-element rack and loose steel billets

July 2020
- Core Grid extension test fit
- Removed old central cavity from floor storage (stored for ~24 years)

Aug 2020
- Installed new Nickel plate reflector

Sept 2020
- FOSAR crawler used to remove FME on pool floor

Nickel Plate Rigging Failure

- During de-coupling of FREC-II and movement of the nickel plate, one leg of the attached rigging failed

Eyebolt not fully seated and bent

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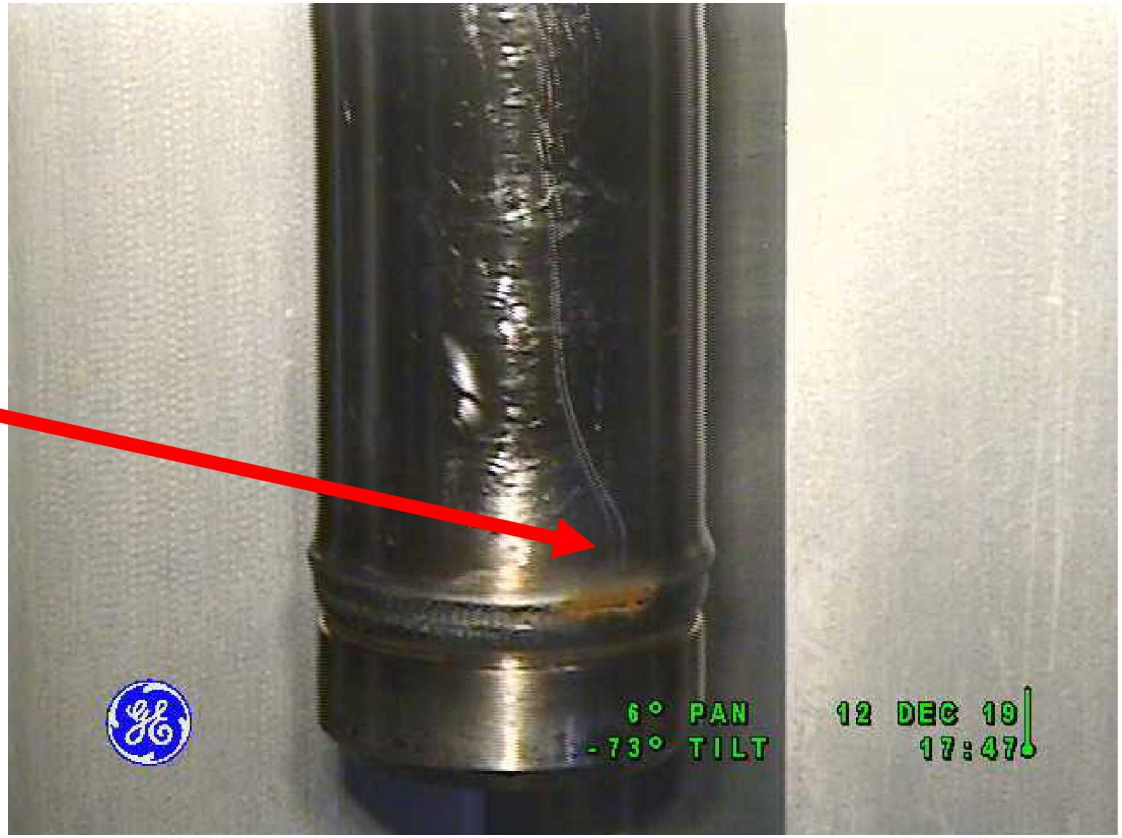
Loose Bolt on SR1 Connecting Rod

- During a pre-operation checkout, operator discovered a bolt backing out on SR1 connecting rod
- The nut and washer were no longer on the bolt
- Removed rod drives in preparation to repair loose bolt and to locate the missing nut and washer

Cladding Breach on SR1

- During maintenance on SR1, operators discovered a breach in the cladding by visual indication of bubbles from the bottom weld seam
- Began remote monitoring of Pool CAM and Ventilation System

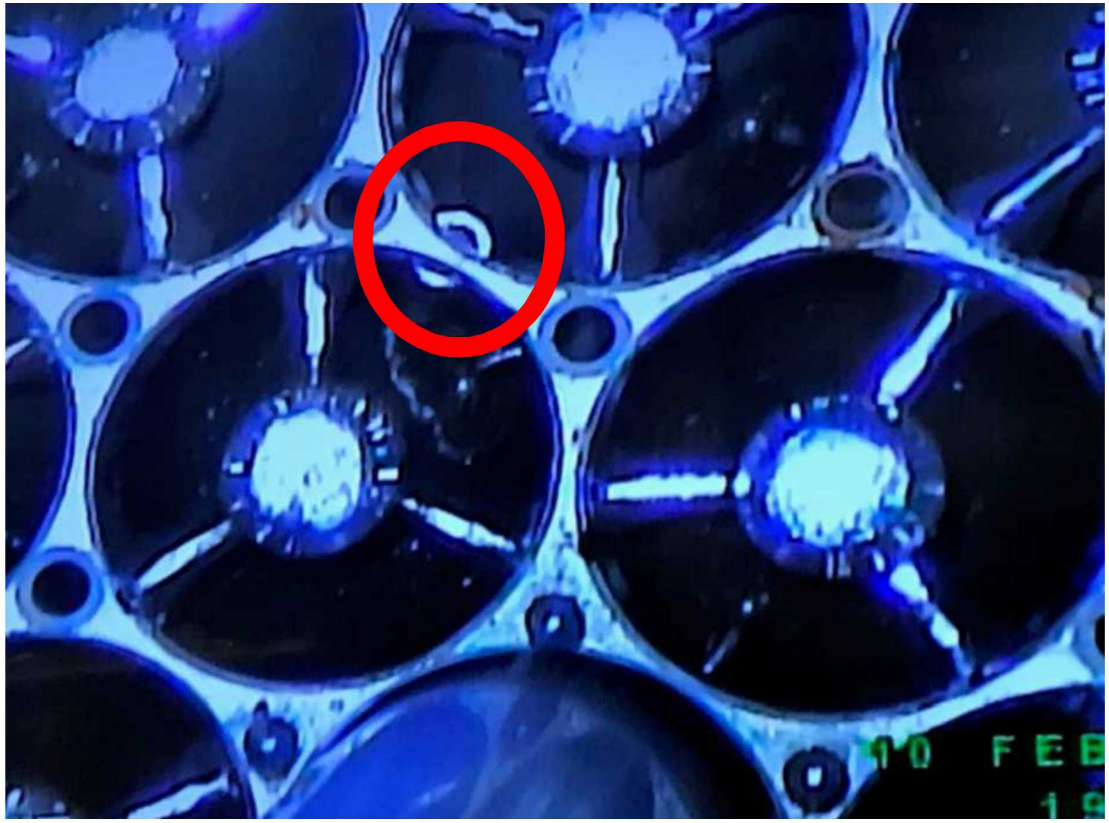


Identification of Suspect Fuel Element #134

- During the search for the missing nut and washer, operators identified suspect fuel damage on FE #134
- FE #134 was sequestered into fuel storage for further evaluation

Bolt Dropped on Core

- In preparation for inspection of regulating rods, a small bolt was dropped
- The bolt fell on the core. During retrieval attempt, bolt fell through the core onto the safety plate.
- Bolt could not be retrieved from the safety plate

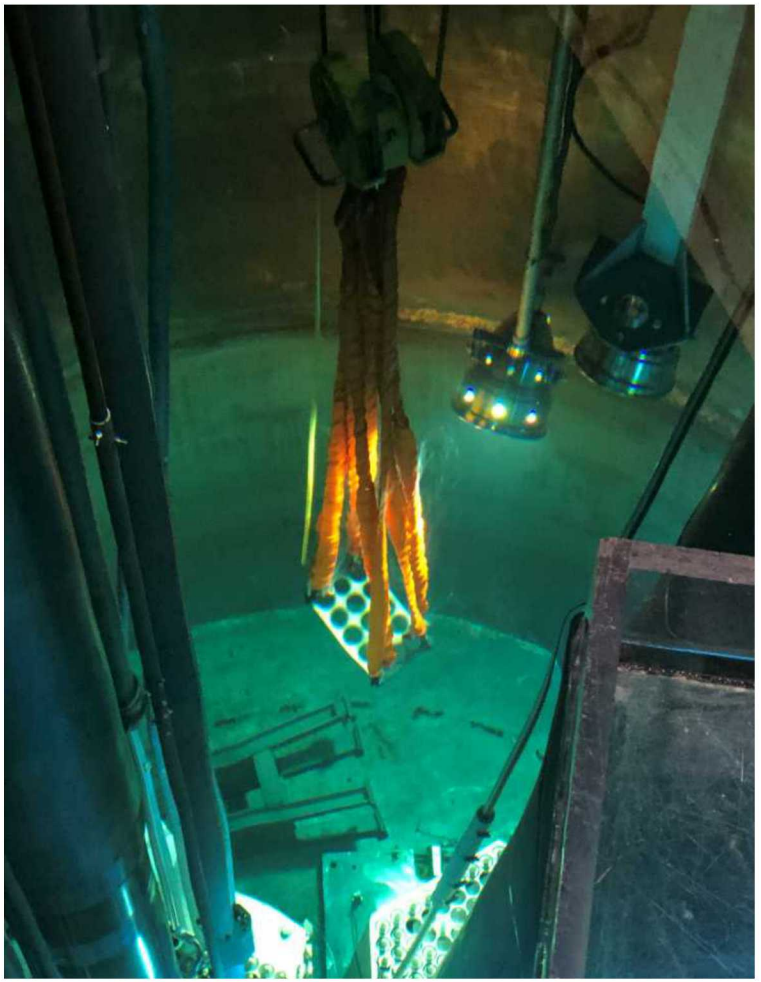


Foreign Material on Safety Plate

- While searching for the dropped bolt on the safety plate, additional foreign material was discovered
- It was also determined that CR2 and CR5 were striking the safety plate (normally the bottom of the rods are approximately an inch above the safety plate)

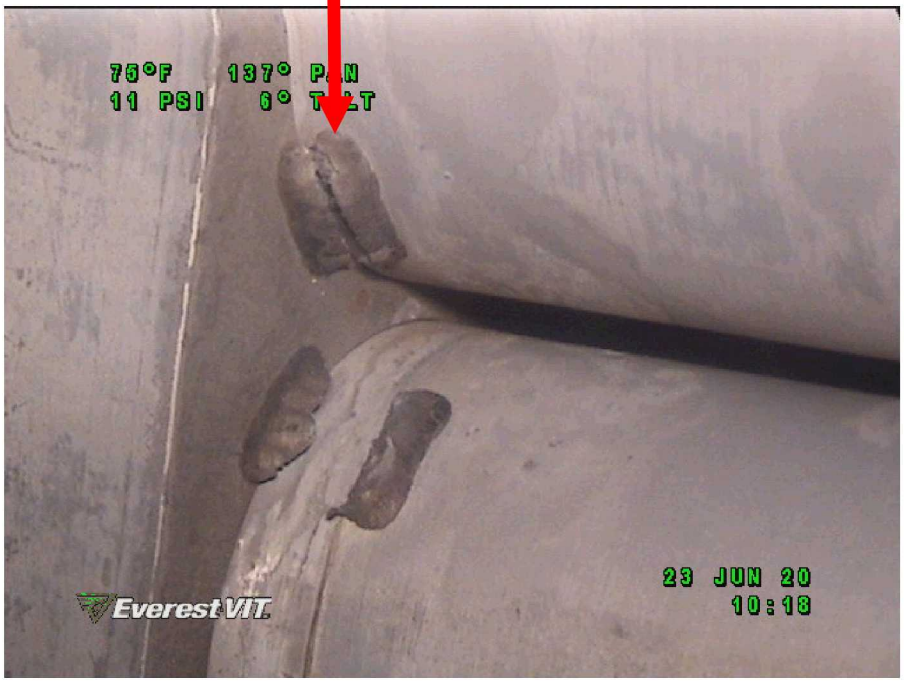
15-Element Rack Failure

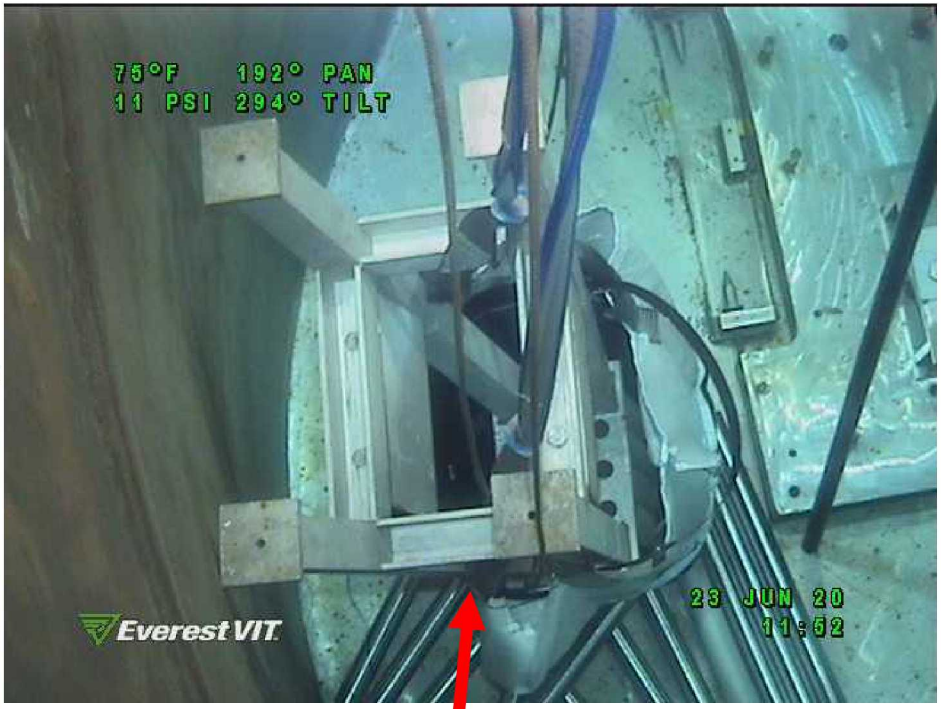
- During a test lift of the 15-element rack loaded with steel billets, the top grid plate detached and the remainder of the stand fell over in the pool



15-Element Rack Failure

Failed tack welds

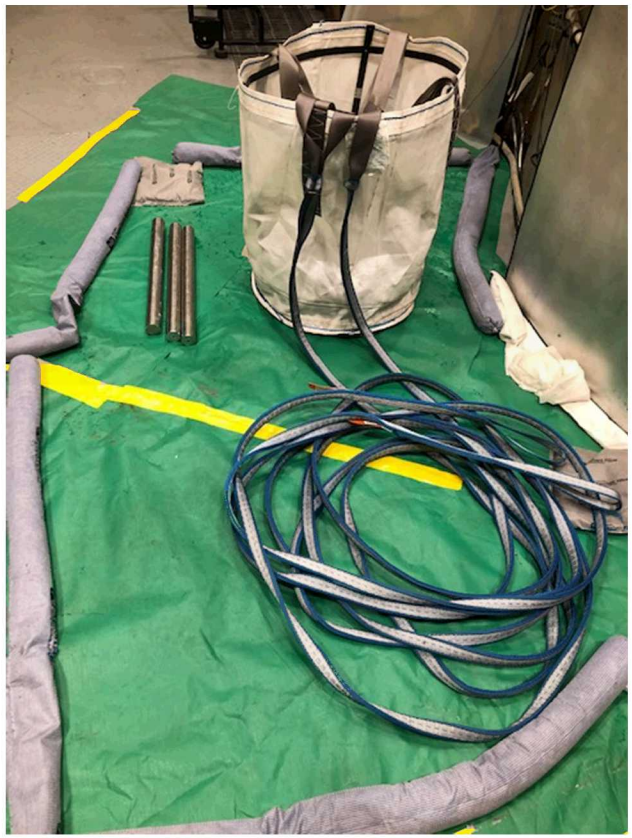


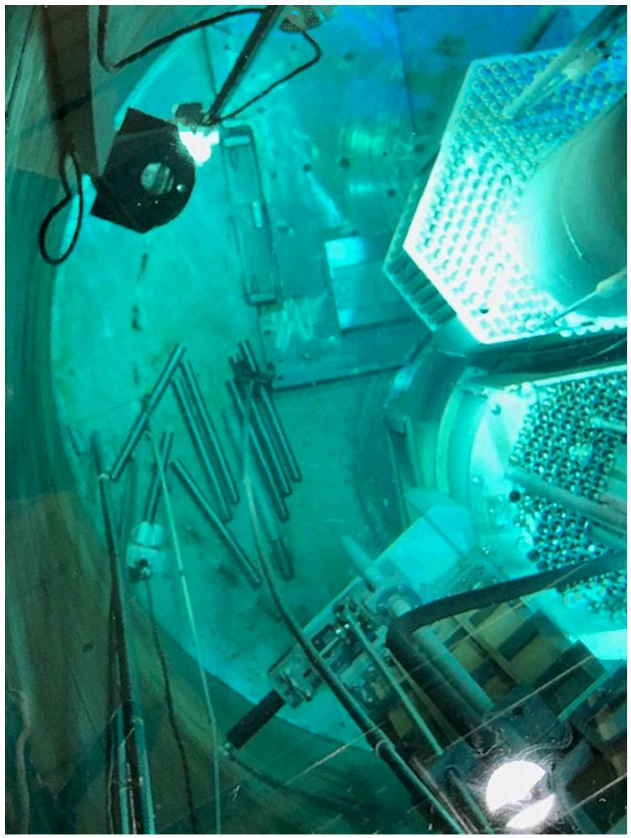


Rigging and bag to remove 15-element rack

15-Element Rack Failure

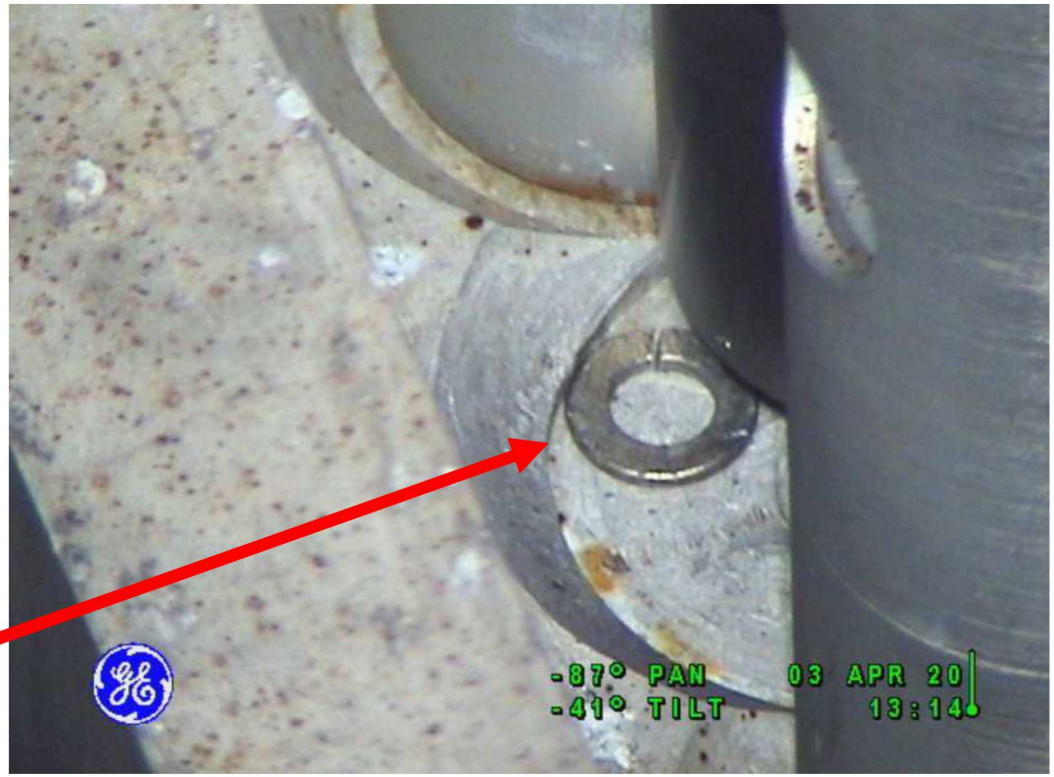
- Retrieval of steel billets was necessary after removal of the 15-element rack
- Steel billets were loaded into a bag with a gripper tool





CR5 Replacement

- CR5 was removed and replaced
- The CR5 connecting rod was shortened to prevent the bottom of the rod from striking the safety plate
- Operators attempted to retrieve and remove the washer



Bolt Dropped in Reactor Tank

- During maintenance activities, a bolt from a dust cap fell into the tank
- Bolt was subsequently found and retrieved
- Lessons learned:
  - FME practices were improved
  - New FME prevention tools were purchased
  - FME covers installed on Reactor Bridge

Core Grid Extension

- An alternative to the Nickel plate (125 lbs) was developed
- The core grid extension (35 lbs) has a grid to allow loading of moveable Nickel elements
  - Goal was to improve ergonomics and reduce potential damage to core from mishandling the Nickel plate
  - Neutronic and reactivity effects were analyzed and determined acceptable
- After testing the core grid extension on the core, it was determined to be more viable to use the Nickel plate

FOSAR Crawler

- An underwater FOSAR Crawler was used to retrieve legacy FME in a previously inaccessible location

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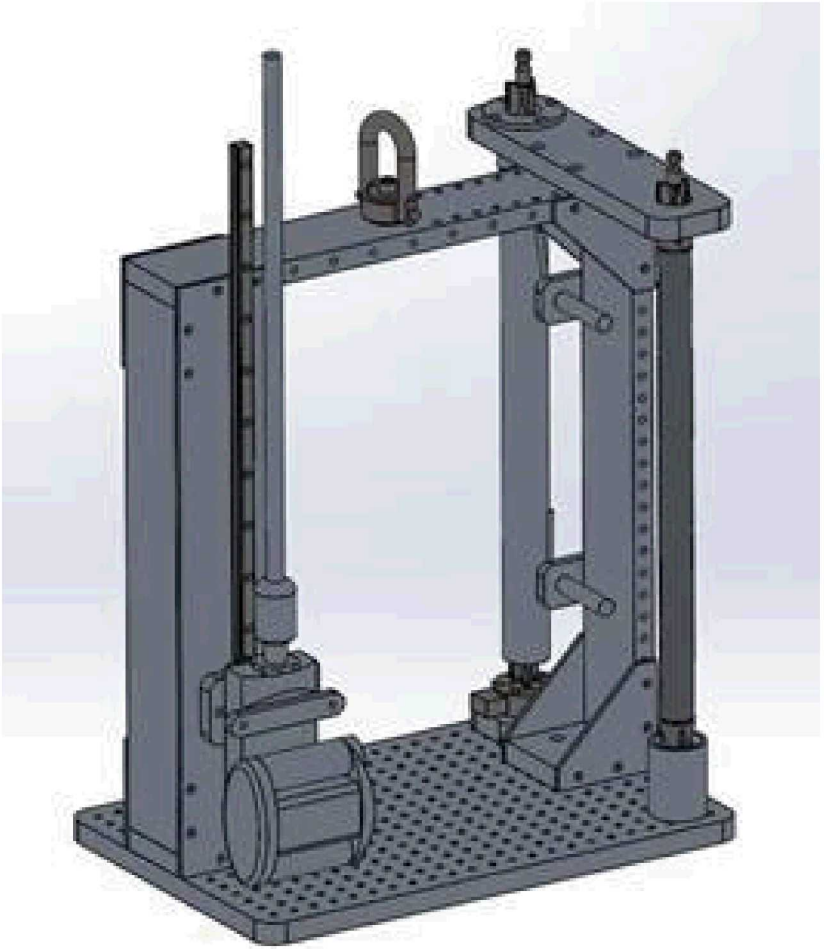
Future Work

- Developed a system for advanced fuel inspections
- A testing rig has been built to hold the fuel element
- Inspections include: visual inspections, ultrasonic testing, Go/No-Go fit testing, and hermeticity testing
- Core fuel inspections planned for next Spring 2021



The End

- Thank you for your time
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