NRC Perspectives on Design and Testing for the Resolution of GSI-191

John Lehning

Office of Nuclear Reactor Regulation

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ATTACHMENT 2

Motivation for NRC Test Program

- Determine the potential extent of ECCS blockage vulnerabilities
  - Focus data collection on the predominant materials/configurations etc.
  - Characterize transport properties and head-loss behavior to the extent needed to demonstrate credible concern
  - Apply best available information to parametric evaluation
  - Pursue identified concerns (cal-sil, chemical effects, etc.)
- Support the regulatory evaluation of licensee submittals
  - Establish knowledge base of important physical effects
  - Understand the complexities of a detailed plant analysis
  - Understand the rigor necessary to conduct a test program
- Never intended as a comprehensive evaluation of all material properties and technical concerns
  - Though all NRC test data is openly shared with industry, there are obvious gaps that must be filled either with supporting data or convincing conservatism

Historical Position

- NRC regulation has always been based heavily on empirical evidence obtained from conditions as close as possible to reality
  - Complexity of phenomena and systems makes it difficult to intuit interactions that may affect the progression of an accident scenario
  - The cost of an incorrect assumption regarding a designated safety system is generally regarded as being higher than the cost of obtaining data
  - Precedent of incorrect assumptions with important safety implications
  - Examples of past test programs:
    - Containment design, coatings qualification, BWR debris generation, BWR and PWR debris transport, BWR strainer design
- Primary role of the NRC is not to solve technical problems
  - Cooperative test programs have benefitted mutual understanding
    - NRC materials tests ⇔ Industry strainer design
  - Must default to conservatism when faced with uncharacterized conditions

Motivation for Continued Testing

- Primary Objective is to Ensure Long-Term Recirculation
  - Design basis challenge must be properly determined
    - Amount and type of debris loading
      - Debris generation and transport
    - Pool characteristics
      - Flow rates, depth, temperature, chemistry
    - Head-loss behavior of debris bed
      - Specific to combination of materials
  - Sump screens must perform as designed
    - Design collection mechanism of parallel flow with sufficient area
    - Understand head loss and loading as debris bed forms
    - Ensure mechanical integrity under pressure drop
    - Validate filtration performance
    - Maintain proper vortex suppression as bed forms
- Fill knowledge base to avoid penalty of overconservatism
  - Prioritized approach to gain greatest benefit

Existing Data Base Not Comprehensive

- Much of the existing data is based on BWR strainer designs and debris loadings
  - Horizontal cylindrical strainer surfaces designed for homogenous pools of well-mixed debris when PWR sumps may have unique debris impingement angles along the floor
  - Particulate head loss investigations dominated by iron oxide sludge
- Transport and head loss data still needed for specific materials
  - High density fiber, mineral wool, min K, asbestos, resident fiber
- Particulate characterization still needed
  - Material density, packed density, porosity, particle size, head-loss contributions in mixed debris beds
    - Cal-sil, resident PWR dust

Extent of Current/Proposed NRC Tests

- Closed loop head-loss testing (report forthcoming)
- Chemical effects on head loss (summer '03)
- Proposed supplemental tests (concurrent)

Matrix of Proposed NRC Tests

Test Type	Fibrous Material	Particulate Material	Number of Tests
Thin-Bed	LDFG	PWR-Surrogate	4
Thin-Bed	LDFG	Add calcium silicate to PWR-Surrogate	2
Mixed Beds	Miscellaneous Fiber Samples	PWR-Surrogate	4
Transient Beds	LDFG	PWR-Surrogate	2
Material Property		PWR-Surrogate Calcium silicate	2

Potential Additional NRC Tests

1. Demonstrate and quantify the 'thin-bed' effect for PWR types of debris using a 'PWR-particulate' surrogate and LDFG fibers.
2. Obtain material property data that can be used to ascertain the appropriate head loss parameters for the NUREG/CR-6224 correlation for beds of fibers and 'PWR-particulate' surrogate
3. Demonstrate and quantify material property data for the 'thin-bed' effect with calcium silicate added to LDFG/particulate debris bed.
4. Demonstrate and quantify head loss associated with samples of resident debris typical of materials potentially found in PWR containments.
5. Obtain head loss data and material property data that can be used to ascertain the appropriate head loss parameters needed to apply the NUREG/CR-6224 for beds of miscellaneous fibrous/particulate materials.
6. Investigate transient bed effects like adding particulate over fiber bed.

Potential Categories of Industry Sponsored Testing

- Validation of new sump screen designs
- Testing of debris bed compositions not previously investigated
- Quantification of specific unknown aspects of debris generation, transport, and head loss
  - Resident debris in PWR containment
  - Decomposition of fibrous debris in sump pool
  - Effectiveness of curbs in trapping volumes of debris

Testing of New Sump Screens and Strainer Designs

- Each new design put in operation should be supported by applicable test data
  - Tests specific to the design with appropriate debris loadings and pool conditions
  - Head loss predictions depend on design of screen/strainer, e.g., stacked disk vs. cone shaped strainers
  - A new design may behave differently than those tested previously
- Must ensure that debris bed growth under shallow pools does not induce vortex air ingestion (bed effectively changes the geometry)
- Representative sections of a regular strainer array may be sufficient to demonstrate performance characteristics
- Demonstrate effective design principles based on an understanding of debris-bed head loss:
  - increased area, parallel flow, low velocity flow, artificial porosity, bed morphology (avoid thin-bed effect/avoid compaction)

Debris Bed Characteristics

- Full NUREG/CR-6224 head loss correlation is flexible enough to treat a variety of bed compositions and constituent debris properties
- However, proper application of head loss correlations requires debris-specific parameters as input
  - particle density, packing density, specific surface area, particle size and shape, bed porosity, compaction behavior
- Proper application also requires knowledge of interstitial flow velocities and turbulence regime
- These parameters have been characterized for only selected types of debris
- Debris bed formation over the surface of a complex geometry can greatly affect the maximum volume of debris accommodated

Quantification of Resident Debris

- Need to quantify composition and rough estimate of quantity for fiber and particulates typically found in PWR containment. No data exist presently. NRC surrogates provide only useful ranges of behavior but no specifics.
- BWR particulates dominated by iron oxide sludge. BWR estimates of dust was not critical, so had no firm basis. Scaling BWR estimate to PWR surface area is suspect
- Recent walk down of volunteer plant containment shows that, while remarkably clean, typical conditions include
  - dust in low traffic areas, cable trays and tops of equipment and pipes,
  - bits of thread, cloth, paper, silicon, and paint flakes found,
  - equipment hatch open for weeks at a time
  - visible accumulation of dirt and lint around drains
- Fiber blanket removal for pipe inspections may release some amount of individual fibers. Other special characteristics of PWR 'dirt'?

Quantification Strategies for Resident Debris

- Microscopic examination of sweepings to confirm presence of glass fiber, concrete dust, pollen, etc. Meaningful surrogates could then be 'manufactured' for head loss testing
- Find visible accumulations of dust, characterize thickness and scale to surface area as bounding estimate (lamp shades near equipment hatch, cable trays, tops of steam generators)
- Systematically vacuum debris from specific areas of containment(s)
  - Characterize collected debris
  - Correlate with volume/area data to provide containment wide estimates
- Systematically wash a section of containment and filter the sump drain effluent
  - Water spills during outage maintenance may provide this opportunity

Decomposition of Debris in Pool

- Decomposition of fibrous debris in sump pool due to turbulence has been observed (e.g., NUREG/CR-6773), but not quantified in terms of rates and turbulence thresholds
- Decomposition of fiber flocks in stagnant zones not confirmed but continued fiber collection observed for many hours
- Decomposition important because individual fibers transport nearly completely to sump screen and form uniform debris bed across entire screen
- For volunteer plant analysis, NRC currently plans to conservatively assume that degradation is an important mechanism when directed flows circulate in containment and cascading water enters the pool
- Potential savings in conservatism to accurately quantify these phenomena

HPSI Throttle Valve Clogging
Path Forward

- optimize the accumulated knowledge base to support resolution of GSI-191

- considering the viability of constructing a logic model that would screen plants for HPSI throttle valve clogging, example parameters:

  ☞ relative flow path dimensions at sump screen and throttle valve

  ☞ sump configuration (new sump Mod at Davis-Besse)

  ☞ ECCS design (can LPSI provide all flow needed to both hot & cold legs?)

  ☞ debris types (does the type of debris present in a plant containment tend to favor or preclude clogging?) -"debris composites"

- further evaluation only at plants "screened in"

NRC/Industry Public Meeting
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Tim Andreychek
NEI Task Team
Westinghouse Electric Co. LLC
(412)-374-6246
andreyts@westinghouse com

Industry Activity Update

Overview

- Pipe Break Locations
- Break Location Exclusions
- Zone of Destruction Geometry Definition
- Debris Generation by Washdown
- Post Accident Containment Environment
- Post Accident Submergence
- Debris Characteristics
- Questions

Debris Generation

Pipe Break Locations

- Determination of all potential ZODs will be based on pipe break criteria consistent with MEB 3-1
- The break location with the most limiting consequences for sump function will be used for the plant evaluation
- Choice of the most limiting break location will be an iterative process: debris generation and transport will be included in the break choice

Debris Generation

Break Location Exclusions

- Dynamic effects associated with postulated pipe ruptures (including local debris generation) may be excluded from consideration when piping system design analyses reviewed and approved by NRC demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping

Debris Generation

Zone Of Destruction Geometry Definition

- Shape of the ZOD
  - Spherical for double-ended breaks
  - Hemispherical for single-ended breaks
  - Will adjust for presence of robust barriers
- Size of the ZOD
  - Defined in terms of pipe diameters
  - Based on
    - Pressure contained by the piping
    - Destruction pressure of the insulation about the break site
- ZOD size will account for:
  - Pipe radial offset
  - Pipe restraints

Debris Generation

- Spherical ZOD adjusted for robust barriers
  - Robust barriers consist of structures and equipment that prevent further expansion of the break jet
- If a robust barrier is encountered by a break jet
  - ZOD will have spherical boundary with the exception of the volume beyond the robust barrier
  - Radius of the resulting sphere encompasses volume equal to spherical ZOD if the robust barrier not present
- Pure reflection of break jets will not be considered
  - Use of the spherical ZOD addresses effects of jet reflection, pipe whip and traveling jet effects

Debris Generation

Debris Generation by Washdown

- Definitions
  - Encapsulated Insulation. Encapsulated insulation is insulation covered on all surfaces by metal sheets Examples of encapsulated insulation include RMI and calcium silicate cassettes
  - Jacketed Insulation: Jacketed insulation is insulation that is covered on the outside of the pipe by a wide variety of materials. Examples of jacketed material include solid fiberglass and calcium silicate wrapped with aluminum foil

Debris Generation

- Encapsulated insulation not within the ZOD:
  - Are resistant to containment spray action
  - Are not a debris source
- RMI is not affected by washdown effects
  - Not soluble
  - Not eroded by water
- Calcium silicate
  - If encapsulated, will not be a debris source
  - If unjacketed and/or unencapsulated, is susceptible to damage as a result of containment sprays

Debris Generation

Pumped Break Flow Washdown

- Not considered to be a credible debris generation mechanism
  - Jet resulting from RCS break will cause significantly more damage to insulation
  - Will result in the distribution of the resulting debris about the containment away from the postulated break location

Debris Generation

Post-Accident Containment Environment Outside The Zone of Destruction

- Non-DBA qualified coating materials outside the effective ZOD to be evaluated as debris sources

Post-Accident Submergence

- Insulation and non-DBA qualified coatings materials that are submerged to be evaluated as debris sources

Debris Generation

Debris Characteristics

- Size distribution of debris
  - Will be assumed for the ZOD
  - If data is available size distribution may be determined by the location of the material from the break location within the ZOD
- Fibrous Insulation
  - Physical characteristics of debris generated from fibrous materials will be characterized
  - Not all generated fibrous debris will be assumed to be of a size that is transportable
  - Specifics of transportability will be discussed in the Debris Transport section

Debris Generation

- Debris types generated when fibrous insulation is damaged
  - Intact blankets
  - Large chunks (greater than 4 inches)
  - .Medium chunks (1 – 4 inches)
  - Small chunks (less than 1 inch)
  - Fines (individual fibers)

Debris Generation

- Calcium Silicate Insulation
  - Debris sizes generated when cal-sil is damaged
    - Large pieces (over 3 inches)
    - Chunks (1 to 3 inches)
    - Small pieces (less than 1 inch)
    - Dust
  - Data from the licensee's condition assessment may be used to determine orientation of seams relative to the postulated break

Debris Generation

- Reflective Metallic Insulation (RMI)
  - RMI debris is assumed generated within the ZOD
    - RMI is typically installed in pre-fabricated cassettes
    - Break jet impingement can dislodge RMI and possibly damage cassettes, creating smaller pieces of debris
  - RMI cassette debris will be evaluated considering:
    - latch mechanism types and characteristics
    - differences in destruction pressure for different insulation brands and types
    - modes of insulation detachment and destruction
    - pressure at which the destruction of the cassettes will occur
    - destruction of insulation adjacent to the break site

Debris Generation

RMI destruction regimes are defined as
- Dislodged cassettes
- Damaged cassettes (individual foils produced)
- Complete destruction (shredded and crumpled foils)

Debris Generation

- Coatings
  - All coating materials within ZOD are assumed to disbond and contribute to the debris source term
  - Outside the ZOD
    - DBA-qualified coatings not be included in debris source term
    - Non-DBA qualified coatings may contribute to debris source term
  - Existing empirical data, will be used to estimate quantity of disbonded non-DBA qualified coatings
    - Will include consideration of location, standard application methods, general coatings conditions, etc
  - Physical characteristics of the disbonded coating materials will be addressed as input to the transport evaluation

Debris Generation

- Tape, Stickers and Labels
  - All tape, stickers and labels located in the ZOD will contribute to the debris source term
  - Duct, electrical, masking, grip tape, equipment labels and tags secured by adhesives or other means are potential debris sources
  - All non-DBA qualified tape, stickers and labels outside the ZOD are assumed to become debris unless a technical justification to exclude them is available

Debris Generation

- Fire Barrier Materials
  - All fire barrier materials within the ZOD are assumed to be damaged
    - Includes board material blanket material and foam material
    - Fire barrier materials are typically unencapsulated
    - Destruction pressures will be lower than encapsulated RCS insulation of comparable composition
  - Example.
    - Marinite™ board debris is generated within the ZOD
    - All damaged Marinite™ board will be assumed to be broken into large chunks

Debris Generation

- Miscellaneous Debris Sources
  - Miscellaneous debris sources inside containment include, but is not limited to, the following
    - Dust, dirt and lint
    - Fire hoses
    - Ventilation system filters
    - Wire ties
    - Rust from unpainted surfaces
    - Tools and tool boxes
    - Fabric equipment covers
    - Ropes
    - Cloth
    - Plastic sheeting
    - Concrete
    - Scaffolding
    - Auxiliary equipment left inside containment
    - Caulking, mastic or filler materials

Debris Generation

- Debris Transport Guidelines under review
- Guidelines nearing completion
  - Debris accumulation
  - Sump screen pressure drop

Debris Generation

QUESTIONS?

DRAFT

Nuclear Energy Institute PWR Sump Performance Task Force
Program to Address
Degradation of ECCS Performance by Sump Blockage

Evaluation Methodology Ground Rules
DRAFT 12-12-2002

I Objective

This document establishes programmatic and technical ground rules for the development of an evaluation methodology to address the potential for containment sump screen blockage following a design basis event This evaluation methodology (EM) will be used in support of plant specific evaluations that address concerns identified in NRC Generic Safety Issue (GSI) 191

The evaluation methodology and associated evaluation tools are intended to provide utilities with guidance to quantitatively determine plant susceptibility to the potential for degraded ECCS performance by debris accumulation on the containment sump screen with consequential loss of ECCS/Containment Spray NPSH The evaluation methodology will also provide utilities with general guidance on actions that can be taken to ensure ECCS operability during design basis events

The programmatic ground rules described in Section II are the principle set of considerations upon which the evaluation methodology will be based These high level considerations help define the boundaries within which the methodology applies.

Section III presents the principal technical considerations and assumptions upon which the evaluation methodology will be developed Detailed technical assumptions and quantitative correlations based on these technical considerations will be established as part of the methodology development effort.

II Program Ground Rules

1 Initiating Events Considered within EM Scope

The evaluation methodology will be developed in consideration of all design basis initiating events that require ECCS operation in the recirculation mode to successfully mitigate that design basis event The program methodology recognizes that LOCA is the principal initiating event and that sump function is necessary to comply with the evaluation criteria of 10CFR50 46. Other design basis events, such as Main Steam Line Break, which necessitate recirculation flow from the containment sump, will be evaluated using methods, assumptions, and inputs typical for those analyses Events that are beyond design basis will not be addressed as part of the evaluation methodology

The methodology includes the consideration of all events that require ECCS operation in the recirculation mode, but focus is upon LOCA events This is warranted since LOCA events are the most risk-significant due to their combination of the requirement to cool the core with the potential for release of significant radionuclides

2 Application of Single Failure Assumption

Consideration of the initiating event will be based on current design analysis principles Component and system failure [illegible] be limited to credible single failure scenarios Only the limiting failure [illegible] be applied to the entire analysis and the effects of that failure will be consistently applied to all phases of the plant response Expected non-faulted system initial conditions timing and operating characteristics will be assumed

3 EM Scope to Address Containment Sump Performance

The evaluation methodology will assess the effect of debris accumulation on the containment sump screen relative to the operation of the ECCS and containment spray system Other considerations (e g , structural integrity, fuel performance) are beyond the scope of the evaluation methodology

4 EM Scope to Address Materials Typically Used in Industry Applications

The evaluation methodology will address materials typically used in the industry as insulation and coating materials The guidance will not necessarily explicitly consider or assess the generation, transport, or accumulation characteristics of non-traditional materials (i e , materials used in a single plant or rare applications)

5. Application of Risk-Informed Considerations

Program methodology will be developed primarily using deterministic methods Risk-informed considerations, where practical and defensible, may also be used It is anticipated that such considerations may be employed in establishing initial conditions, timing and operating characteristics of plant systems and components

6 Validity of Supporting Data

Data employed in the development of the EM or applied directly through the EM may not have been produced under a 10CFR50, Appendix B program. Such data will be carefully evaluated through a validation and verification process that may include analytical methods such as comparison to theoretical predictions or to other similar but independent empirical results

III General Technical Considerations

Outlined in this section are the working level assumptions and inputs to be used to develop the methodology with which to assess, on a plant specific basis, the potential for degraded ECCS performance These assumptions and inputs are based on the current knowledge basis and existing research activities The assumptions and inputs are categorized based on the phenomena associated with generation, transport, debris deposition and head loss, and the potential for margin recovery

For the purposes of this document, a Zone of Destruction (ZOD) will be defined as follows:

Zone of Destruction — The region surrounding a postulated break location in which the energy of the fluid released from the break will cause sufficient damage to materials (for example insulation and protective coatings) in that area such that debris is generated

This definition is consistent with that developed and used [illegible] NEI-02-[illegible] Condition Assessment Guidelines: Debris Sources Inside PWR Containments

1 Debris Generation

1.1 Pipe Break Locations

Determination of all potential ZODs will be based on pipe break criteria consistent with MEB 3-1

The break location with the most limiting consequences for sump function will be used for the plant evaluation. Choice of the most limiting break location will be an iterative process since debris generation and transport will have to be included in the break choice

1.2 Break Location Exclusions

Dynamic effects associated with postulated pipe ruptures (including local debris generation) may be excluded from consideration when piping system design analyses reviewed and approved by NRC demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping

1.3 Zone Of Destruction (ZOD) Geometry Definition

1.3.1 The shape of the ZOD for each postulated break location will be spherical for double-ended breaks and hemispherical for single-ended breaks unless robust barriers are present, as described below

1.3.2 The size of the ZOD will be defined in terms of pipe diameters, and will be determined based on the pressure contained by the piping and the destruction pressure of the insulation surrounding the break site

Two recommended methods for determining the ZOD are

1. The size of the spherical ZOD can be calculated based on the insulation with the lowest destruction pressure, and all insulation contained within the ZOD is assumed to be damaged such that it becomes debris, regardless of insulation type

2. For each insulation type, a spherical ZOD is calculated

The destruction pressure for each type of insulation is contained in the subsequent sections

Pipe break radial offset may be accommodated for in the calculation of the spherical ZOD size. Similarly, pipe restraints may be accommodated for in the calculation of the spherical ZOD size

The spherical ZOD should be adjusted to appropriately account for robust barriers. Robust barriers consist of structures and equipment that are impervious to jet impingement and prevent further expansion of the break jet

If a robust barrier is encountered by a break jet, the ZOD created will have a spherical boundary with the exception of the volume beyond the robust barrier. The radius of the spherical boundary will be redefined such that the volume encompassed by the ZOD is equal to that encompassed by the spherical ZOD that would be created if the robust barrier were not present

3.4 Pure reflection of break jets will not be considered. The use of the spherical ZOD is intended to address any jet reflection effects. Likewise, the effects of pipe whip and traveling jets are addressed by the spherical ZOD

1.4 Debris Generation by Washdown

For the purposes of this section, the following terms are defined

Encapsulated Insulation	Encapsulated insulation is insulation covered on all surfaces by metal sheets. Examples of encapsulated insulation include RMI and calcium silicate cassettes.
Jacketed Insulation	Jacketed insulation is insulation that is covered on the outside of the pipe by a wide variety of materials. Examples of jacketed material include solid fiberglass and calcium silicate wrapped with aluminum foil

1.4.1 Containment Sprays

Encapsulated insulation materials not within the ZOD are resistant to containment spray action and therefore are not a debris source. Containment spray impingement on insulation materials will have a low stagnation pressure. Based on the experimental results in NUREG/CR-3170, the encapsulation on even the weakest of insulation blankets would not be susceptible to damage from containment spray

RMI is not affected by washdown effects as it is not soluble or easily penetrable by water

Calcium silicate with metal encapsulation will not become a debris source from the action of containment sprays

Jacketed insulation will be evaluated as a debris source

Unjacketed and [illegible] unencapsulated insulation may be susceptible to damage as a result of containment sprays Unjacketed insulation is typically used as fire barrier material

Pumped Break Flow Washdown

This is not considered to be a credible debris generation mechanism as the jet resulting from RCS depressurization will cause significantly more damage to insulation and will result in the distribution of the resulting debris about the containment away from the postulated break location

1 5 Post-Accident Containment Environment Outside The Zone of Destruction

Non-DBA qualified coating materials outside the effective ZOD are to be evaluated as debris sources

1 6 Post-Accident Submergence

Insulation and non-DBA qualified coatings materials that are submerged are to be evaluated as debris sources

1 7 Debris Characteristics

The size distribution of the debris will be assumed for the ZOD If data is available, size distribution of the debris may be determined by the location of the material from the break location within the ZOD

1 7 1 Fibrous Insulation

Physical characteristics of debris generated from fibrous materials will be specifieid Not all generated fibrous debris will be assumed to be of a size that is transportable The specifics of transportability will be discussed in the Debris Transport section

When fibrous insulation is damaged, a number of types of debris can be generated

1 Intact blankets

2 Large chunks (greater than 4 inches)

Medium chunks (1 – 4 inches)

Small chunks (less than 1 inch)

Fines (individual fibers)

Calcium Silicate Insulation

The debris generated from Calcium Silicate insulation systems can be categorized based on size and material

1. Large pieces (over 3 inches)
2. Chunks (1 to 3 inches)
3. Small pieces (less than 1 inch)
4. Dust

Data from the licensee's walkdown program may be used to determine the orientation of seams relative to the postulated break The method of treating seam orientation is being developed. Data regarding distruction pressures for calcium silicate insulation materials is being collected

NRC confirmatory analyses performed to support resolution of strainer issues for BWRs indicate a destruction pressure of 150 psi for calcium silicate insulation with an aluminum jacket Testing with calcium-silicate indicates that the destruction pressures can be less than 24 psid, depending on the orientation of the cladding seams

1 7 3 Reflective Metallic Insulation (RMI)

RMI debris is assumed to be generated within the ZOD Typically, RMI is installed in pre-fabricated cassettes that conform to the piece of equipment being insulated Break jet impingement can dislodge RMI and possibly destroy cassettes, creating smaller pieces of debris

The following information will be used to evaluate the potential for debris generation from RMI cassettes

- latch mechanism types and characteristics
- differences in destruction pressure for different insulation brands and types
- modes of insulation detachment and destruction
- pressure at which the destruction of the cassettes will occur

destruction of insulation adjacent to the break site

RMI destruction regimes are defined as

Dislodged cassettes

Damaged cassettes individual foils protruded

Complete destruction shredded and crumpled foils

1 7 4 Coatings

All coating materials within the ZOD are assumed to disbond and contribute to the debris source term

DBA-qualified coatings outside the ZOD will not be included in the debris source term

Non-DBA qualified coatings outside the ZOD may disbond from the substrate and contribute to the debris source term A quantity of disbonded non-DBA qualified coatings will be estimated from existing empirical data with consideration of location, standard application methods, general coatings conditions, etc and included in the debris source term

Non-DBA qualified coatings that are potential debris sources include coatings on equipment stored in containment or left behind after an outage

Physical characteristics of the disbonded coating materials will be addressed as input to the transport evaluation

1 7 5 Tape, Stickers and Labels

All tape, stickers and labels located in the ZOD will contribute to the debris source term This includes materials that are qualified for service in DBA conditions

Duct, electrical, masking, and grip tape are potential debris sources but other types of adhesive tape can be used inside containment Equipment labels and tags secured by adhesives or other means are also potential sources of debris

All non-DBA qualified tape, stickers and labels outside the ZOD are assumed to become debris unless a technical justification to exclude them from the source term is available Non-water soluble tape, stickers, and labels secured by adhesives located outside the ZOD will be assumed to become debris by peeling off the surface they are attached to Water soluble tape stickers and tags secured by adhesives or other means will be assumed to dissolve under the action of containment sprays or other sources of water

Fire Barrier Materials

Fire barrier materials may be a source of debris inside containment. This includes board material, blanket material and foam material. Fire barrier materials within the ZOD will be evaluated as potential debris sources. Since fire barrier materials are typically unencapsulated, the destruction pressures for these materials will be lower than encapsulated RCS insulation of comparable composition. An example of a fire barrier material is discussed below

Marinite™ board debris is generated within the ZOD According to NUREG/CR-6772, large amount of plastic deformation is necessary to break the board apart Therefore, Marinite™ board is assumed to be destroyed within the ZOD but left intact outside the ZOD All destroyed Marinite™ board will be assumed to be broken into large chunks

Miscellaneous Debris Sources

This section discusses the generation of debris from sources inside containment other than piping and fire barrier insulation

Miscellaneous debris sources inside containment include, but are not limited to, the following:

Dust, dirt and lint

Fabric equipment covers

Fire hoses

Ropes

Ventilation system filters

Cloth

Wire ties

Plastic sheeting

Rust from unpainted surfaces

Concrete

Tools and tool boxes

Scaffolding

Auxiliary equipment left inside containment

Caulking, plastic or filler materials

~~1 Debris Generation~~

~~1.1 Potential Pipe Break Locations~~

~~1.2 Debris Types, Location, Amounts~~

~~1.3 Break Jet Destruction Model~~

~~1.4 Type, Volume and Size Distribution of Debris Generated~~

~~Insulation~~

~~Coatings~~

2 Debris Transport

2.1 Volume of Debris Introduced

2.1.1 Insulation

2.1.2 Coatings

2.1.3 Other Particulates or Materials Present

2.2 Debris Transport Characteristics

2.3 Containment Flood-up Characterization

2.4 Intervening Structures

3 Sump Blockage

3.1 Debris Materials Transported to Sump

3.2 Transient Buildup of Debris on Sump

3.3 Debris Pressure Drop

3.4 Head Loss Incurred Across Debris Bed

4 NPSH Calculation

4.1 Containment Overpressure

5 Operator, Design and System Response Considerations

5.1 ECCS Flow

5.2 Event Duration