WENTWORTH
Institute of Technology

Department of Mechanical Engineering and Technology

STRENGTH ANALYSIS ON AN ENGINE HOIST

The MECH625-major design project
Mech625-Simulation-based design
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Strength Analysis on an Engine Hoist – Executive Summary

The purpose of the following report is to analyze the strength of a provided engine hoist. This provided hoist is composed of a variety of manufactured and customized parts which need to be tested to be sure that they can withstand the required loading conditions. As this is an engine hoist, loads of 0.5 T, 1 T, and 2 T are analyzed on both a level and an angled setting. This will show how the separate settings for the hoist will affect the strength of the hoist's components.

Through use of SolidWorks static simulations, two main sub-assemblies of the engine hoist are analyzed. From this analysis of the original components, the maximum von Mises Stress, the maximum deflection, and the minimum factor of safety are acquired via plots. These plots reveal where the weakness of each component lies and the factor of safety reveals whether or not these components are a viable option in a redesigned assembly.

If certain components are sure to fail, they are then redesigned and the simulation is run again to be sure that the redesigned assembly is working properly. Should the redesign fail, additional modifications are made and taken into account until the redesigned hoist meets the required conditions for maximum allowed deflection and minimum factor of safety.

In addition to this, pins that are used to hold the assemblies together have their shear stress measured, in order to theoretically analyze their factor of safeties. Should these prove ineffective, they must be replaced or removed and the design adjusted for.

Drawings for redesigned components and assemblies will be provided, along with an updated bill of materials that will guide the production of the modified engine hoist. These will be compiled in Chapter 4 of the report.

So long as the design specifications are met, the redesigned engine hoist should be considered a success. These specifications will be laid out in Chapter 2 of the report.

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1. Introduction

Engine hoists, also known as engine cranes are common repair tools that are often used in vehicle repair shops to remove or install gasoline or diesel engines in small and crowded vehicle engine compartments. They are also used in small workshops or other businesses to lift and move heavy objects. The design of these tools is fairly simplistic, yet they must be structurally secure in order to be used in these heavy-weight situations. If "engine hoist" is searched over the internet, many different engine hoists can be found. Take for example, those shown in Figure 1.

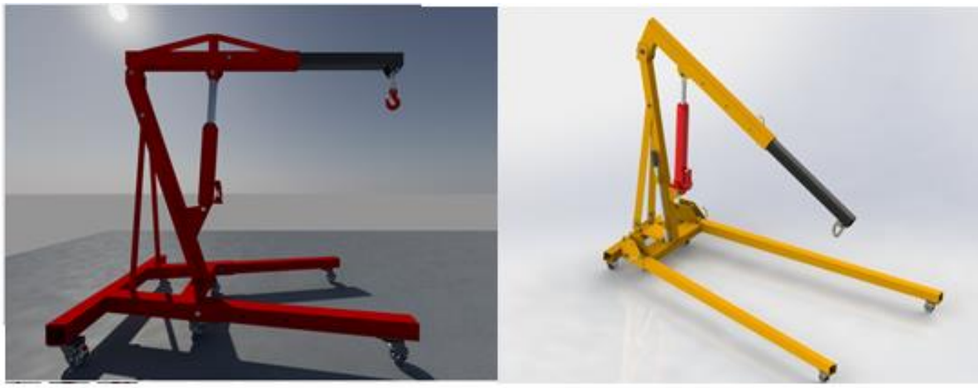


Figure 1: Images of some engine hoists

2. Design Requirements

The Engine Hoist:

A 2T engine hoist has been designed. The main task of the design teams is to verify the strength of the design through running the strength analysis by theoretical analysis and FEA analysis. If the design does not satisfy design specifications, redesign should be done by the design teams.

Design Specifications:

- Factor of Safety must be rated at 1.5 or above.
- The maximum deflection allowed is 1"
- The three pin locations between the boom extensions (PN# 10015) and the boom (PN# 10013) will give the rated loadings 2 T, 1 T, and 0.5 T as shown in Figures 2, 3, and 4.
- The piston rod of the hydraulic pump can be extended by 0~17" as shown in Figure 5.

Part Number System:

The part # between 10001 and 49999 is a manufactured parts. The part # between 50001 and 59999 is a purchased part. The part # between 60001 to 69999 is an assembly.

Materials:

- The manufactured parts (part #10001 to 100015) is made of AISI 1020 steel (equivalent material brand name)
- The u-shape hook (PN#100016) is Alloy Steel (equivalent material brand name).
- The bolts are all SAE J249 Grade 5 with the proof (tensile) strength 85 ksi.

Notes: Majority of the bolts in the design are mainly used as pivot pins. Some bolts are tightened with 75% of the proof loading. For FEA simulation or the theoretical calculation, the allowable shear proof strength will be 0.577 of the proof strength. If needed, the other properties such as Young's modulus and Poisson ratio can be treated as the same of Alloy Steel.

Loading Conditions:

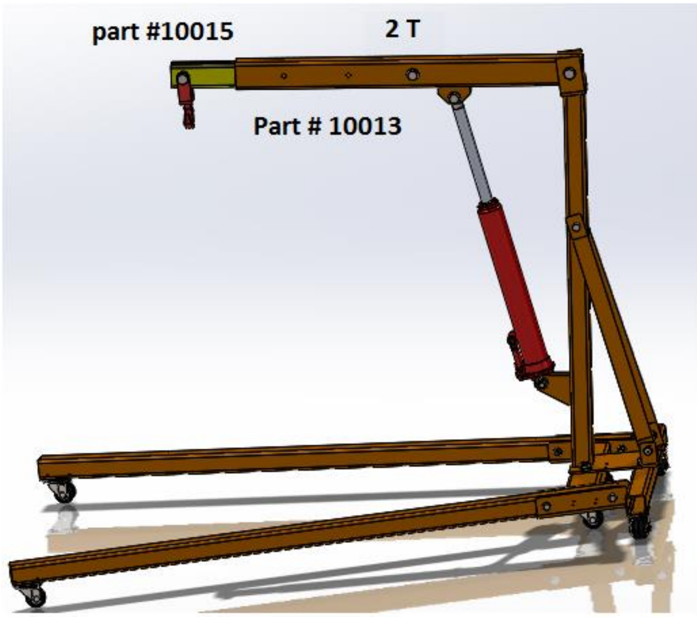


Figure 2: The Configuration for the Rated Loading 2T

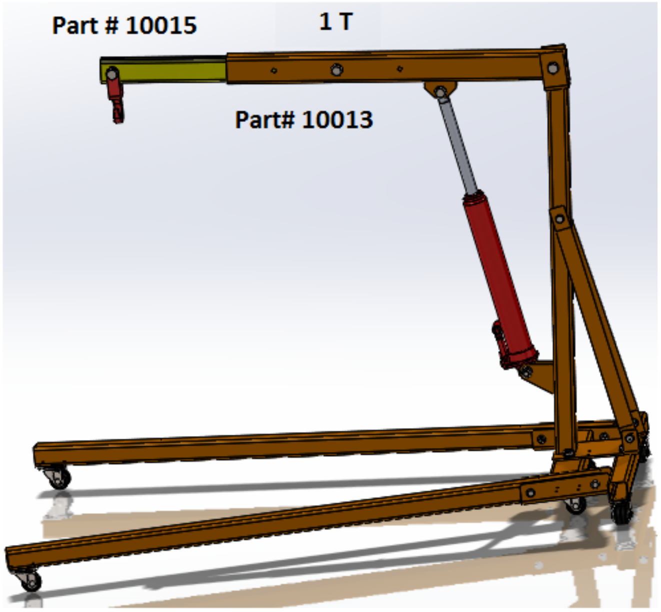


Figure 3: The Configuration for the Rated Loading 1T

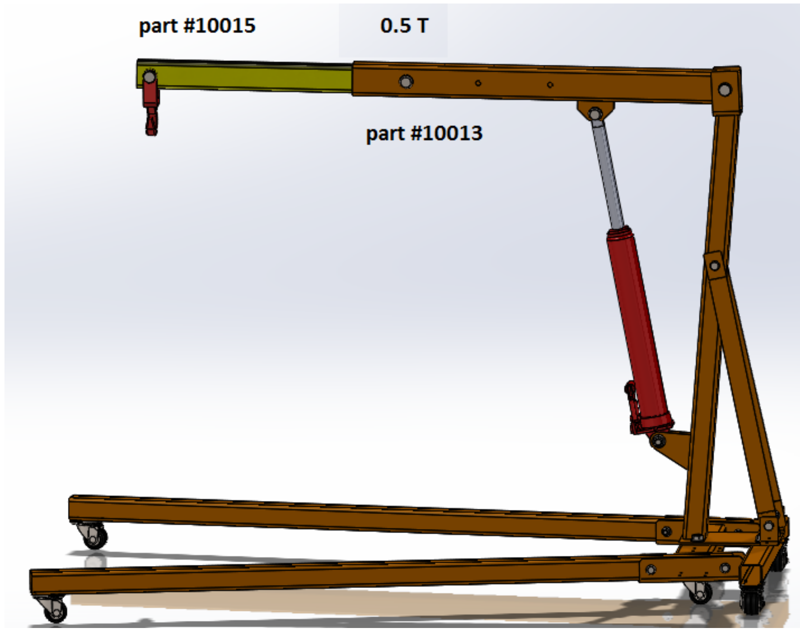


Figure 4: The Configuration for the Rated Loading 0.5T

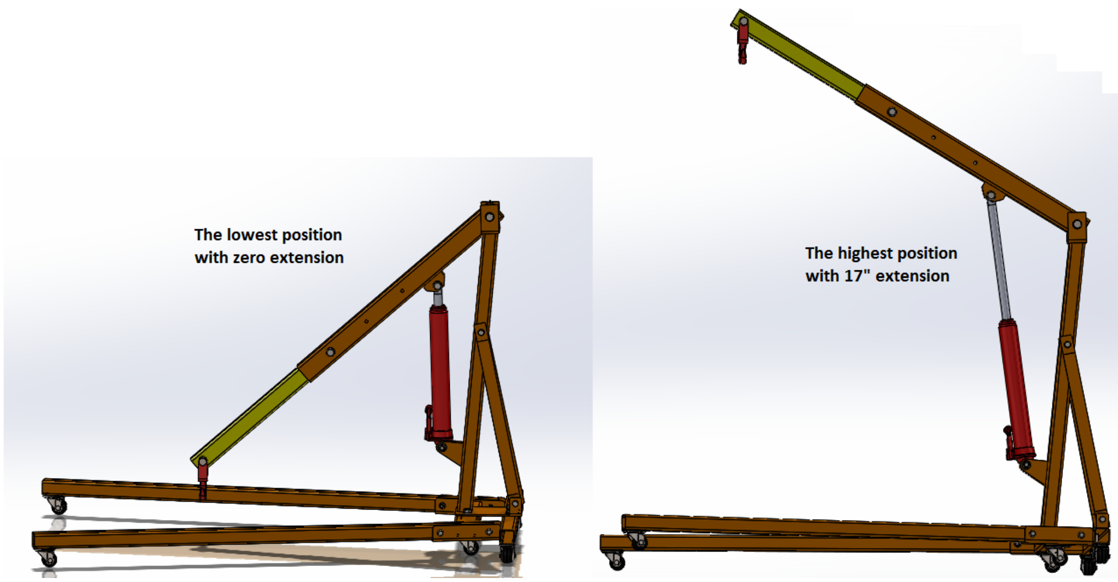


Figure 5: The Hydraulic Pump with Zero and Maximum 17" Extension

Bill of Materials:
The engine hoist has one top assembly with 4 sub-assemblies. The Bill of Materials for the top assembly and the 4 sub-assemblies are shown in the following.

60005-Engine Hoist Assy

ITEM NO.	PART NUMBER	DESCRIPTION	1T configuration/QTY.
10	60001	Main Frame	1
20	60002	Leg Assy	2
30	60003	Post Assy	1
40	60004	boom asm	1
50	10015	boom extension	1
60	10016	U-hook	1
70	50015	LONG RAM-cy	1
80	50014	Long Ram-rod	1
90	50008	flat washer type a narrow-0.5	10
100	50009	hex jam nut-0.5"	4
110	50012	HBOLT 0.5000-13x3.75x1.25-N	4
120	50005	flat washer type a narrow-0.75	14
130	50013	HBOLT 0.7500-16x3.75x1.75-N	4
140	50006	hex jam nut-0.75	7
150	50011	HBOLT 0.7500-10x2.5x1.75-N	1
160	50004	heavy hex finished bolt-0.75	1
170	50016	HBOLT 0.7500-10x3.5x1.75-N	1

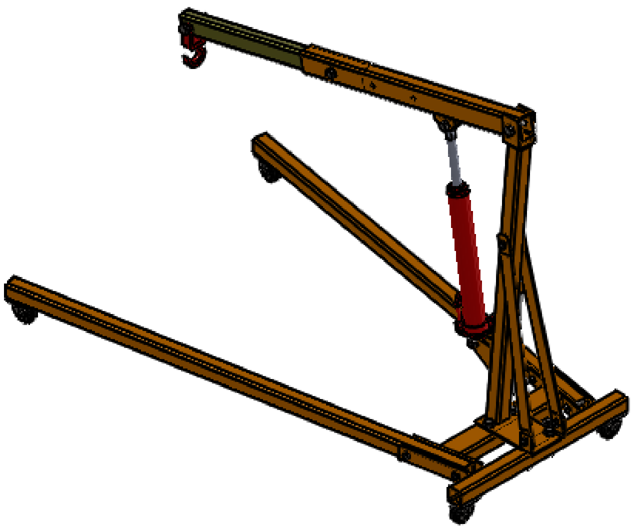


Figure 6: Engine Hoist Assembly and BOM

60001-Main Frame

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	10001	center support	1
20	10002	Rear Wheel Support	1
30	50001	Caster_shrinkwrap	4
40	10003	Right Side plate	1
50	10004	Left side plate	1
60	50002	HEX SCREW,0.25V0.375	16
70	50003	Washer-0.25	16

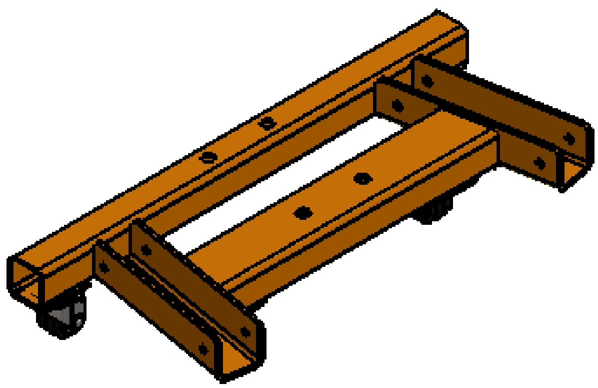


Figure 7: Main Frame and BOM

60002-Leg Assy

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	10005	leg	1
20	50001	Caster_shrinkwrap	1
30	50002	HEX SCREW,0.25V0.375	4
40	50003	Washer-0.25	4

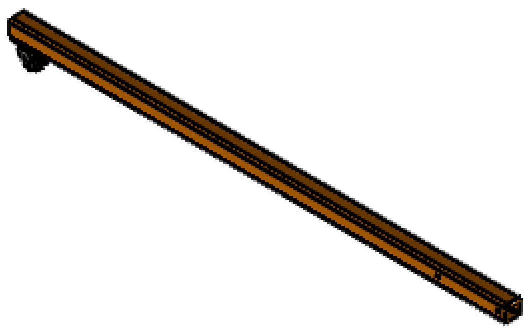


Figure 8: Leg Assembly and BOM

60003-Post Assy

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	10007	Upright Base	1
20	10006	post	1
30	10008	brace	2
40	10009	Post Pivot	1
50	10010	Lower Ram Gusset	2
60	10011	Handle Hoop	2
70	10012	Jack Handel-1	1
80	50008	flat washer type a narrow-0.5	6
90	50009	hex jam nut-0.5"	3
100	50010	HHBOLT 0.5000-13x3.75x1-N	1
110	50007	HHBOLT 0.5000-13x1.25x1-N	2
120	50005	flat washer type a narrow-0.75	4
130	50004	heavy hex finished bolt-0.75	1
140	50006	hex jam nut-0.75	2
150	50011	HBOLT 0.7500-10x2.5x1.75-N	1

Figure 9: Post Assembly and BOM

60004-Boom Assy

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	10013	Boom 3.5X2.5	1
20	10014	gusset	2

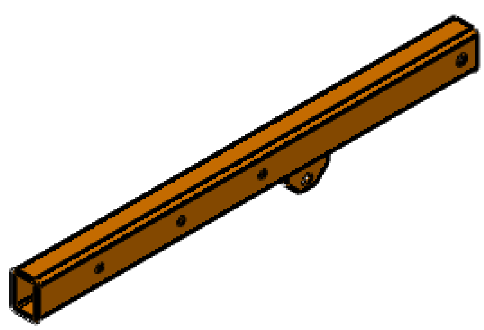


Figure 10: Post Assembly and BOM

3. Analysis and Redesign

3.1 Loading Analysis and Strength Calculations

3.1.1 Loading Analysis:

Before the simulation can be run the forces at the reaction points must be known. These reaction points are at the pins with PN#50004 and 50011 that connect the boom to the post. These can be solved for statically using Engineering Equation Solver (EES). The first step is the free body diagram which can be used to set up the equation.

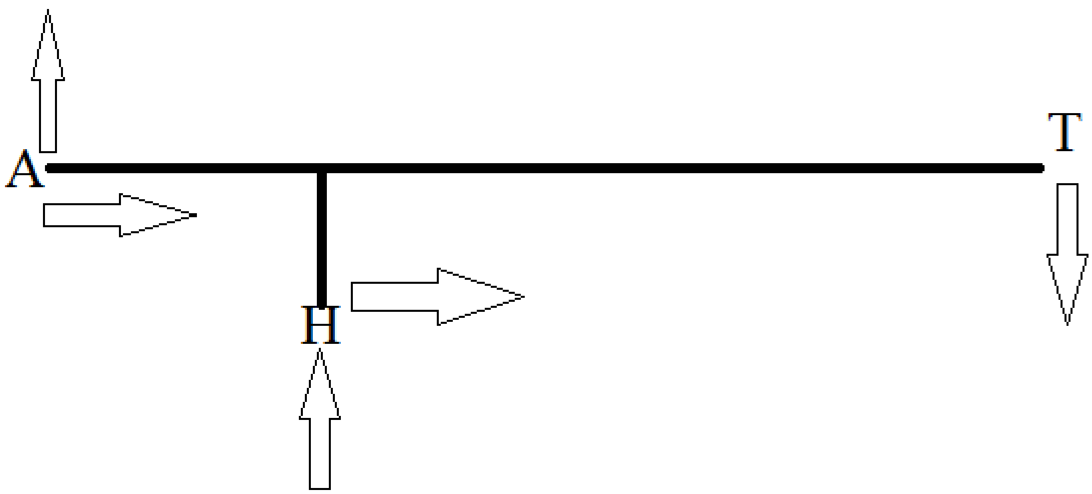


Figure 11: FBD Horizontal

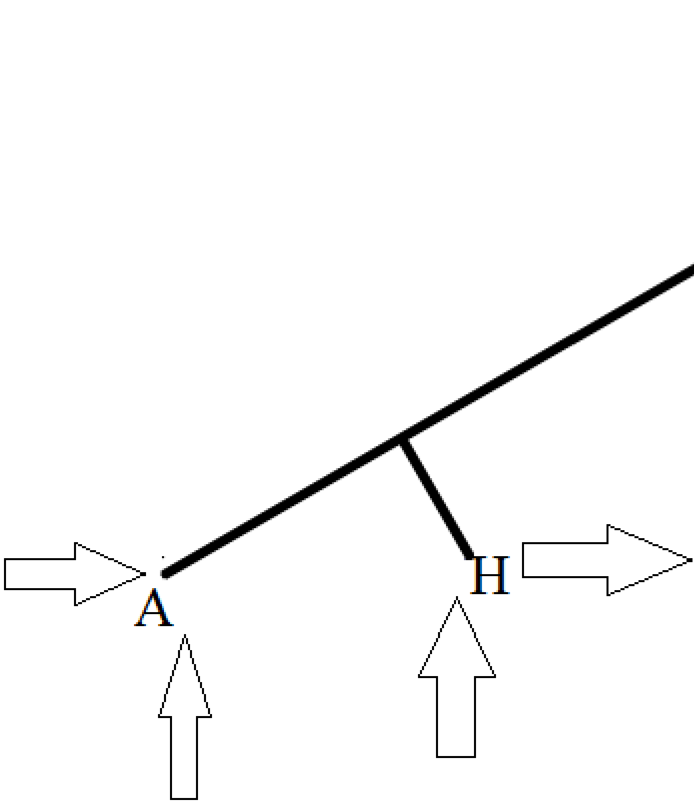


Figure 12: FBD Maximum Extension

Point A correlates with the PN#50004 that connects the boom to the post. Point H correlates with PN#500011 that connects the boom to the pump. The method of sections says that the force exerted by point H will be felt on the lower ram gusset (PN#10010) of the post assembly. With each design scenario set, then the reaction forces for all the cases can be run on EES. Each EES output is shown in Figures 13 and 14. The value of x in the EES output tables is the distance between points A and T.

Parametric Table

Table 1

1..3	A [lbs]	A_x [lbs]	A_y [lbs]	H [lbs]	H_x	H_y	T [lbs]	X [in]
Run 1	3325	-773.3	-3234	4304	773.3	4234	1000	64
Run 2	5576	-1353	-5409	7532	1353	7409	2000	56
Run 3	9006	-2320	-8702	12912	2320	12702	4000	48

Figure 13: EES Horizontal Analysis

Parametric Table

Table 1

1..3	A	A_x	A_y	H	H_x	H_Y	T	X
Run 1	3320	-606.8	-3264	4307	606.8	4264	1000	64
Run 2	5564	-1062	-5462	7537	1062	7462	2000	56
Run 3	8978	-1821	-8792	12921	1821	12792	4000	48

Figure 14: EES Analysis Angled Up Position

3.1.2 Theoretical Strength Calculations

No theoretical strength calculation was run on any part other than the pins with PN#50004 and #50011

3.1.3 Theoretical Calculations for Pins:

Pins with PN#50004 and 500011 had their strength calculated through the results from the static analysis shown in Figures 13 and 14. Pins with PN#50007, 50010, and 50016 had resultant forced from the FEA analysis used to determine their factors of safety (F.O.S.). Specifically the connector force option was used from FEA analysis to the forces felt by the mathematical pins.

Table 1: Pin Calculation PN#50004

Loading	Horizontal	Vertical	Resultant	Factor of safety	Safe or not
.5 T level	-773.3	-3234	3325	6.516	Safe
.5 T up	-606.8	-3264	3320	6.527	Safe
1 T level	-1353	-5409	5576	3.886	Safe
1 T up	-1062	-5462	5564	3.894	Safe
2 T level	-2320	-8702	9006	2.406	Safe
2 T up	-1821	-8792	8979	2.413	Safe

Table 2: Pin Calculation PN#50011

Loading	Horizontal	Vertical	Resultant	Factor of safety	Safe or not
.5 T level	773.3	4234	4304	5.034	Safe
.5 T up	606.8	4264	4307	5.031	Safe
1 T level	1353	7409	7532	2.877	Safe
1 T up	1062	7462	7537	2.875	Safe
2 T level	2320	12702	12912	1.678	Safe
2 T up	1821	12792	12921	1.677	Safe

Table 3: Pin Calculations PN#50007

Loading	Resultant Force	Factor of safety	Safe or not
.5 T level	2664	3.612583	Safe
.5 T up	3170	3.037077	Safe
1 T level	4610	2.088402	Safe
1 T up	5488	1.754288	Safe
2 T level	7783	1.236995	not safe
2 T up	9264	1.039242	not safe

Table 4: Pin Calculations PN#50010

Loading	Resultant Force	Factor of safety	Safe or not
.5 T level	2664	3.612583	Safe
.5 T up	3170	3.037077	Safe
1 T level	4610	2.083882	Safe
1 T up	5488	1.754288	Safe
2 T level	7783	1.236995	not safe
2 T up	9264	1.039242	not safe

Table 5: Pin Calculation PN#50016

Loading	Resultant	Factor of safety	Safe or not
.5 T level	1876.1	11.86	Safe
.5 T up	555.82	40	Safe
1 T level	1039	21.4	Safe
1 T up	1029.8	21.6	Safe
2 T level	602	38.2	Safe
2 T up	1066.8	20.9	Safe

Pins with the PN#500010, and 50007 failed to support the loadings at two tons each. This means a redesign of some sort is required for these pins. The other pins passed so as long as the redesign does not change the forces on the pins then they should be fine.

3.2 FEA Analysis

3.2.1 Pre-processing for FEA

Only a couple assemblies on the original design need to run in the baseline assessment. These are the boom assembly (PN#60004) plus the boom extension and the post (PN#60003). The other assemblies on the engine hoist are strong enough as it is to support the loading conditions without verification.

Boom Assembly

For the post and boom ASSM# 60003 and 60004, a static simulation was developed to analyze the original assembly design. Split lines were added for the contact area between PT# 10013 and 10015 in order to create a localized contact set to prevent penetration of the parts. A construction or split line was added for the upwards position simulation in order to apply the force in the proper direction.

Original pin parts were removed in favor of running the simulation with mathematical pin replacements. The hook was removed during testing in order to test the boom assembly itself under the given force loads.

Setting up the static simulation afterwards is a simple process. Boundary conditions include no-penetration contact sets between parts 10013 and 10015 through the use of the split lines that were created during earlier preprocessing. Cylindrical face boundary conditions with no axial or radial movement allowance were set for the pins involved in this simulation.

Forces were applied based on the simulation being run. Simulations were run for 0.5 T, 1 T, and 2 T force values, based on the extension of the boom. Each of these loading values were tested at a perpendicular direction to the boom assembly, and a diagonal direction based on the construction line that was created before to apply the force in the proper direction. All simulations had force applied at the location of the hook.

Post Assembly

The post was run with a number of assumptions to simplify the pre-processing as much as possible. First off is the fixtures. The only fixture needed is on the underside of the base (PN#10007). Figure 15 shows this fixture. This is a full fixed geometry setting so the bottom cannot move in any direction. It is interesting to note how many of the green arrows accumulate around the upper left whole in the picture.

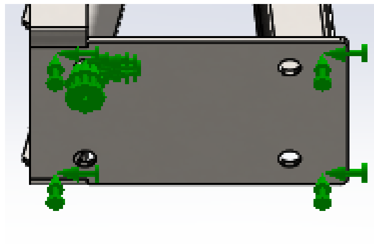


Figure 15: Post Fixture

The forces used in the post assembly came straight from the static EES simulations. The forces where placed on the inside faces of the lower ran gusset (PN#10010) and the post pivot (PN#10009). They were oriented using the base plate and that is shown in Figure 16.

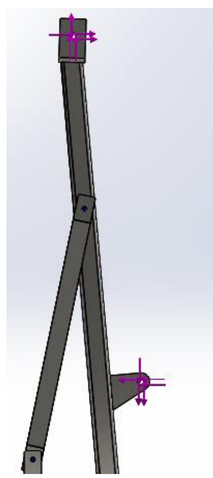


Figure 16: Post Assembly Force Orientation

Mathematical pins where used in place of bolts. This is because the bolts function as pivot pins. Four of these pins where used in the design. Figure 17 shows the setup of and location of these pins.

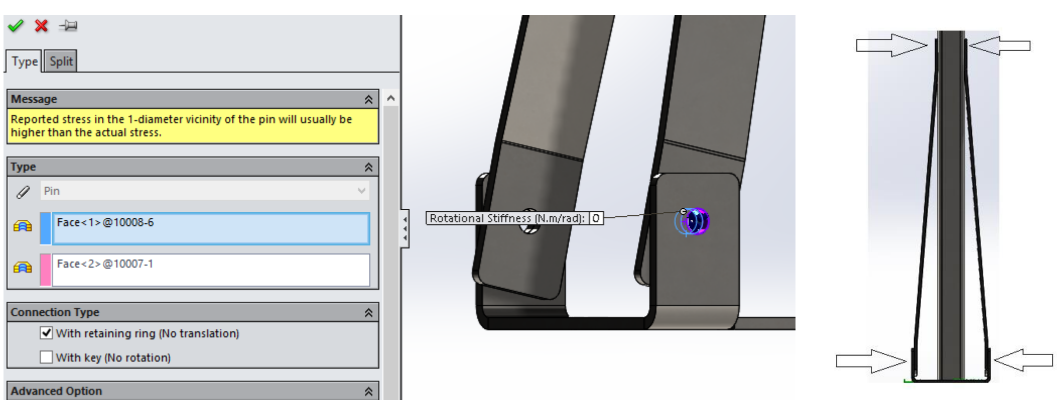


Figure 17: Post - Mathematical Pins

The bolts that got replaced by the mathematical pins still held together two different plates. These plates had to be set as contacting sets. The respective faces that where in contact had to be set as “no penetration.” Figure 18 demonstrates this setup.

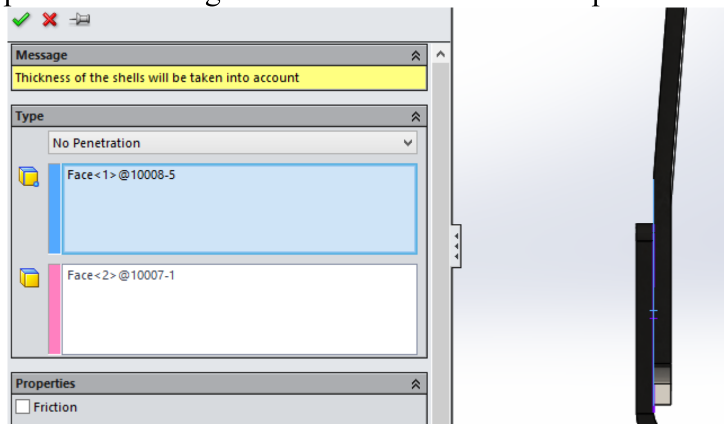


Figure 18: Post - No Penetration Settings

A few areas on the post assembly are welded together. For these areas the contact set option “bonded was used. Figure 19 shows the welded areas that were treated as such.

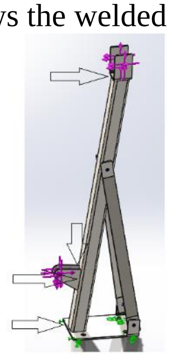


Figure 19: Post Bonded Areas

The global mesh used in the post assembly was 0.35”. Only a little mesh control had to be used. This was because the base (PN#10007) had two edge flanges on it that connected to other parts of the assemblies. These flanges created small crevices that required mesh control to be used. Figure 20 shows the setup of the mesh control in the crevice.

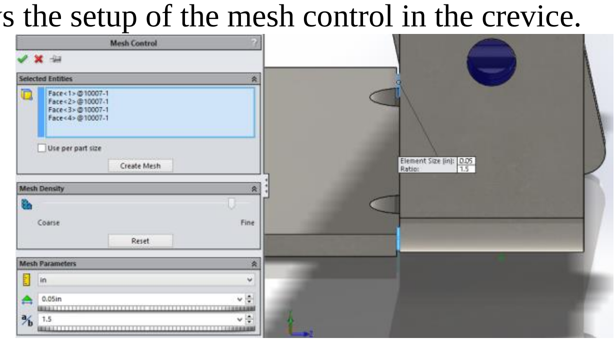


Figure 20: Mesh control Settings

Hook

The hook had to be tested to ensure it could handle the 2 ton loading. The only fixture on the hook came on the inside to the bolts holes on it. The fixture settings allowed only rotation of the component since the bolt functions as a pin. Figure 21 shows this setup.

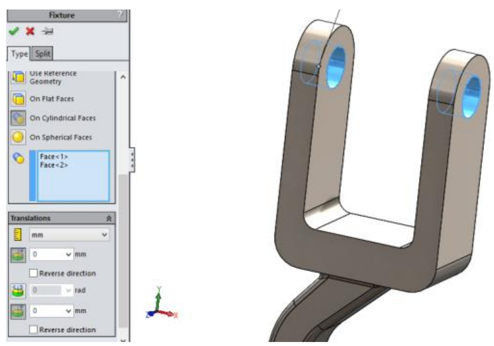


Figure 21: Hook Fixtures

The loading on the hook was applied in a downward direction. The inside curvature of the hook was the location of this force application. Plane 2 was used as a reference for this as is indicated in Figure 22.

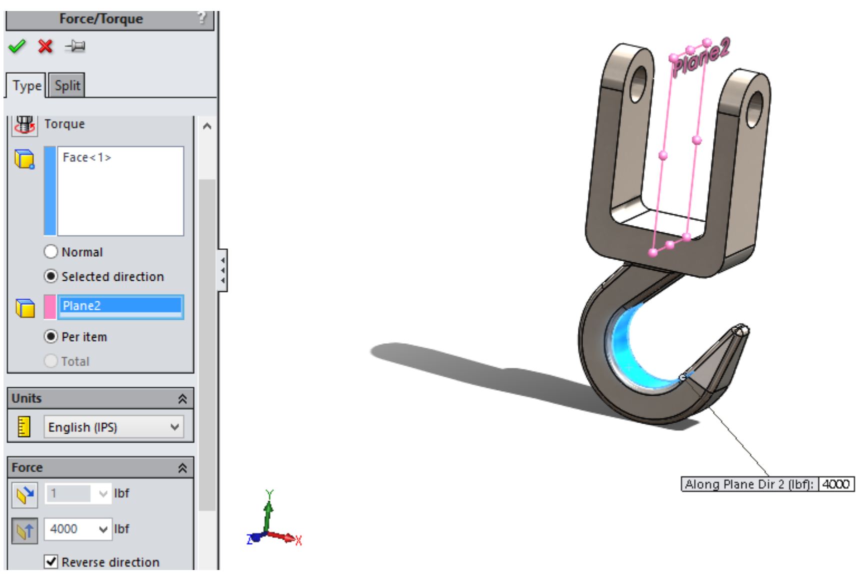


Figure 22: Hook Loading

No Mesh control was used on the hook. The global meshing element size was 0.1”.

3.2.2 Original design FEA

Assembly 60003 - Post Assembly – Original 2T Horizontal Loading

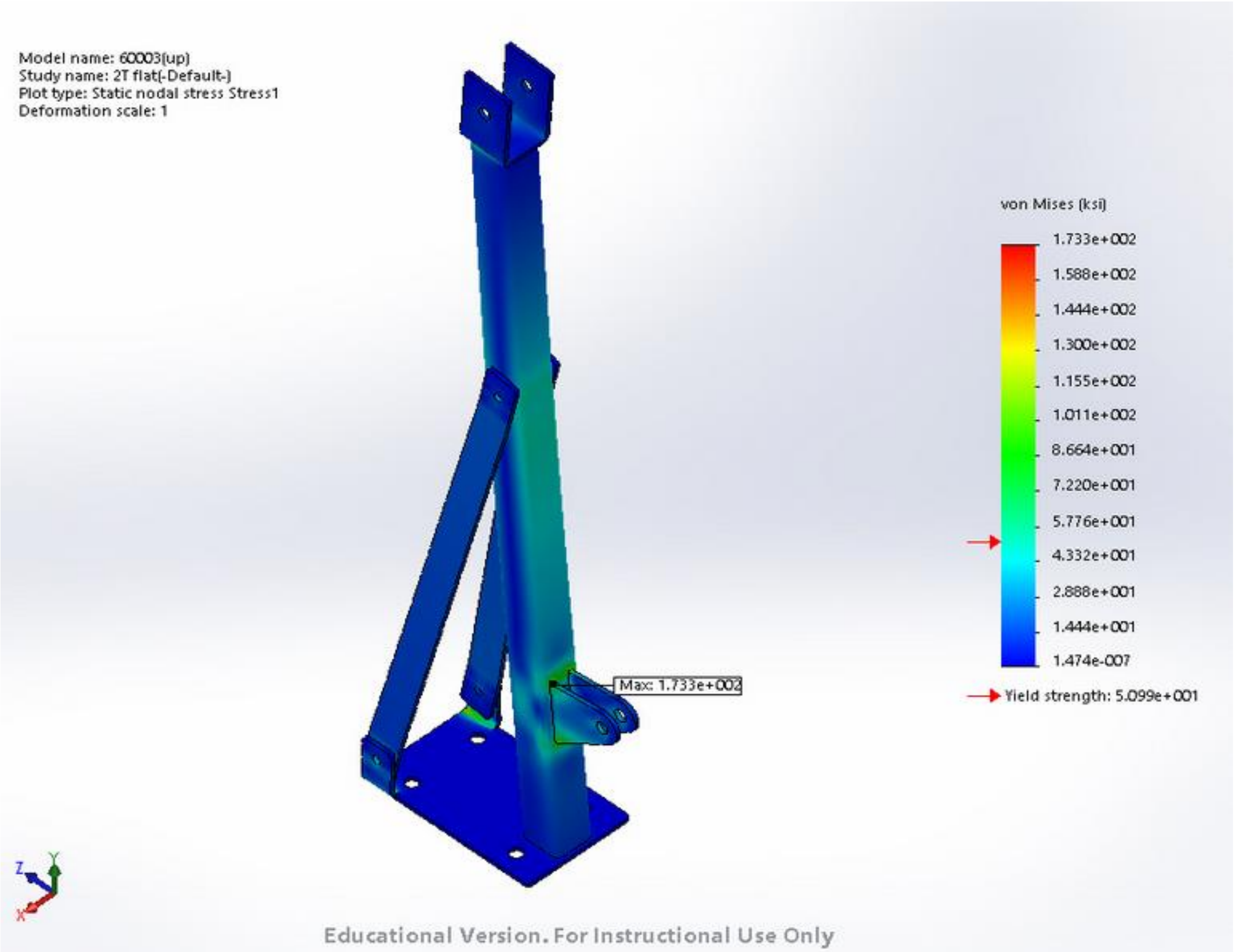


Figure 23: PN#60003 2T Horizontal - Von Mises Stress

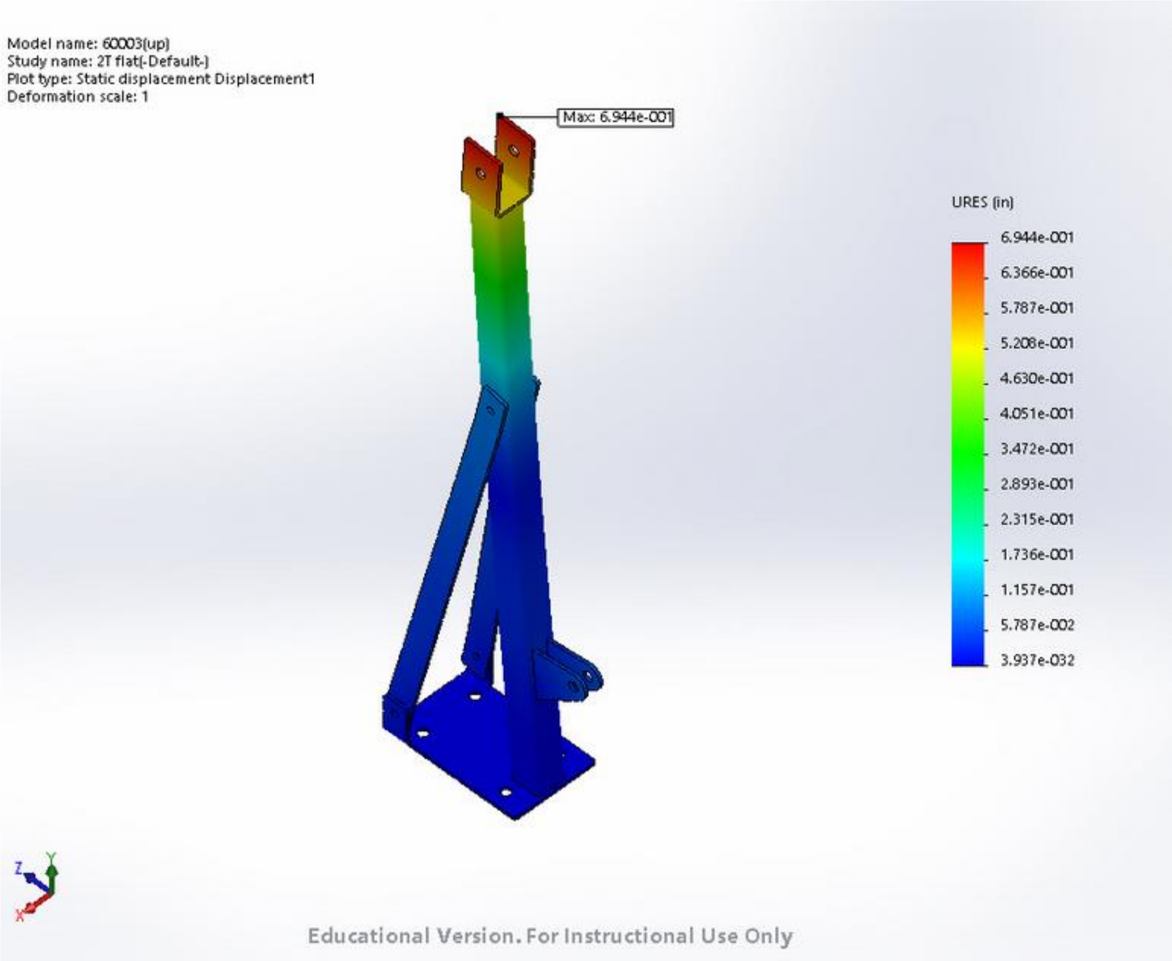


Figure 24: PN#60003 2T Horizontal - Displacement

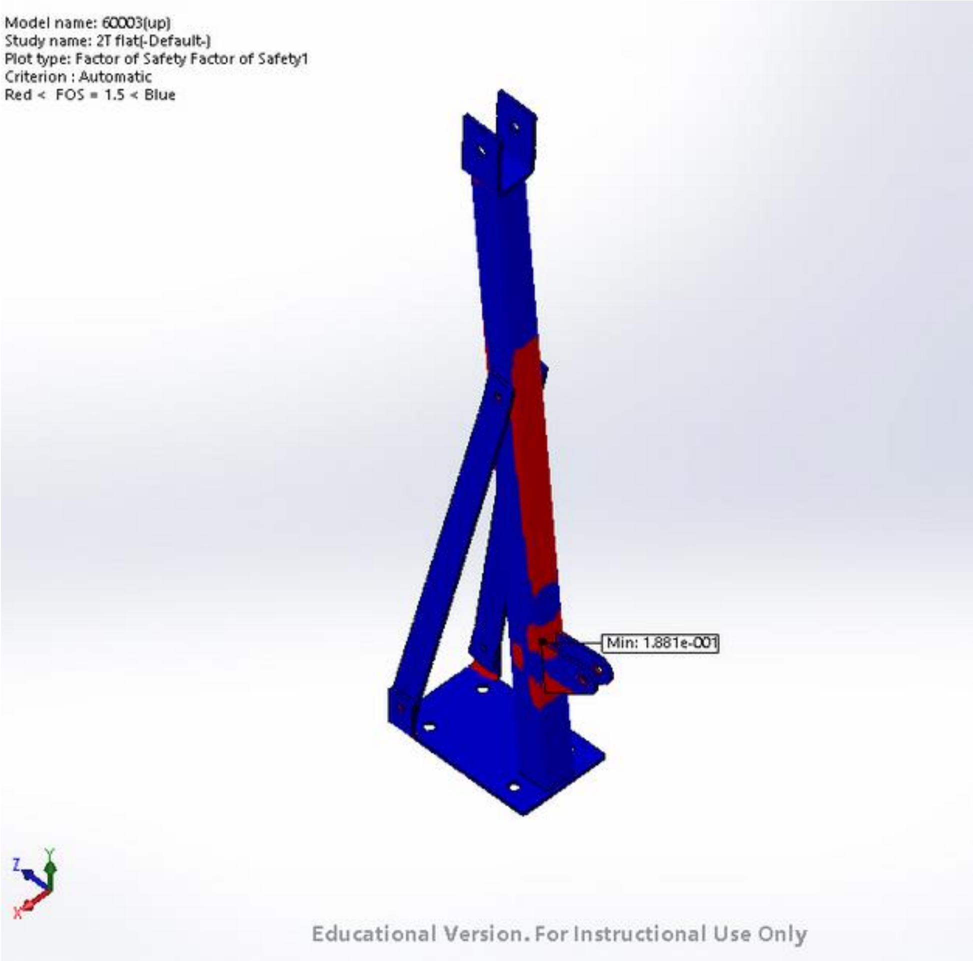


Figure 25: PN#60003 2T Horizontal - F.O.S.

Assembly 60003 - Post Assembly – Original 2T Angled Loading

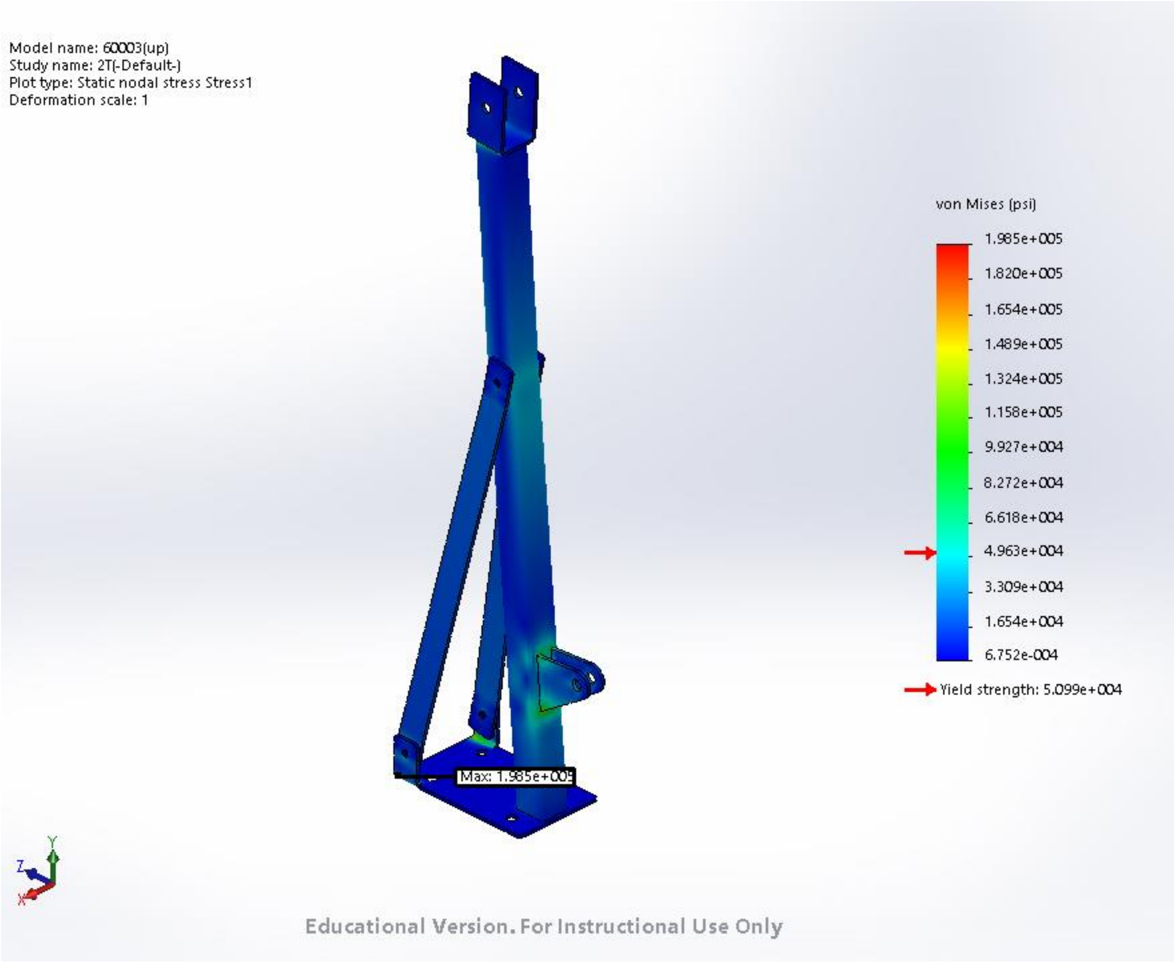


Figure 26: PN#60003 2T Angled Up - Von Mises Stress

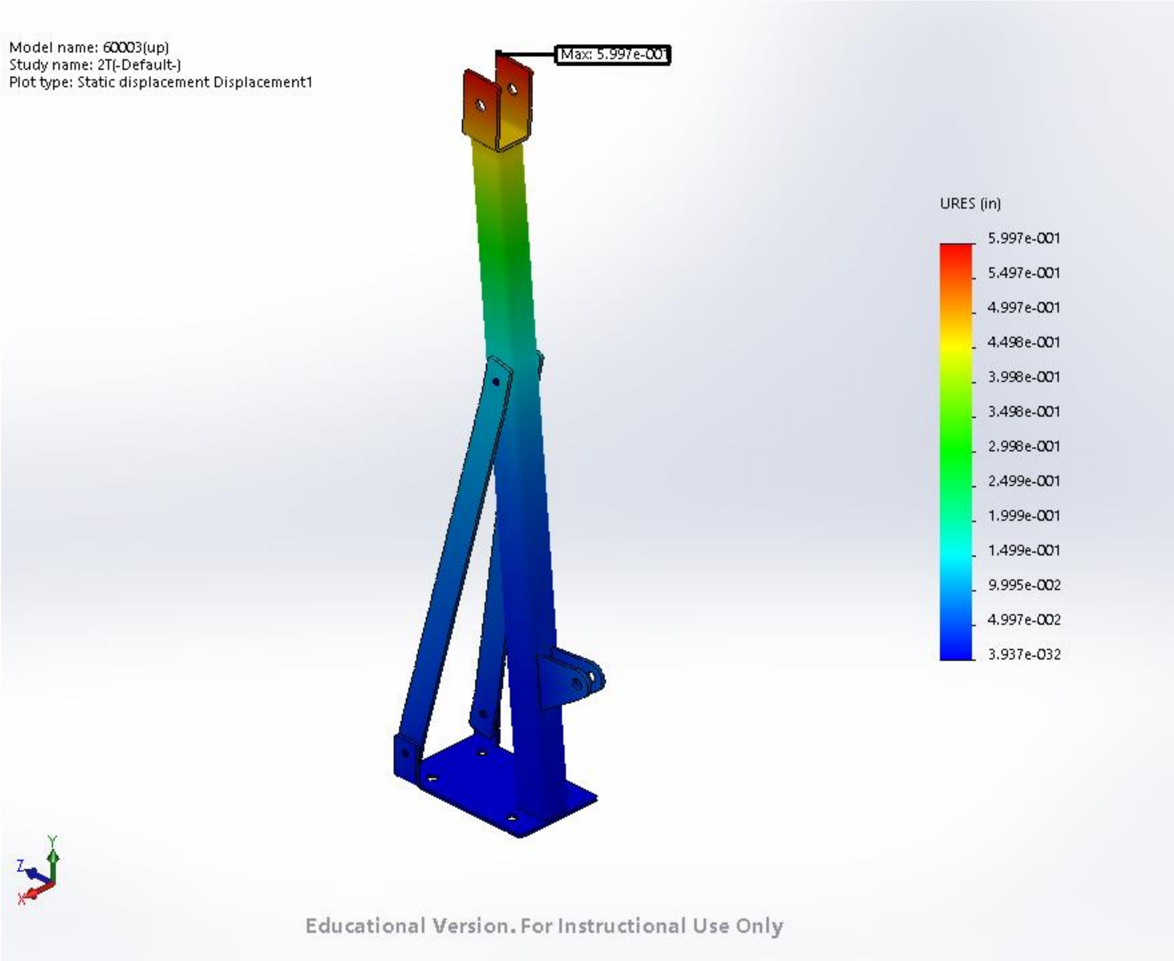


Figure 27: PN#60003 2T Angled - Displacement

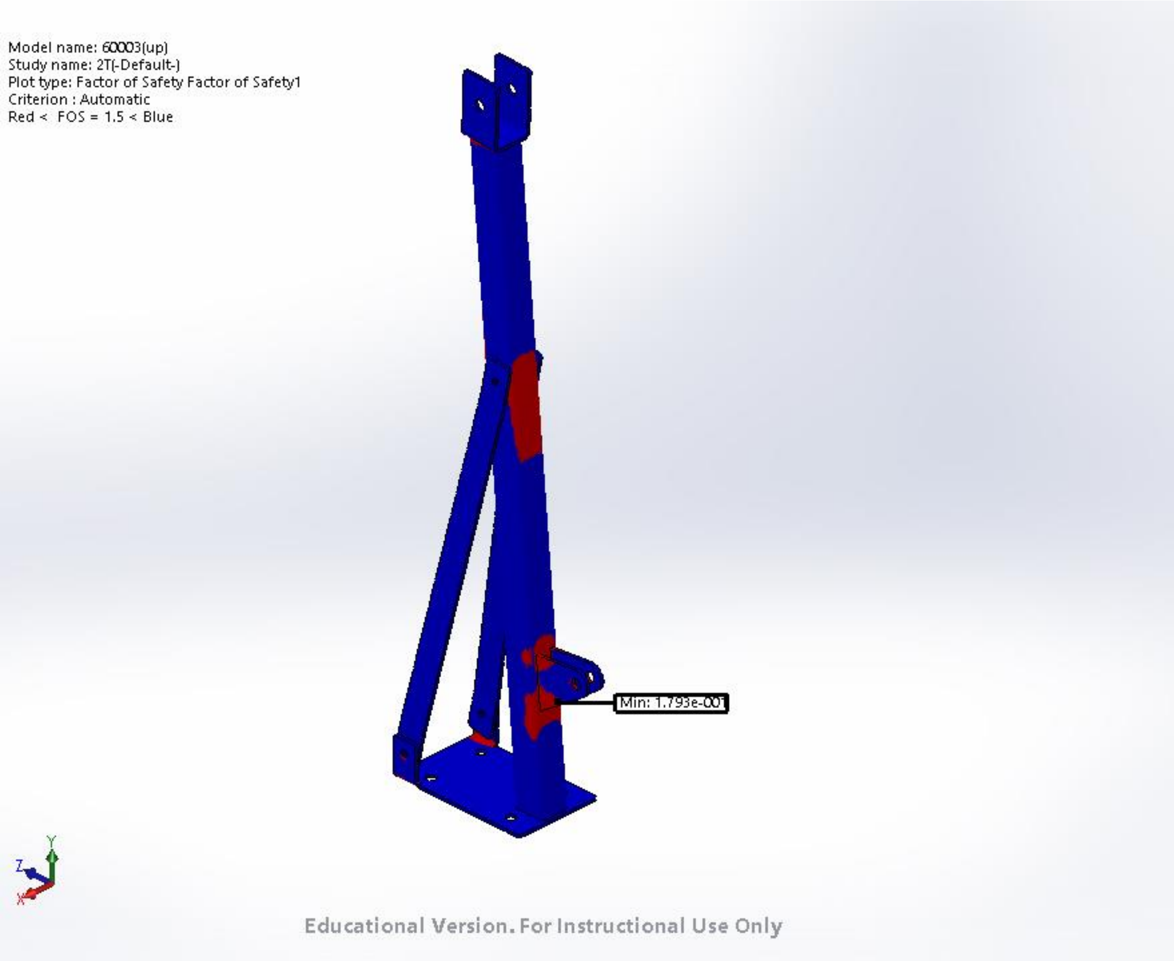


Figure 28: PN#60003 2T Angled Up - F.O.S.

PT# 10006 – Original 2T Horizontal Loading

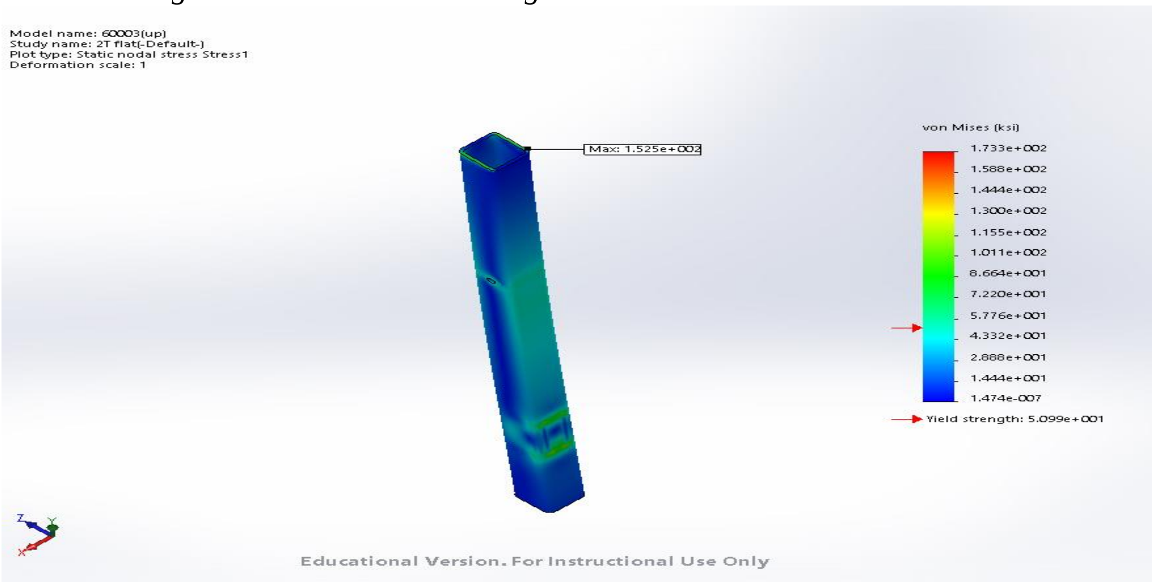


Figure 29: PN#10006 2T Horizontal - Von Mises Stress

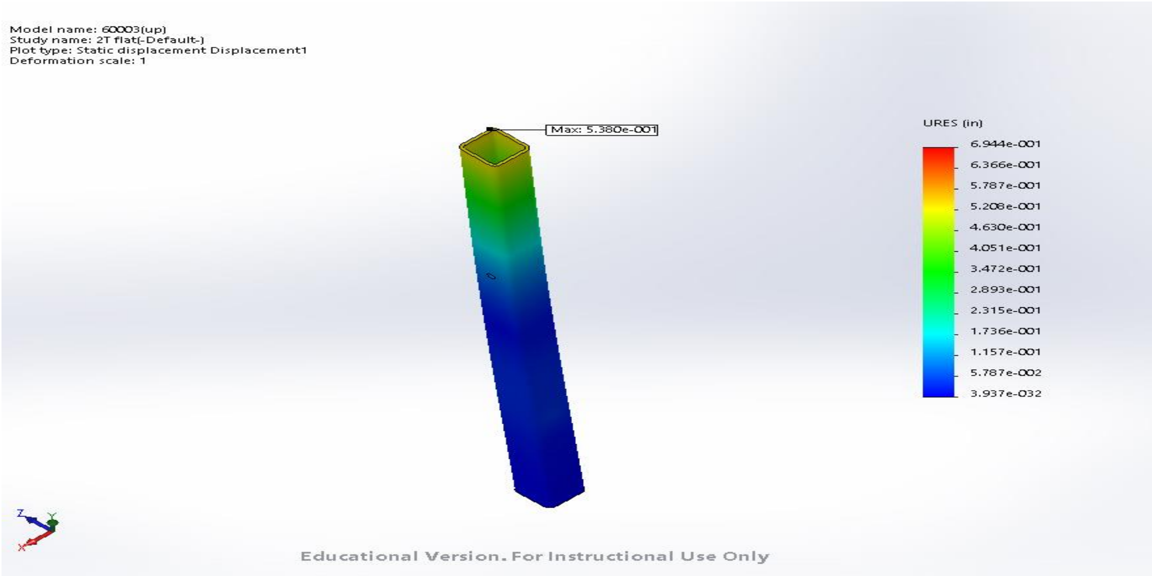


Figure 30: PN#10006 2T Horizontal - Displacement

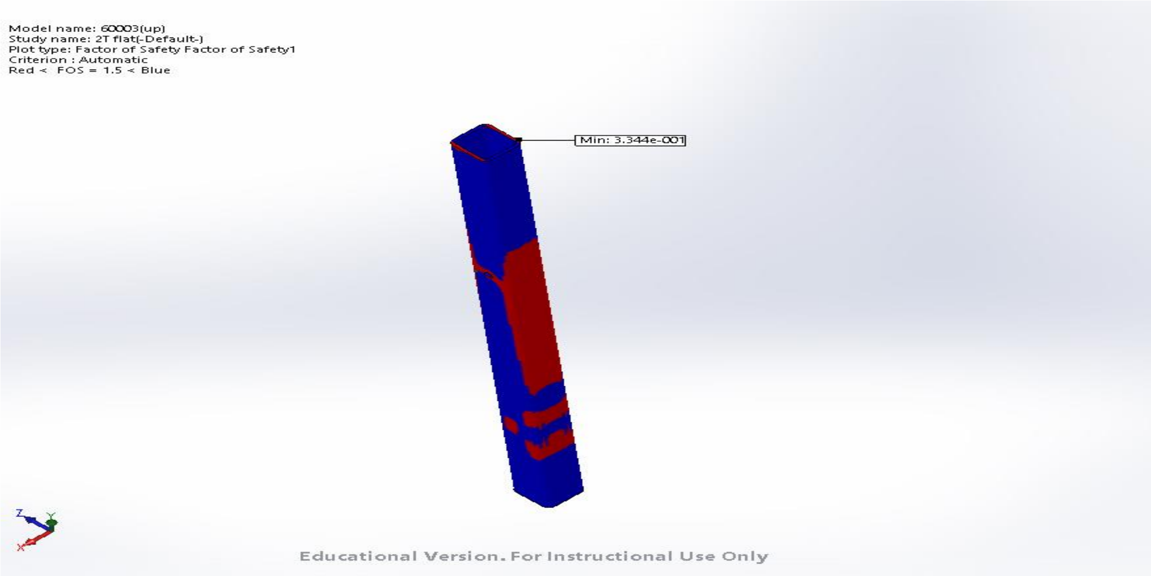


Figure 31: PN#10006 2T Horizontal - F.O.S

PT# 10006 – Original 2T Angled Loading

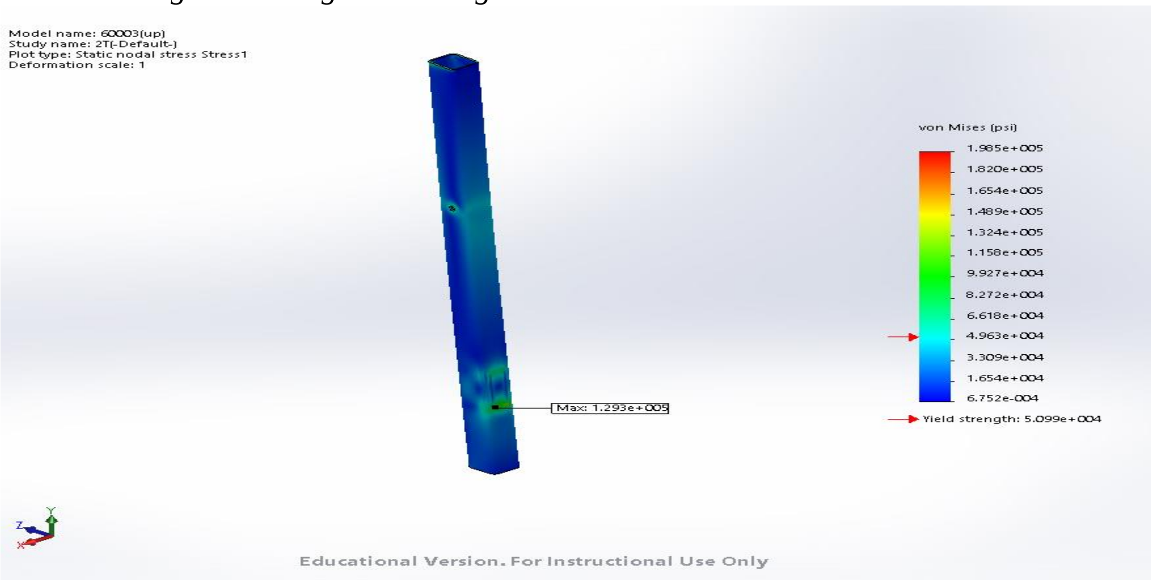


Figure 32: PN#10006 2T Angled Up - Von Mises Stress

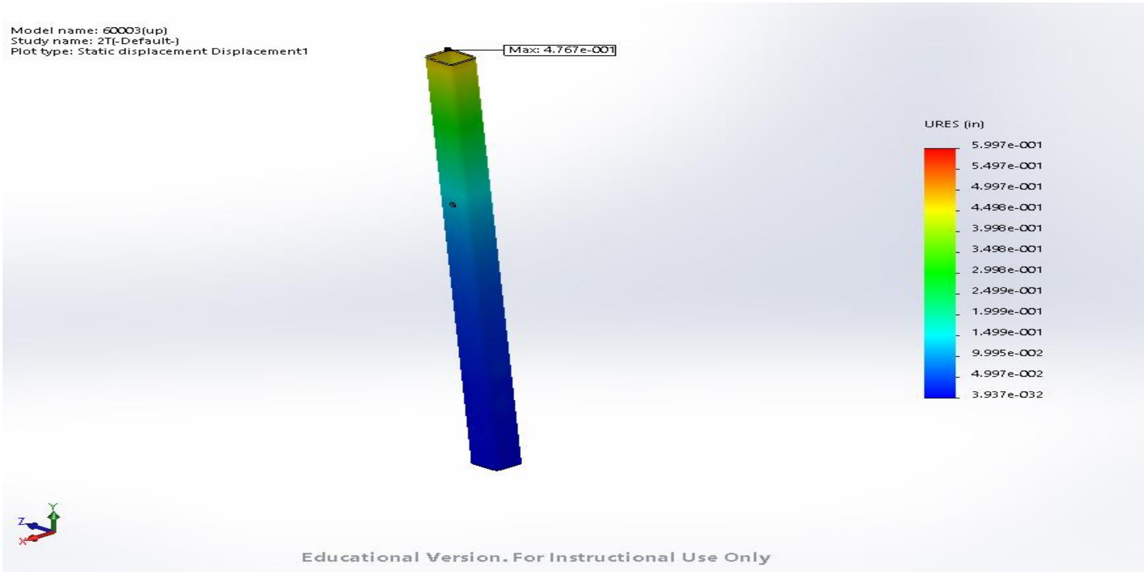


Figure 33: PN#10006 2T Angled Up - Displacement

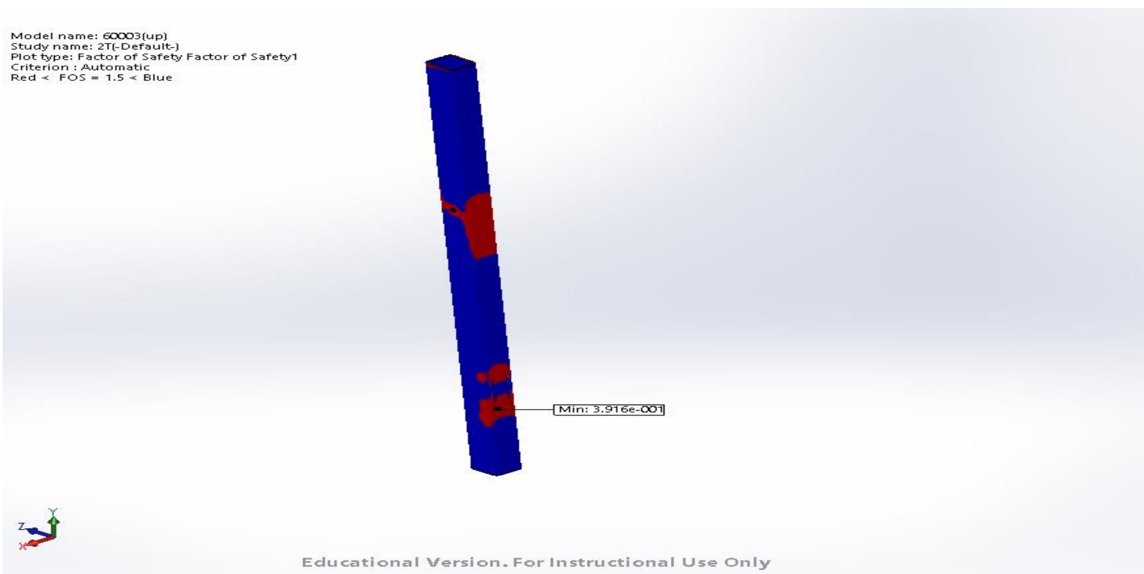


Figure 34: PN#10006 2T Angled Up - F.O.S.

PT# 10007 – Original 2T Horizontal Loading

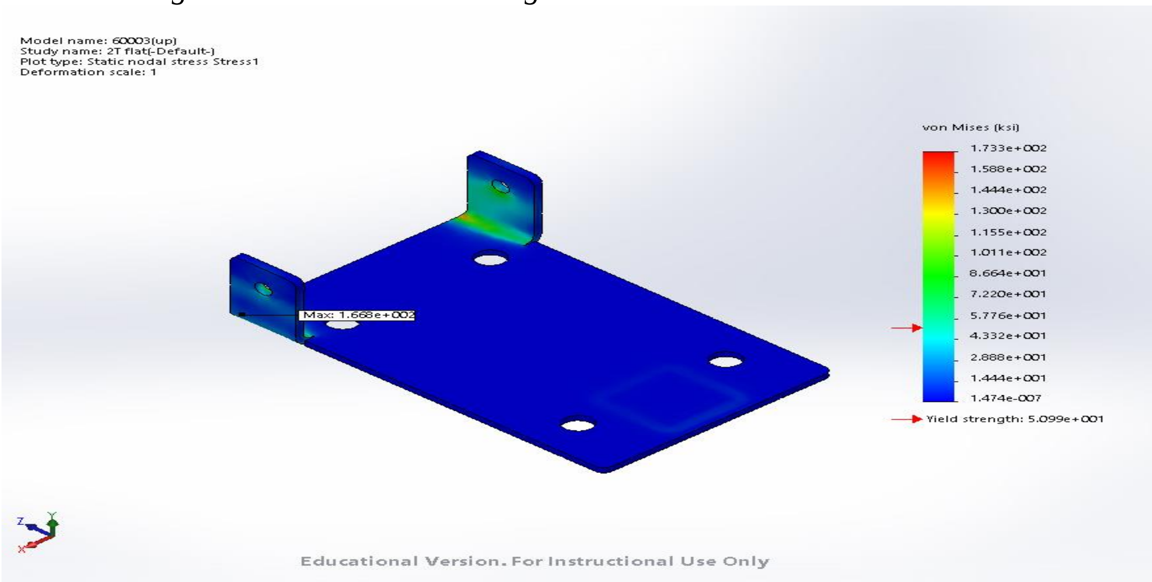


Figure 35: PN#10007 2T Horizontal - Von Mises Stress

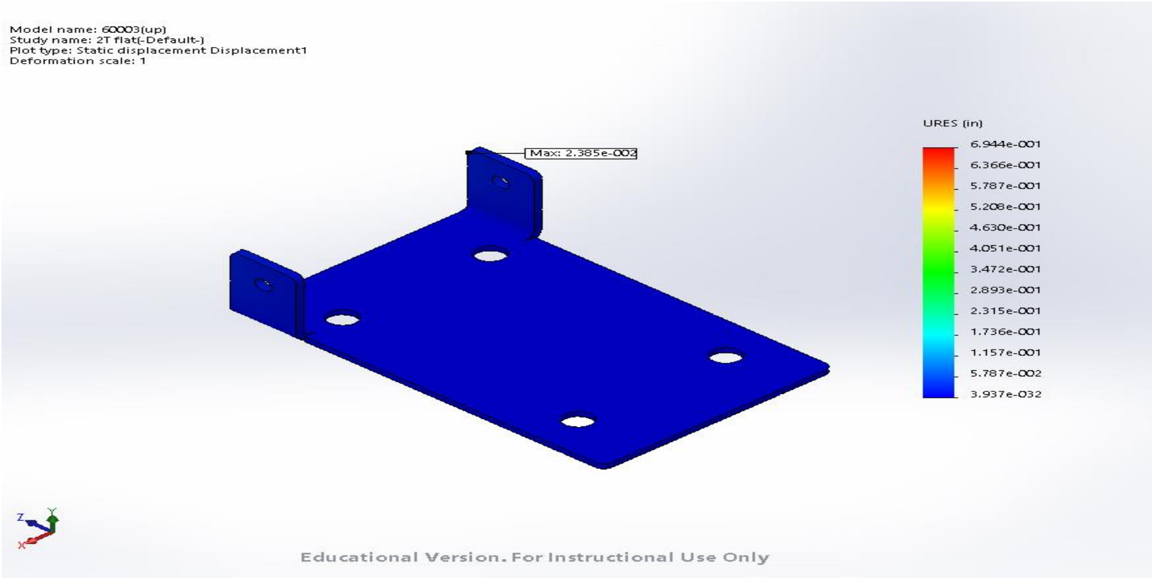


Figure 36: PN#10007 2T Horizontal - Displacement

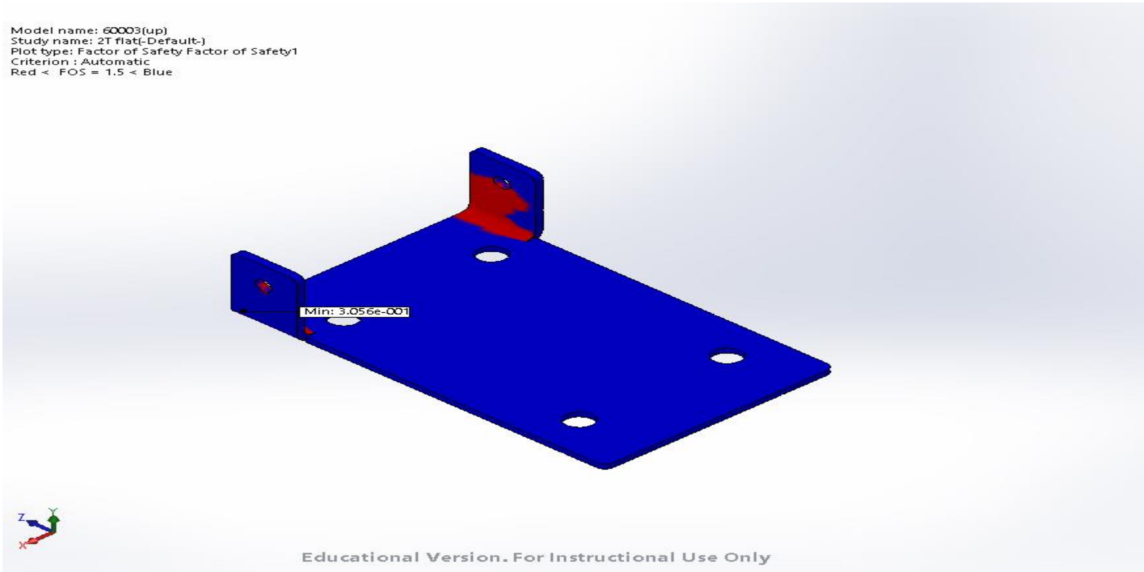


Figure 37: PN#10007 2T Horizontal - F.O.S.

PT# 10007 – Original 2T Angled Loading

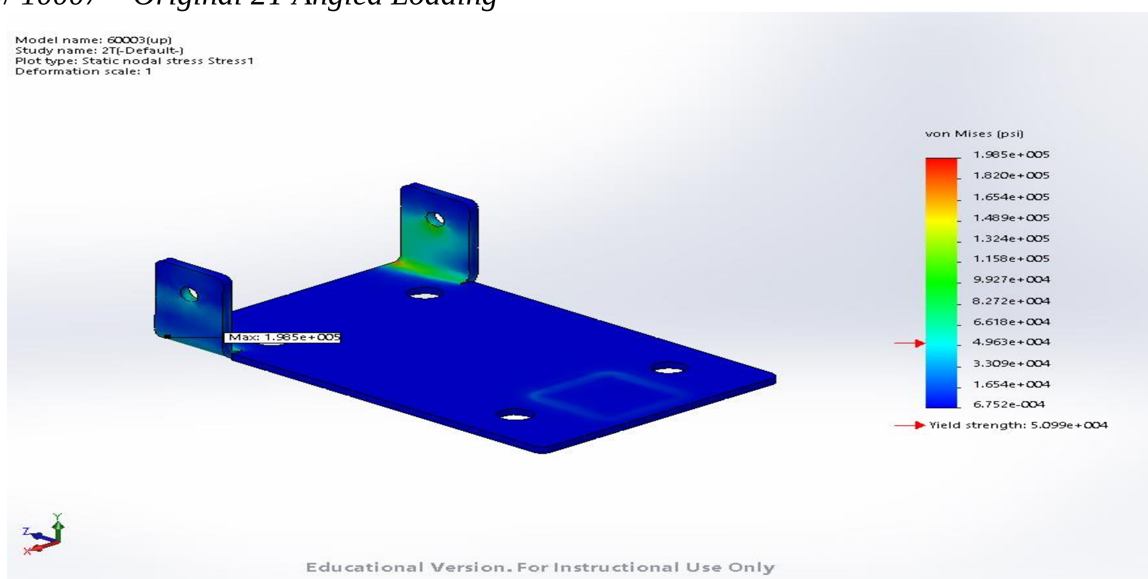


Figure 38: PN#10007 2T Angled Up - Von Mises Stress

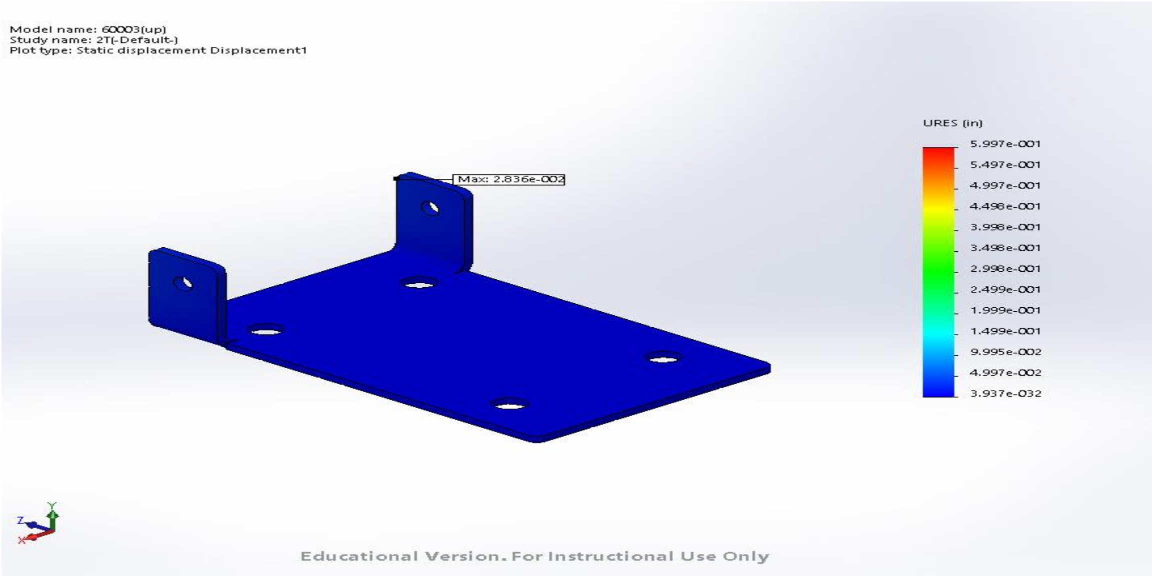


Figure 39: PN#10007 2T Angled Up - Displacement

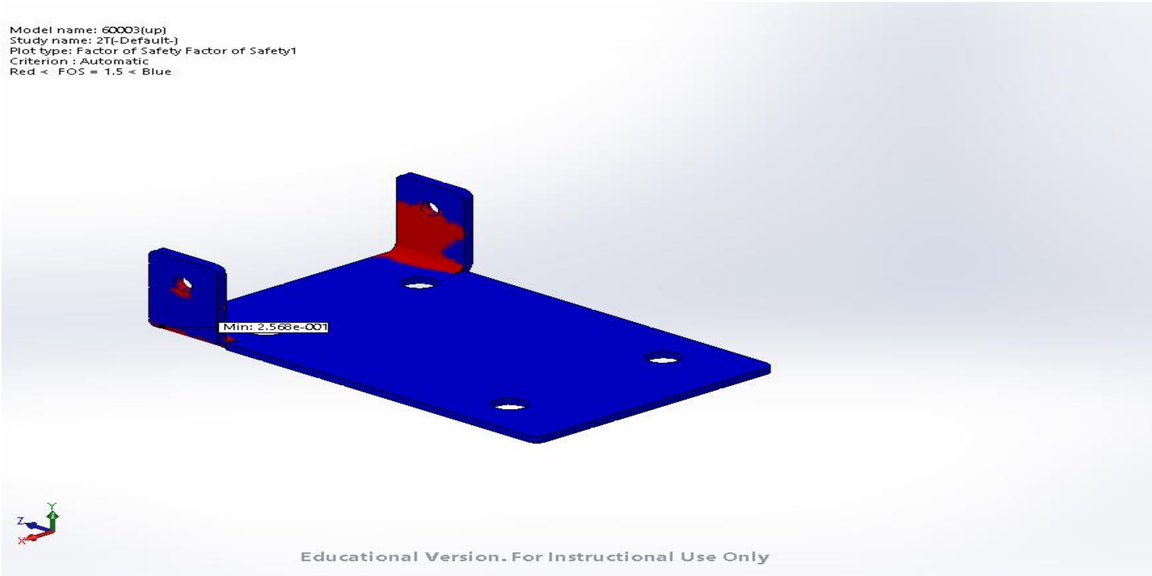


Figure 40: PN#10007 2T Angled Up - F.O.S.

PT# 10008 – Original 2T Horizontal Loading

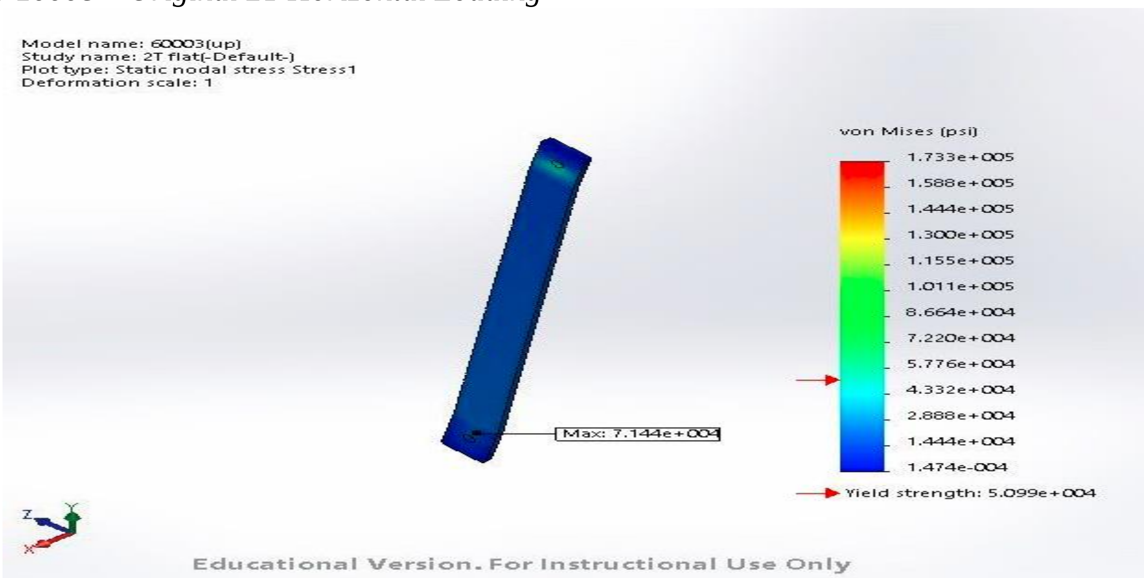


Figure 41: PN#10008 2T Horizontal - Von Mises Stress

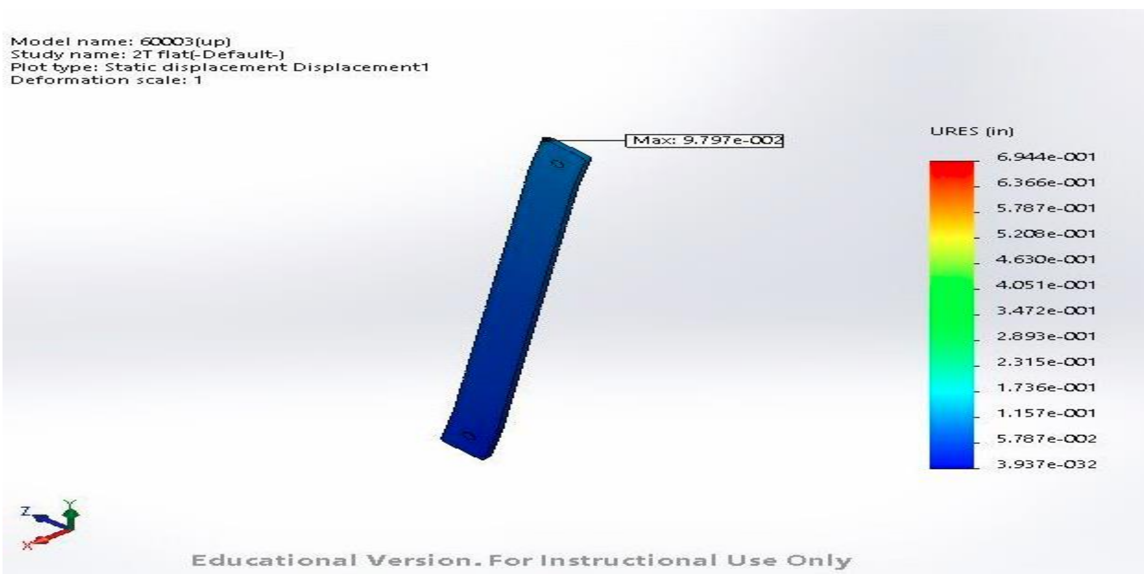


Figure 42: PN#10008 2T Horizontal - Displacement

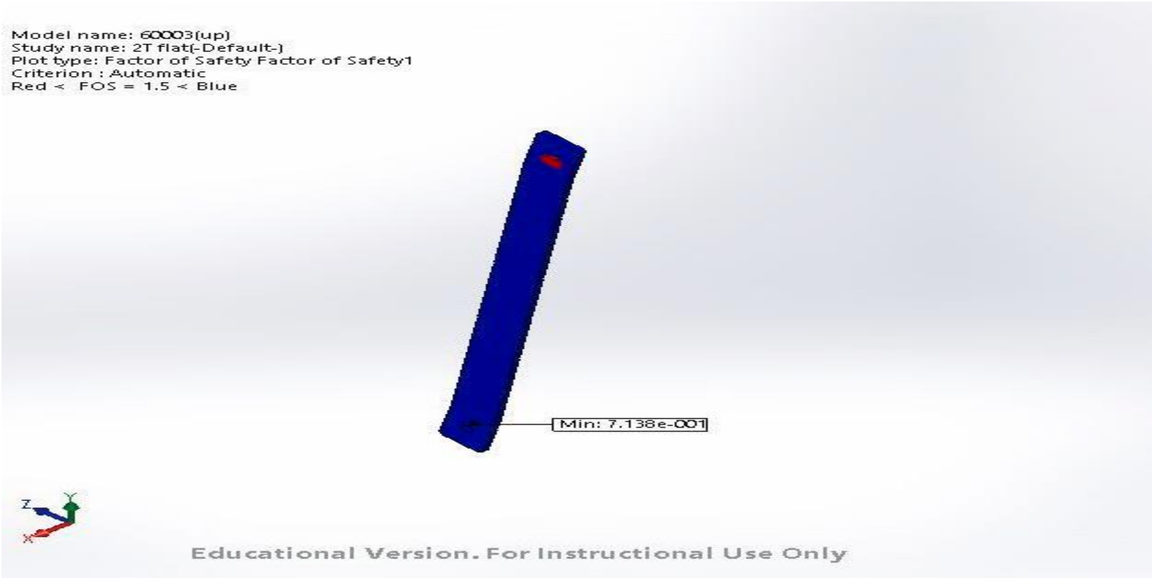


Figure 43: PN#10008 2T Horizontal - F.O.S.

PT# 10008 – Original 2T Angled Loading

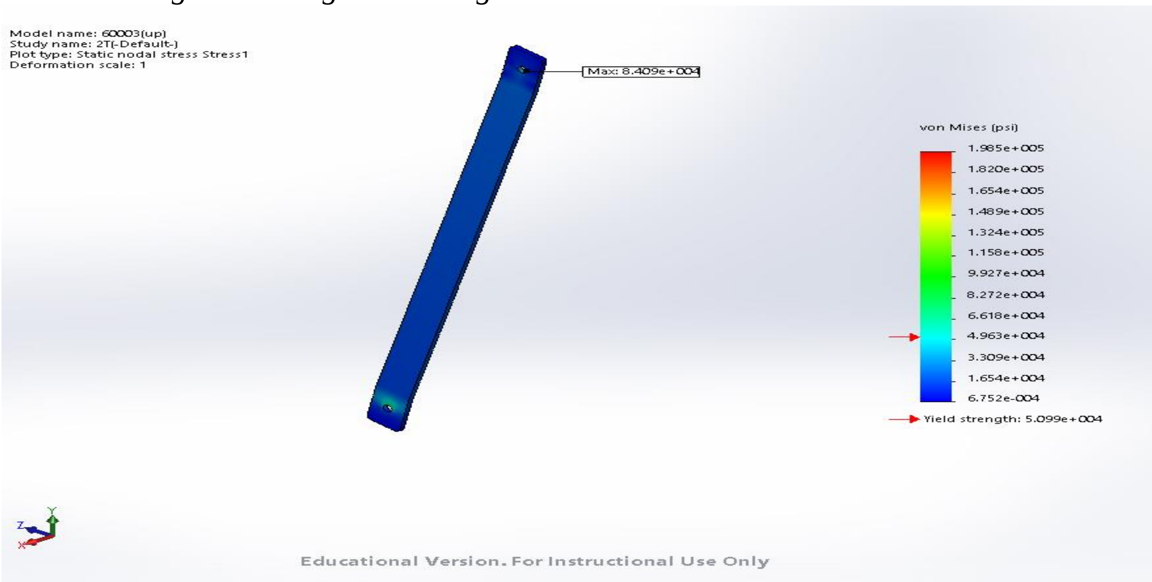


Figure 44: PN#10008 2T Angled Up - Von Mises Stress

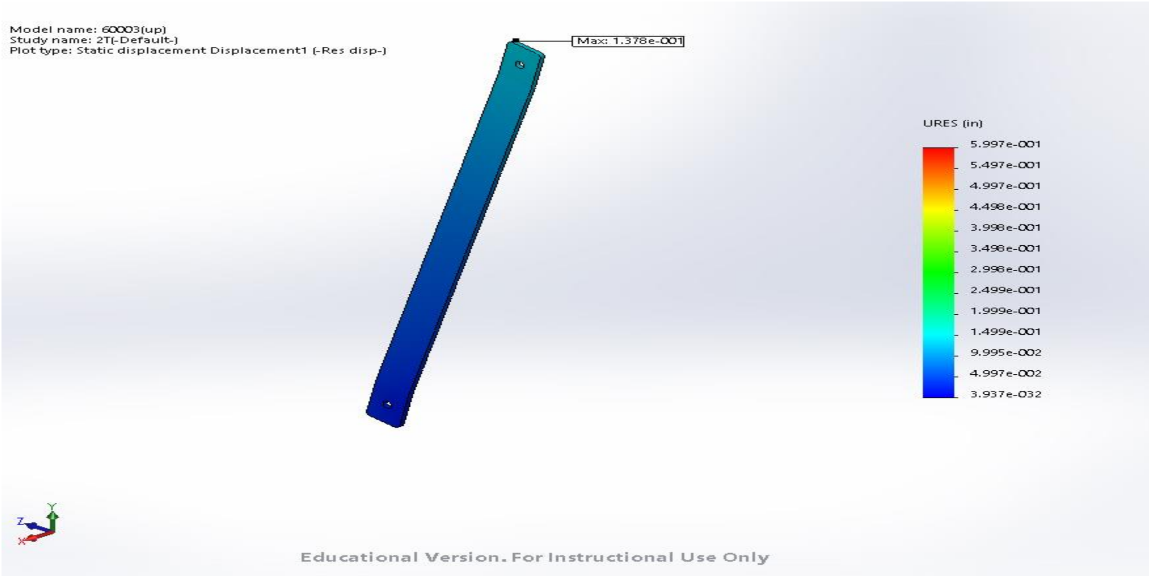


Figure 45: PN#10008 2T Angled Up - Displacement

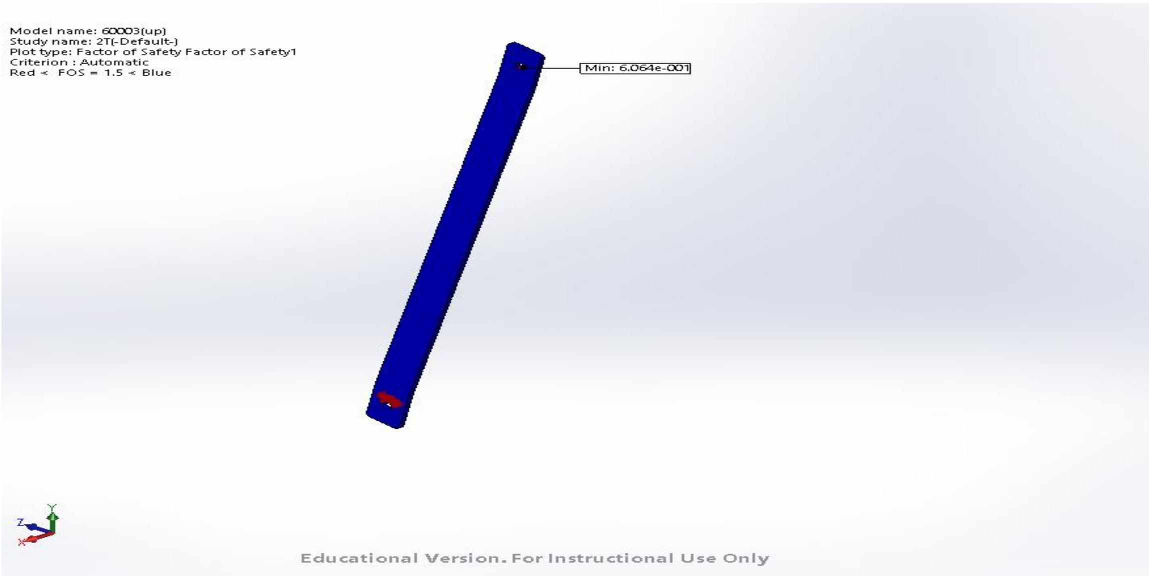


Figure 46: PN#10008 2T Angled Up - F.O.S.

PT# 10009 – Original 2T Horizontal Loading

Figure 47: PN#10009 2T Horizontal - Von Mises Stress

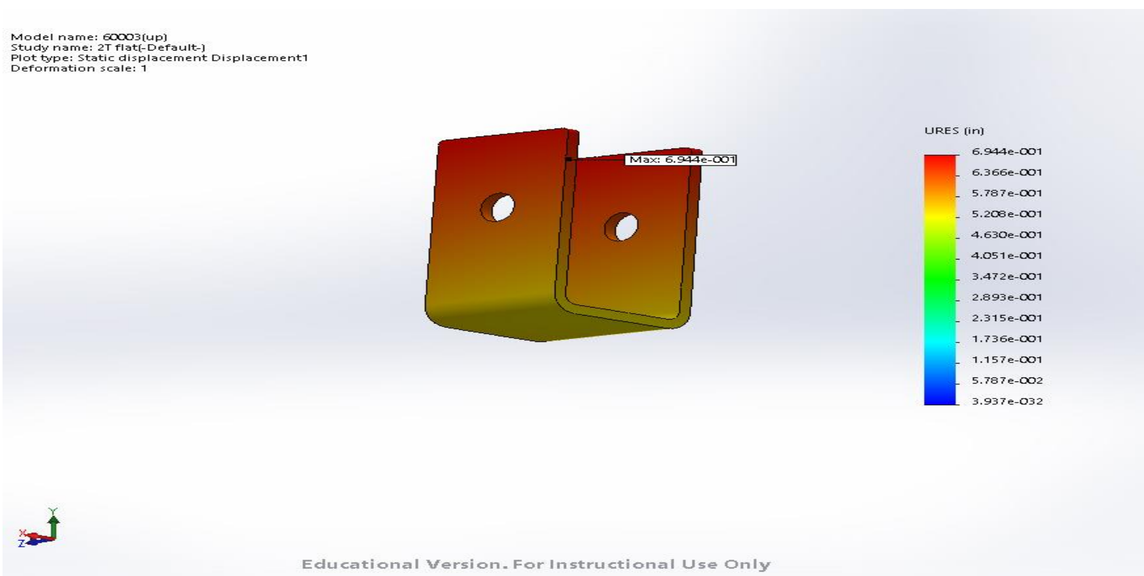


Figure 48: PN#10009 2T Horizontal - Displacement

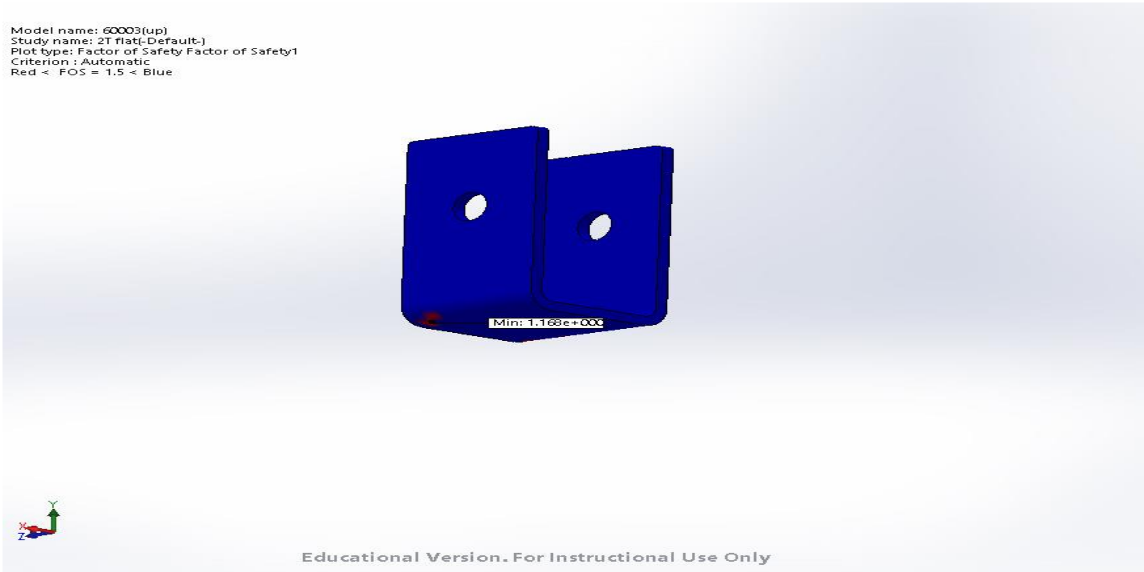


Figure 49: PN#10009 2T Horizontal F.O.S.

PT# 10009 – Original 2T Angled Loading

Figure 50: PN#10009 2T Angled Up - Von Mises Stress

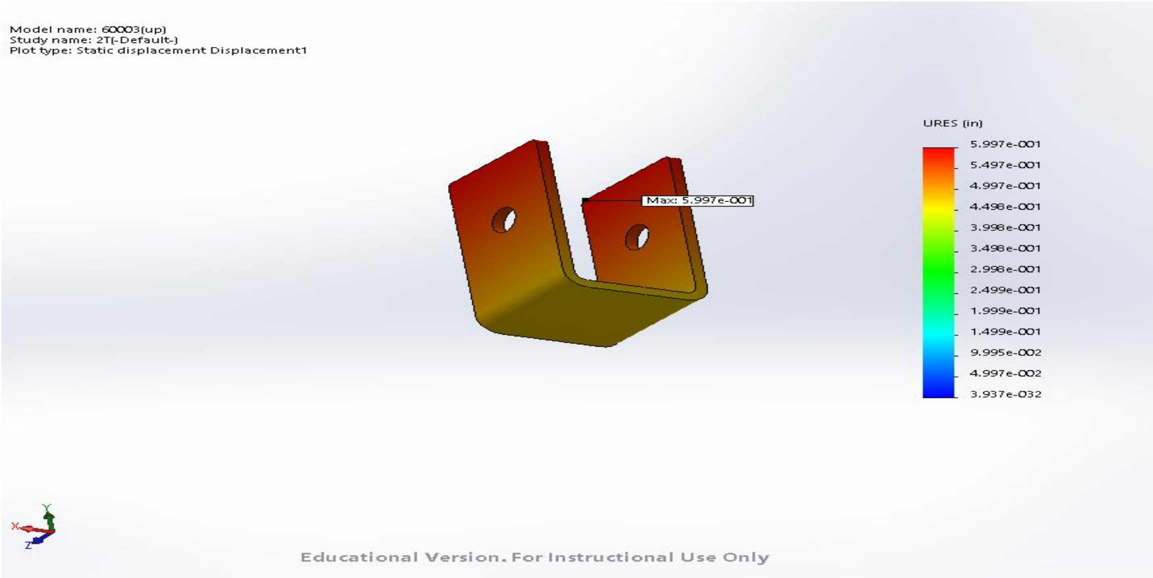


Figure 51: PN#10009 2T Angled Up - Displacement

Figure 52: PN#10009 2T Angled Up - F.O.S.

PT# 10010 – Original 2T Horizontal Loading

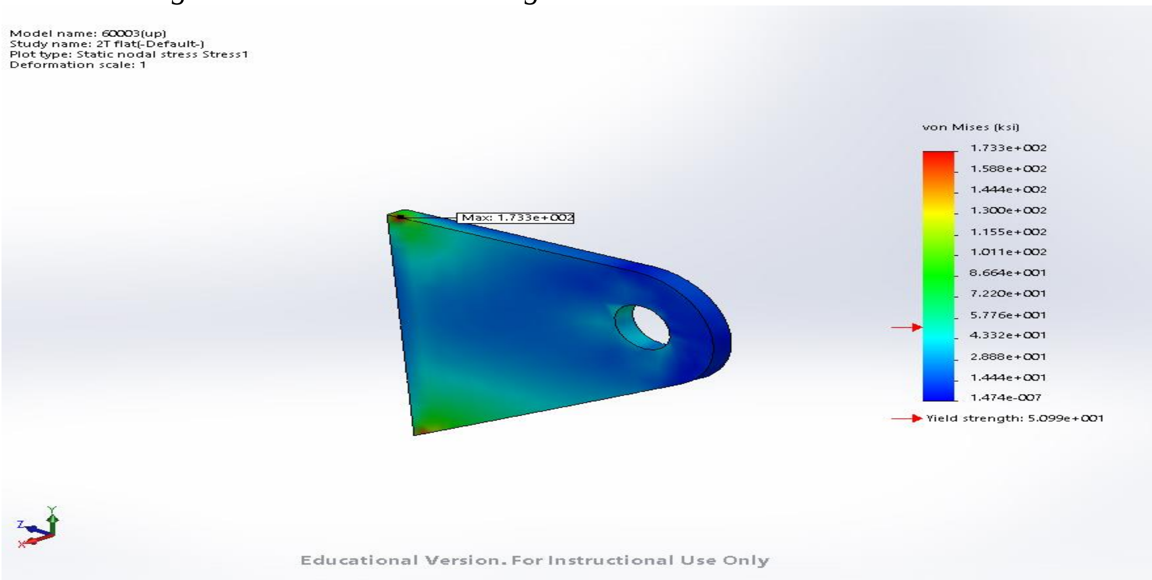


Figure 53: PN#10010 2T Horizontal - Von Mises Stress

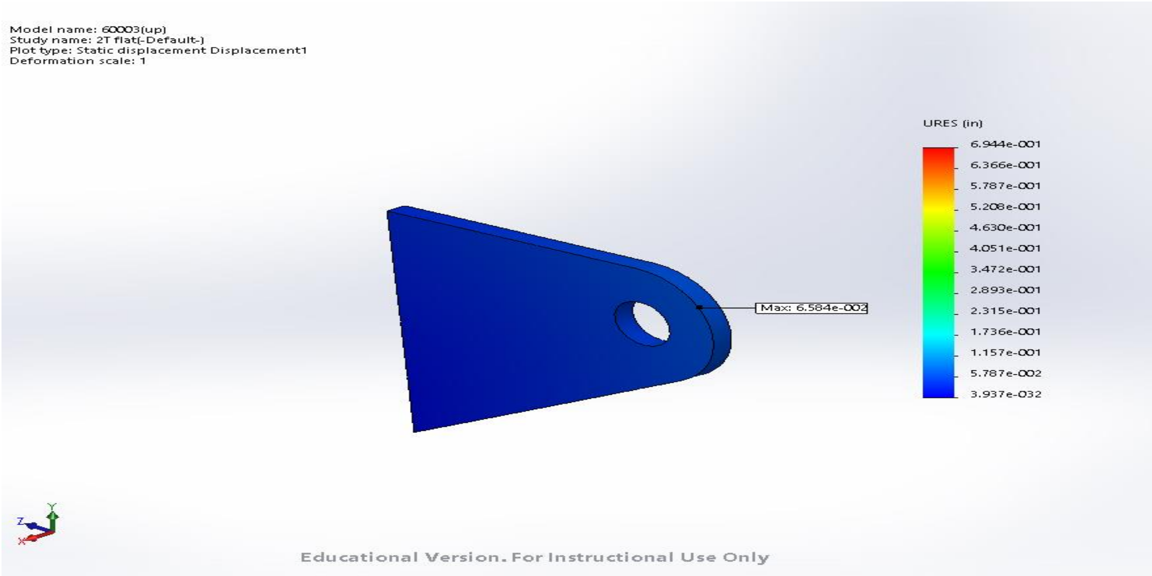


Figure 54: PN#10010 2T Horizontal - Displacement

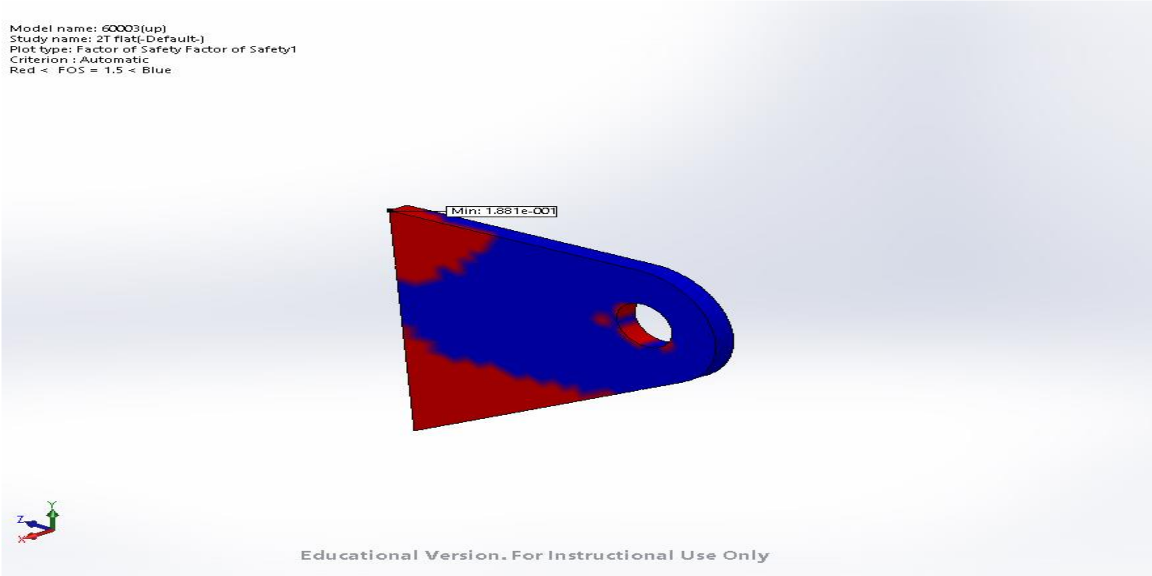


Figure 55: PN#10010 2T Horizontal - F.O.S.

PT# 10010 – Original 2T Angled up Loading

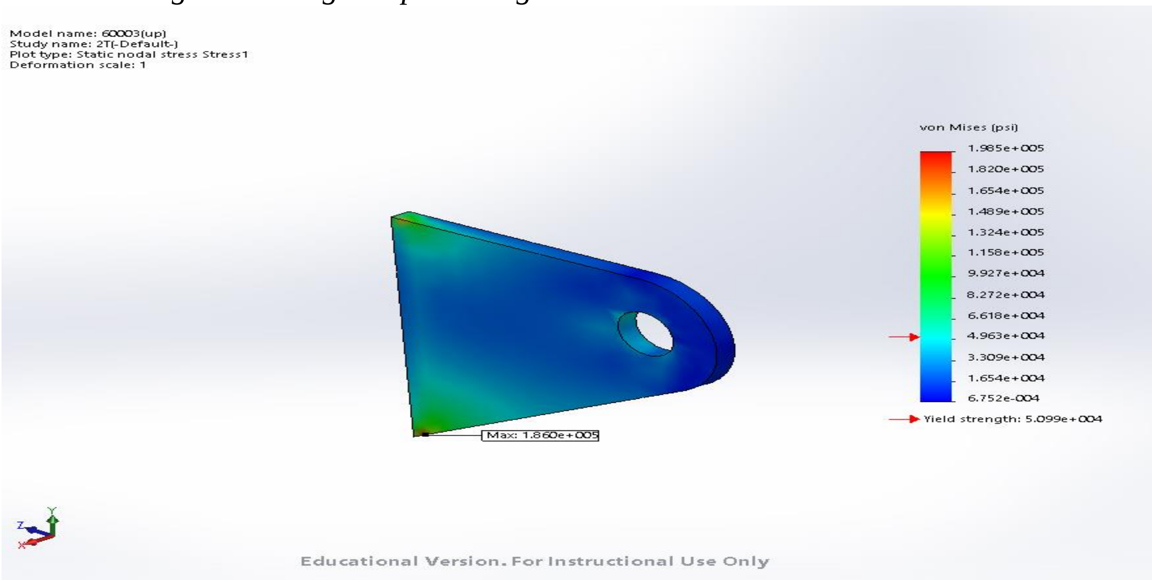


Figure 56: PN#10010 2T Angled Up - Von Misses Stress

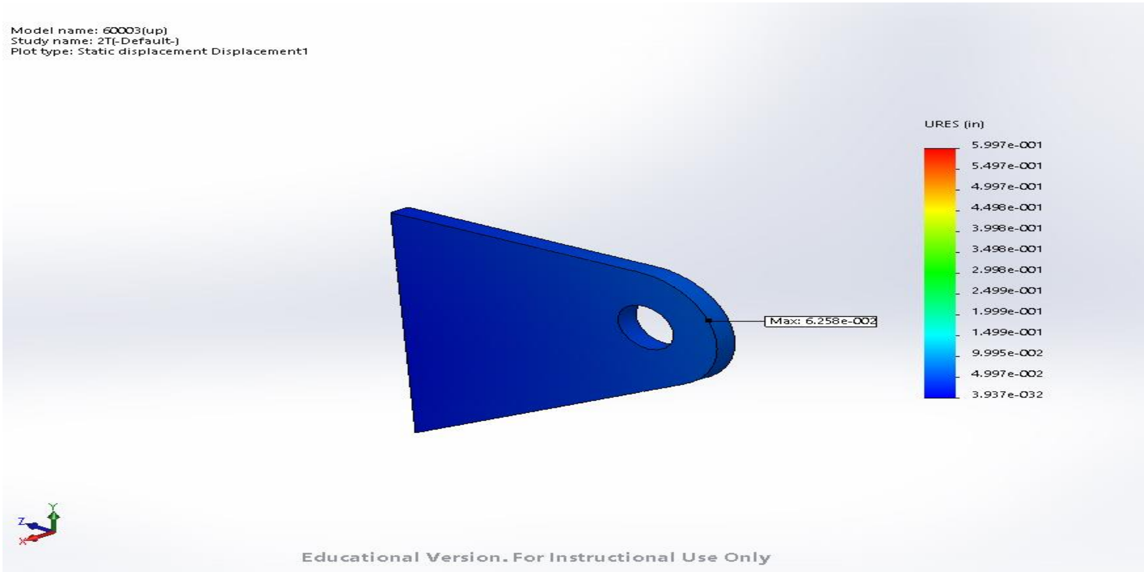


Figure 57: PN#10010 2T Angled Up - Displacement

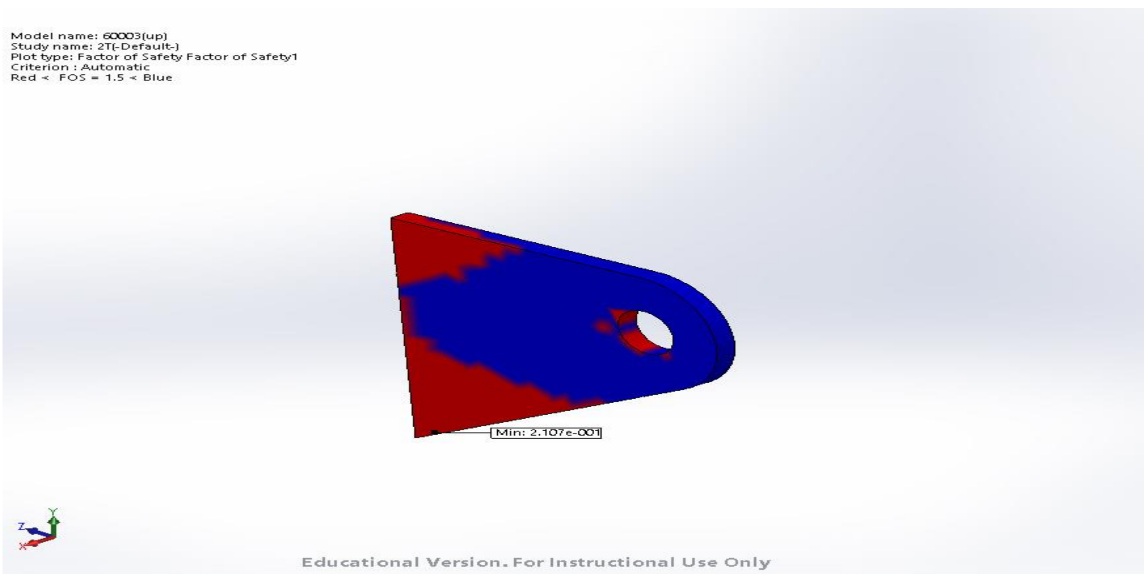


Figure 58: PN#10010 2T Angled Up - F.O.S.

Assembly 60004 - Boom Assembly – Original 2T Horizontal Loading

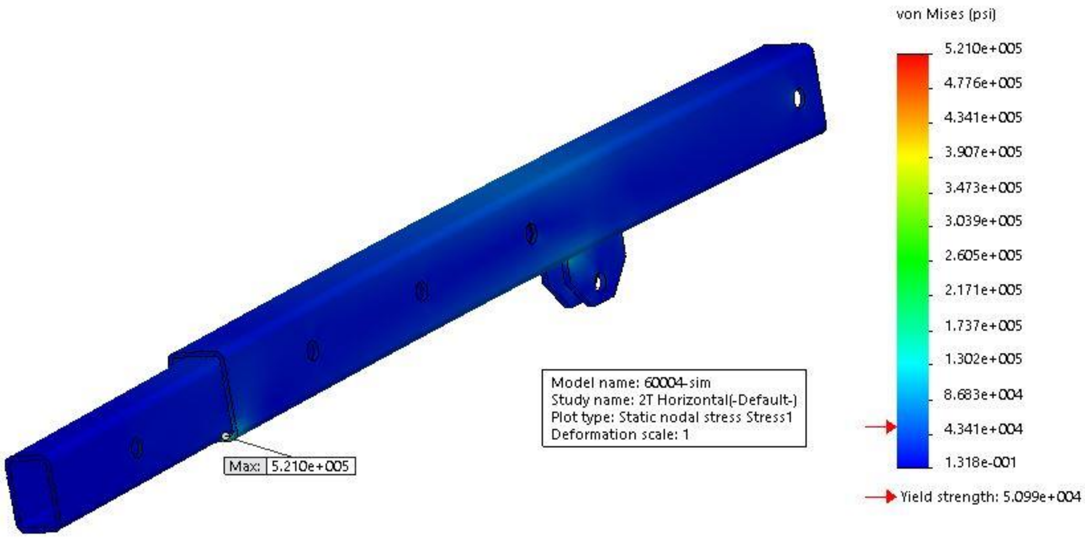


Figure 59: PN#60004 2T Horizontal - Von Misses Stress

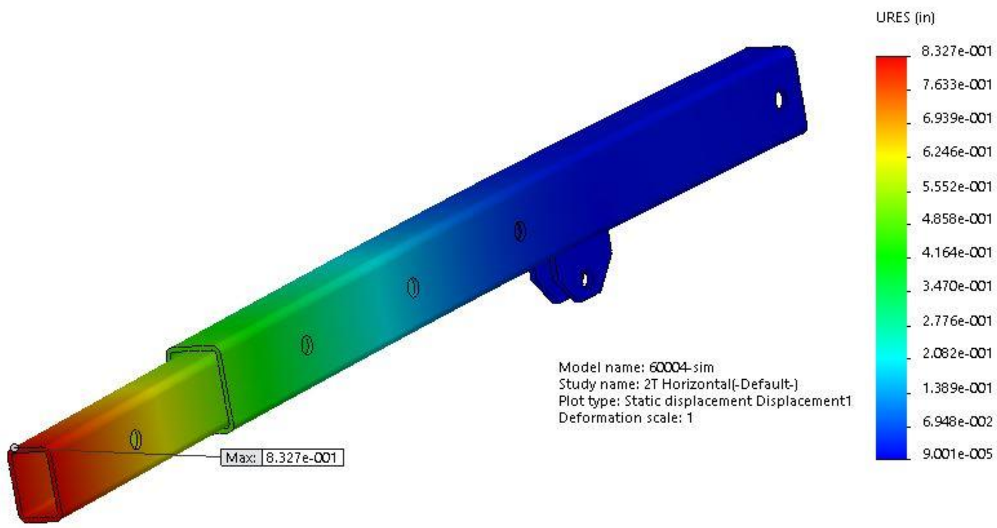


Figure 60: PN#60004 2T Horizontal - Displacement

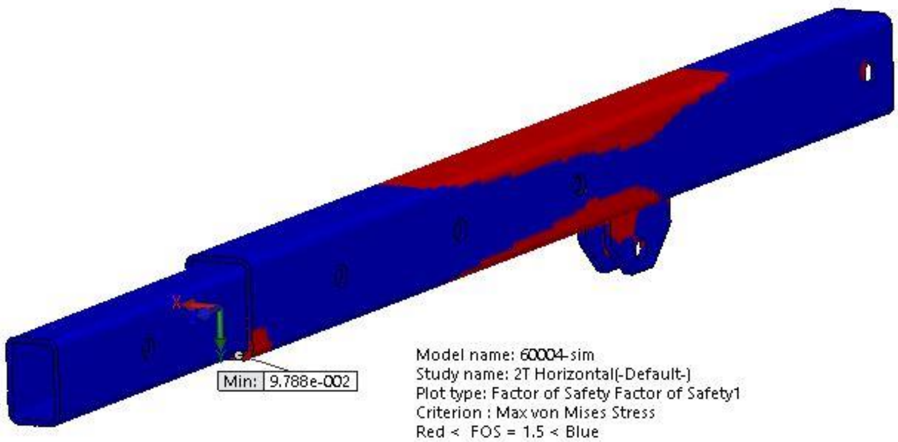


Figure 61: PN#60004 2T Horizontal - F.O.S.

Assembly 60004 - Boom Assembly – Original 2T Angled Loading

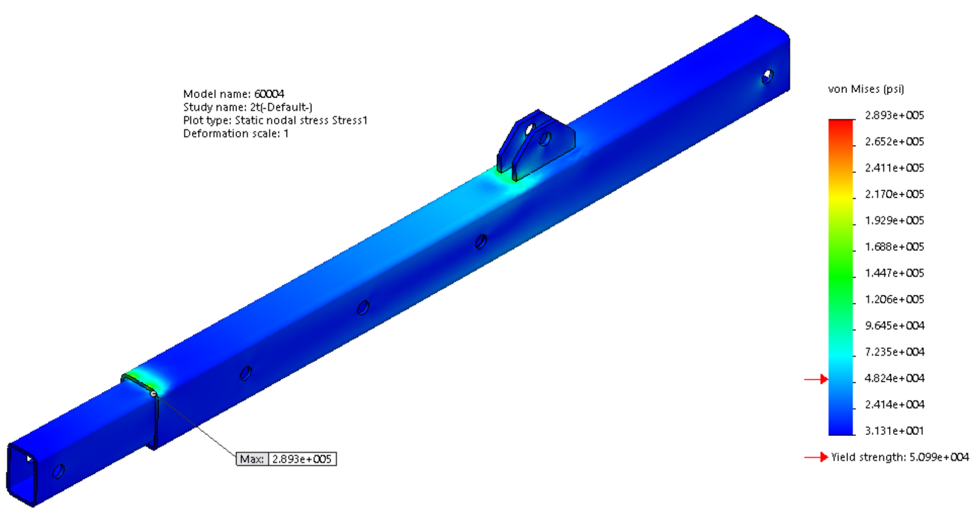


Figure 62: PN#60004 2T Angled Up - Von Misses

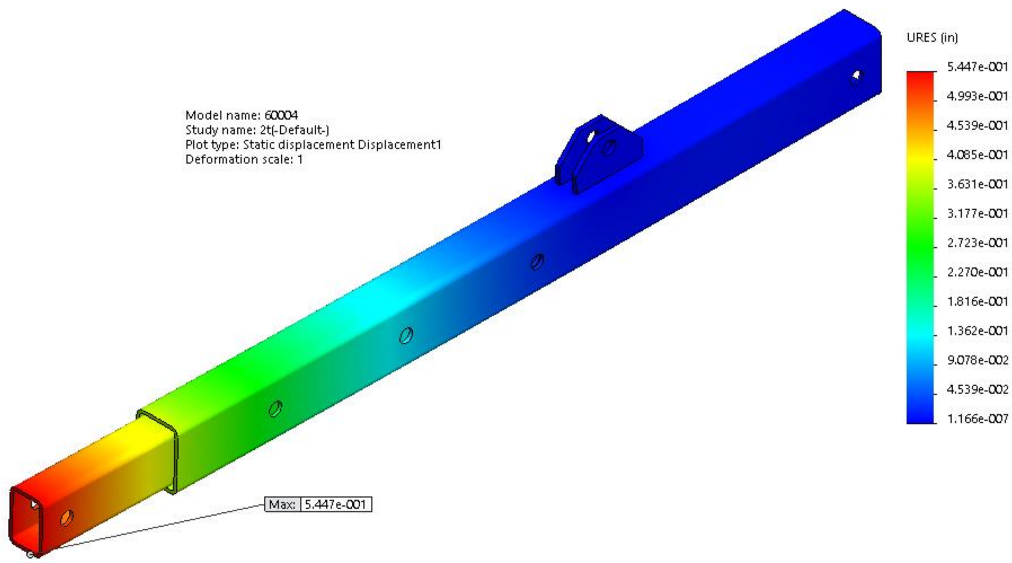


Figure 63: PN#60004 2T Angled Up - Displacement

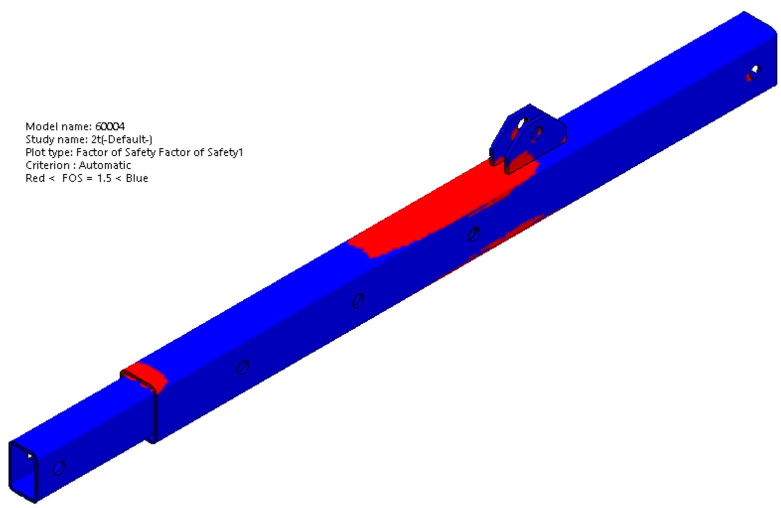


Figure 64: PN#60004 2T Angled Up - F.O.S.

PT# 10013 – Original 2T Horizontal Loading

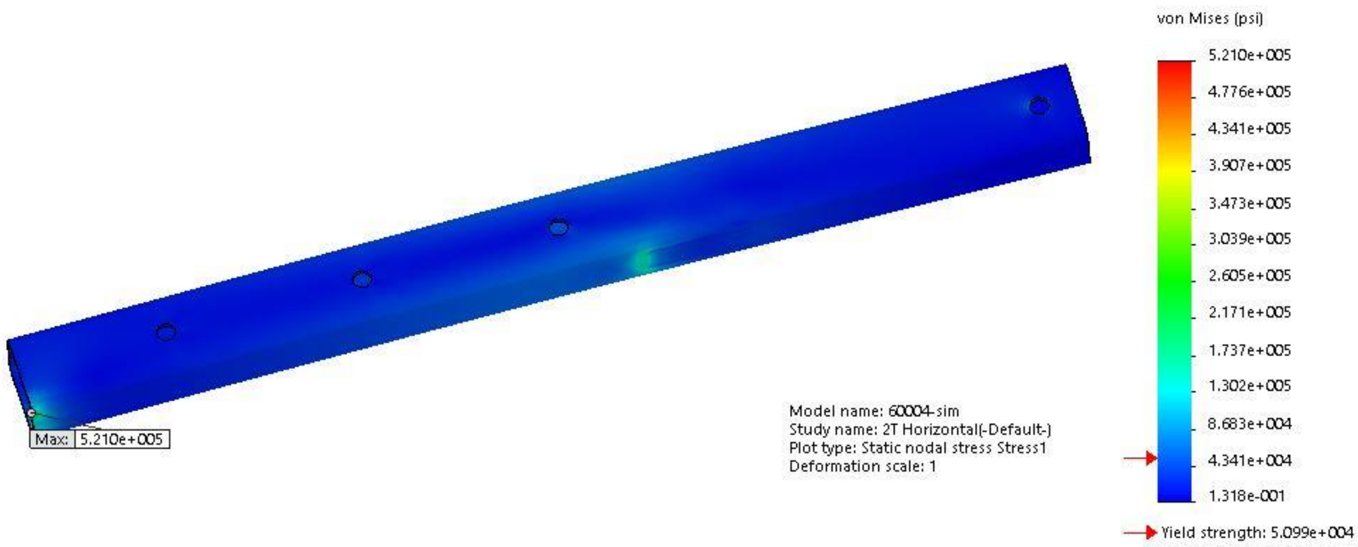


Figure 65: PN#10013 2T Horizontal - Von Misses Stress

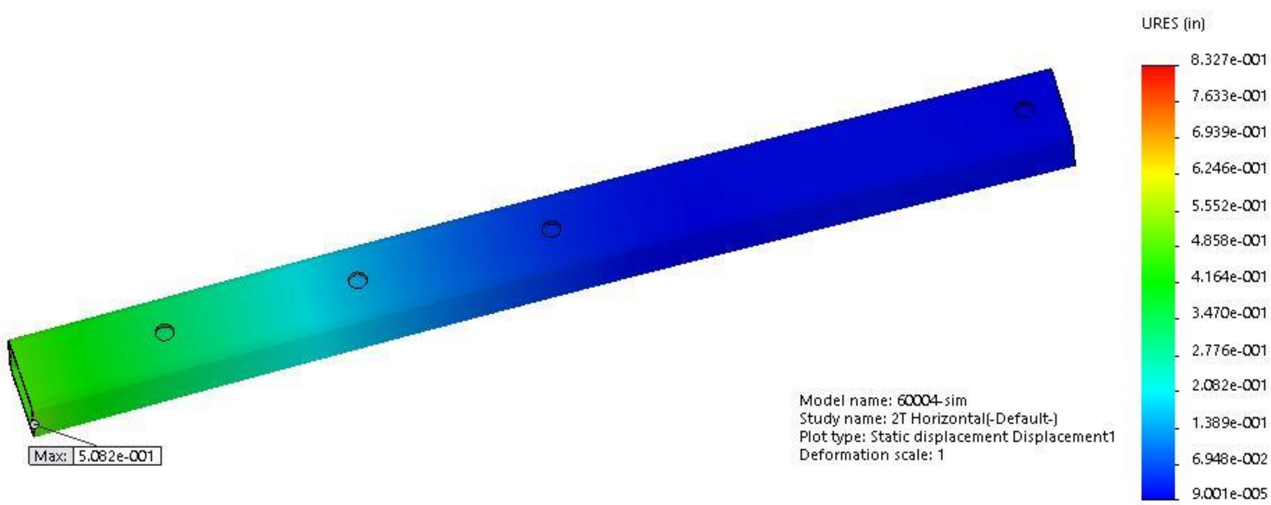


Figure 66: PN#10013 2T Horizontal - Displacement

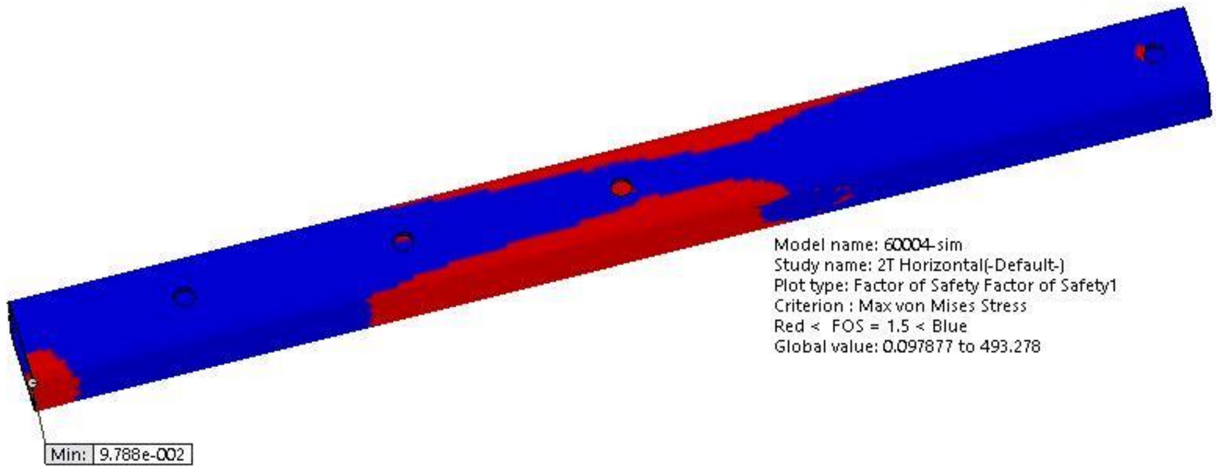


Figure 67: : PN#10013 2T Horizontal - F.O.S.

PT# 10013 – Original 2T Angled Loading

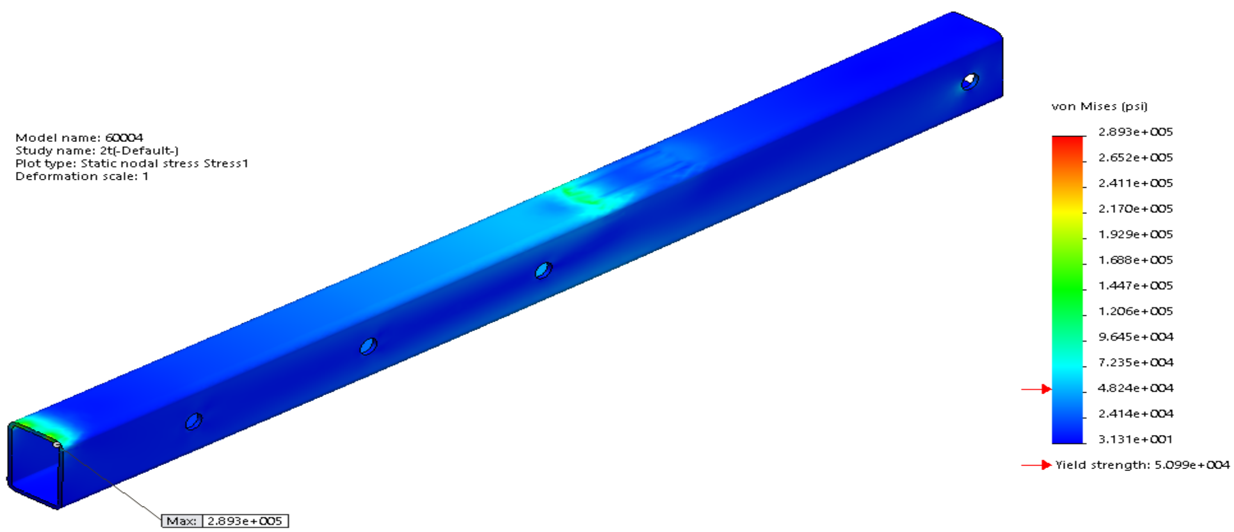


Figure 68: PN#10013 2T Angled Up - Von Misses Stress

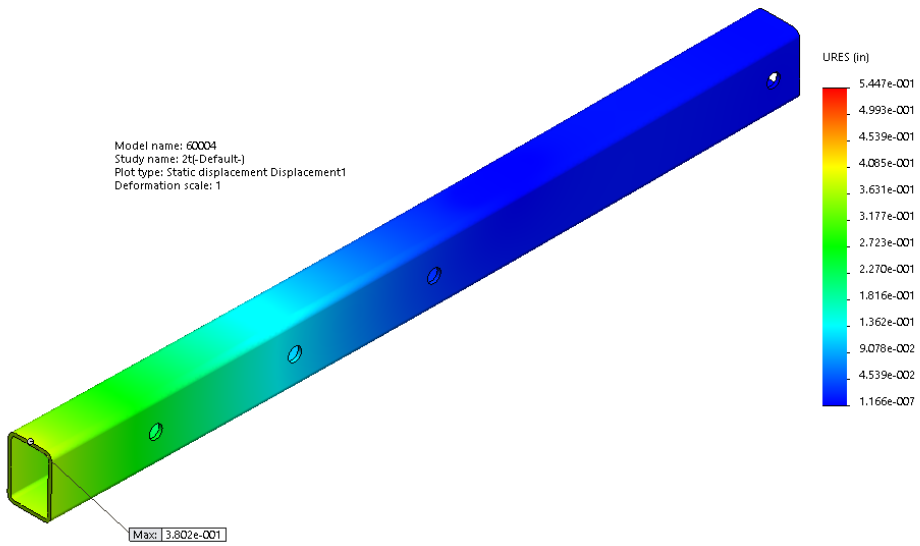


Figure 69: PN#10013 2T Angled Up - Displacement

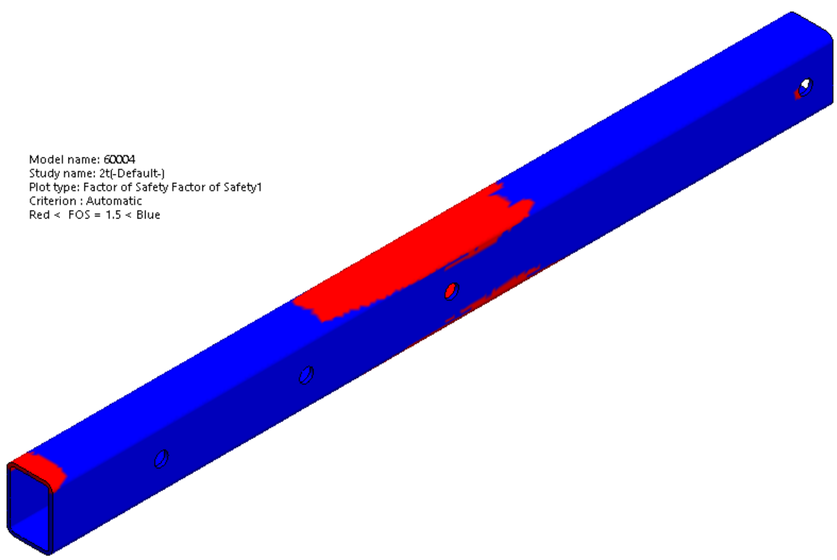


Figure 70: PN#10013 2T Angled Up - F.O.S.

PT# 10004 – Original 2T Horizontal Loading

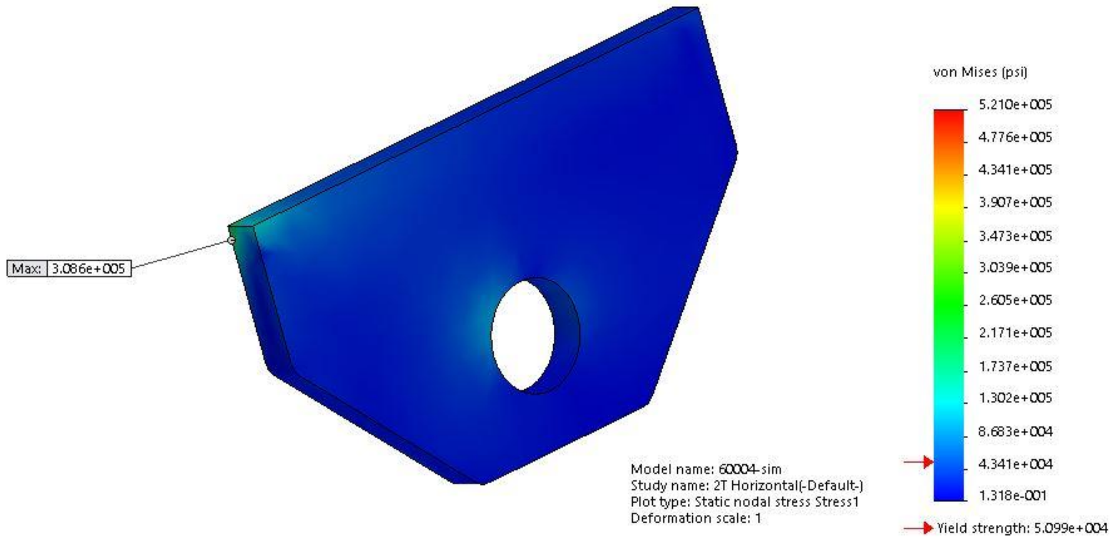


Figure 71: PN#10004 2T Horizontal - Von Misses Stress

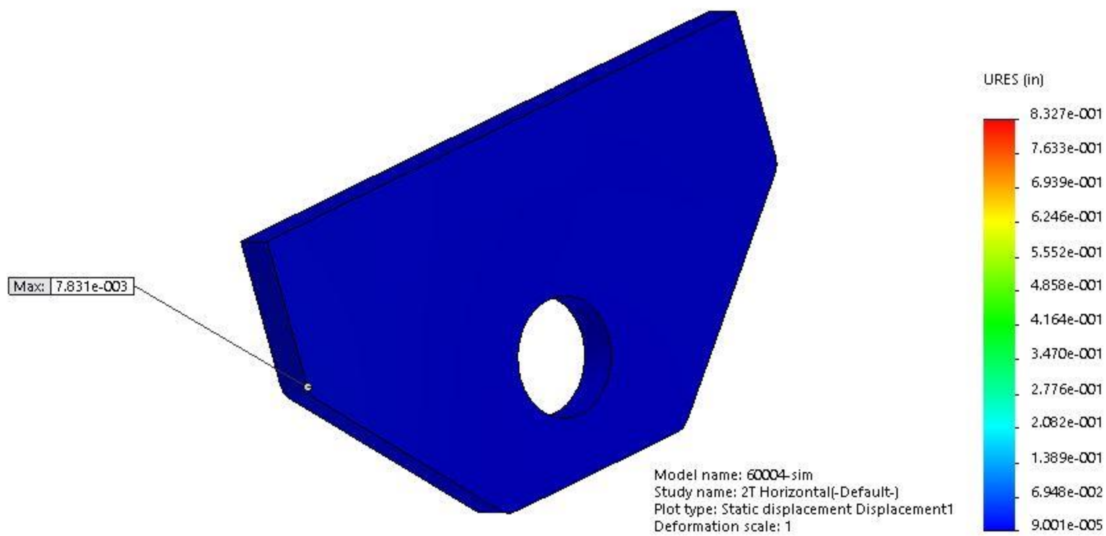


Figure 72: PN#10004 2T Horizontal - Displacement

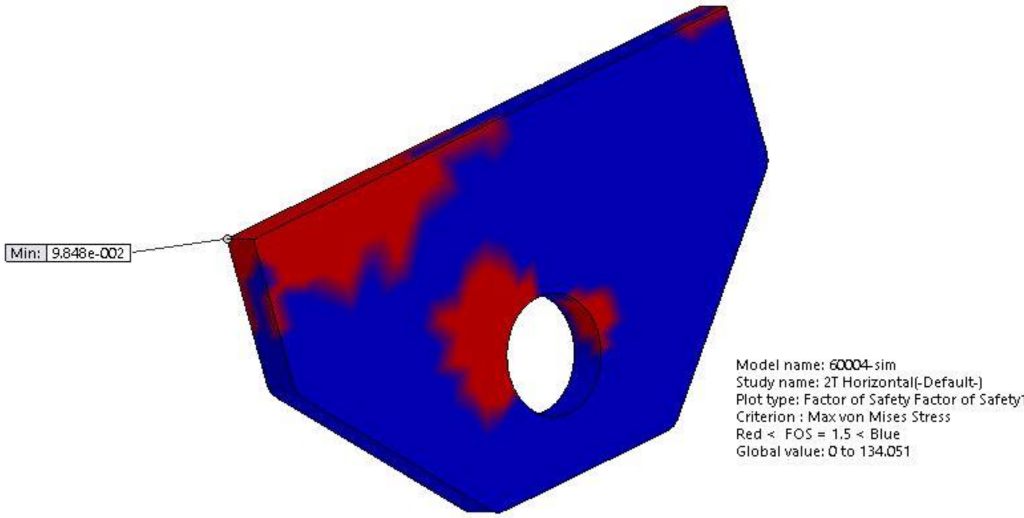


Figure 73: PN#10004 2T Horizontal - F.O.S.

PT# 10004 – Original 2T Angled Loading

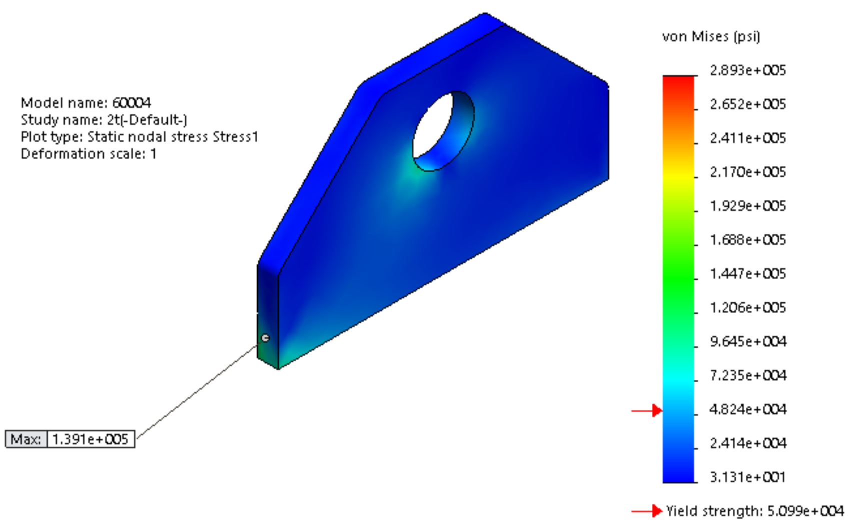


Figure 74: PN#10004 2T Angled Up - Von Misses Stress

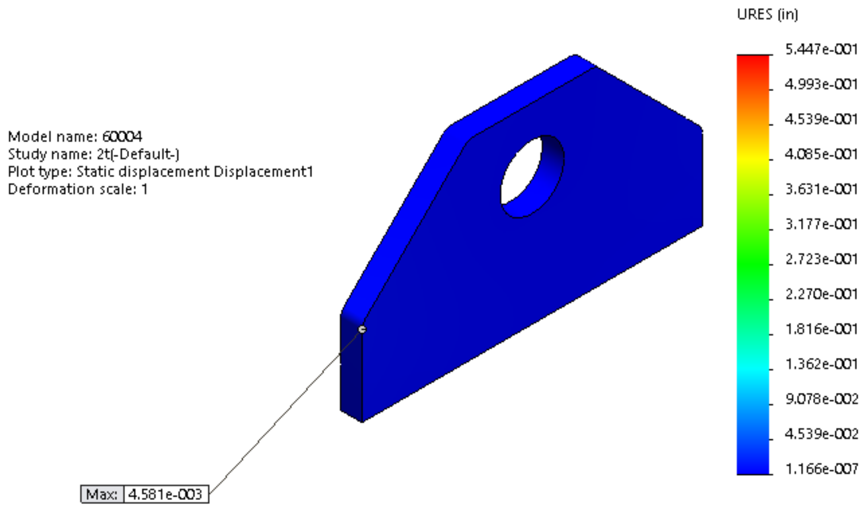


Figure 75: PN#10004 2T Angled Up - Displacement

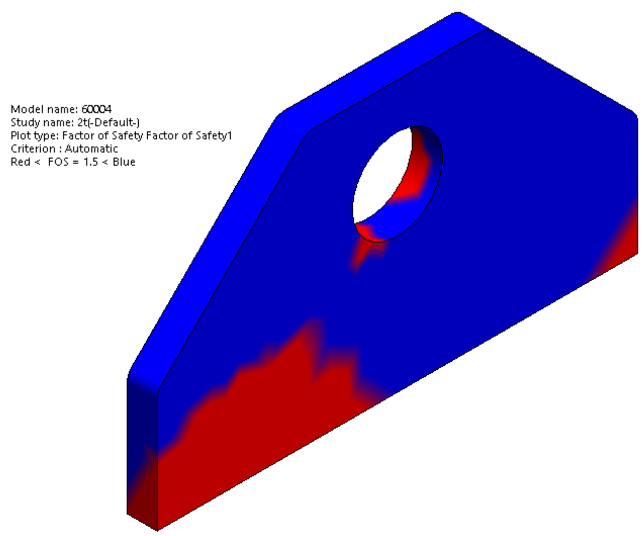


Figure 76: PN#10004 2T Angled Up - F.O.S.

PT# 10005 – Original 2T Horizontal Loading

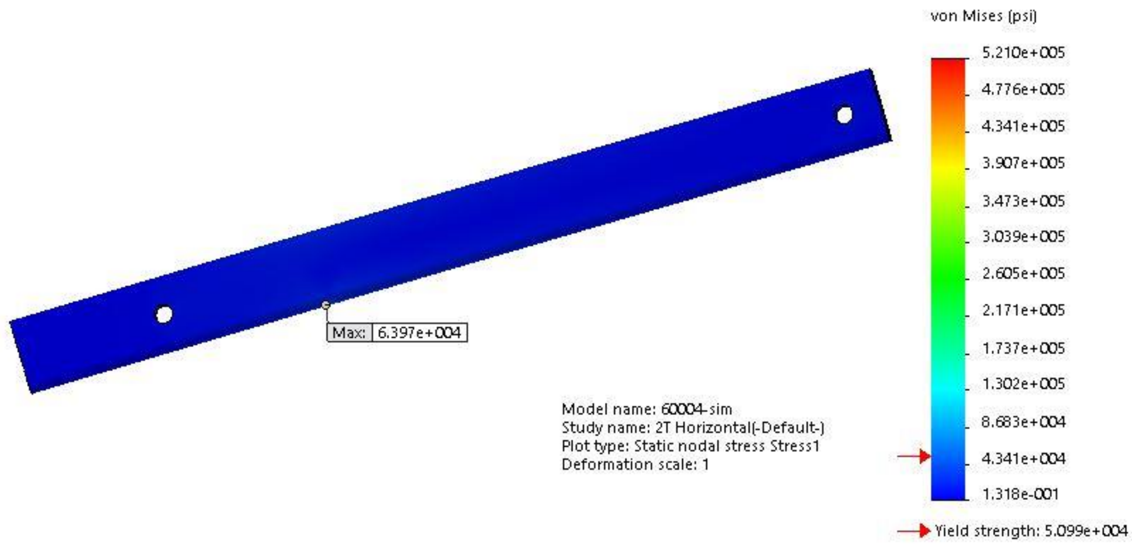


Figure 77: PN#10005 Horizontal - Von Misses Stress

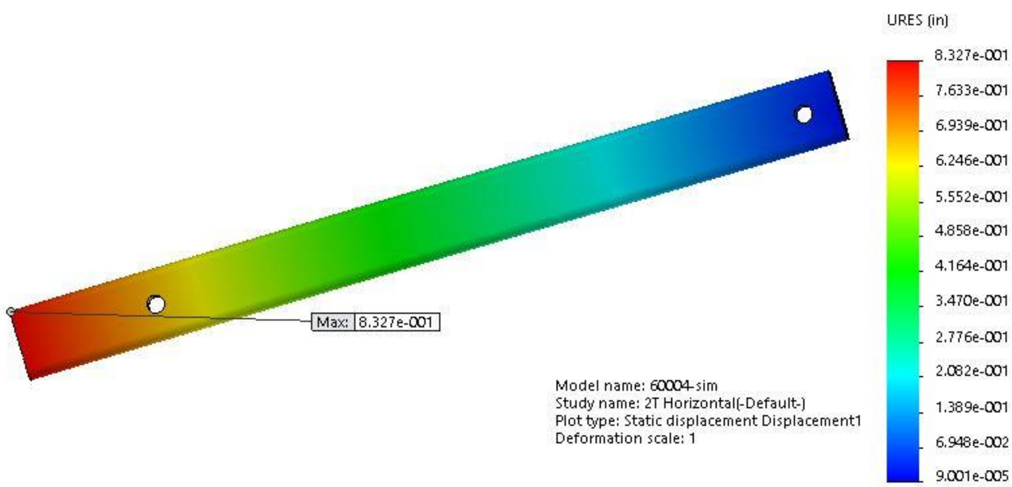


Figure 78: PN#10005 Horizontal - Displacement

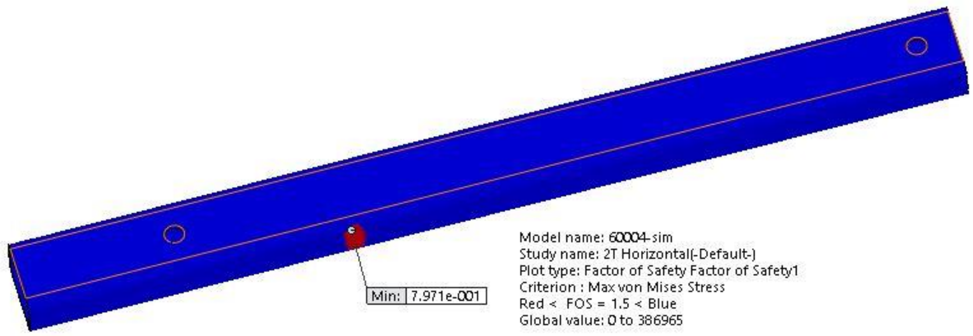


Figure 79: PN#10005 Horizontal - F.O.S.

PT# 10005 – Original 2T Angled Loading

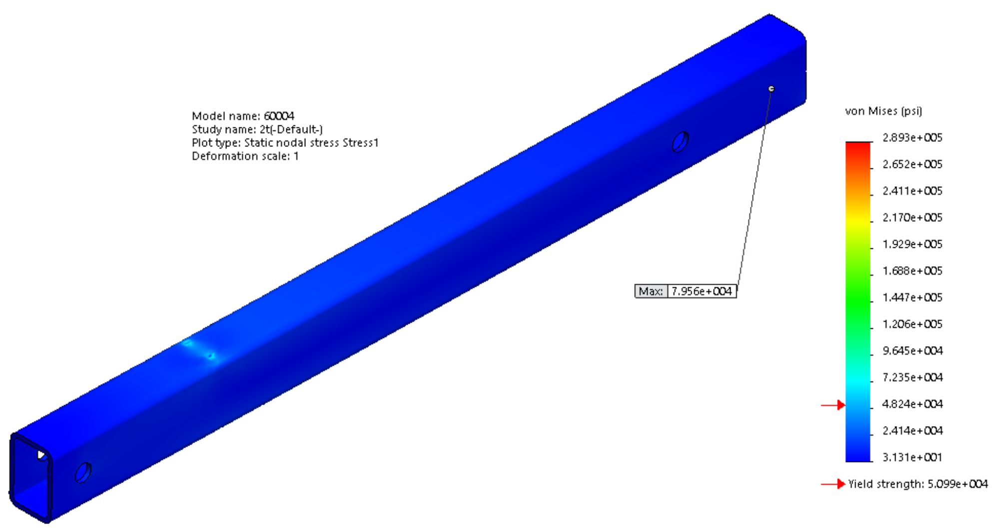


Figure 80: PN#10005 Angled Up - Von Misses Stress

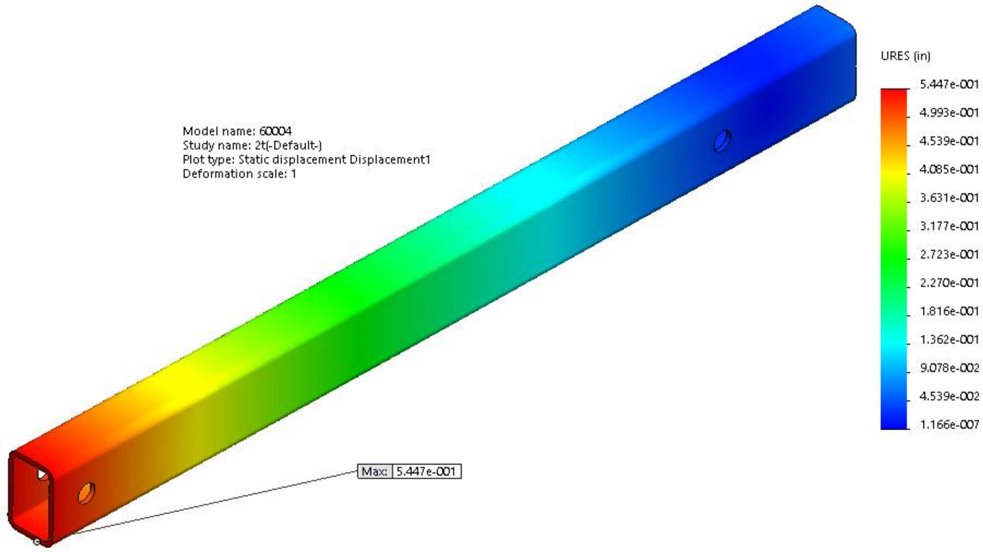


Figure 81: PN#10005 Angled Up - Displacement

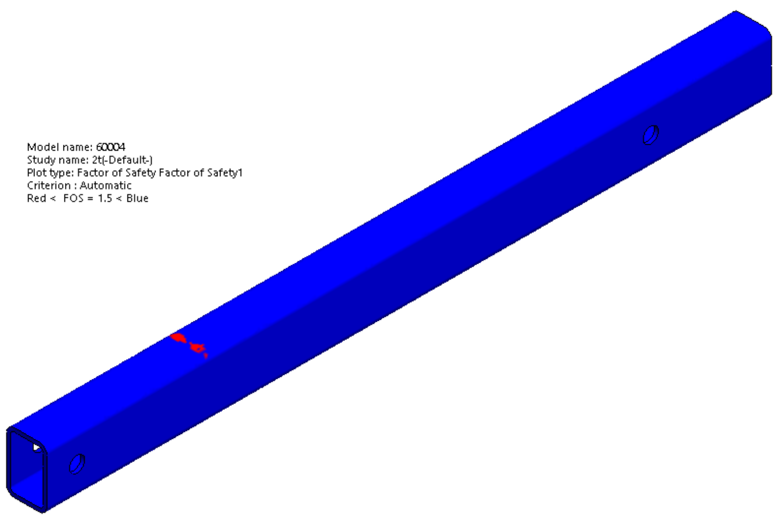


Figure 82: PN#10005 Angled Up - F.O.S.

PN#10016 2T loading

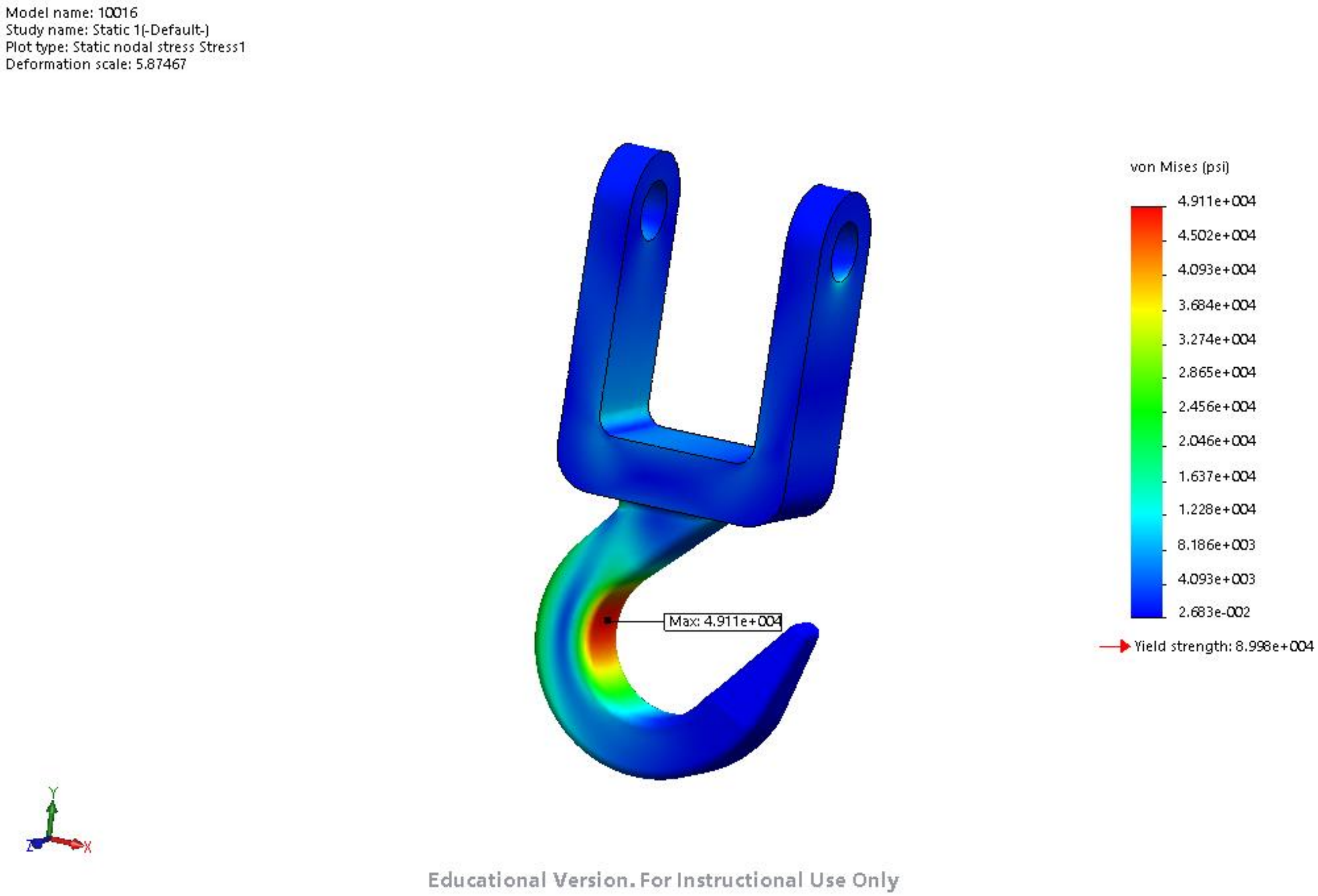


Figure 83: PN#10016 2T - Von Misses Stress

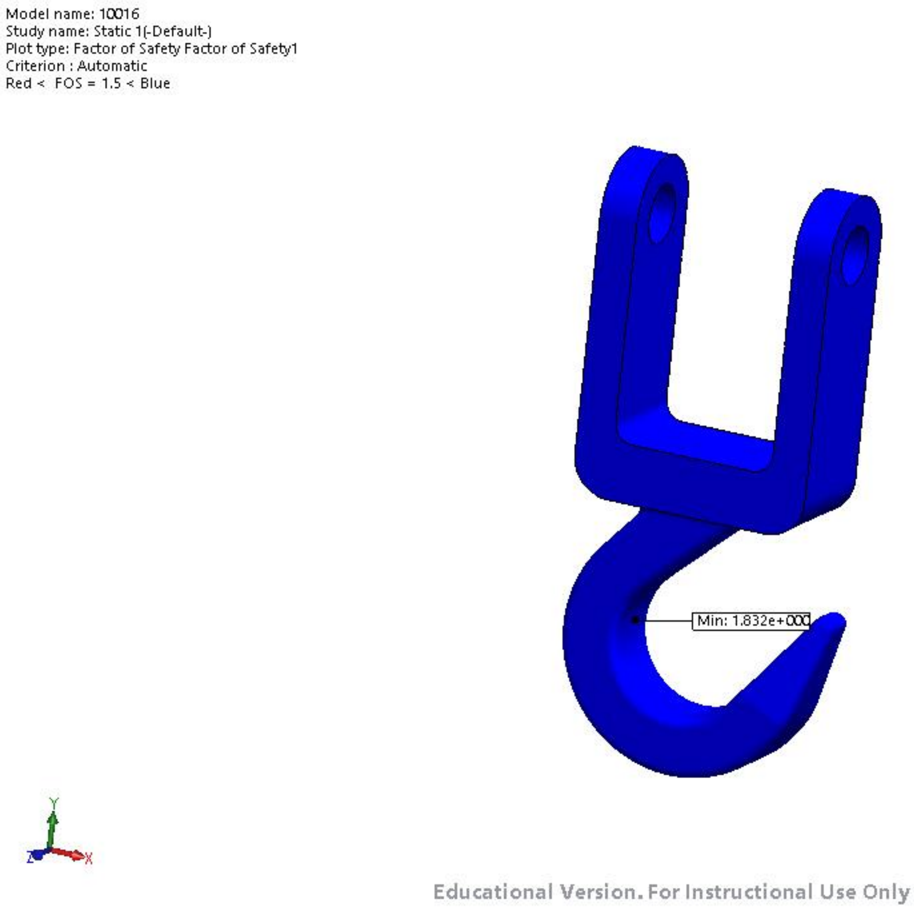


Figure 84: PN#10016 2T - F.O.S.

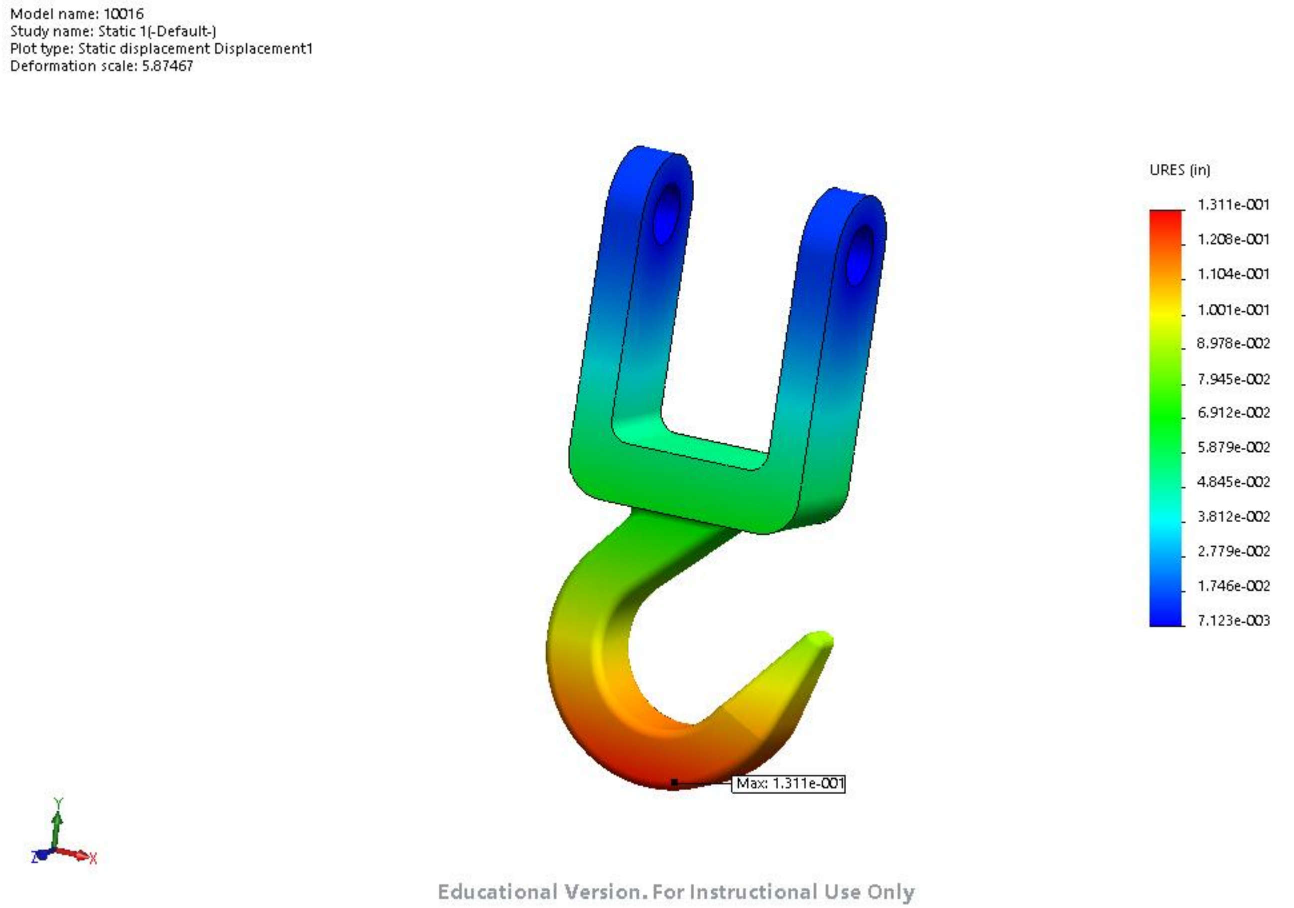


Figure 85P: PN#10016 2T - Displacement

3.2.3 Original Design - Maximum stress, minimum factor of safety, and maximum displacement tables:

Table 6: Half Ton Loading Table

Loading	FEA results	PN#10001	PN#10002	PN#10003	PN#10004	PN#10005	PN#10006	PN#10007	PN#10008	PN#10009	PN#10010	PN#10011	PN#10012	PN#10013	PN#10014	PN#10015
0.5 T level	Maximum Stress (psi)	N/A	N/A	N/A	N/A	N/A	51761	57512	24626	15334	57331	N/A	N/A	4.73E+05	9.27E+04	5.69E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	0.98152	0.8862	2.0706	3.3254	0.65964	N/A	N/A	0.10788	0.37857	0.89702
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.18294	0.008221	0.033349	0.23605	0.021923	N/A	N/A	0.22736	0.002697	0.79527
	Location of failure	N/A	N/A	N/A	N/A	N/A	bolt holes, contact point with PN#10009	Back flanges where it bolts to PN#10008	Bolt/pin holes	contact area with PN#10006	Corners of welded attachment point to PN#10006	N/A	N/A	Areas where it contacts PN#10015, bottom of part near where it is welded to PN#10014	Area where it is welded to PN#10013	Bottom area of contact between PN#10015 and PN#10013
0.5 up	Maximum Stress (psi)	N/A	N/A	N/A	N/A	N/A	43002	67966	29106	13679	65674	N/A	N/A	1.36E+05	4.86E+04	1.37E+05
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	1.174	0.75	1.75	3.727	0.538	N/A	N/A	0.37519	0.82705	0.37211
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.16246	0.00971	0.046498	0.2044	0.020718	N/A	N/A	0.16559	0.00162	0.49062
	Location of failure	N/A	N/A	N/A	N/A	N/A	bolt holes, contact point with PN#10009	Back flanges where it bolts to PN#10008	Bolt/pin holes	contact area with PN#10006	Corners of welded attachment point to PN#10006	N/A	N/A	Areas where it contacts PN#10015, bottom of part near where it is welded to PN#10014, areas around pin holes	Area where it is welded to PN#10013	Bottom area of contact between PN#10015 and PN#10013

Table 7: 1 Ton Loading Table

Loading	FEA results	PN#10001	PN#10002	PN#10003	PN#10004	PN#10005	PN#10006	PN#10007	PN#10008	PN#10009	PN#10010	PN#10011	PN#10012	PN#10013	PN#10014	PN#10015
1 T level	Maximum Stress (psi)	N/A	N/A	N/A	N/A	N/A	89838	99276	42510	26246	100320	N/A	N/A	4.08E+05	1.57E+05	5.62E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	0.56759	0.51363	1.1995	1.9428	0.32481	N/A	N/A	0.12504	0.22319	0.90618
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.3174	0.014191	0.057901	0.4096	0.038245	N/A	N/A	0.3398	0.004651	0.80033
	Location of failure	N/A	N/A	N/A	N/A	N/A	bolt holes, contact point with PN#10009, moderate area around bolt holes in middle of beam	Back flanges where it bolts to PN#10008	Bolt/pin holes	contact area with PN#10006	Corners of welded attachment point to PN#10006	N/A	N/A	Areas where it contacts PN#10015, top and bottom of part near where it is welded to PN#10014.	Area where it is welded to PN#10013, pin hole	Bottom area of contact between PN#10015 and PN#10013
1 T up	Maximum Stress (psi)	N/A	N/A	N/A	N/A	N/A	93274	117350	49861	22469	1.13E+05	N/A	N/A	2.48E+05	8.56E+04	5.59E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	0.54668	0.43452	1.0226	2.2694	0.31414	N/A	N/A	0.20591	0.43239	0.91242
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.28165	0.01685	0.080902	0.35433	0.036426	N/A	N/A	0.27014	0.002756	0.56046
	Location of failure	N/A	N/A	N/A	N/A	N/A	bolt holes, contact point with PN#10009, moderate area around bolt holes in middle of beam	Back flanges where it bolts to PN#10008	Bolt/pin holes	contact area with PN#10006	Corners of welded attachment point to PN#10006	N/A	N/A	Areas where it contacts PN#10015, top and bottom of part near where it is welded to PN#10014, areas around pin holes	Area where it is welded to PN#10013, pin hole	Bottom area of contact between PN#10015 and PN#10013

Table 8: 2 Ton Loading Table

Loading	FEA results	PN#10001	PN#10002	PN#10003	PN#10004	PN#10005	PN#10006	PN#10007	PN#10008	PN#10009	PN#10010	PN#10011	PN#10012	PN#10013	PN#10014	PN#10015
2 T level	Maximum Stress (psi)	N/A	N/A	N/A	N/A	N/A	1.52E+05	1.67E+05	71439	43669	173270	N/A	N/A	5.21E+05	2.60E+05	6.40E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	0.33444	0.30563	0.71377	1.1677	0.18806	N/A	N/A	0.097877	0.13568	0.79713
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.023849	0.53797	0.097975	0.69443	0.065844	N/A	N/A	0.50819	0.007777	0.83272
	Location of failure	N/A	N/A	N/A	N/A	N/A	bolt holes, contact point with PN#10009, large area around bolt holes in middle of beam	Back flanges where it bolts to PN#10008	Bolt/pin holes	contact area with PN#10006	Corners of welded attachment point to PN#10006	N/A	N/A	Areas where it contacts PN#10015, top and bottom of part near where it is welded to PN#10014, areas around pin holes	Area where it is welded to PN#10013, pin hole	Bottom area of contact between PN#10015 and PN#10013
2 T up	Maximum Stress (psi)	N/A	N/A	N/A	N/A	N/A	1.29E+05	1.99E+05	85022	38676	197140	N/A	N/A	2.89E+05	1.39E+05	7.96E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	0.39164	0.25683	0.6064	1.3184	0.17934	N/A	N/A	0.17626	0.26716	0.64094
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.47675	0.028365	0.13775	0.59965	0.062578	N/A	N/A	0.3802	0.004581	0.54469
	Location of failure	N/A	N/A	N/A	N/A	N/A	bolt holes, contact point with PN#10009, large area around bolt holes in middle of beam	Back flanges where it bolts to PN#10008	Bolt/pin holes	contact area with PN#10006	Corners of welded attachment point to PN#10006	N/A	N/A	Areas where it contacts PN#10015, top and bottom of part near where it is welded to PN#10014, areas around pin holes	Area where it is welded to PN#10013, pin hole	Bottom area of contact between PN#10015 and PN#10013

Table 9: Hook Loading Table

2T loading	PN#10016
Maximum Stress (psi)	4.91E+04
Minimum Safety of factor	1.832
Maximum deflection (in)	0.1311
Location of failure	No failure

3.2.4 Redesign FEA analysis

Redesign FEA Preprocessing

If any preprocessing is not mentioned here then it was never changed from the baseline assessment. That includes the mesh settings (mesh control not needed).

For the post a few factors where changed in the redesign preprocessing. The new support tube (PN#10018) was treated as bonded contact where it connected to the base (PN#10007) and the post (PN#1006). This is because it is assumed to be welded at these points. The mathematical pins where removed because the braces (PN#1008) where removed. The fixture option “on flat faces” was used on each side of the post and support tube to prevent horizontal deflection. Figure 81 shows this setup.

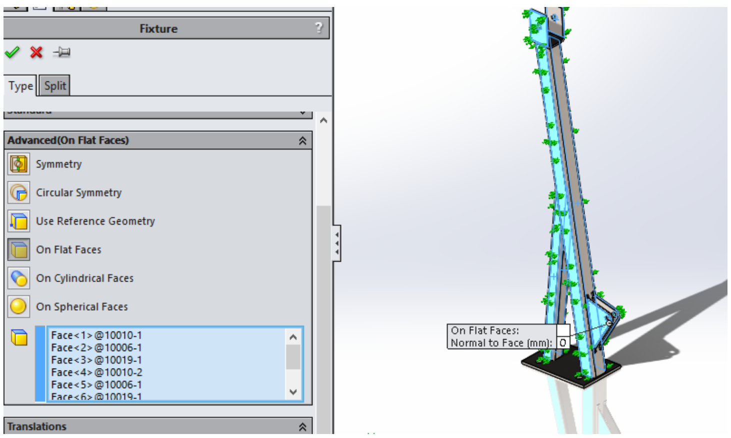


Figure 86: Post - On Flat Faces Fixture

In addition H-adaptive methods where used to observe the difference it makes in this simulation. The settings of the adaptive method are shown in Figure 82.

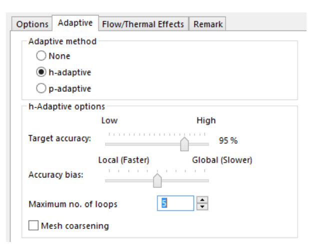


Figure 87: H-Adaptive

Assembly 60003 - Post Assembly – Redesign 2T Horizontal Loading

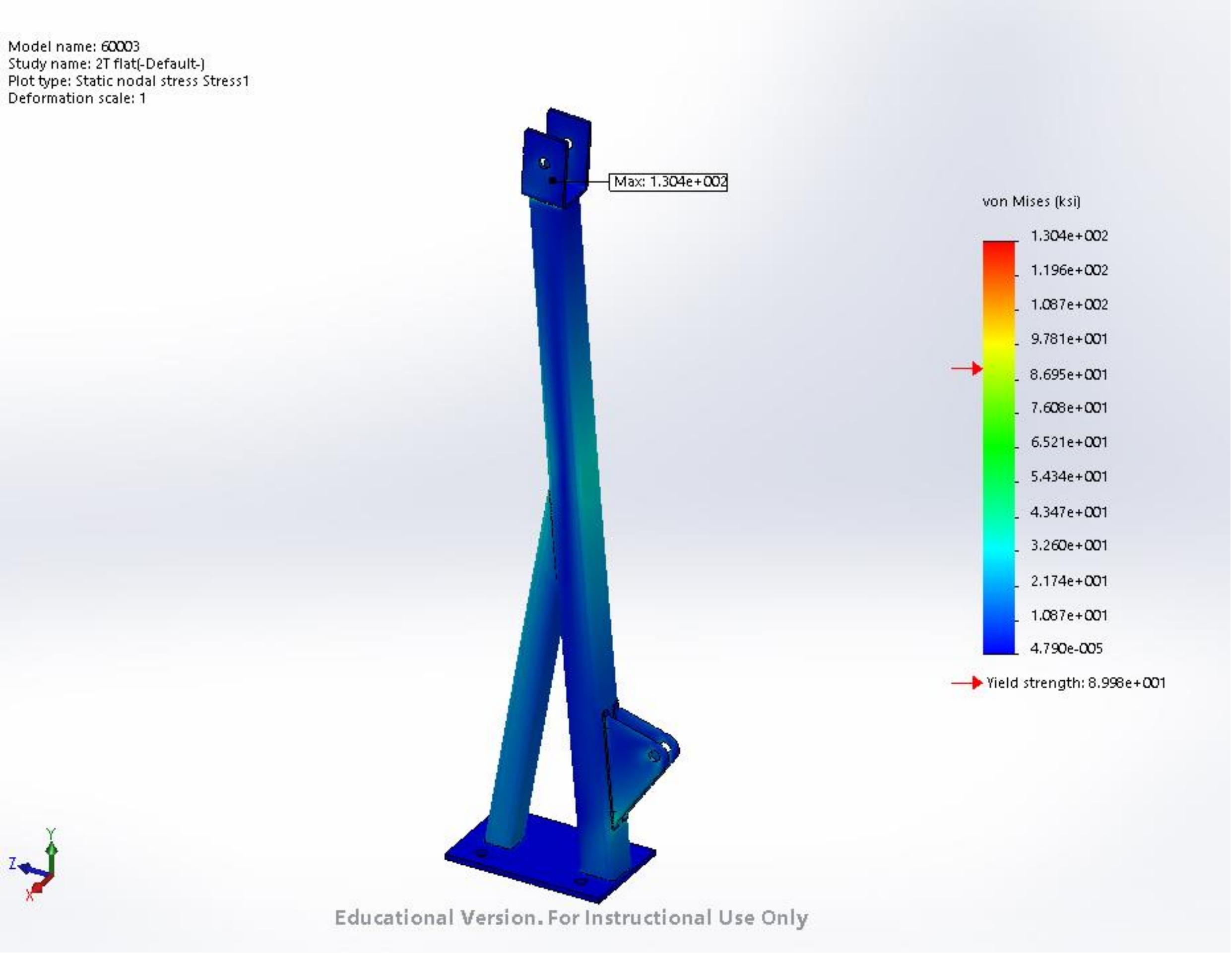


Figure 88: PN#60003 2T Horizontal - Von Misses

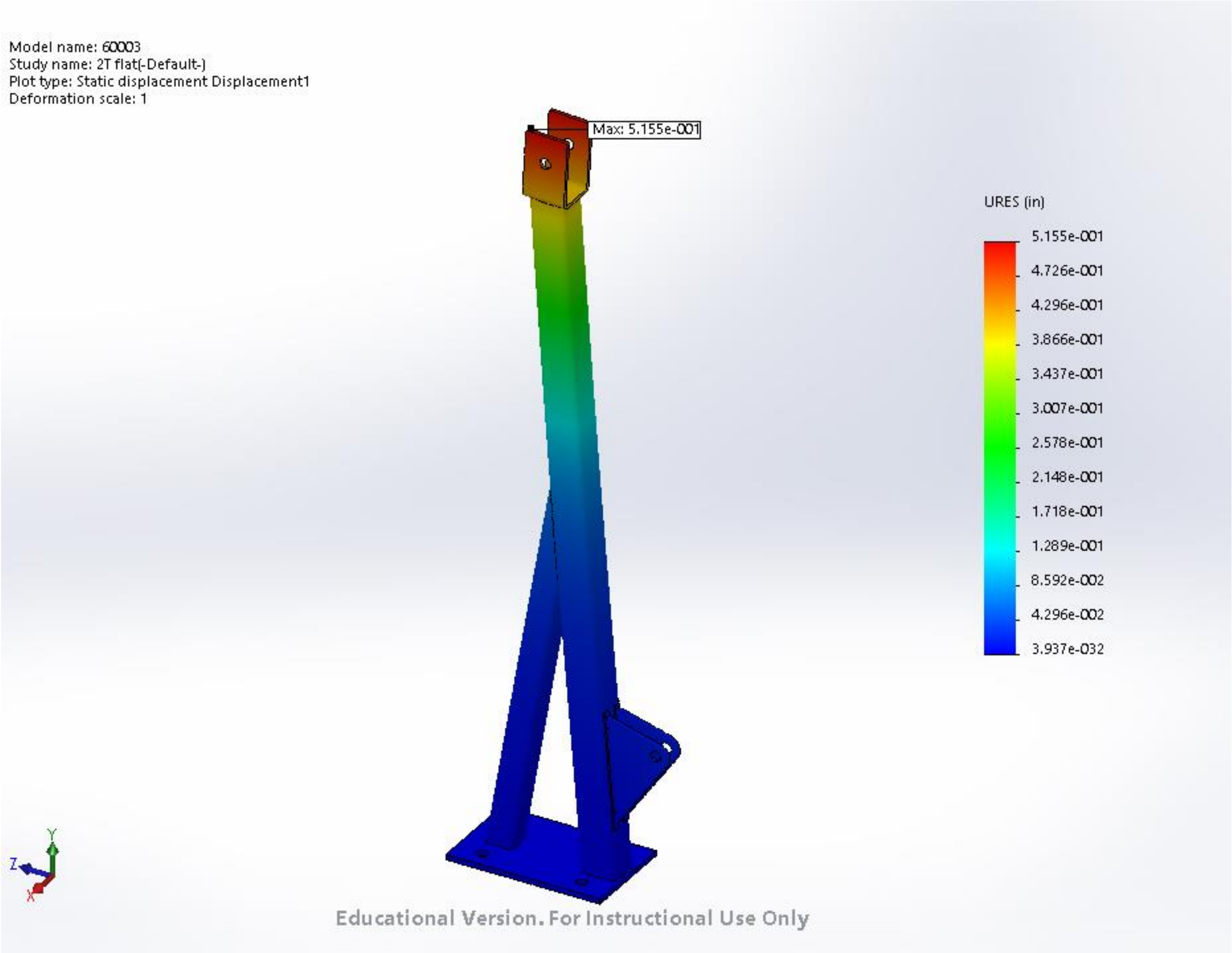


Figure 89: PN#60003 2T Horizontal - Displacement

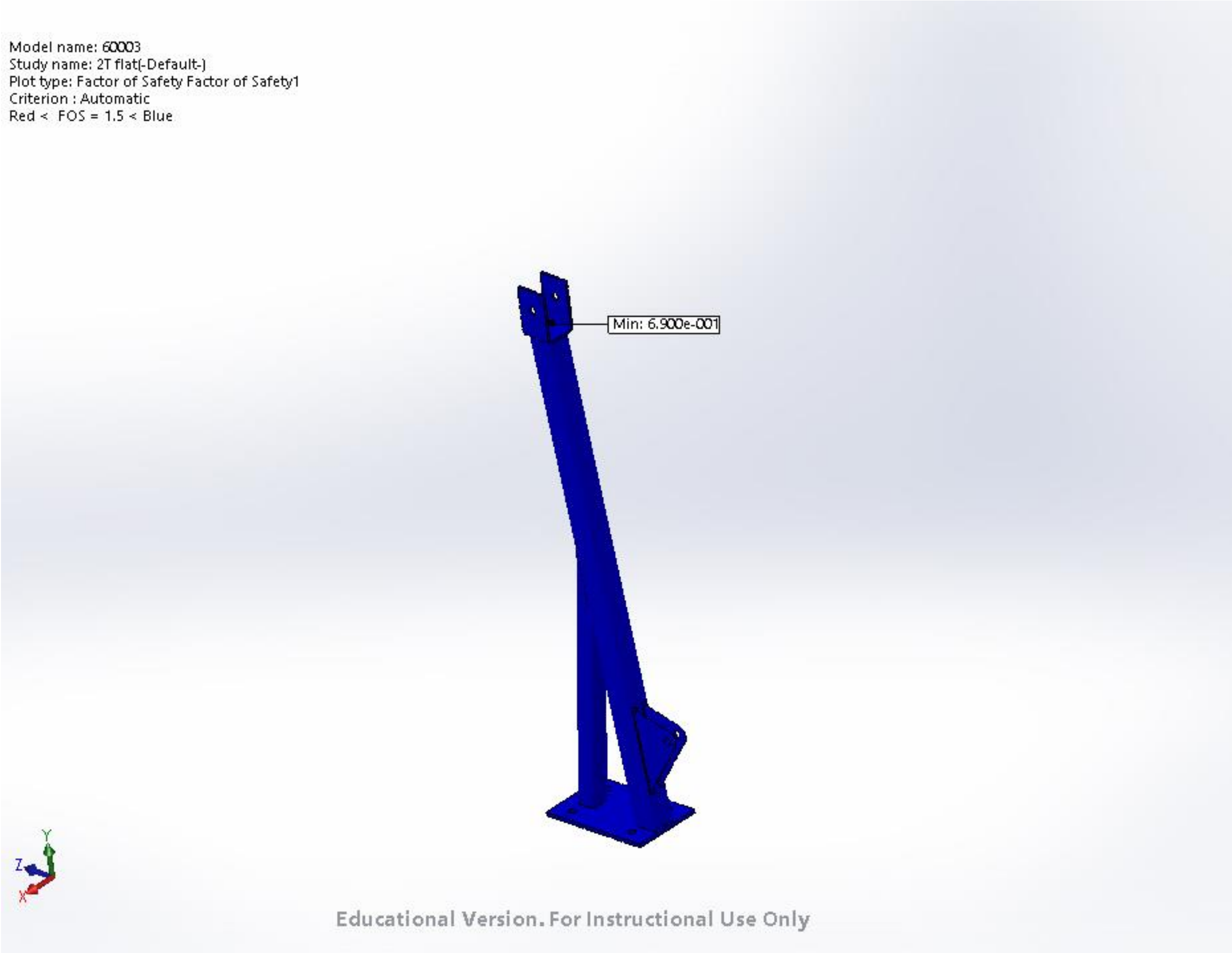


Figure 90: PN#60003 2T Horizontal - F.O.S.

Assembly 60003 - Post Assembly – Redesign 2T Angled Loading

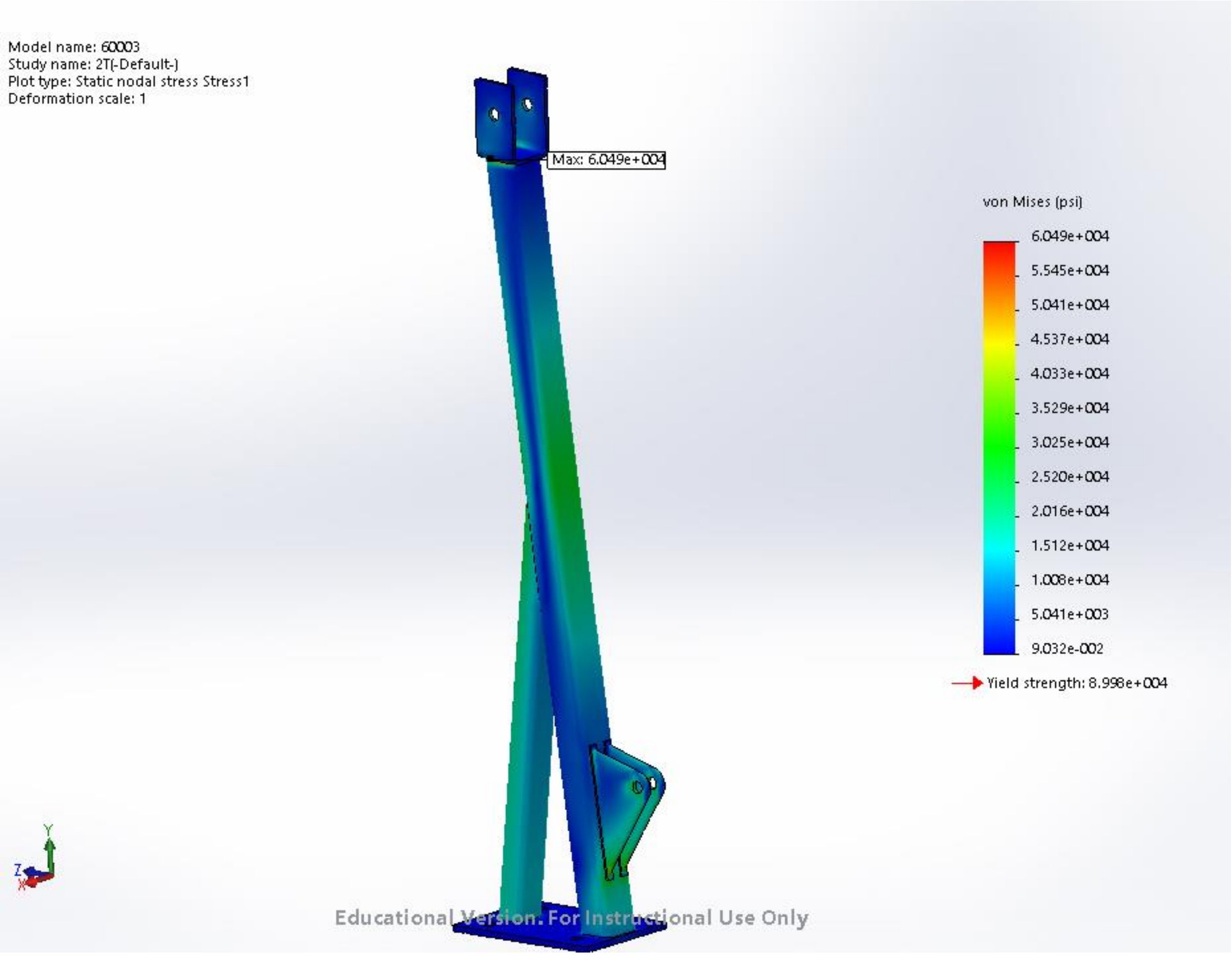


Figure 91: PN#60003 2T Angled Up - Von Misses Stress

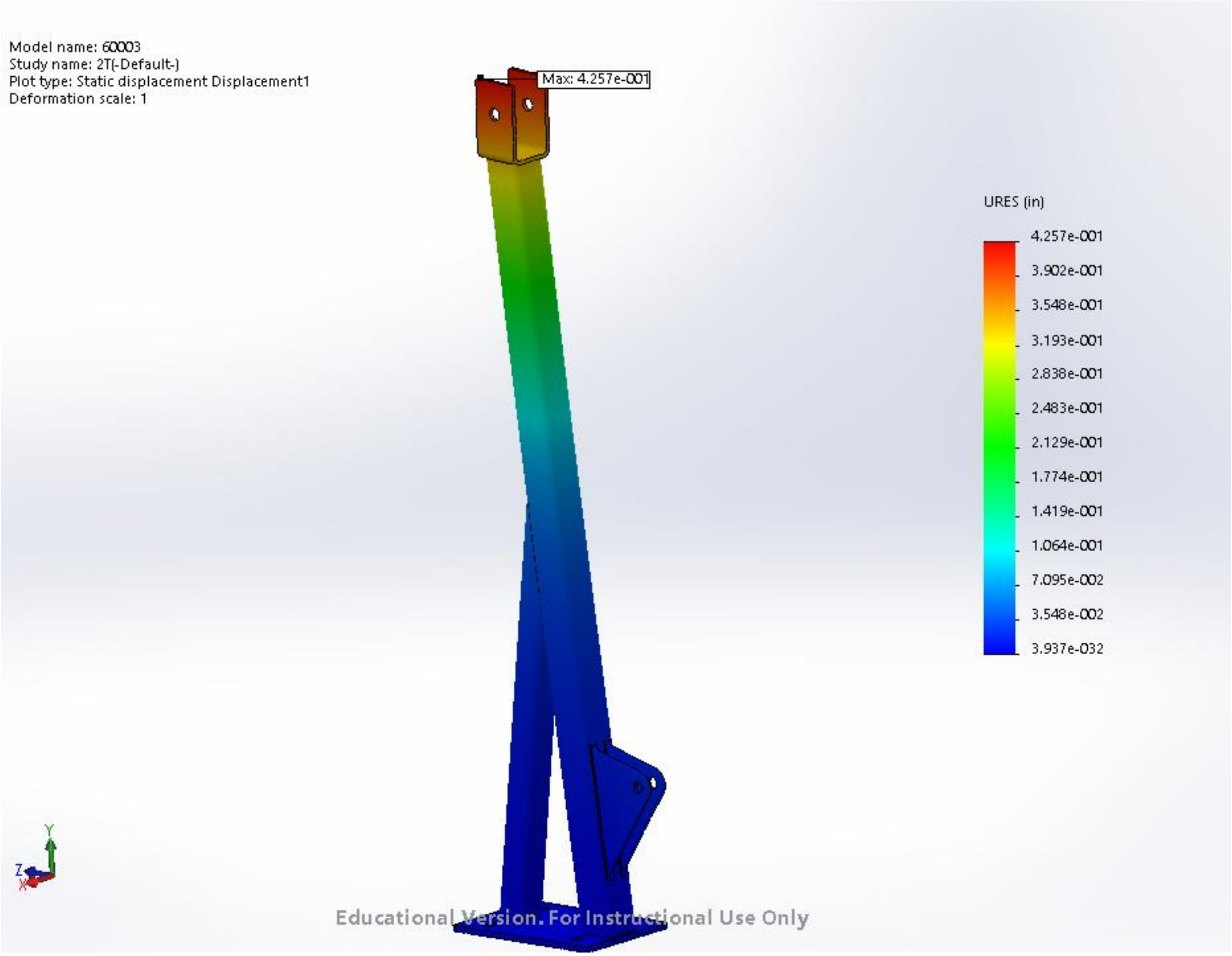


Figure 92: PN#60003 2T Angled Up - Displacement

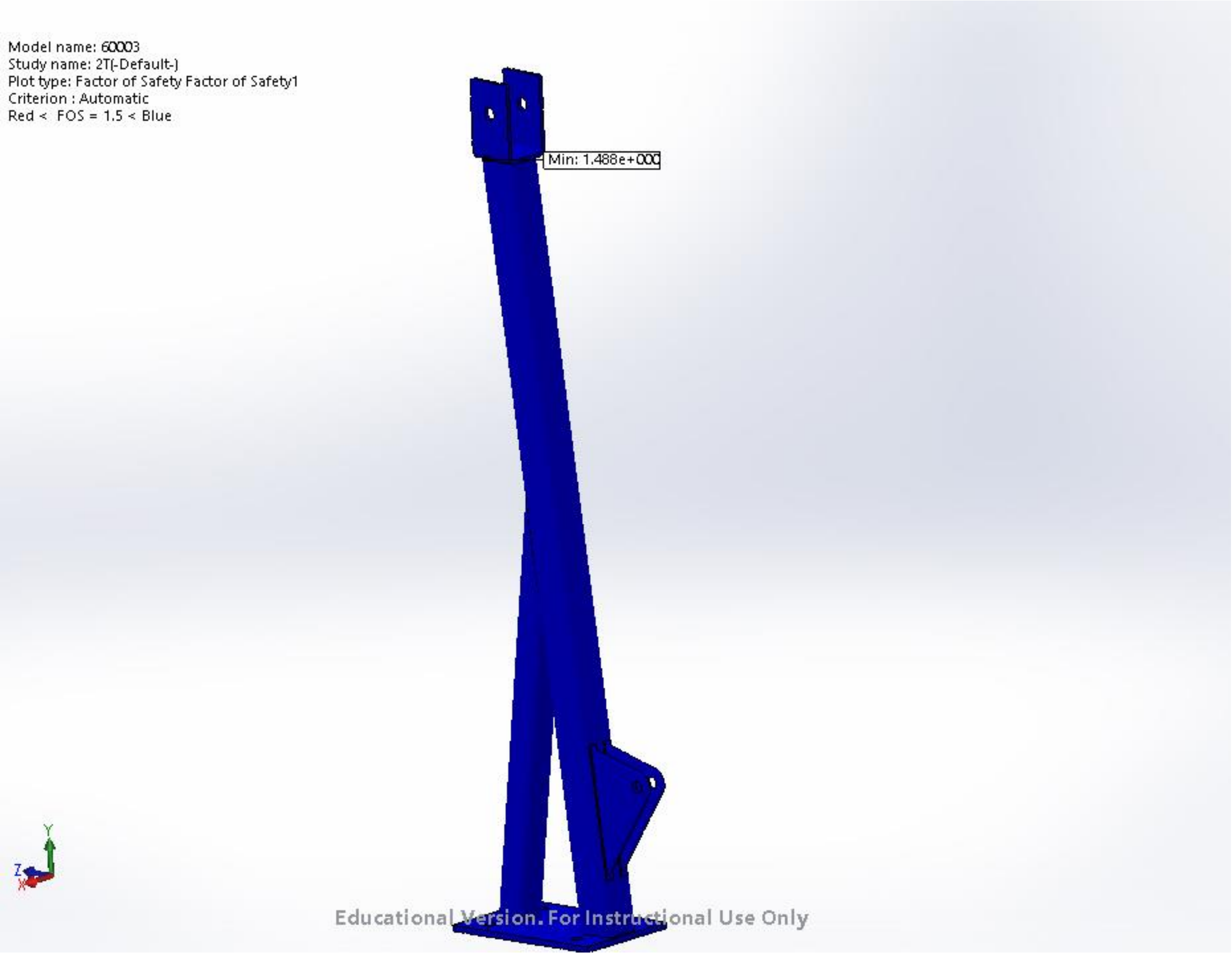


Figure 93: PN#60003 2T Angled Up - F.O.S.

PT# 10006 – Redesign 2T Horizontal Loading

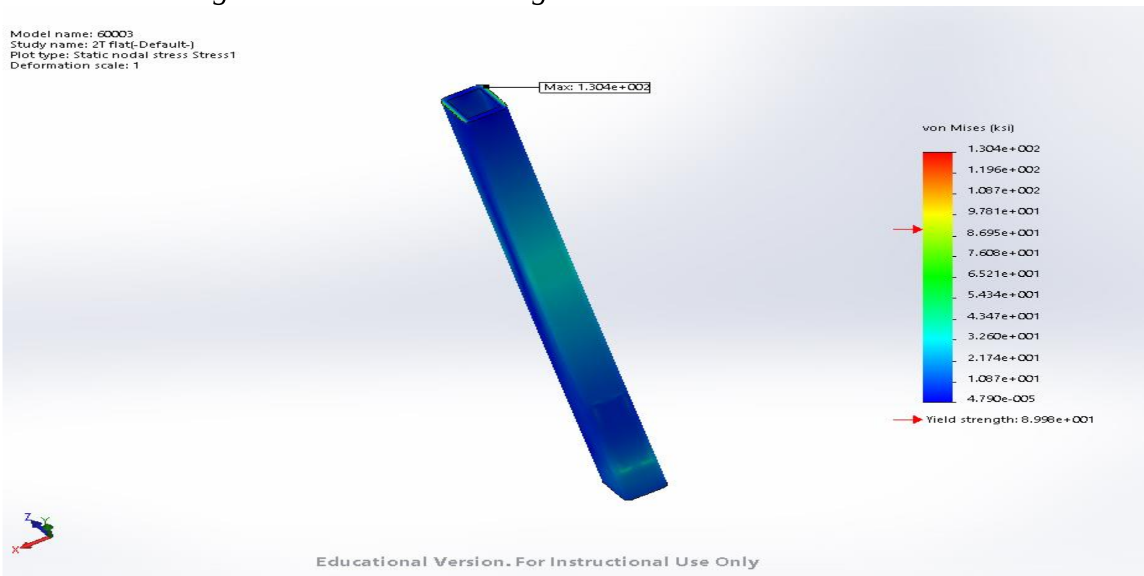


Figure 94: PN#10006 2T Horizontal - Von Misses Stress

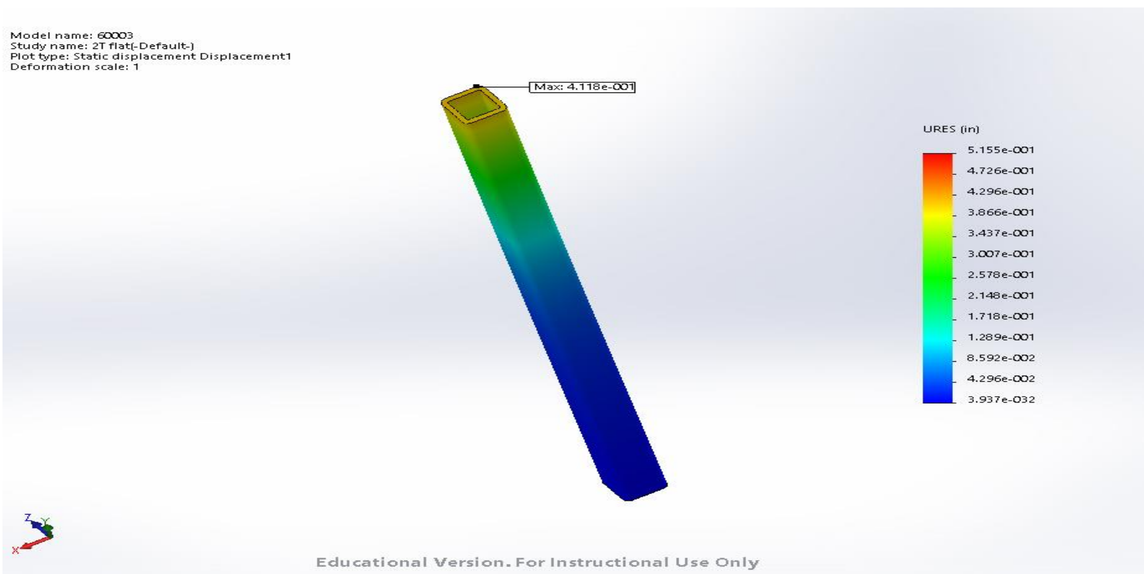


Figure 95: PN#10006 2T Horizontal - Displacement

Figure 96: PN#10006 2T Horizontal - F.O.S.

PT# 10006 – Redesign 2T Angled Loading

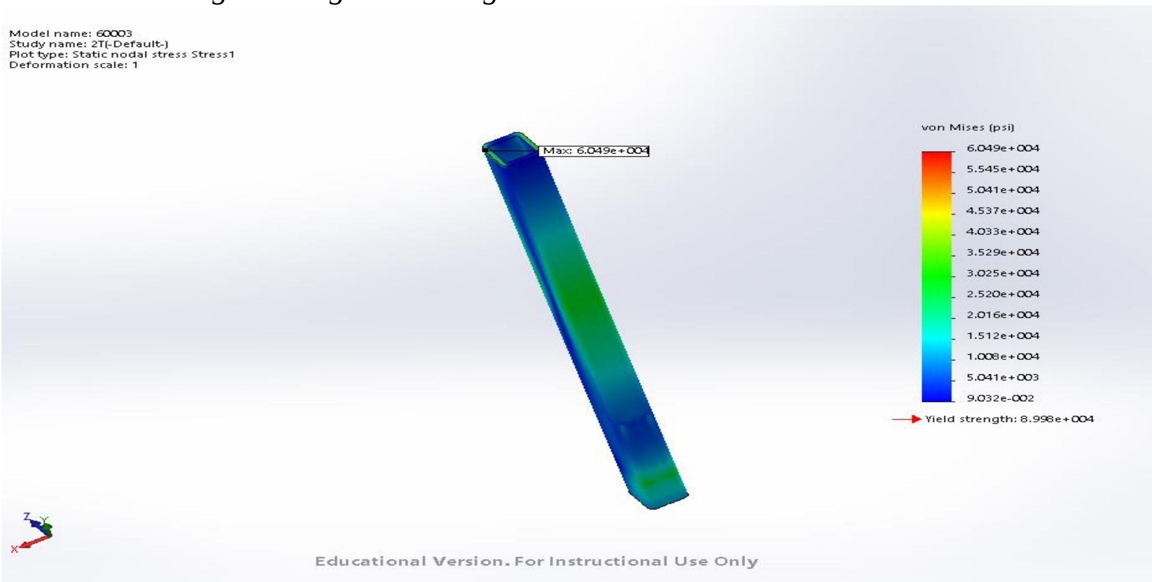


Figure 97: PN#10006 2T Angled Up - Von Misses Stress

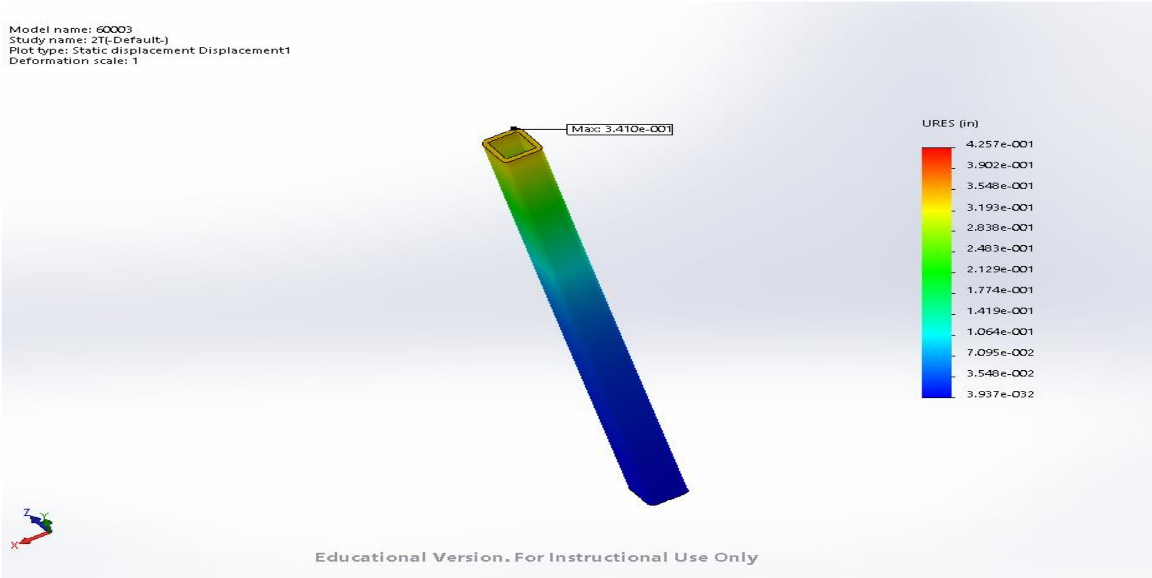


Figure 98: PN#10006 2T Angled Up - Displacement

Figure 99: PN#10006 2T Angled Up - F.O.S.

PT# 10007 – Redesign 2T Horizontal Loading

Figure 100: PN#10007 2T Horizontal - Von Misses Stress

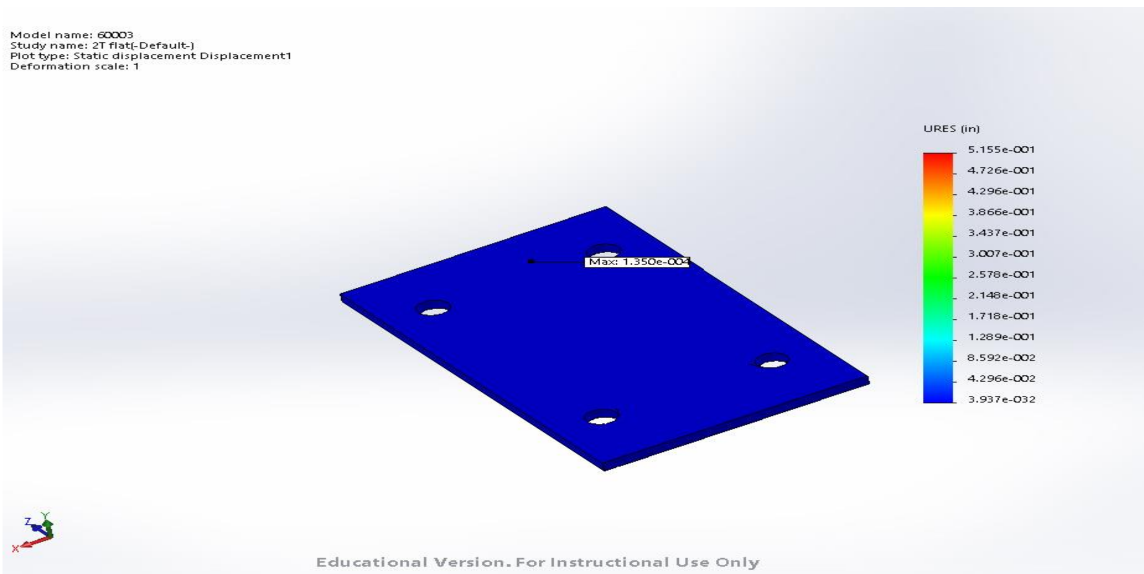


Figure 101: PN#10007 2T Horizontal - Displacement

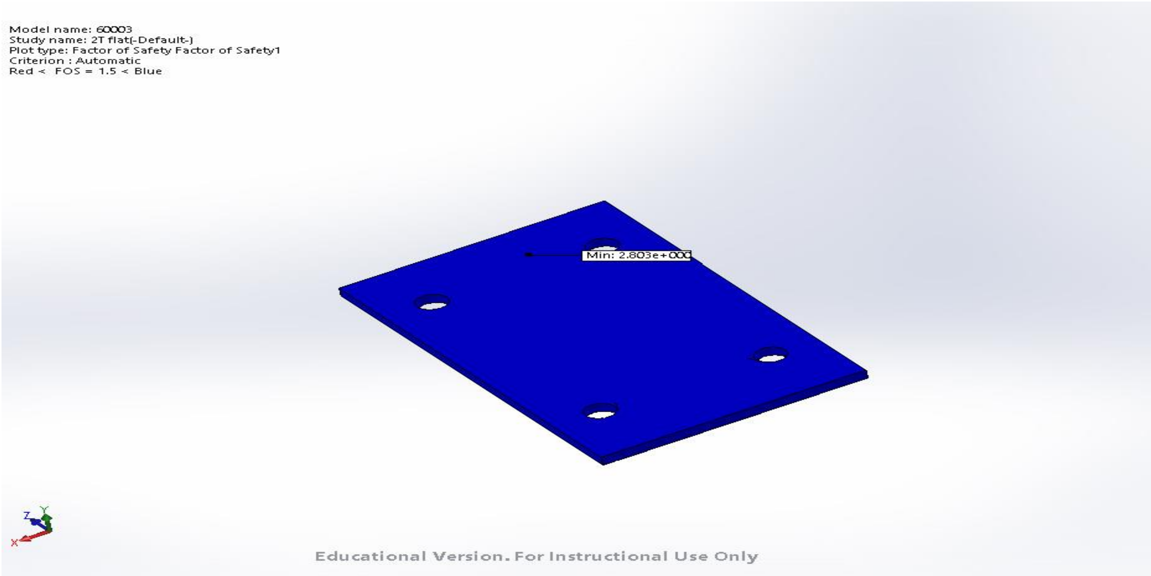


Figure 102: PN#10007 2T Horizontal - F.O.S.

PT# 10007 – Redesign 2T Angled Loading

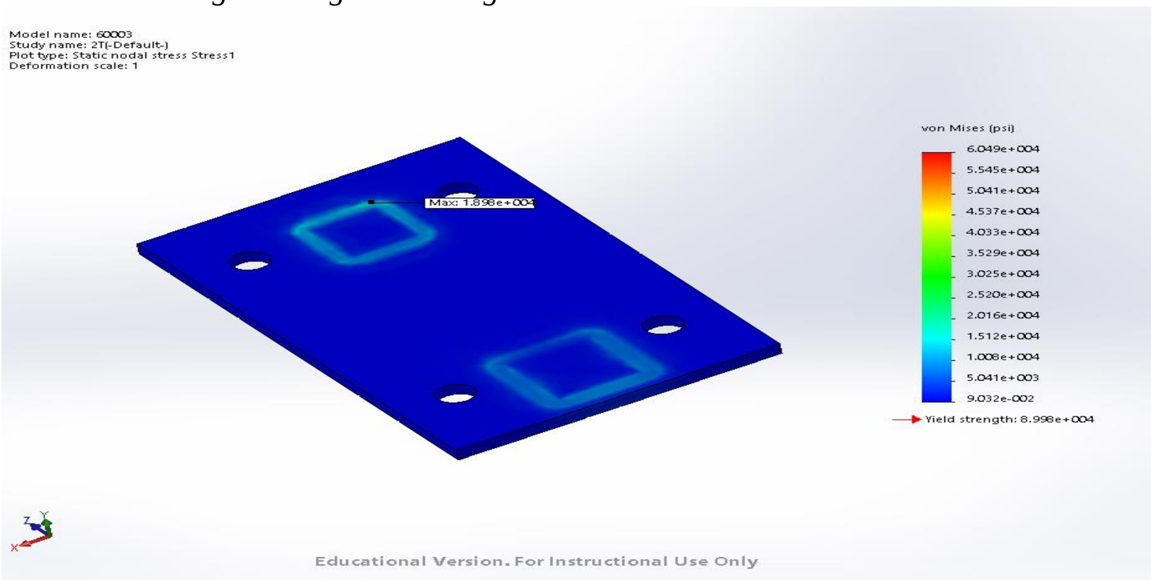


Figure 103: PN#10007 2T Angled Up - Von Misses Stress

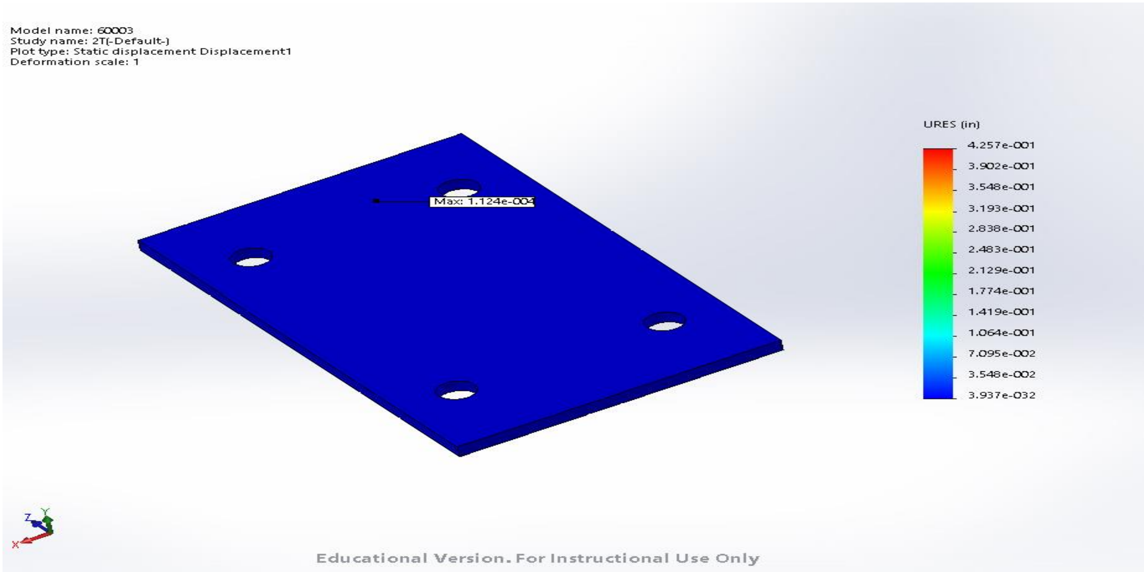


Figure 104: PN#10007 2T Angled Up - Displacement

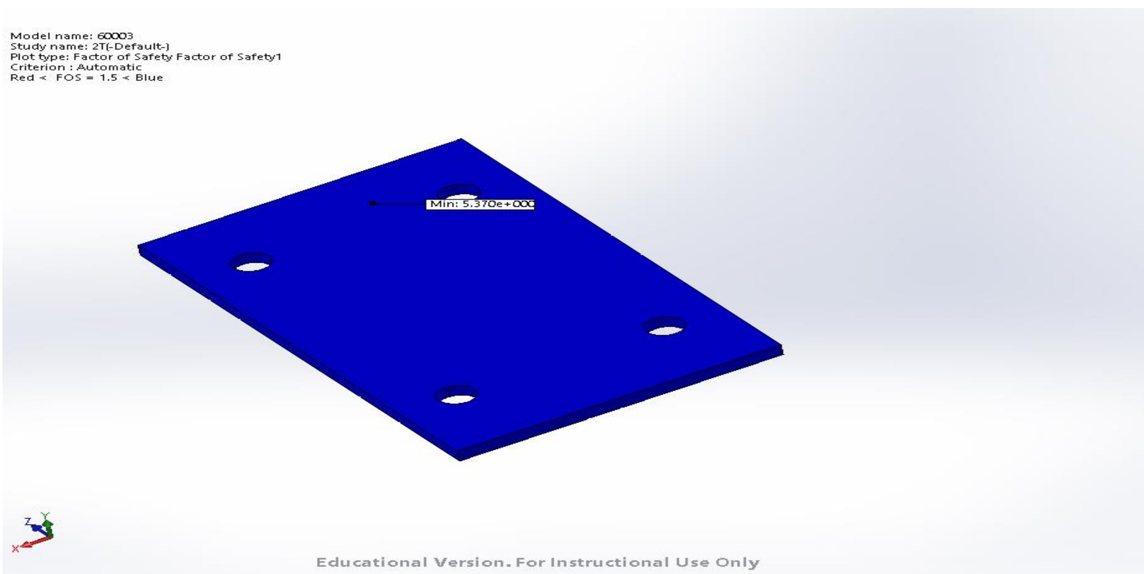


Figure 105: PN#10007 2T Angled Up - F.O.S.

PT# 10009 – Redesign 2T Horizontal Loading

Figure 106: PN#10009 2T Horizontal - Von Misses Stress

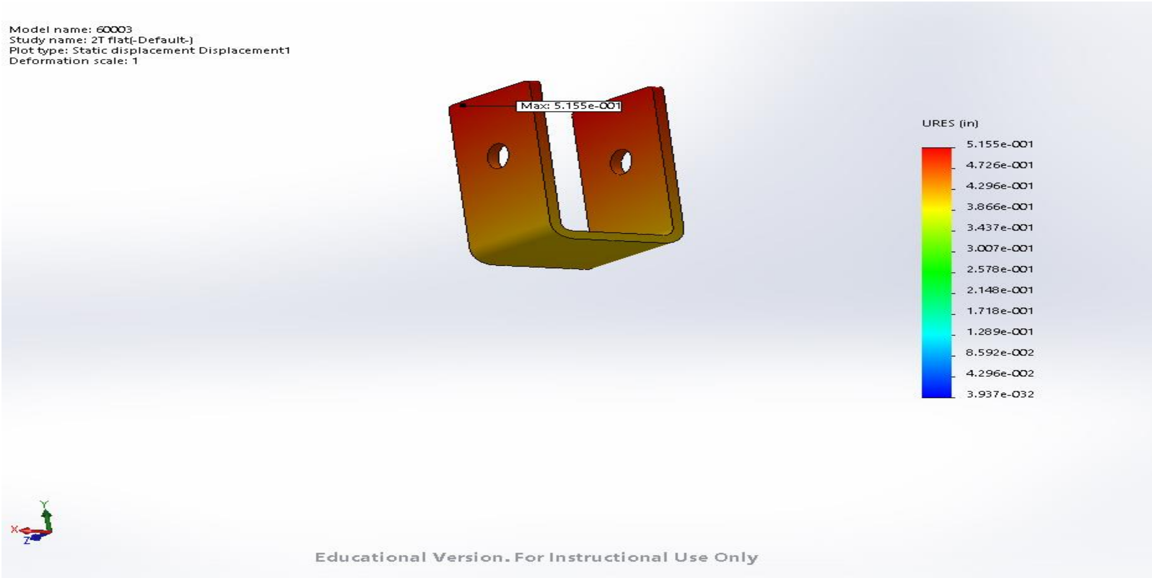


Figure 107: PN#10009 2T Horizontal - Displacement

Figure 108: PN#10009 2T Horizontal - F.O.S.

PT# 10009 – Redesign 2T Angled Loading

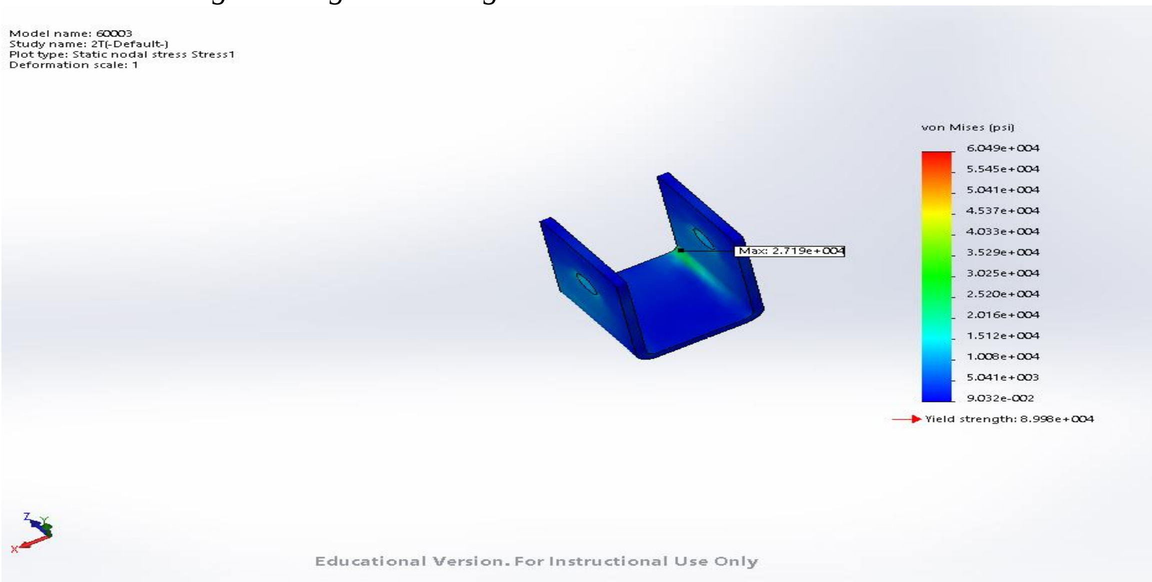


Figure 109: PN#10009 2T Angled Up - Von Misses Stress

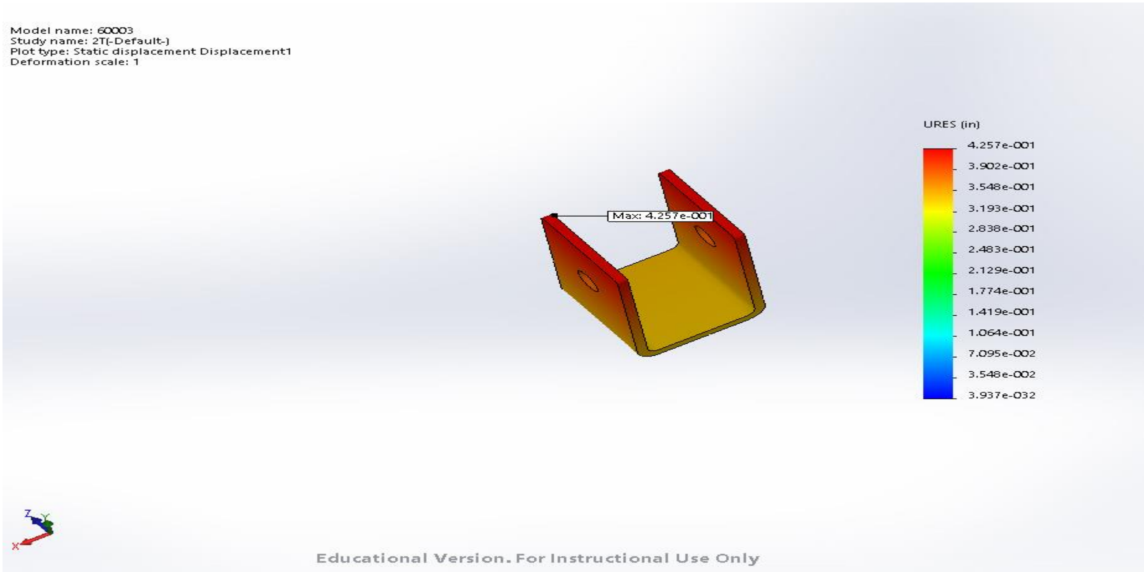


Figure 110: PN#10009 2T Horizontal

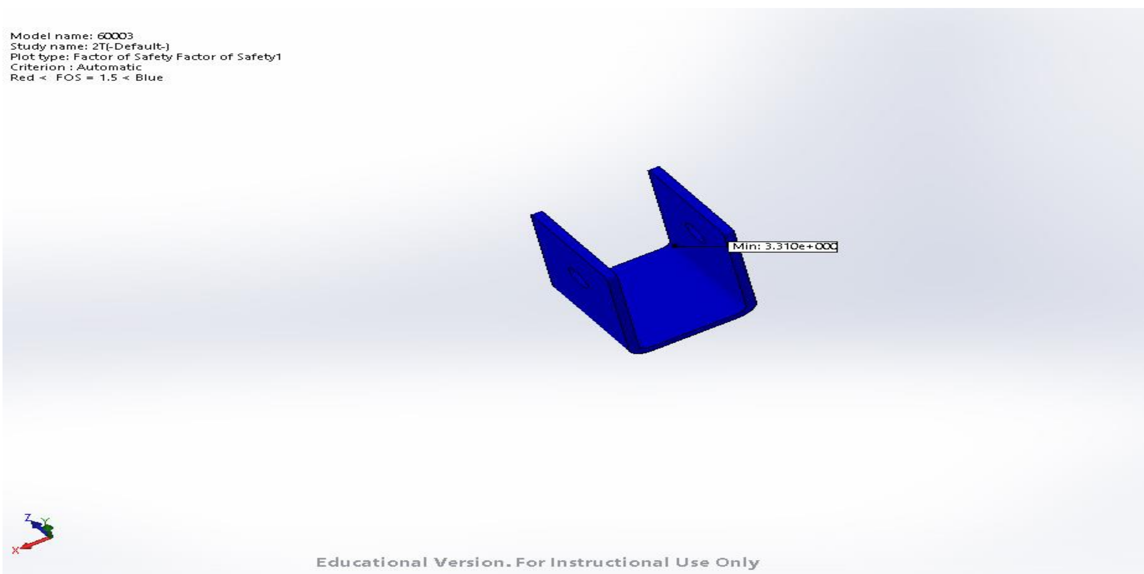


Figure 111: PN#10009 2T Horizontal

PT# 10010 – Redesign 2T Horizontal Loading

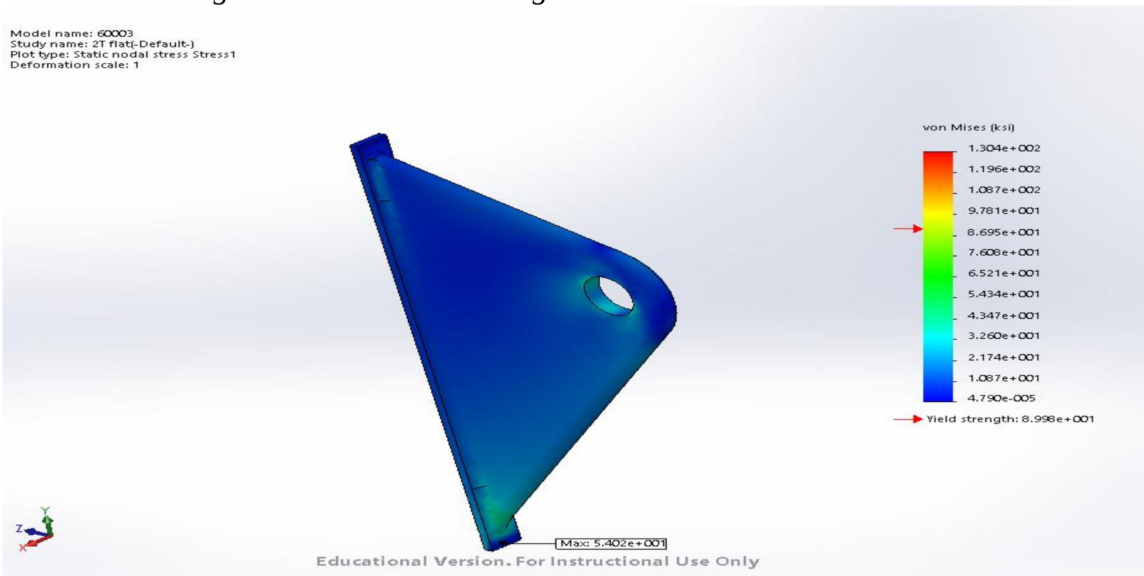


Figure 112: PN#10010 2T Horizontal Von Misses Stress

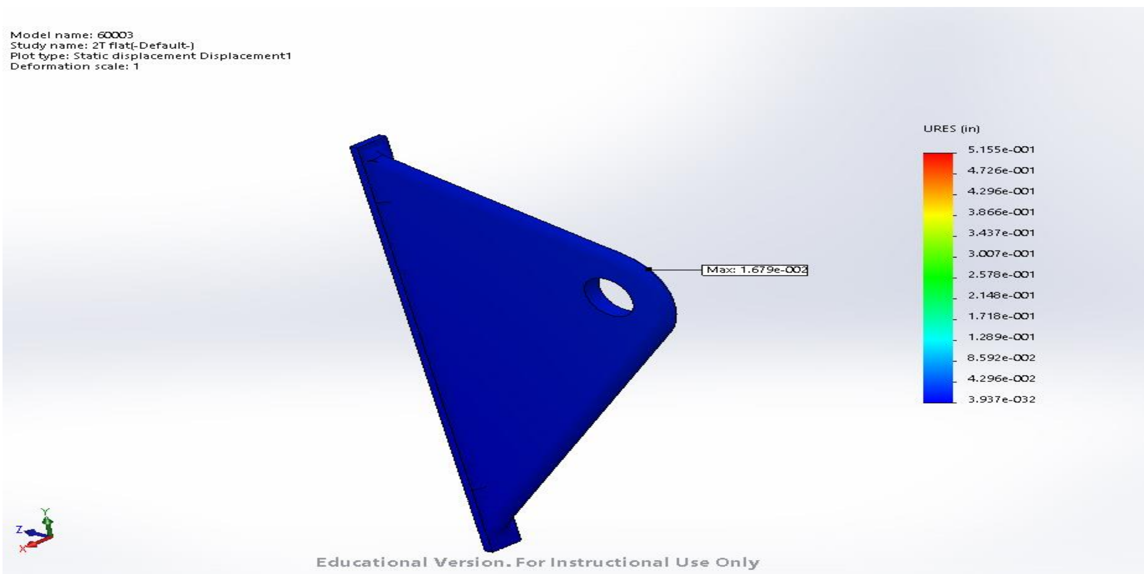


Figure 113: PN#10010 2T Horizontal - Displacement

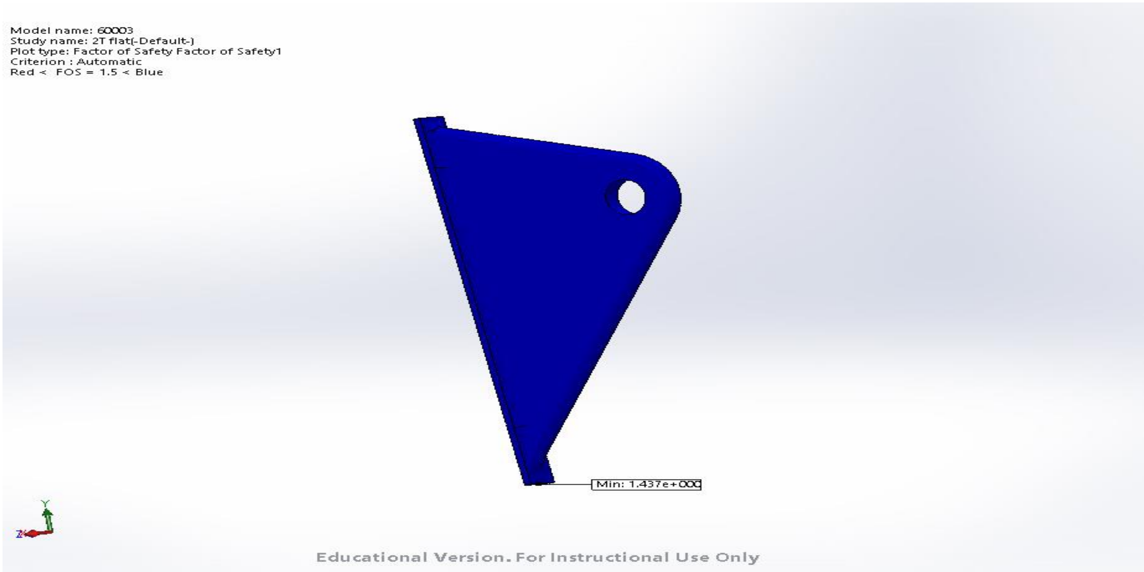


Figure 114: PN#10010 2T Horizontal - F.O.S.

PT# 10010 – Redesign 2T Angled Loading

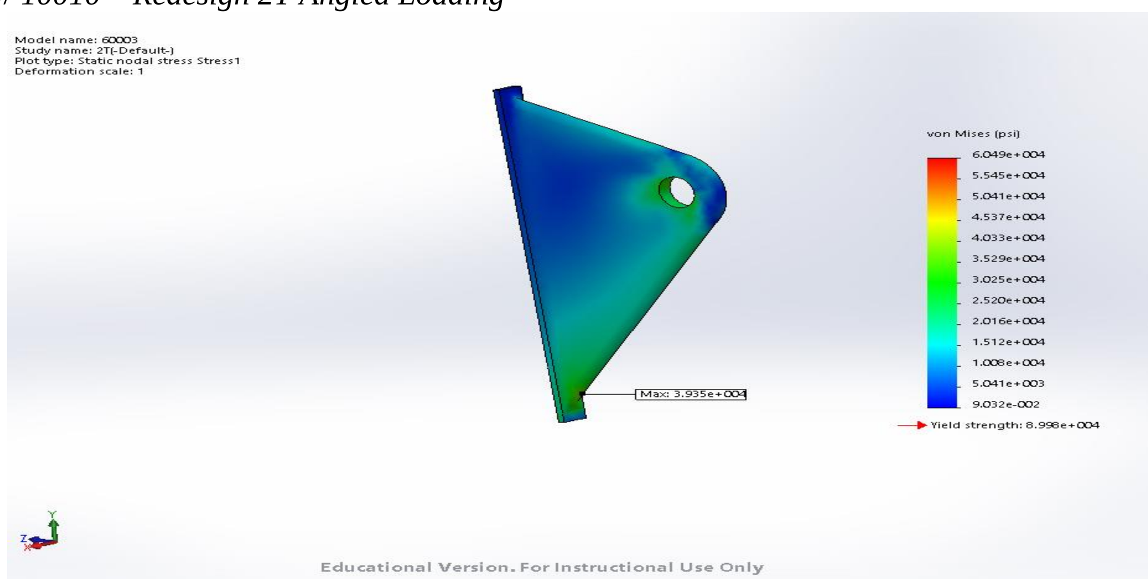


Figure 115: PN#10010 2T Angled Up - Von Misses Stress

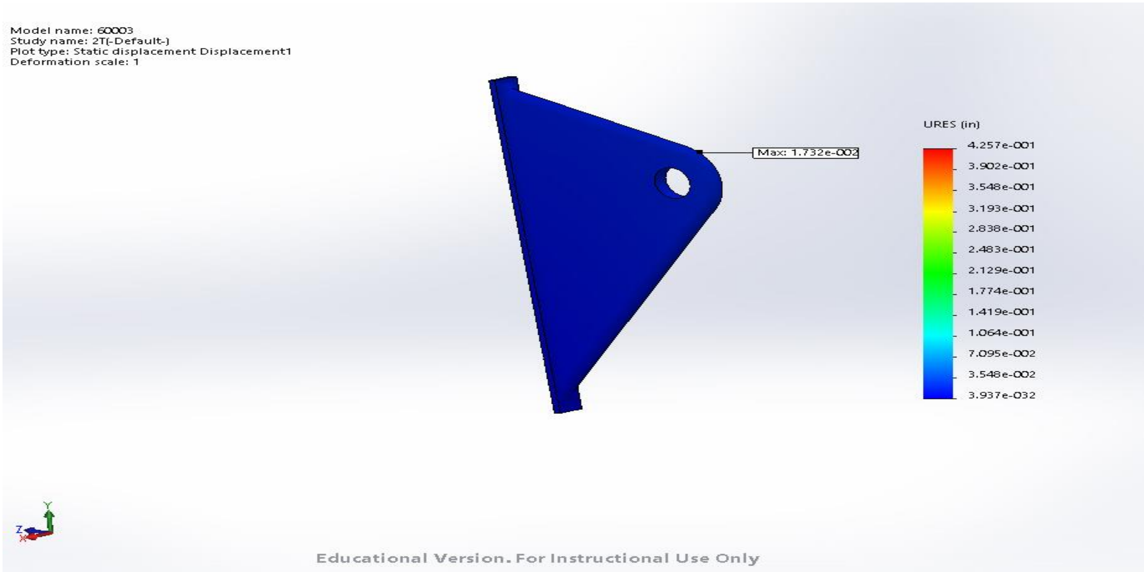


Figure 116: PN#10010 2T Horizontal - Displacement

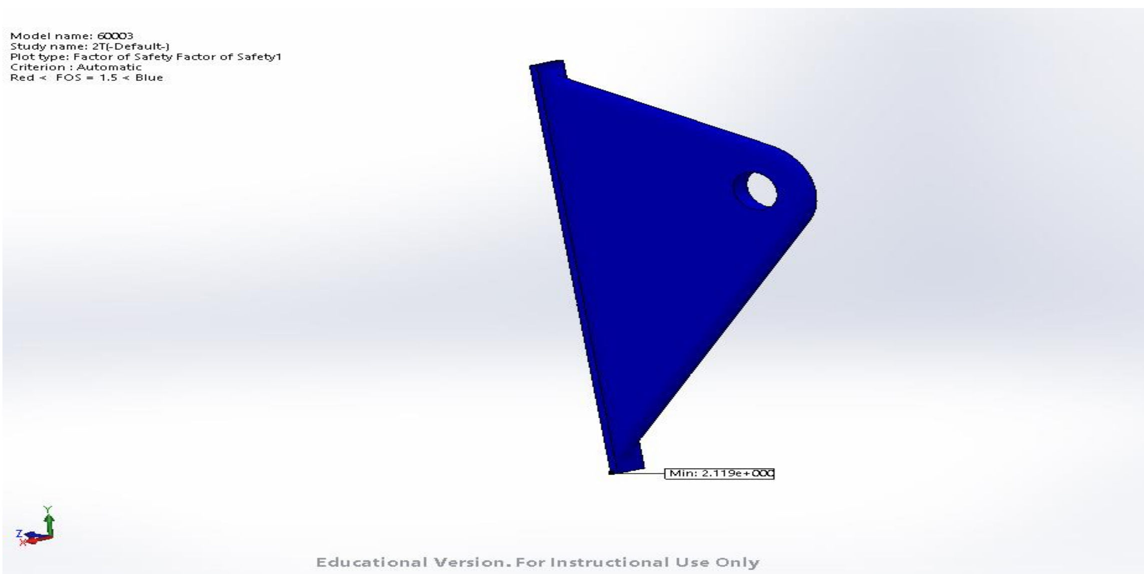


Figure 117: PN#10010 2T Horizontal - F.O.S.

PT# 10018 – Redesign 2T Horizontal Loading

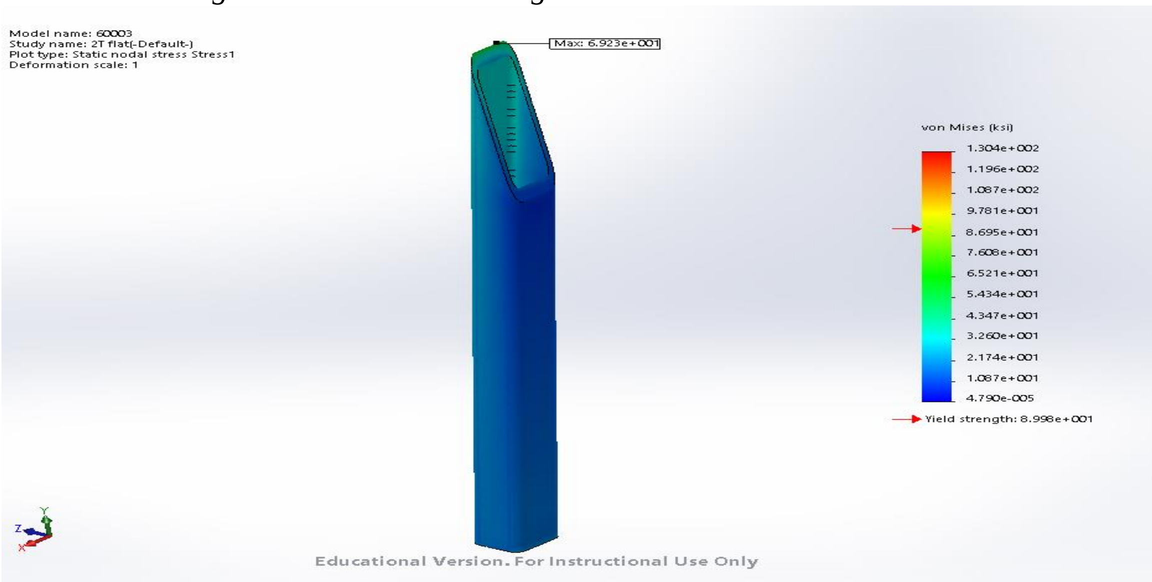


Figure 118: PN#10018 2T Horizontal – Von Misses Stress

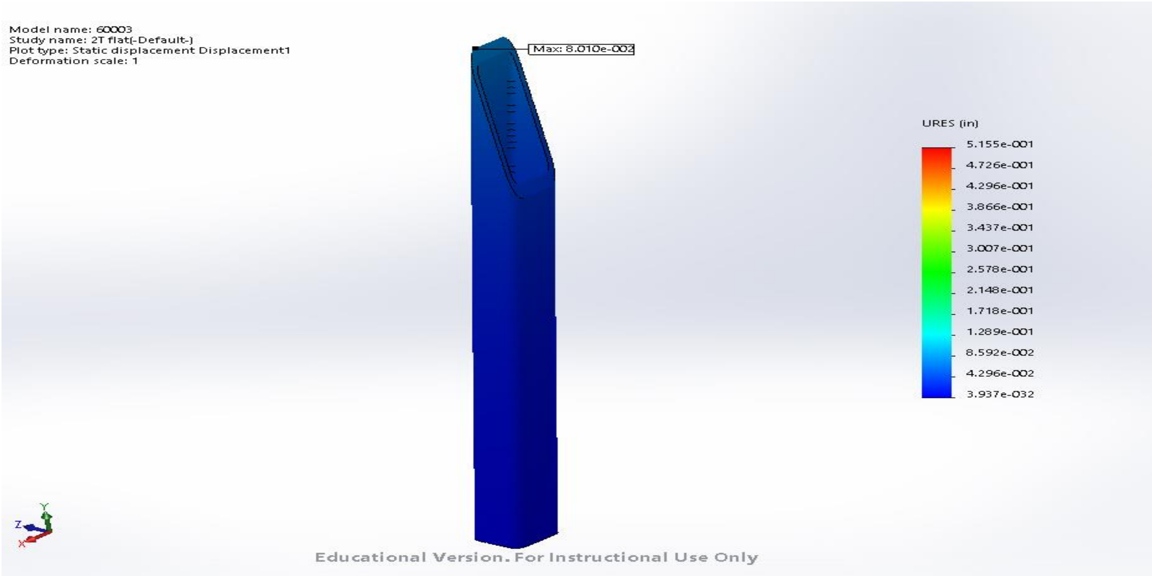


Figure 119: PN#10018 2T Horizontal - Displacement

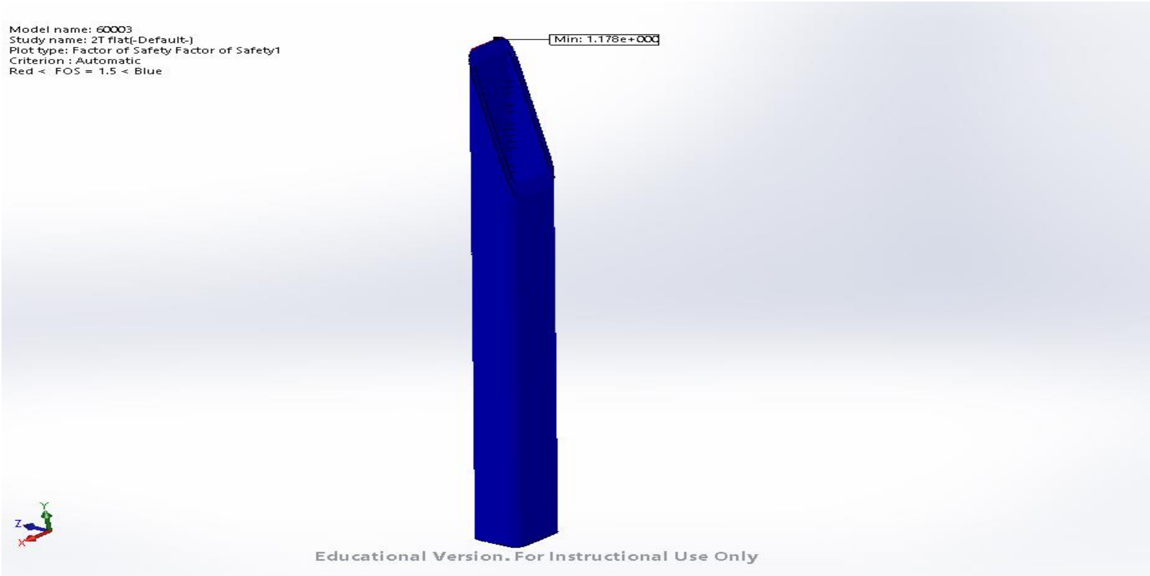


Figure 120: PN#10018 2T Horizontal - F.O.S.

PT# 10018 – Redesign 2T Angled Loading

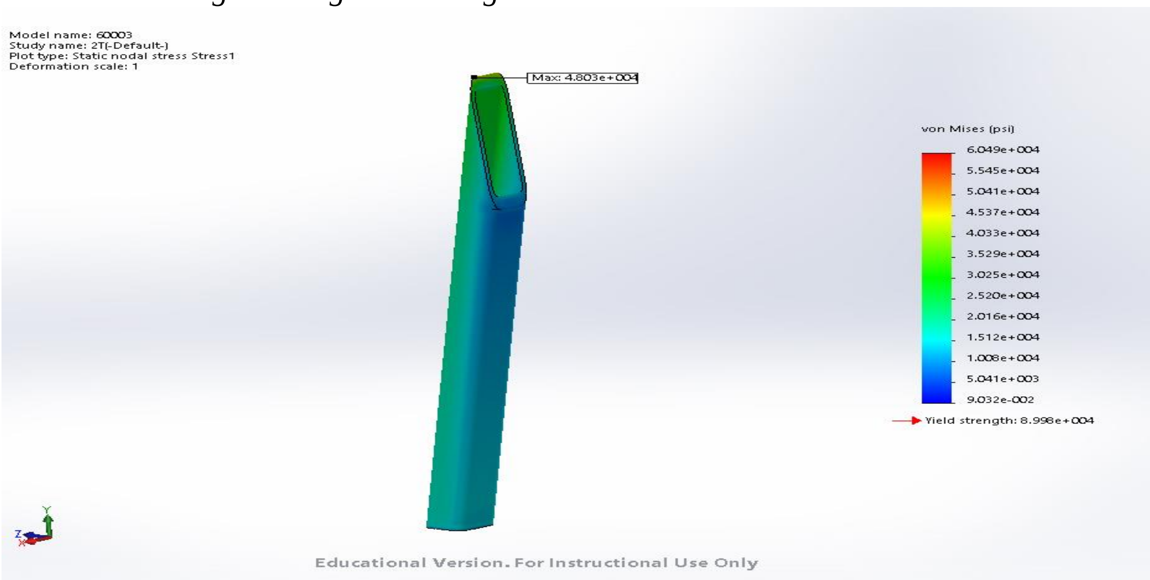


Figure 121: PN#10018 2T Angled Up - Von Misses Stress

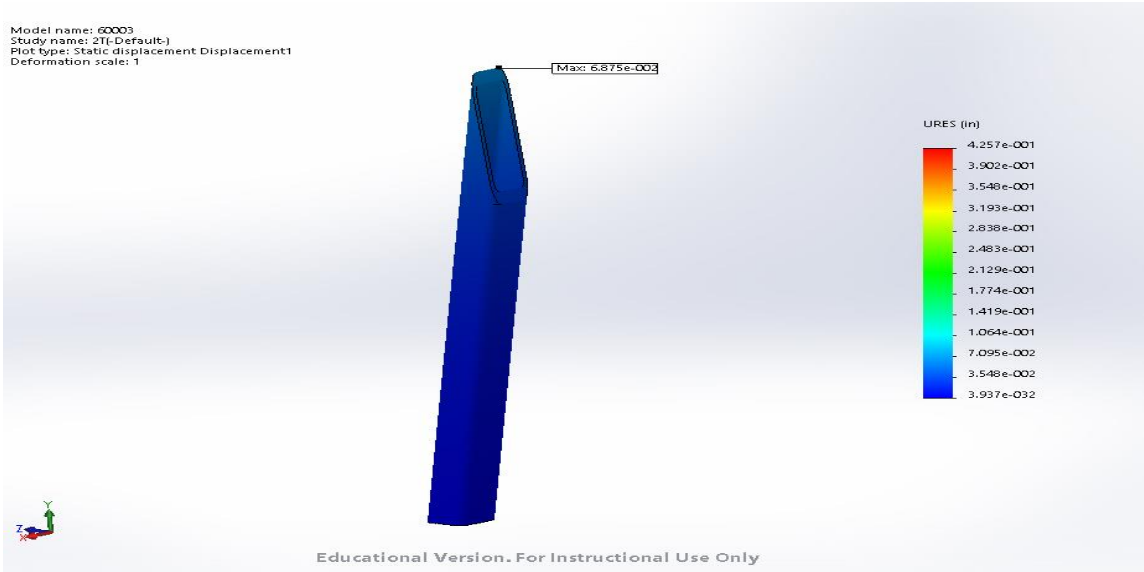


Figure 122: PN#10018 2T Angled Up - Displacement

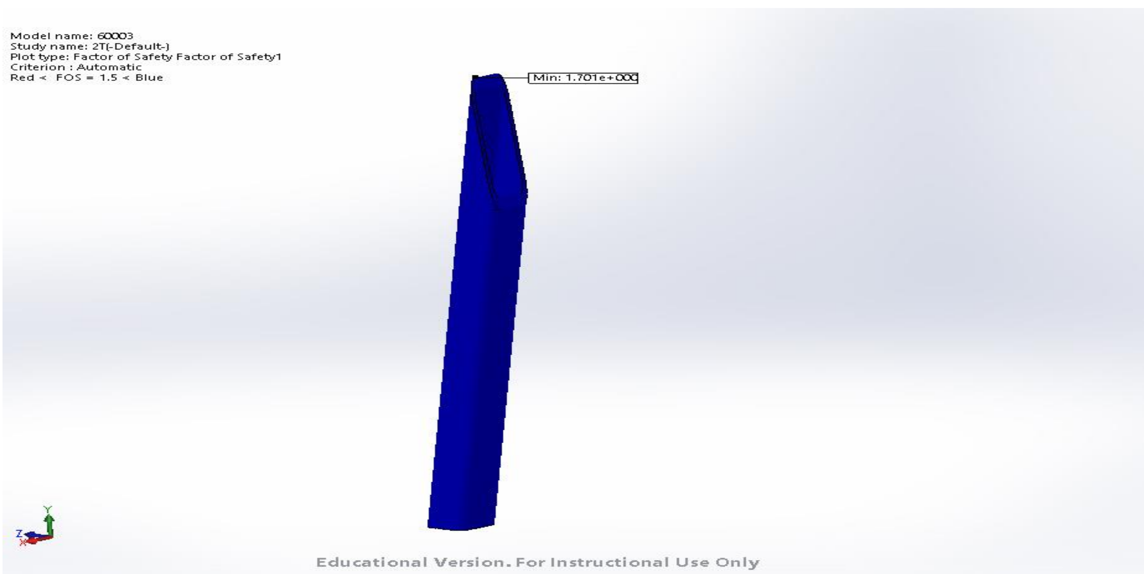


Figure 123: PN#10018 2T Angled Up - F.O.S.

Assembly 60004 – Boom Assembly – Redesign 2T Horizontal Loading

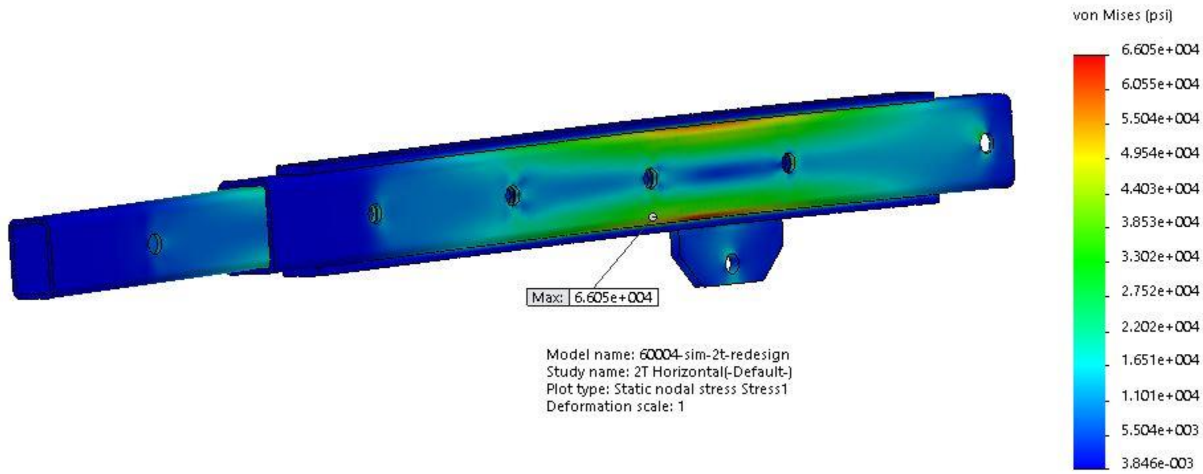


Figure 124: PN#60004 2T Horizontal - Von Misses Stress

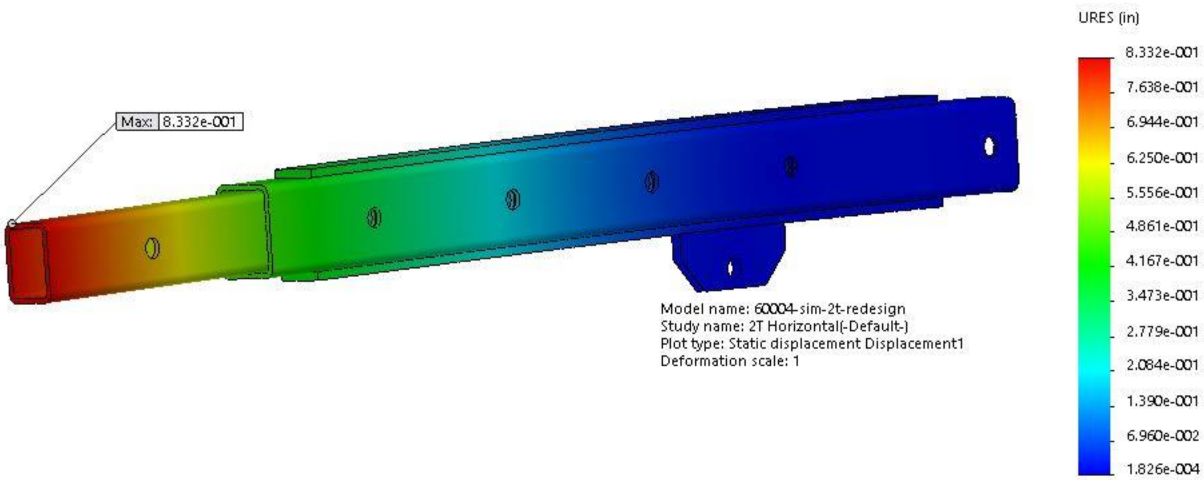


Figure 125: PN#60004 2T Horizontal - Displacement

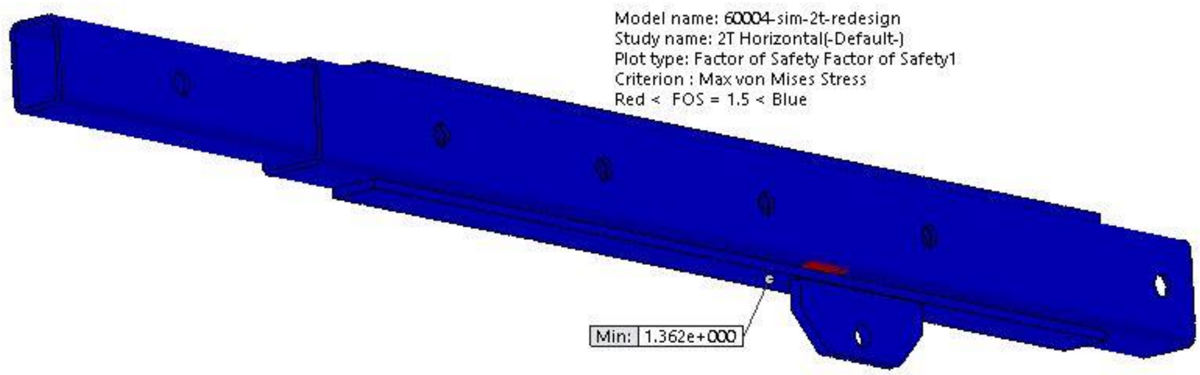


Figure 126: PN#60004 2T Horizontal - F.O.S.

Assembly 60004 – Boom Assembly – Redesign 2T Angled Loading

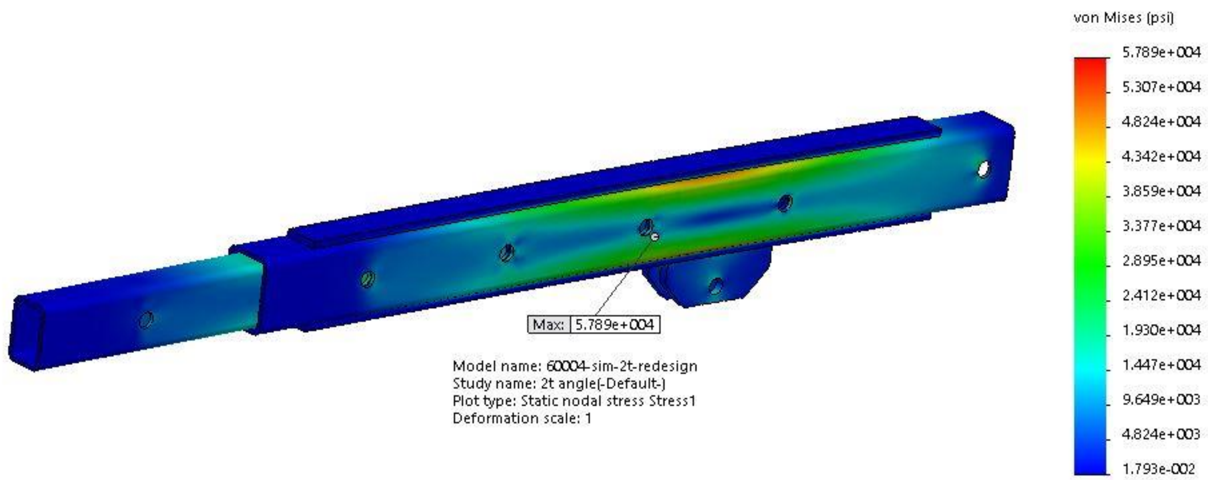


Figure 127: PN#60004 2T Angled Up - Von Misses Stress

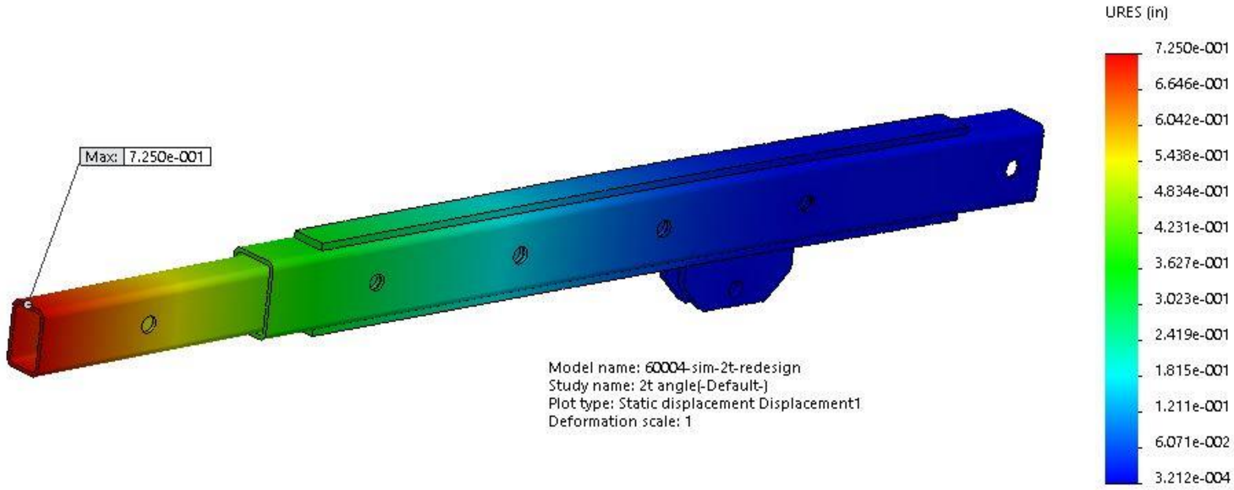


Figure 128: PN#60004 2T Angled Up - Displacement

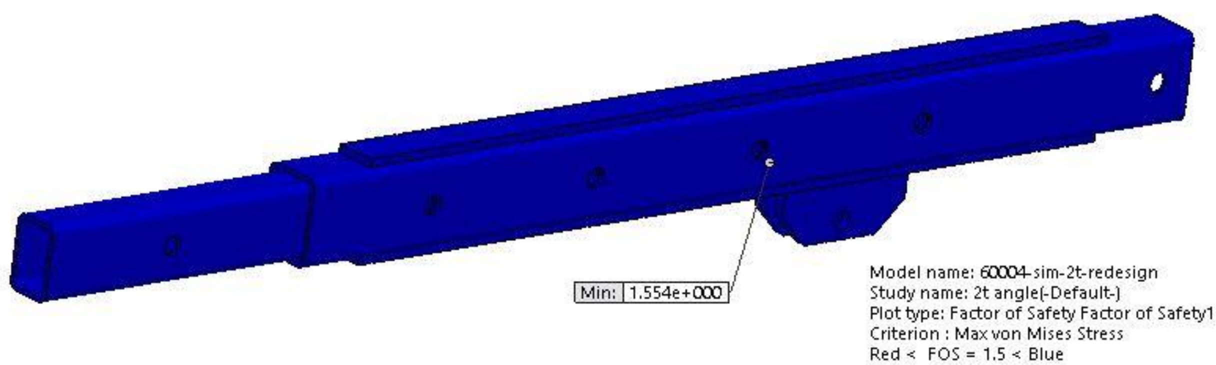


Figure 129: PN#60004 2T Angled Up - F.O.S.

PT# 10013 – Redesign 2T Horizontal Loading

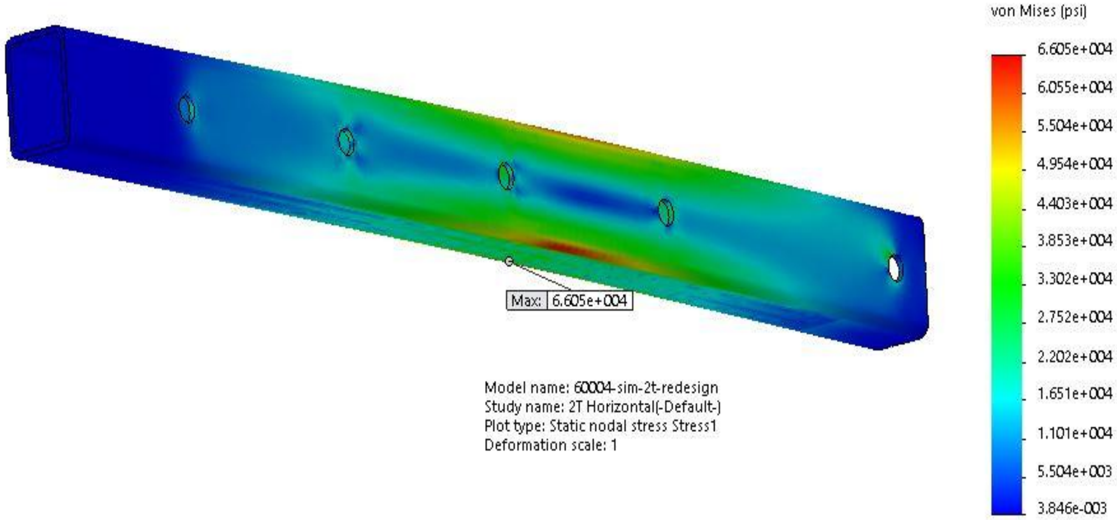


Figure 130: PN#10013 2T Horizontal - Von Misses Stress

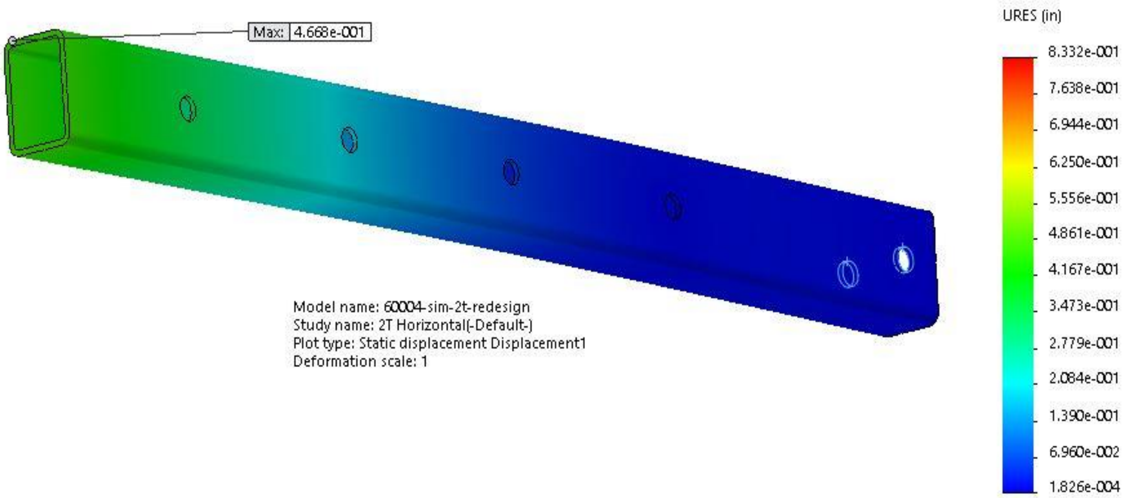


Figure 131: PN#10013 2T Horizontal - Displacement

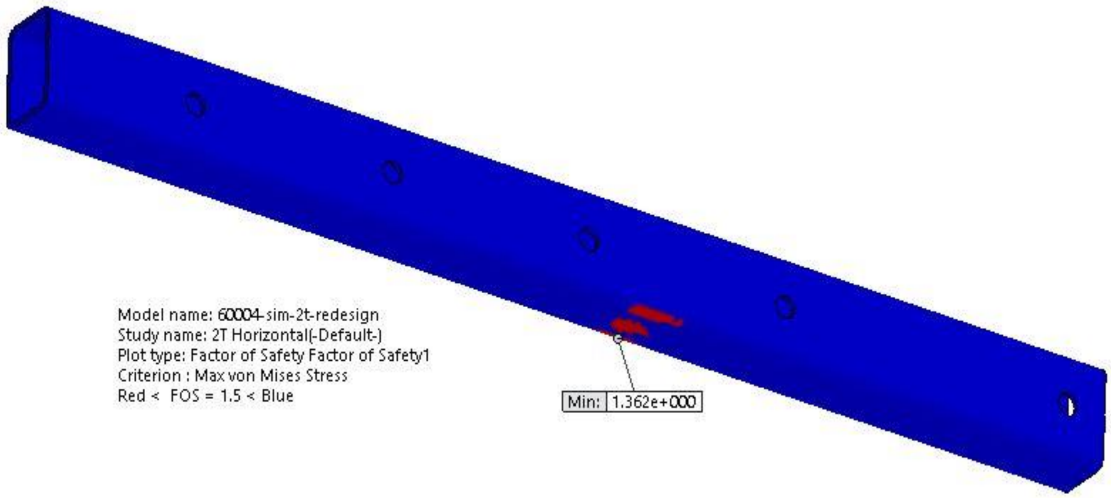


Figure 132: PN#10013 2T Horizontal - F.O.S.

PT# 10013 – Redesign 2T Angled Loading

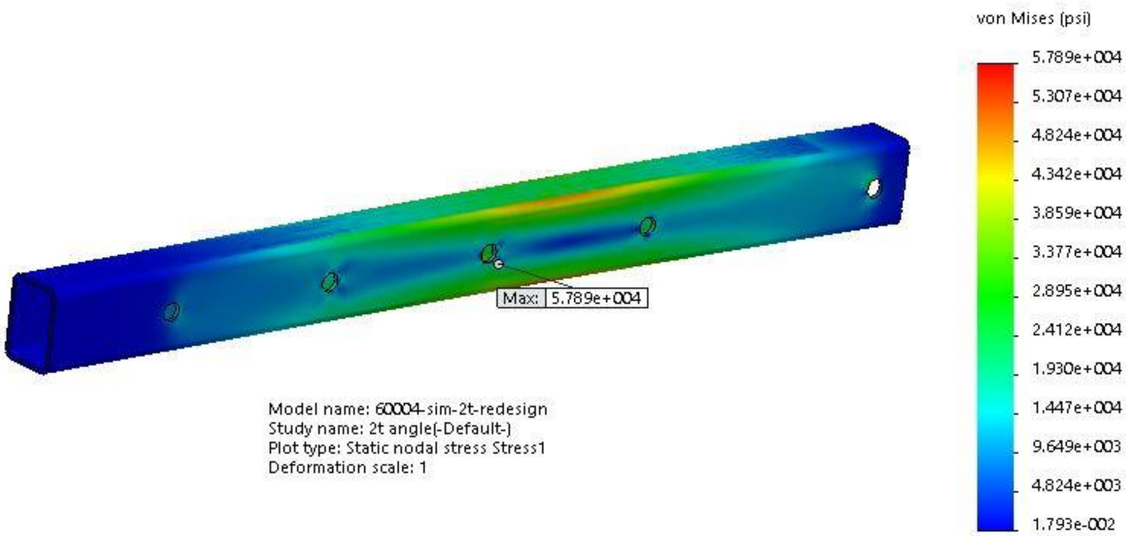


Figure 133: PN#10013 2T Angled Up - Von Misses Stress

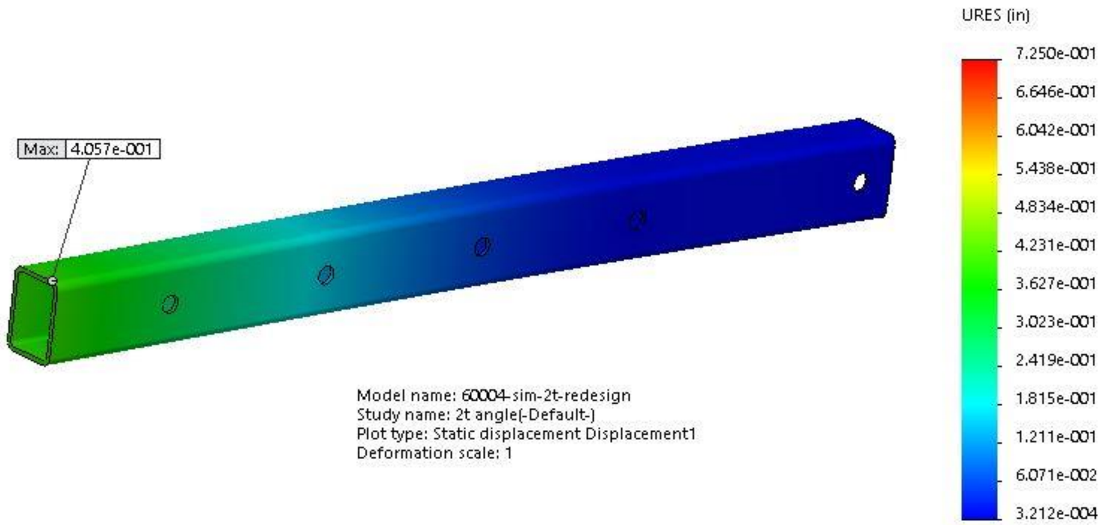


Figure 134: PN#10013 2T Angled Up - Displacement

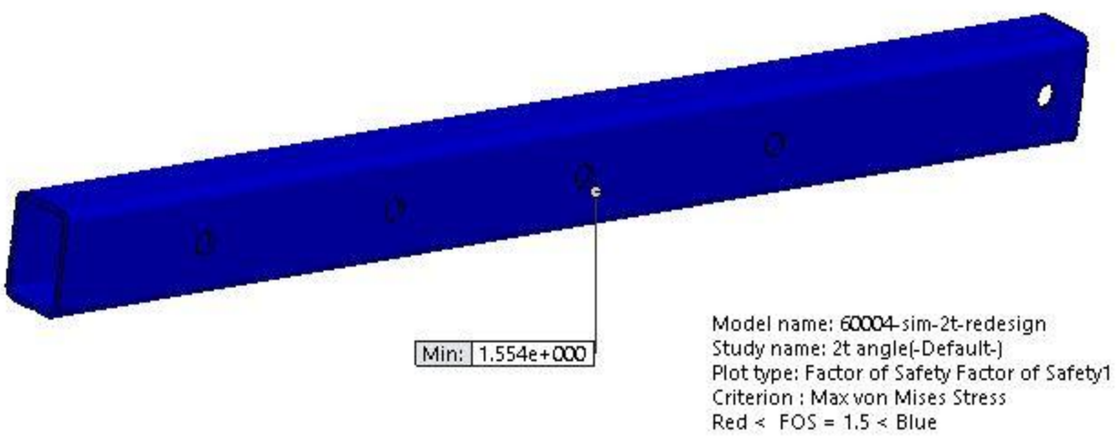


Figure 135: PN#10013 2T Angled Up - F.O.S.

PT# 10014 – Redesign 2T Horizontal Loading

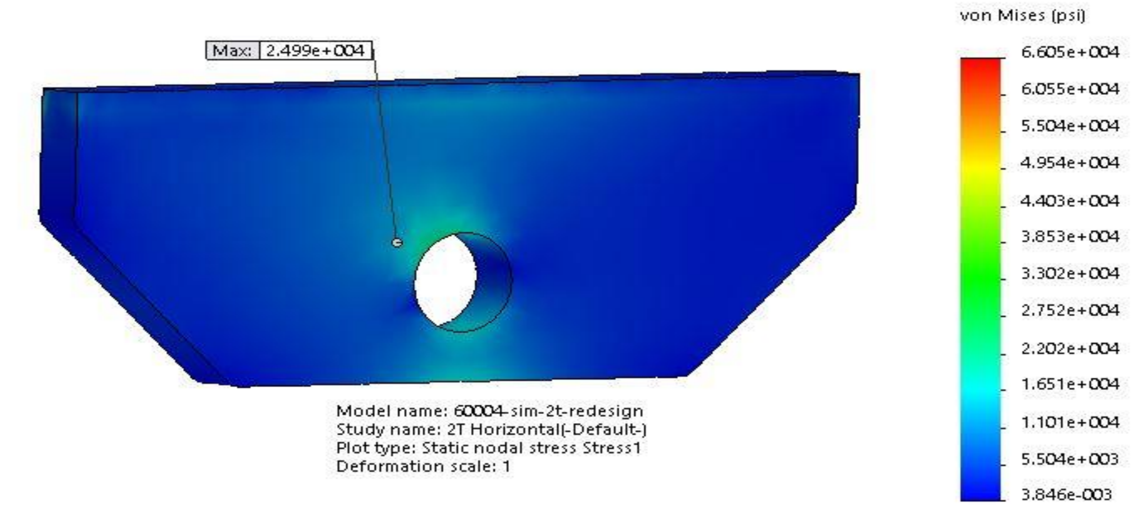


Figure 136: PN#10014 2T Horizontal - Von Misses Stress

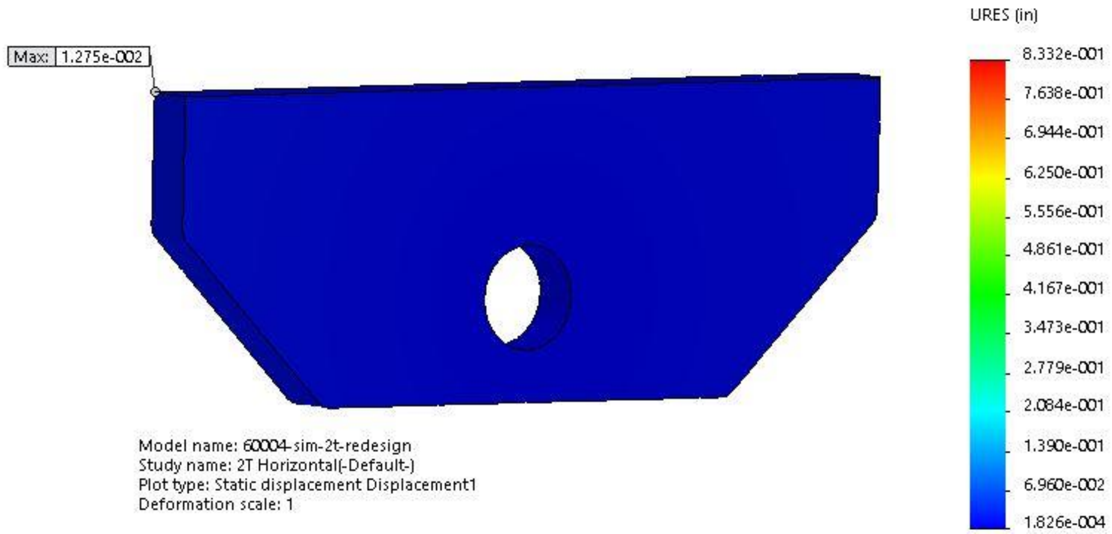


Figure 137: PN#10014 2T Horizontal - Displacement

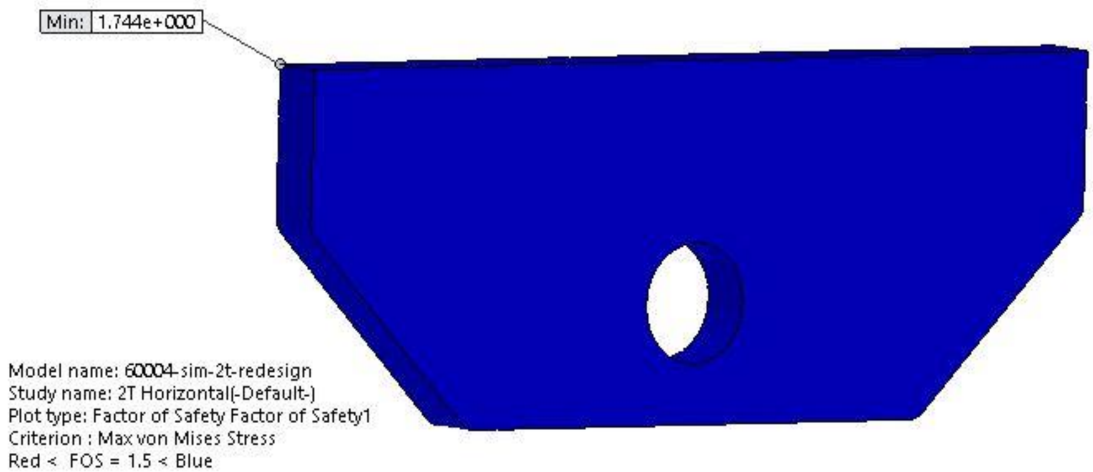


Figure 138: PN#10014 2T Horizontal - F.O.S.

PT# 10014 – Redesign 2T Angled Loading

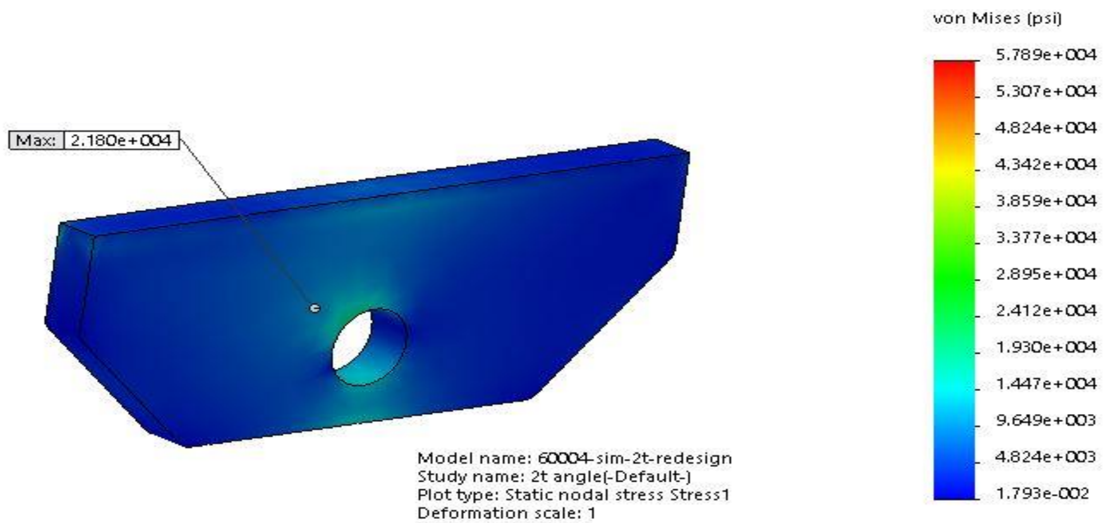


Figure 139: PN#10014 2T Angled Up - Von Misses Stress

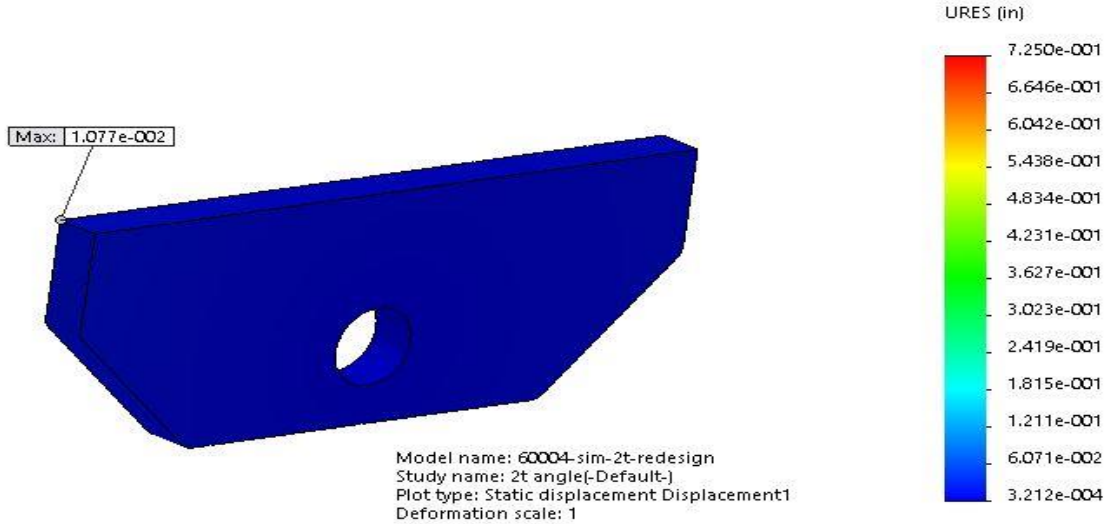


Figure 140: PN#10014 2T Angled Up - Displacement

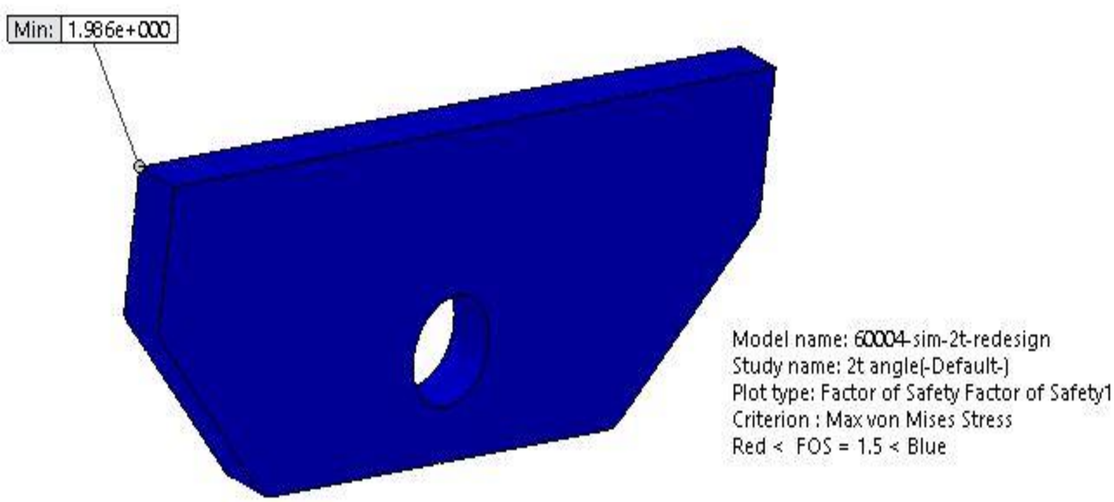


Figure 141: PN#10014 2T Angled Up - F.O.S.

PT# 10015 – Redesign 2T Horizontal Loading

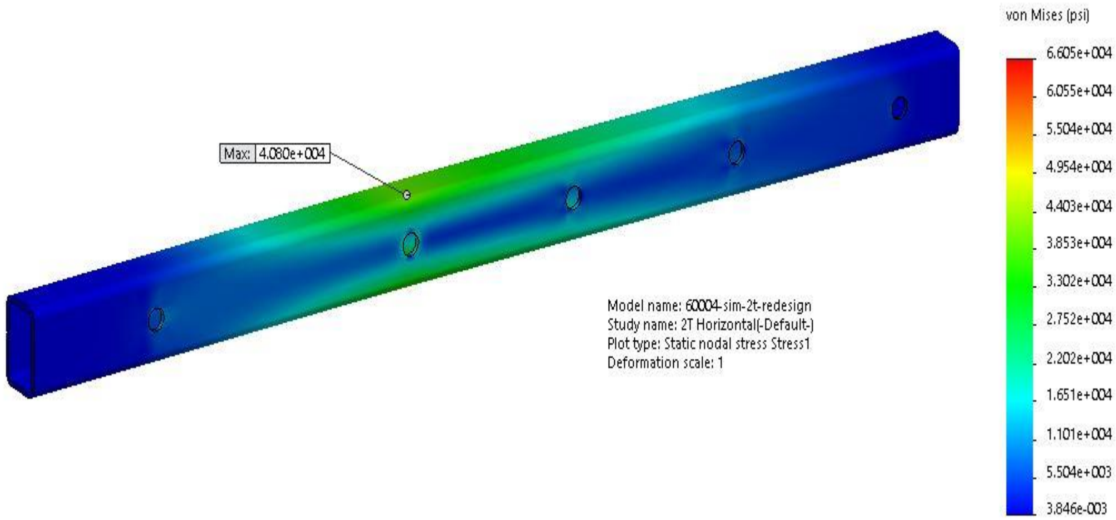


Figure 142: PN#10015 2T Horizontal – Von Misses Stress

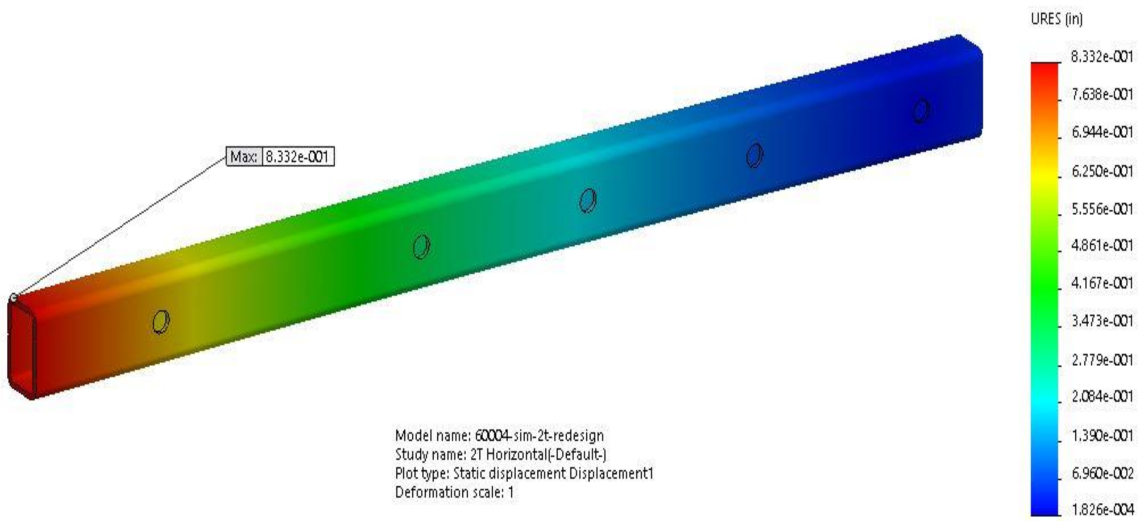


Figure 143: PN#10015 2T Horizontal - Displacement

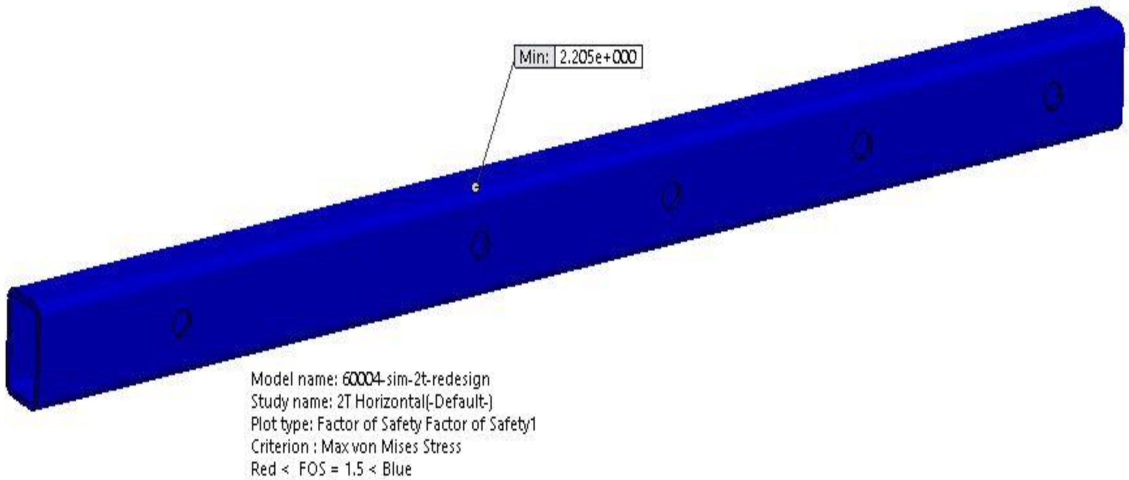


Figure 144: PN#10015 2T Horizontal - F.O.S.

PT# 10015 – Redesign 2T Angled Loading

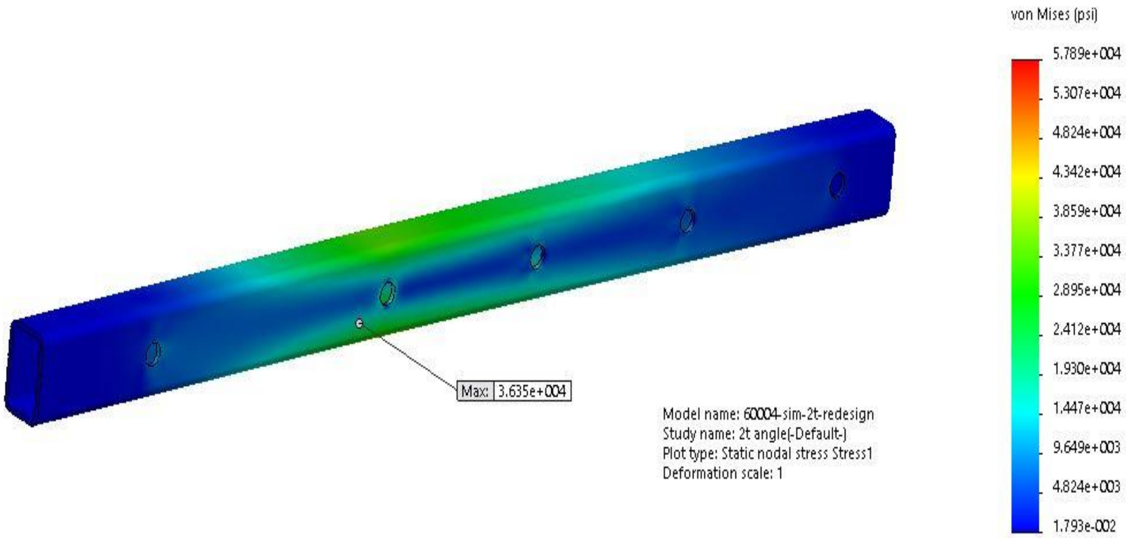


Figure 145: PN#10015 2T Angled Up - Von Misses Stress

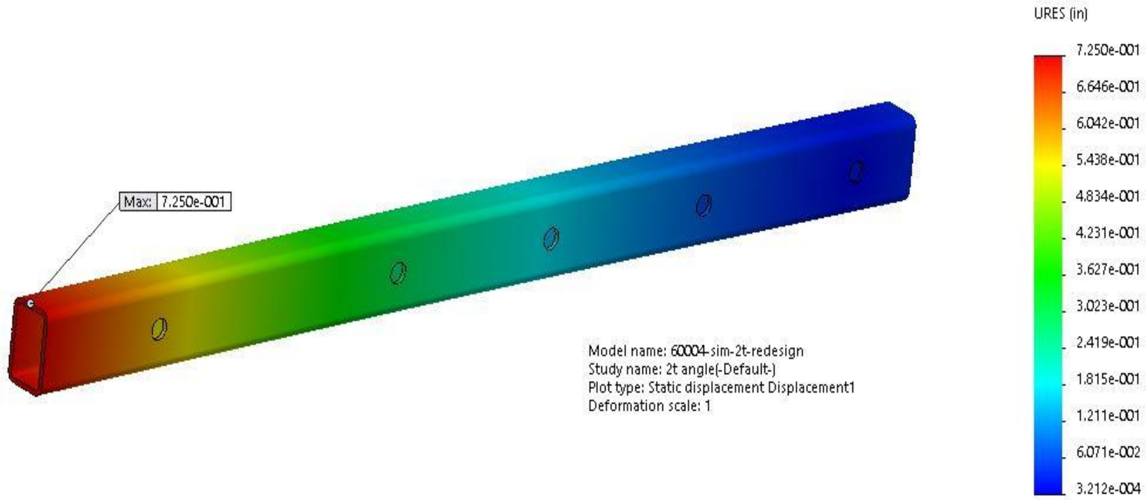


Figure 146: PN#10015 2T Angled Up - Displacement

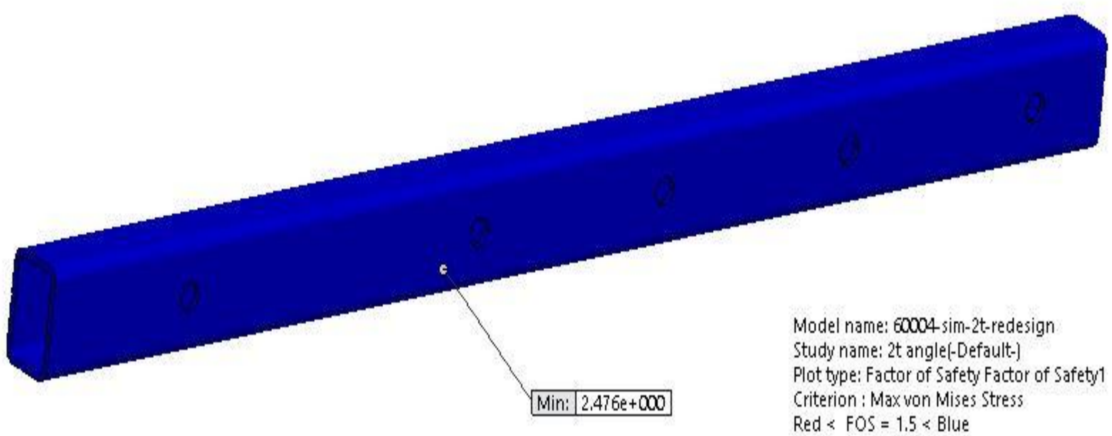


Figure 147: PN#10015 2T Angled Up - F.O.S.

PT# 50017 - Redesign 2T Horizontal Loading Top Plate

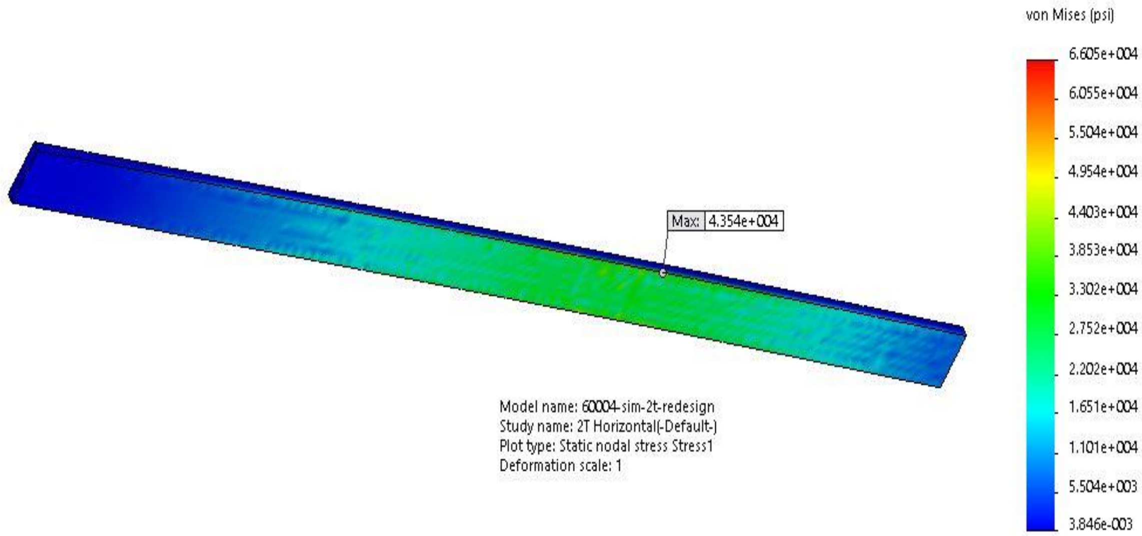


Figure 148: PN#50017 2T Horizontal - Von Misses Stress

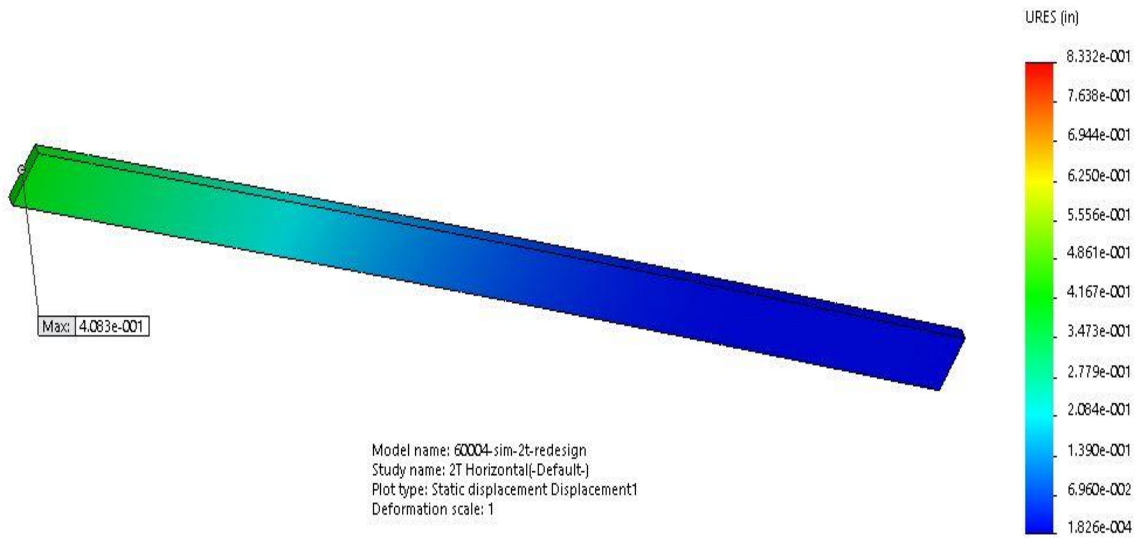
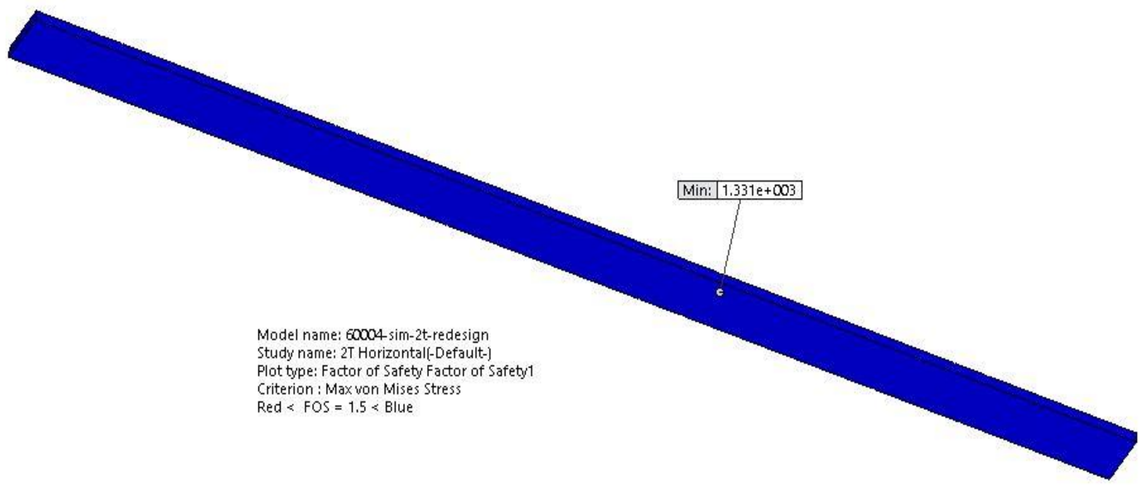


Figure 149: PN#50017 2T Horizontal - Displacement



PT# 50017 - Redesign 2T Angled Loading
Top Plate

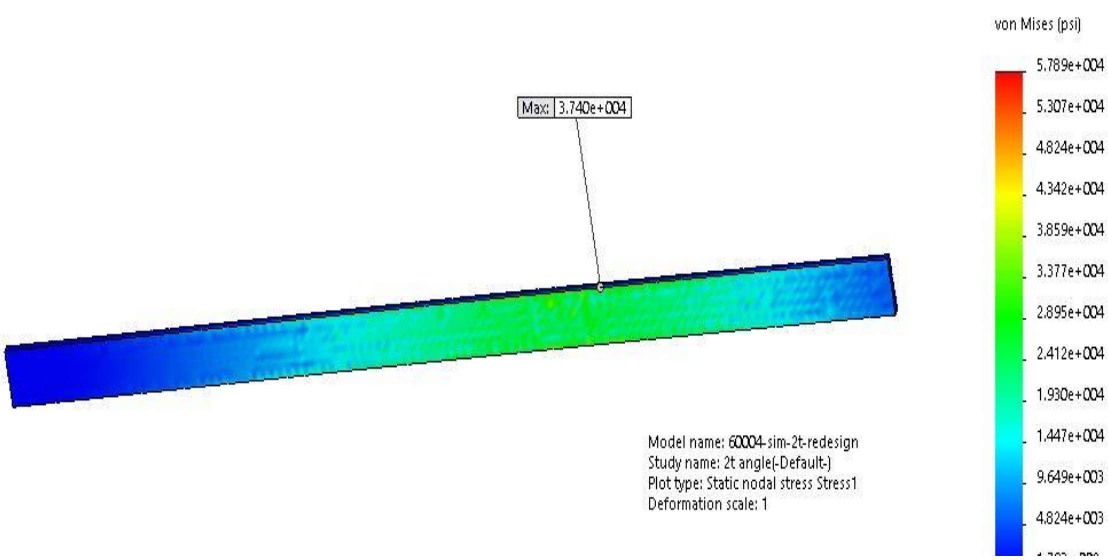


Figure 150: PN#50017 2T Angled Up - Von Misses Stress

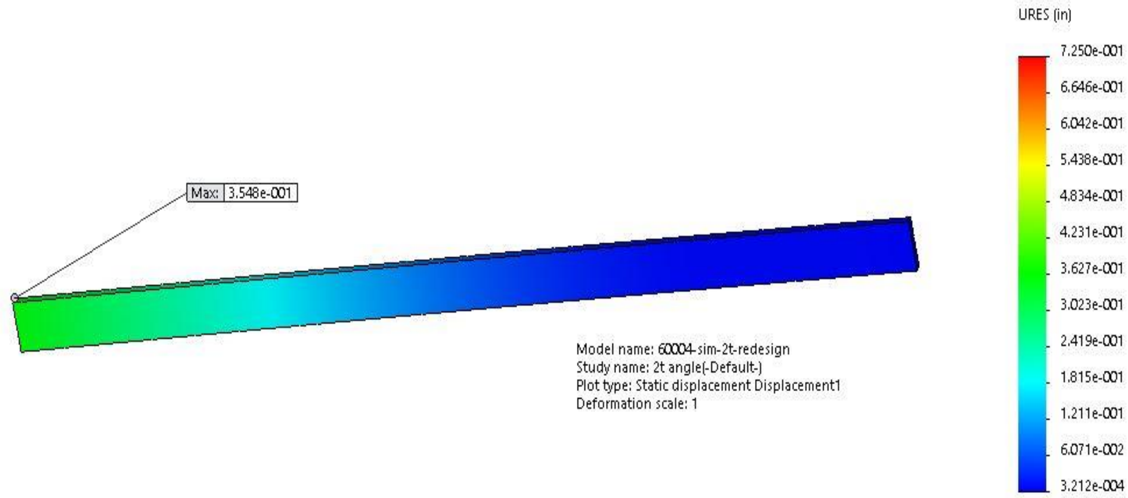


Figure 151: PN#50017 2T Angled Up - Displacement

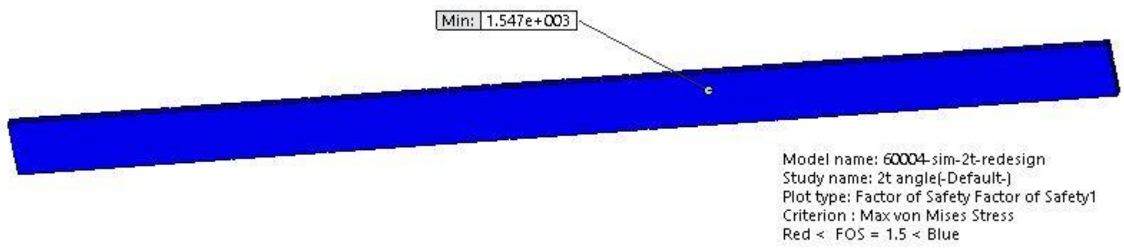


Figure 152: PN#50017 2T Angled Up - F.O.S.

PT# 50017 - Redesign 2T Horizontal Loading
Bottom Plate

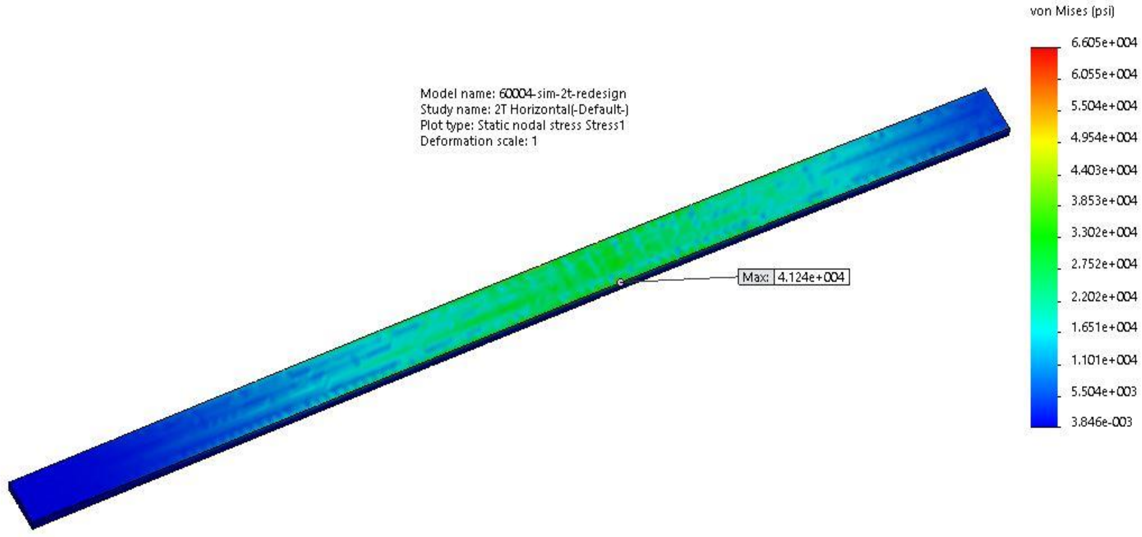


Figure 153: PN#50017 2T Horizontal - Von Misses Stress

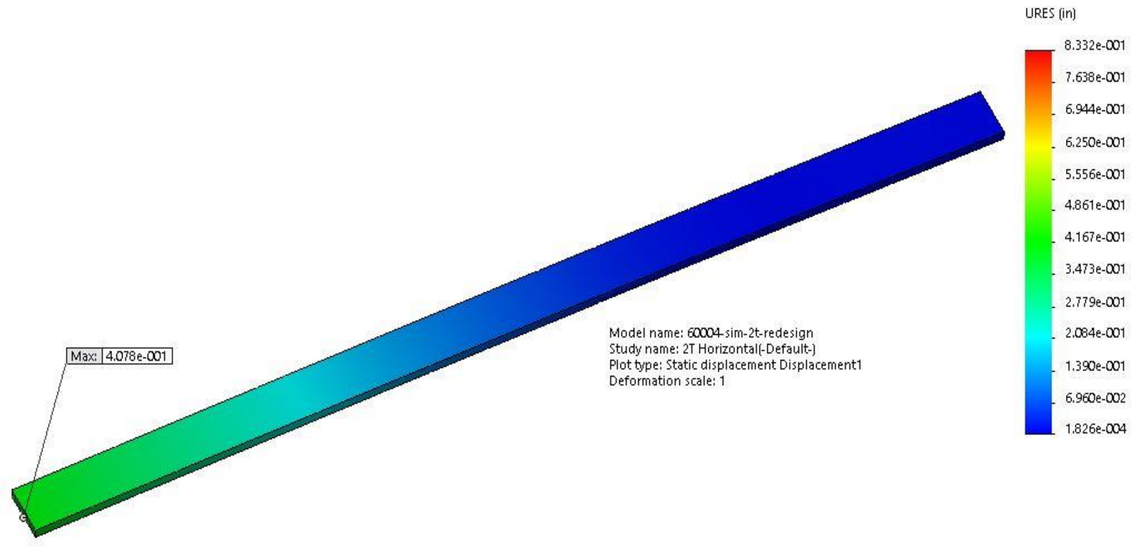


Figure 154: PN#50017 2T Horizontal - Displacement

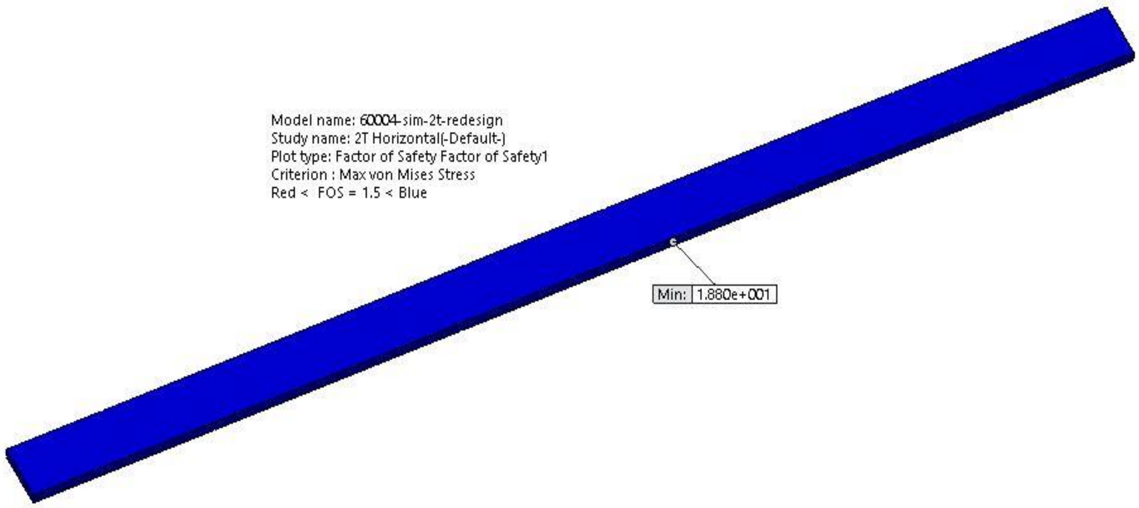


Figure 155: PN#50017 2T Horizontal - F.O.S.

PT# 50017 - Redesign 2T Angled Loading
Bottom Plate

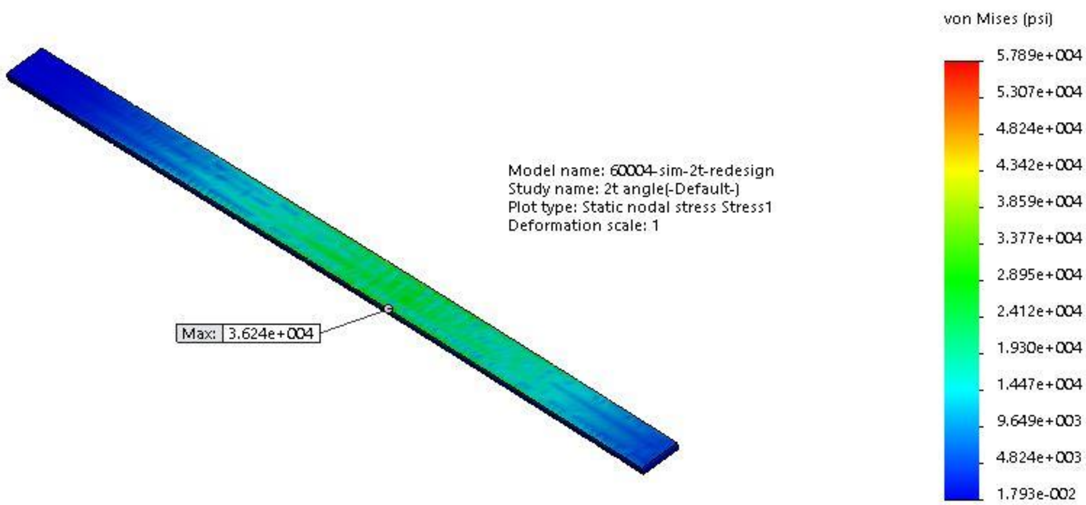


Figure 156: PN#50017 2T Angled Up - Von Misses Stress

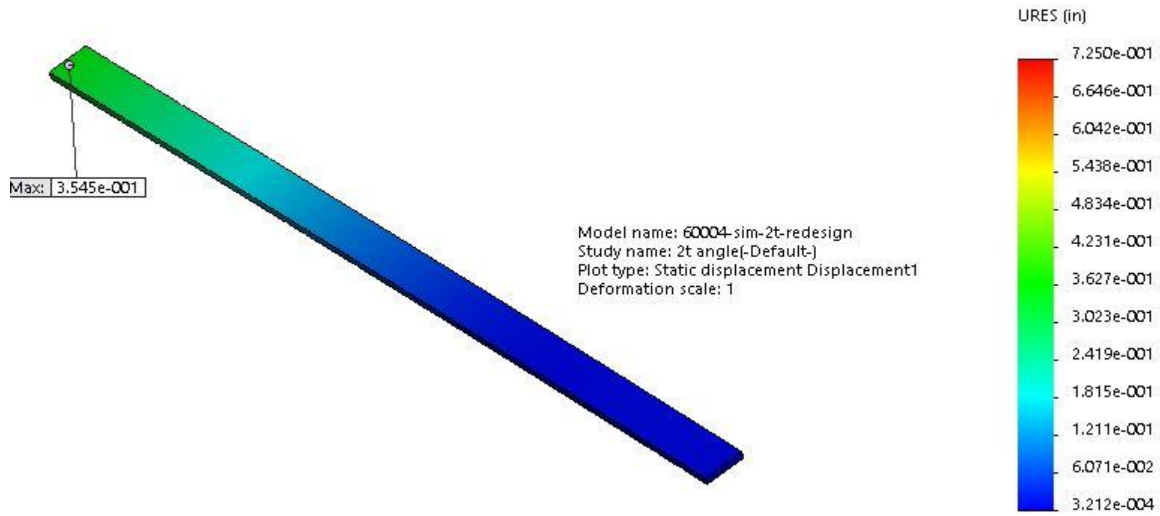


Figure 157: PN#50017 2T Angled Up - Displacement

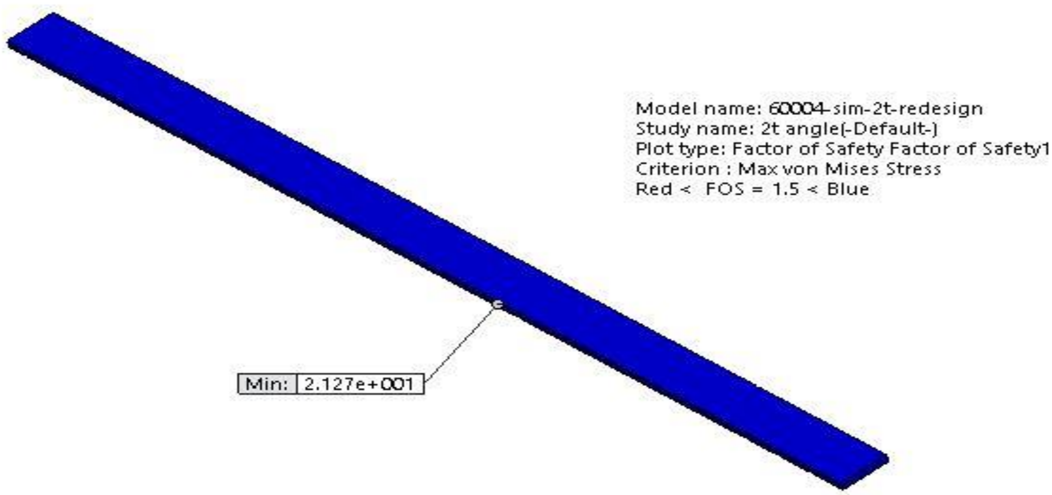


Figure 158: PN#50017 2T Angled Up - F.O.S.

3.2.5 Redesign - Maximum stress, minimum factor of safety, and maximum displacement table:

Table 10: Redesign Half Ton Loading

Loading	FEA results	PN#10001	PN#10002	PN#10003	PN#10004	PN#10005	PN#10006	PN#10007	PN#10008	PN#10009	PN#10010	PN#10011	PN#10012	PN#10013	PN#10014	PN#10015	PN# 10019 new tube (post)	PN#50017 Top Support Bar (boom)	PN#50017 Bottom Support Bar (boom)
0.5 T level	Maximum Stress (PSI)	N/A	N/A	N/A	N/A	N/A	20759	6444.8	N/A	9486.6	13083	N/A	N/A	2.94E+04	9.37E+03	2.37E+04	16591	1.82E+04	1.83E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	4.3347	15.813	N/A	9.4855	6.2978	N/A	N/A	2.9991	9.6084	3.8036	4.925	3090.8	61.916
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	3.82E-05	0.11635	N/A	0.11548	0.005736	N/A	N/A	0.21309	0.004191	0.72324	0.023293	0.18457	0.1844
	Location of failure	N/A	N/A	N/A	N/A	N/A			N/A			N/A	N/A						
0.5 up	Maximum Stress (PSI)	N/A	N/A	N/A	N/A	N/A	44565	10993	N/A	34065	17876	N/A	N/A	2.57E+04	8.15E+03	2.08E+04	23787	1.56E+04	1.61E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	2.0192	8.2676	N/A	2.6416	3.798	N/A	N/A	3.4296	10.836	4.3314	3.4287	3601.3	70.959
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.13998	4.58E-05	N/A	0.17523	0.005561	N/A	N/A	0.18462	0.003542	0.62735	0.02708	0.15988	0.1598
	Location of failure	N/A	N/A	N/A	N/A	N/A			N/A			N/A	N/A						

Table 11: 1 Ton Loading Redesign

Loading	FEA results	PN#10001	PN#10002	PN#10003	PN#10004	PN#10005	PN#10006	PN#10007	PN#10008	PN#10009	PN#10010	PN#10011	PN#10012	PN#10013	PN#10014	PN#10015	PN# 10019 new tube (post)	PN#50017 Top Support Bar (boom)	PN#50017 Bottom Support Bar (boom)
1 T level	Maximum Stress (PSI)	N/A	N/A	N/A	N/A	N/A	77150	19096	N/A	59000	31379	N/A	N/A	4.94E+04	1.63E+04	3.38E+04	41087	3.01E+04	2.91E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	1.1664	4.7595	N/A	1.5252	2.1637	N/A	N/A	1.7815	5.3837	2.6624	1.985	1858.4	28.309
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.24288	7.95E-05	N/A	0.3045	0.009758	N/A	N/A	0.32846	0.007242	0.83407	0.047097	0.2867	0.28642
	Location of failure	N/A	N/A	N/A	N/A	N/A			N/A			N/A	N/A						
1 T up	Maximum Stress (PSI)	N/A	N/A	N/A	N/A	N/A	35887	11189	N/A	16283	22921	N/A	N/A	4.33E+04	1.42E+04	2.98E+04	28598	2.58E+04	2.55E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	2.5074	9.1083	N/A	5.5264	3.5892	N/A	N/A	2.0322	6.1694	3.0245	2.8573	2163	32.215
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.20158	6.63E-05	N/A	0.26167	0.010065	N/A	N/A	0.28508	0.006104	0.7249	0.040479	0.2488	0.24868
	Location of failure	N/A	N/A	N/A	N/A	N/A			N/A			N/A	N/A						

Table 12: 2 Ton Redesign

Loading	FEA results	PN#10001	PN#10002	PN#10003	PN#10004	PN#10005	PN#10006	PN#10007	PN#10008	PN#10009	PN#10010	PN#10011	PN#10012	PN#10013	PN#10014	PN#10015	PN# 10019 new tube (post)	PN#50017 Top Support Bar (boom)	PN#50017 Bottom Support Bar (boom)
2 T level	Maximum Stress (PSI)	N/A	N/A	N/A	N/A	N/A	130420	32420	N/A	99796	54024	N/A	N/A	6.61E+04	2.50E+04	4.08E+04	69229	4.35E+04	4.12E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	0.68997	2.8043	N/A	0.90169	1.2567	N/A	N/A	1.3624	1.7443	2.2053	1.1781	1331.2	18.804
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.41177	0.000135	N/A	0.51552	0.01679	N/A	N/A	0.46684	0.012751	0.83324	0.0801	0.40829	0.40784
	Location of failure	N/A	N/A	N/A	N/A	N/A	Welded area (contact line only)		N/A	Welded area (contact lines only)	Welded area	N/A	N/A	around weld area between plate and boom			Welded area		
2 T up	Maximum Stress (PSI)	N/A	N/A	N/A	N/A	N/A	60490	18978	N/A	27187	39353	N/A	N/A	5.79E+04	2.18E+04	3.635	48030	3.74E+04	3.62E+04
	Minimum Safety of factor	N/A	N/A	N/A	N/A	N/A	1.4876	5.3701	N/A	3.3099	2.0863	N/A	N/A	1.5544	1.9864	2.4758	1.7013	1547.4	21.273
	Maximum deflection (in)	N/A	N/A	N/A	N/A	N/A	0.34098	0.000112	N/A	0.42571	0.017317	N/A	N/A	0.40567	0.010773	0.72501	0.068749	0.35475	0.35455
	Location of failure	N/A	N/A	N/A	N/A	N/A	Welded area		N/A			N/A	N/A						

3.3 Discussion and Conclusions

After running the final simulations and comparing the results with the desired factor of safety and displacement design specifications, it is clear that the redesigned engine hoist assembly is capable of meeting the specifications set. With the material changes that are made, the cost effectiveness of the redesigned hoist should be taken into account. Costs of additional parts should also be noted before the hoist is sent into development. Factor of safety measurements have been met throughout the assembly, ensuring that the design is both safe and effective for its intended purpose.

4. Drawings

4.1 Redesign Bill of Materials

Table 13: Full Assembly BOM

ITEM NO.	PART NUMBER	DESCRIPTION	1.0 T configration/QTY.
10	60001	Main Frame	1
11	60002	Leg Assy	2
12	60003	Post Assy	1
13	10016	U-hook	1
14	50015	LONG RAM-cy	1
15	50014	Long Ram-rod	1
16	50008	flat washer type a narrow-0.5	10
17	50009	hex jam nut-0.5"	4
18	50012	HBOLT 0.5000-13x3.75x1.25-N	4
19	50005	flat washer type a narrow-0.75	20
20	50013	HBOLT 0.7500-16x3.75x1.75-N	4
21	50006	hex jam nut-0.75	10
22	50011	HBOLT 0.7500-10x2.5x1.75-N	2
23	50004	heavy hex finished bolt-0.75	2
24	50016	HBOLT 0.7500-10x3.5x1.75-N	2
25	60004	boom asm	1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	10007	Upright Base	1

11	10006	post	1
12	10009	Post Pivot	1
13	10010	Lower Ram Gusset	2
14	10019	Support Tube	1

Table 14: Boom Assembly BOM

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	10013	Boom 3.5X2.5	1
2	10014	Base of boom	2
3	10015	boom extension	1
4	50017	stress reduction plate	2

4.2 Part Drawing

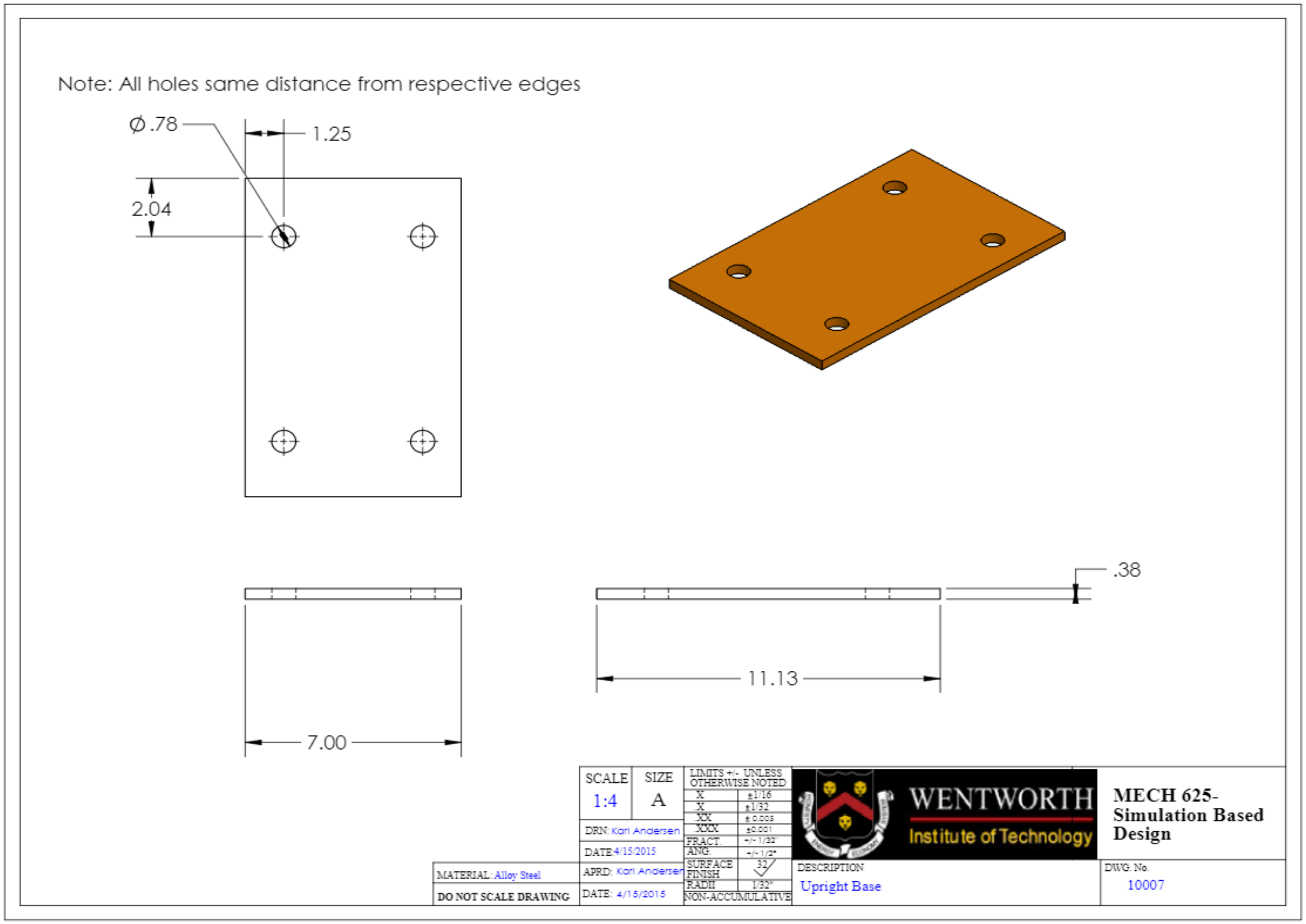


Figure 159: PN#10007 Redesign Drawing

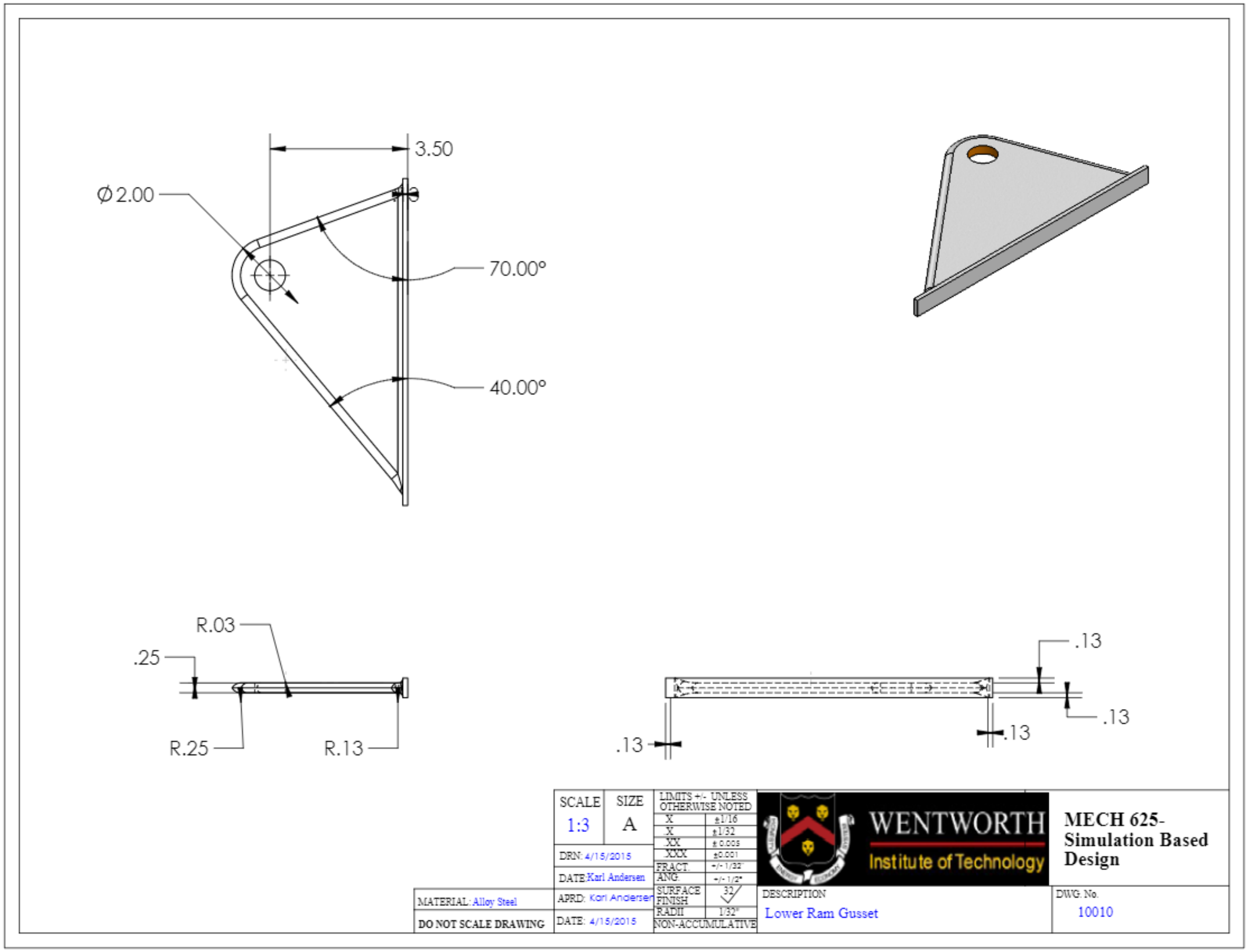


Figure 160: PN#10010 Redesign Drawing

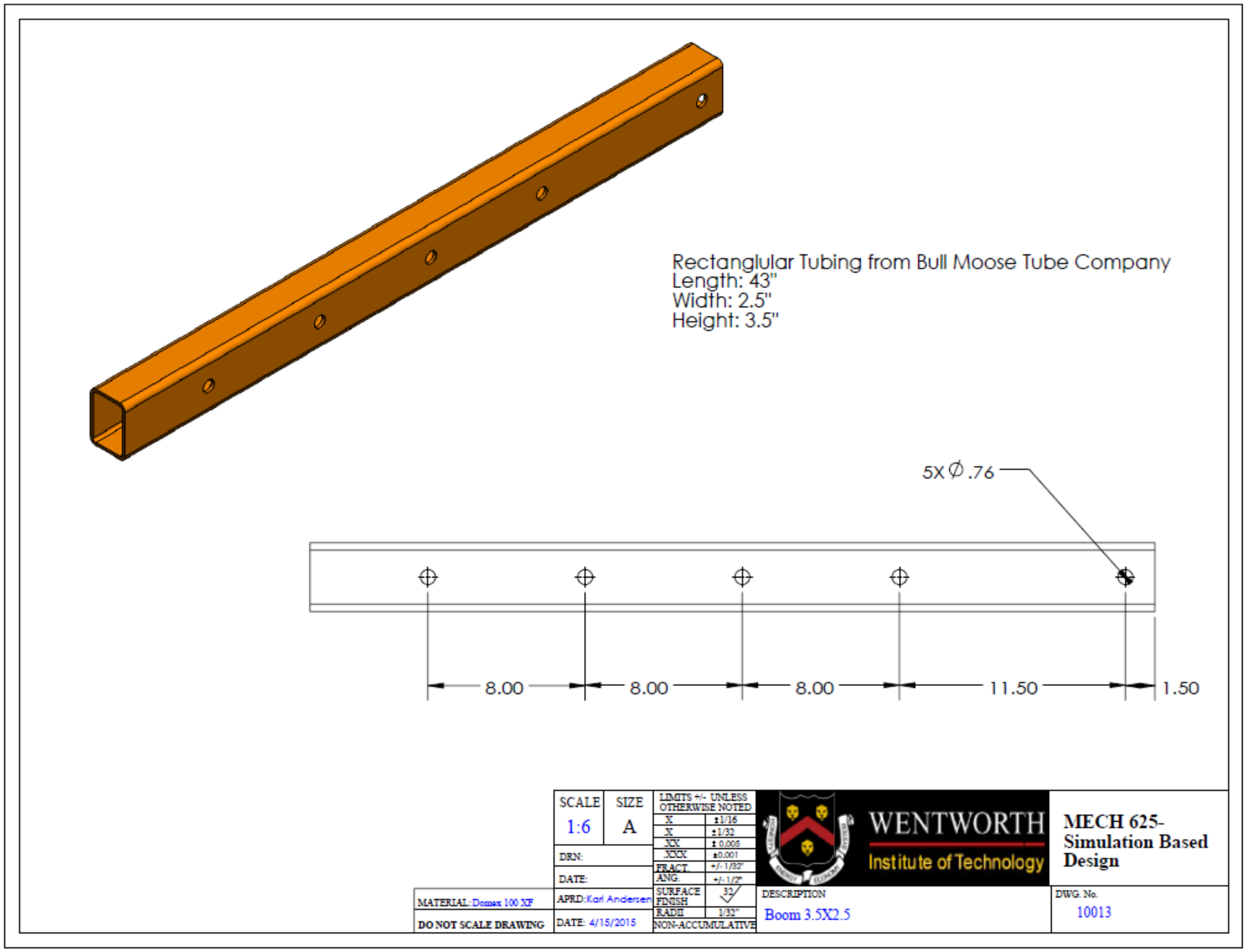


Figure 161: PN#10013 Redesign Drawing

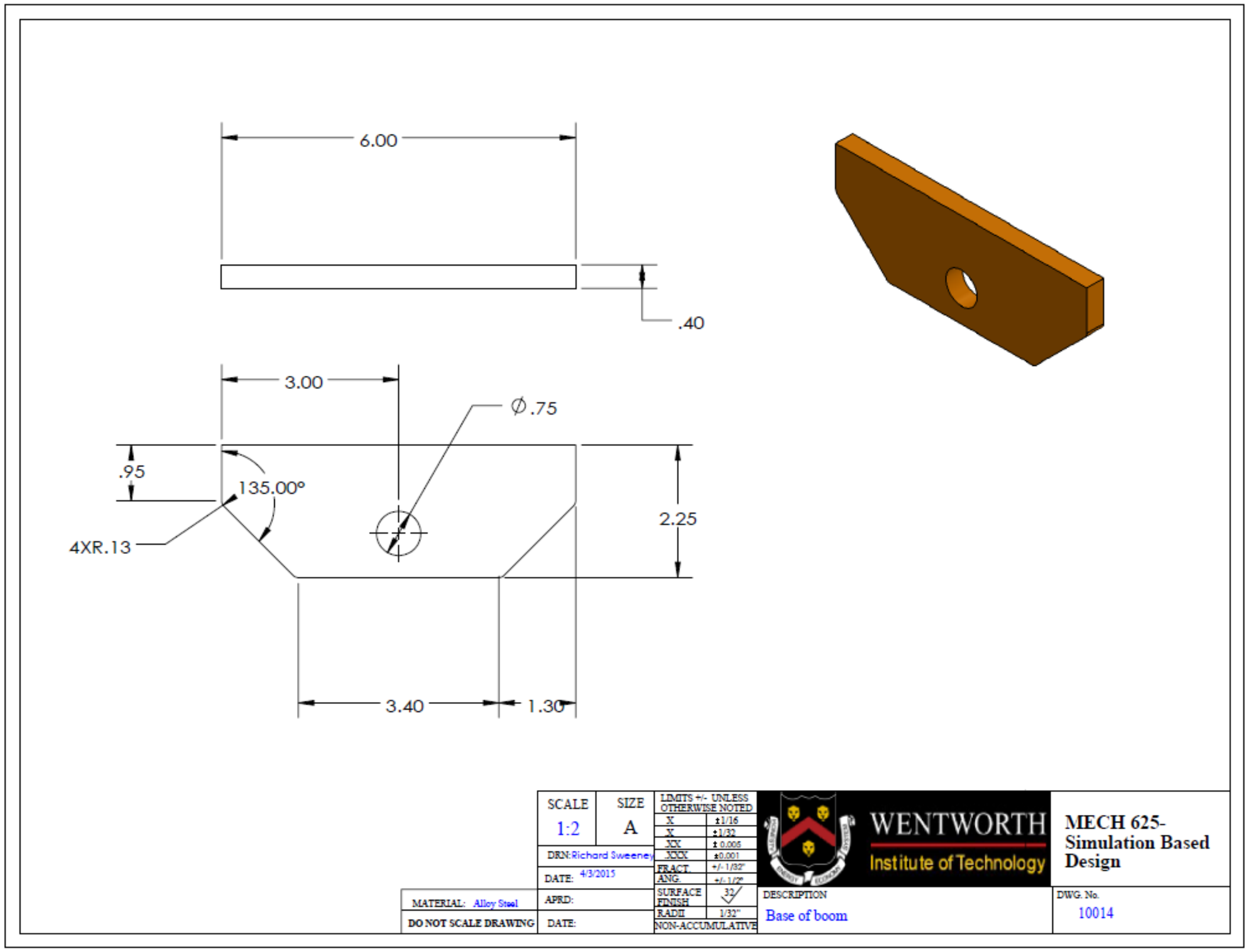


Figure 162: PN#10014 Redesign Drawing

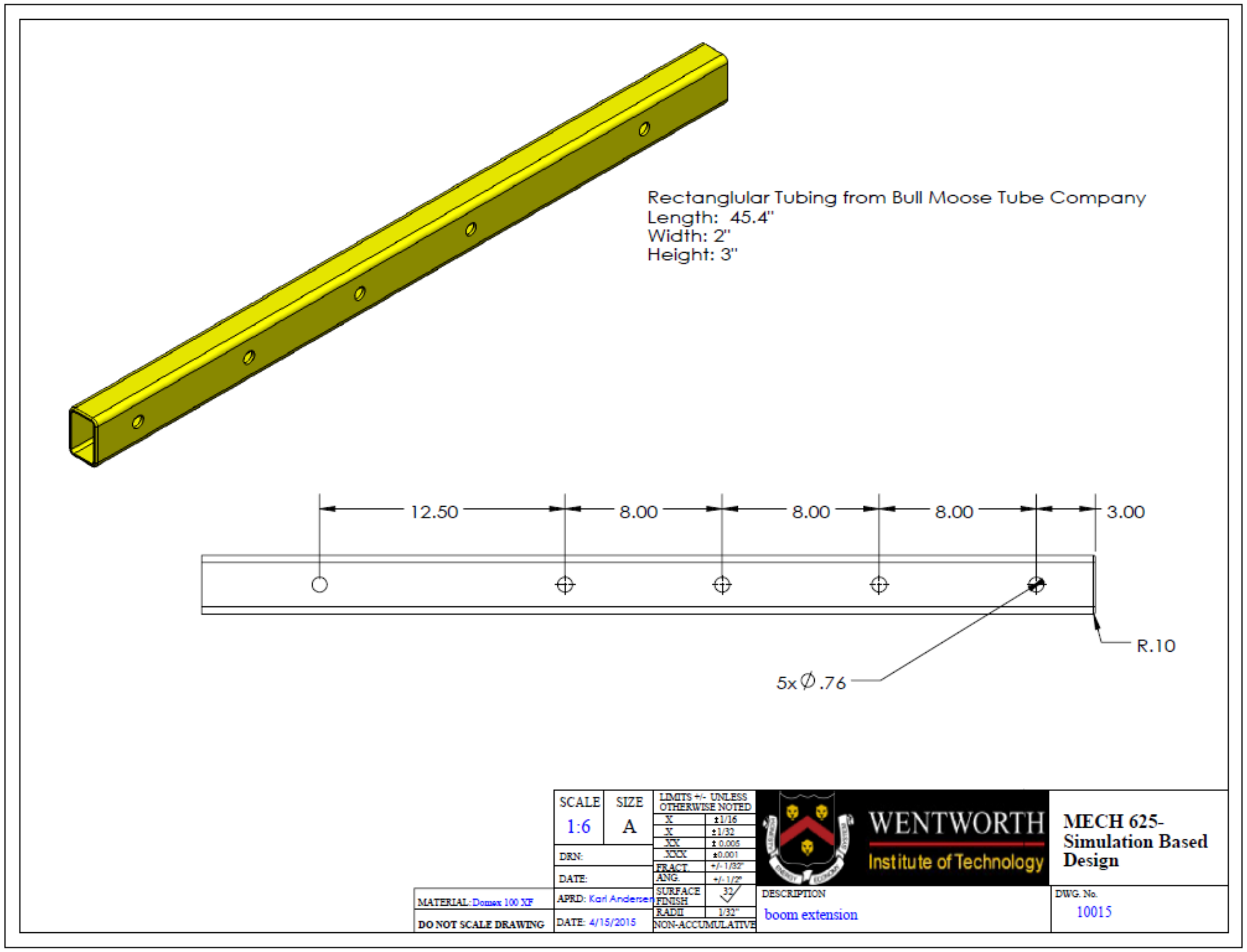


Figure 163: PN#10015 Redesign Drawing

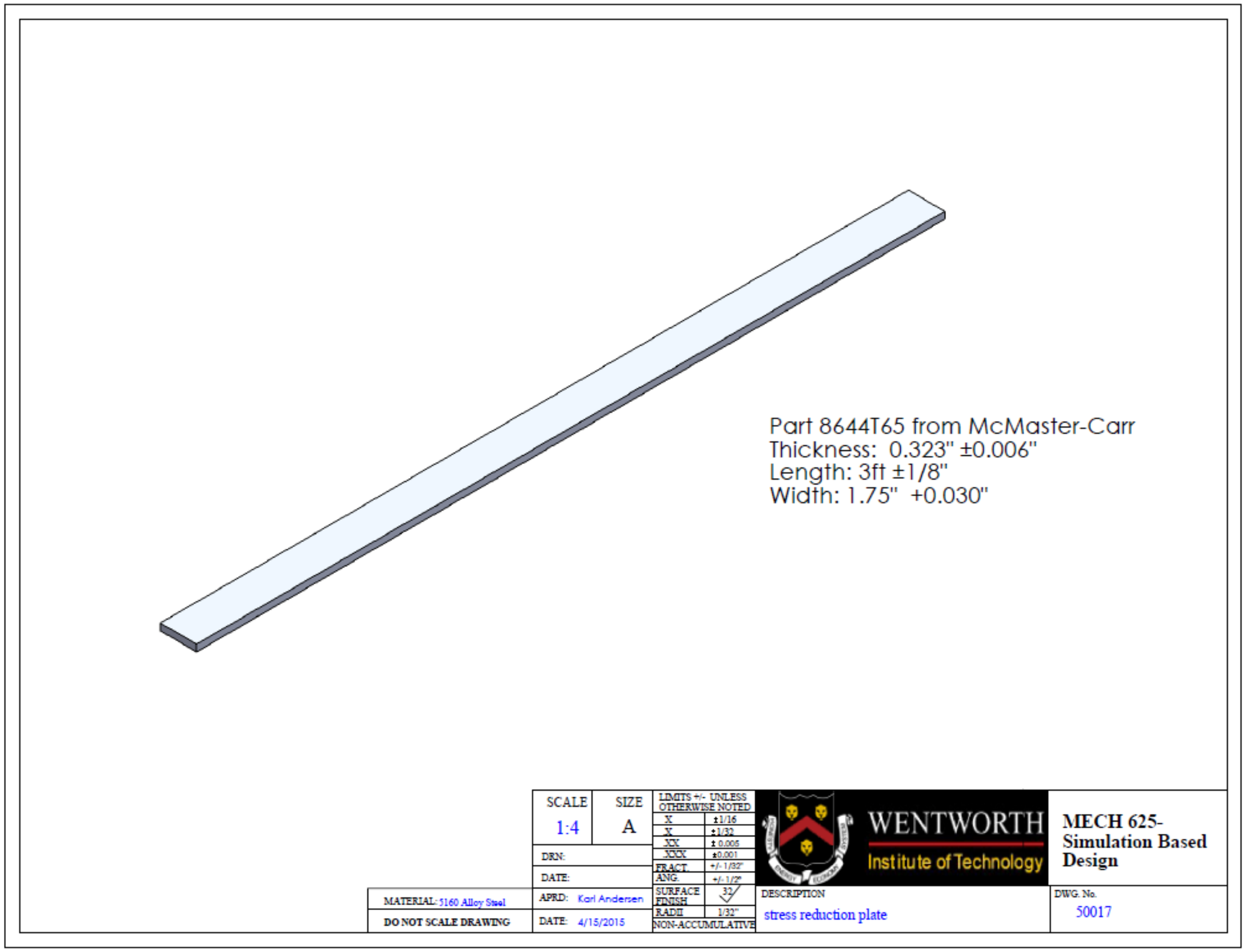
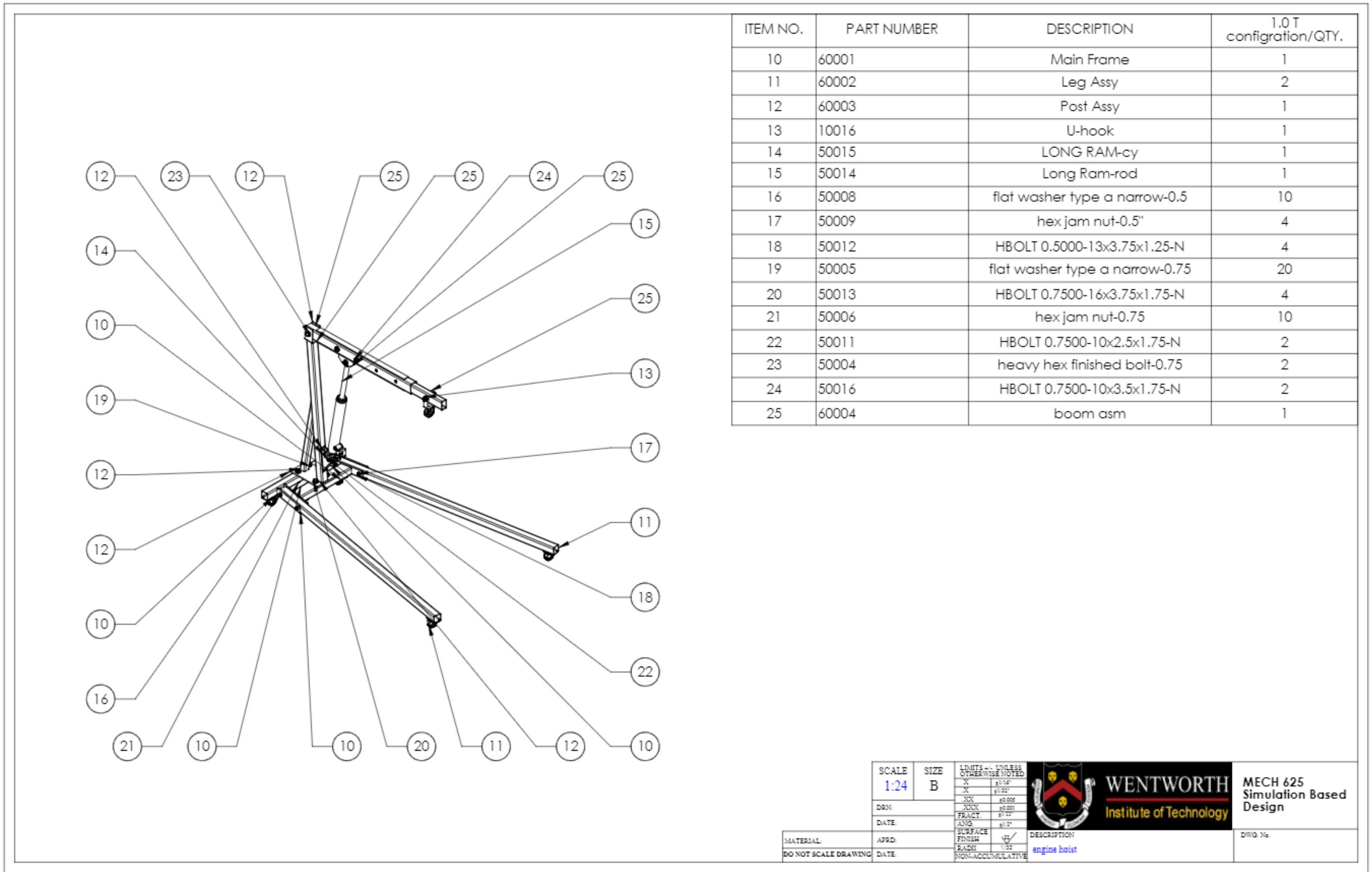


Figure 164: PN#50017 New Engineer Drawing

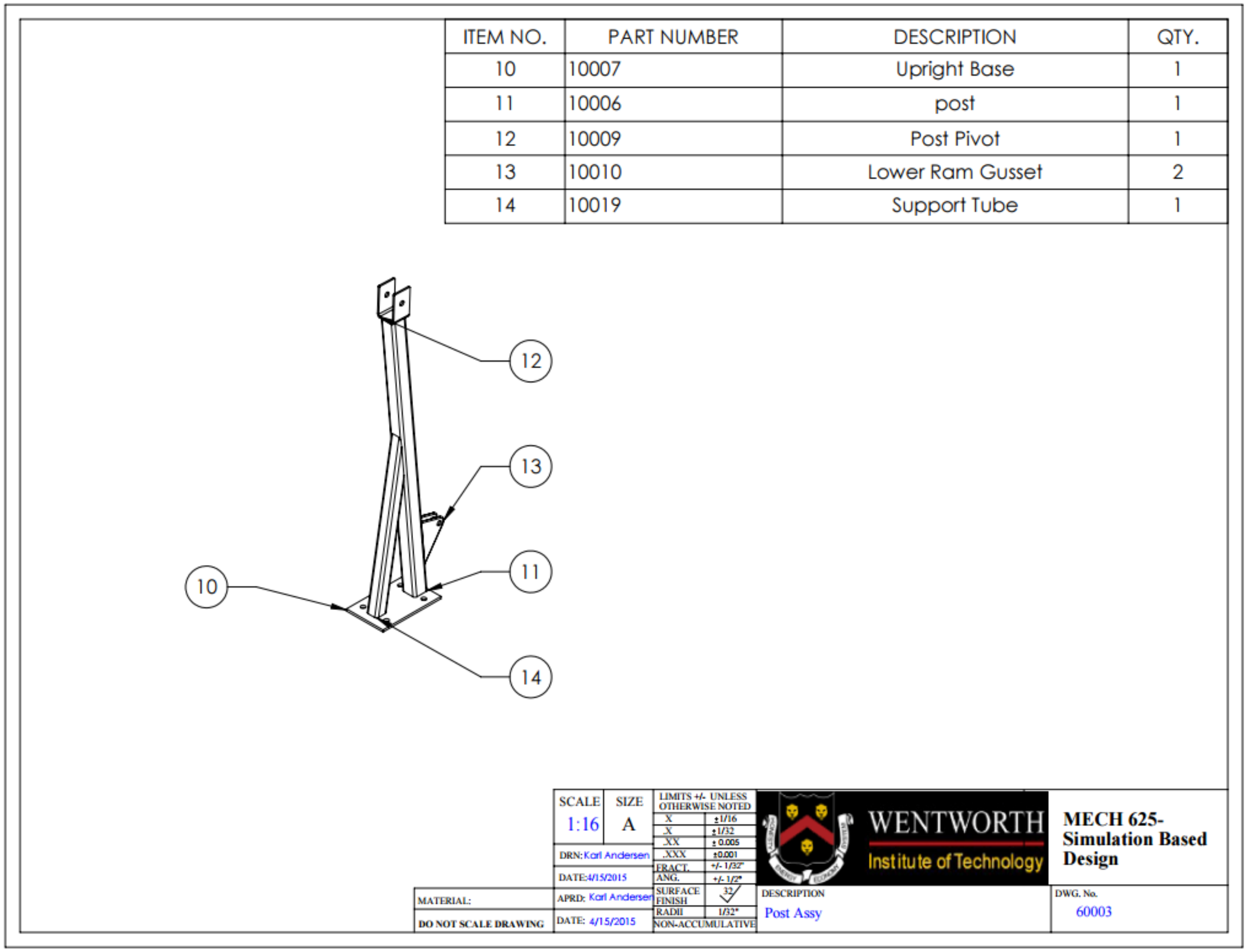
Figure 165: PN#10019 New Engineering Drawing

4.3 Assembly Drawings



ITEM NO.	PART NUMBER	DESCRIPTION	1.0 T configration/QTY.
10	60001	Main Frame	1
11	60002	Leg Assy	2
12	60003	Post Assy	1
13	10016	U-hook	1
14	50015	LONG RAM-cy	1
15	50014	Long Ram-rod	1
16	50008	flat washer type a narrow-0.5	10
17	50009	hex jam nut-0.5"	4
18	50012	HBOLT 0.5000-13x3.75x1.25-N	4
19	50005	flat washer type a narrow-0.75	20
20	50013	HBOLT 0.7500-16x3.75x1.75-N	4
21	50006	hex jam nut-0.75	10
22	50011	HBOLT 0.7500-10x2.5x1.75-N	2
23	50004	heavy hex finished bolt-0.75	2
24	50016	HBOLT 0.7500-10x3.5x1.75-N	2
25	60004	boom asm	1

Figure 166: PN#60005 Full Assembly Redesign Drawing with BOM



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
10	10007	Upright Base	1
11	10006	post	1
12	10009	Post Pivot	1
13	10010	Lower Ram Gusset	2
14	10019	Support Tube	1

Figure 167: PN#60003 Post Assembly Redesign Drawing with BOM

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	10013	Boom 3.5X2.5	1
2	10014	Base of boom	2
3	10015	boom extension	1
4	50017	stress reduction plate	2

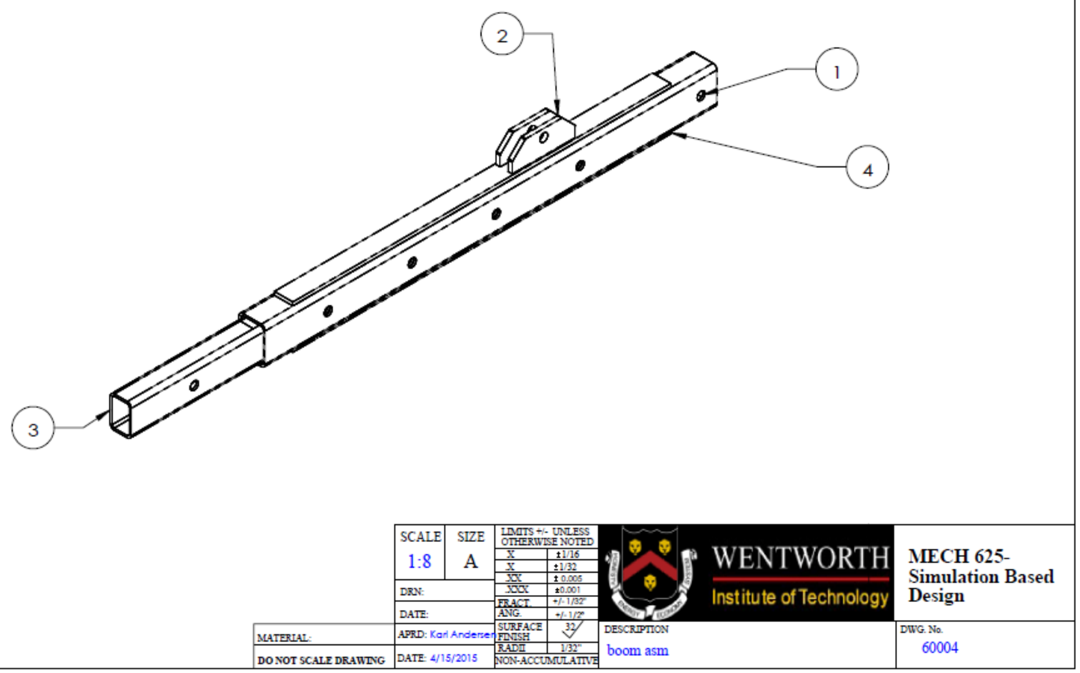


Figure 168: PN#60004 Boom Assembly Redesign Drawing with BOM

5. Recommendations

5.1 Redesign Approach

The hook never failed the baseline assessment so it does not need to be redesigned.

5.1.1 Boom

The Boom assembly failed around the pin holes, the areas of contact between the two tubing parts, and the weld area around the base. In order to solve these issues, a number of changes were made to the design.

The first major change was the material of the tubing parts. We found a manufacturer called “Bull Moose Tubing Company” that supplied the tubing we were looking for in a much stronger material called “Domex 100 XF.” This allows the material to handle more force without failing, but this was still not enough to completely prevent the design from failing.

The second change was adding a fillet to the end of the inner tubing that contacts the outer tubing. This allows the force to spread out more evenly as the two parts contact, reducing the overall stress.

The third change was including an additional pin to hold the inner tubing in place. This was done to lower the loading experienced near the areas of contact between the two tubing parts.

The fourth change was made to the dimensions of the base that connects the boom to the hydraulic lift. Increasing the thickness of this part allows it to experience less stress at the same level of force.

The final change was welding support plates to the top and bottom of the outer tubing part. We found these plates on McMaster-Carr, and they are made out of a strong material called 5160 Alloy Steel. These plates absorb a large amount of the bending stress applied to the plates, and was able to prevent the assembly from failing.

5.1.2 Post

In the baseline assessment on the boom it is clear where the stress concentrations are. The brace proved to be a huge source of stress concentrations and was thus removed. This also removed the pins that had failed. Without the mathematical pins the simulation ran much quicker. Thus it was decided to use h-adaptive methods to observe the changes it created. The AISI 1020 steel was too weak to support any loading condition effectively.

The material of the redesign was changed to Alloy Steel with a yield strength of about 90 ksi. This material was used on the redesigned manufactured parts. The lower ram gusset was redesigned to support more load. The bottom was made larger to help distribute the load over a larger area. A lot more fillets where used to smooth out edges to prevent stress concentrations. It was also made a little thicker overall (within design spec.) to increase its strength.

New structural tubing was found from the Bull Moose Tube Company. This tubing uses Domex 100XF, a hot rolled, extra high strength, cold forming steel. This steel has a yield strength of 100 ksi. Not enough information was given to make a new material in SolidWorks however, so Alloy Steel (yield = 90 ksi) was used instead.

5.1 Discussion

On the post using the H-adaptive severely lowered the minimum F.O.S. This is most likely because H-adaptive methods increase the mesh size in areas where the results are inconclusive. In the case of the post this meant anywhere where an existing stress concentration already exists. Because of that the extremely low F.O.S. numbers seen on the post in the tables and the plots can be ignored to an extent. The proof of this is in the deflection. The deflection never breaks or even comes with 25% of the maximum allowable deflection. If the stress was as high as it was over a sufficient area then this would not be the case. Even in the plots this is evident as the actual area where the F.O.S. is below specification is extremely small. H-adaptive methods forced the numbers lower than they needed to be.

In addition using H-adaptive caused an anomaly in SolidWorks. Once it was run and the undesirable results were found SolidWorks could not undo the results. What is meant by this is that even after turning off the adaptive settings that the results would not change. This is most likely because SolidWorks stores some of the meshing data to simplify its own static anaylsis. This would keep the overly focused meshing on the contact stress concentrations that would normally be resolved by welding fillets.

6. References

Steffen, John. Analysis of Machine Elements Using Solidworks Simulation 2014. Mission, Kan.: Schroff Development, 2013. Print.

"Ultra High Strength." Bull Moose Tube — Cutting-edge Tubing for Today's Industries. N.p., n.d. Web. 12 Apr. 2015.

Hibbeler, R. C. Mechanics of Materials. 8th ed. Upper Saddle River, NJ: Prentice Hall, 1997. Print.

7. Appendix

Report Format

Chapter 3: Analysis and Redesign

3.1 loading analysis and strength calculation

- 3.1.1 If there are some loading analysis such as reaction forces at the post support assembly, process and results will be included here.
- 3.1.2 If there are some theoretical strength calculation, the strength calculation formula, process and results will be included here.
- 3.1.3 Theoretical calculation might be performed on some pins (bolts served as pins)
- If bolts don't satisfy the design specification, redesign is required.

3.2 FEA analysis

- 3.2.1 Pre-processing for FEA analysis
- 3.2.2 For every component, the design team should provide three plots
    - Von Mises stress plots with the notation of maximum Von Mises stress in psi
    - Resultant displacement plot with the notation of maximum displacement in inch
    - The factor of safety plot which shows the red area when the factor of safety is less than design specification.
- 3.3.3 Compile a table to show the maximum stress, minimum factor of safety, and the maximum displacement of the manufacturing parts: PN#10001 to PN#10016.
- 3.3.4 If components don't satisfy the design specification, redesign of the failed components are required. For each redesigned components, the same three plots (Von Mises stress, Resultant displacement and the factor of safety plot) are needed
- 3.3.5 Compile a table to show the maximum stress, minimum factor of safety, and the maximum displacement of the manufacturing parts and the redesigned components

3.3 Discussion and conclusions

Chapter 4: Drawings

4.1 Bill of Materials for the redesigned engine joint

- Bill of Materials of the top assembly
- Bill of materials of each sub-assembly

4.2 Part drawings

- The new designed components
- Three part drawings: PN#10001, PN#10007, PN#100013

4.3 Assembly drawing

- Three assembly drawings: PN#60001, PN#60003 and PN#60004

Chapter 5: Recommendations

- Conclusions and comments on the provided engine hoist

- Recommendation based on the new designed engine hoist

Chapter 6: References

- At least three references

EES Code

Horizontal loading

```
{Static Anaylsis Major Project}


0=A_x+H_x                       {Sum of the forces on the X-Axis}
0=A_y+H_y-T                     {Sum of the forces on the Y-Axis}
0=14.87*H-X*T                   {Sum of the moments about P}

theta=79.65[deg]
A=sqrt(A_x^2+A_y^2)
H_x=H*cos(theta)
H_y=H*sin(theta)
```

Angled Up Loading

```
{Up static anaylsis}

0=A_x+H_x                       {sum of the forces X-axis}
0=A_y+H_Y-T                     {sum of the forces Y-axis}
0=H*14.86-T*X                   {Sum of the moments about point A}

A=sqrt(A_x^2+A_y^2)
H_x=H*cos(81.9)
H_y=H*sin(81.9)
```