ENCLOSURE 1

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BWROG ECCS Strainers

Drywell & Wetwell Walkdown Guidance Document

**Effect of PWR Sump Screen Effort
(GSI-191)
on
BWR ECCS Strainers**

Guidance for conducting containment walkdowns to determine potential debris source term

Author:	Tom Morales, Energy Northwest
Project Manager:	Fred Emerson, GEH
Committee Chair:	Vacant

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1. INTRODUCTION

The industry's PWR fleet is currently completing its response to GSI-191, *Assessment of Debris Accumulation on PWR sump Performance*, and NRC Generic Letter 2004-02, *Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors* [ML042360586]. This issue had its genesis with the BWR effort during the 1990's to remediate ECCS strainers in response to NRC Bulletin 96-03, *Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in BWRs*.

With the PWR program winding down, the NRC has identified differences between the methodologies of PWR sump screens and BWR strainers, and has asked the BWROG to provide information that could ameliorate the need for future regulation[1].

By and large, the PWR program used the methodologies of the BWR URG as a starting point, and built upon them. A result was additional levels of rigor in establishing debris source terms for each plant. The URG relied on a mixture of testing, analysis, and judgment. The same was so for the PWRs, however, in the absence of hard data from testing, the application of judgment tended to be more conservative, and relied heavily on the acquisition and use of walkdown data from each power plant.

The guidance provided in this document is intended to allow each plant to build upon information it developed during its application of the URG in the 1990's. PWR guidance for walkdowns is found in NEI 02-01 rev 1, *Condition Assessment Guidelines: Debris Source Terms inside PWR Containments*, which was issued in September, 2002. It provided a systematic approach that PWR plant personnel could use to gather information on potential post-LOCA debris. The BWR guidance of this document is modeled upon NEI 02-01, with focus on the identified Δ's between the URG and the PWR effort[1].

Further information on the evaluation of latent debris is found in NEI 04-07, *Pressurized Water Reactor Sump Performance Evaluation Methodology* [ML041550332], and its Safety Evaluation [ML043280007].

The extent of walkdown activities required to support strainer performance assessments will vary from plant-to-plant. It is recommended that, as a minimum, all plants perform drywell and wetwell walkdowns to confirm that quantities of materials that can contribute to post-LOCA debris are consistent with current plant design, FME practices, and wetwell sludge accumulation rates. Variability in plant-specific programs may lead some facilities to develop supplemental documentation that others already possess. Also, facilities may vary in their

[1] April 10, 2008 letter from John A. Grobe, Associate Director for Engineering and Safety Systems, to Richard Anderson BWROG Executive Chairman, Potential Issues Related to Emergency Core Cooling Systems, [ML080500540]

execution of ongoing condition assessment programs (e.g., coatings assessment programs) that they can readily apply in addressing GSI-191 issues.

2. PURPOSE and SCOPE

The purpose of this guidance document is to identify walkdowns that help confirm source terms for potential post-LOCA debris in BWR drywells. It defines the specific actions that each plant may need to quantify and characterize debris. Information from the walkdowns will support the following activities that are needed to resolve questions that have arisen during the recent PWR efforts to resolve GSI-191 for ECCS strainers:

1. Confirmation of source terms for latent debris.
2. Confirmation of source terms for insulations that are known to have adverse effects on strainer head losses.
3. Identification of materials that may contribute to post-LOCA chemical interactions that result in precipitates.
4. Confirm assumptions on coatings debris

These, in turn will provide input to address:

- Strainer head loss correlations
- Downstream effects on ECCS components
- Downstream effects on fuel.

Note that the scope of PWR walkdowns included coatings. PWRs verified amounts of unqualified coating systems in their containments, and confirmed the adequacy of DBA-qualified coating systems.

It is expected that each BWR facility has a program in place to maintain the qualification of containment coatings. Also, BWRs will have established and confirmed inventories of non-qualified coating systems inside containment during the original effort strainer effort, and that control of unqualified coatings is in place. Accordingly, this document provides no-BWR specific direction on the walkdown of coatings.

The BWROG ECCS Strainer Committee is developing a technical paper on coatings, which is assessing industry guidance that has developed since issuance of the URG. This technical paper, which will be completed in January, 2009, will identify activities that BWROG and individual plants should consider confirm coating's contributions to debris source terms.

Should the technical paper make recommendations regarding coatings qualifications that entail walkdowns, this walkdown guidance will be updated at that time. In the interim, this document includes an Appendix B (p. 26) that has the walkdown guidance given to PWRs in NEI 02-01. BWRs should review their coatings programs to confirm that it includes appropriate elements to ensure ongoing qualification of their coating systems.

3. WALKDOWN PREPARATION

This section identifies actions that are recommended to prepare for the containment walkdowns

3.1. Design and Licensing Considerations

The walkdown and assessment team should understand the design basis and licensing commitments for the ECCS Strainers. Toward than end, the assembly and review of the following information will be helpful:

- ECCS strainer design: Identify the design requirements of the ECCS strainers. Retrieve and review debris transport calculations. Locate, retrieve and review calculations for ECCS strainer head losses and pump $NPSH_A$. Identify the basis for those calculations (e.g., suppression pool / torus water level, water temperature, the debris source terms defined for the strainers, and the pipe break(s) that governed the debris source terms.)

- Licensing bases: Identify, locate, extract and list the licensing bases requirements and commitments for the ECCS strainers and the relevant design basis accidents (DBA). Note that, depending upon plant-specific designs, design basis transients other than large-break LOCA may suspend debris that could be entrained in ECCS recirculation flow from the suppression pool or torus (e.g., events utilizing the Automatic Depressurization System). Identify requirements and commitments for use of drywell and wetwell sprays, dislodging latent debris.

- FME excursions: Review the plant's condition reporting database to identify containment debris that has been documented since installation of replacement ECCS strainers in response to NRC Bulletin 96-03. Examples of these include, but are not limited to, coatings failures, failures of flex conduit sheathing, and foreign materials (electrician's tape, etc.) found inside containment during outages.

- Housekeeping: Review the plant's condition reporting database to identify problems with housekeeping practices in the drywell and wetwell.

3.2. Construction and Maintenance Records

Prior to the walkdown, the team should attempt to locate, retrieve and review construction and maintenance records associated with materials (insulation, coatings, etc.) inside containment that have been identified as contributing to post-accident debris generation. These records include, but are not limited to:

3.2.1 Records of Insulation Installation

- What insulation was used inside containment,
- Where it was used (on equipment, in penetrations, on piping, etc.),
- How it was installed; encapsulated, banded, etc.,
- Inspection records, if appropriate or available, and
- Design changes that may have changed insulation used.

3.2.2 Foreign Materials Exclusion Program

The walkdown team should review and be aware of the site-specific foreign materials exclusion program to identify specific items and exclusions addressed under the program.

3.3. Selection of Regions of Containment for Walkdowns

3.3.1 Selection Criteria

The following general guidance is offered to assist in selecting those areas or regions within the containment for the detailed walkdowns. Selection of walkdown locations and planning must address ALARA considerations.

3.3.1.1 Identify potential break locations for large-break LOCAs.

3.3.1.2 Identify other design basis transients for which ECCS recirculation from the suppression pool / torus will be needed. Note that, depending upon plant-specific designs, design basis transients other than large-break LOCA may require recirculation from the suppression pool / torus, including small-break LOCA, ATWS.

3.3.1.3 Identify areas or regions of containment for detailed inspection based on a plant-defined zones of influence (ZOI) from a pipe break, as well as regions in the direct line of sight[2] from the postulated break location. (See Footnote 5 on page 7 for further discussion on ZOI methodologies.)

3.3.1.4 Identify special conditions and zones that warrant additional inspection and material quantification.

3.3.1.5 Develop a plan for general inspection for drywell spray wash-down.

Once the plan is developed, all insulation materials, coatings and foreign materials are to be carefully reviewed within the areas or regions to be inspected in detail. A more general inspection may be conducted for the rest of drywell to ensure that all other insulation materials outside the detailed inspection zones are not subject to destruction by drywell sprays.

Walkdowns should identify all potential debris. Subsequent analyses of pipe breaks may credit for intervening structures between break locations and the debris source. This credit should be taken only when the intervening structures are robust and large structures, such as walls, that will block or deflect jets or pressure waves resulting from postulated breaks.

3.4. Walkdown Materials

Materials to Support the Walkdown As a minimum, the following materials may be useful to the walkdown team to support their effort.

- Topographical containment layout drawings for markup,
- Piping isometric drawings for markup,
- Process diagrams for markup,
- Radiation protection survey drawings,
- Scaffolding and ladders, as appropriate,
- Measuring tape,
- Measuring probe (ruler), to determine thickness of insulation,

[2] The consideration of line-of-sight is addressed further in this document's discussion of problematic insulations in section 4.1.1.2 on page 7.

- Flashlights or other high-intensity light sources, as appropriate,
- Cameras, choice of digital, Polaroid, 35mm, video camera (voice recording may also be useful),
- Non-destructive magnetic pull gauge (for measuring paint thickness on ferrous metals),
- Sample bags (for collecting samples of insulation, failed coatings and other materials of interest) with latent debris swipes (see section 4.2.2.3 on p. 14),
- Sample knife, and
- Marking pen(s).

3.5. Timing of Walkdown(s)

The walkdown for latent debris (Section 4.2 on p. 12) should be done early in an outage to establish an as-found baseline for containment cleanliness. Other elements of the walkdowns may be performed at any time during an outage.

4. Drywell and Wetwell Walkdowns

The following are specific items to look for and record during the walkdown.

4.1. Insulation

4.1.1 Why Look at Insulation?

Each plant will have identified their drywell insulations during their resolution of NRC Bulletin 96-03. During the PWRs' effort, several issues arose that raise questions about BWR insulation and its contribution to debris source terms.

- Many PWRs based their initial assessment of post-LOCA debris on design drawings. There were often disparities between the type of insulation shown on the drawings and that installed on piping and components.
- The extent of insulation was not always properly depicted on drawings. For instance, insulation was found on pipe hangers and within penetrations that was never captured on drawings.

- The strict application of ZOIs may have inappropriately excluded problematic debris that would contribute to significant head losses across strainer debris beds.[3]

These issues are particularly sensitive to those plants that used calcium silicate or micro-porous insulations (e.g., Microtherm, Min-K) in their drywells. These insulations have been demonstrated to be bad actors for head losses across debris-laden strainers.[4]

The adverse effects of these problematic insulations can be compounded for those BWRs considered to have "low-fiber" drywells (e.g., all-RMI). PWR walkdowns identified small, undocumented sources of potential fibrous debris (e.g., fire barriers within penetrations, cable wraps, fibrous binders within particulate insulation). Low amounts of fibrous debris, when combined with particulate debris, can contribute to excessive head-losses across strainers, the result of thin-bed effects.

To the degree that walkdowns were performed, executed rigorously and documented during a BWR's resolution of NRC bulletin 96-03, Potential for Plugging of ECCS Suction Strainers by Debris in BWRs, further validation may not be required. However, each BWR should assure the following:

4.1.1.1 Insulation types and inventories identified during the URG effort are complete. Plants should confirm the extent of calcium silicate and micro-porous insulation in their drywells. Plants that claimed no calcium silicate or micro-porous insulations should confirm that assertion.

4.1.1.2 Plants with known calcium silicate or micro-porous insulations should verify any judgments made to exclude them from post-LOCA debris source terms. Such insulations that are located in the line-of-sight of a pipe break, yet outside nominal zones of influence, as determined by URG ZOI methods[5] 2, 3 and 4, should

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[3] There is a parallel concern that is being addressed by the BWROG. The NRC questioned the application of air-jet derived ZOI's for two-phase breaks. This concern stemmed from the prevalence of two-phase breaks in PWRs. Anecdotal evidence suggests that air-jet test results are conservative for two-phase breaks. Until this is confirmed, however, there exists the potential for larger ZOI's being required for recirculation line breaks. For this reason, good documentation of insulation is needed beyond the envelope of previously-defined ZOIs.

[4] The NRC has questioned the conservatism of head loss correlations developed for cal-sil and micro-porous insulations. This issue is being addressed by the BWROG ECCS strainer committee, and may result in changes to head loss correlations used during resolution of NRC bulletin 96-03.

[5] URG Section 3.2.1.2.3 (p. 36) identified four methods:

Method 1: Entire drywell is assumed the ZOI: All insulation is assumed to become debris.
Method 2: Target-based ZOI: ZOI selected based upon worst-case location of insulations

(a) Include the insulation in debris source terms, or

(b) Provide case-by-case justification for exclusion of the insulation from the debris source term, or

(c) Replace the insulation with a more benign type of insulation.

4.1.1.3 Sampling may be needed of calcium silicate insulations to determine their precise properties. These properties may factor into a reassessment of strainer head losses caused by entrained debris.[6]

4.1.2 Who Should Participate in the Walkdown?

The walkdown should be conducted with personnel familiar with the installation of equipment insulation (e.g., plant craft involved with insulation maintenance) and the engineer responsible for the plant's response to this issue.

4.1.3 Walkdown Preparation

4.1.3.1 Retrieve and review analyses and documentation developed during the original resolution of NRC Bulletin 96-03. Determine the ZOI methodology used for identifying target insulations.

4.1.3.2 For plant using URG ZOI Method 2 (target-based ZOI), identify the target areas that were originally assessed.

4.1.3.3 For those plants using URG ZOI Method 3 (Break Specific Analysis using Break-Dependent ZOIs) or Method 4 (CFD Analyses), identify the break locations and nominal zones of influence of the breaks.

4.1.3.4 For URG Methods 1, 2, 3 and 4, identify how target materials were identified (e.g., design drawings, walkdowns, or combination of both). Retrieve the relevant drawings.

Method 3: Break-Specific Analysis: ZOI's determined for largest identified pipe breaks
Method 4: Computational Fluid Dynamics (CFD) used to determine more limited ZOI(s).
Note that use of Method 4 required plant-specific justification per the URG NRC 1SE.

[6] The requirement for sampling cal-sil is tentative. The NRC has expressed concern regarding the existence of two types of calcium silicate insulation, hard and fragile. The latter type, fragile, is presumed to disintegrate like "aspirin", when wetted. [ML070520218]. Further investigation is required to determine whether this concern is valid and requires action by BWRs.

4.1.3.5 Other documents that may be useful:

(a) Piping and Instrumentation Drawings

(b) Piping layout drawings

(c) Piping isometrics

(d) Insulation specifications

(e) Work orders for insulation installation, repair and modifications

(f) Past insulation surveys (e.g., Original resolution of NRC Bulletin 96-03 for BWR ECCS Strainers

4.1.3.6 Assess design documentation (drawings, specifications) for RMI to determine whether aluminum or stainless steel foil was used for its construction. If there is uncertainty in this regard, walkdowns should confirm the extent of aluminum-based RMI for inclusion in the inventory of reactive materials. (See Section 4.3 of this guideline.)

4.1.3.7 Perform a pre-job briefing, addressing:

(a) Purpose and objective of walkdowns

(b) Examples of different types of insulation expected to be observed inside drywell during the walkdown

(c) Details of construction for jacketed insulation

4.1.4 What to Look For

4.1.4.1

(a) Insulations

Walkdown piping, equipment, structures, and penetrations and survey the installed insulation. Insulation products commonly used in containments are identified in the table below. The insulation types listed in the table are not intended to be an all-inclusive list, but rather serve as an illustrative example of what to look for during the walkdown. These insulations may be jacketed and, depending upon the expertise of the walkdown personnel, removal of jacketing may be required to confirm the underlying material.

Insulation Products Commonly Used in BWR Containments

Calcium Silicate (Cal-Sil)	Min-K
Kaowool	NUKON
Koolphen-K	Microtherm
Reflective Metal Insulation (RMI)	TempMat
Knauf fiberglass blankets	

(b) Fire Barriers

Similarly, BWRs with installed fire barriers (e.g., in non-inerted containments) should inspect for potential fibrous or particulate debris from these materials. These may include penetration seals and cable fire-wraps (e.g., Interam insulation).

(c) Lead Blanket Shielding

Lead blanket shielding maybe encased in fibrous materials, subject to destruction and liberation, when hit with a pipe jet.

4.1.4.2 Debris Sources from Drywell Sprays

Insulation may also be subjected to impingement from drywell sprays, resulting in degradation of the insulation material and thereby generating debris. Examples of this will be piping exposed directly to drywell sprays or located under floor grating that provides for drywell spray to drain from upper elevations of drywell to the drywell floor. It is suggested that plants examine their drywells for these configurations as part of their drywell walkdown performed under this guideline.

Documentation of piping subjected to drywell sprays or resulting drainage from upper to lower elevations may be accomplished through markups of topographical maps, detailed design drawings or photographs.

4.1.5 Where to Look[7] (Per plant-specific design)

The walkdown should address the drywell regions that are within and outside established ZOIs. Inspect piping, equipment, temporary equipment left inside

[7] The NRC has used a sphere having the radius of L = 12D, where "D" is the diameter of the break and "L" is the radius of a sphere that is centered at the break location, to assess the debris generation capability of a postulated break. However, the size of the zone of destruction about the break location is subject to interpretation. Therefore, it is recommended that the location and characteristics of all insulation materials used outside the sacrificial shield wall be documented and confirmed by a walkdown.

containment, structures between the reactor pedestal / sacrificial shield wall and drywell wall that could be influenced by a postulated high energy line break or drywell sprays.

Examine piping within guard-pipe type (e.g., flued head) containment penetrations. Accessible piping penetrations in reactor pedestal / sacrificial shield wall should be surveyed.

Also, other components that may have fibrous materials applied to them should be included in the walkdown. For example, these include, but are not limited to, all insulated equipment, pipe hangers, whip restraints, fire barriers, HVAC air cleaning filter media, electrical cable trays and electrical cables inside containment.

4.1.6 Documentation

Each plant should develop a method of documentation of walkdown results that supports the validation or update of original analyses performed for their URG resolution. This may include mark-ups of design drawings for insulation or inspected components and features.

In addition, the use of a video camera, still pictures and/or digital photographs may be useful to augment walkdown documentation, and for future reference for details such as;

- Condition of the insulation and jacketing,
- Details on the how jacketing and wrapping are secured/fastened to piping

The following attributes were identified in NEI 02-01 for PWRs, and may be of use in documenting walkdowns:

4.1.6.1 Identification of transitions from one insulation type to another (i.e., temp-mat vs. NUKON or Transco fibrous insulation, calcium-silicate vs. Unibestos block insulation, or reflective metallic insulation vs. calcium silicate).

4.1.6.2 Equipment or component identification (including piping line numbers, cable tray numbers, hanger identifications, etc.)

4.1.6.3 Identification of intervening structures between known break locations and targets. These structures must be of a size that would block jet impingement and pressure waves. The recording of structure sizes /

locations and photographing of barriers may be useful for future assessment of their efficacy in preventing damage.

4.1.6.4 Insulation properties

(a) If the insulation is RMI, also record if the insulation is aluminum or stainless steel.

(b) Insulation thickness/pipe size.

(c) Length (and width, if appropriate) of insulation.

(d) The type of fastening, jacketing or wrapping, if used.

(e) The details of the construction of jacketing (spot-welding or reinforced jacketing), as appropriate.

(f) The general condition of the jacketing or wrapping.

(g) The method used to band the insulation and the number of bands used, if appropriate.

(h) Other relevant information regarding the type and installation of insulation.

4.1.7 Alternate Sources of Plant Insulation Documentation

Plant programs that control and document the use and location of various types of insulation inside containment may be used as either an alternate or supplemental source of information to support an evaluation of potential debris sources.

4.2. Latent Debris[8]

4.2.1 Why Look for Latent Debris?

[8] Plants conduct walkdowns to identify and remove foreign materials prior to reactor restart following a shutdown. To address GSI-191 concerns, additional tasks of identifying certain materials not removed from containment and estimating and/or characterizing potential debris sources inside containment, should either be implemented as a part of the foreign materials exclusion walkdown or conducted separately.

If a walkdown to identify and remove foreign materials is not currently conducted prior to reactor restart following a shutdown, consideration should be given to implementing a walkdown using the full guidance given in this section.

The URG defined, and the NRC approved use of a generic value of 150 lbs. of dirt and dust for latent debris. The URG did not attempt to impose a generic FME/housekeeping standard on it utilities. However, it put forward the expectation that each utility have a performance goal for their FME/housekeeping program that would maintain the validity of the assumed quantity of latent debris.

The NRC has now judged this treatment of latent debris to be potentially non-conservative, especially for low-fiber plants. If latent debris takes a different form – i.e., fibers - from that assumed dirt and dust, it could contribute to unforeseen thin-bed effects.

The NRC required that PWRs determine latent debris loading on a plant-specific basis. This was coupled with a call for programmatic controls for containment cleanliness inspections and verifications. The NRC further suggested that such controls may not be in place for BWRs.

The potential presence of corrosion products in BWRs, in the NRC's judgment, warrants additional work to evaluate whether the BWR assumption regarding latent debris is conservative, and, if not, whether additional action (e.g., programmatic monitoring of latent debris) is needed.

4.2.2 Preparation

The purpose is to provide for a quantitative assessment of dirt, dust and lint as a debris source. A complete, direct measurement of this debris source is difficult and impractical. For this reason, a sampling technique is recommended. This sampling process should be documented in a procedure.

In order to provide a statistical basis for the sampling, each plant should develop a conservative estimate for the total surface area where material can accumulate in the drywell and wetwell.

4.2.2.1 Identify and assemble drawings of drywell and wetwell designs, including

(a) Structural steel, concrete, platforms and catwalks

(b) Piping, valves (including operators), supports and restraints, insulation

(c) Pipe whip restraints

(d) HVAC ducts, equipment, dampers (including operators), supports and restraints

(e) Cable Trays / Conduit, supports and restraints

(f) Recirculation pumps, motors, and supports

4.2.2.2 Develop a tally of horizontal and vertical surface areas for each type, above. The use of simplifying and conservative assumptions on surface area should be considered. These assumptions should be documented, and subject to further refinement, as may be needed. [For further guidance, see Section 3.5 of NEI 04-07, *Pressurized Water Reactor Sump Performance Evaluation Methodology*, included as Appendix C, herein (p. 1).]

4.2.2.3 Develop standard, sealable plastic bags with pre-weighed debris-capture items for walkdowns. These may be:

(a) Masslinn® dusting cloth, or equivalent.

(b) HEPA Vacuum bags

(c) Sticky-cloths

4.2.3 Who Should Participate in the Walkdown?

The walkdown should be conducted with cognizant personnel responsible for containment decontamination and/or outage housekeeping activities. Consideration should also be given to reviewing both the walkdown plans and the walkdown results with the cognizant personnel responsible for the site foreign materials exclusion program and appropriate system engineers.

4.2.4 What to Look for

4.2.4.1 For each type of surface identified above, look for and record, either by notes or photographs or both, buildup of dirt, dust and lint inside containment greater than what is found in the general areas of the containment; that is, look for concentrated areas of buildup of these items.

4.2.4.2 If one or more areas of buildup are found:

4.2.4.3 Visually inspect the buildup to determine the nature of the buildup; dirt, lint, grit, sand, etc.

4.2.4.4 Record observations on the nature of the buildup.

4.2.4.5 Collect and label a sample of the buildup in sample bags[9]. Record on the bag:

(a) Source of the sample

(b) Area (ft^2) of surface swabbed

(c) Date and time of sample

4.2.4.6 Perform similar sample collections of remaining horizontal and vertical surfaces types for which no unusual accumulation is identified.

4.2.4.7 Issue Condition Reports to address any other FME materials found during walkdown, such as:

(a) Tape: E.g., electrician's tape, duct tape, masking tape, all of which are frequently used on the containment walls to identify equipment locations. Also included is non-slip tape applied to ladders (although not readily removed under normal wear conditions, this material may become dislodged and mobile when wetted).

(b) Equipment labels, such as paper/plastic labels, stickers or signs that could be dislodged and transported. This also includes operations tags not properly secured.

(c) Construction and maintenance debris. This includes rags, plastic face shields, plastic bags, packaging, gasket material, excess sealant materials, foam ear plugs, sawdust from custom scaffolding construction, etc.

4.2.5 Evaluation

4.2.5.1 The sample bags for each surface type should be weighed, and Δ's identified by surface type.[10]

4.2.5.2 Using appropriate sampling techniques, develop an estimate for total latent debris in the containment. (See Appendix C of this guidance.)

4.2.5.3 Low-fiber plants should evaluate the collected samples for particle composition (grit, sand, lint, etc.), size and density. NEI 04-07 provides guidance for the characterization of latent debris in its

[9] The control of latent debris samples will require appropriate HP participation.
[10] The control of latent debris samples will require appropriate HP participation.

Section 3.5.2.3, *Define Debris Characteristics*, included on page 36 in Appendix C of these guidelines.

4.2.5.4 Assess the condition reports initiated per step 4.2.4.7 to confirm the continuing validity of FME assumptions used in the facility's calculation of debris source terms.

4.2.6 Where to Look (Per plant-specific design)

4.2.6.1 The walkdown should be performed for those areas of the wetwell and drywell that may be affected by either wetwell or drywell sprays following a postulated LOCA.

4.2.6.2 Locations to look for dirt, dust and lint buildup inside containment include, but are not limited to: equipment surfaces, floor recesses, cable trays and ledges of walls and partitions.

4.2.7 Documentation

The walkdown data and supporting statistical extrapolation should be captured in a formal analysis that documents the location and the type of foreign material inside containment.

Foreign materials that may become debris sources should be characterized with respect to specific gravity and, if applicable, particle size, to the extent practical.

When practical, foreign material should be removed from containment as a general housekeeping activity, and to minimize potential debris causing strainer head losses.

4.3. Reactive Materials

Chemical reactions can occur in the wet post-LOCA wet environment of the suppression pool and drywell. Drywell sprays will contribute to this effect by washing debris to the wetwell, leaching chemicals from drywell materials, and reacting directly with materials. This effect may be accelerated by the addition of sodium pentaborate into the ECCS flow stream.

Once in the suppression pool, the degradation of insulation materials will add to the water's chemical constituents and affect its pH. The recycling of the water through the drywells sprays continues the process.

PWR tests have shown that fine precipitates – generally compounds of aluminum, calcium, and silicon - can form from these reactions. While BWR chemistry is demonstrably less aggressive than that of PWRs, there remains a likelihood that some amount of precipitates will form.

4.3.1 Why Look for Reactive Materials?

Chemical precipitates have been found to be a major contributor to head losses across PWR strainer debris beds.

4.3.2 Preparation

4.3.2.1 Walkdown participants should review Appendix A[11] of this guideline to establish the potential scope of materials that could affect post-LOCA chemistry.

(See Section 4.1.3.6 for discussion of RMI using aluminum foil)

4.3.2.2 Develop a log to document materials found, and to identify items of unknown material type for further investigation.

4.3.3 Who Should Participate in the Walkdown?

Initial walkdowns may be performed by system engineers or other personnel. Subsequent drywell or wetwell entries may be required by cognizant staff to resolve questions regarding items with unidentified materials.

4.3.4 What to Look for

4.3.4.1 Bare metal

4.3.4.2 Unjacketed insulation

4.3.4.3 Items that do not appear on design documents (e.g., materials left behind during original construction.

4.3.4.4 Lubricant reservoirs (i.e., identify potential liquid contaminants).

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[11] The PWROG's topical report WCAP-16530-NP-A, "Evaluation of Post-Accident Chemical Effects in Containment sump Fluids to Support GSI-191", provides detail on the PWR's execution of the program, as well as the NRC's safety evaluation. The document can be found at the NRC website [ML081150379]. Appendix A, following, provides an extract of WCAP-16530-NP-A, identifying typical materials found in PWR containments, and supporting information.

4.3.5 Where to Look

All surfaces that can be wetted by drywell or wetwell sprays.

5. RECORDS RETENTION

Documentation should be of sufficient quality to support the preparation of safety-related Design Input Records and/or Design Calculations. Documentation collected in the records review and walkdowns should be retained for future use. The documentation should also identify areas where records are incomplete or where information identified in this guideline was either not applicable or unavailable.

APPENDIX A

PWR Materials Classification from WCAP 16530-NP-A

Classification of Containment Materials Found in PWRs

The base chemical composition of each containment material was determined from published information, including information from product data sheets, material safety data sheets, vendor web sites and text books. For natural products such as asbestos and vermiculite, nominal composition data were used. The data [from PWRs] were used to establish general classifications of the materials. These classifications are discussed in this section and are summarized in Table 3.2-2.

Aluminum

This classification includes all aluminum alloys. Aluminum is primarily present as structural members, coatings, small components (e.g., valves) and thin foil coatings on insulation. Commercially pure aluminum (SA 1100) was used for bench-scale dissolution testing. This approach is considered to be conservative since aluminum alloys are typically more corrosion resistant than pure aluminum.

Aluminum Silicate

This classification includes both synthetic aluminum silicate insulation materials and natural aluminum silicates such as kaolin clay and vermiculite. The containment materials represented in this classification are 3M M-20C insulation, 3M I-Series insulation, Cerablanket, Fiber Frax Durablanket, Kaowool, Mat-Ceramic insulation, mineral fiber, and PAROC mineral wool. Fiber Frax Durablanket was used in bench-scale dissolution testing to represent this material class.

Calcium Silicate

This classification includes low-density calcium silicate mat insulation, asbestos and asbestos-containing insulation, and the high density refractory materials (e.g., transite). The containment materials represented in this classification are asbestos, Cal-Sil insulation, Kaylol, marinite, Mudd, transite, and Unibestos. Low-density calcium silicate was used in bench-scale dissolution testing to represent this material class. Asbestos is a broad classification of naturally-occurring minerals that are primarily mixed metal silicates' 5. Most forms of asbestos are typically resistant to dissolution under a broad pH range. To bound all asbestos materials, it was assumed that all asbestos is chrysotile (primarily magnesium silicate), and has the same dissolution behavior as calcium silicate. This conservative assumption is considered acceptable due to the low occurrence of asbestos.

Carbon Steel

This classification includes all uncoated/ungalvanized carbon and low alloy steels. These materials are typically present as structural members. Carbon steel SA 508 Class 2 was used in bench-scale dissolution testing to represent this material class. Although no steps were taken to intentionally pre-oxidize the specimens, a thin natural, low temperature oxide was present.

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Concrete
Concrete is a complex mixture of cement, natural sand and gravel/rocks (all primarily silicon dioxide), and admixing agents (e.g., fly ash). Cement is prepared by heating a mixture of calcium oxide and silicate-containing materials to create tricalcium silicate and dicalcium silicate. Based on the base composition of concrete, the dissolution behavior of this material could reasonably be expected to be similar to that of calcium silicate. However, concrete was classified as a distinct material since it is ubiquitous in PWR containments. Ground concrete was used in bench-scale dissolution testing to represent this material class. The concrete sample was aged for greater than 28 days prior to use. Use of ground concrete is considered conservative due to its high surface area relative to that of structural concrete.

Copper
This classification includes all copper-containing alloys. As demonstrated in prior testing and based on published data, this material class is resistant to corrosion under expected post-accident conditions. Therefore, this material was not included in the current test program.

E-Glass
This classification includes all fiberglass insulation and cellular glass. E-glass is an amorphous material containing silicon dioxide, calcium oxide, aluminum oxide and boric oxide. The material is typically resistant to dissolution in aqueous solutions over a broad range of temperature and pH, but some reaction does occur at high temperatures in alkaline solution. The containment materials represented in this classification are all fiberglass insulation (unspecified manufacturers), Foamglas, NUKON1, Temp-Mat and Thermal Wrap. Unspecified fiberglass and NUKON were used in dissolution testing to represent this material class.

Amorphous Silica
Similar to the E-glass category, the amorphous silica class contains materials made up of predominately amorphous silica with a small percentage of E-glass. The containment materials in this classification are Min-K' 8 and Microtherm 20. Min-K was used in the bench-scale dissolution testing to represent this material class and was found to behave differently enough from the E-glass class to require its own class.

Interam E-Class Insulation
Interam E-Class insulation is nominally composed of a blanket of fibrous hydrated alumina and aluminum silicate, with an aluminum alloy foil outer layer. No other materials were of similar composition. Therefore, this classification only includes the Interam E-Class material, and this material was included in bench-scale dissolution testing.

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Mineral Wool

This classification includes mineral wools produced from steel slag and rock wools produced from naturally-occurring minerals such as basalt and dolomite . Mineral wools are typically slightly less resistant to chemical attack than rock wools 24. Steel slag is nominally composed of calcium oxide, silicon dioxide, iron oxides, iron metal and minor amounts of other metal oxides and sulfur. The containment materials represented in this classification are Min-Wool and rock wool (manufacturers unspecified). Min-Wool was used in bench-scale dissolution testing to represent this material class.

Nickel

This classification includes all nickel-containing alloys. As demonstrated in prior testing, and based on published data', this material class is resistant to corrosion under expected post-accident conditions. Therefore, this material was not included in the current test program.

Organic Mastics

This classification includes all mastic coatings that contain inorganic materials in organic binders. The containment materials represented in this classification are CP-10 and Thermolag 330-1. The inorganic components of these compounds are encased in polymeric materials, vinyl acetate for CP- 10, epoxides for Thermolag, and thus would not be exposed to sump fluids. On this basis, these materials were not represented in bench-scale testing.

Other Organic Materials

This classification includes rubber, foam rubber, phenolic resins, pressed wood products, and liquid hydrocarbons. The containment materials represented in this classification are: Armaflex, Benelex 401, Kool-Phen 30, and RCP motor oil. Consistent with the protocols established in the ICET program, organic materials were generally excluded from bench-scale dissolution testing. The basis for excluding such materials is that they were judged to be unlikely to breakdown to produce precipitate-forming species under the temperature and chemistry conditions tested.

Reactor Coolant Oxides

This material class includes the nickel ferrite and other oxides typically present in the corrosion product film on the inner surfaces of the reactor coolant system during normal operation. Under accident conditions, a small fraction of this film may spall off or be solubilized due to oxidation of the coolant. Based on measured releases during intentional coolant oxidation routinely conducted as part of normal plant shutdown, the magnitude of this release is expected to introduce a negligible quantity of material into the sump under accident conditions. Therefore, this material class was not included in the current test program.

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Zinc
This classification includes galvanized coating on carbon steel, including both hot-dipped and electrodeposited galvanization, and zinc coatings. Hot-dipped galvanized steel was used in bench-scale dissolution testing to represent this material class. Organic zinc coatings in which zinc is bound in an organic matrix, and therefore not exposed to the coolant, should be classified under "Other Organic Materials." Other organic zinc coatings should be treated as zinc metal.

Table 3.2-1: Base Composition of PWR Containment Materials

Material	Composition	Notes
3M Interam E-5	70% hydrated alumina, 25% aluminum silicate, 3% metal foil (aluminum alloy), organic binders	
3M M-20-C	50% vermiculite (aluminum and magnesium silicate + other metal silicates), 13% aluminum silicate, foil/binders	
Aluminum	aluminum	
Armaflex	nitrile rubber + PVC	
Asbestos	magnesium silicate + other metal silicates	
Benelex 401	lignocellulose hardboard (pressed wood)	
Calcium Silicate Insulation	calcium silicate	
Cerablanket	100% aluminosilicate -	
Concrete	>80% silicon dioxide, 13% cement - -	3
CP-10	20% silica (quartz), 12% hydrated alumina, 5% titanium dioxide + vinyl acetate	
Fiberfrax Durablanket	100% aluminosilicate	

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Table 3.2-1: Base Composition of PWR Containment Materials

Material	Composition	Notes
Foamglas	100% E-glass	1
Kaowool	80% aluminum silicate -t- 20% kaolin clay (hydrated aluminum silicate)	4
Kaylo	90% calcium silicate ÷ 10% asbestos	5
KoolPhen	phenolic resin	
Marine	70% calcium silicate ' 22% calcium metasilicate + organic fiber + fiberglass	6
Mat-Ceramic	100% aluminosilicate	
Microtherm	90% (amorphous silica + silicon carbide) + 10% (E-glass + aluminum oxide)	1
Mineral Fiber	100% aluminosilicate	
Min-K	amorphous silica + E-glass (fiberglass)	1
Min Wool	steel slag + 5% phenolic resin binder	2
Mudd	50% calcium silicate, >10% cement, 10% (silicon dioxide + aluminum oxide) + other metal oxides/silicates	
Nukon Base Wool	>95% E-glass (fiberglass) + <5% binders	1
PAROC Mineral Wool	100% aluminosilicate	
Tempmat	100% E-glass fiberglass	1
Thermal Wrap	>95% E-glass (fiberglass) + <5% binders	1

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Table 3.2-1: Base Composition of PWR Containment Materials		
Material	**Composition**	**Notes**
Thermolag 330-1	6% silicon dioxide (quartz), 3% 13-glass (fiber glass) + epoxides	
Transite	70% calcium silicate + 22% calcium metasilicate + organic fiber + fiberglass	6
Unibestos	calcium silicate + asbestos (magnesium silicate)	

Notes:

1. 1. E-glass is nominally composed of: *52-56%* silicon dioxide, *16-25%* calcium oxide 12-16% aluminum oxide, *5-10%* boric oxide and minor amounts of sodium oxide, potassium oxide magnesium oxide iron (111) oxide, and titanium oxide.
2. Steel slag is nominally composed of: *40-52%* calcium oxide, 10-19% silicon dioxide, 7-30% iron (II) oxide, 2 10% iron (III) oxide, 5% manganese oxide, *5%* magnesium oxide, and minor amounts of aluminum oxide, phosphorous pentoxide, sulfur and iron.
3. Cement is predominantly dicalcium and tricalcium silicate, with minor amounts of calcium oxide, aluminum silicate, ferroaluminum silicate and other metal silicates.
4. This material may contain minor amounts of other inert additives such as titanium dioxide.
5. Newer material may contain other silicates in place of asbestos.
6. Transite is a higher density version of marinite,

APPENDIX B: NEI 02-01 Rev 1 Guidance on Coatings Walkdowns for PWRs [12] [13]

1. Why Look at Coatings?

   In LA-UR-01-4083, GSI-191: Parametric Evaluations for Pressurized Water Reactor Recirculation sump Performance, the NRC identified coatings inside containment as one of several potential particulate debris sources.

   It is also noted that all containment coatings (acceptable, DBA qualified or other) located within a defined Zone of Destruction 1 of a postulated LOCA should be characterized to fail for analytical purposes.

   On July 14, 1998, the NRC issued Generic Letter (GL) 98-04, Potential for Degradation of the Emergency Core Cooling System after a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment. The generic letter addressed, in part, licensee programs for the use of protective coatings inside containment at PWR facilities. All PWR licensees have responded to GL 98-0 1 . Plant responses to GL 98-04[14] identify plant programs associated with

[12] The emphasis of this topical area is the identification of coatings inside containment that might detach under normal or accident conditions.

[13] Definitions and Background: ASTM D 5144-00, Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants, contains two definitions related to coatings inside containment, which will not fail under normal or accident conditions. These definitions are:

Acceptable Coating or Lining System ¬ A safety-related coating or lining system for which a suitability for application review which meets the plant licensing requirements has been completed and there is reasonable assurance that, when properly applied and maintained, the coating or lining will not detach under normal or accident conditions.

DBA Qualified Coating System ¬ A coating system used inside reactor-containment that can be attested to having passed the required laboratory testing, including irradiation and simulated Design Basis Accident (DBA), and has adequate quality documentation to support its use as DBA qualified.

American National Standards Institute (ANSI) standards defining the requirements for DBA qualified coatings were issued in the 1972 to 1974 time period. Plants with licensing bases and attendant containment coating systems that are dated after the issuance of the ANSI standards typically refer to DBA qualified coatings. PWR plants with licensing bases and attendant containment coating system designs predating 1972 typically refer to acceptable coatings.

Coatings inside containment that cannot be classified as either acceptable or DBA qualified may fail and have typically been included as debris sources for post-accident sump performance evaluations.

[14] The responses made by PWR licensees to GL 98-04 included the following information:
a. Service Level I coatings procured, applied and maintained by the licensee or its contractors comply with the plant licensing basis and thus are "acceptable" or "DBA qualified" as applicable.
b. The condition of Service Level I coatings are regularly assessed as part of plant procedures, including ASME Section XI IWE, Maintenance Rule (10 CFR 50.65), and/or plant-specific procedures covering coatings condition assessment. The provisions of these procedures require that defective coating areas in containment be identified, evaluated and remediated as necessary.

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"acceptable" and "DBA qualified" coatings, as applicable to that plant. The NRC has reviewed and accepted the responses to GL 98-04 made by all PWR licensees.

With the exception of those coatings located within the Zone of Destruction, PWR facilities that maintain their "acceptable" or "DBA qualified" coatings may credit those coatings as not adding significantly to coating debris that may be generated during normal plant operation and accident conditions. All coatings that are not identified as "acceptable" or "DBA qualified," or coatings that were initially applied as "acceptable" or "DBA qualified" but are observed to be degraded are to be considered as possible debris sources for design basis events that result in the recirculation from the containment sump.

A comprehensive coating program that includes clearly documented periodic containment coating assessments, evaluations of deficient coating conditions, as well as mitigation, and routine containment coating maintenance support a PWR plant's evaluation and determination of the degree to which coating debris may be a debris source for GSI-191 considerations. In the event that such documentation is not available, plant operators may choose to develop this information by performing appropriate walkdowns.

2. Who Should Participate in the Walkdown?

   The walkdown should be conducted with a coatings specialist or personnel familiar with the application and maintenance of coatings inside containment.

3. What to Look for

   The following table lists types of acceptable and DBA qualified coating systems commonly used in PWR containments.

   Typical Coating Systems Commonly Used in PWR Containments

- Concrete Substrate
- Steel Substrate
- Surfacer, epoxy phenolic topcoat
- Inorganic zinc primer, epoxy
- phenolic topcoat

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- Surfacer, epoxy topcoat
- Inorganic zinc primer, epoxy
- topcoat
- Epoxy phenolic primer, epoxy
- phenolic topcoat
- Epoxy phenolic primer, epoxy
- phenolic topcoat
- Epoxy primer, epoxy topcoat
- Epoxy primer, epoxy topcoat
- Inorganic zinc primer

4. Where to Look (Per plant-specific design)

Typical systems, structures and components to which coatings may have been applied but cannot be classified as acceptable or DBA qualified include, but are not limited to, the items listed in the following table. The review of coatings should include the general containment volume, and not be limited to the area within the crane wall or areas affected by a non-isolable primary system break as particulate debris may result from the exposure of non-qualified coatings to post- accident environmental conditions.

Systems, Structures and Components That May Be Coated with Coatings Which Are Neither "Acceptable" nor "DBA Qualified":

- Accumulator tanks
- Seismic platforms and tie rods
- Reactor coolant system supports
- Reactor internals lifting rig
- Manipulator crane

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- Head lifting rig
- Valves
- Transmitters and small instruments
- Electrical cabinets
- Heat exchanger supports
- Reactor coolant pump
- Reactor coolant pump motor and motor stand
- Transducers Mounting brackets

5. Documentation

Using containment drawings, the walkdown should document the location of "DBA qualified" or "acceptable" coatings and unqualified or non-qualified coatings. In regards to safety-related coatings, the type of coatings system(s) applied in the areas defined as a Zone of Influence about the containment sump should be documented. If multiple safety-related coating systems have been employed in these areas then the lightest (i.e., the one with the lowest specific gravity) coating system can be assumed to be applied throughout the defined zone of destruction area (or exact documentation of all of the coating systems can also be obtained). Other data that should be obtained to the extent possible are the approximate area and thickness of the respective safety-related coating system(s). In regards to unqualified coatings, to the extent possible, the type of coating (i.e., alkyd, epoxy, etc.), approximate area, and thickness should be documented.

6. Sources of Plant Coatings Documentation

A comprehensive coating program that includes clearly documented periodic containment coating assessments, evaluations of deficient coating conditions, as well as mitigation, and routine containment coating maintenance support a PWR plant's evaluation and determination of the degree to which coating debris may be a debris source for GSI-191 considerations.

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7. Industry Guidance

   Extensive industry and regulatory guidance concerning containment coating condition assessment is available from a number of sources, such as:

   - NRC NUREG-1801, Volume 2, April 2001, Generic Aging Lessons Learned (GALL) Report, Section XI.S8, Protective Coating Monitoring and Maintenance Program
   - ASTM D 5144-00, Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants
   - ASTM D 5163-91 (1996), Standard Guide for Establishing Procedures to Monitor the Performance of Safety-Related Coatings in an Operating Nuclear Power Plant

   EPRI Report 1003102, Revision 1 , Guideline on Nuclear Safety-Related Coatings, (Formerly EPRI TR-109937). These references should be considered, as appropriate, for incorporation into the plant specific procedures for containment coating condition assessments.

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NEI 04-07 Guidance on Latent Debris

3.5 LATENT DEBRIS

3.5.1 Discussion

The potential for latent debris in containment during plant operation that may impact head loss across the emergency core cooling sump screens should be considered. Therefore, it is necessary to determine the types, quantities, and locations of latent debris sources.

Due to the variations in containment design and size from unit to unit, many miscellaneous sources should be evaluated on a plant-specific basis. It is not appropriate for the licensees to say that their foreign materials exclusion (FME) programs can entirely eliminate sources of miscellaneous debris unless plant-specific walkdowns verify this. Plant-specific walkdown results can be used to determine a conservative amount of dust and dirt to be included in the debris source term. The walkdown will not be able to directly measure this type of debris. However, it is possible to quantify the amount of debris with additional steps.

It is recommended that the following activities be performed to quantify the amount of latent debris inside containment:

- Calculate the horizontal and vertical surface areas inside containment. This calculation will determine the total area with the potential for accumulation of debris.
- Evaluate the resident debris buildup. It is necessary to determine the amount of debris present on surfaces inside containment.
- Define the debris characteristics. This information will be used in subsequent steps of the sump performance evaluation.
- Calculate the total quantity and composition of debris. This information will also be used in subsequent steps of the sump performance evaluation, such as evaluation of the transport of latent debris to the sump screen and the resulting head loss. Detailed guidance for accomplishing the recommended activities for quantification of the amount of latent debris is provided below.

3.5.2 Baseline Approach

Latent debris is a contributor to head loss across the sump screen and should be evaluated accordingly. Information is provided in the guidance below to evaluate the quantity of latent debris with sufficient rigor to eliminate excessive conservatism. Note, however, that in many cases, the contribution to head loss by latent debris will be small in comparison to that caused by debris from other sources such as insulation materials. In these cases, latent debris will not determine the course of action for mitigating ECCS sump strainer issues.

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The impact on the results of the sump performance evaluation as a whole should be considered before performing an extremely rigorous analysis of latent debris loading. While it is possible to evaluate the effects of latent debris to a high degree of detail, use of conservative strategies is recommended. Furthermore, the use of conservative strategies in the evaluation of latent debris effects can provide for more head loss analysis margin and can improve operational flexibility if sump modifications are made.

3.5.2.1 Estimate Horizontal and Vertical Surface Area Inside Containment

Estimates are made of the horizontal and vertical surface areas. Vertical surfaces such as walls and sides of equipment are considered although a significant amount of debris does not typically collect on vertical surfaces in the absence of factors that promote adhesion of solids to the surface.

The following is a sample of the surfaces that are included in the surface area estimate:

- Floor area
- Walls
- Cable trays
- Major ductwork
- Control rod drive mechanism coolers
- Tops of reactor coolant pumps
- Equipment (such as valve operators, air handlers, etc.) Other surfaces should be included as appropriate for plant-specific applications (junction boxes, etc.).

Use the following guidance in the calculations:

1. Flat surfaces are considered to be floors, cable trays, AOV diaphragms, and other flat or nearly flat surfaces. The bases for this are:

- Unless the surface is highly convoluted (e.g., a heat exchanger or similar device), assuming a flat surface will not have a significant effect on the surface area calculation. Furthermore, the area projected onto the horizontal plane by the surface would be the key determining factor for the settling and accumulation of debris. For example, while a series of heat exchanger fins may have a large surface area, a significant percentage of that area could be vertical which would preclude accumulation of debris on much of the surface area.

- The surface area calculations are greatly simplified if the intricacies of surfaces are not explicitly accounted for.

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2. Half of the surface area of round surfaces such as conduits and ladder rungs is used. The basis for this assumption is that the lower half of the surface area is either inverted or tangent to the vertical plane, so accumulation of debris in this area does not occur. In reality, it is likely that the percentage of surface area susceptible to debris accumulation is less than half, because it is unlikely that debris would remain on the regions of the surface that are nearly vertical.

3. Ten percent of the vertical surfaces inside containment is used. The basis for this assumption is that accumulation of debris on vertical surfaces will typically not occur, but is considered for conservatism. Although walls are considered, the containment dome itself is not considered. Debris accumulation on this surface is precluded because it is inverted or tangent to the vertical plane.

4. Perform thorough calculations to determine the surface area to be considered for each area of containment. The information needed to perform the calculations can be obtained through plant drawings (plans) and photographic evidence obtained during containment walkdowns.

5. If exact dimensions are unavailable, use estimated dimensions. Acceptable sources of estimated dimensions are plant drawings (plans) that do not include explicit dimensions for the component in question (i.e., a representation of the component is shown but not detailed) and photographic evidence. Conservatively large values shall be used when dimensions are estimated and bases for the values used shall be provided.

3.5.2.2 Evaluate Resident Debris Buildup

Although recent sampling of surfaces inside containment at a number of plants indicated that it is likely that the maximum mass of latent debris inside containment is less than 200 pounds, it is recommended that a survey of the containment be performed, with the objective of determining the quantity of latent debris.

Surveying the containment for latent debris will ensure that higher-than-average debris loads are accounted for and will allow plants to take advantage of smaller latent debris loading if lower quantities are present.

Note that it will be necessary to perform periodic surveys (as part of outage efforts) to validate that there has been no significant change in the latent debris load inside containment. This evaluation of the presence of foreign material is described in NEI-02-01 (Reference 2). The necessary rigor of these surveys is dependent on the effectiveness of the licensee's FME and housekeeping programs with respect to containment cleanliness. If the licensee has rigorous programs in place to control the cleanliness of containment and documents the condition of

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containment following an outage, it is adequate to perform inspections and limited sampling of surfaces. If the cleanliness of containment is not controlled through rigorous programs, or if the programs in place do not address all areas of containment, it is necessary to perform more comprehensive surveys.

3.5.2.2.1 Evaluate the Resident Debris Buildup on Surfaces

To quantify the amount of latent debris on horizontal surfaces in containment, determine the thickness of the debris layer on a surface and the surface area the layer covers. This information can be used with the macroscopic debris density (with respect to volume) to determine the mass of debris present.

Use the following steps to evaluate the resident debris buildup on horizontal surfaces:

1 Divide containment into areas based on the presence of robust barriers. This will allow differing (from section to section) latent debris concentrations and compositions to be adequately represented and will facilitate subsequent debris transport calculations. Examples of appropriate areas include:

- Accumulator rooms
- *In-core instrumentation room*
- Loop subcompartments
- Steam generator or pressurizer subcompartments

2 Determine representative surfaces for each section of containment. For each section, this involves defining survey areas of known dimensions. The number of sampling areas examined per section of containment must be determined on a plant-specific basis. Use the following guidance to select representative surfaces:

- If the worst surface in a given section can be readily identified, it is acceptable to use that surface to represent the entire section. For example, if little or no debris is present on the surfaces in a section except for one, that one surface can be used to represent the debris accumulation in the entire section.

- If multiple surfaces have debris accumulation with different compositions and thicknesses, it is necessary to sample each of the surfaces to adequately represent the latent debris load for that section.

- If the area has a uniform and homogeneous latent debris load, a convenient surface can be chosen as the representative surface.

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3 Survey the representative surfaces in each section to measure the debris quantity. Take care to ensure that all health physics procedures are followed for any samples collected. Two strategies are recommended.

- Collect the debris using equipment that will allow measurement of the quantity of debris at a later time. The volume of debris collected is then divided by the surface area to determine the thickness of the debris layer.

  The collection method should allow estimation of the debris layer thickness and not change the macroscopic density of the debris that is collected. An acceptable method for collection is the use of swipes to remove the debris from the area in question. Since there is the potential to damage samples during the collection process, take care to not destroy or otherwise change the physical properties of the debris.

- Measure or estimate the thickness of the debris layer directly. Since it is unlikely that a measurement device (such as calipers) can determine the layer thickness directly, it is recommended that the layer thickness be determined by comparison to an object of known or measurable thickness. Since the debris layers are expected to be quite thin (mils or fractions of mils), comparison to objects like sheets of paper or very thin sheets of metal is recommended.

  While it is possible to determine the thickness of the debris layer to an acceptable degree of accuracy, it may be difficult to accomplish, even if the debris layer is of uniform thickness and homogeneous composition. Therefore, care should be taken in the measuring process to achieve the most accurate results possible.

4 Calculate the thickness of the debris layer, based on the quantity of debris collected and the surface area of the sampling area.

3.5.2.2.2 Evaluate the Quantity of Other Miscellaneous Debris

In addition to determining the amount of latent debris accumulation on surfaces, other miscellaneous debris sources are to be accounted for in the debris source term. The survey of containment for these materials is to be performed consistent with the guidance in NEI 02-01 (Reference 2). Use the following guidance for each source to be considered:

- Equipment tags: Determine the number and location of equipment tags of each material type (paper, plastic, metal) within containment. Evaluate the transport of tags to the sump screen when performing the debris transport analysis (Section 3.6). Although paper tags may dissolve in the post-accident containment environment, it is conservative to assume that they remain intact and available for transport to the sump screen. This assumption shall be used unless there is information that indicates the tags will not remain intact.

- Tape: Determine the amount and location of each type of tape within containment. Evaluate the transport of tape to the sump screen when performing the debris transport analysis (Section 3.6). Although FME and housekeeping programs will remove most of the tape used during outage and construction activities, there may still be quantities present in containment. These pieces of tape could be in inaccessible areas or attached to components in plain view. Pieces of tape that have partially disintegrated from being in containment during plant operation should be considered in the latent debris source term. Additionally, tape affixed to surfaces such as ladder rungs to improve grip shall be assumed to fail and become transportable debris.

- Stickers or placards affixed by adhesives: Include items such as stickers and signs that are not mechanically attached to a structure or component in the latent debris source term. Evaluate the transport of these materials to the sump screen when performing the debris transport analysis (Section 3.6). It is likely that adhesives would fail in post-accident conditions. Assume that all stickers and placards affixed by adhesives fail and become transportable debris.

3.5.2.3 Define Debris Characteristics

Debris characteristics can be defined using two methods:

- Analyze debris samples to determine composition and physical properties.

- Assume composition and physical properties of the debris, using conservative values.

Because of the additional rigor and complexity as well as the additional time required to perform detailed analysis of the samples, it is recommended that conservative characteristics (with respect to head loss, as documented in Section 3.7) are assumed for the latent debris. The following debris characteristics should be used:

Use an appropriate fiber/particulate mix for the plant being evaluated.

- Fiber density = 62.4 lbm/ft^3. The basis for this value is that it effectively makes the fiber neutrally buoyant, which results in maximum transport to the sump screen.

- Particle density = 100 lbm/ft^3. The basis for this value is that most particulate material can be categorized as "dirt." A representative material would likely be soil or sand, brought into containment during outage activities or construction. According to

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Reference 19, the densities of "Earth," dry and packed and "Sand" are both 95 lbm/ft^3. Therefore, 100 lbm/ft^3 is recommended.

- Particle diameter = 10 μm. Based on typical diameter of dust particles (Reference 20), a diameter of 10 μm is suggested. This diameter is conservatively small with respect to transport to the sump screen, since the diameter of "dirt" particles such as earth or sand is larger than that of dust. Furthermore, the diameter of 10 μm is consistent with the size of particles of failed coatings (Reference 21).

Note that ongoing research efforts by NRC and Los Alamos National Labs may provide additional information regarding the physical characteristics of latent debris.

If it is decided to analyze the debris samples to determine the composition and physical properties, the work should be performed by a laboratory experienced in material identification, analysis of the macroscopic and microscopic properties of material samples, and handling of radioactive materials. Note that there are challenges to effectively determining the debris characteristics by analysis:

- It is likely that thorough analysis of samples would be extremely expensive, possibly with little benefit.
- It is potentially impractical or impossible to separate the debris from the media or device used to capture it.
- It is possible that the macroscopic density of the debris as well as other characteristics will be changed during the sampling process or transportation to the analysis facility. These changes in characteristics would result because it is likely that the debris is not a homogenous solid; therefore it is possible for the debris to be compacted, damaged, or otherwise manipulated.

3.5.2.4 Determine Fraction of Surface Area Susceptible to Debris Accumulation

Not all areas are susceptible to accumulation of debris. For example, housekeeping activities at some plants may involve cleaning floors with special wipes, vacuum cleaners, or other methods. In these cases, the areas that are within the scope of the cleaning program could have essentially no debris accumulation, whereas inaccessible areas of the same surface could have an accumulation of debris. A single debris layer thickness would not accurately represent the entire surface.

It is appropriate to conservatively assume that the entire surface area is susceptible to debris accumulation. If it is unreasonable to use this assumption, in addition to determining the total horizontal surface area inside containment (per subsection 3.5.2.1) it is necessary to determine

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the fraction of the surface area of each component and surface that is susceptible to debris accumulation. To accomplish this, evaluate the fraction of the surface area susceptible to debris accumulation a component-by-component or surface-by-surface basis using the results from subsections 3.5.2.1 and 3.5.2.2 as input. Use the following guidance:

1 Assume that 100 percent of the surface area is susceptible to debris accumulation for inaccessible areas as well as accessible areas that are not thoroughly cleaned and documented as clean per plant procedures prior to restart (e.g., cable trays, junction boxes, and valve operators), and floors with gratings sitting on flat surfaces.

2 Evaluate the fractional area susceptible to debris accumulation for smooth floor areas and other surfaces cleaned per plant procedures prior to restart on a case-by- case basis. Considerations include the method of cleaning (e.g., pressure washing versus vacuuming) and accessibility of areas. Because of wide variations in containment design and effectiveness of housekeeping and FME programs, evaluations must be performed on a plant-specific basis.

For all cases in which the area susceptible to debris accumulation is reduced, a conservatively large fractional area susceptible to accumulation must be determined, and bases must be provided for the fractions used. Use the following guidance:

- Calculate the total surface area of the surface being considered.
- Calculate the area of the surface that is clean. Use simplifying assumptions that will result in a conservatively small clean area.
- Calculate the ratio of potentially dirty area to the total area.

3.5.2.5 Calculate Total Quantity and Composition of Debris

The final step in determining the quantity of latent debris located inside containment is to compute the total quantity of latent debris using the results from subsections 3.5.2.1 to 3.5.2.3 as input.

Use the following guidance when performing the final calculations:

1. The calculations should be performed on an area-by-area basis (consistent with subsections 3.5.2.1 to 3.5.2.3). Performing the calculations in this way will facilitate adequate representation of the debris densities and characteristics in the different areas inside containment.

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2. Compute the total quantity of debris for each area by multiplying the total surface area susceptible to debris accumulation by the debris layer thickness for the area of containment being considered.

3. Include quantities of other types of latent debris such as tape, equipment tags, and stickers.

4. Categorize and catalog the results for input to the debris transport analysis.

3.5.3 Sample Calculation

The sample calculation considers the bottom level of containment. Equipment tags, tape, and stickers have been excluded from this example since minimal calculations are required for these items and guidance is included in Reference 2. The following surfaces are included in the calculation:

- Floor areas
- Cable trays
- Sump drain pumps

For an actual calculation, more detail and rigor are required to document all the surface area on a given level of containment. Since this is a sample calculation, only representative examples were used.

Subsection 3.5.3.1 documents the calculation of the horizontal areas for complex rooms and cable trays. Subsection 3.5.3.2 documents the calculation of the amount of debris present in the area being considered.

3.5.3.1 Calculate Horizontal Surface Area

The examples below show the calculation of a number of complex floor areas. Rooms of simpler geometry are calculated with less effort and therefore, examples of those calculations have not been shown.

1 Calculate area between containment shell and steam generator (SG) compartments.

The floor area between the containment shell and SG compartments looks roughly like the region between the octagon and circle in the figure below:

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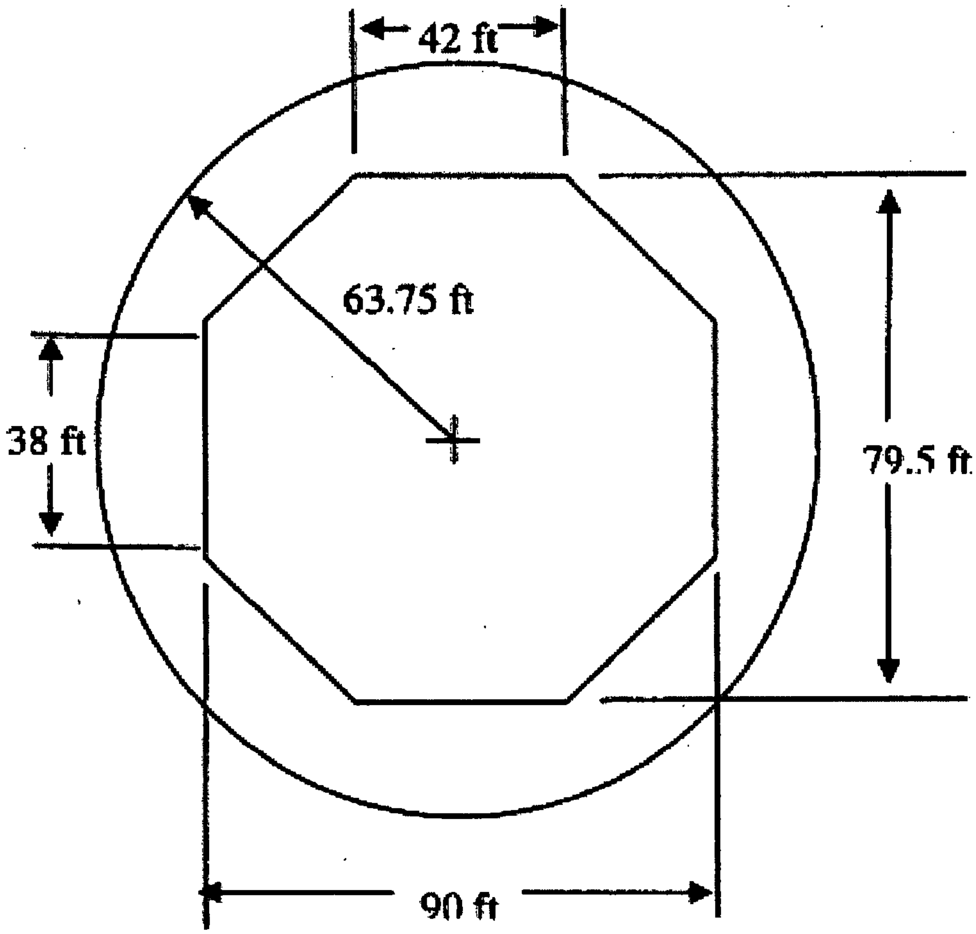

Therefore, the area of the octagon is calculated as:

A = (90 ft) (75 ft) (4) (0.5) [(0.5) (79.5-38)]*[(0.5) (90-42)]

A = 5754 ft^2

Subtract area of octagonal region from round region: A = (63.75 ft) 2 5754 ft^2

A = 7014 ft^2

Subtract area of the reactor coolant drain tank (RCDT) room and excess letdown heat exchanger room (these areas protrude from the rough octagonal shape):

A = 7014 ft^2 56 ft^2 94.6 ft^2

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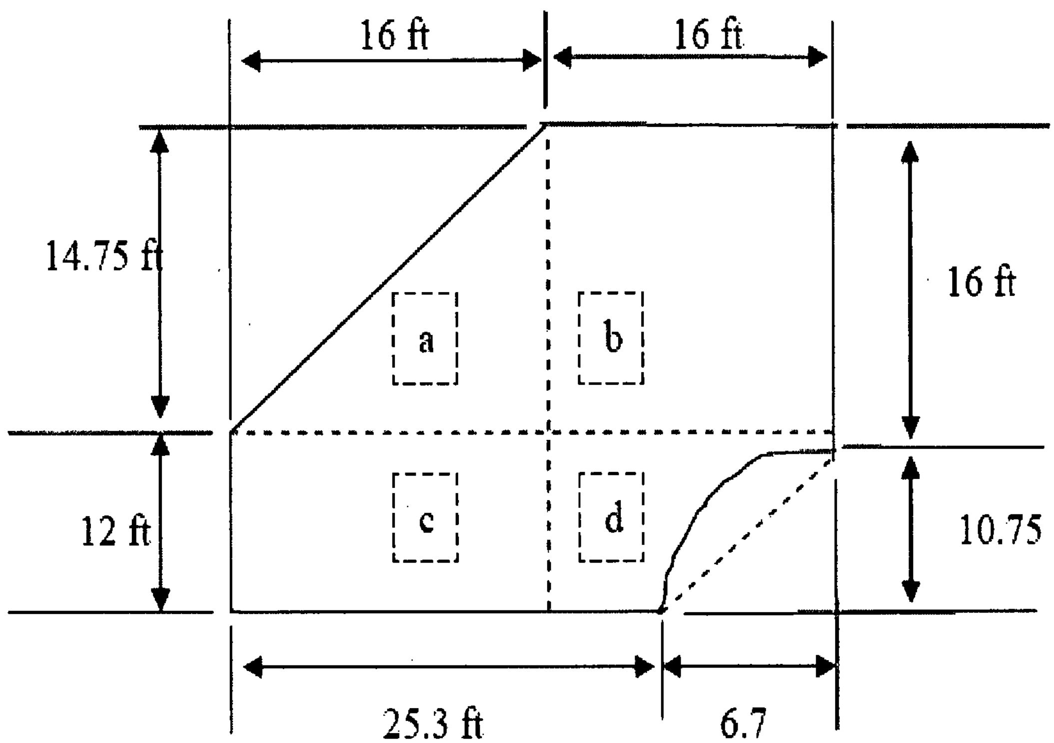
$A = 6914\ ft^2$

2 Calculate area inside SG compartments.

Each SG compartment has a shape and dimensions roughly like the shape with the solid border below. To simplify the calculations, the room was divided into four regions and the round wall was assumed to be straight:



$A = a + b + c + d$ $a = 0.5(16\ ft)\ (14.75\ ft) = 118\ ft^2$

$b = (16\ ft)\ (14.75\ ft) = 236\ ft^2$

$c = (12\ ft)\ (16\ ft) = 192\ ft^2$

$d = (16\ ft)\ (12\ ft)\ (0.5)\ (10.75\ ft)\ (6.7\ ft) = 156\ ft^2$

A = 466 ft2

$A_{total} = 4(A)$ (since there are four steam generators) $= 1864\ ft^2$

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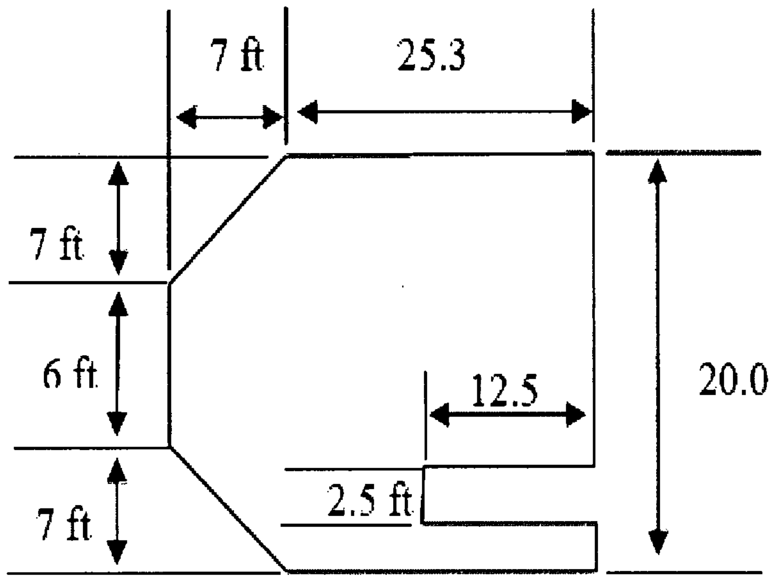
3 Calculate area inside seal table room.

The geometry of the seal table room is as shown in the figure below. One simplifying assumption was with regard to the six-foot-long wall. It is actually curved and protrudes into the room, but was assumed to be straight. This assumption results in prediction of a conservatively large floor area.



A = (32.3 ft) (20 ft) (2) (0.5) (7.0 ft) (7.0 ft) (2.5 ft) (12.5 ft)

A = 563.8 ft^2

4 Calculate area of cable trays and other components. For this sample calculation, 300 linear feet of cable trays was assumed. It was also assumed that the trays were 1 foot wide, resulting in a total surface area of 300 ft^2. For all cable trays, the length and width should be documented and used to calculate the horizontal surface area.

The other example of component surface area in this sample calculation is the rectangular cover on the sump drain pumps, as shown in the spreadsheet below. It is noteworthy that the covers over the sump were documented as part of the floor area, since there is no floor area considered below them.

Other components were not examined in detail for this sample calculation. Components that should be examined include, but are not limited to:

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- RCS piping and other piping
- Pressurizer relief tank
- Excess letdown heat exchanger (depending on location)
- Air handling units
- RCS draindown tank and associated heat exchanger
- Junction boxes

3.5.3.2 Calculate Quantity of Debris

This section documents sample calculations of the quantity of debris in the area considered. The calculations are relatively straightforward. To calculate the mass of debris in a given area:

Volume = (Debris layer thickness) * (Surface area)

Mass = (Volume) * (Density)

Example results are presented in Table 3-4. It is noteworthy that the results are for demonstration only and are based on hypothetical debris survey results.

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Table 3-4. Sample Calculation of Debris Quantity

Description	Length ft	Width ft	Surface Area ft²	Layer Thickness in	Percent Clean %	Debris Volume ft³	Fiber by Volume %	Fiber Volume ft³	Fiber Density lb/ft³	Fiber Mass lb	Particulates Volume ft³	Particulates Density lb/ft³	Particulates Mass lb
Floor Areas													
1 Area between SG rooms and cont. shell			6914.0	1.00E-03	25.0	0.43	50.0	0.22	62.40	13.48	0.22	100.00	21.61
2 SG rooms (4 rooms)			1864.0	1.00E-03	25.0	0.12	50.0	0.06	62.40	3.63	0.06	100.00	5.83
3 RCDT room	24.00	8.00	192.0	1.00E-03	0.0	0.02	50.0	0.01	62.40	0.50	0.01	100.00	0.80
4 RCDT HX room	20.00	6.75	135.0	1.00E-03	0.0	0.01	50.0	0.01	62.40	0.35	0.01	100.00	0.56
5 RCDT HX room anteroom	13.30	11.25	149.6	1.00E-03	0.0	0.01	50.0	0.01	62.40	0.39	0.01	100.00	0.62
6 Excess letdown HX rm	22.25	4.25	94.6	1.00E-03	0.0	0.01	50.0	0.00	62.40	0.25	0.00	100.00	0.39
7 Seal table room			563.8	1.00E-03	0.0	0.05	50.0	0.02	62.40	1.47	0.02	100.00	2.35
Equipment													
1 Sump drain pump cover	6.00	4.00	24.0	1.00E-03	0.0	0.00	50.0	0.00	62.40	0.06	0.00	100.00	0.10
2 Cable trays	300.00	1.00	300.0	1.00E-03	0.0	0.03	50.0	0.01	62.40	0.78	0.01	100.00	1.25
Totals						0.67		0.34		20.91	0.34		33.51

Notes:
Sump top plate surface area included in Floor Area #1
Calculations for floor areas #1, 2, 7 documented separately
Debris layer thicknesses are hypothetical, not based on actual survey data.