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# Revision of Regulatory Guide 1.183 “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors”

Mark Blumberg, Senior Reactor Engineer (Technical Lead)

NRR/DRA/ARCB  
mark.blumberg@nrc.gov

Micheal Smith, Health Physicist (Project Lead)

NRR/DRA/ARCB  
micheal.smith@nrc.gov

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# Agenda

- Key Messages
- Background
- Regulatory Guide (RG) Update Process
- RG 1.183 Guidance Proposed Actions
- Looking Forward
- Feedback/Discussion
- Comments and input from the public

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# Key Messages

- The NRC staff has restarted efforts to revise RG 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors.”
- The objectives of the revision are to:
  - incorporate lessons learned from recent NRC staff reviews of Alternative Source Term (AST) and Main Steam Line Isolation Valve (MSIV) leakage LARs;
  - incorporate relevant operating experience as well as recent post-Fukushima seismic risk insights and walkdowns;
  - respond to change of regulatory environment (e.g., backfit guidance SRM-SECY-18-0049 & NuScale SRM-SECY-19-0036);
  - make the guidance more useful by considering feedback and comments from licensees;
  - ensure sufficient guidance is in place for licensing advanced light-water reactors (LWRs), accident tolerant fuel (ATF), high-burnup, and increased enrichment fuel; and,
  - incorporate insights from new research activities.

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## Key Messages (Cont'd)

- NRC staff expects for RG 1.183 Rev. 0 and Rev. 1 to co-exist as a result of SRM-SECY-18-0049, “Management Directive and Handbook 8.4, Management of Backfitting, Issue Finality, and Information Collection.”
- NRC staff will hold additional public meetings as necessary for external stakeholder engagement on the revision of RG 1.183.
- Publish the draft RG for comment in 4<sup>th</sup> Quarter CY 2021.
- Final revised RG being issued in 2<sup>nd</sup> Quarter CY 2022.

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# Background

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# Background

- Origin: Footnote to 10 CFR 100.11(a) is a performance-based rule to evaluate the defense-in-depth provided by the containment.
  - TID-14844 Source term provided guidance which assumed the source term is instantaneously available in the containment.
- Radionuclide behavior observed during the TMI accident did not appear at all similar to the TID-14844 source term.
  - NRC initiated research efforts in the area of severe accidents which culminate in publication of NUREG-1150.
  - NUREG-1465 source term was derived from the sequences in NUREG-1150.
    - RG 1.183 Rev. 0 adopted the NUREG-1465 early in-vessel fuel melt source term.

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## Background (cont'd)

- NRC staff developed RG 1.183 Rev. 0 (July 2000) to support implementation of 10 CFR 50.67, “Accident source term”
- RG 1.183 Rev. 0 is applicable to nuclear power reactor applicants and licensees adopting 10 CFR 50.67
  - Limited range of applicability on Non-LOCA release fractions
- RG 1.183 Rev. 0 identified the significant attributes of an acceptable accident AST based on NUREG-1465, “Accident Source Terms for Light-Water Nuclear Power Plants” (1995)
- RG 1.183 Rev. 0 provides assumptions and methods that are acceptable to the NRC staff for performing design basis radiological analyses using an AST

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# DG-1199

- In October 2009, the NRC issued for public comment DG-1199 as a proposed Rev. 1 of RG 1.183.
- Staff received 150 public comments
- The reasons for revision of RG 1.183 in DG-1199 were:
  - Providing additional guidance for modeling BWR MSIV leakage,
  - Expand applicability of Non-LOCA release fractions to support modern fuel utilization,
  - Extending the applicability of the proposed RG for use in satisfying the radiological dose analysis requirements contained in 10 CFR Part 52 for advanced LWR design and siting,
  - Providing additional meteorological assumption guidance.



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# Modern Fuel Utilization

- Since DG-1199 was issued for public comment, NRC issued several license amendments to support modern fuel utilization.
  - Oconee Units 1, 2, and 3 (2019)
  - Shearon Harris (2018)
  - H.B. Robinson (2017)
  - Catawba Units 1 and 2, McGuire Units 1 and 2, Oconee Units 1, 2, and 3 (2016)
  - Diablo Canyon Units 1 and 2 (2015)
- Reinforce need for expanded Non-LOCA release fractions

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# 2019 License Amendment Requests

- In 2019, NRC received several AST LARs requesting increased MSIV leakage
- As a result, work on DG-1199 was postponed to allow NRC staff to incorporate lessons learned, from evaluation of the LARs, into the revised RG 1.183:
  - James A. FitzPatrick Amendment No. 338 for AST, July 21, 2020 (ML20140A070)
  - Quad Cities Nuclear Power Station, Units 1 & 2 – Amendment Nos. 281 and 277 to increase allowable MSIV leakage, June 26, 2020 (ML20150A328)
  - Nine Mile Point Nuclear Station, Unit 2 – Amendment No. 182 to change allowable MSIV leak rates, October 20, 2020 (ML20241A190)
  - Dresden Nuclear Power Station, Units 2 & 3 – Amendments Nos. 272 and 265 to increase allowable MSIV leakage, October 23, 2020 (ML20265A240)

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# Regulatory Guide Update Process

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# Regulatory Guide Update Process

- Identify which RGs need to be revised based on:
  - Rulemakings
  - Lessons learned
  - Stakeholder feedback
  - Periodic reviews
- Develop draft RG through internal collaboration
- Draft RG available for public comment (4<sup>th</sup> Quarter CY 2021)
- Internal staff comment resolution
- Finalize RG package for OGC and ACRS review
- Issue final RG (2<sup>nd</sup> Quarter CY 2022)

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# RG 1.183 Guidance Proposed Actions

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## Additional Method for Aerosol Deposition Models

- Staff is considering an additional method for aerosol deposition models
- Staff is addressing issues in RIS 2006-04, “Experience with Implementation of Alternative Source Terms” (considering reconstitution of the AEB-98-03 settling velocity modeling parameters and reviewing the “multigroup method” to address changing settling velocity distributions).
- Regulatory position in Rev. 0 continues to be acceptable. As a result, RG 1.183 Rev. 0 and Rev. 1 are expected to co-exist.
- Over the last 10 years no applicant or licensee has adopted the methodology from SAND2008-6601, “Analysis of Main Steam Isolation Valve Leakage in Design Basis Accident Using MELCOR 1.8.6 and RADTRAD.”
- There have been no communications that applicants or licensees intend to adopt the SAND2008-6601 methodology.
- NRC staff plans to consider stakeholder input/feedback to inform the NRC’s decision on what methodologies to include in RG 1.183 Rev. 1.

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# ATF, HBU, Extended Enrichment (LOCA)

- Update RG 1.183 Tables 1, 2, and 4 which hybridizes accident source term tables from SAND2011-0128, “Accident Source Terms for Light Water Nuclear Power Plants Using High-Burnup of MOX Fuel,” utilizing the maximum release fractions from the low burnup and high burnup tables.
  - Expanded to encompass near-term ATF design concepts<sup>1</sup> fuel burnup extension to 59 GWD/MTU max assembly-averaged discharge burnup (~68 GWD/MTU peak rod-average) and <sup>235</sup>U enrichments up to 8.0 wt%.
  - Staff finds that the extension from 62 GWD/MTU from SAND2011-0128 to 68 GWD/MTU is appropriate<sup>1</sup>. The SAND2011-0128 calculations used MELCOR 1.8.5 for accident progression and ORIGEN for radionuclide and decay heat inventories.
  - Provide conditions and limitations of the report applicability for regulatory purposes.
  - Considering impact of FFRD for the Appendix A assumptions.
  - Not applicable for MOX Fuel and long-term designs concepts (doped UO<sub>2</sub>, coated Zirc-cladding, FeCrAl cladding are considered near-term ATF concepts).

1- NRC Memorandum, “Applicability of Source Term for Accident Tolerant Fuel, High Burn Up and Extended Enrichment,” dated May 13, 2020, ADAMS Accession Number ML20126G376

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## ATF, HBU, Extended Enrichment (LOCA) Cont'd

- Initial research efforts are underway to update the SAND2011-0128 accident source term to accommodate higher burnup and increased enrichments for LOCA releases. However, completion of the updated analyses may not be finished before the update to the regulatory guide.
  - What burnup and enrichment targets are the industry pursuing for PWR and BWR?
  - Is there readily available data, studies, and/or analyses which could be useful for NRC review? Note, this is not a request to perform experiments, studies, or analyses.
- Changes to facility analyses of record must represent those design changes being implemented. For instance, “swapping margin” from atmospheric dispersion data to justify increased radionuclide inventories due to higher reactor core burnups and/or increased fuel enrichments will not be acceptable.
  - What licensing challenges within the DBA radiological consequence analyses do vendors and licensees foresee before loading these new fuel types (e.g. the design criterion, additional capital improvements)?



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## ATF, HBU, Extended Enrichment (LOCA) Cont'd

- **Current draft:** Hybridizes accident source term tables from SAND2011-0128 to utilize most conservative release fractions and timing between the high- and low burnup recommendations.
  - SAND 2011-0128 LBU: 26-38 GWD/MTU discharge burnup, which varied depending on the plant analyzed.
  - SAND 2011-0128 HBU: 59 GWD/MTU max assembly-averaged discharge burnup (~ 62 GWD/MTU peak rod-averaged burnup).
- **Reasoning:** Different radionuclide abundances peak at different burnups throughout the operating cycle. For a facility operating at the 62 GWD/MTU peak rod-averaged burnup envelope, it would therefore be reasonable to select peak abundances which bound potential releases at mid- and end points of the operating cycle.

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# ATF, HBU, Extended Enrichment (LOCA) Cont'd

Example of a hybridized RG 1.183 Rev. 1, Table 1, BWR Core Inventory Fraction Released into Containment Atmosphere:

Group	Gap	Early In-Vessel Phase	Total
Noble Gases	0.008	0.96	0.968
Halogens	0.003	0.54	0.543
Alkali Metals	0.003	0.14	0.143
Tellurium Metals	0.003	0.39	0.393
Barium, Strontium	0	0.005	0.005
Noble Metals	0	0.0027	0.0027
Cerium Group	0	1.6E-7	1.6E-7
Lanthanides	0	2.0E-7	2.0E-7
Molybdenum	0	0.03	0.03

Example of a hybridized RG 1.183 Rev. 1, Table 4, LOCA Release Phases:

Phase	PWRs		BWRs	
	Onset	Duration	Onset	Duration
Gap Release	30 sec	0.22 hr	2 min	0.16 hr
Early In-Vessel	0.22 hr	4.5 hr	0.16 hr	8.0 hr

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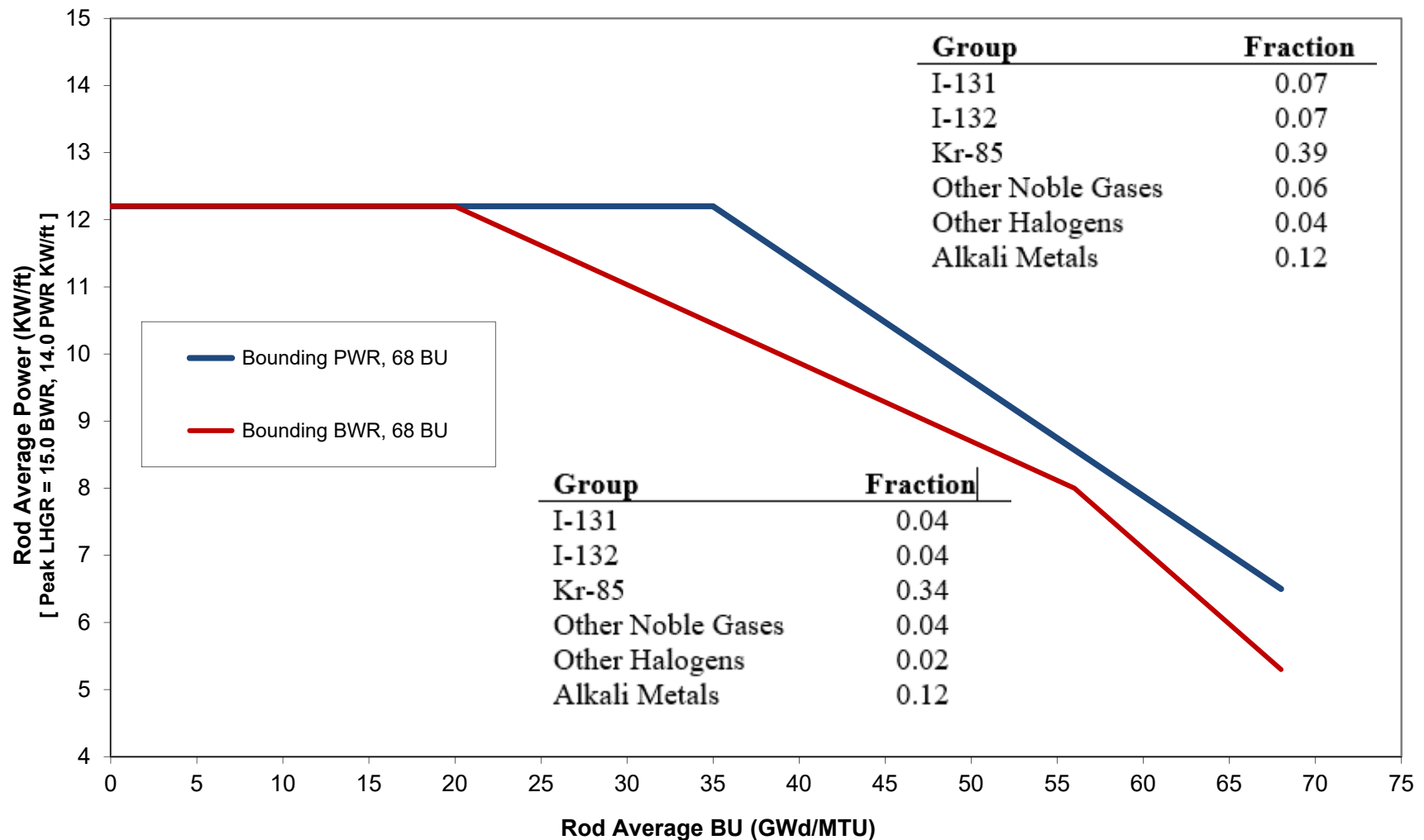
These are preliminary examples, not regulatory guidance.

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## Planned Updates for Non-LOCA Release Fractions

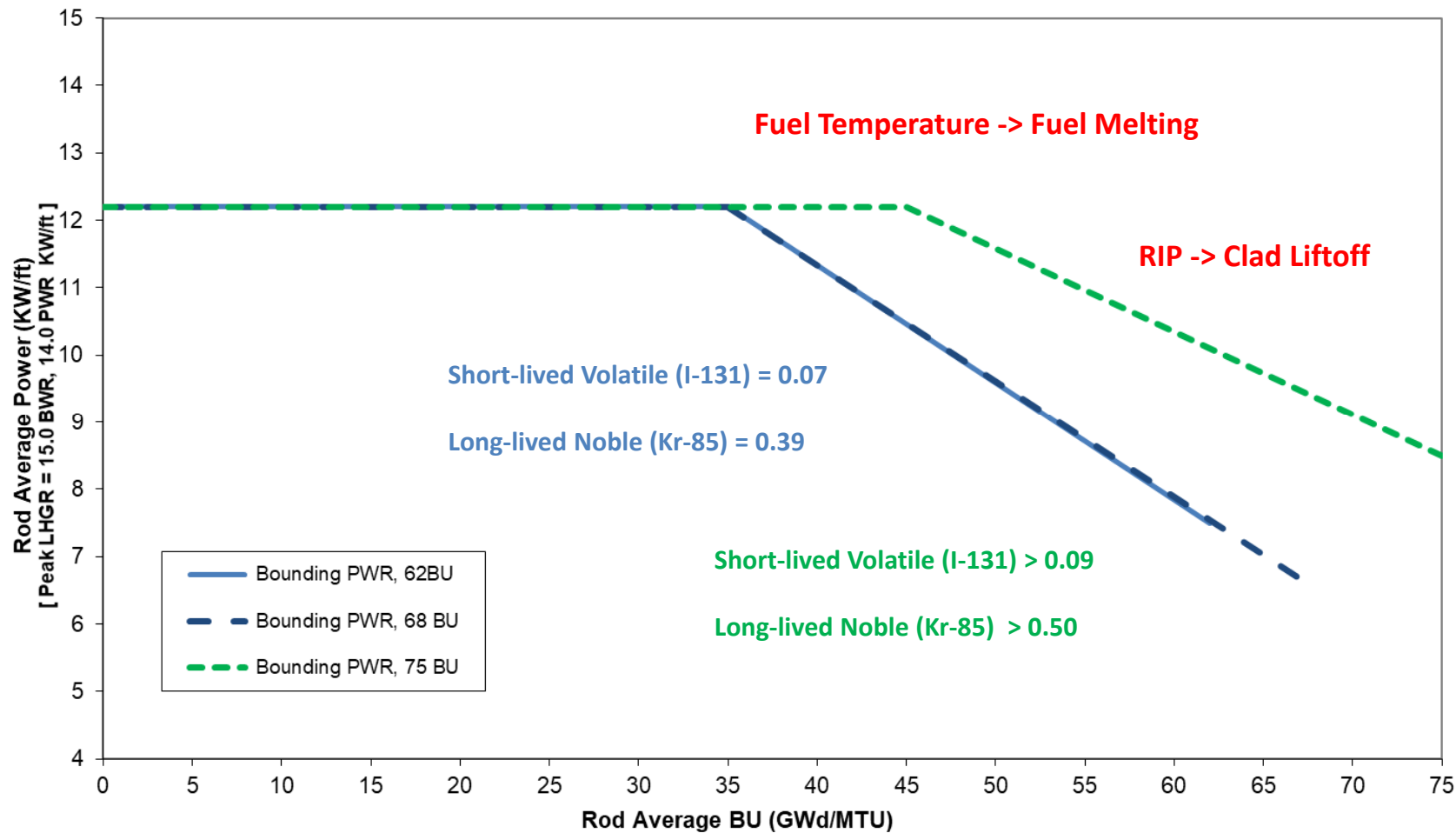
1. Expanded applicability to 68 GWd/MTU rod average burnup
2. Separate BWR and PWR release fractions
3. Burnup-dependent transient FGR correlations for prompt power increase accidents
4. Analytical procedure for calculating revised Non-LOCA release fractions

# Draft Non-LOCA Release Fractions



Disclaimer: These are preliminary examples, not regulatory guidance.

# Impact of Burnup Extension on Non-LOCA Release Fractions



Disclaimer: These are preliminary examples, not regulatory guidance.

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## Open Items for Non-LOCA Release Fractions

1. Expanded PWR/BWR rod power profiles for 75 GWd/MTU?
2. How to address BWR part-length fuel rods?
  - Treat PLRs as FLRs for dose assessments
3. How to address doped  $\text{UO}_2$  fuel pellets?
  - Vendors demonstrate applicability by showing FGR is equivalent or lower than standard  $\text{UO}_2$
4. How to address IFBA fuel pellets?
  - Licensees confirm that power setbacks ensure equivalent or lower FGR than standard  $\text{UO}_2$

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# Revised Fuel Handling Accident

- Accidents during refueling operations continue to be creditable and thus need to be evaluated despite their low safety significance.
- Appendix B will be revised to reflect the Revised FHA analysis.<sup>1</sup>
  - Provides regulatory relief and operational flexibility when considering ATF, high burn-up and increased burnup fuels.
- “Mixing models” between Rev. 0 and Rev 1 will not be accepted. Both Rev. 1 iodine transport steps (initial bubble rise and re-evolution) must be modeled.

1 - Memo from RES to NRR, “Closeout to Research Assistance Request for Independent Review of Regulatory and Technical Basis for Revising the Design-basis Accident Fuel Handling Accident,” November 23, 2019 (ML19270E335)

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# Use of Risk and Engineering Insights

## Seismic Credit

- Staff is exploring a streamlined approach for quantitative credit for hold-up or retention of MSIV leakage within the power conversion system for BWRs.
- Technical assessment considering 20+ years of operational and seismic risk insights supports seismic ruggedness of power conversion system.
- Extension of leakage aerosol deposition methodologies to steam line downstream of MSIV.
- Additional hold-up or retention may be credited in power conversion system with designated and evaluated pathway (e.g., drain to the main condenser).



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# Consideration of MSIV Leakage Values

- NRC has approved MSIV leakage of 200 scfh or below per MSIV with a total MSIV leakage of 400 scfh or below. Higher values will be considered on a case-by-case basis with sufficient justification.
- Maintaining MSIV leakage at or below certain values is based on the following considerations:
  - Leakage in excess of 200 scfh per MSIV could be indicative of substantial valve defects
  - These values represent maximum values in existing fleet
  - 400 scfh is on the order of total containment leakage
  - Comparison to original design value of 11.5 scfh per MSIV

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# Lessons Learned from Licensing Reviews

- Staff are considering the following clarifications:
  - augmenting the expectations for containment spray in BWR drywells/containments as follows: (i.e. Rev. 0 Appendix A Assumption 3.3)

*“In addition, since spray droplets are assumed to be ineffective once they impact a structure, the obstructions present in drywells and containments (particularly in BWR Mark I and Mark II Drywells) should be considered in the determination of decontamination factors and removal coefficients credited for the drywell or containment.”*
  - augmenting the expectations for performing and using sensitivity analysis as follows: (i.e., Rev. 0, RP 1.3.3)

*“Sensitivity analyses should avoid the inclusion of well-defined parameters such as atmospheric dispersion factors based on site specific data.”*

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## Lessons Learned from Licensing Reviews Cont'd

- GDC 19 Control room specifies access and occupancy:
  - The TEDE analysis should consider all sources of radiation that will cause exposure to control room personnel *during access and occupancy*.
- Staff are considering whether to clarify:
  - the expectations for BWR MSIV Leakage LOCA analysis assumptions with respect to pipe breaks

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# Additional Considerations

- Revising footnote 7 which provides an incorrect method to convert thyroid dose to TEDE to read as follows:

“In performing screenings and evaluations pursuant to 10 CFR 50.59, it may be necessary to compare dose results (figures-of-merit) expressed in terms of whole body and thyroid with results expressed in terms of TEDE. Each figure-of-merit represents different systems of dosimetry (e.g. ICRP 2 and ICRP 26/30) which have recognized dose-conversion-factors specifically designed to compute them. There is no methodology which converts between these systems. When performing 50.59 evaluations, the figure-of-merit of interest must be computed with the appropriate dose-conversion-factors.”

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# Expected General Updates

- The NRC staff expects for RG 1.183 Rev. 0 and Rev. 1 to co-exist.
- In addition to items discussed earlier, NRC plans to include changes proposed in DG-1199 as modified by public comments.
  - Incorporate updates, new or withdrawn regulatory guidance (i.e., RG 1.194 (meteorology)).
  - Guidance for modern fuel utilization (non-LOCA gap fractions).
  - Changes due to Regulatory Information Summaries (i.e., 06-04, 01-19).
  - Lessons learned from license reviews (i.e., clarify DFs and containment isolation as used in the FHA).
  - Clarify TEDE calculation terminology (i.e., EDEX vs. EDE).
  - Remove environmental qualification guidance from RG and refer to RG 1.89.

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# Looking Forward

- Consider feedback from stakeholders
- Continue development of updated draft RG 1.183 Rev. 1
- Draft RG 1.183 Rev. 1 issued for public comment (4<sup>th</sup> Quarter CY 2021)
- Hold additional public meetings as necessary prior to the end of public comment period
- Staff review and disposition of public comments
- Update draft RG 1.183 Rev. 1 as necessary
- ACRS and OGC review of final draft (1<sup>st</sup> Quarter CY 2022)
- Issuance of RG 1.183 Rev. 1 (2<sup>nd</sup> Quarter CY 2022)

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# Discussion/Feedback

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# Questions/Comments?

Mark Blumberg, Senior Reactor Engineer (Technical Lead)  
NRR/DRA/ARCB  
mark.blumberg@nrc.gov

Micheal Smith, Health Physicist (Project Lead)  
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micheal.smith@nrc.gov