NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Corrective Action Program at NIST

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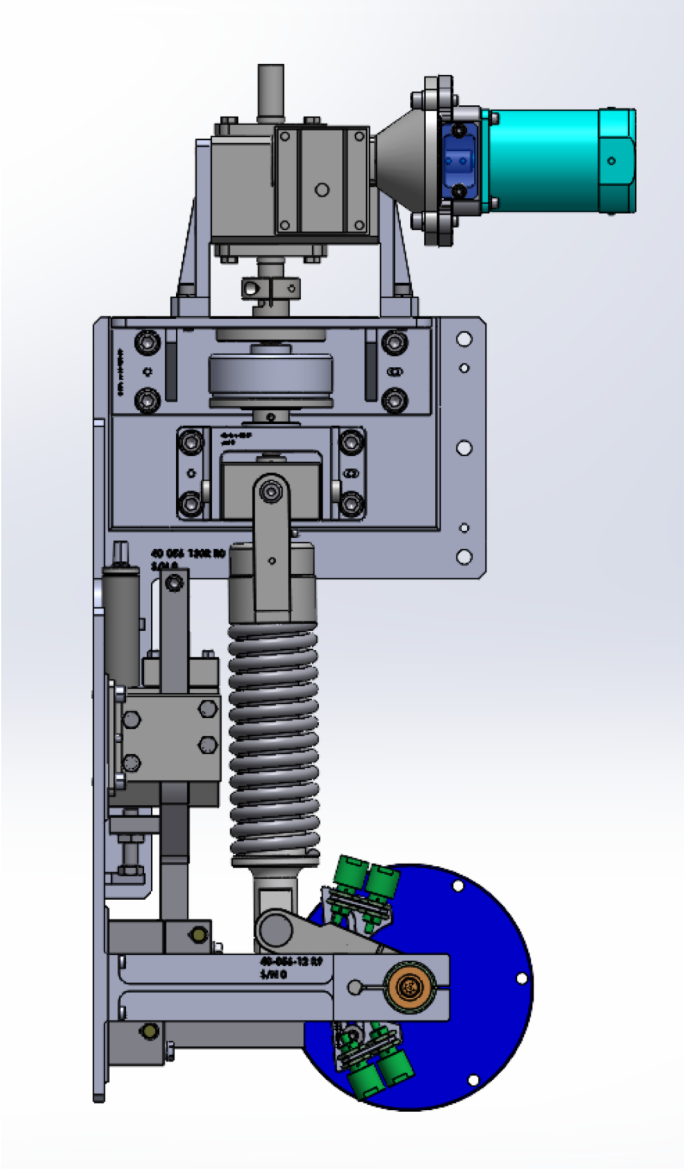
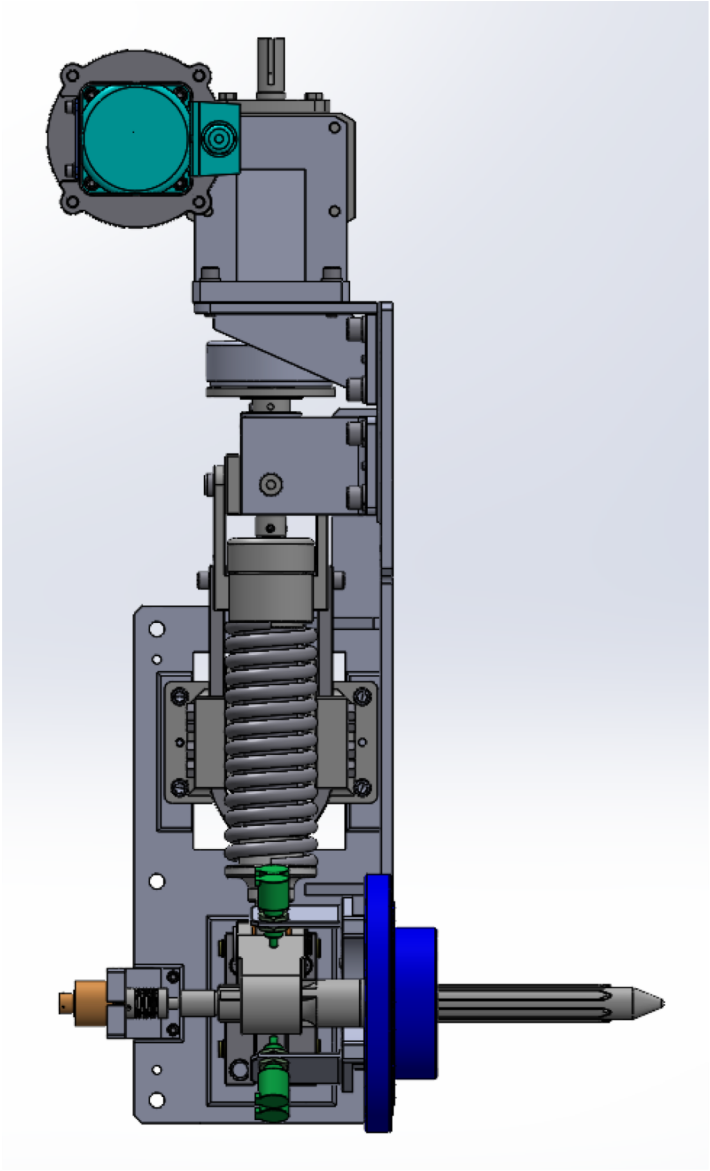
CENTER FOR NEUTRON RESEARCH

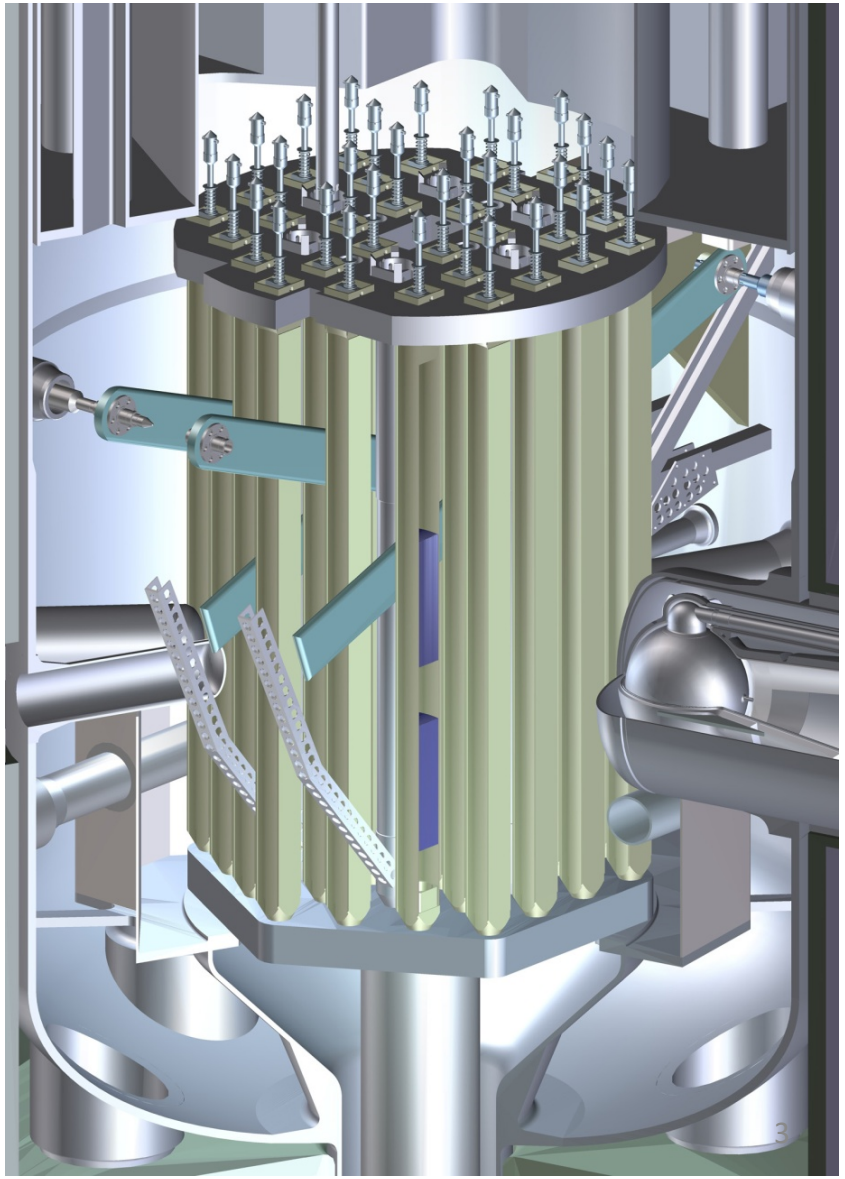
Bit of a back story

- NBSR has 4 shim arms
  - Each arm has an independent drive mechanism
  - Controlled from the Reactor Console in either gang or individual mode.
  - Shim Arm Drives move at one constant speed in and out of core
- The new design would eliminate some common issues all 4 drives shared.
  - Position indicator potentiometer failure
  - Ball Screw binding/failure
  - Misalignment between Shim Arm Shaft & Drive
- Shim Arm Drives were a multi-year redesign effort

Shim Arm/Shim Arm Drive Mech…







Still setting the scene

- Installation occurred during a 4-month outage in 2017
- Small teething issues during installation
  - Alignment issues with Shim Arm Shaft and Drive
  - Alignment issues with new position indication system
  - Loose contamination due to 40+ years of small primary leaks pass shaft seals
- In the end, all 4 shim arm drives passed prescribed testing
- Reactor successfully restarted in early 2018

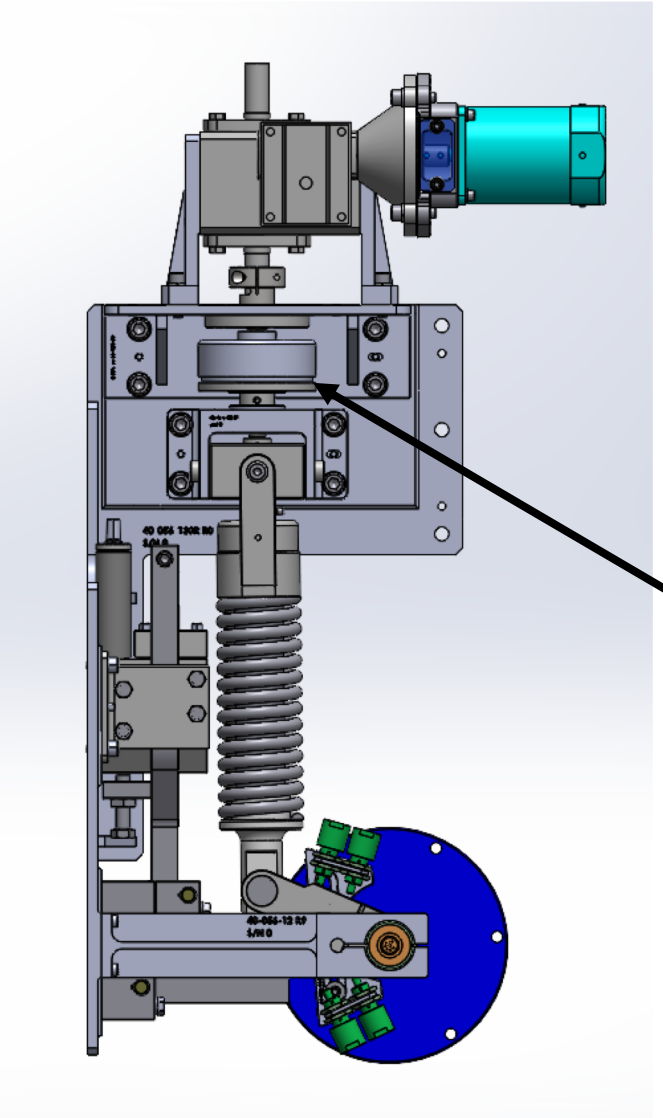
Alignment issues

- Steel frame with pins designed and fabricated in house
- Frame installed in 3 steps
  - Arm bolted to frame to center installation on Shim Arm Drive Shaft
  - Tac weld and alignment re-checked
  - Finally, a skip weld of frame to cavity and final check of alignment

Refurbished Cavities

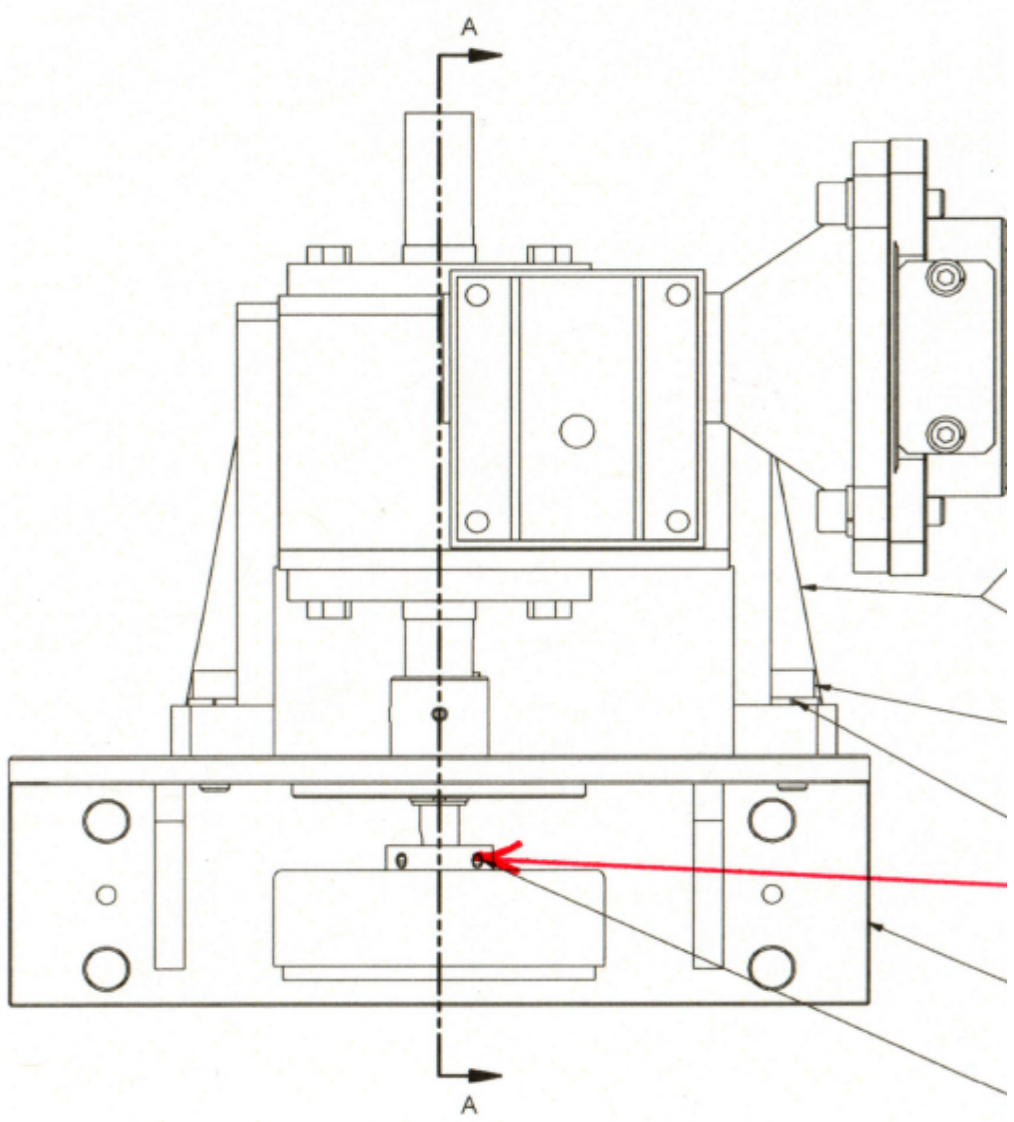
Initial issues post installation

- Air gap is required in design to allow for TS required scram times
- ~.040”-.060”
- Gap begin closing in cavity 3 months after installation



First fix attempt

- Multiple ECNS to address the issues were produced.
- Set screws were found backed so we zeroed in on that being our problem
- The Fix
  - Increase the seating torque
  - Use jam screws to keep the set screws in place



February 3rd & The Cap Program

- Normal reactor startup w/ an unlatched fuel element
  - Unlatched element suffered damage to fuel cladding
- One condition for re-start in the Confirmatory Order was to establish a Corrective Action Program (CAP)
- Cultural change included a greater emphasis on ECN quality.
- CAP has existed at the NCNR for ~ 2 years now

CAP Program

- Purpose:
  - Document identified issues
  - Evaluate their significance
  - Allocate resources to correct them
  - Monitor process to completion
- 4 Levels of designation
  - Level 0 – Minor equipment failures, findings from report/critique
  - Level 1 – Multiple re-occurrences of a Level 0
  - Level 2 – Systemic issue
  - Level 3 – Reactor safety consequences, Elevated by NCNR Management

2nd fix

- Modified gear clutch shaft
- Hinged coupling designed and installed
- Gap begin closing ~3 months after installation

3rd fix

- After the completion of rod calibrations, #3 shim failed to scram
  - In cavity inspection determined that the gap for #3 shim was non-existent.
- Cap #333 created (Level 2)
- CAP Investigation Team formed
  - Team: David Hix, Dan Mattes, David Griffin, Connor Miele, and Sam MacDavid (Strader/Sahin Oversight)
  - Team should be small enough to focus on the problem statement
  - Contain SMEs/stakeholders
  - For higher level CAPs, management attendance should be considered

Investigation Team Meeting Format

- Meetings held daily with investigation team
- Meeting flow
  - As found
  - Extent of condition
  - Determine problem statement
  - 5 why’s
  - Root cause determination
  - Determination of corrective actions
  - Testing to determine effectiveness of repair

Investigation Team Results

5 Why's and Root Cause

1 Why?	After performing rod calibrations #3 shim clutch chattered upon a scram indicating that the clutch gap was below it's minimum value.
2 Why?	It was observed that there was no clutch gap on #3 shim clutch.
3 Why?	Further investigation showed that the hinged coupling had moved down the gear box output shaft closing the gap.
4 Why?	Video of the shim movement confirms that the shaft is moving when the shim is moving. The oscillations observed in the video makes it evident that there may be an alignment issue between the gearbox output shaft and the lower clutch plate shaft.
5 Why?	Alignment of the gear output shaft and the lower clutch plate shaft was out of the clutch specification.

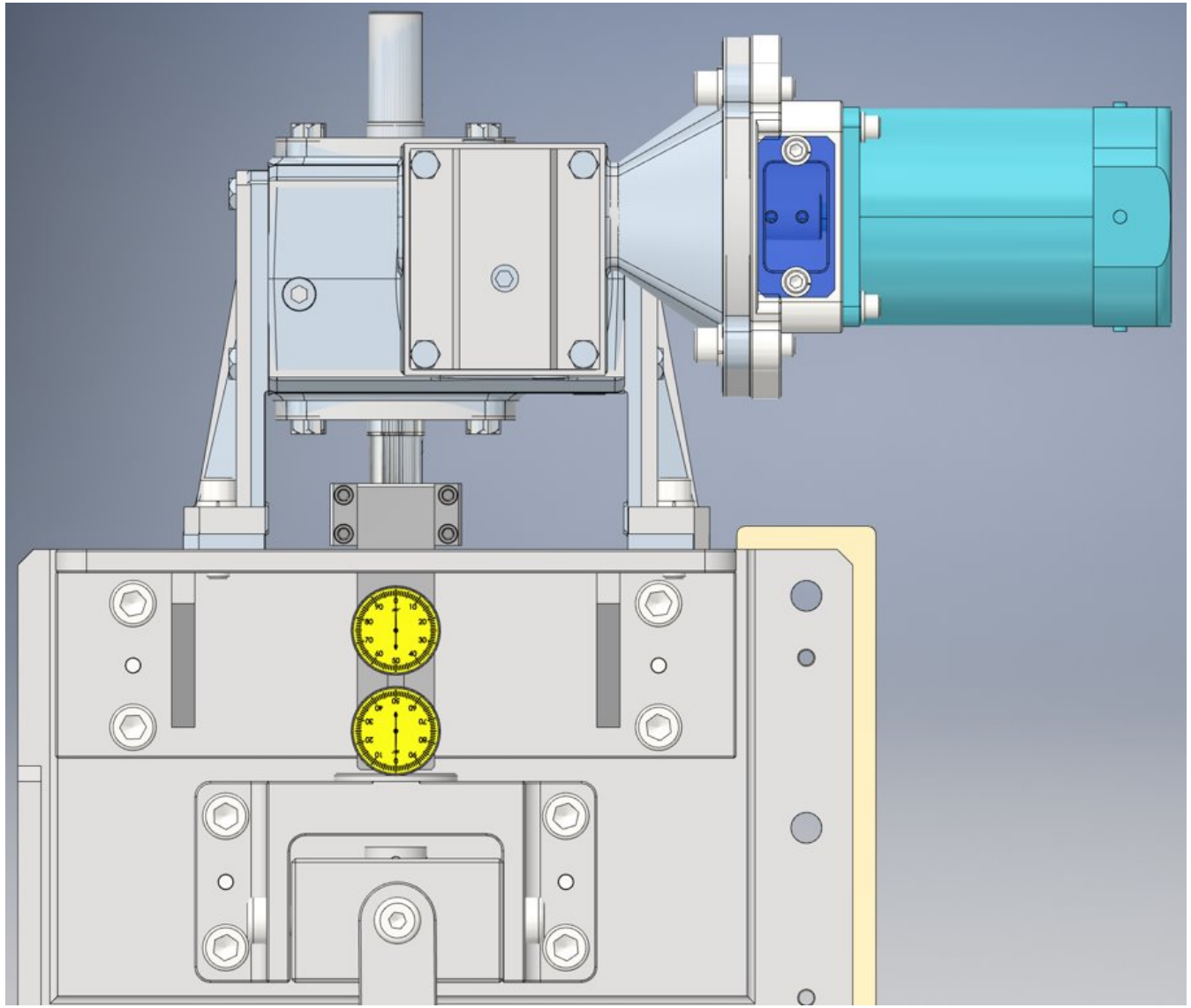
Root Cause: The misalignment between the gear box output shaft and the lower clutch plate shaft caused the upper clutch shaft to move during normal shim movements.

Corrective Action: Align the gear box output shaft to the lower clutch plate shaft. See document "CAP 333 Shim Arm 3 Shaft Alignment"

Extent of Conditions: The shafts of #1, 2, and 4 shafts have not been aligned and will require alignment.

Corrective Action

- Alignment issue between the motor output shaft and upper clutch assembly
- Angular mis-alignment reduced to ~ zero°
  - Fixed by shimming gear box feet
- Parallel misalignment ~.010”
  - Fixed by rough adjustment of gearbox feet in reference to support bracket



Corrective Action

- Correction was re-produceable on all 4 shim drives
- Maintenance procedure can be used for all future gearbox/lower clutch alignment issues.
- CAP entry allowed me to produce this presentation from documentation and not from memory

Questions?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