Checks for Calculation No: NSTXU-CALC-11-29-00 **Revision No: 0**

Title: OBD12 Hold Down Submodel

Component was checked against latest design

All required load cases are included and current

Discuss method used in the calculation

A simplified OBD12 tile hold down rod submodel with one mounting hole is simulated to resolve the local high contact stress between the rods and tiles around the mounting holes. Only 1/4 of ANSYS APDL submodel is calculated due to the symmetry. The results indicate that the taped rod near the mounting hole can help reduce the contact stress significantly.

Discuss how the calculation was checked (*)

In order to check the results of OBD12 hold down submodel, I did the independent calculations using Workbench. Since the tile material was changed to POCO TM for OBD12, the comparison calculation is based on POCO material, not the original Sigrafine R6510 material. I also compare the stress results of POCO tile submodel with different locations of rod contact points. Please see the calculation form NSTXU-CALC-11-27-00 for details.

List issue identified and how they were resolved

The attached report is to confirm the results of calculation form, and also the calculation form NSTXU-CALC-11-27-00 shows how to reduce the contact stress further.

Checker's name: Jiarong Fang

Technical Authority: Peter H. Titus Digitally signed by Peter H. Titus Date: 2018.09.27 12:05:31 -04'00' ______(sign and date)

(*) independent calculations can be appended

Simplified Analysis of Tile Hold Down Rods

Jiarong Fang, 29 May 2018

Stress analyses of the OBD Row 1-2 tiles presented at the November 2017 Preliminary Design Review showed high contact stresses where the hold-down rods cross the holes for their #8-32 screws. (Figure 1) These stresses can be reduced by thinning the rods where they cross over the screw holes, thus shifting the contact area away from the edge of the hole.

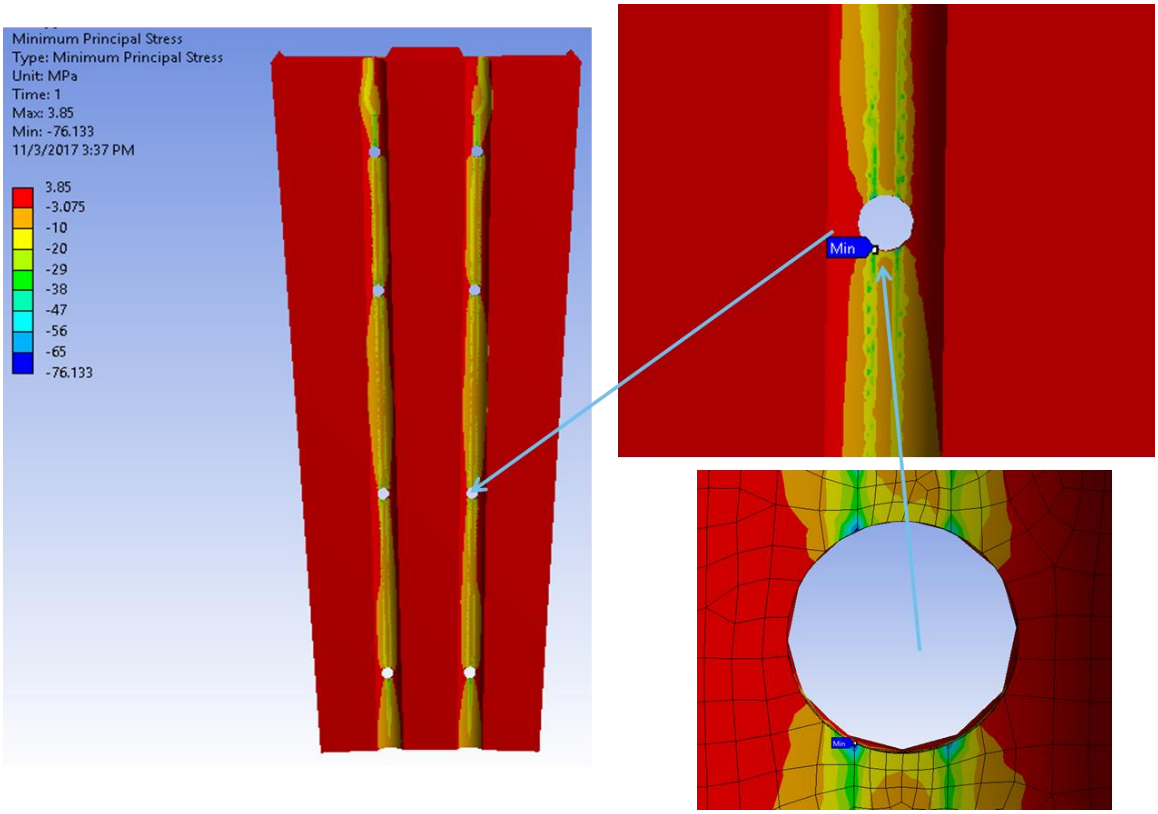

Figure 1. Minimum Principal Stress, PDR analysis. Material is Sigrafine SGLR6510; allowable S3 is -65MPa

A tapered rod (Figure 2) was analyzed with a simple ANSYS model (Figure 3) SOLID186 hexahedron elements were used, with a mesh size of 1mm, along with CONTA174 contact elements.

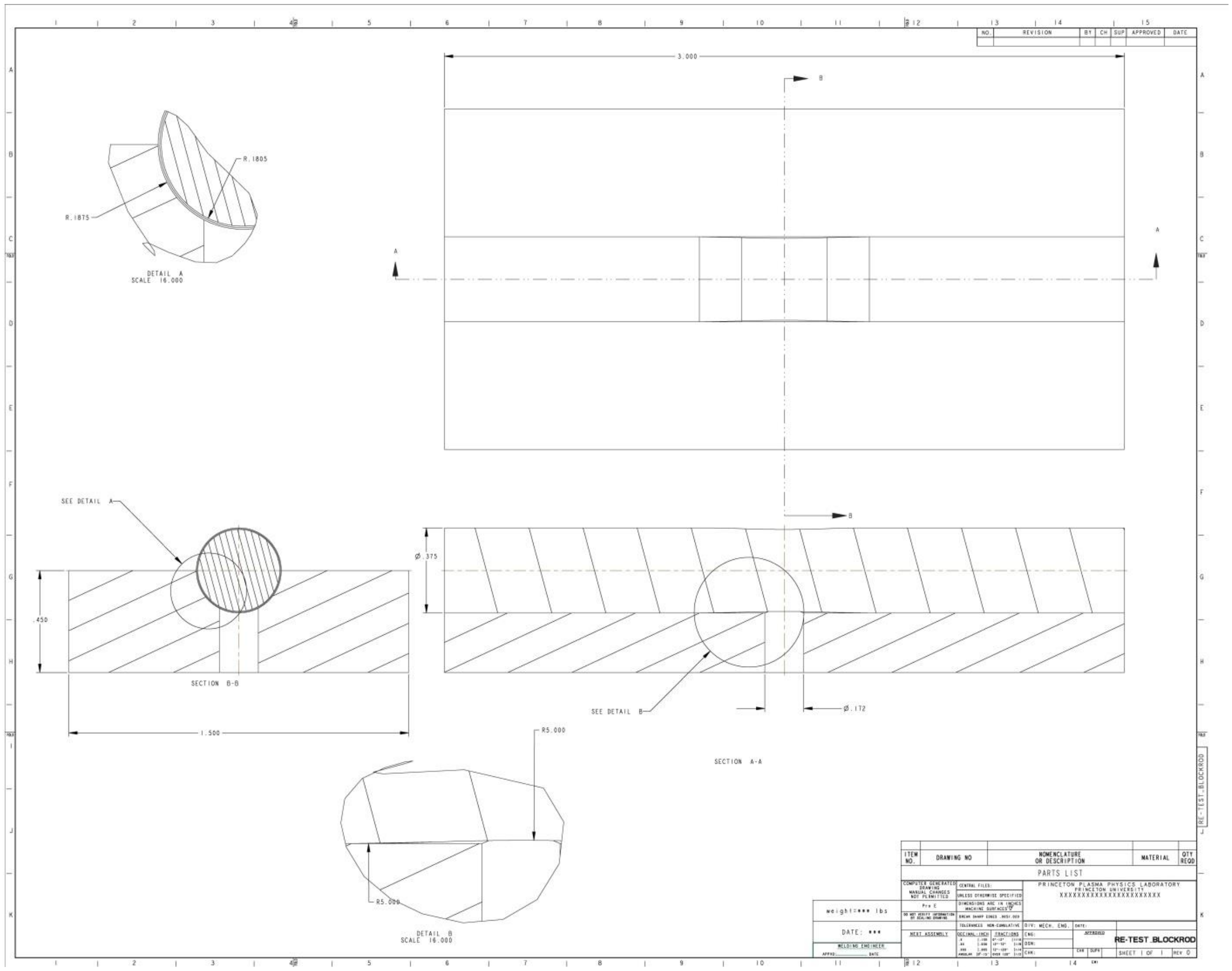

Figure 2. Tapered rod and simple graphite block

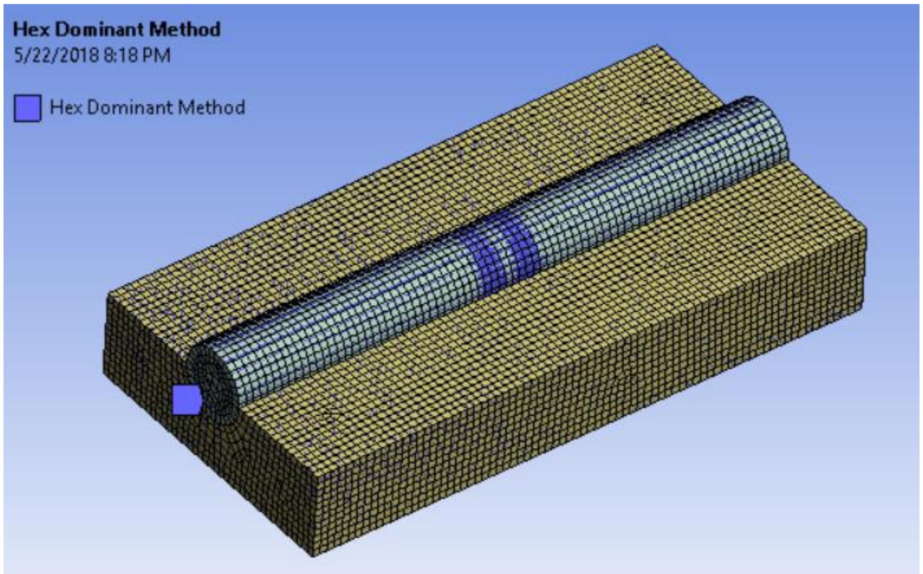

Figure 3. ANSYS model of rod and graphite block

A total of 44,562 SOLID186, 1,156 CONTA174, and 1,248 TARGE170 elements, and 188,702 nodes, comprised the model. Properties for POCO TM graphite and 316 Stainless Steel were used. (Table 1)

Material	Modulus (GPa)	Poisson's Ratio	Allowable S1 (MPa)	Allowable S3 (MPa)
Poco TM	10.5	0.3	19.5	-55.0
316 Stainless Steel	193	0.31	193	

Table 1. Material Properties

The bottom surface of the graphite was constrained vertically (u_y=0) and lateral constraints were applied at two nodes to eliminate rigid body motion. A downward force of 890N (200 lbf) was applied at the top midpoint of the rod. (Figure 4)

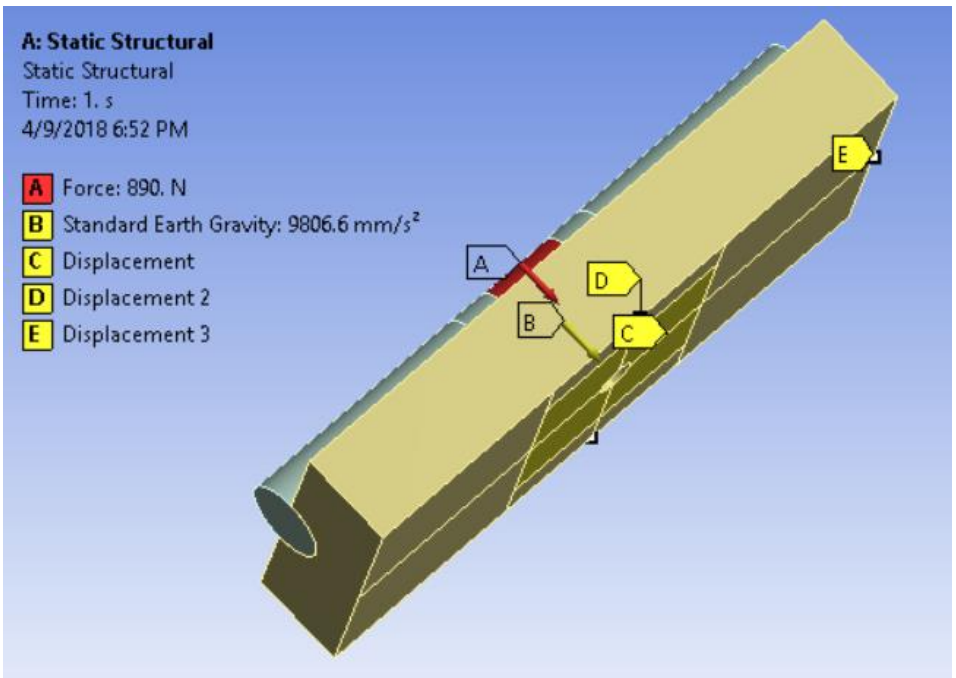

Figure 4. Boundary Conditions

Figures 5 and 6 show the major and minor principal stresses within their allowable ranges. The analysis shows that the contact point can be moved closer to the screw hole, from .375 inches to .250 inches. Figure 7 shows displacement contours for the rod and the block.

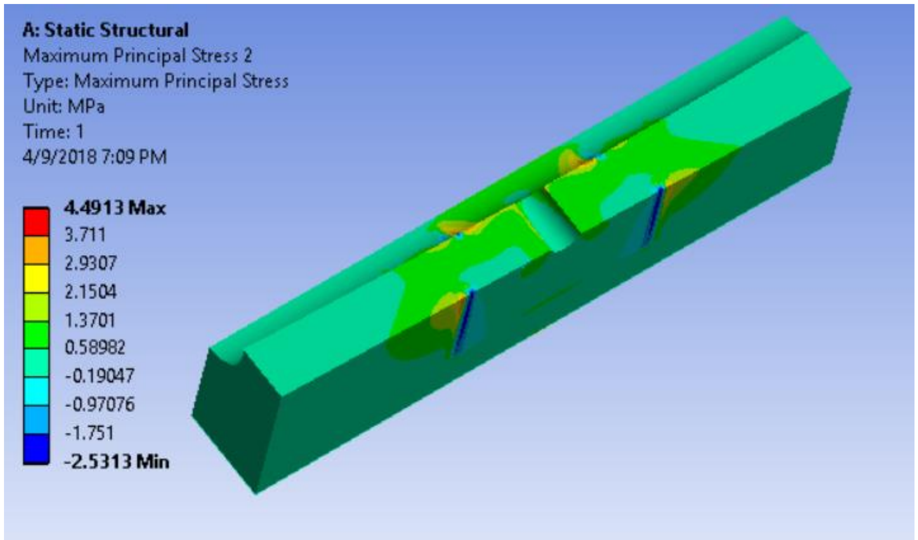

Figure 5. Major Principal Stress

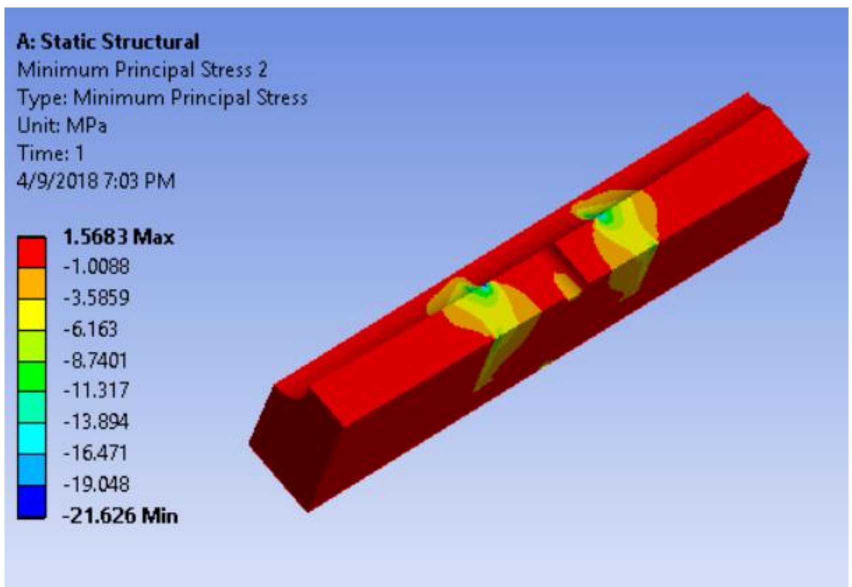

Figure 6. Minor Principal Stress

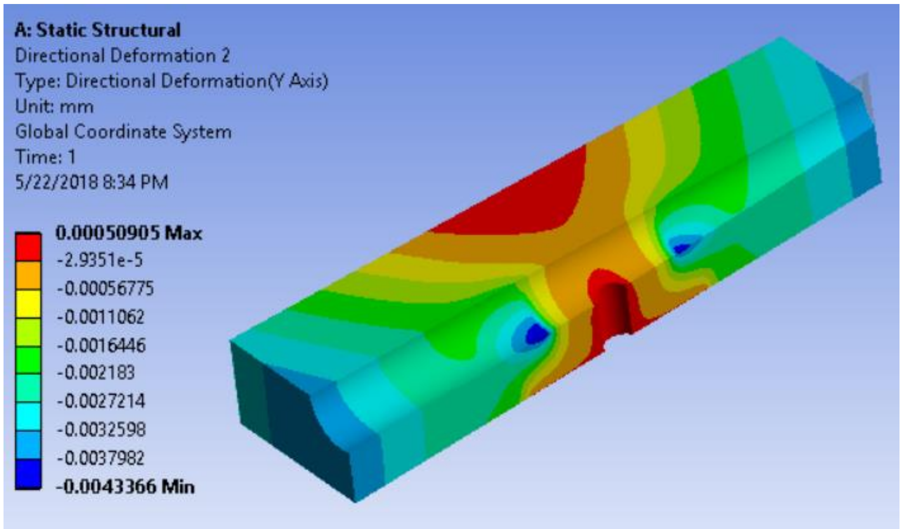

Figure 7. Vertical Displacement Contours

Minimum Requirements for Checking Calculations

1. Assure that inputs were correctly selected and incorporated into the design.

2. Calculation considers, as appropriate:

   - Performance Requirements (capacity, rating, system output)
   - Design Conditions (pressure, temperature, voltage, etc.)
   - Load Conditions (Electromagnetic (Lorentz Force), seismic, wind, thermal, dynamic)
   - Environmental Conditions (radiation zone, hazardous material, etc.)
   - Material Requirements
   - Structural Requirements (foundations, pipe supports, etc.)
   - Hydraulic Requirements (NPSH, pressure drops, etc.)
   - Chemistry Requirements
   - Electrical Requirements (power source, volts, raceway, and insulation)
   - Equipment Reliability (FMEA)
   - Failure Effects on Surrounding Equipment
   - Tolerance Buildup

3. Assumptions necessary to perform the design activity are adequately described and reasonable.

4. An appropriate calculation method was used.

5. The results are reasonable compared to the inputs.

6. Error bars (range) for inputs used, results / conclusions, assumptions, have been considered and are acceptable.

NOTE: IT IS THE RESPONSIBILITY OF THE CHECKER TO USE METHODS THAT WILL SUBSTANTIATE TO HIS/HER PROFESSIONAL SATISFACTION THAT THE CALCULATION IS CORRECT.

BY SIGNING CALCULATION, CHECKER ACKNOWLEDGES THAT THE CALCULATION HAS BEEN APPROPRIATELY CHECKED AND THAT THE APPLICABLE ITEMS LISTED ABOVE HAVE BEEN INCLUDED AS PART OF THE CHECK.