ECCS Suction Strainers
Spherical ZOI
Issue No. 12

Tony Borger
ECCS Suction Strainers Committee
Source Term Vice Chairman

NRC / BWROG Resolution Plans
September 22 - 23, 2010
Rockville, MD

Topics

- Technical Concern
- Issue History
- Resolution Strategy
- Next Steps and Milestones

Technical Concern

While a spherical ZOI may have maximized the quantity of debris, it may have precluded selection of a lesser amount of more problematic debris, such as microporous or calcium silicate insulation

Issue Overview
Zone of Influence (ZOI)

Definition

- *Zone within which the postulated break jet would have sufficient energy to generate transportable debris. The zone within which debris may be generated is dependent on the size of the break, the break geometry, and the types of potential targets in the vicinity of the break. (URG Section 3.2.1.2.1)*

- *The ZOI represents the zone around a postulated break in which a given material is assumed to be destroyed by the high-energy water/steam jet emanating from the break. (SECY-10-0113)*

Issue Overview
Zone of Influence (ZOI)

URG Provided four methods to determine the zone of influence:

Method 1: Entire Drywell is the ZOI

Method 2: Target based analysis with limiting size ZOI

Method 3: Break specific analysis using break dependent ZOI

Method 4: Explicit Use of CFD Model Results (not accepted)

“Spherical ZOIs only relate to Method 2 and 3.”

Issue Overview
Illustration of ZOIs

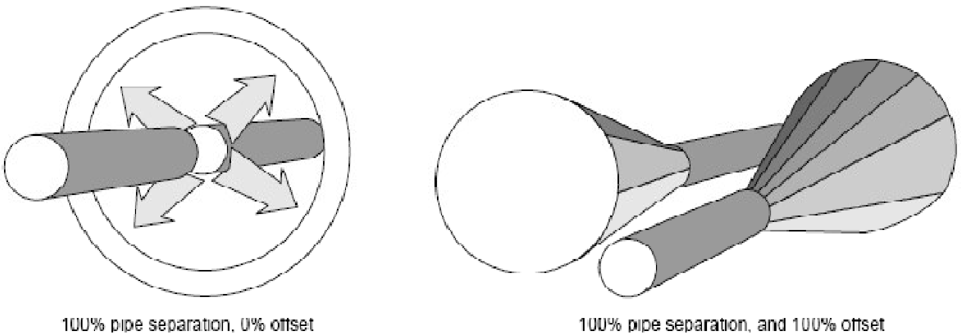


Figure 3-2 Variation in the ZOI Shape with DEGB Separation and Offset

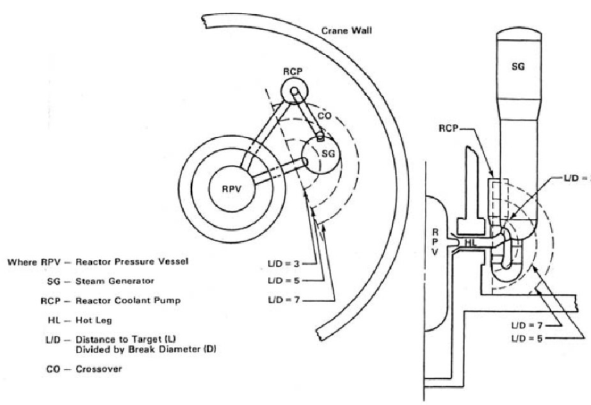
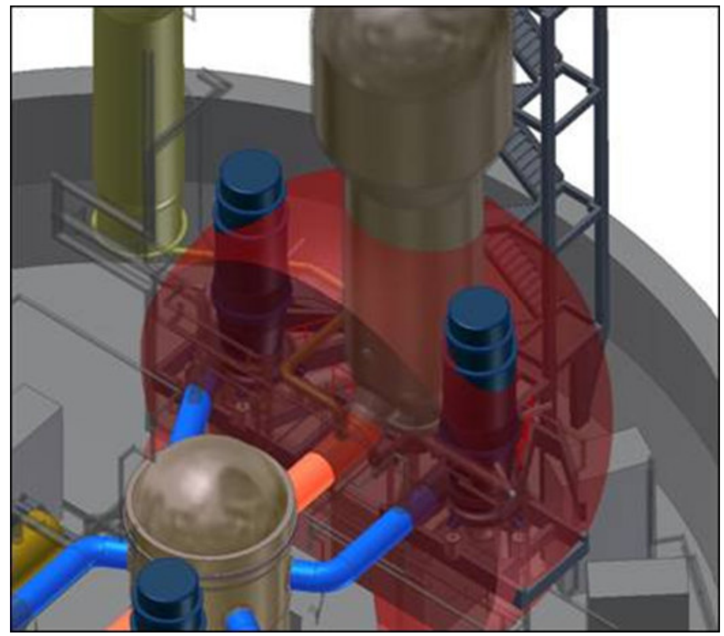


Figure 3-1 Example ZOI at a Postulated Break Location[3-5]

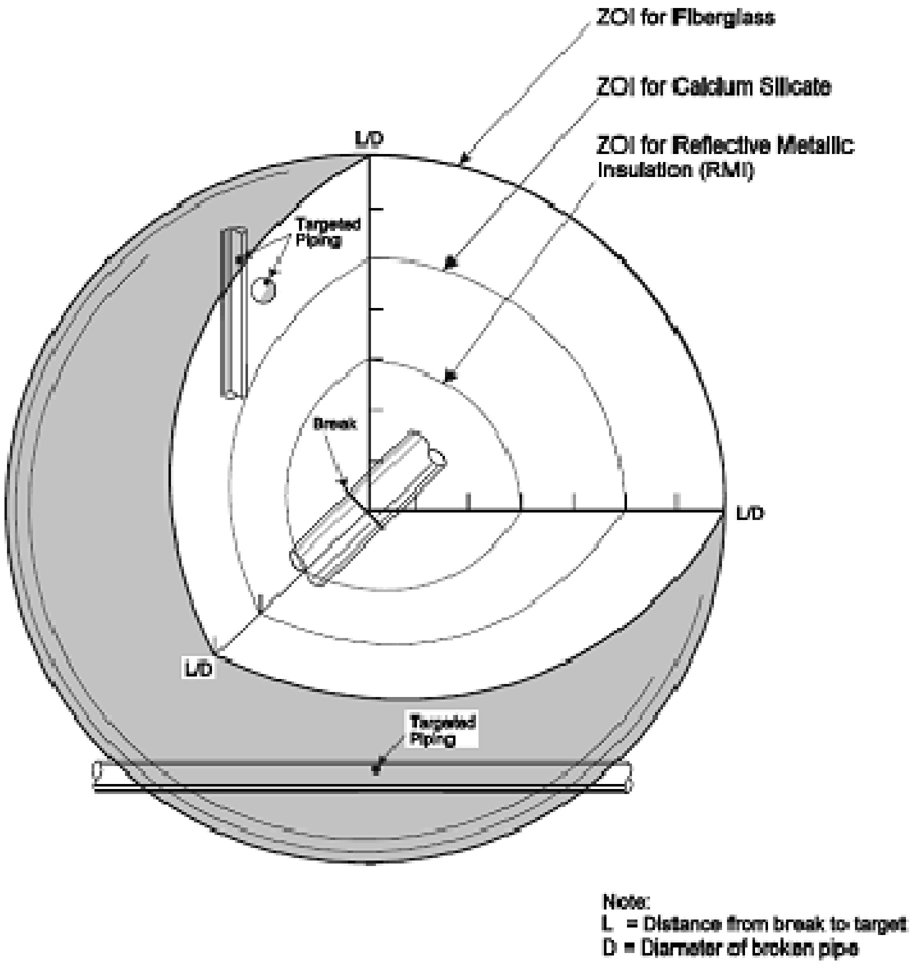


Issue Overview
Spherical ZOI Development

1. Determine the damage or destruction pressure (Pdest) for an insulation material/debris source.
2. Determine the total volume of space swept out by the isobar defined by the destruction pressure. Multiply this volume by 2 to represent both sides of the pipe break.
3. Convert the total volume within the isobar to a sphere of radius R expressed in pipe diameters (D).
4. Place the origin of the sphere at a specific postulated break location and determine the quantity of insulation within the sphere.
5. Move the origin of the sphere to all other potential break locations and repeat the exercise to find the limiting quantity/types of debris.

Note: (1-4) are Methods 2/3; (5) is Method 2

Issue Overview
Spherical ZOI Development



Insulation Type	BWR Assumed Destruction Pressure (psi)	BWR ZOI radius (D = break diameter)
RMI	190	6.1D
Cal-Sil	150	6.4D
K-Wool	40	7.9D
Temp-Mat	17	9.2D
Nukon	10	10.4D
Koolphen-K	6	11.4D
Min-K	<4	>11.9D

Issue Overview
NRC Staff Analysis

SER on URG, Section 3.2.1.2 – “The ZOIs developed using Methods 1, 2, and 3 and subsequently the volume of insulation assumed to be damaged and available for drywell transport, are very large. For some insulations, the ZOI enveloped between a fourth to a third of the drywell. As an example, the ZOI computed for steel jacketed NUKON using Method 2 is a spherical region approximately 11 break diameters (D) in radius, **which is much larger than the volume of the ZOI calculated using CFD codes** by the staff and the 7D sphere used in the NUREG/CR-6224 study, as well as the NUREG-0897 guidance.

Issue Overview
NRC Staff Analysis

SER on URG, Section 3.2.1.2 – “The BWROG choice of mapping a spherical ZOI with a volume equal to the volume of the doubled-ended conical ZOI for a freely expanding jet is unsupported either by analytical modeling or experimental evidence. The BWROG’s rationale, however, appears logical (although qualitative). As a result, the staff conducted a confirmatory analysis using a limited CFD model to demonstrate the effect of the jet interaction with structure and piping in the drywell. This analysis demonstrated the diffusion of the break jet as it interacts with structures and piping. On the basis of this analysis, the staff concludes that the **spherical ZOIs developed using methods 2 or 3 in Section 3.2.1.2 of the URG are conservative** and acceptable.

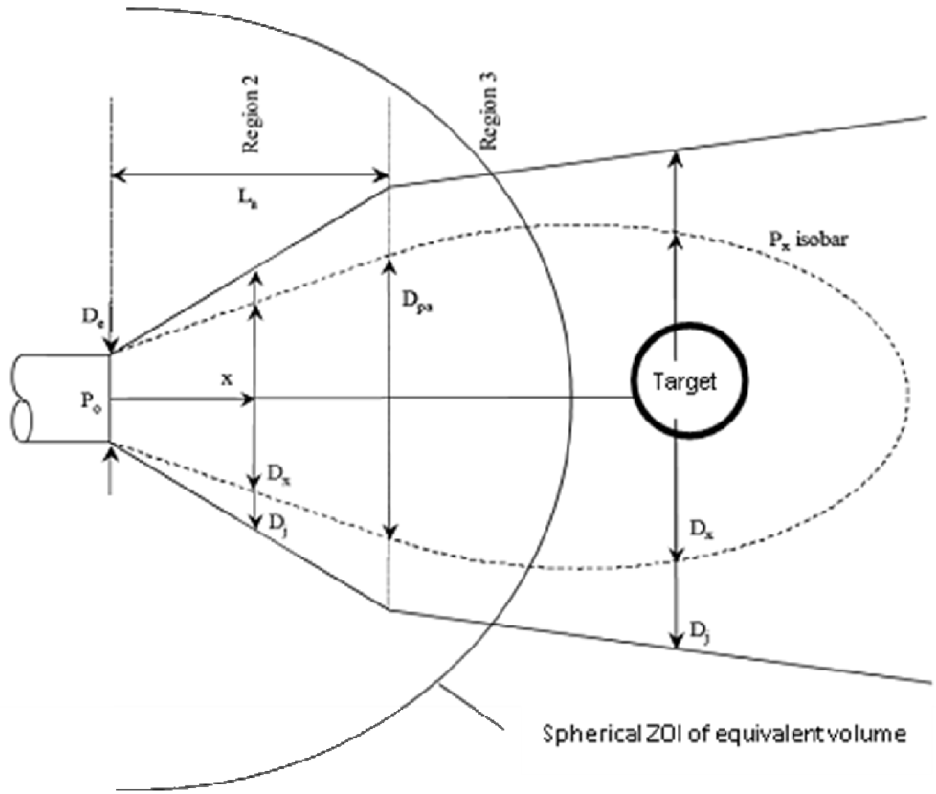
Issue Overview NRC Staff Analysis

SER on URG, Section 5.2, (Conservatism) Size of the ZOI – "The majority of the built-in conservatism in the BWROG's analytical methodologies lies in this part of the analysis…(discounting the use of Method 4). Of the remaining methods, Method 3 has the least built-in conservatism of the three methods approved for calculating ZOIs. The staff considers Method 3 to be conservative for two reasons. The primary reason is because the method does not account for interaction of the break jet with surrounding pipes and structures. This interaction would likely cause the jet to lose energy and, therefore, **the actual ZOI would probably be smaller than the calculated**…The analysis method in the URG (Methods 2 and 3) assumes that debris is generated equally throughout the ZOI - *and 100% dislodged.* **No credit is taken for the shadowing of debris sources** by piping and structures. As a result, the **assumption of a spherical ZOI in itself appears to add some conservatism to the analysis**."

Technical Concern

While a spherical ZOI may have maximized the quantity of debris, it may have precluded selection of a lesser amount of more problematic debris targets, such as microporous or calcium silicate insulation.

Such a target could be outside the nominal spherical ZOI but within directed jet flow.



Resolution Strategy

Although the spherical ZOI remains conservative, the BWROG will address this issue by providing enhanced guidance in the area of debris generation, specifically looking at problematic targets:

- Identify all “problematic” debris that was excluded from calculated, design-basis source terms. Problematic debris is defined as microporous insulations, calcium silicate, asbestos or other unique debris that could have significant head loss implications in the debris bed
- Either include the debris source term or justify its exclusion. Justification can include:
  - Assessment of the target’s distance from any possible break
  - Identifying shadowing/obstructions between break and problematic debris source

Next Steps and Milestones

Develop Revised Guidance for BWR Method 2/3 Break Analysis	4Q 2010
Submit Report to NRC for Comment	1Q 2011
Resolve NRC Concerns	2Q 2011
Utilities execute supplemental guidance at plant level	