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PWR Owners Group Testing and Analysis Program to Define Debris Generation Zones of Influence for GSI-191

Project Summary
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ZOI Project Update

- An approach has been developed to combine
  - Jet expansion (instrumented) and jet impingement (target) test data, and,
  - An enhanced 2-dimensional subcooled jet expansion model

  to evaluate ZOI's for problematic material configurations for PWR's.
- The following summarizes this approach.

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METHOD OF CALCULATING ZOI's

1. Evaluate the Expanding Jet Pressure Field
   - Use new 2-dimensional jet expansion model and test parameters (nozzle size, supply pressure and temperature, etc.) to calculate pressure field of the expansion.
   - Instrumented test data will be used to confirm jet model prediction of stagnation pressures.

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METHOD OF CALCULATING ZOI's

2. Calculate an Isobar
   - Use the new 2-dimensional jet expansion model to calculate the isobars.
   - Recall that the ability of the jet expansion model to accurately calculate isobars will be demonstrated by comparisons of model predictions to data from;
     - Marviken tests,
     - Westinghouse Canada tests, and,
     - The current Westinghouse-Wyle tests.

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METHOD OF CALCULATING ZOI's

3. Calculate Volume within the Isobar
   - Use the trapezoidal rule to calculate volume contained within the rotation of the isobar about the jet centerline.
   - The volume equation will take the form;

$$\text{Volume}_{\text{Single Nozzle}} = \sum_{i=1}^{n-1} \pi \left(\frac{h_i + h_{i+1}}{2} \right)^2 \Delta x$$

where;

Δx	=	A constant incremental distance along the jet centerline,
h	=	Radius from jet centerline to intersection with an isobar
i	=	index associated with radius, h, between jet centerline and isobar
n	=	Number of increments (Δx's) from jet nozzle to target

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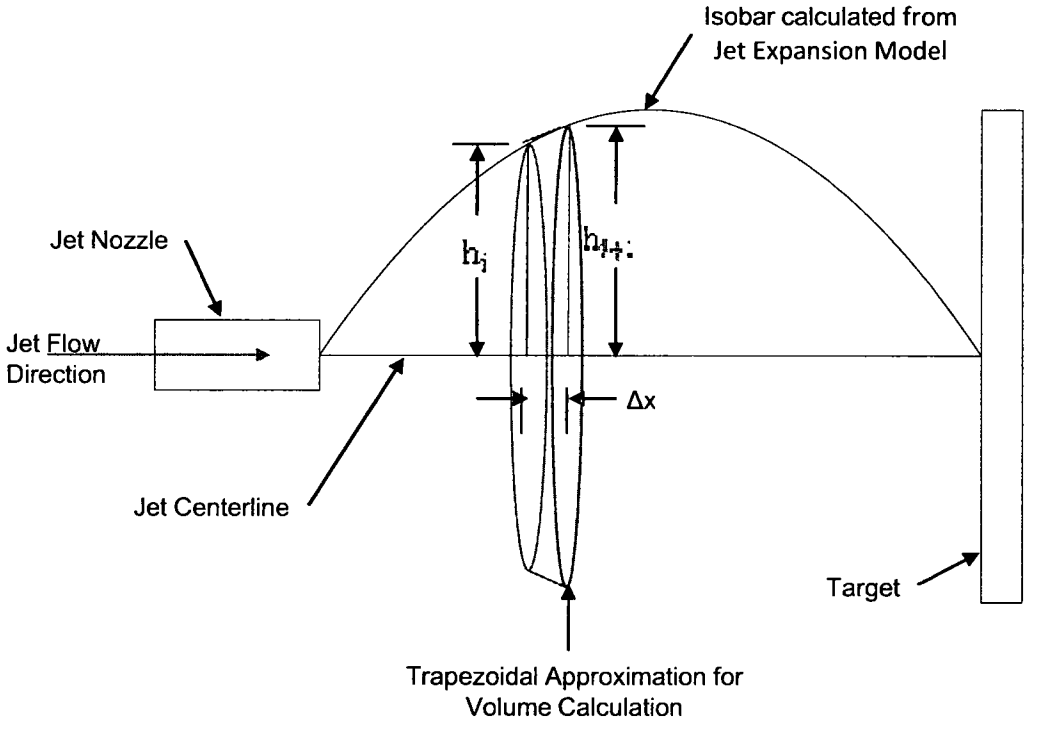
METHOD OF CALCULATING ZOI's



Schematic Diagram - ZOI Volume Calculation for a Single-Ended Break using the Trapezoidal Rule

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METHOD OF CALCULATING ZOI's

4. Calculate Volume for a Double-Ended Break
   - Total volume of under the isobar for a double-ended break is;

$$\text{Volume}_{\text{Double-Ended Break}} = 2 \times \text{Volume}_{\text{Single Nozzle}}$$

   - Value of "Volume $_{\text{Double-Ended Break}}$" is the total volume of the ZOI associated with a postulated double-ended jet of a given size.

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METHOD OF CALCULATING ZOI's

5. Calculate Radius of the Equivalent Spherical Volume

   – The volume of a sphere, V_{Sphere}, is calculated as;

$$V_{Sphere} = \frac{4}{3}\pi r^3$$

   where

   r = radius of the sphere

   – Rearranging and solving for "r", the radius of the ZOI for a postulated double-ended jet of a given size is calculated as;

$$r = \sqrt[1/3]{\frac{3}{4\pi} Volume_{Double\text{-}Ended\ Break}}$$

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METHOD OF CALCULATING ZOI's

6. Calculate Dimensionless ZOI
   - Calculate a dimensionless radius of a spherical equivalent ZOI, R_{ZOI}, by dividing the "r" term from Step 6 by the diameter of the nozzle used in the test.

$$R_{ZOI} = \frac{r}{D_{Nozzle}}$$

   - The equation above expresses the radius of a spherical equivalent ZOI as a dimensionless multiplier on the diameter of a double-ended pipe break.

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METHOD OF CALCULATING ZOI's - SUMMARY

- The 2-dimensional jet expansion model (from previous presentation) will be used to calculate axial-radial pressure distributions (isobars).
- From the predicted isobars, the radius of equivalent spherical ZOI calculated using trapezoidal rule.
- For different problematic materials, different ZOI's will be defined.