NUHOMS® EOS System – Application Resubmittal

May 21, 2015

AREVA TN

AREVA

Review/Overview of NUHOMS® EOS System Status and Prior Submittals

12/19/2014 – AREVA initial application submittal

02/02/2015 – NRC request for supplemental information (RSI)

02/16/2015 – AREVA response to RSI

03/23/2015 – AREVA submittal of Calculation related to RSI #2 Structural – non proprietary (NP)

04/03/2015 – AREVA submittal of revised response to RSI #2 Structural – NP, and associated SAR changes

04/24/2015 – AREVA withdrawal of EOS application

04/27/2015 – NRC acknowledgement of EOS application withdrawal

NRC Staff Issue #1

- **Summary: (1) Provide justification and compensatory measures for partial penetration closure welds, and (2) provide justification for the interpretation of ASME code for the partial penetration welds**
- **Justification and compensatory measures for the partial penetration welds are provided in DSC ASME Code Alternatives Table in the proposed Technical Specifications**
  - **Based on NUREG 1536 Rev-1 Section 8.4.7.4**
  - **Multiple-pass PT examination**
    - Reduction factor of 0.8 for weld strength
    - Critical flaw size calculation

NRC Staff Issue #1

▶ Proposed ASME Code Alternative (Section 4.4)

Reference ASME Code Section/Article	Code Requirement	Justification and Compensatory Measures
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or radiographic testing (RT) and either PT or magnetic particle testing (MT).	The shell to the outer top cover weld, the shell to the inner top cover weld and the siphon cover and vent plug welds are all partial penetration welds. As an alternative to the non-destructive examination (NDE) requirements of NB-5230 for Category C welds, all of these closure welds will be multi-layer welds and receive a root and final PT examination, except for the shell to the outer top cover weld. The shell to the outer top cover weld will be a multi-layer weld and receive multi-level PT examination in accordance with the guidance provided in NUREG 1536 Revision 1 for NDE. The multi-level PT examination provides reasonable assurance that flaws of interest will be identified. The PT examination is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000. The cover to shell welds are designed to meet the guidance provided in ISG-15 for stress reduction factor.

NRC Staff Issue #1

ASME Definitions

- **Primary stress (P_m, P_b, P_L) – Per NB-3213.8, primary stress is any normal or shear stress which is necessary to satisfy the laws of equilibrium, e.g., general membrane in shell, bending in center of flat plates.**
- **Primary general membrane stress (P_m) – Per Figure NB-3221-1, general membrane stress is average primary stress across solid section. Excludes discontinuities and concentrations.**
- **Primary local membrane stress (P_L) – Per Figure NB-3221-1, local membrane stress is average stress across any solid section. Considers discontinuities but not concentrations.**
- **Primary bending stress (P_b) – Per Figure NB-3221-1, primary bending stress is the component of primary stress proportional to distance from centroid of solid section. Excludes discontinuities and concentrations.**
- **Secondary membrane plus bending stress (Q) - Per Figure NB-3222-1, secondary membrane plus bending stress is self-equilibrating stress necessary to satisfy continuity of structure. Occurs at structural discontinuities and excludes local stress concentrations**

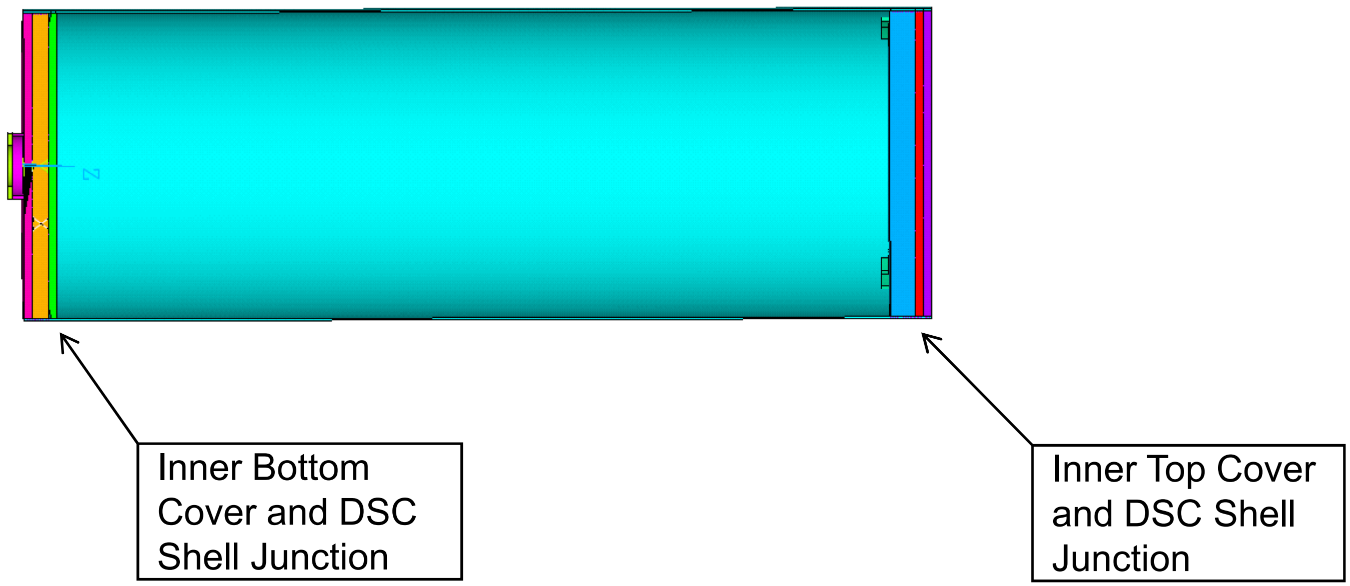
NRC Staff Issue #1

ASME Definitions (continued)

- Gross structural discontinuity - Per NB-3213.2, gross structural discontinuity is a geometric or material discontinuity which affects the stress or strain distribution through the entire wall thickness of the pressure - retaining member. Examples of gross structural discontinuities are head-to-shell junctions, flange-to-shell junctions, and nozzles.
- ASME Table NB-3217-1 concludes that at the junction of shell and head, the membrane stresses are PL and bending stresses are Q, provided that the edge restraint is not required to maintain the bending stress in the middle to acceptable limits.
- Section NB-3224.4 states that the requirement of primary plus secondary stress intensity does not need to be satisfied for Level C service limits.
- Appendix F, Section F-1332.3 states that bearing stress does not need to be evaluated for Level D service limits.

NRC Staff Issue #1

- **EOS DSC Shell confinement boundary consists of two regions of gross structural discontinuity as defined by NB-3213.2**



NRC Staff Issue #1

- **EOS partial penetration closure weld evaluation**
  - Welds are located at gross structural discontinuity areas
  - Membrane stresses at these locations are compared to primary local membrane stress, P_L, limits (ASME Table NB-3217-1); which would be minimum of 3.6Sm of Su for level D conditions (elastic)
  - Bending stresses at these locations are compared to secondary stress, Q, limits (ASME Table NB-3217-1)
  - There are no defined ASME stress limits for secondary and compressive stresses for level D events
  - A 0.8 stress allowable reduction factor is used per NUREG 1536 Rev. 1 (ISG-15) for multiple-pass PT examination, while maintaining the required in-process PT inspection interval less than the critical flaw size

NRC Staff Issue #1

- **AREVA TN recent experience (CoC 1029 Amendment 3 – 32PTH2 DSC)**
  - **Analysis described in RAI response dated June 10, 2013 (ADAMS Accession # ML13182A044)**
  - **Inner top cover plate to shell weld modeled as line weld**
  - **Maximum stress derived from maximum resultant nodal forces**
  - **Maximum stress compared to a limit of 50.4 ksi, which is derived from PL stress limits**

NRC Staff Issue #2

- **Summary: Effects of gap presence on the calculated weld stress should also be subjected to a sensitivity analysis**

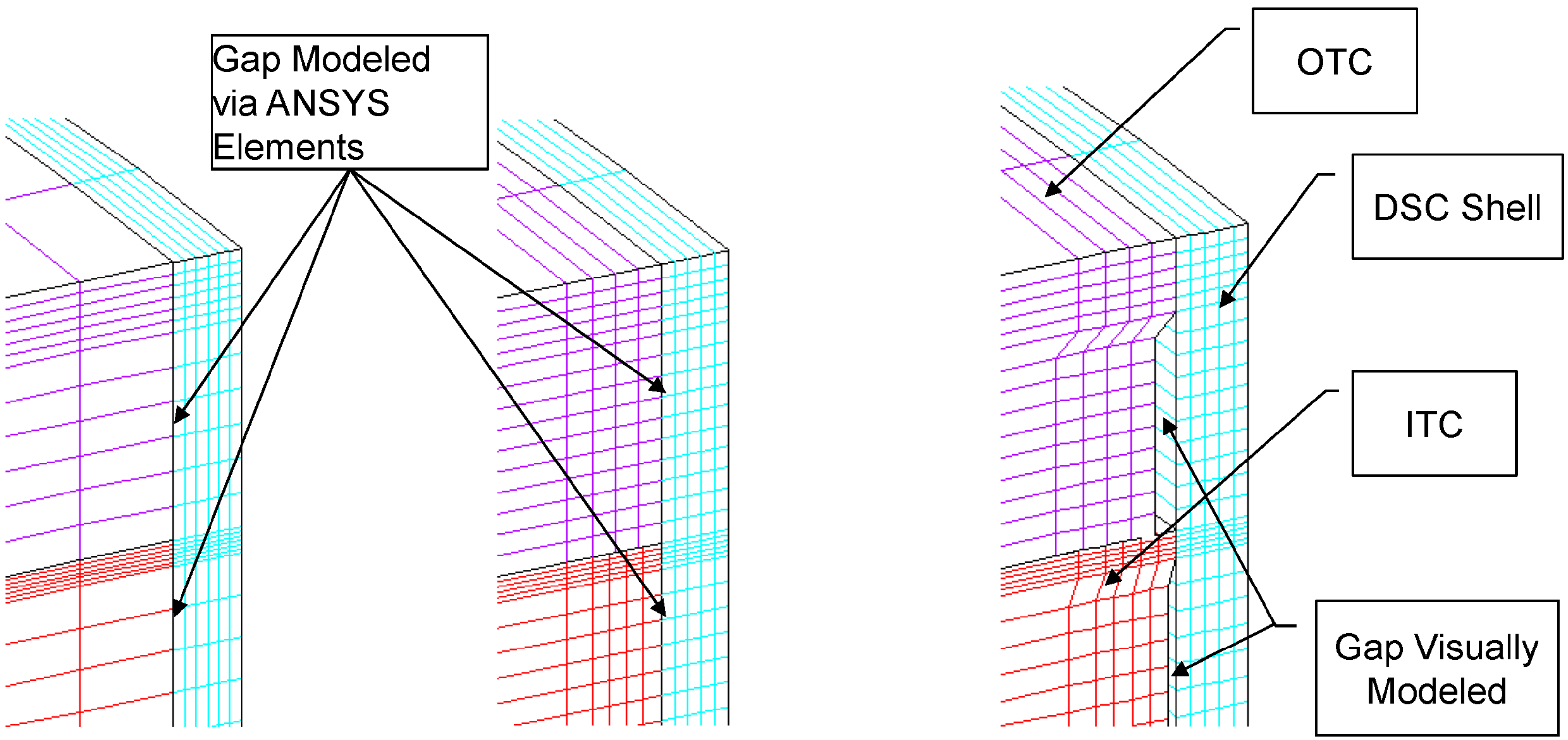
NRC Staff Issue #2

- **Sensitivity study has been performed between three models (preliminary results)**

Model	Gap Modeling Technique	Weld Element Length (Radial Direction)
Model 1 (4/3/15 Submittal)	Via ANSYS element options	0.69 inch
Model 2	Via ANSYS element options	0.17 in. OTC Weld 0.125 in. ITC Weld
Model 3	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld

- **Side drop (75g) loading conditions were applied**

NRC Staff Issue #2

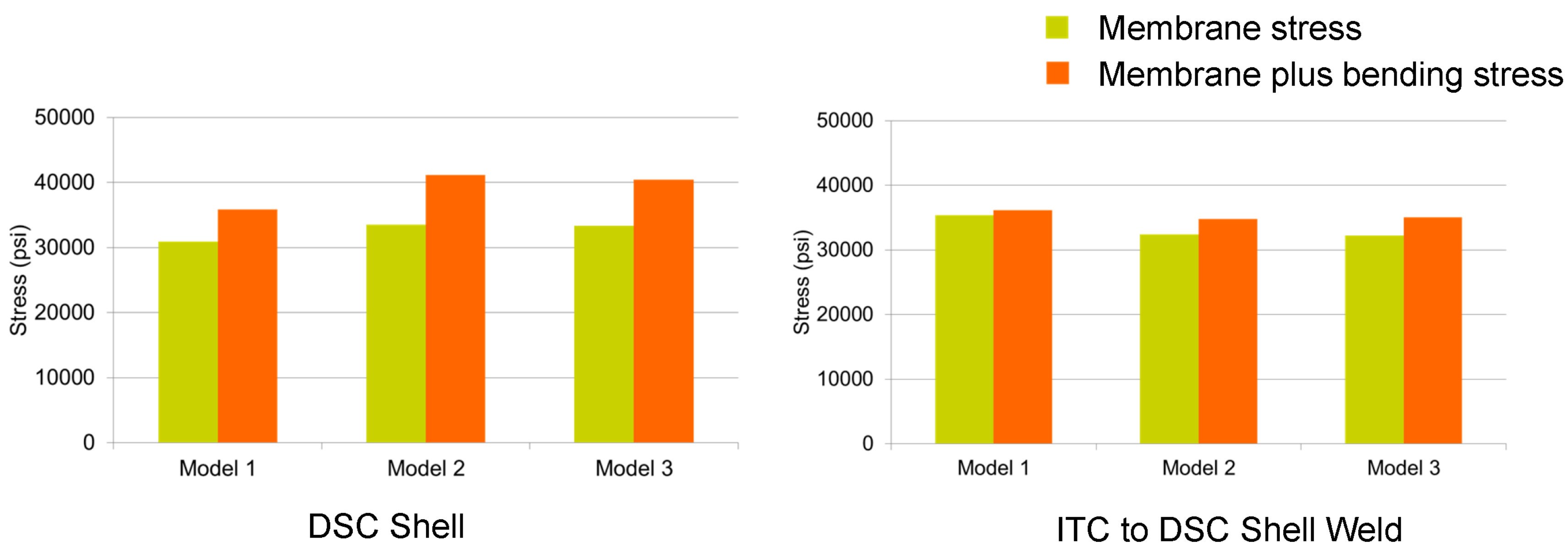


Model 1
(Original)

Model 2

Model 3

NRC Staff Issue #2



- It is concluded that results are not sensitive to whether the gap is modeled visually or simulated through ANSYS contact element options
- Results for other components (such as the OTC to DSC Shell weld) follow the same trend

NRC Staff Issue #3

- **Summary: For an appropriate weld size, a sensitivity analysis needs to also be performed for discretizing the weld into layers in the radial direction.**

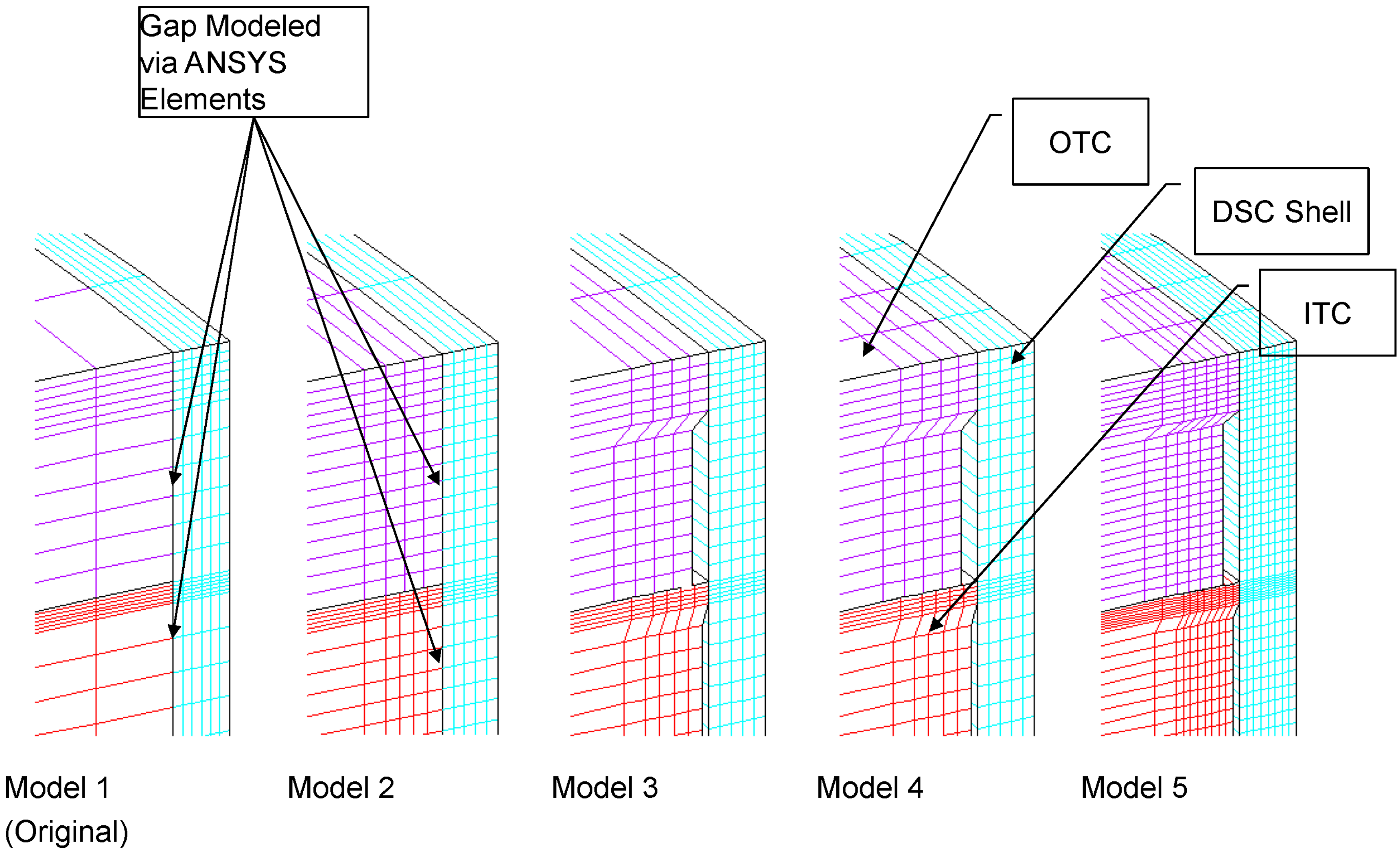
NRC Staff Issue #3

- **Sensitivity study has been performed between five models (preliminary results)**

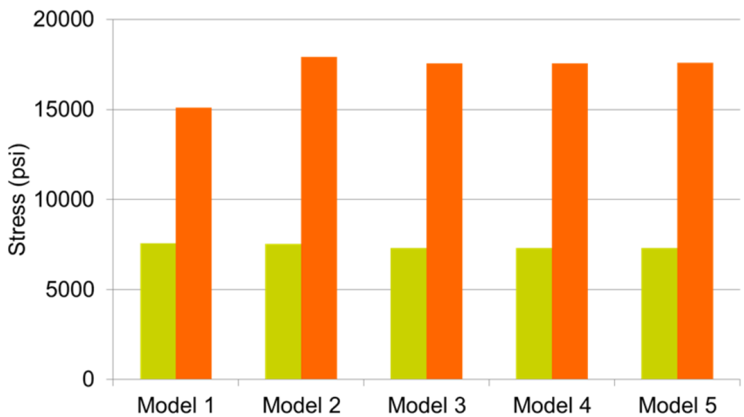
Model	Gap Modeling Technique	Weld Element Length (Radial Direction)	Weld Element Length (Circumferential Direction)
Model 1 (4/3/15 Submittal)	Via ANSYS element options	0.69 inch	1.4 in
Model 2	Via ANSYS element options	0.17 in. OTC Weld 0.125 in. ITC Weld	1.4 in
Model 3	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld	1.4 in
Model 4	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld	0.7 in
Model 5	Visually	0.10 in. OTC Weld 0.06 in. ITC Weld	0.7 in

- **Internal pressure loading conditions were applied**

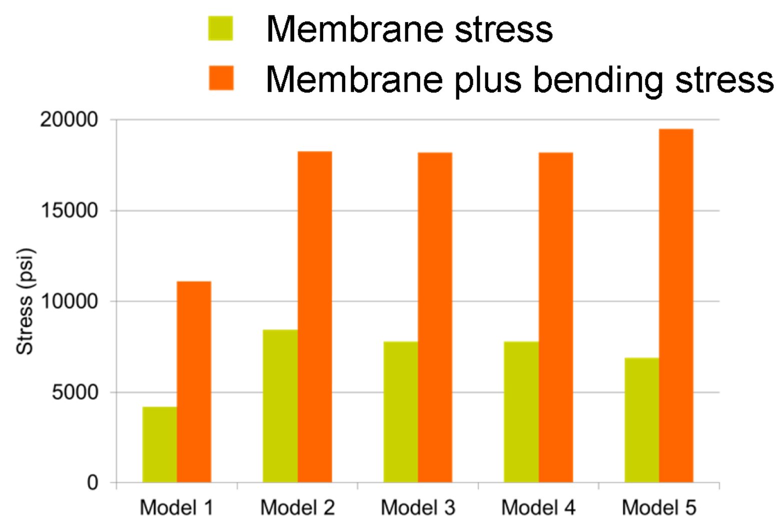
NRC Staff Issue #3



NRC Staff Issue #3



DSC Shell



ITC to DSC Shell Weld

- **It is concluded that the stress at weld locations is sensitive to element length but converges at an element length of 0.17 inch for the OTC to DSC Shell weld and 0.125 inch for the ITC to DSC Shell weld**
- **The results for other components (such as ITC) follow the same trend as the DSC Shell**
- **Results for the OTC to DSC Shell weld follows the same trend as the ITC to DSC Shell weld**

NRC Staff Issue #4

- **Summary: A 2D mesh sensitivity study does not apply to the 3D side drop scenario; a separate sensitivity study is required for 3D side drop scenario**

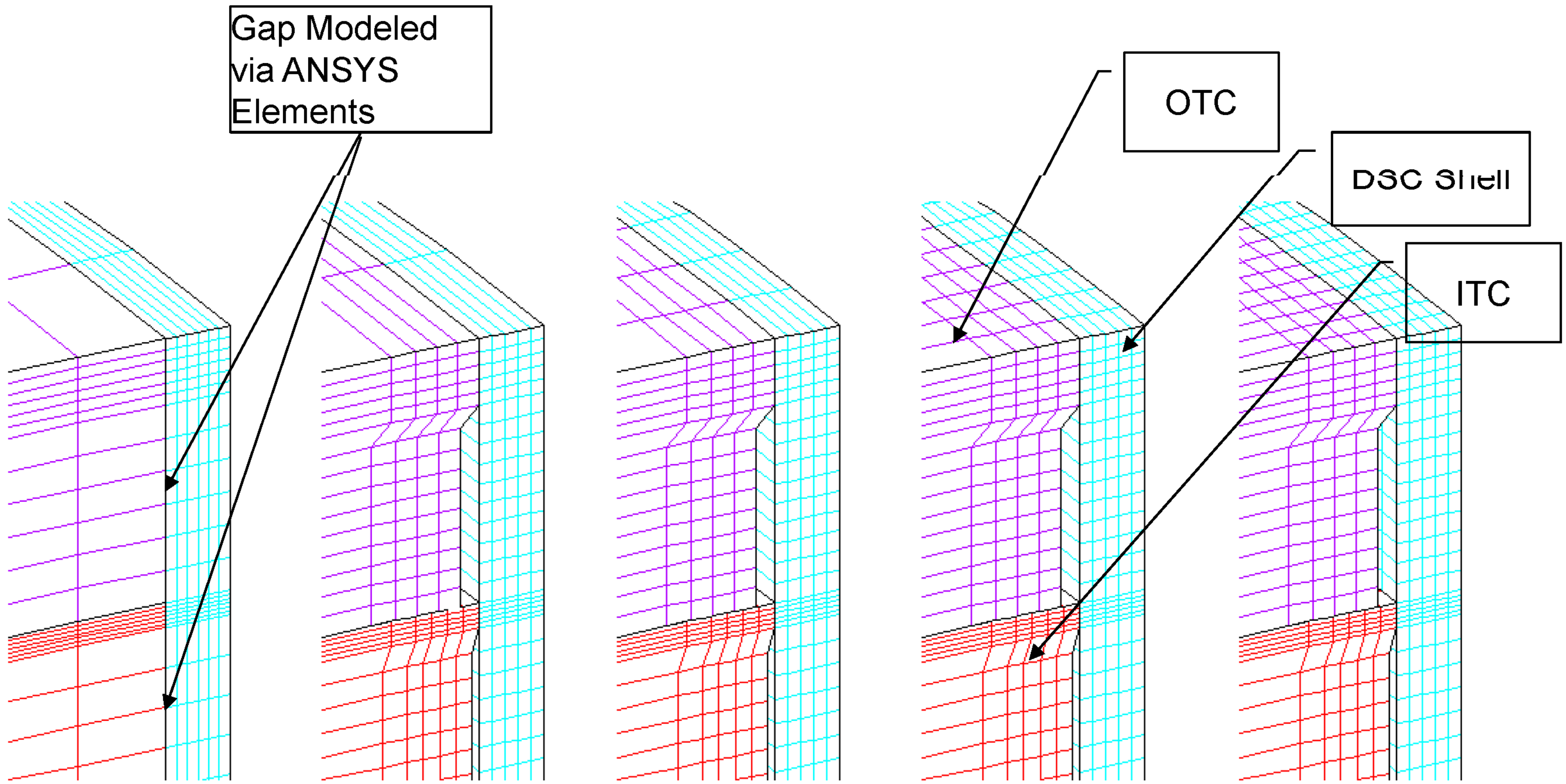
NRC Staff Issue #4

- **Sensitivity study has been performed between five models (preliminary results)**

Model	Gap Modeling Technique	Weld Element Length (Radial Direction)	Weld Element Length (Circumferential Direction)
Model 1 (4/3/15 Submittal)	Via ANSYS element options	0.69 inch	1.4 in
Model 2	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld	1.4 in
Model 3	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld	0.72 in
Model 4	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld	0.36 in
Model 5	Visually	0.17 in. OTC Weld 0.125 in. ITC Weld	0.24 in

- **Side drop (75g) loading conditions were applied**

NRC Staff Issue #4



Model 1 (Original)

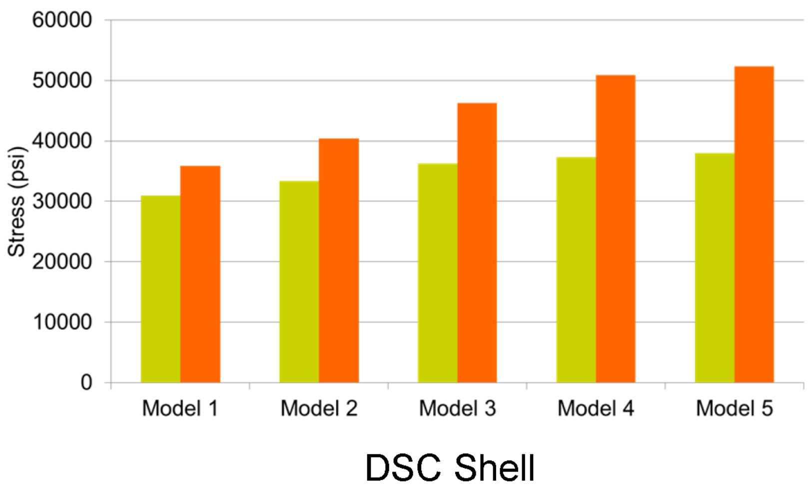
Model 2

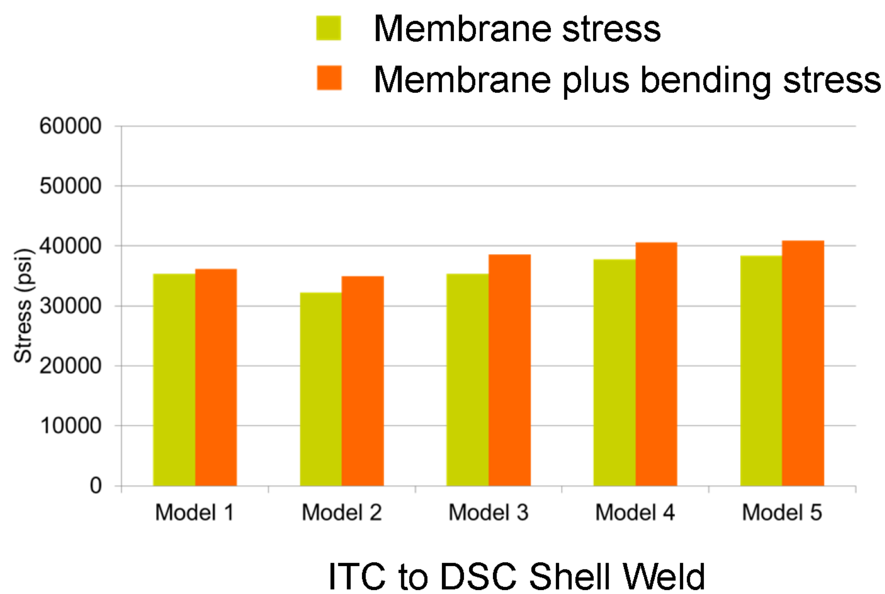
Model 3

Model 4

Model 5

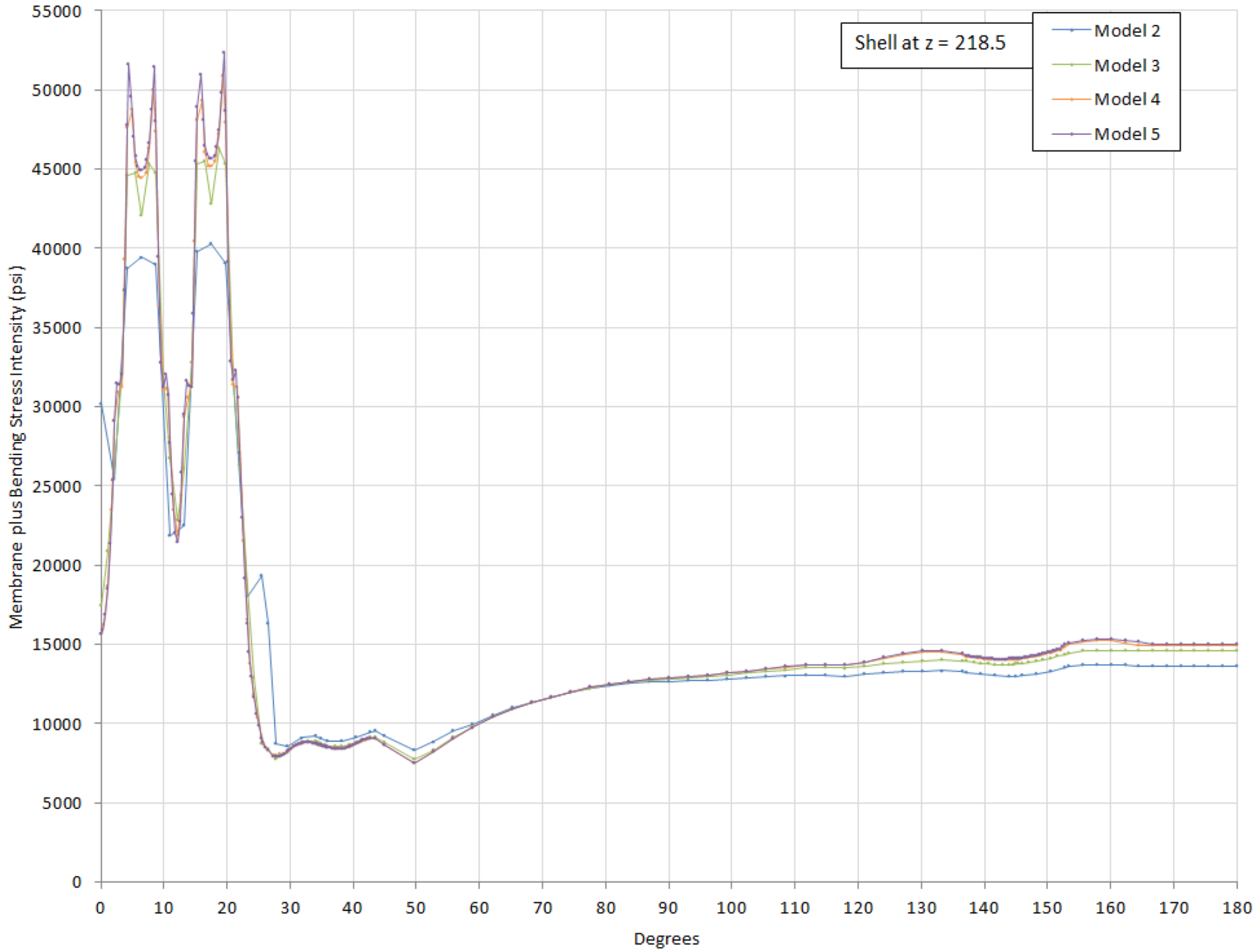
NRC Staff Issue #4





- **It is concluded that an element length of 1.4 inch produces converged results away from impact area and 0.36 inch produces converged results in the impact area**
- **The results for other components (such as the OTC to DSC Shell weld) follow the same trend as ITC to DSC Shell weld**

NRC Staff Issue #4



Summary

- **SAR Appendix 3.9.1 will be revised**
  - A new section will be added to explain ASME code classification as it pertains to the analysis
  - The ANSYS model will be updated with the following changes
    - The gap between the cover plates and shell will be visually included
    - Converged model from the sensitivity studies (Model 4 from Issue #4) will be used for all analysis
  - All results will be updated
- Questions or Comments

Acronyms and Abbreviations

- ASME – American Society of Mechanical Engineers
- CoC – Certificate of Compliance
- DSC – Dry Shielded Canister
- ISG – Interim Staff Guidance
- ITC – Inner Top Cover
- MT – Magnetic Particle Testing
- NDE – Non-Destructive Examination
- NP – Non-Proprietary
- OTC – Outer Top Cover
- RAI – Request for Additional Information
- PT – Liquid Penetrant Testing
- RSI – Request for Supplemental Information
- RT – Radiographic Testing
- SAR – Safety Analysis Report