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Industry Plans to Address Thermal Sleeve Operating Experience

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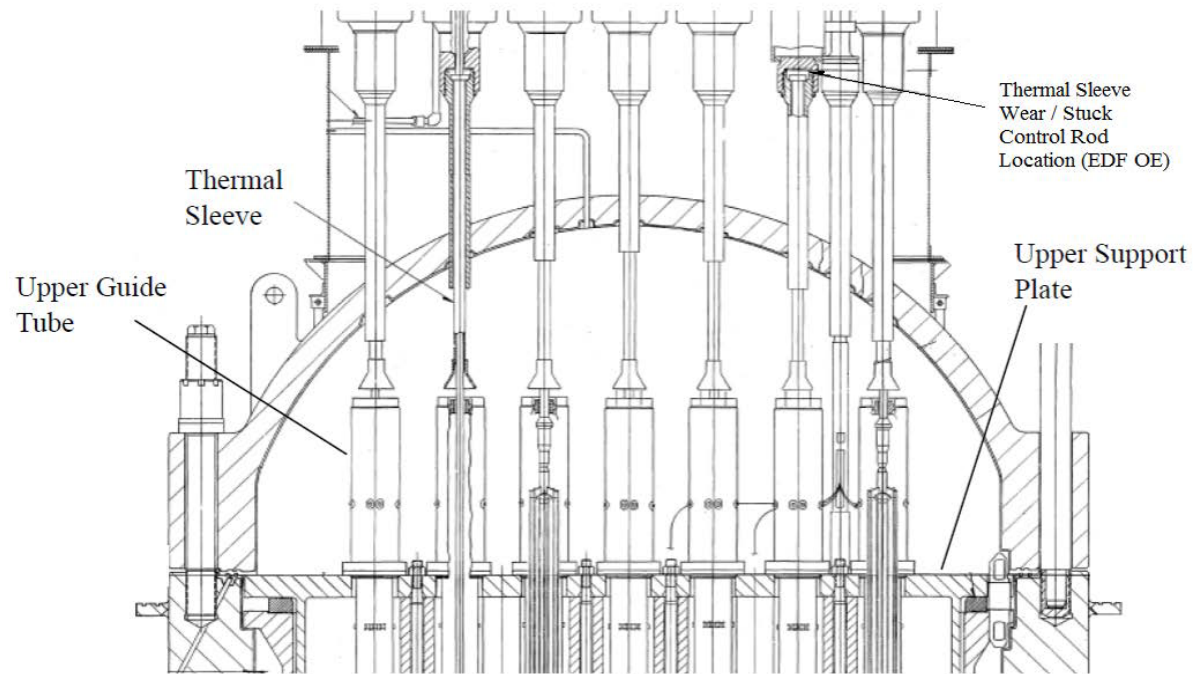
RAI 28 – Impact of Recent Thermal Sleeve OE

NRC RAI 28

During the May 2018 Materials Information Exchange Meeting, the Electric Power Research Institute, Materials Reliability Program (EPRI-MRP) and the Pressurized Water Reactor Owner's Group (PWROG) Materials Subcommittee made presentations describing recent operating experience with accelerated wear of control rod drive mechanism (CRDM) thermal sleeves (ML18142A395, ML18142A457). This wear has the potential to generate loose parts which could jeopardize control rod insertion.

Describe how this operating experience will be addressed in MRP-227, Rev.1.

Overview of the Thermal Sleeves



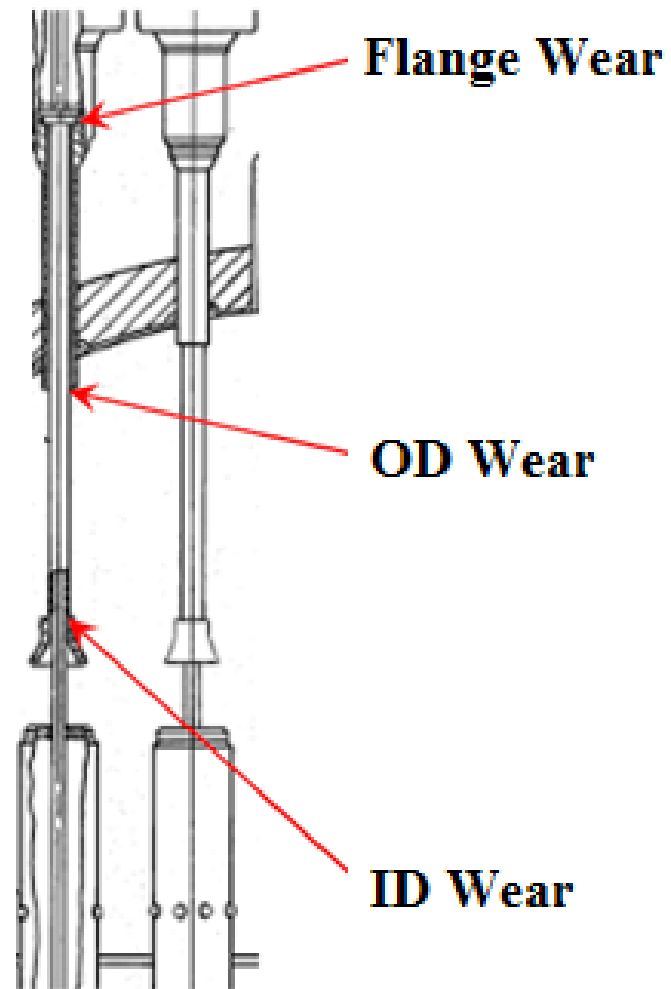
- Located at all CRDM housing locations with full-length drive rods, at reactor vessel level-indicating system probe locations, and some other locations
- Protect the CRDM drive rod from coolant flow, direct coolant flow during scram events, and limit the temperature increase in the CRDM housing

Thermal Sleeve Wear

- Three types of thermal sleeve wear have been observed
 - Sleeve outer diameter wear
 - Sleeve inner diameter wear
 - Flange wear
- OD wear occurs where the sleeve contacts the head penetration housing, creating a step
- ID wear occurs near the bottom of the sleeve due to contact with the drive rods – can result in separation of the guide funnel from sleeve
- Flange wear occurs on the bottom side of the flange where it contacts the CRDM housing – can result in separation of the sleeve and flange dropping the sleeve
- Flange wear is covered by Part 21 report (ML18143B678)

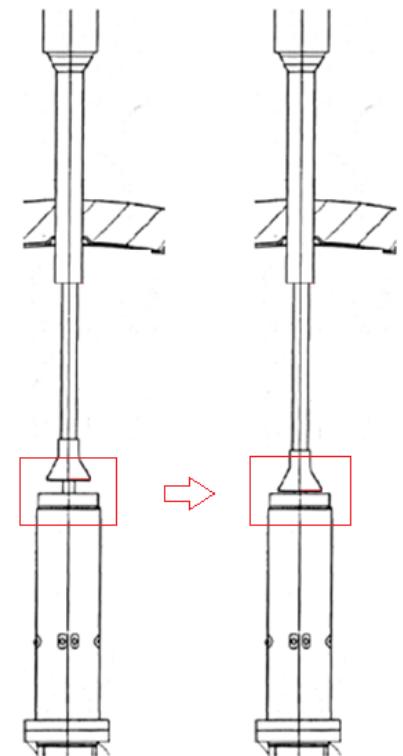


Examples of Thermal Sleeve Wear



Background on Historical Thermal Sleeve Wear

- OD and ID wear first observed around the 2007 timeframe
 - First plant detected wear during an Alloy 600-related ISI
 - Plants with high cross-flow in the upper head are more susceptible
- Flange wear first detected at one US plant in 2014
 - Flange wore through and thermal sleeve dropped
 - Plants with high cross-flow in the upper head expected to be more susceptible
 - Distance between bottom of thermal sleeve and top of CRGT assembly affects the potential for early detection or complete failure
 - OE resulted in TB-07-2 Rev.3
- Stuck control rod due to a failed thermal sleeve flange identified at an EdF plant during startup in 2017
 - Flange remnant wedged in the path of the control rod
 - Freed by exercising control rod but then stuck again
 - OE resulted in NSAL-18-1



Communications on Thermal Sleeves

- TB-07-2
 - Originally issued to address OD wear (2007)
 - Current Revision 3 includes flange wear (2015)
 - Flange wear recommendations superseded by NSAL-18-1 (2018)
- Documents for wear evaluation and disposition
 - WCAP-16911, Revision 0 (7/2008) – disposition and prediction of ID/OD wear
 - PWROG-16003-P, Revision 1 (8/2017) – acceptance criteria for thermal sleeve lowering due to wear and flange wear prediction
- Notifications of the potential safety issue with flange wear
 - WANO event report 2018-0110 – EdF notification (3/1/2018)
 - EPRI OE notification letter MRP 2018-010 (4/20/2018)
 - NRC event report 53422 (5/23/2018)
 - Notification of potential Part 21, LTR-NRC-18-34 (5/23/2018)
 - Nuclear safety advisory letter NSAL-18-1 (7/17/2018) (ML18198A275)
 - NRC information notice 2018-010 (8/29/2018) (ML18214A710)
 - Interim guidance for inspection, MRP 2018-027 (8/31/2018)
 - Interim guidance provide to NRC via MRP 2018-033 (9/5/2018)

Thermal Sleeve Interim Guidance

- Issued as NEI 03-08 “Needed” guidance in EPRI letter MRP 2018-027
 - Transmitted to NRC via MRP 2018-033, dated 9/5/2018
 - Makes the NSAL-18-1 guidance “Needed” under NEI 03-08 Materials Management Initiative
 - Conservatively adjusts the NSAL-18-1 initial inspection requirement from 25 to 20 EFPY
 - Provides inspection guidance for the Table 1 and 2 plants in NSAL-18-1
 - Guidance is applicable to units with CRDM thermal sleeves installed in either original or replacement heads

Thermal Sleeve Interim Guidance

- MRP 2018-027 guidance:
 1. Units which are between 20 and 25 EFPY shall perform the dimensional measurements and/or visual inspections outlined in the “RECOMMENDED ACTIONS” section of NSAL-18-1 no later than the first refueling outage after 1/1/2019.
 2. Units which have exceeded 25 EFPY shall perform the dimensional measurements and/or visual inspections outlined in the “RECOMMENDED ACTIONS” section of NSAL -18-1 during the next refueling outage after issuance of this interim guidance.
 3. As an alternative, T-hot units may implement the “RECOMMENDED ACTIONS” for T-cold plants, if desired.
 4. Dimensional measurements and/or visual inspections performed prior to 1/1/2019 are acceptable.
 5. There are no recommendations for units that have less than 20 EFPY on their original or replacement reactor vessel closure head.

Thermal Sleeve Interim Guidance Details (1)

1. Units which are between 20 and 25 EFPY shall perform the dimensional measurements and/or visual inspections outlined in the “RECOMMENDED ACTIONS” section of NSAL-18-1 no later than the first refueling outage after 1/1/2019.
 - T-cold and T-cold capable plants
 - Perform measurements of the thermal sleeve lowering using as-built elevation relative to a reference point
 - Determine further actions or re-inspection frequency based on inspection results and acceptance criteria
 - T-hot plants
 - Perform visual inspection of the top of the upper guide tubes for evidence of lowering and wear during each refueling outage
 - Perform visual inspection of the bottom of the thermal sleeve guide funnels for evidence of lowering and wear
 - Implement the inspection and mitigation strategies recommended for T-cold plants if evidence of advanced wear is detected
2. Units which have exceeded 25 EFPY shall perform the dimensional measurements and/or visual inspections outlined in the “RECOMMENDED ACTIONS” section of NSAL-18-1 during the next refueling outage after issuance of this interim guidance.
 - Same inspection and evaluation requirements as Item 1 above

Thermal Sleeve Interim Guidance Details (2)

3. As an alternative, T-hot units may implement the “RECOMMENDED ACTIONS” for T-cold plants, if desired.
 - More conservative option for management of the lower susceptibility plant designs
 - T-hot plants have lower cross-flow in the upper head region by design
4. Dimensional measurements and/or visual inspections performed prior to 1/1/2019 are acceptable.
 - Interim guidance does not implement new requirements on the exact implementation of the inspection itself
 - Visual inspections are not a replacement for physical measurement where measurement is required
5. There are no recommendations for units that have less than 20 EFPY on their original or replacement reactor vessel closure head.
 - Slightly more conservative than NSAL-18-1 recommendations

Thermal Sleeve Interim Guidance and MRP-227, Rev. 1

- Interim guidance of MRP 2018-027 is first step in addressing the potential safety issue of thermal sleeve flange wear
- Additional guidance may be warranted as OE or industry understanding increases
 - More precise information on unit susceptibility
 - Revised timing of inspection requirements
 - Broader coverage of acceptance criteria
- Plan to develop document to detail inspection and evaluation requirements
 - Complete a revision of existing PWROG-16003-P proprietary report (due mid-2019)
 - Reference thermal sleeve report PWROG-16003-P in future MRP-227 revisions
 - This is similar to the aging management approach used for control rod guide tube guide card wear (i.e., WCAP-17451-P proprietary report)
- Industry proposes incorporation of EPRI letter MRP 2018-027 interim guidance in MRP-227 Revision 2 (4Q2020)
 - Industry's interim guidance addresses near-term inspections for 2018-2020

Questions?



The Materials Committee is established to provide a forum for the identification and resolution of materials issues including their development, modification and implementation to enhance the safe, efficient operation of PWR plants.



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