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FINITE ELEMENT STRESS ANALYSIS OF ITER MODULE 13

Elastic Finite Element Stress Analysis of Modules 13 Shield Block and First Walls Under Operational Pressure and Temperature Distribution

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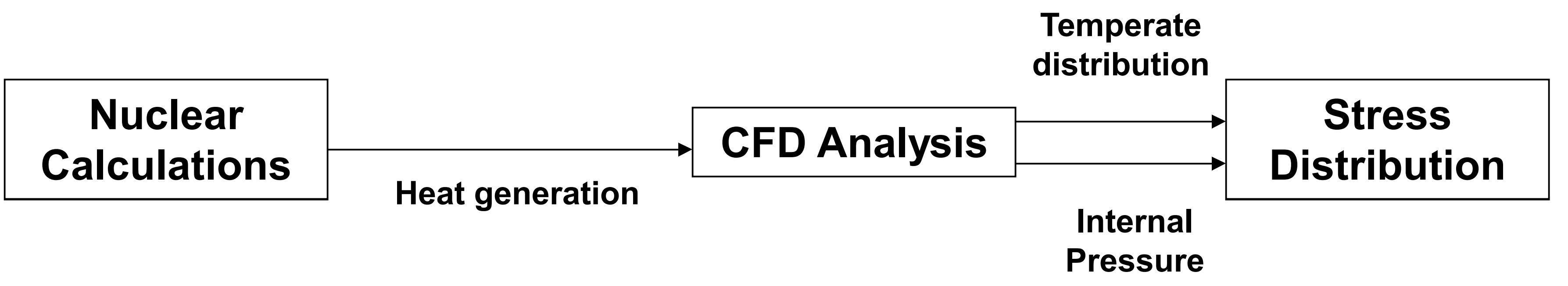
Purpose Of Analysis

- **Demonstrate FEA stress results based on nuclear heating and CFD analysis**



- **Compare initial stress results to ITER criteria for stress limits during operating conditions**

Stress Criteria per ITER SDC-IC

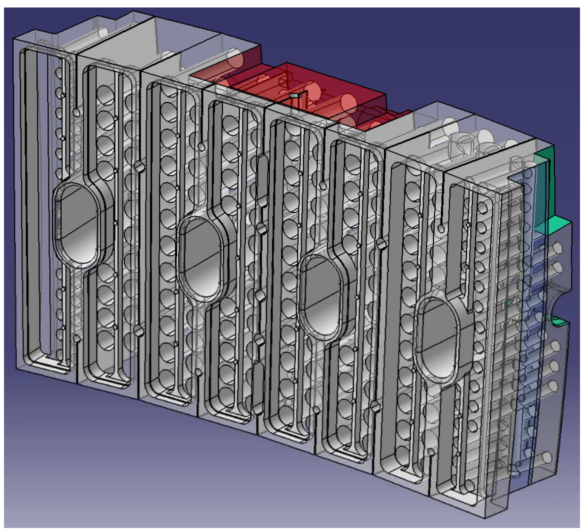
- **Acceptable stress intensity Is dictated by Sm for elastic analysis.**
  - Sm is defined for each material based on a percentage of minimum, temperature dependant, ultimate and yield strengths.

- **Sm is the stress limit for primary stresses.**
  - Stresses caused by internal coolant pressure are classified as primary stresses

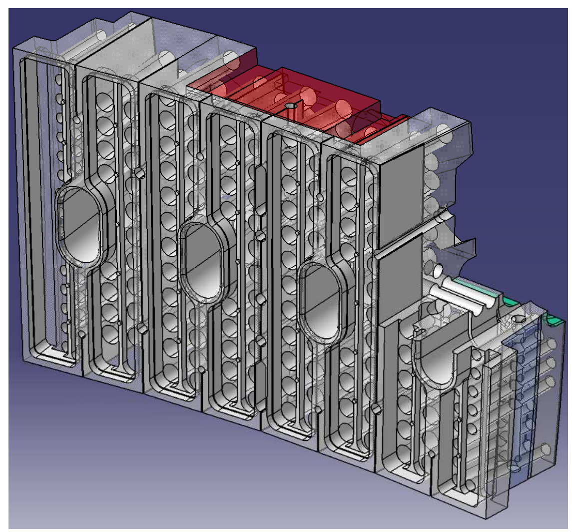
- **3Sm is the stress limit for the combination of primary and secondary stresses.**
  - Stresses cased by temperature distribution classify as secondary stresses.

FEA Geometry For Shield Modules

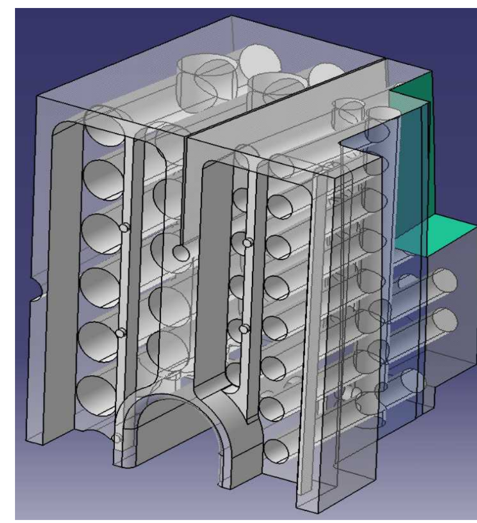
- **Linear Tetrahedral meshes created in CFDesign**
- **Temperature distribution taken from CFDesign results**
- **Thermal stresses based on initial temperature of 100°C**
- **Pressure stresses based on 3MPa coolant pressure**
- **ABAQUS used for elastic static FEA**



Full Geometry of Shield Block

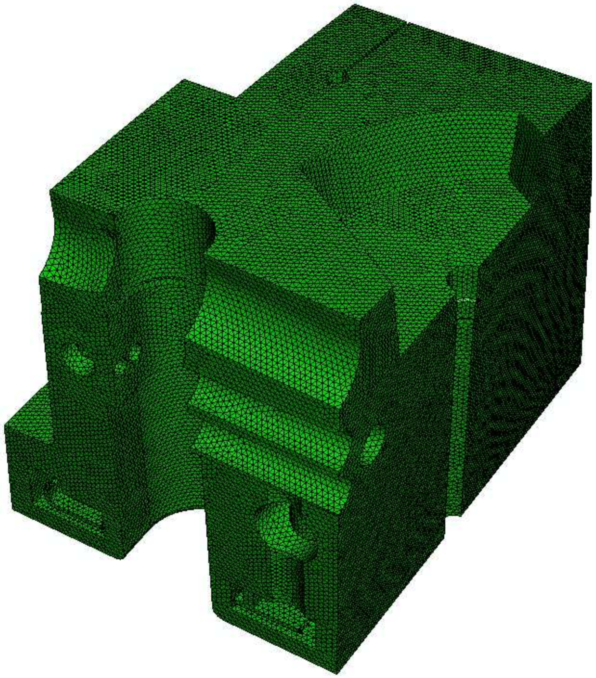


Analyzed Section Missing

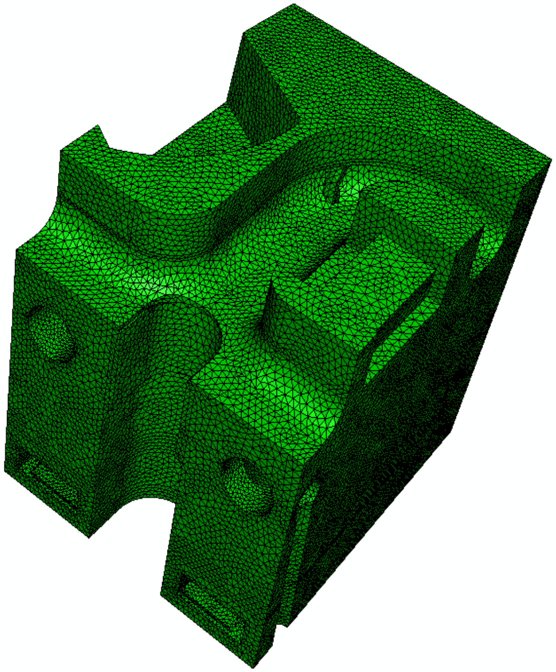


Analyzed Section

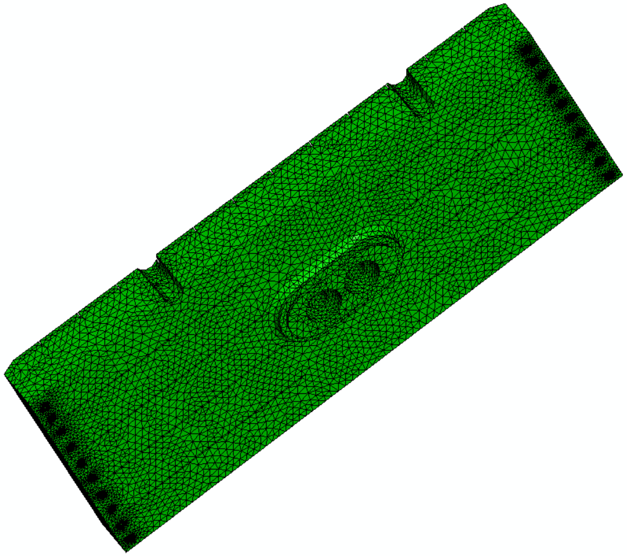
FEA Meshes For Shield Modules



Module 13 Corner

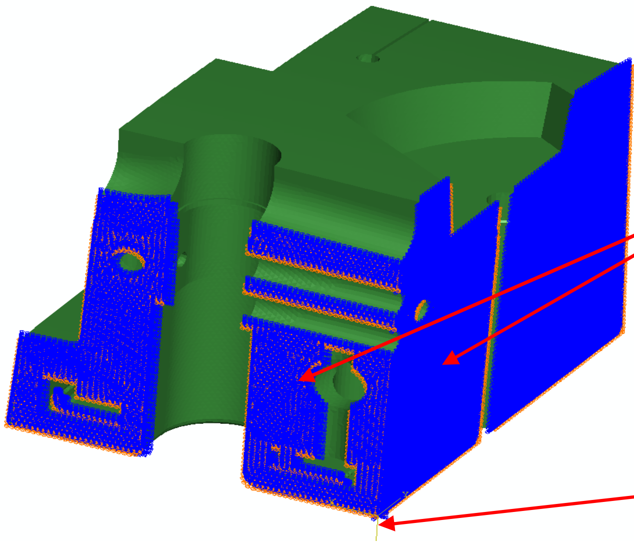


Module 13 Mid 1/8th



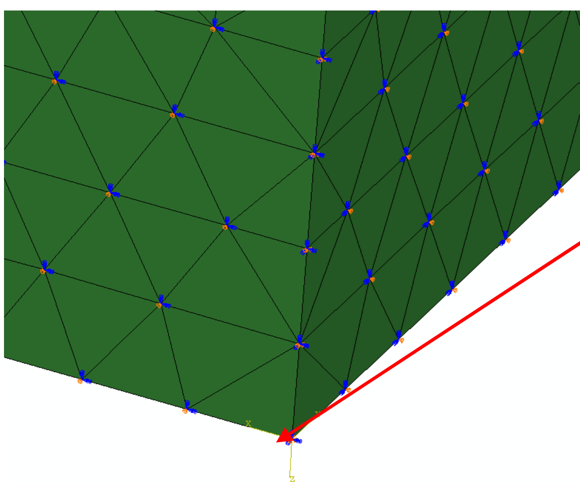
Module 13 First Wall

Boundary Conditions



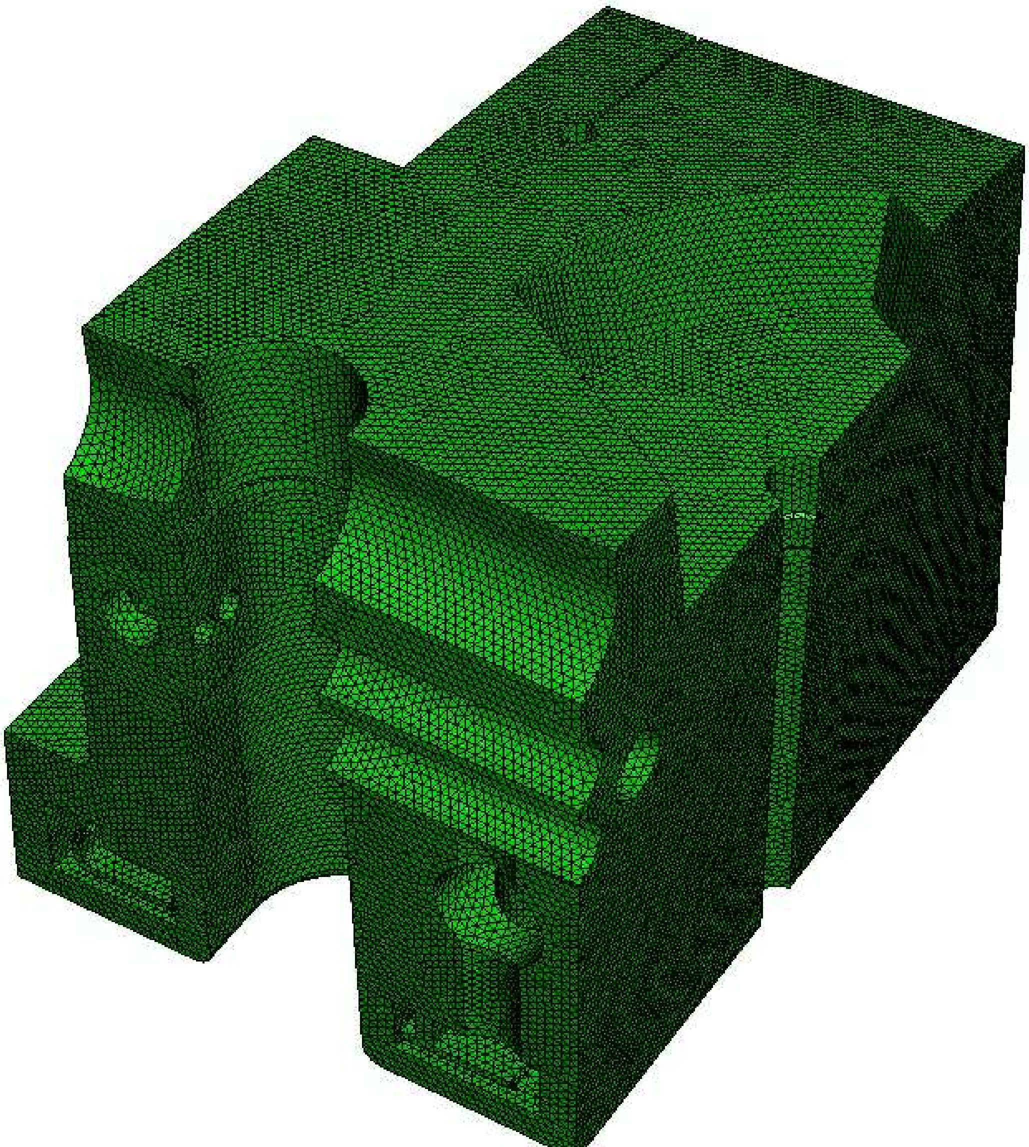
Cut faces (shown in blue) were restrained in 1 DOF relative to local coordinate system

Pinned Corner

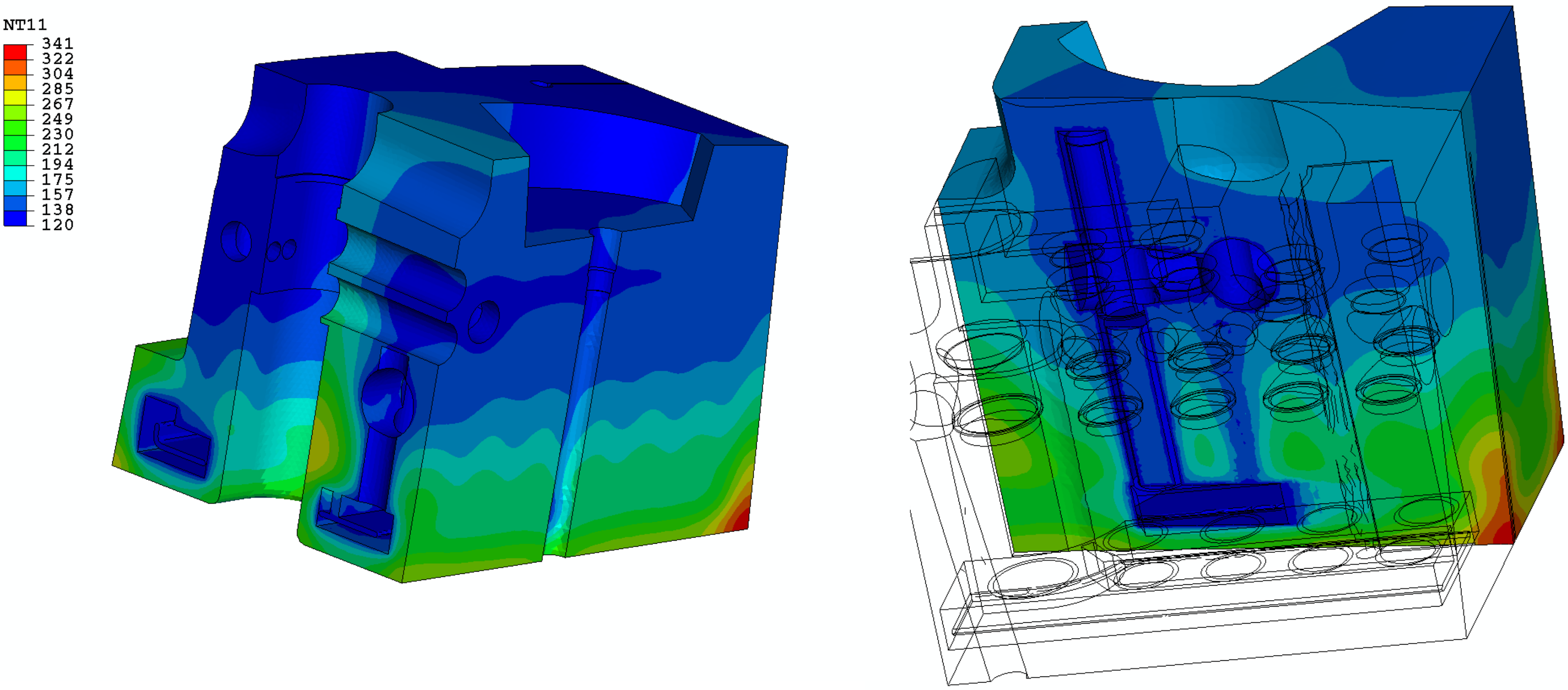


Local coordinate system located at pinned node

FEA Mesh of Shield Module 13 Corner Section

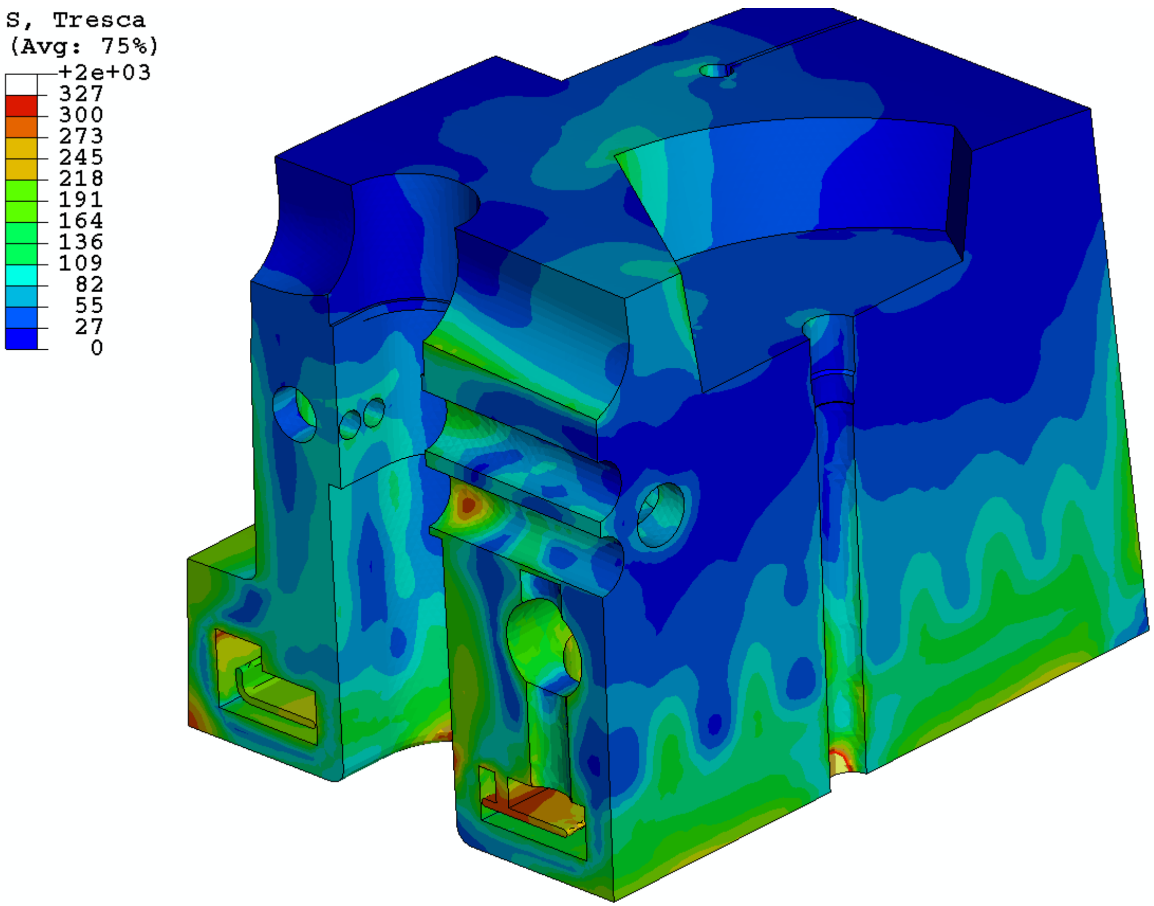


Temperature Distribution for Shield Module 13 Corner section °C



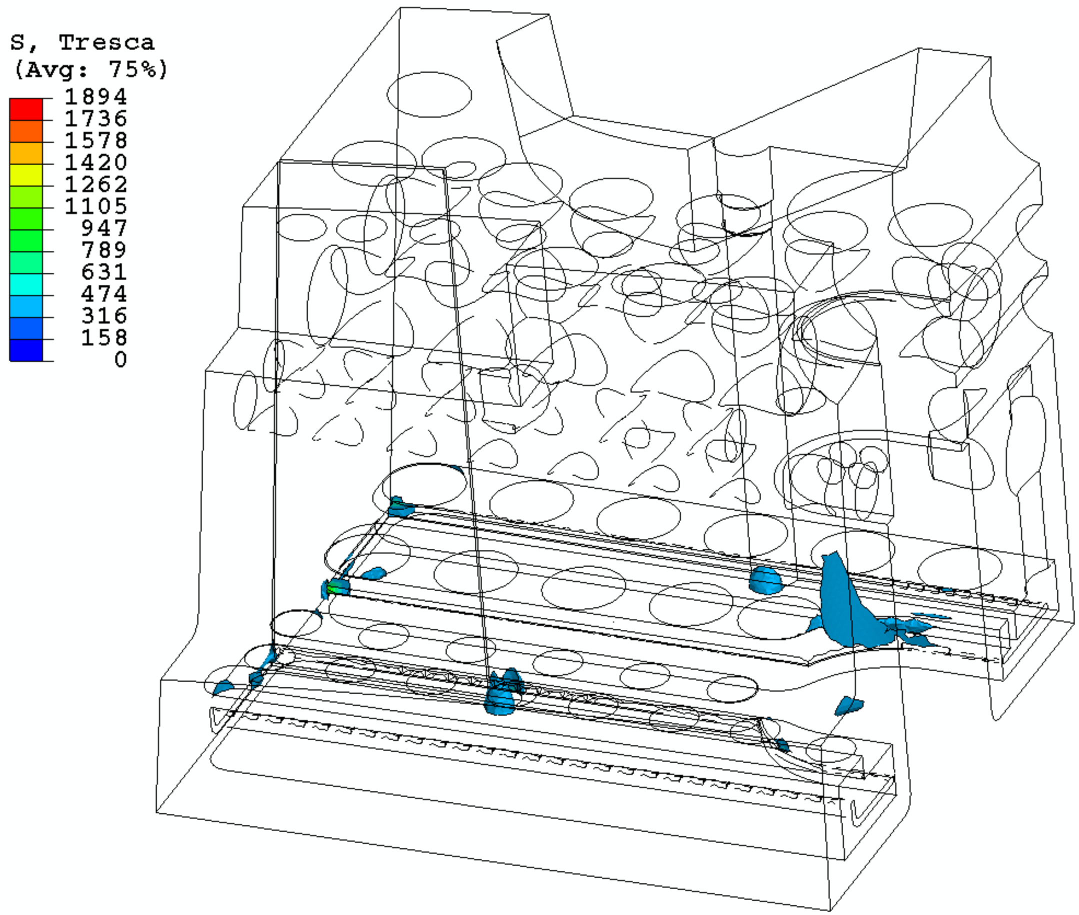
FEA Thermal Stress Results for Shield Module 13 Corner section

Tresca stress distribution (MPa) with upper contour limit set to 3Sm

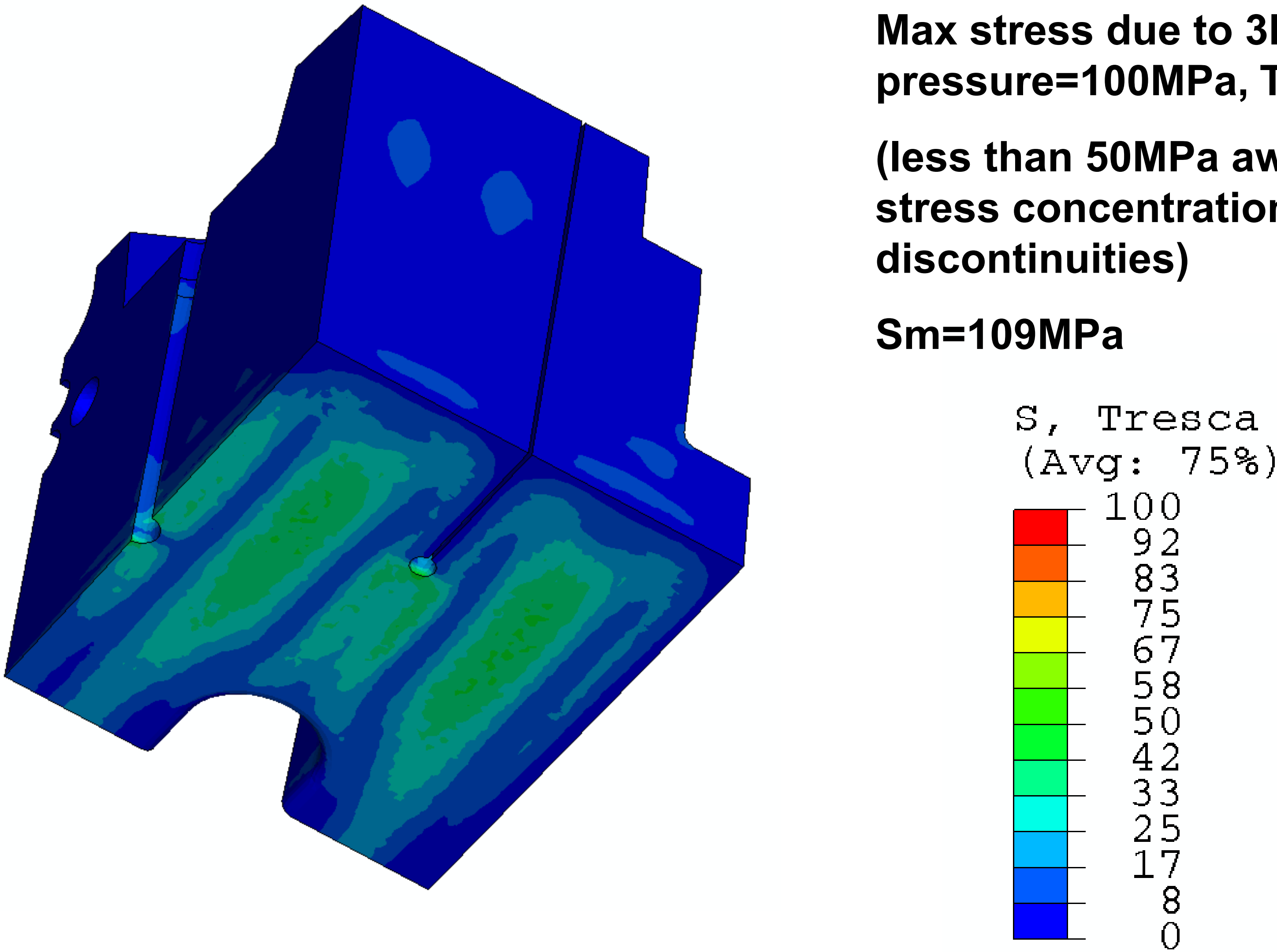


FEA Thermal Stress Results for Shield Module 13 Corner section

Tresca stress results (MPa) showing regions over 3Sm



FEA Pressure Stress Results for Shield Module 13 Corner section

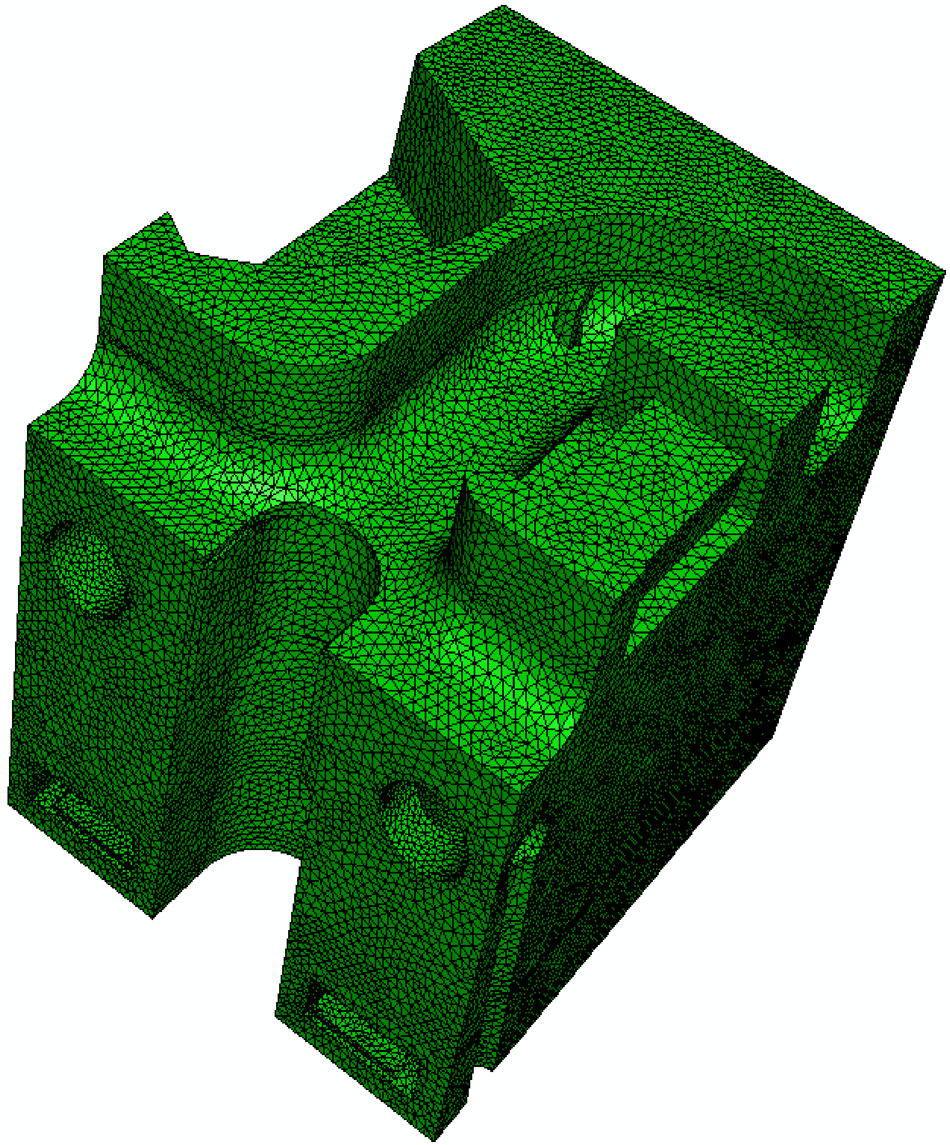


Max stress due to 3MPa coolant pressure=100MPa, Tresca

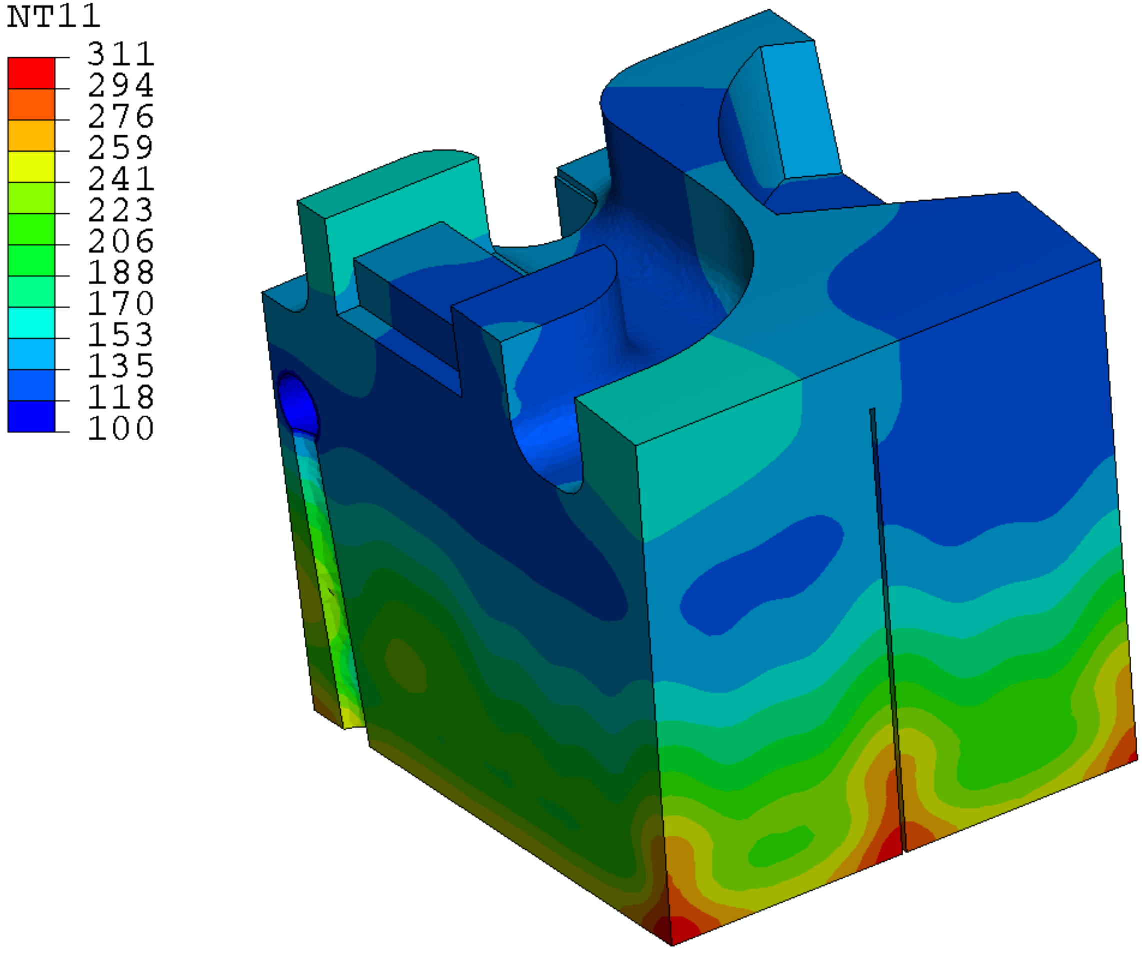
(less than 50MPa away from stress concentrations and discontinuities)

Sm=109MPa

FEA Mesh of Shield Module 13 Mid Section

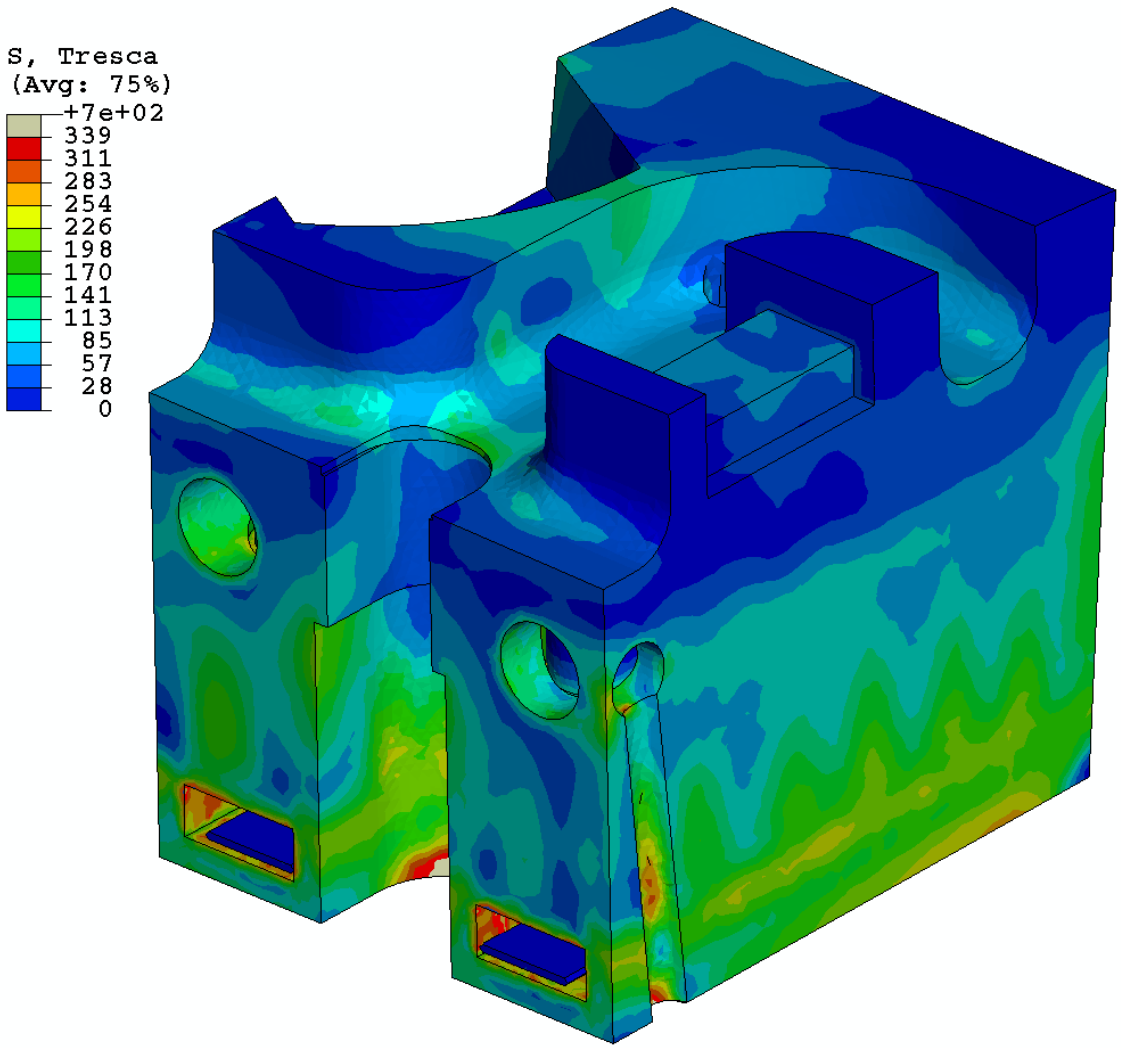


Temperature Distribution for Shield Module 13 Mid Section °C



FEA Thermal Stress Results for Shield Module 13 Mid Section

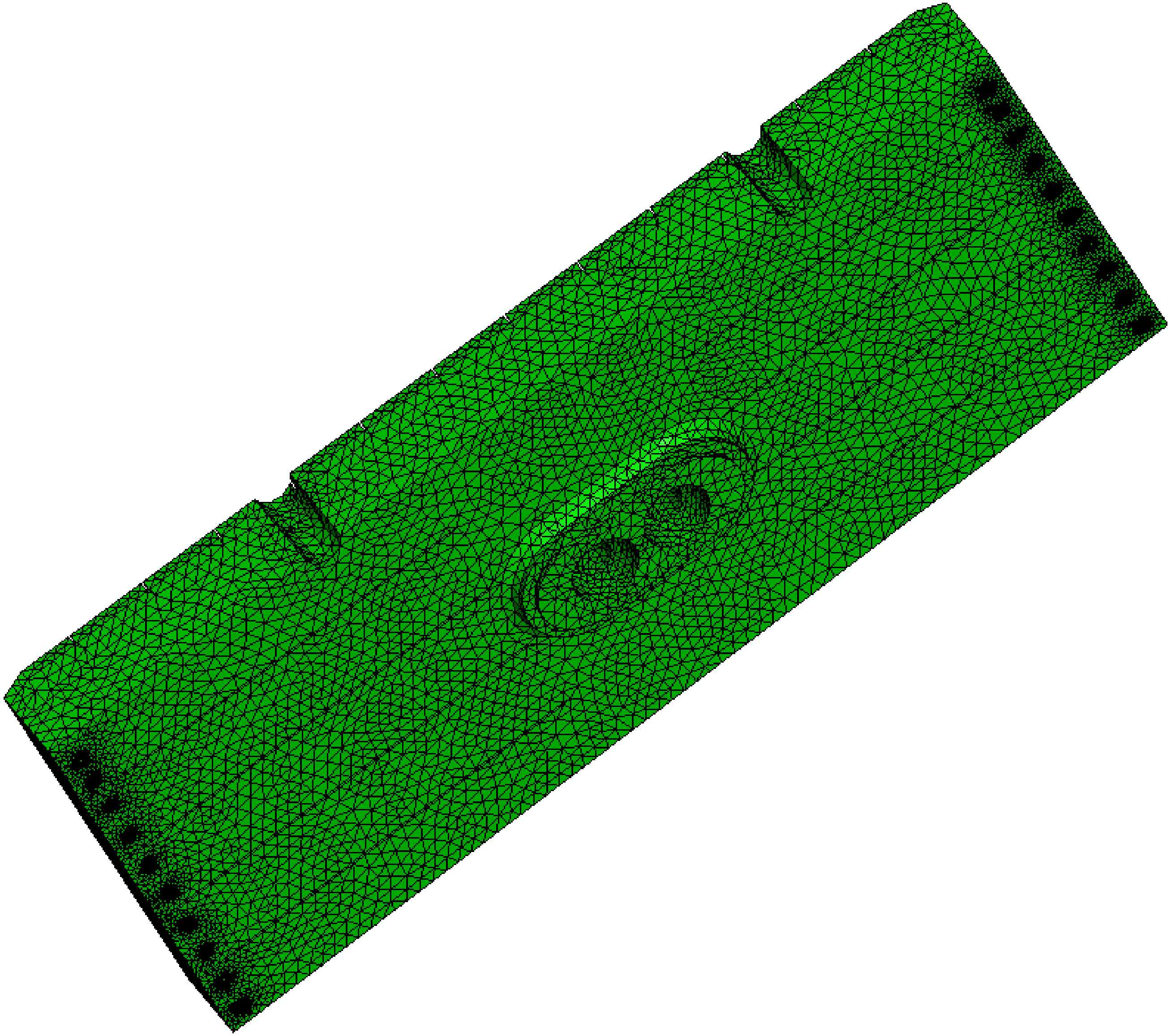
Tresca stress distribution (MPa) with upper contour limit set to 3Sm



Thermal Stress FEA Of First Walls

- Tetrahedral meshes created in CFDesign
- Temperature distribution taken from CFDesign results
- Thermal stresses based on initial temperature of 100°C
- Used “Stabilize”- no other boundary conditions
- ABAQUS used for elastic static FEA

FEA Mesh of Module 13 First Wall



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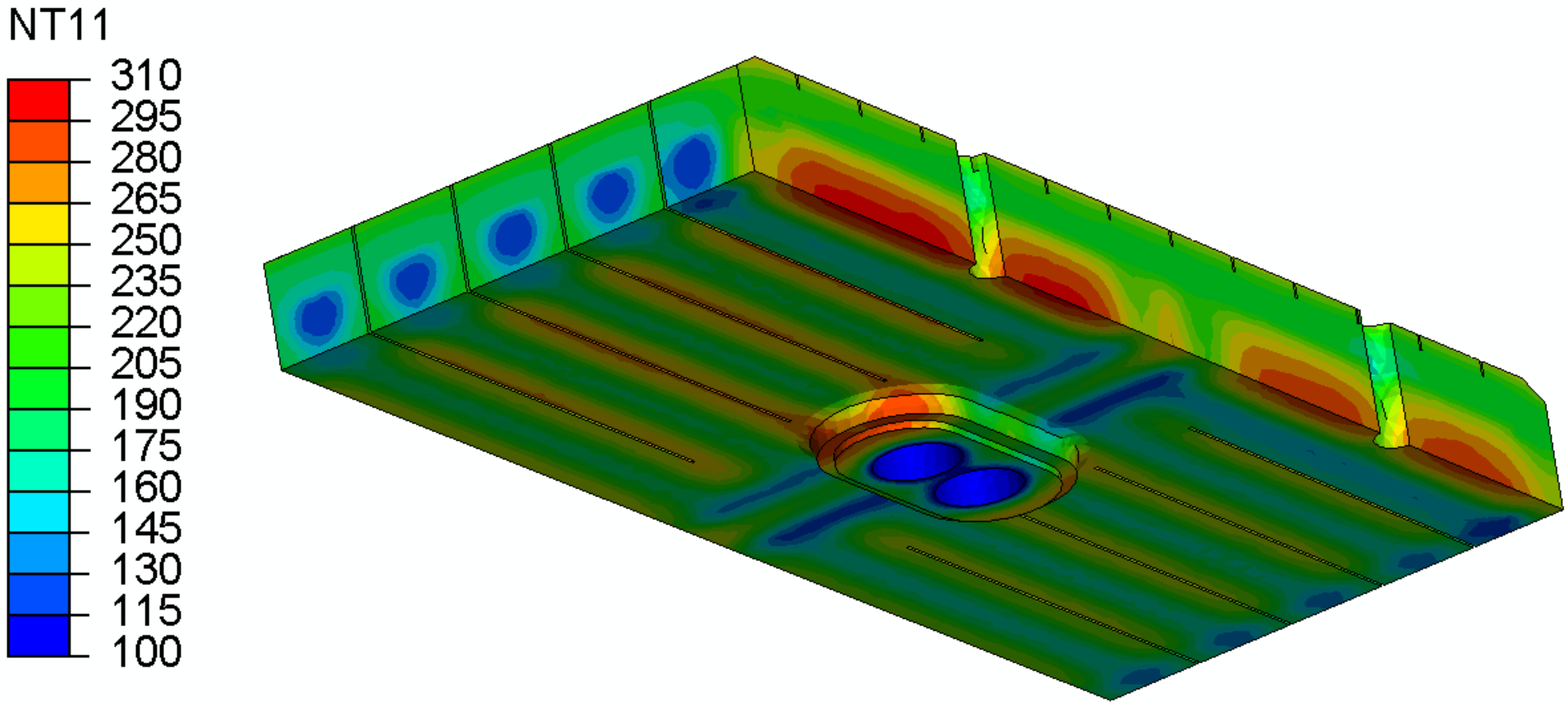
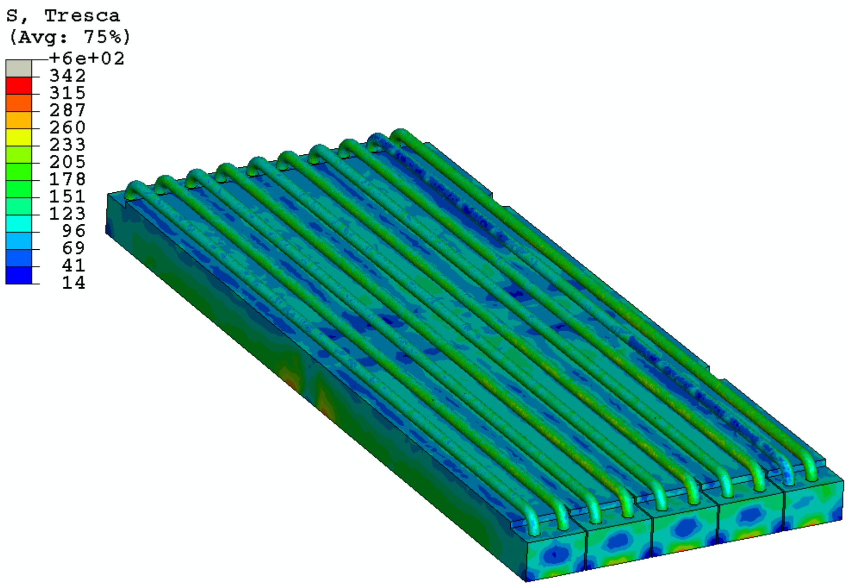
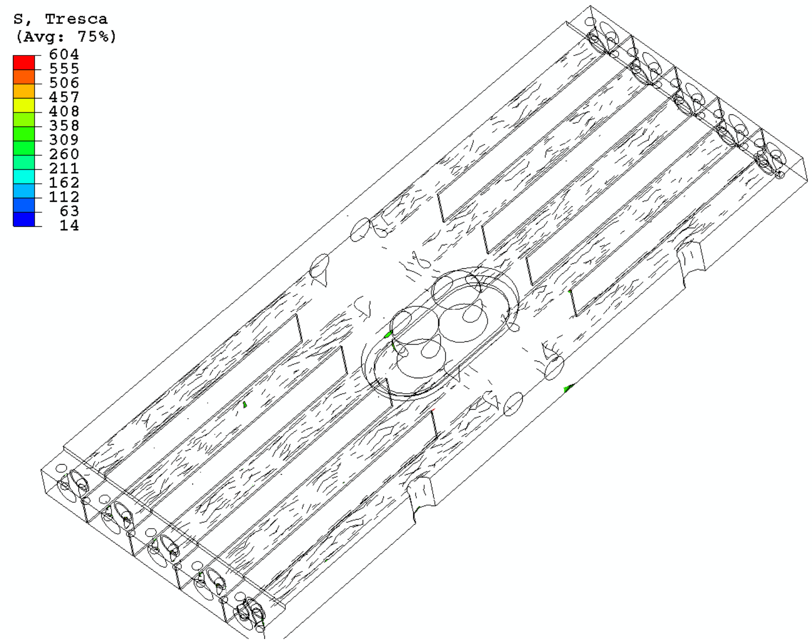
Temperature Distribution In Module 13 First Wall



Module 13 First Wall Thermal Stress Analysis Results in SS316L(N)-IG

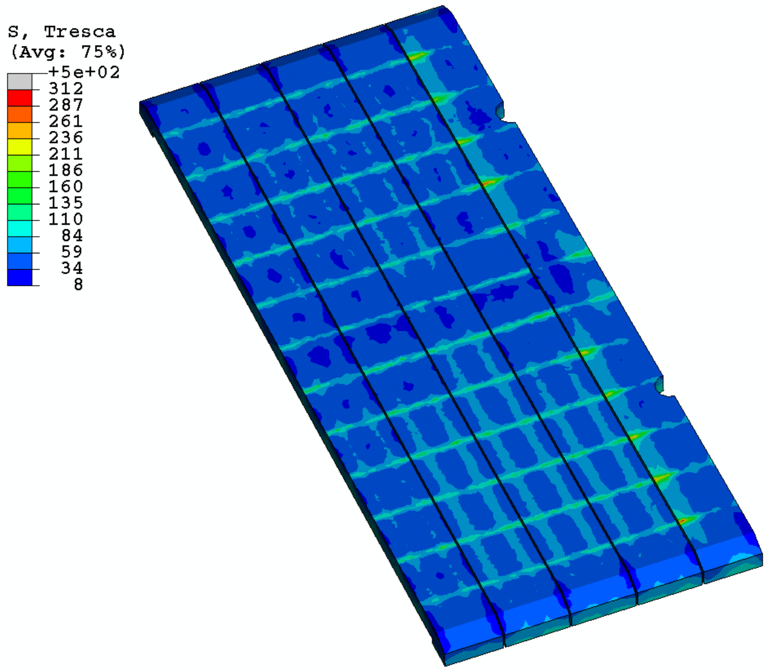


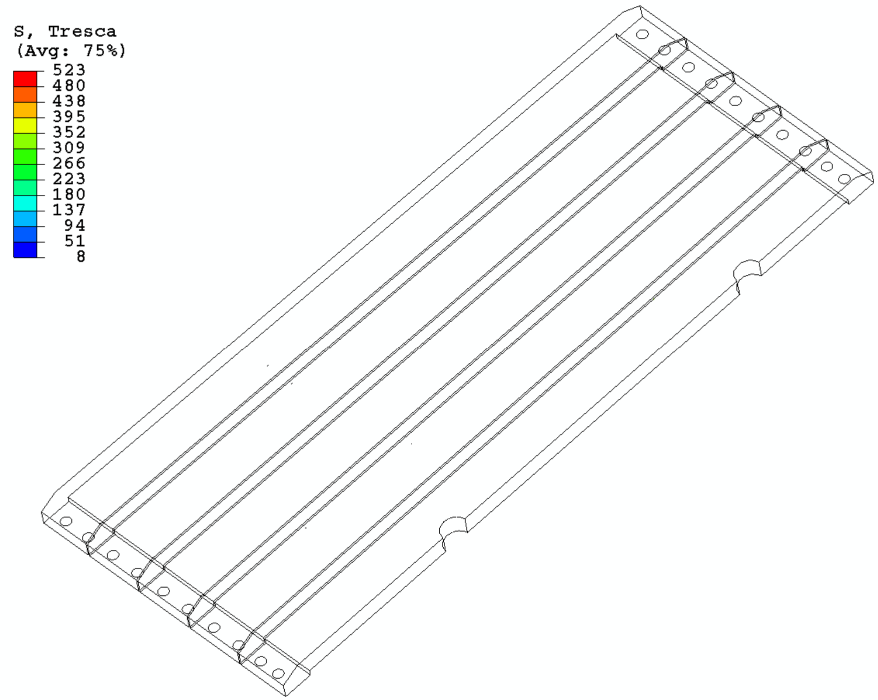


Tresca stress distribution (MPa) with upper contour limit set to 3Sm

Tresca stress results (MPa) showing regions over 3Sm

Module 13 First Wall Thermal Stress Analysis Results in CuCrZr

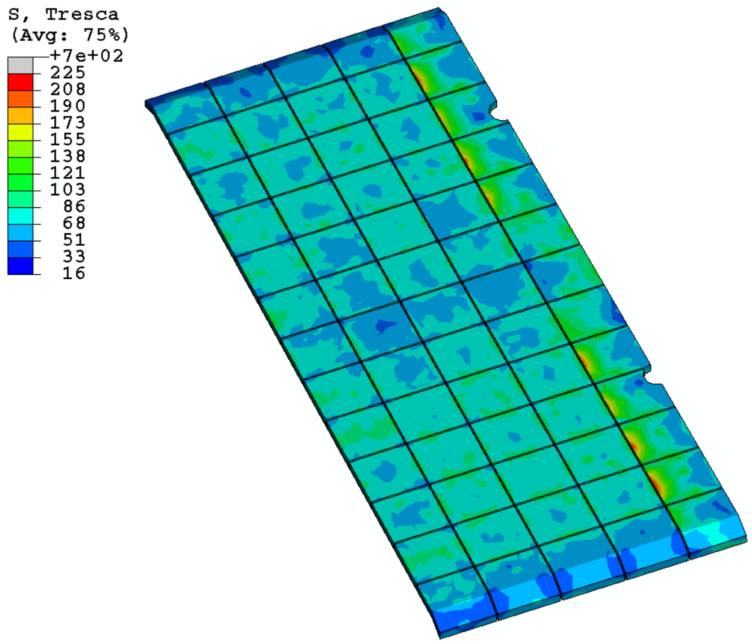




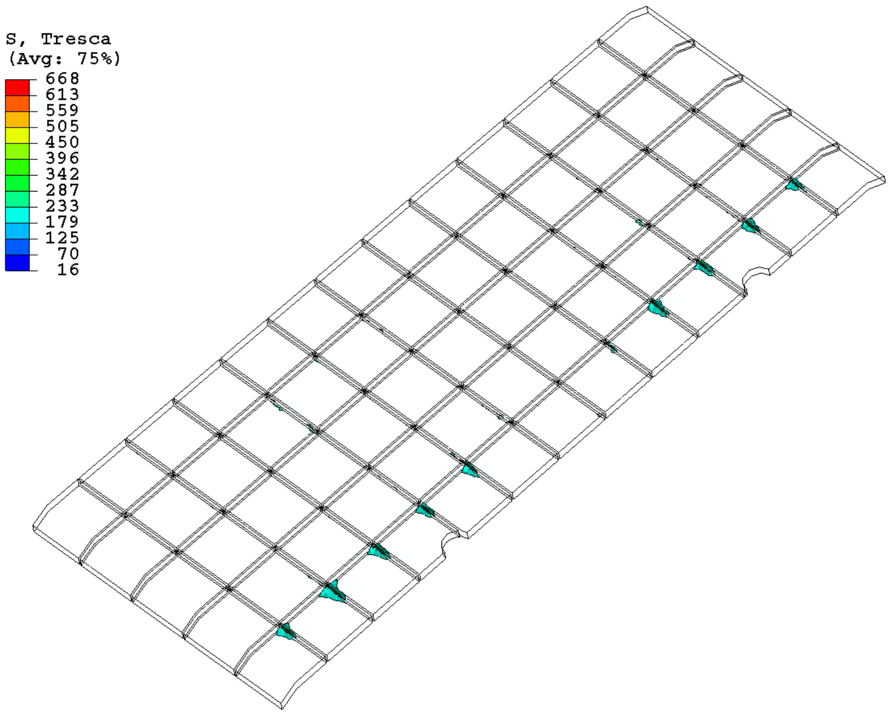
Tresca stress distribution (MPa) with upper contour limit set to 3Sm

Tresca stress results (MPa) showing regions over 3Sm

Module 13 First Wall Thermal Stress Analysis Results in Be(S65C)



Tresca stress distribution (MPa) with upper contour limit set to 3Sm



Tresca stress results (MPa) showing regions over 3Sm

Conclusion

- FEA Stress results were successfully produced based on nuclear heating calculations and the corresponding CFD thermal and pressure results.

- Stress levels in module 13 were shown to be generally under the limits set by ITER IO for elastic analysis of components during operating conditions.

Next Steps

- Analyze larger sections of modules
  - Better fit for symmetry boundary conditions
- Optimize meshes for mechanical stress analyses
  - Mesh refinement near smaller geometric features
- Include electromagnetic forces