PWR Reactor Internals Categorization and Risk Ranking Analysis - 2018

Updates to MRP-191 for SLR

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EPRI and NRC Public Meeting, May 1, 2019, Rockville, MD

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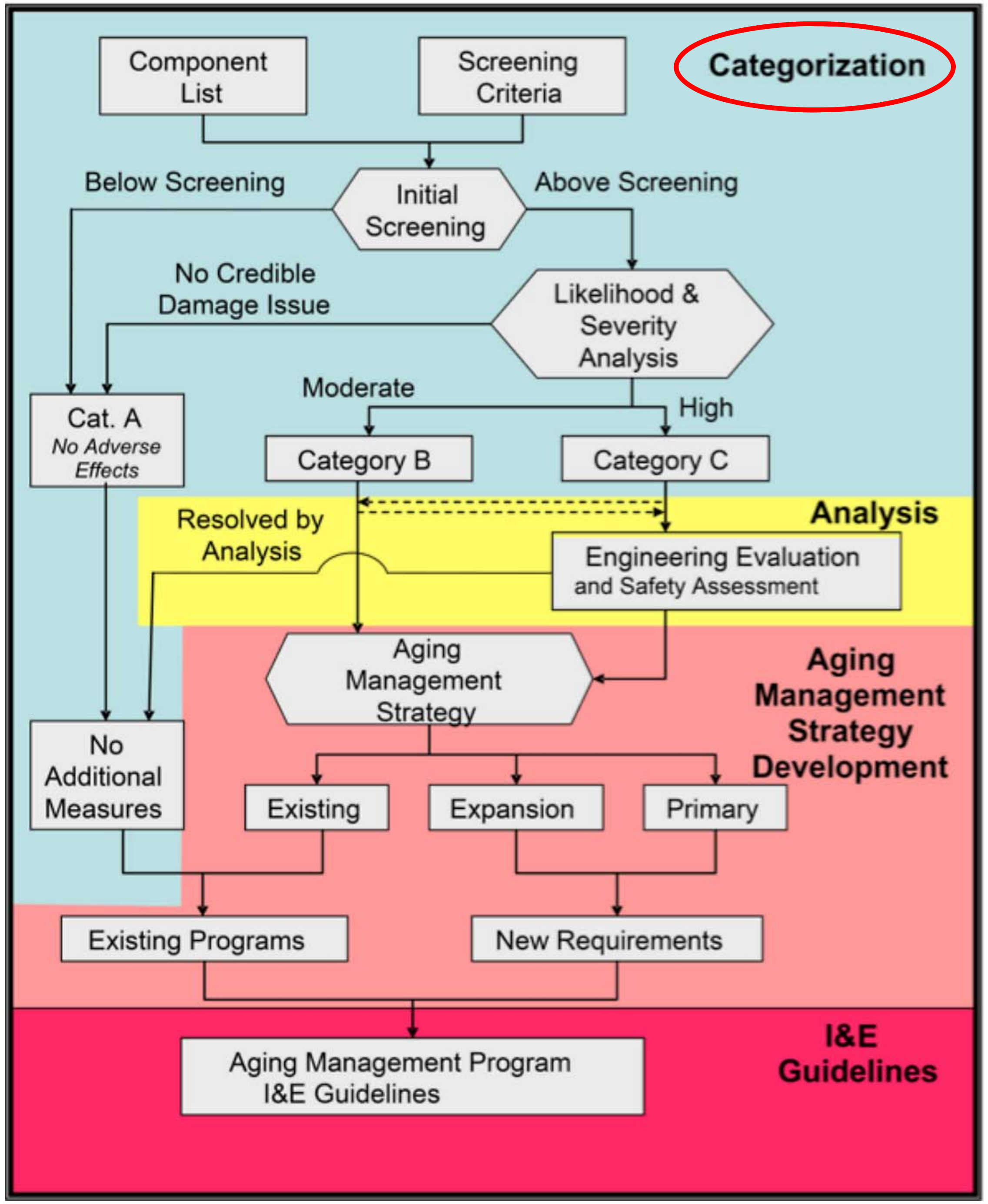
Background

- MRP-191 Rev.0 originally published in 2006 (ML091910130)
- Revision 1 published in 2016 and submitted for information in October 2017 under MRP 2017-025 (ML17289A507)
  - Incorporated updates from plant A/LAI 1 and 2 responses
  - Supported MRP-227, Revision 1
- Document performs critical role in developing MRP-227
  - Lists in-scope components for CE and Westinghouse plants
  - Compiles the input parameter results for the components (dose, stress, fatigue, wear, preload, etc.)
  - Documents the results of expert panel evaluations for component susceptibility and risk
  - Contains applicability criteria for MRP-227

Background (cont.)

- MRP-191 contains everything in the "Categorization" box
  - Provides key input to downstream steps
  - Made updates based on new data and OE
- Higher risk category components
  - Receive additional engineering assessment
  - Become leading components
- Approach is the same as for MRP-227, Rev. 0 and 1



Gap Analysis for Subsequent License Renewal (SLR)

- Overall program is focused on bridging the "gaps" (NUREG-2191)
  - Between MRP-227-A and SLR
  - Between MRP-227-A and developments since its publication (MRP-227, Revision 1, operating experience, etc.)
- Screening basis published in 2017 (MRP-211 and MRP-175) (ML17361A168)
  - MRP-211, Revision 1 summarizes the available degradation data
  - MRP-175, Revision 1 provided the screening criteria for the current work
  - MRP-175 and MRP-211 were discussed at a public meeting with NRC on February 13-15, 2018 (ML18025B454)
- Today's discussion will focus on differences, similarities, and application of the MRP-191 Revision 2 for SLR (ML19081A060)
- Consideration should be given to updating ISG for GALL-SLR

Differences in MRP-191 Revision 2 from Prior Revisions

- Changes to how categorization is determined
- Separation of Safety and Economic consequences
- Inclusion of environmental effects of fatigue for screening
- Operation through subsequent period of extended operation
  - Impacts accumulating time-based effects
  - Fatigue increases with cycles accumulated
  - Fluence-driven degradation mechanisms increase with dose

Adjustments to Ranking and Categorization Assignment

- Impact of failure likelihood on FMECA results was increased
  - Provides more weight to actual observed degradation (OE from PWRs)
  - Provides more weight to items with high expectation for degradation
  - Conservative relative to previous revisions
- FMECA group number is a key input to the final risk Category (A, B, C) and risk ranking

MRP-191, Revision 0 and 1:
Table 6-4: Reactor internals FMECA (significance) groups

Failure Likelihood	Consequence (Damage Likelihood) Low	Medium	High
High	2	3	3
Medium	1	2	3
Low	1	1	2
None	0	0	0

MRP-191, Revision 2:
Table 6-5: Reactor internals FMECA (significance) groups

Failure Likelihood	Consequence (Either Safety or Economic) Low	Medium	High
High	3	3	3
Medium	2	2	3
Low	1	1	2
None	0	0	0

Separation of Safety and Economic Consequences

- MRP-191 Revisions 0 and 1 treated Safety and Economic considerations together in the "Consequence" assignment
- Consequences were separated throughout the updated evaluation
  - Started with the failure modes, effects, and criticality analysis (FMECA) assignment and carried through the categorization and risk ranking
  - Created definitions for both safety and economic in support of the evaluation
  - Two FMECA results were developed for each component
  - Safety and Economic consequences incorporated within risk analysis "heat maps" in MRP-191 Revision 2 Appendix E and Appendix F
- Improvement over the previous revisions
  - Prevents assigning safety concern to components that have high consequence due to economic issues
  - Permits the user to understand which components require aging management for safety concerns and which require asset management for economic concerns

Screening Treatment of Environmental Effects of Fatigue

- Previous MRP-175, Revision 0 screening criteria addressed potential environmental effects with 40-year screening of CUF > 0.1
- MRP-175 Revision 1 screening applied more conservative approach
  - Used a 14x environmental factor from NUREG-6909
  - CUF ≤ 0.036 at 40 years for 80 years planned life screens out
  - CUF ≤ 0.028 at 40 years for 100 years planned life screens out
- Other screening criteria for bolted or spring items with irradiation stress relaxation and creep were kept the same in Revision 1
- Based on SER for MRP-227, Revision 1, applying environmental effects like this is unnecessary for internals → very conservative

Accumulating Degradation Mechanisms (Fatigue)

- MRP-175, Revision 1 updated fatigue screening to account for SLR
- Expert panel supplied fatigue results developed for the review:
  - Components screened in at CUF > 0.1 for previous revisions automatically screened in
  - Existing fatigue usage calculations examined for CUF values
  - Fatigue expert elicitation conducted for components without calculations
- MRP-227-A base load assumption still applies

	CE	Westinghouse
Approximate % Components with CUF > 0.1 from Rev. 1	19%	24%
Approximate % Component with Calculated CUF	22%	32%
Approximate % Components Evaluated by Expert Panel	59%	44%

Accumulating Degradation Mechanisms (Fluence)

- Fluence-driven degradation mechanisms
  - Irradiation-assisted stress corrosion cracking (IASCC)
  - Irradiation stress relaxation and creep (ISR/IC)
  - Irradiation embrittlement (IE)
  - Void Swelling (VS)
- Mechanisms increase with dose with some saturation effects
  - IE saturates by 10 dpa and is effectively unchanged afterwards (excluding very high VS effects)
  - VS does not saturate, but the VS rate may eventually saturate
  - IASCC does not appear to saturate but above 10 dpa, dose effects are small
  - ISR/IC does not saturate, but will decrease as remaining preload decreases

Fluence Input Development

- Conducted fluence analysis to provide 80-year (72 EFPY) fluence inputs for Westinghouse and Combustion Engineering plants
- Followed same fluence ranges used in prior MRP-191 Revisions
  - Associated with degradation mechanism screening ranges from MRP-175
  - Fluence thresholds in MRP-175, Revision 1 have not changed
- Started with values from one CE plant, one 3-loop Westinghouse plant and one 4-loop Westinghouse plant
  - Values increased based on other plant cases with known higher parameters
  - Results considered "representative" similar to previous revisions
    - However, these results should not be construed as "bounding"
  - Values extended to designs that were not specifically analyzed

Fluence Input Development (cont.)

- Two dose projections were developed for each plant design
  - Flat axial distribution → conservative above and below the core
  - Best estimate distribution with margin → conservative radially from core
- Margin added to the distributions for conservatism:
  - CE: axial used as-is and 30% added to best estimate
  - W 3-loop: 30% added to axial and 60% added to best estimate
  - W 4-loop: axial used as-is and 30% added to best estimate
- Composite distribution of the axial and best estimate created by selecting the maximum values at each location

Accumulating Degradation Mechanisms (Time)

- Some degradation mechanisms have an inherent time component
  - Wear, Stress corrosion cracking (SCC), IASCC, Thermal embrittlement (TE)
  - Note that the time effect on other mechanisms is accounted for by increased fluence or increased fatigue usage
- Time aspect of these mechanisms included in MRP-175 Revision 1 screening criteria for use over the plant life
  - Wear: any component with potential relative motion
  - SCC: any component that exceeds threshold stress
  - IASCC: any component that exceeds threshold stress and dose
  - TE: any component that embrittles at reactor temperatures
- Time is already addressed by this conservative approach

Unchanged Aspects of MRP-191 Revision 2

- Process
  - Expert panel approach, with same member composition
  - Consensus approach on decisions
  - Screening → Categorization → Ranking
- Starting component list
  - Small number of additions will be discussed
  - Several clarifications made
- Assumptions affecting inputs (fuel management, base load operation, plant design changes)
- Role of document and results in MRP-227 Rev.2 development

MRP-191 Revision 2 Process

- Inputs for expert panel review
  - List of components and materials
  - Updated fluence and fatigue inputs and initial component screening
  - Drawings, sketches, and descriptions of components and assemblies
  - Definitions for review process
- Expert panel Review
  - Panel members covered the same MRP-191, Section 6 areas as before
  - Validated component list and screening, performed FMECA, and assigned risk ranking category
  - Applied a 100% consensus decision-making approach
  - Process is unchanged from previous revisions and documented in Section 6
- Results summarized in the MRP-191 report

MRP-191 Degradation Mechanism Screening

- Started with the updated screening criteria in MRP-175 Revision 1
- Applied MRP-175 Revision 1 criteria directly in three cases:
  - Wear: components with relative motion, clamping, or relaxed preload
  - Irradiation embrittlement: 1 dpa for CASS and welds and 1.5 dpa for austenitic stainless steel
  - Fatigue: CUF values as provided in MRP-175 Revision 1

MRP-191 Degradation Mechanism Screening (cont.)

- Applied more conservative criteria in the other cases:
  - IASCC: 1.5 minimum dpa instead of 3 dpa, > 30 ksi up to 15 dpa, and all components above 15 dpa, regardless of stress
  - SCC: screening per MRP-175 Revision 1 except all large welds screen in
  - Thermal embrittlement: all CASS materials screened in, regardless of ferrite content; welds were not screened in due to fabrication restrictions
  - Void swelling: components above 15 dpa screened in instead of 20 dpa; assumed that all components screened in due to dose also exceeded temperature
  - Irradiation stress relaxation and creep: components above 0.15 dpa screened in instead of 0.2 dpa

Scope of Components Evaluated

- MRP-191 Revision 1 added many components found during plant-specific MRP-227-A A/LAI 1 and 2 evaluations over the past 6-7 years
- MRP-191 Revision 2 expert panel added additional items
- Examples shown below
  - W: flux thimble anti-vibration sleeve, Type 316 LCP fuel alignment pins, thermal sleeve components
  - CE: Components from bolted plants removed (due to plant shutdown plans)
- Several clarifications also made
  - W: Bracket bolts and corner bolts specifically named, Sub-components of irradiation specimen plugs, Stellite wear surface of radial support keys and UCP alignment pins
  - CE: Clarified System 80 components

Input Applicability for the MRP-191 Rev. 2 Evaluation

- Assumptions were kept the same as used in MRP-227-A
  - Operation for 30 years or less with high-leakage core loading followed by low leakage loading – same core parameter limits as MRP 2013-025
  - Operation as a base load unit for majority of plant life
  - No design changes beyond those identified in general industry guidance or by the OEM
  - Updated basis for no design changes after November 2017
- Must be verified by a licensee as part of implementation (similar to A/LAI 1 on MRP-227-A)

Role of MRP-191 Rev. 2 in Developing MRP-227 Rev. 2

- Scoping – Defined the components that must be managed for extended operation (determined based on drawings and experts)
- Screening – Selected the components that could potentially experience aging degradation (assigned based on MRP-175)
- Categorization – Determined by expert panel through FMECA
  - Likelihood of degradation assigned (informed by OE)
  - Safety and Economic consequences assigned
  - Results in a FMECA group assignment
- Ranking – Assigned Categories A, B, and C (from expert panel)

Role of MRP-191, Rev. 2 Ranking Results in MRP-227

- Category A:
  - Components with aging effects below the screening criteria or that the panel considers to have minimal likelihood to cause failure
  - Components are screened out of further consideration for future steps in developing MRP-227 for SLR
- Category B:
  - Components above screening levels that are judged to have moderate susceptibility and potentially significant consequences, such that the effects on function cannot easily be dispositioned by screening but that do not rise to the level of lead items
  - Some components in Category B may be re-assigned to Category A if existing aging management is sufficient to preclude a concern
  - Components may require additional evaluation to be shown tolerant of the aging effects with no loss of functionality

Role of MRP-191, Rev. 2 Ranking Results in MRP-227 (cont.)

- Category C:
  - "Lead" components with aging effects above screening levels and high or moderate likelihood and aging degradation significance—not analytically demonstrated as sufficiently damage-tolerant to remain functional
  - Enhanced or augmented inspections or surveillance may be warranted under MRP-227
- Category C components are the primary focus for MRP-227
- Some Category C and B components will be evaluated analytically through modeling and other options (e.g., baffle-former-barrel)

Summary of Results

- Updates made to address parameters that increase for SLR
  - Fluence projections updated
  - Fatigue usage factors evaluated
- Expert panel reviewed the components and assigned risk ranking and categorization for SLR
  - Largest number of components remained in "No Additional Measures" category A
  - Smallest number of components in Safety Category C
  - Larger numbers of components in Economic Categories B and C than in the corresponding Safety Categories
    - Reflects expensive nature and economic risk of materials degradation

Number of Components in Each Risk Category

- Westinghouse components
  - Safety category C: 9 components
  - Economic category C: 21 components
  - Safety category B: 36 components
  - Economic category B: 43 components
- CE components
  - Safety category C: 1 component
  - Economic category C: 10 components
  - Safety category B: 17 components
  - Economic category B: 25 components

Westinghouse Category C Components

Components	Safety Category C	Economic Category C	Components	Safety Category C	Economic Category C
Westinghouse Components					
CRGT assembly flexures	✓	✓	Lower core barrel girth welds		✓
Guide cards	✓	✓	Upper core barrel girth welds		✓
Guide tube support pins (X-750)	✓	✓	Lower core barrel axial welds		✓
CRGT sheaths	✓	✓	Upper core barrel axial welds		✓
Upper core plate		✓	Thermal shield flexures		✓
Brackets, clamps, terminal blocks, and conduit straps		✓	Radial support keys	✓	✓
Baffle-edge bolts		✓	Clevis insert bolts		✓
Bracket bolts		✓	Clevis inserts	✓	✓
Baffle-former bolts	✓	✓	Type 304 SS hold down spring		✓
Corner bolts	✓	✓	Thermal sleeves	✓	✓
Barrel-Former Bolts		✓			

CE Category C Components

Components	Safety Category C	Economic Category C	Components	Safety Category C	Economic Category C
CE Components					
System 80 Core Support deep beams	✓	✓	Lower cylinder core support barrel axial welds		✓
Fuel alignment plate		✓	Core stabilizing lug shim bolts		✓
Upper cylinder core support barrel girth welds		✓	Core shroud tie rods		✓
Lower cylinder core support barrel girth welds		✓	Core shroud tie rod nuts		✓
Upper cylinder core support barrel axial welds		✓	Lower core barrel flange flexure weld		✓

Heat Map Based on SLR Expert Panel (W, Safety)

		Safety Consequence		
		Low	**Medium**	**High**
Likelihood	**High**	**CRGT assemblies and flow downcomers:** Flexures, Guide tube support pins (X-750) **UCP and fuel alignment pins:** Fuel alignment pins (304 SS) **Upper instrumentation conduit and supports:** Brackets, clamps, terminal blocks, and conduit straps (304 SS) **Baffle and former assembly:** Baffle bolting lock devices, Baffle, edge bolts, Bracket Bolts, Barrel, former bolts **Flux thimbles (tubes):** Flux thimbles (tubes) **LCP and fuel alignment pins:** Fuel alignment pins (304 SS), XL LCP fuel alignment pins **Neutron panels/ thermal shield:** Thermal shield bolts **Interfacing components:** Clevis insert bolts, Internals hold-down spring (304 SS), Thermal Sleeve Guide funnels	**Upper instrumentation conduit and supports:** Conduit seal assembly: body, tubesheets, tubesheet welds, Conduit seal assembly: tubes **Baffle and former assembly:** Baffle, former bolts, Corner Bolts **Radial support keys:** Radial support keys (stellite) **Interfacing components:** Clevis inserts (stellite)	**CRGT assemblies and flow downcomers:** Guide plates/cards, Sheaths **Interfacing components:** Thermal sleeves
	Medium	**UCP and fuel alignment pins:** Protective skirt bolts **Upper instrumentation conduit and supports:** Brackets, clamps, terminal blocks, and conduit straps (302 SS) **BMI column assemblies:** BMI column bodies, BMI column bolts, BMI column collars, BMI column cruciforms **Flux thimbles (tubes):** Flux thimble tube plugs **LCP and fuel alignment pins:** LCP and manway bolts **LSC assemblies:** LSC bolts **Neutron panels/ thermal shield:** Thermal shield flexures **Interfacing components:** Clevis insert dowels, Head and vessel alignment pins (stellite), UCP alignment pins (stellite)	**CRGT assemblies and flow downcomers:** C-tubes, Flanges, lower **UCP and fuel alignment pins:** Upper core plate, Upper core plate insert **Core barrel:** Lower core barrel girth welds (LGW and LFW), Upper core barrel girth welds (UFW and UGW), Lower core barrel axial welds (MAW and LAW), Upper core barrel axial welds (UAW)	
	Low	**CRGT assemblies and flow downcomers:** Bolts (304 SS), Flexureless inserts, Flexureless inserts (spring), Guide tube support pins (316 SS), Housing plates (CF8), Inserts (CF8), Lock bars, Cover plates, Cover plate cap screws, Cover plate, guide tube locking caps and tie straps, Support pin nuts, Probe holder shroud **Mixing devices:** Mixing devices **UCP and fuel alignment pins:** Fuel alignment pins (316 SS), Upper core plate insert bolts, Upper core plate insert locking devices & dowel pins, Protective skirt, Protective skirt lock bars, Protective skirt dowel pins **Upper instrumentation conduit and supports:** Brackets, clamps, terminal blocks, and conduit straps (CF8), Flange bases, Locking caps, Support tubes **Upper plenum:** UHI flow column bases, UHI flow columns **Upper support column assemblies:** Bolts, Column bases, Column bodies, Extension tubes, Lock keys, Nuts **Upper Support Plate (USP) assembly - Inverted Top Hat Design:** ITH flange, ITH USP, ITH Upper support ring or skirt **USP assembly - Top Hat Design:** USP, Deep beam ribs, Deep beam stiffeners, Bolts, Locking Device **USP assembly - Flat Plate Design:** USP, Upper support ring or skirt, Deep beam ribs, Deep beam stiffeners, Bolts, Locking Device **Baffle and former assembly:** Baffle plates, Former dowel pins, Former plates **BMI column assemblies:** BMI column extension bars, BMI column extension tubes, BMI column locking devices, BMI column nuts **Core barrel:** Upflow conversion core barrel plug body, Upflow conversion core barrel plug mandrel **Flux thimbles (tubes):** Flux thimble anti-vibration sleeves **Head cooling spray nozzles:** Head cooling spray nozzles **Irradiation specimen guides:** Irradiation specimen guides, Irradiation specimen guide bolts **LCP and fuel alignment pins:** Fuel alignment pins (316 SS), LCP and manway locking devices **LSC assemblies:** LSC bodies, LSC bolt locking devices, LSC nuts **Neutron panels/ thermal shield:** Neutron panel bolts, Thermal shield dowels, Thermal shield flexure bolts, Thermal shield flexure locking devices and dowel pins, Thermal shield or neutron panels **Radial support keys:** Radial support key bolts, Radial support key dowels, Radial support key lock keys **SCS assembly:** SCS base plate, SCS bolts, SCS guide post, SCS housing, SCS lock keys, Upper and lower tie plates **Interfacing components:** Clevis insert locking devices, Clevis inserts (304 SS/Alloy 600), Head and vessel alignment pin bolts, Head and vessel alignment pins (304 SS), Internals hold-down spring (403 SS/F6NM), UCP alignment pins (304 SS)	**CRGT assemblies and flow downcomers:** Bolts (316 SS), Enclosure pins, Guide tube enclosures, Flanges, intermediate **USP assembly - Top Hat Design:** Flange, Upper support ring or skirt **Core barrel:** Core barrel flange, Core barrel outlet nozzles, Safety Injection Nozzle Interface **LCP and fuel alignment pins:** Lower core plate, XL lower core plate **Lower support casting or forging:** Lower support casting, Lower support forging **Radial support keys:** Radial support keys (304 SS)	
	None	**CRGT assemblies and flow downcomers:** Anti-rotation studs and nuts, Housing plates (304 SS), Inserts (304 SS), Water flow slot ligaments **Upper instrumentation conduit and supports:** Bolting, Conduits **Upper support column assemblies:** Adapters, Flanges **Diffuser plate:** Diffuser plate **Irradiation specimen guides:** Irradiation specimen guide lock caps, Irradiation specimen plug (spring)	**Irradiation specimen guides:** Irradiation specimen plug (dowel pin), Irradiation specimen plug (plug) **Lower support column assemblies:** Lower support column sleeves **Neutron panels/ thermal shield:** Neutron panel lock devices **SCS assembly:** SCS energy absorber, SCS guide post, SCS housing **Interfacing components:** Head and vessel alignment pin lock caps, Instrumentation Nozzle funnels, RRVH Extension Tubes	

Heat Map Based on SLR Expert Panel (W, Economic)

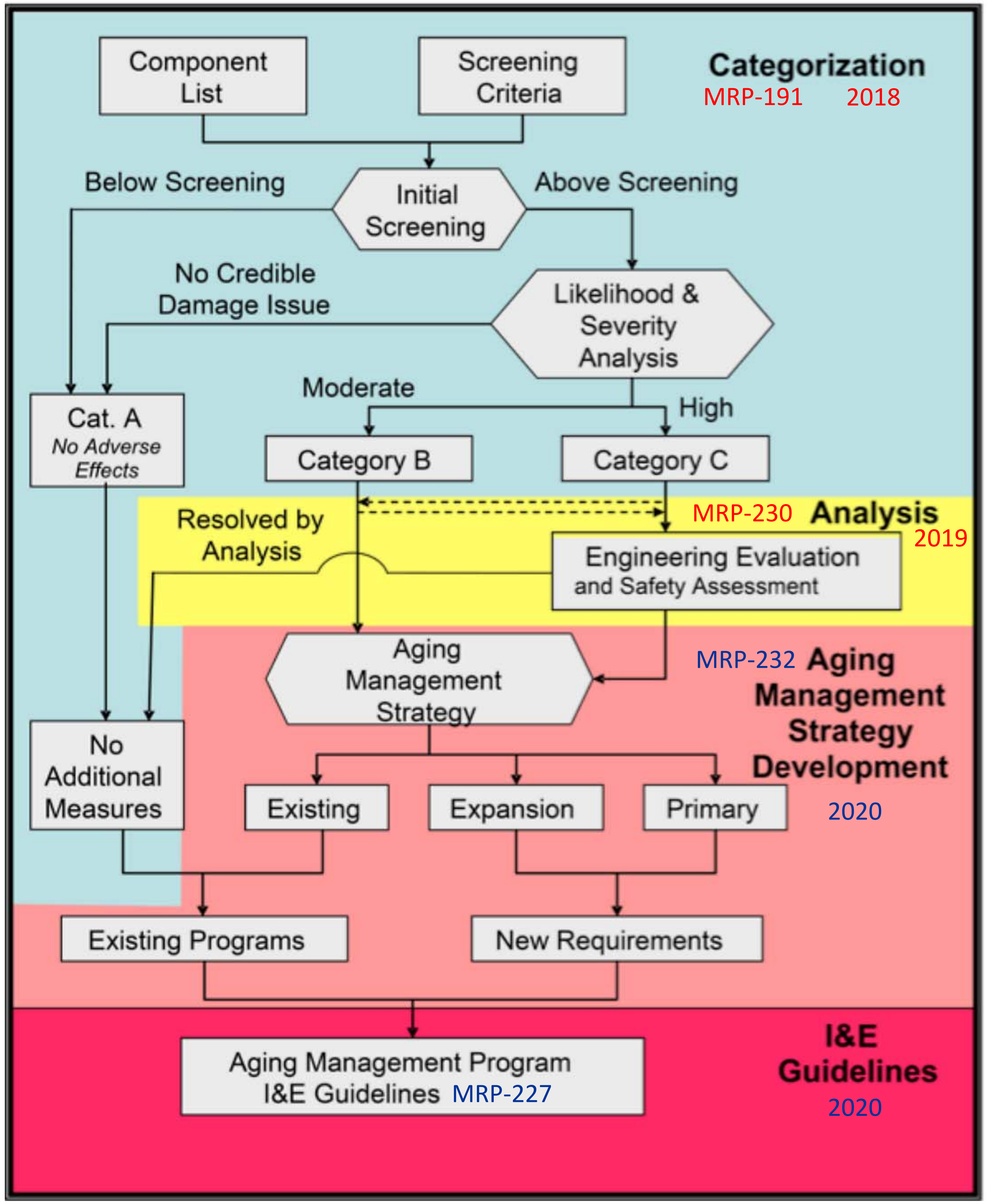
		Economic Consequence		
		Low	**Medium**	**High**
Likelihood	**High**	**Flux thimbles (tubes):** Flux thimbles (tubes) **Neutron panels/ thermal shield:** Thermal shield bolts **Interfacing components:** Thermal Sleeve Guide funnels	**CRGT assemblies and flow downcomers:** Guide plates/cards, Sheaths, Flexures, Guide tube support pins (X-750) **UCP and fuel alignment pins:** Fuel alignment pins (304 SS) **Upper instrumentation conduit and supports:** Conduit seal assembly: body, tubesheets, tubesheet welds, Conduit seal assembly: tubes **Baffle and former assembly:** Baffle bolting lock devices, Baffle, edge bolts, Bracket Bolts, Barrel, former bolts, Baffle, former bolts, Corner Bolts **LCP and fuel alignment pins:** Fuel alignment pins (304 SS), XL LCP fuel alignment pins **Radial support keys:** Radial support keys (stellite)	**Upper instrumentation conduit and supports:** Brackets, clamps, terminal blocks, and conduit straps (304 SS) **Interfacing components:** Clevis insert bolts, Internals hold-down spring (304 SS), Thermal sleeves, Clevis inserts (stellite)
	Medium	**UCP and fuel alignment pins:** Protective skirt bolts **BMI column assemblies:** BMI column bodies, BMI column collars, BMI column cruciforms **Flux thimbles (tubes):** Flux thimble tube plugs **Interfacing components:** Clevis insert dowels, Head and vessel alignment pins (stellite)	**CRGT assemblies and flow downcomers:** C-tubes, Flanges, lower **UCP and fuel alignment pins:** Upper core plate insert **BMI column assemblies:** BMI column bolts **LCP and fuel alignment pins:** LCP and manway bolts **LSC assemblies:** LSC bolts **Interfacing components:** UCP alignment pins (stellite)	**UCP and fuel alignment pins:** Upper core plate **Upper instrumentation conduit and supports:** Brackets, clamps, terminal blocks, and conduit straps (302 SS) **Core barrel:** Lower core barrel girth welds (LGW and LFW), Upper core barrel girth welds (UFW and UGW) ·Lower core barrel axial welds (MAW and LAW), Upper core barrel axial welds (UAW) **Neutron panels/ thermal shield:** Thermal shield flexures
	Low	**CRGT assemblies and flow downcomers:** Bolts, Flexureless inserts, Flexureless inserts (spring), Inserts (CF8), Cover plates, Cover plate cap screws, Cover plate, guide tube locking caps and tie straps **UCP and fuel alignment pins:** Protective skirt, Protective skirt lock bars, Protective skirt dowel pins **Upper plenum:** UHI flow column bases, UHI flow columns **USP assembly - Top Hat Design:** Deep beam ribs, Deep beam stiffeners, Bolts, Locking Device **USP assembly - Flat Plate Design:** Deep beam ribs, Deep beam stiffeners, Bolts, Locking Device **Baffle and former assembly:** Baffle plates, Former dowel pins, Former plates **BMI column assemblies:** BMI column extension bars, BMI column extension tubes, BMI column locking devices, BMI column nuts **Core barrel:** Upflow conversion core barrel plug Body, Upflow Conversion core barrel plug Mandrel **Head cooling spray nozzles:** Head cooling spray nozzles **Flux thimbles (tubes):** Flux thimble anti-vibration sleeves **Irradiation specimen guides:** Irradiation specimen guides, Irradiation specimen guide bolts **LSC assemblies:** LSC bodies, LSC bolt locking devices, LSC nuts **Neutron panels/ thermal shield:** Neutron panel bolts, Thermal shield dowels, Thermal shield flexure bolts, Thermal shield flexure locking devices and dowel pins, Thermal shield or neutron panels **Radial support keys:** Radial support key bolts, Radial support key dowels, Radial support key lock keys **SCS assembly:** SCS base plate, SCS bolts, SCS guide post, SCS housing (CF8), SCS lock keys, Upper and lower tie plates **Interfacing components:** Clevis insert locking devices, Head and vessel alignment pin bolts, Head and vessel alignment pins (304 SS)	**CRGT assemblies and flow downcomers:** Guide tube support pins (316 SS), Housing plates (CF8), Lock bars, Support pin nuts, Probe holder shroud, Enclosure pins, Guide tube enclosures, Flanges, intermediate **Mixing devices:** Mixing devices **UCP and fuel alignment pins:** Fuel alignment pins (316 SS), Upper core plate insert bolts , Upper core plate insert locking devices & dowel pins **Upper instrumentation conduit and supports:** Flange bases, Locking caps, Support tubes **Upper support column assemblies:** Bolts, Lock keys, Nuts **LCP and fuel alignment pins:** Fuel alignment pins (316 SS), LCP and manway locking devices **Radial support keys:** Radial support keys (304 SS) **Interfacing components:** UCP alignment pins (304 SS)	**Upper instrumentation conduit and supports:** Brackets, clamps, terminal blocks, and conduit straps (CF8) **Upper support column assemblies:** Column bases, Column bodies, Extension tubes **USP assembly - Inverted Top Hat Design:** ITH flange, ITH USP, ITH Upper support ring or skirt **USP assembly - Top Hat Design:** USP, Flange, Upper support ring or skirt **USP assembly - Flat Plate Design:** USP, Upper support ring or skirt **Core barrel:** Core barrel flange, Core barrel outlet nozzles, Safety Injection Nozzle Interface **LCP and fuel alignment pins:** Lower core plate, XL lower core plate **Lower support casting or forging:** Lower support casting, Lower support forging **Interfacing components:** Clevis inserts (304 SS/Alloy 600), Internals hold-down spring (403 SS/F6NM)
	None	**CRGT assemblies and flow downcomers:** Anti-rotation studs and nuts, Housing plates (304 SS), Inserts (304 SS), Water flow slot ligaments **Upper instrumentation conduit and supports:** Bolting, Conduits **Upper support column assemblies:** Adapters, Flanges **Diffuser plate:** Diffuser plate **Irradiation specimen guides:** Irradiation specimen guide lock caps, Irradiation specimen plug (spring), Irradiation specimen plug (dowel pin), Irradiation specimen plug (plug)		**Lower support column assemblies:** Lower support column sleeves **Neutron panels/ thermal shield:** Neutron panel lock devices **SCS assembly:** SCS energy absorber, SCS guide post, SCS housing **Interfacing components:** Head and vessel alignment pin lock caps, Instrumentation Nozzle funnels, RRVH Extension Tubes

Conclusions of MRP-191 for SLR

- Leading components for 40-60 years are still the appropriate leading components for SLR
- Components promoted to higher categories were generally those with degradation experience since last revision
- Degradation mechanism data from MRP-211 and MRP-175 clearly show that no failure cliffs are imminent
- Sampling inspection strategy used in MRP-227-A is the fundamental foundation and is still valid for SLR aging management
- Evaluation has not identified across-the-board increases in materials degradation susceptibility

Next Steps

- MRP-191 Rev.2 updated the "Categorization" box for SLR
  - Provides key input to downstream steps
  - Made updates based on new data and OE
- Next steps for 2019-2020 include updates associated with engineering analysis, inspection strategies and establish final I&E guidelines
- Goal is single I&E guideline of MRP-227 Revision 2 by end of 2020
  - Guidance is independent of license period
  - MRP-227 remains a "living program"



Initial Staff Questions Related to MRP-191 Rev.2 for SLR

(1) Lower support columns/welds in CE units are considered Category A—high consequence (precludes safe shut down) in "IMT consequence of failure" classification. However, in Westinghouse units, these components are not classified under Category A. Please provide an explanation.

RESP: Industry previously addressed this in topical report PWROG-14048-P Rev.1, which NRC staff assessed in ML17251A905. IMT is planned for update in 2019 and will reflect this new information.

(2) Fuel Management for SLRA—the values for the heat generation figure of merit and average core power density would be expected to change in the axial direction of the vessel. If any new components are screened in for potential aging degradation due to radiation, please discuss the access issues with respect to the inspections of these components. Or alternatively, discuss any other method that could be used to evaluate the aging degradation in these components.

RESP: Future work during next 2 years with updates to MRP-232 and MRP-227 Rev.2.

(3) FMECA tables in MRP-191, R2 indicate that the lower support column bodies in CE and Westinghouse units are susceptible to the following additional aging degradation---IASCC, Void Swelling, Irradiation Embrittlement (IE). Since these columns are not easily accessible for inspections, the staff requests that EPRI should discuss how the aging management in the lower support columns are managed for 60-80 years of operation.

RESP: Future work during next 2 years with updates to MRP-232 and MRP-227 Rev.2.

Together…Shaping the Future of Electricity