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Concrete AMP Development

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Concrete AMP Criteria

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- **<u>Valid criteria include applicable consensus codes/standards and/or NUREG guidance</u>, e.g.:**
  - ACI 349.3R, “Evaluation of Existing Nuclear Safety-Related Concrete Structures”
  - ASME Code Section XI, Subsection IWL, “Requirements for Class CC Concrete Components of Light-Water-Cooled Plants”
  - NUREG-1801, “Generic Aging Lessons Learned (GALL) Report”
- **<u>Applicant may propose AMPs based on alternate criteria:</u>**
  - Exclusion of aging effects/mechanisms in the above codes/standards **should be justified** with a site-specific technical basis (e.g., engineering analysis, operational experience data).
  - Justification should demonstrate that the excluded aging mechanisms will not adversely affect the ability of the in-scope structure to perform its intended ITS function during the license period of extended operation.

Aging Effects/Mechanisms

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Mechanism	Effect
Freeze-thaw	Cracking, loss of material (spalling, scaling)
Chemical attack [Cl, SO_4]	Cracking, loss of material (spalling, scaling)
Aggregate reactions/expansion	Cracking and loss of strength
Corrosion of embedded steel	Cracking, loss of material (spalling, scaling) and loss of bond
Leaching of $Ca(OH)_2 \rightarrow CaCO_3$	Increase in porosity/permeability, loss of strength
Settlement	Cracking, distortion
Gamma irradiation	Cracking, reduction in strength (change in mechanical properties)
High temperature dehydration	Cracking, reduction in strength (change in mechanical properties)

Not necessarily all-inclusive

Gamma Radiation / Thermal Dehydration

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"Change in Materials Properties"

- Definition per either ASTM C1562 or EPRI 1002950 **not implicit**, i.e.:
  - increases in permeability and porosity
  - reduction in pH value, tensile strength, compressive strength, modulus of elasticity, and bond strength
- Reference to this "aging effect" **must include proper definition** in the LRA

AMP Element 1:
Scope of the Program

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NUREG-1927: The scope of the program should include the specific structures and components subject to an AMR

1. **Visual inspection** of all above-grade (accessible, inaccessible) and below-grade (underground) concrete areas
   - ACI 349.3R: "All safety-related structures should be visually inspected at intervals not to exceed 10 years"
2. **Groundwater chemistry program** to manage below-grade (underground) effects
   - Corrosion of embedded steel
   - Chemical attack (chloride, sulfate induced degradation)
3. **Periodic radiation surveys**
   - Controlled Area: Compliance with 10 CFR 72.104.
   - Near cask (1m): Monitor effectiveness as neutron shield; SAR validation

AMP Element 2:
Preventive Actions

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NUREG-1927: Preventive actions should mitigate or prevent the applicable aging effects

- Program is for ***Condition Monitoring***
- Design in accordance to **ACI 318 or ACI 349**, as applicable.

  Otherwise,

  - For locations in moderate (100-500 day-inch/yr) and severe (>500 day-inch/yr) weathering conditions, concrete mix design must meet the air content & water-to-cement ratio requirements of ASTM C260 or ASME Sect. III, Div. 2.
  - Petrographic examination (ASTM C295 or equivalent) must demonstrate reactive aggregates do not lead to loss of function.
- Site-specific AMP required if:
  - Dewatering system used to prevent settlement
  - Embedded aluminum components without protective insulating coating

AMP Element 3:

Parameters Monitored/ Inspected

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NUREG-1927: Parameters monitored or inspected should be linked to the effects of aging on the intended functions of the particular structure and component

- **Quantify effects including cracking, material loss (spalling, scaling), loss of bond, increased porosity/permeability.**
- ACI 201.1R and SEI ASCE 11-99: exemplary visuals of effects.
- **Evaluation should identify**, e.g:
  - affected surface area
  - geometry/depth of defect
  - cracking, crazing, curling
  - delaminations, deflections
  - honeycombing, bug holes
  - popouts, voids
  - exposure of embedded steel
  - staining/ evidence of corrosion
  - dusting, efflorescence of any color
- **Contributing factors should be documented**, e.g.:
  - surface geometry supporting ponding
  - widening due to abrasion/ other weather effects

AMP Element 4:

Detection of Aging Effects

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NUREG-1927: Define method or technique, frequency, sample size, data collection, and timing to ensure timely detection of aging effects

- **Method/technique**
  - ***AMP must include justification that the technique can achieve the acceptance criteria***
  - ABOVE-GRADE (accessible): visual (e.g., feeler gauges, crack comparators)
  - ABOVE-GRADE (inaccessible)/ BELOW-GRADE (underground)
    - Visual: site-qualified system with valid sensitivity/resolution (e.g., video/ fiber optic camera)
    - Ground water monitoring program: qualified chemical analysis method (e.g. ICP-MS, IC)
    - Radiation surveys: calibrated detector for expected energy range
- **Frequency of Inspection (commensurate with ACI 349.3R)**
  - ABOVE-GRADE (accessible and inaccessible): ≤ 5 years
  - BELOW-GRADE (underground): ≤ 10 years
  - ***Use of opportunistic inspections in lieu of planned inspections must include valid technical basis (engineering justification, operational experience data).***

AMP Element 4:

Detection of Aging Effects (cont.)

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NUREG-1927: Define method or technique, frequency, sample size, data collection, and timing to ensure timely detection of aging effects

- **Frequency of Inspection (cont.)**
  - Water chemistry program/ radiation survey measurements: ≤ 5 years, or justified
  - Daily inspections of inlet/outlet vents to ensure ACI 349.3R temperature limits (or technical specifications) are not exceeded.
- **Sample size:**
  - All surface areas as stated in scope, or justified size
  - Locations justified by application
- **Data collection**
  - Commensurate with ACI 562, ACI 224.1R guidelines for quantitative crack analysis (width, depth, extent)
- **Timing**
  - Lead canister inspection / frequency specified by AMP
  - Inspection frequencies may be accelerated per site CAP
- **Inspector Qualifications**
  - Commensurate with ACI 349.3R

AMP Element 5:
Monitoring & Trending

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NUREG-1927: Should provide for prediction of the extent of the effects of aging and timely corrective or mitigative actions

- **Commensurate with:**
  - Defect evaluation standards/references (e.g. ACI 201.1R, ACI 562, ACI 224.1R for crack evaluation)
  - Acceptance criteria and inspector qualifications (e.g., ACI 349.3R, ASME Code Section XI)

- **AMP should describe CAP components/procedures used to:**
  - Update a given SSC baseline based on previous inspections
  - Track trending of parameter, or effect not corrected in a previous inspection, i.e.:
    - Crack growth rates
    - Corrosion rates
    - Pore density/ affected areas
    - Radiation data

AMP Element 6:
Acceptance Criteria

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NUREG-1927: Acceptance criteria, against which the need for corrective action will be evaluated; should ensure that SSC functions are maintained

- ***Visual:*** **Commensurate with ACI 349.3R (3-Tier Quantitative Criteria):**
  - Acceptance without further evaluation
  - Acceptance after review
  - Acceptance requiring further evaluation
- ***Groundwater Chemistry Program:*** **ASME Code Section XI, NUREG-1801**
  - Aggressive below-grade environment: pH < 5.5, chlorides > 500 ppm, or sulfates > 1500 ppm
- ***Radiation Surveys***
  - Controlled area: 10 CFR 72.104
  - Near cask (1 m): Per bounding value/ justified variance (fluence, energy range)
- ***Alternative acceptance criteria may be provided*****, but must:**
  - Include a quantitative basis (justifiable by OE, engineering analysis/standards)
  - Avoid use of non quantifiable phrases (e.g. significant, moderate, minor, little, slight, few, etc.)
  - Be achievable – Method/technique must be able to meet the stated values (i.e. sufficient resolution/sensitivity)

AMP Element 7:
Corrective Actions

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NUREG-1927: Corrective actions, including root cause determination and prevention of recurrence, should be timely

- **CAP commensurate with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B.**
  - Justification for non-repairs (e.g., engineering analysis)
  - Cracking: ACI 224.1R, ACI 562 and ACI RAP Bulletins
  - Spalling/scaling: ACI 562, ACI 506R, and ACI RAP Bulletins
- **AMP should provide criteria applied to determine which inspection results will require either:**
  - An Action Request (e.g, Tier 2 Acceptance per ACI 349.3R)
  - Modification to the existing AMP
  - Notification to the NRC (e.g., Tier 3 Acceptance per ACI 349.3R)
- **AMP should provide details on how CAP will capture and evaluate operating experience from other ISFSIs with similar in-scope SSCs.**
  - Clarify how external OE will initiate any of the above action items

AMP Elements 8/9:
Confirmation Process/Admin Controls

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NUREG-1927:

- The confirmation process should ensure that preventive actions are adequate and appropriate corrective actions have been completed and are effective
- Administrative controls should provide a formal review and approval process

- **Licensee's Quality Assurance Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B.**

AMP Element 10:
Operating Experience

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NUREG-1927: Include past corrective actions; provide objective evidence to support a determination that the effects of aging will be adequately managed so that the SSC intended functions will be maintained during the period of extended operation

Source Review:

- **Internal/External Condition Reports**
  - Identify age-related degradation
    - Include justification for CRs not identified as age-related degradation
  - Consider CARs for proposed:
    - Acceptance criteria
    - Frequency of inspection
- **Information Notices**
- **Acceptable Industry Initiatives** (e.g. DOE cask demo, EPRI-sponsored inspections)
- **OE presented in LRA should support the proposed AMP**

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Additional Slides

Radiation Acceptance Criteria

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NUREG-1536 (SRP Spent Fuel Dry Storage Systems/ General License)

Section 6.5.4.3 – Dose Rates

Guidance for the selection of points at which the dose rates should be calculated.

- For normal and off-normal conditions, applicant should indicate the dose rate at all locations accessible to occupational personnel during cask loading, transport to the ISFSI, and maintenance and surveillance operations.
  - Locations include points at or near various cask components and in the immediate vicinity of the cask and the bottom of the transfer cask.
    - e.g.: vent areas, trunnion areas, peak side of the cask, peak top of the cask, the canister-gap region
  - Calculate dose rates at 1m from these locations

NUREG 1567 (SRP Spent Fuel Dry Storage Facilities)

Section 11.4.3 – Dose Assessment

- Estimated dose rates should be provided for representative points within the restricted areas as well as on and beyond the perimeter of the controlled area.