# Fermilab

## Particle Physics Division

## Mechanical Department Engineering Note

Number: CMS-doc-3019 Date: 09/23/10

Project Internal Reference: CMS CO2 Test Stand

Project: CMS Upgrade Cooling System Test Design

Title: Storage Tank Support Structure

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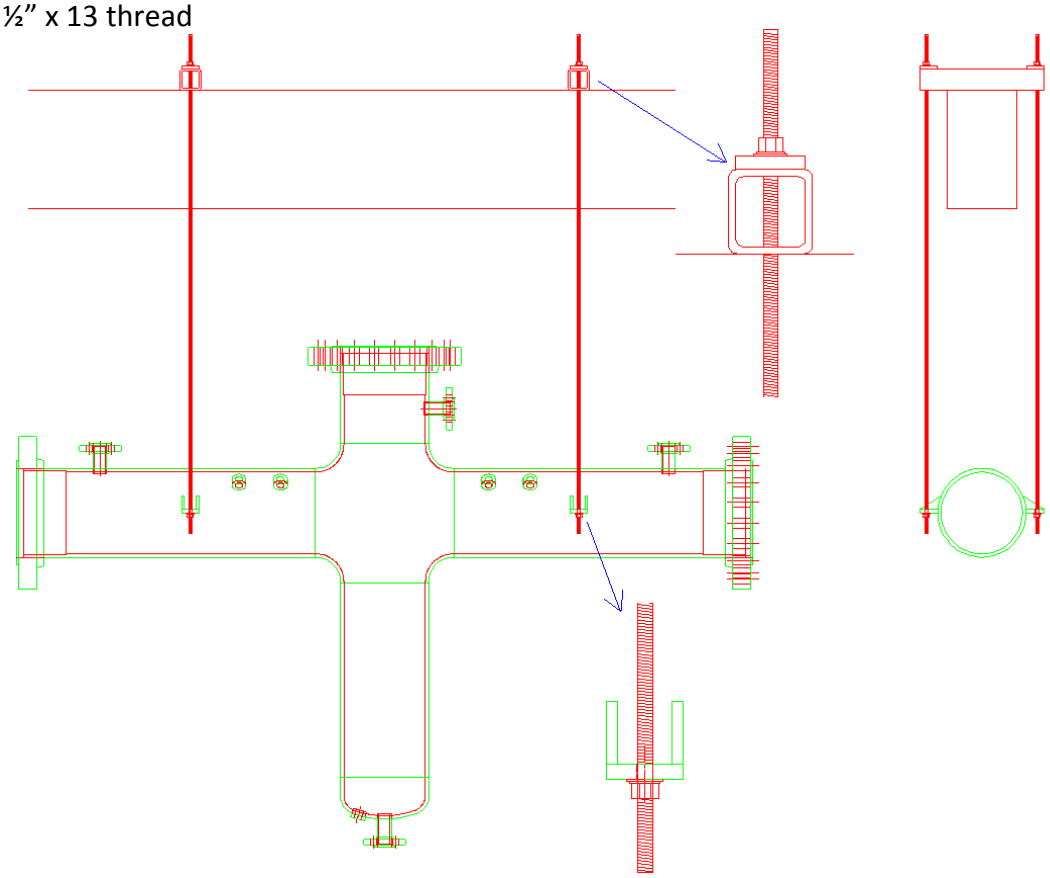
Key Words: Hanger, support, storage vessel

Abstract Summary:

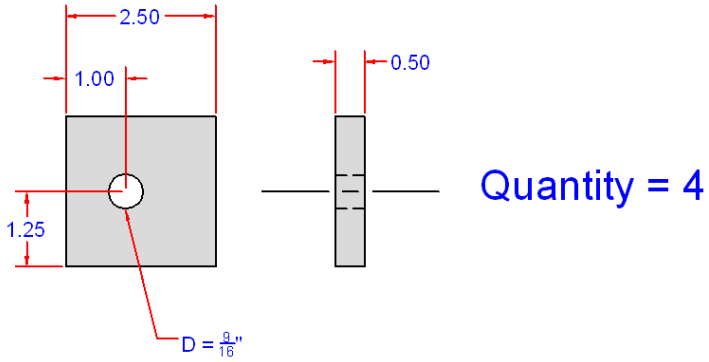
The CMS CO2 Detector contains a storage vessel which will be hung from the 10 ton crane support rail which is without question capable of supporting the weight of the vessel. This document will details the analysis of the components chosen for the support structure and their ability to support the load.

## Structural Components:

1) Hanger Brace - Qty 2
   a) 3” x 3” square channel 18” in length.
   b) 0.25” wall thickness
2) Washer Plates - Qty 4
   a) 2.5” x 2.5” plate
   b) ½” thickness
3) Hanging Rods - Qty 4
   a) ASTM A193 Stainless Steel Grade B8 threaded rod
   b) 6’ length
   c) ½” x 13 thread
4) Heavy Hex Nuts - Qty 4
   a) Type 316 Stainless Steel Heavy Hex
   b) ½” x 13 thread
5) Heavy Hex Nuts - Qty 4
   a) Grade Dh Steel Heavy Hex Structural Nut Hot-Dipped Galvanized
   b) ½” x 13 thread



## Component Drawings:

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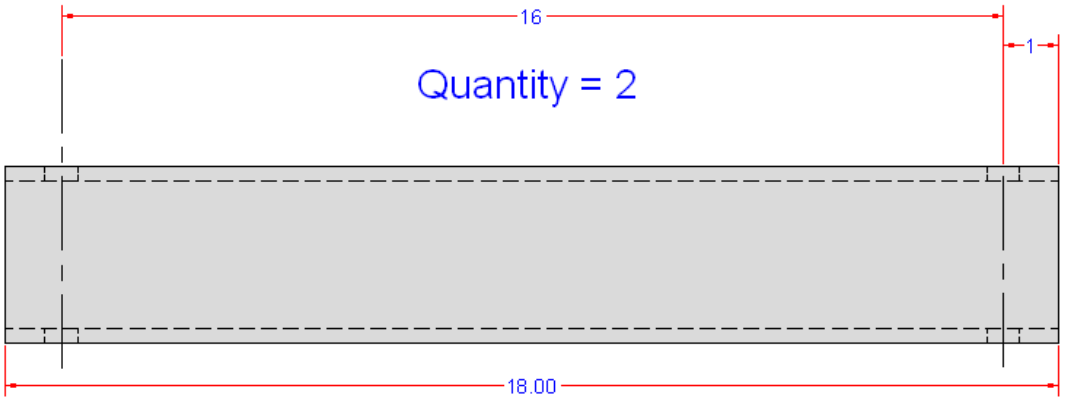


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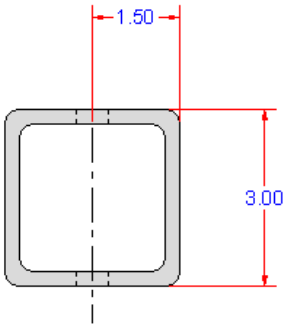


The CMS CO2 Tank contains a Storage vessel constructed of stainless steel. Calculations for the Vessel weight follow:

$OD_{12} := 12.75in$ $t := 0.5in$ $ID_{12} := OD_{12} - 2t$ $Area := \frac{\pi}{4}\cdot\left(OD_{12}^{2} - ID_{12}^{2}\right)$

$Height_{Vessel} := 6ft$

$Width_{Vessel} := 106in$

$\rho_{SS} := 8000\frac{kg}{m^3} = 0.289\frac{lb}{in^3}$

$Volume_{Vessel} := Area\cdot\left(Width_{Vessel} + Height_{Vessel}\right) = 3425\cdot in^3$

$Weight_{Vessel} := Volume_{Vessel}\cdot\rho_{SS} = 989.923\,lb$

$SO_{FlangeVolume} := 2.75in\cdot\left[\frac{\pi}{4}\cdot\left[(22in)^2 - (12.75in)^2\right]\right]$

$SO_{FlangeWeight} := SO_{FlangeVolume}\cdot\rho_{SS} = 200.652\,lb$

$Blind_{FlangeVolume} := 2.75in\cdot\left[\frac{\pi}{4}\cdot(22in)^2\right] = 1045\cdot in^3$ $\frac{106}{118.6875} = 0.893$

$Blind_{FlangeWeight} := Blind_{FlangeVolume}\cdot\rho_{SS} = 302.13\,lb$

$WeightSteel := Weight_{Vessel} + 3Blind_{FlangeWeight} + 3SO_{FlangeWeight} = 2498\,lb$

$WeightCO2 := 300lb$

$WeightTotal := WeightSteel + WeightCO2 = 2798\,lb$ We will use 3000 lb in weight calculations

# Threaded rod analysis

tensile stress area of 1/2-13 threads

$A_{t\_0.5} := .1419in^2$

force used in analysis

$F := 750lbf$

tensile stress of threaded rod

$\sigma_{tensile} := \frac{F}{A_{t\_0.5}} = 5285\cdot psi$

Structural Code allows 40% of yield stress maximum in tension

$\sigma_{yield} := 50ksi$

$\sigma_{allowed} := 40\%\cdot\sigma_{yield} = 20000\,psi$

$\sigma_{tensile} < \sigma_{allowed}$

Half inch stainless steel grade B8 threaded rods will be used with heavy hex nuts. These Calculations shov the rod is capable of supporting the full weight of the storage vessel.

# Hanger Brace Analysis

The Hanger brace will be an 18 inch long 3" x 3" square channel with 0.25" thick walls. It will be placed on t and supported by the crane rail which is 10 inches wide. It will have holes 0.53" in diameter drilled in the symetrically 16" from one anothers center, which would be 1 inch from each end. The square channel will have 0.5 inch thick plates, 2.5" x 2.5" with holes drilled in them as well. The threaded rod will go through th holes in the channel and plate and be fastened with heavy hex nuts, washers and lock washers.

Thickness

$t := 0.25in$

Height

$h_o := 3in$

Inner Height

$h_i := h_o - 2t = 2.5\,in$

$Area := h_o^2 - h_i^2 = 2.75\,in^2$

Second moment of area

$I := \frac{h_o^4 - h_i^4}{12} = 3.495\,in^4$

$c := \frac{h_o}{2}$

Moment load

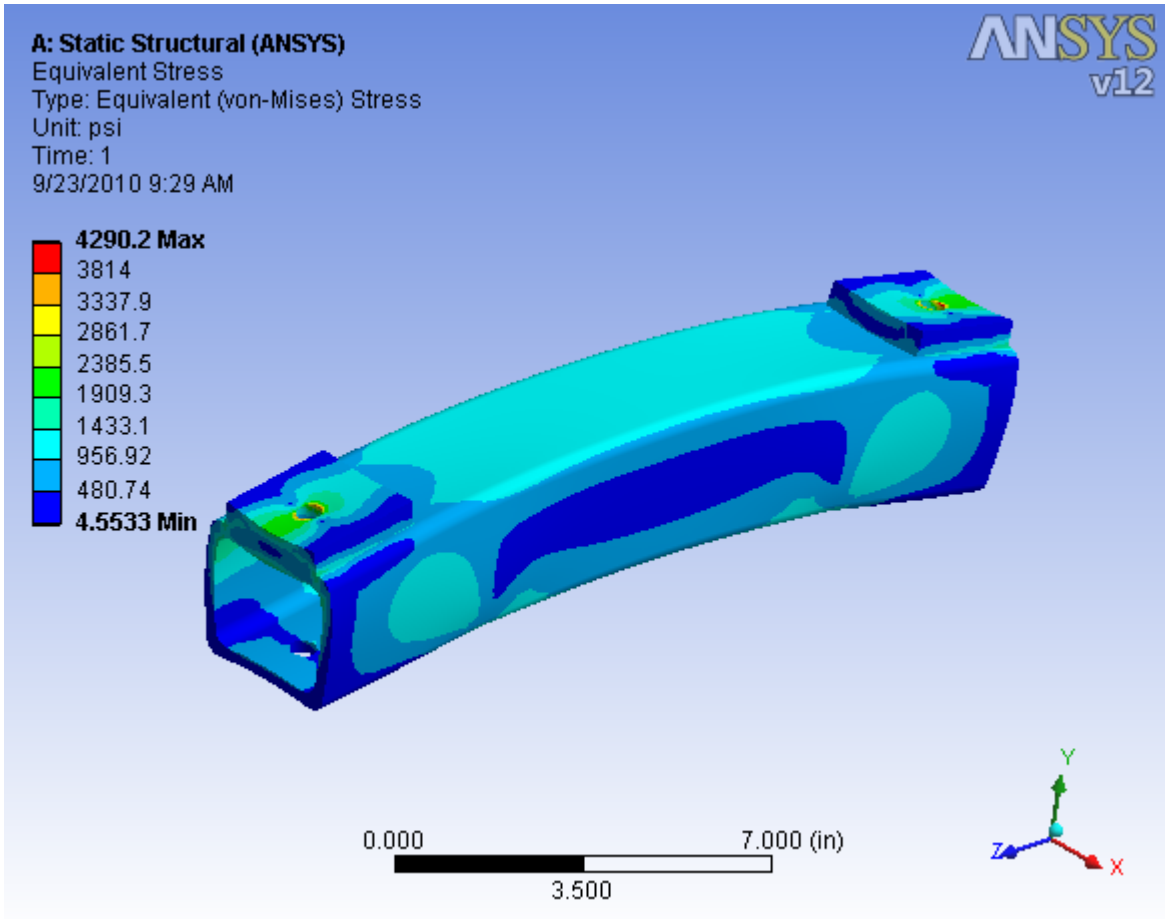
$M := F \cdot 3in = 2250 \cdot lbf \cdot in$

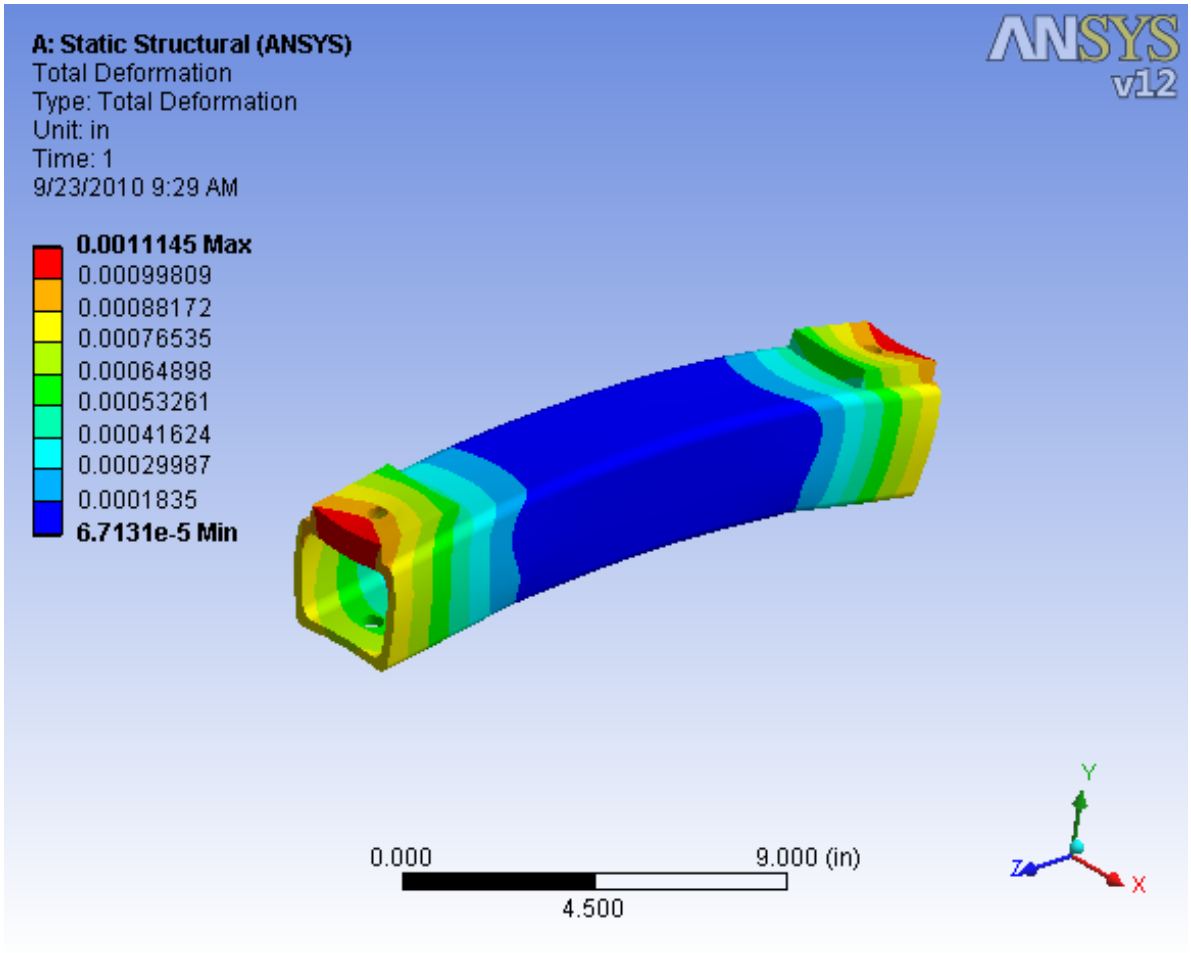
$\sigma_{bending} := \frac{M \cdot c}{I} = 966\,psi$

$\sigma_{shear} := \frac{F}{Area} = 272.727\,psi$

This shows the channel will be adequate to support the load.

FEA Calculations agree with hand calculations, Highest level of stress is at plate/washer interface and is much below the yield stress of steel.

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ANSYS
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Y
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X