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Materials Reliability Program Update

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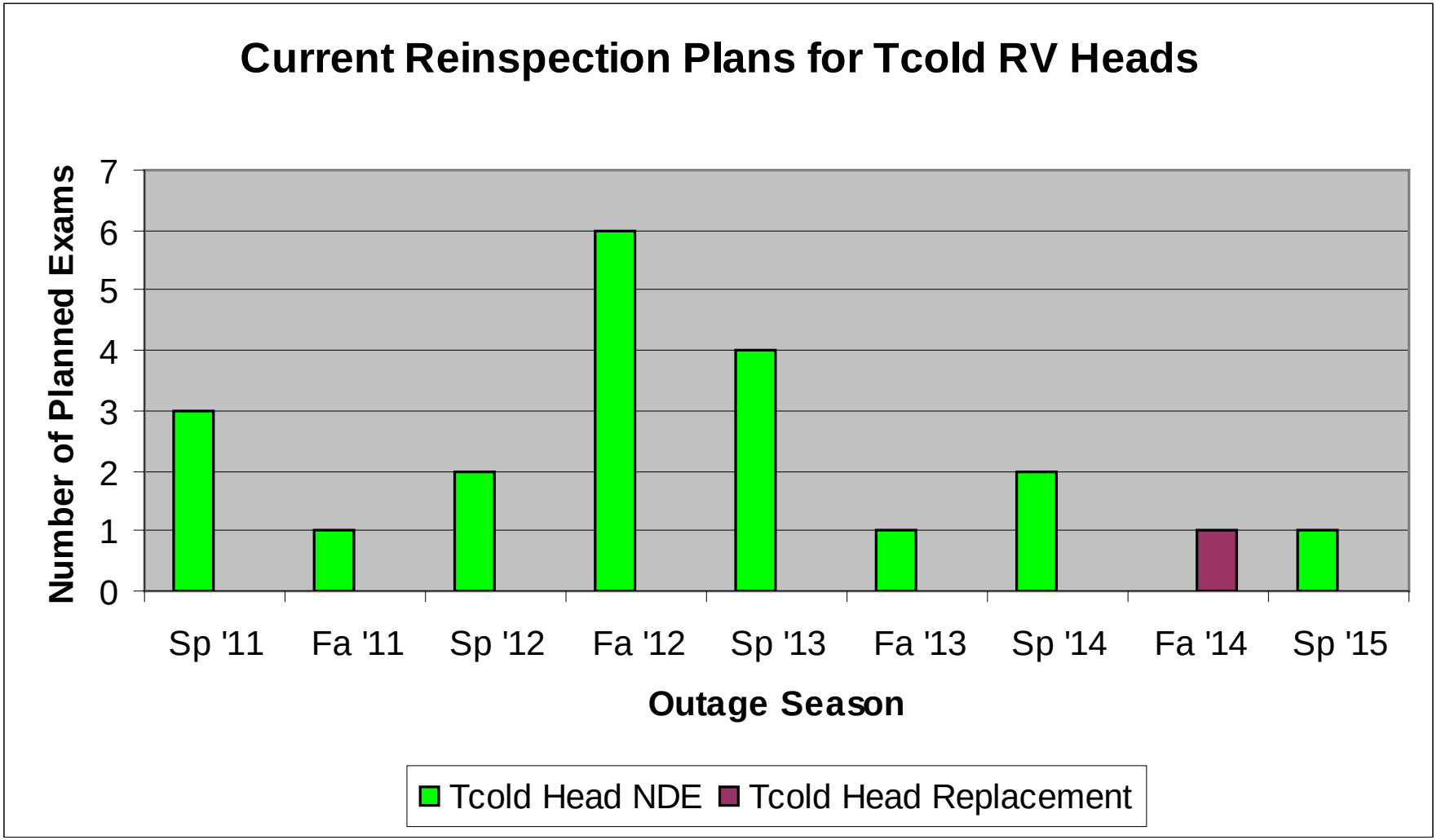
T_{cold} RV Heads Inspection Results Summary

- PWSCC indications have been detected in four U.S. cold heads:
  - 2007 in one CRDM nozzle
    - Associated with lack-of-fusion defects
  - 2011 in four CRDM nozzles
    - Included some base metal flaws not connected to the weld
  - 2012 in four CRDM nozzles
  - 2012 in one CRDM nozzle
- PWSCC degradation was detected in its relatively early stages
  - With modest numbers of nozzles affected by part-depth cracking
  - More often located below the weld, where the nozzle tube is inside (not directly a part of) the pressure boundary

Recent Industry-NRC Interaction

- A detailed assessment of the U.S. inspection experience for Alloy 600 top head nozzles through 2011 has been previously provided:
  - *MRP Letter 2011-034, dated December 21, 2011, NRC ADAMS Accession No. ML12009A042*
- An overview presentation including spring 2012 inspection findings was made July 19, 2012 at the International BWR & PWR Materials Reliability Conference
  - *PWR Reactor Vessel Top Head Alloy 600 CRDM Nozzle Inspection Experience*
- Discussed during industry-NRC technical exchange meeting July 20, 2012

T_{cold} Head CRDM Reinspection Plans



T_{cold} Head CRDM Inspection Plans

- Information of note from the re-inspection schedule
  - Five of the six 2nd examinations have been of one penetration tubing manufacturer (B&W tubular products)
  - 2nd examination of final Tcold closure head containing B&W tubular products will occur this Fall
  - Fall 2012 will include examination of five additional Tcold closure heads of other manufacturers (2-Sandvik, 3-Huntington)
  - Spring 2013 scope will include four additional Tcold closure heads (all Huntington)
- Industry will better understand if earlier degradation is biased towards a particular manufacturer

Assessment of T_{cold} RV Heads Inspection Results

- Plant experience to date indicates a somewhat higher probability of crack initiation for cold heads than assumed in the MRP safety assessments published in 2004
  - However, this is concluded to have an acceptably small effect on the probability of nozzle ejection per MRP-105
  - Inspection results since 2004 confirm that the MRP-105 approach includes rather significant sources of conservatism
- Current reinspection requirements have been effective in detecting the PWSCC reported across the fleet in a timely fashion, before the degradation produces flaws of safety significance

T_{cold} RV Heads Conclusions

- The time-at-temperature approach (EDY and RIY) has been effective to prioritize baseline NDE inspections and set NDE inspection intervals
- Material and fabrication factors are also apparent in the inspection results
- ASME Code Case N-729-1 inspection requirements for Alloy 600 top head nozzles are still concluded to be conservative and adequate to ensure nuclear safety with respect to the PWSCC degradation concern
- Industry will continue to closely monitor and assess inspection results, particularly for Tcold heads, against the relevant technical bases

Bottom Mounted Nozzle Recent Operating Experience

- **Tracking recent foreign OE on BMN cracking as details can be released to MRP**
  - Additional evaluation results expected ~August
  - BMN volumetric exam schedule requested from subject utility as background information (# units by outage season)
  - Factor in other inspection results
- **This OE is significant and will be evaluated against current inspection guidance**
  - ASME CC N-722-1
  - MRP-206 - *Inspection and Evaluation Guidelines for Reactor Vessel Bottom-Mounted Nozzles in U.S. PWR Plants,* published as a technical basis but not issued as guidance (pre-empted by N-722-1 rulemaking)

Bottom Mounted Nozzle Recent Operating Experience

- **Going forward**
  - MRP-206 – *I&E Guidelines for Reactor Vessel BMNs* – MRP to assess need to update
  - MRP and NRC have agreed to share (to the extent permitted) any new intelligence on French inspection plans
  - Strategic planning
    - BMNs included in revised peening technical basis, topical report
    - Repair capabilities
    - Improve inspection capabilities

PWR Reactor Internals Operating Experience

- Two units have completed MRP-227 examinations since 2011 meeting:
  - Robinson – Extensive visual examinations - no findings
  - Surry-2 – Visual exams and baffle-former bolt volumetric examinations
    - Two bolts with indications out of >1000
    - No visual findings
- Completed review of DC Cook baffle-former OE with no additional recommendations beyond MRP-227-A
- MRP to publish MRP-228 revision 1 this year
  - Updates visual examination guidance

PWR Reactor Internals Operating Experience

- Industry is working towards a future revision to MRP-227-A to incorporate:
  - Updated CRGT guide card recommendations
  - Updated technical bases to address certain Topical Report conditions and licensee action items
  - Issues identified during initial examinations
  - NRC review/approval of WCAP-17096 acceptance methodologies
- Industry's issue programs (MRP, PWROG-MSC) responsible for PWR internals guidance and support are well-coordinated

PWSCC Mitigation by Peening Status

- MRP to publish MRP-335 and MRP-267 Revision 1 late summer
  - MRP-335 is technical basis for inspection relief for peening mitigation of alloy 600 / alloy 82/182 locations
  - MRP-267 Revision 1 is updated to include UHP and BMN mitigation of PWSCC by peening technical basis
- MRP intends to submit MRP-335 for NRC review and approval
  - Will request fee waiver
  - Review will ensure earlier implementers address NRC questions
  - ASME Code revision route to trail slightly
- Foreign and domestic vendors collaborating to bring proven technology to US fleet

Coordinated Reactor Vessel Surveillance Program (CRVSP)

- *Coordinated PWR Reactor Vessel Surveillance Program (MRP-326)*
  - Produces high fluence data (3-10 x10^{19} n/cm^2) from remaining Appendix H capsules by 2025 to support future Embrittlement Trend Curve (ETC) development
    - CRVSP defers capsules only if >3E+19 n/cm^2 attained by 2025
  - Implemented as a "Needed" guidance under NEI 03-08
    - 13 plant schedules affected
- Requires NRC approval to implement schedule changes

CRVSP Results

- Number of total capsules to be tested by 2025 at or above the stated fluence

Fluence (n/cm^2)	Pre-CRVSP	CRVSP
$\geq 3.0 \times 10^{19}$	25	29
$\geq 6.0 \times 10^{19}$	7	12
$\geq 8.0 \times 10^{19}$	1	5
$\geq 9.0 \times 10^{19}$	0	2

- CRVSP will increase fluence levels of many remaining capsules

PWR Supplemental Surveillance Program (PSSP)

- Design/Fabricate/Irradiate a supplemental surveillance capsule(s) containing previously-irradiated PWR materials
  - Specimens can be reconstituted (ASTM E1253) either before or after irradiation and then tested
  - Goal: Obtain 15-30 new high-fluence data points
- Materials selected based on information value to the PWR ETC
- For research use, not plant-specific surveillance
  - Plants would not revise P-T operating curves from PSSP data
- NRC approval will be required to use surveillance material
  - MRP can facilitate Plant Regulatory interaction
    - *Staff interaction needed to define regulatory expectations*

PSSP Design and Planning

- Optional PSSP approaches
  - Fabricate one capsule containing inserts that are reconstituted after further irradiation
    - Lower initial cost but higher lifetime cost and higher risk to success
  - Fabricate two capsules, reconstitute specimens before capsule fabrication
    - Redundancy reduces risk from host plant issues
    - Allows for different fluence increments
- PSSP development spread over three years, 2012-2014
  - Planning for host plants and materials has started
- Goal: insert capsule(s) in 2014
  - Irradiate ~9 years

Concluding Remarks

- MRP is focused on the resolution of materials issues associated with PWR primary systems and components
  - MRP continues to make significant contributions to the industry in nickel-base alloys, stainless steels, reactor internals, reactor pressure vessel integrity and fatigue areas
  - MRP continues to monitor PWR operating experience and assess inspection results against the relevant technical bases for inspections

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