Product Readiness Review

Diamond Turning Machine Assembly

Team 1 a.k.a Team K.I.S.S

Stephen Armstrong (Team Leader)
Chris Blackwell
Casey Funk
Brandon Hodges
Charles Renegar

11/11/2010

MAE 491-01 Product Realization
Instructor – Dr. Christina Carmen
Customer – Tim Blackwell
Advisor – Steve Collins
Sponsor – Hubbard and Drake General Mechanical Contractors

Overview

- Purpose of PRR
- Mission Statement
- Product Design Specifications
- Design Drawings
- Technical Analysis
- Verification Tests
- Final Cost Analysis
- Manufacturing/Assembly/Installation
- Problems and Solutions
- Lessons Learned
- Summary

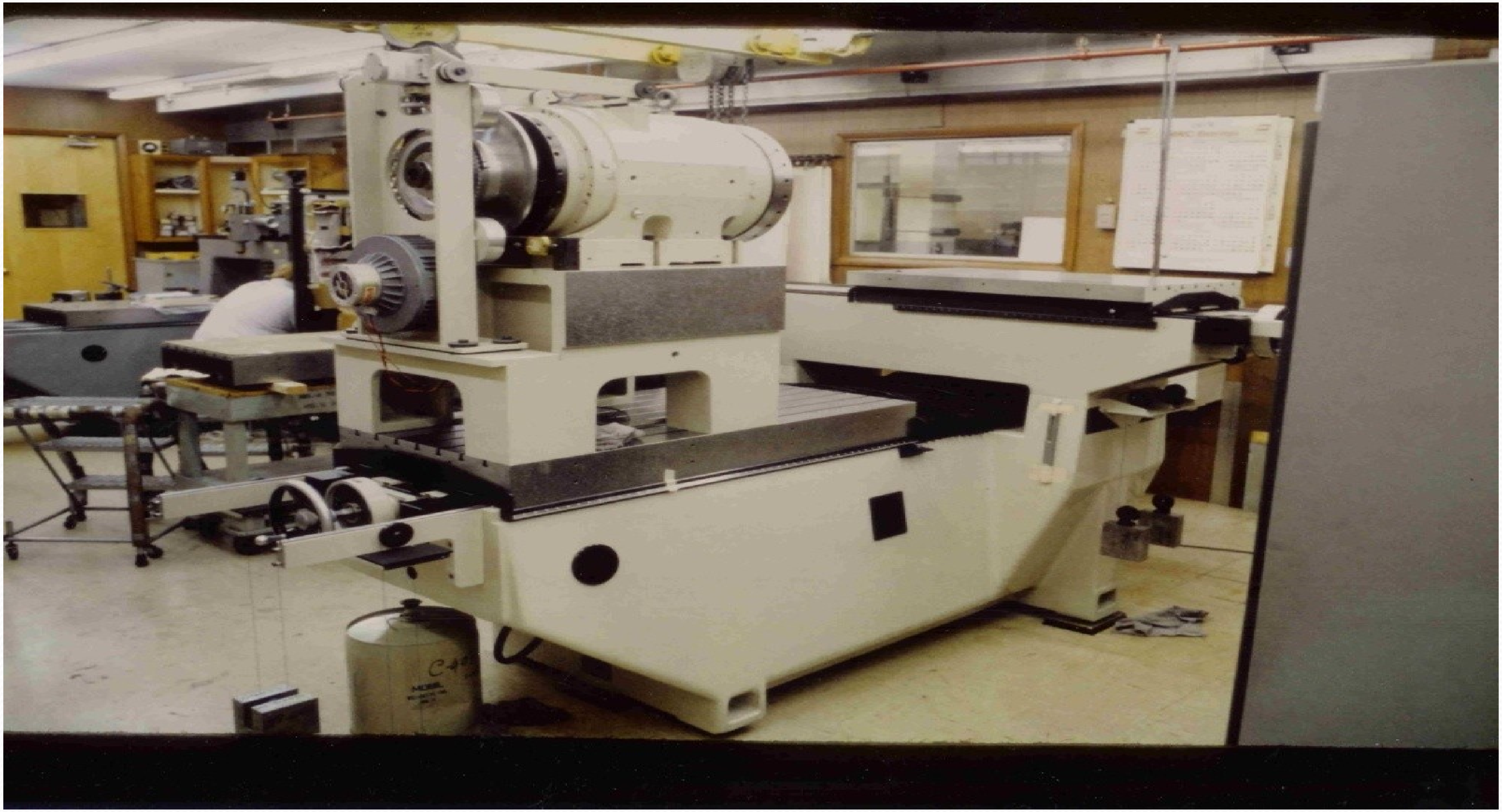
Purpose of PRR

- Review the results of the system verification processes
- Provide Final Cost information
- Demonstrate product to verify it meets the product design specifications

Mission Statement:

To design a lifting system for the Center for Applied Optics at UAHuntsville that will be able to properly and safely lift and lower two slides of a Moore 30” diameter Diamond Turning Machine, from their packaged state onto the machine. The system must be able to rotate the slides 180 degrees and set the slides down softly to avoid denting the precision burnished slide grooves.

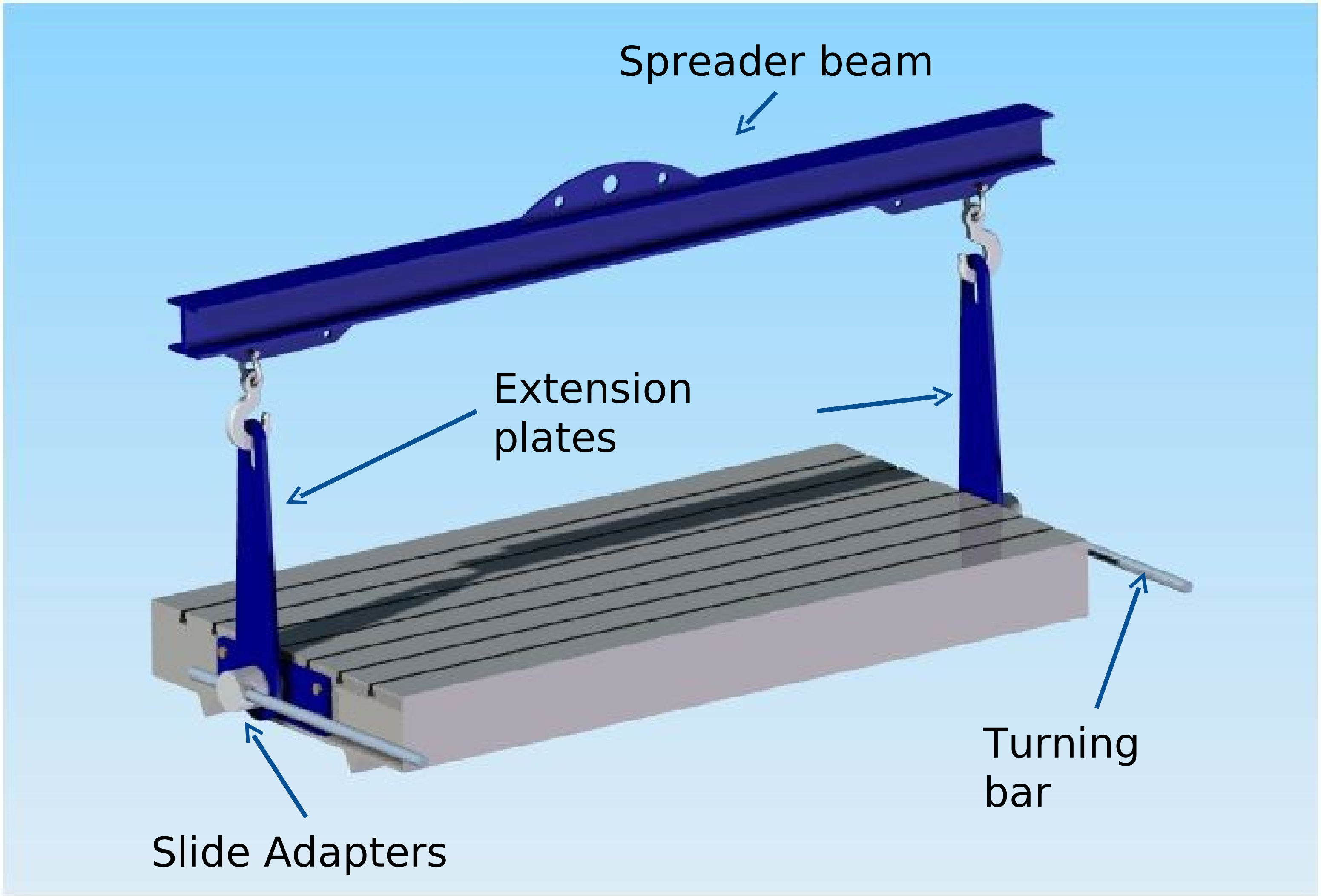
Diamond Turning Machine



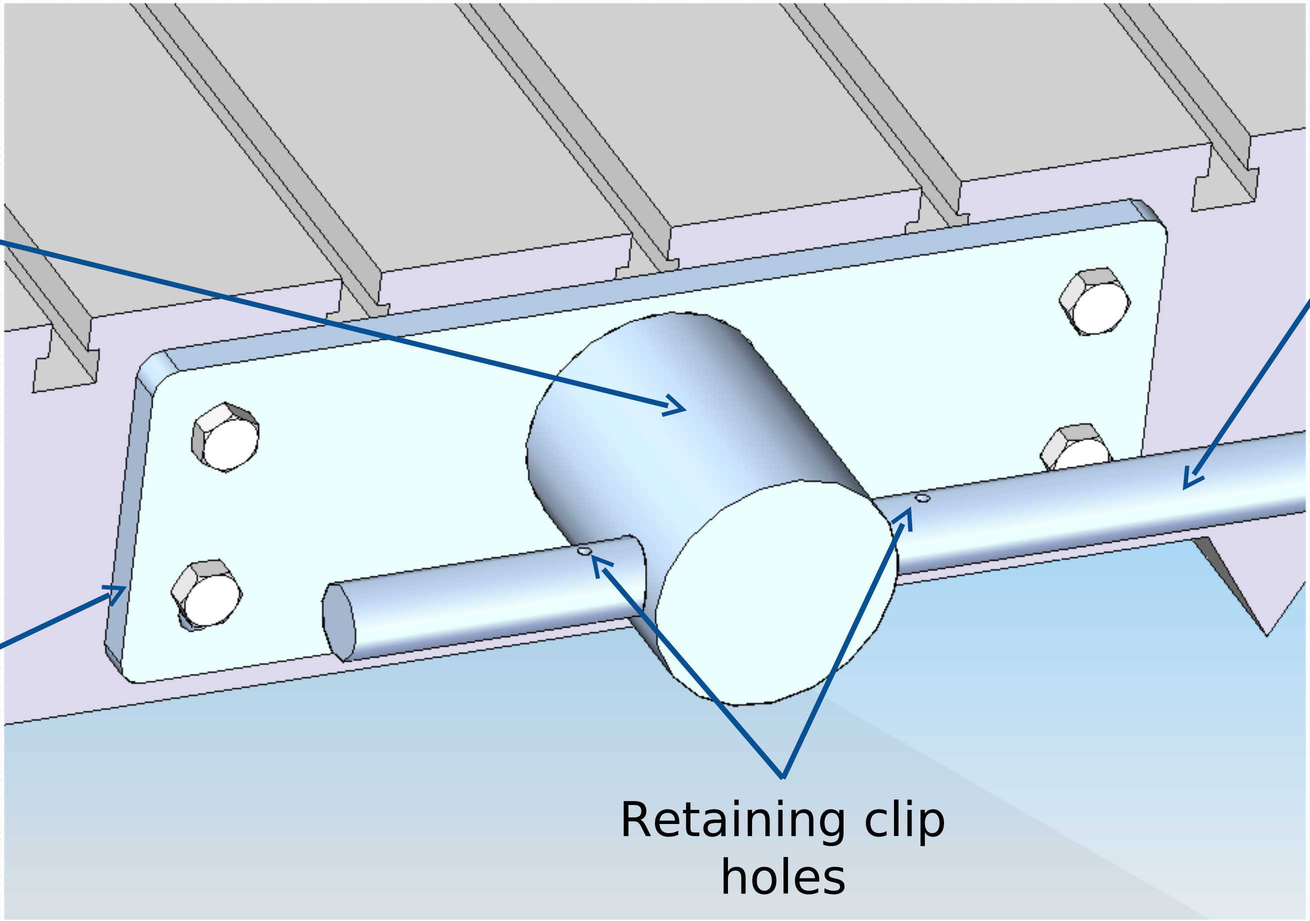
Product Design Specifications

- The lifting beam must able to attach to a fork lift or a cherry picker like device.
- The device to which the beam is attached must be able to lower the beam slow enough not damage the machine as well as mobile enough to be moved into the proper position.
- The beam must be able to support the weight of the slides as well as rotate them 360 degrees
- There should be a factor of safety of at least 2 for all designed loads.

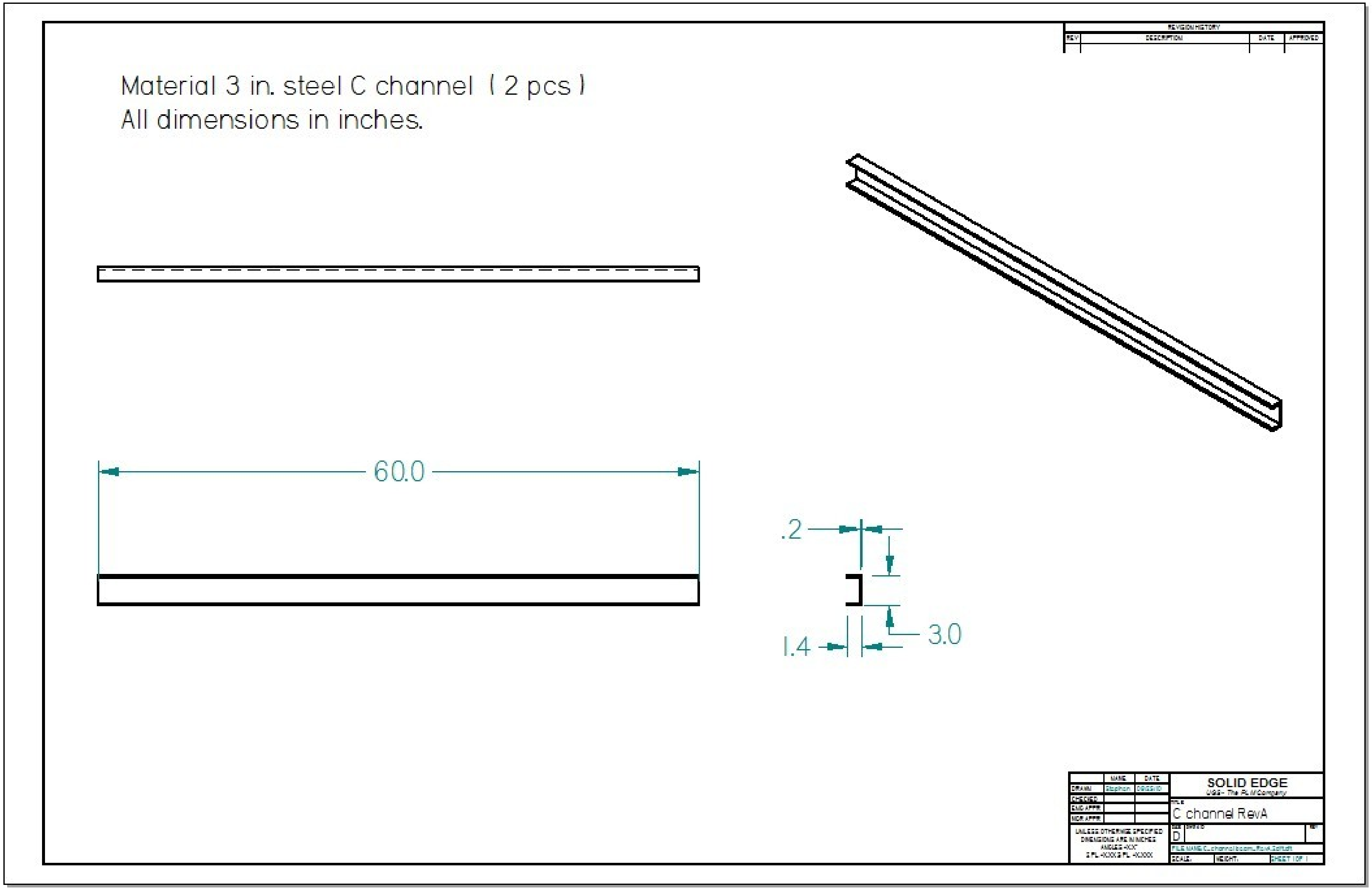
Design Drawings



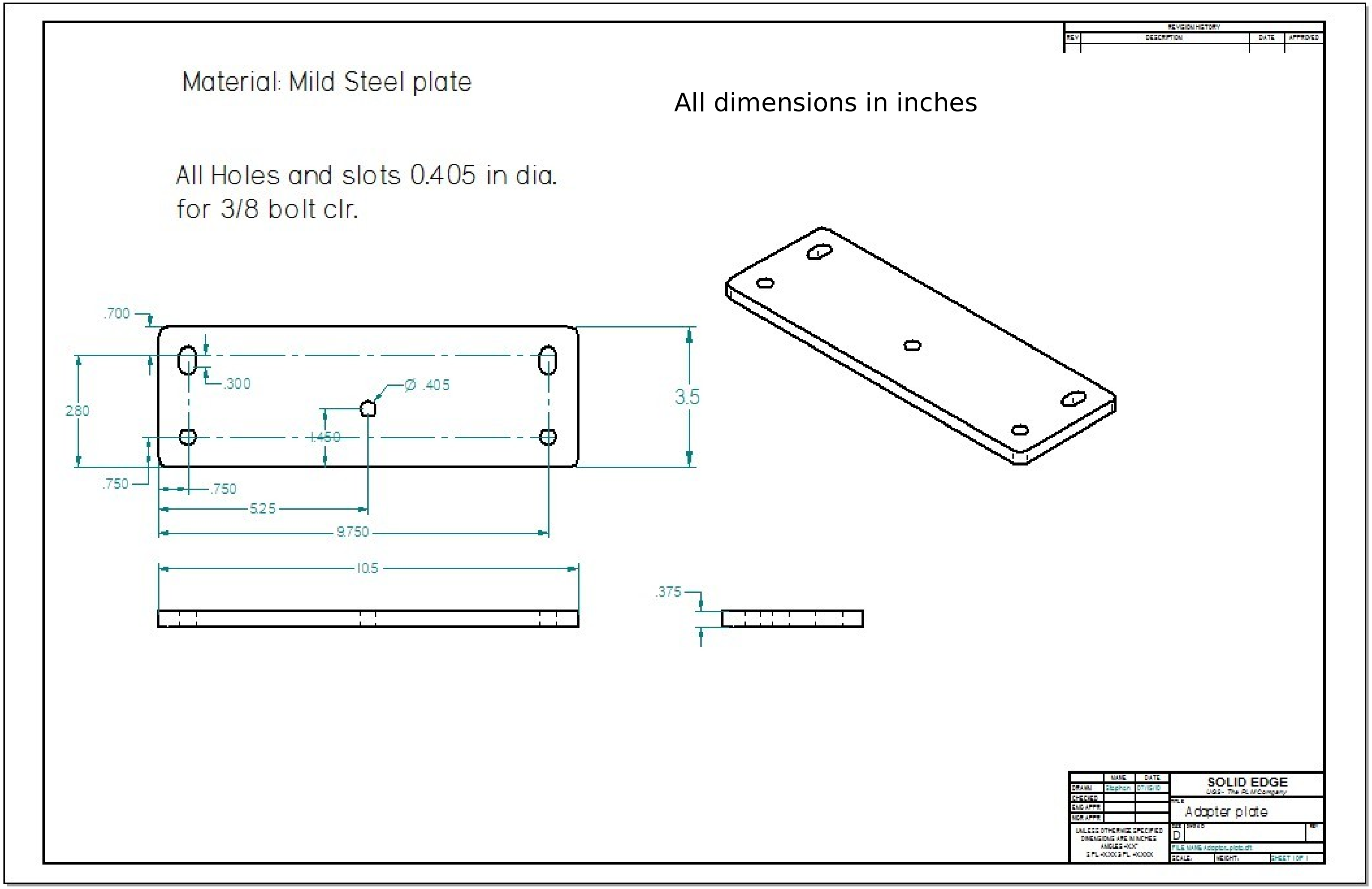
Design Drawings



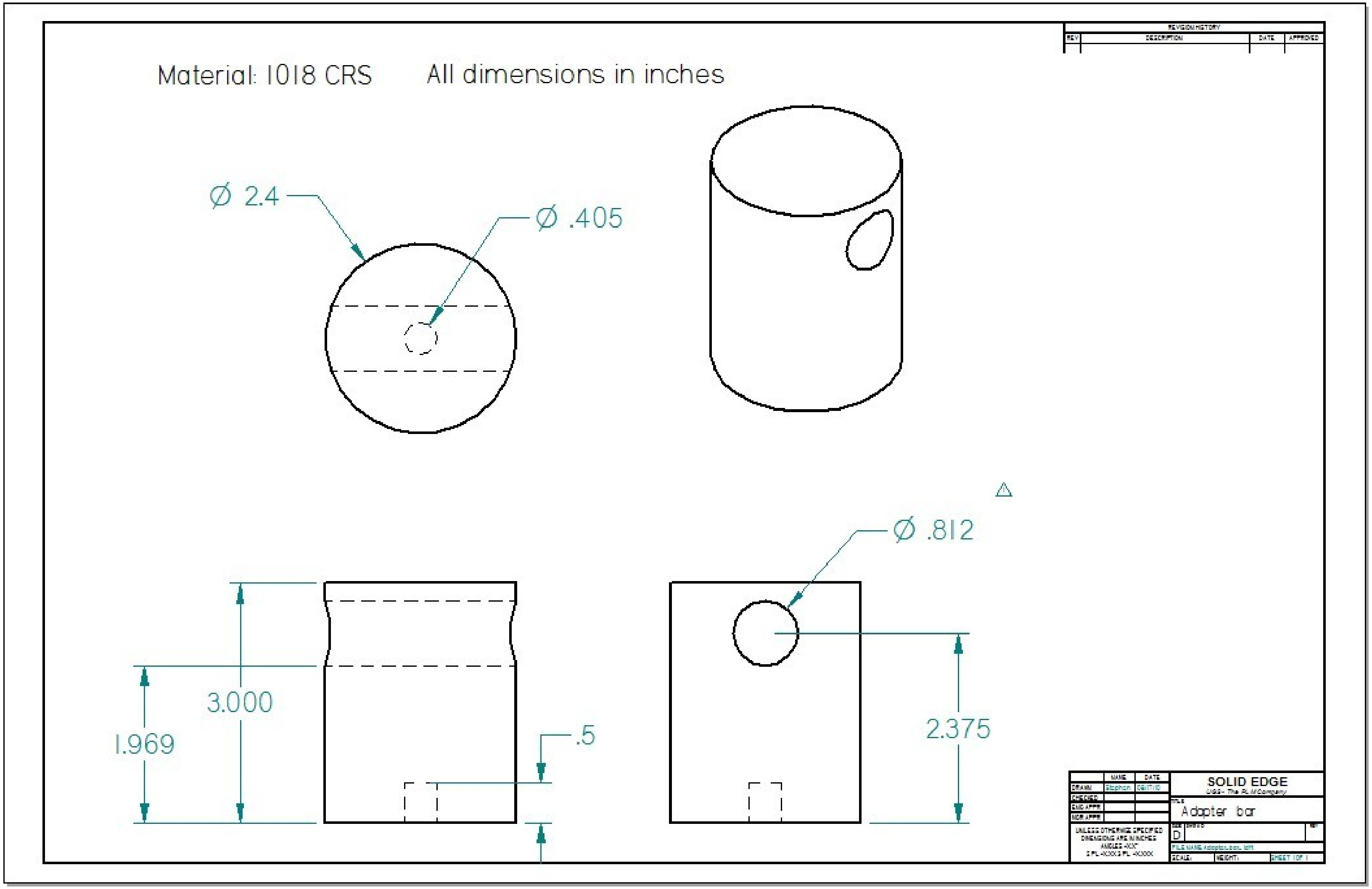
Design Drawings – C channel



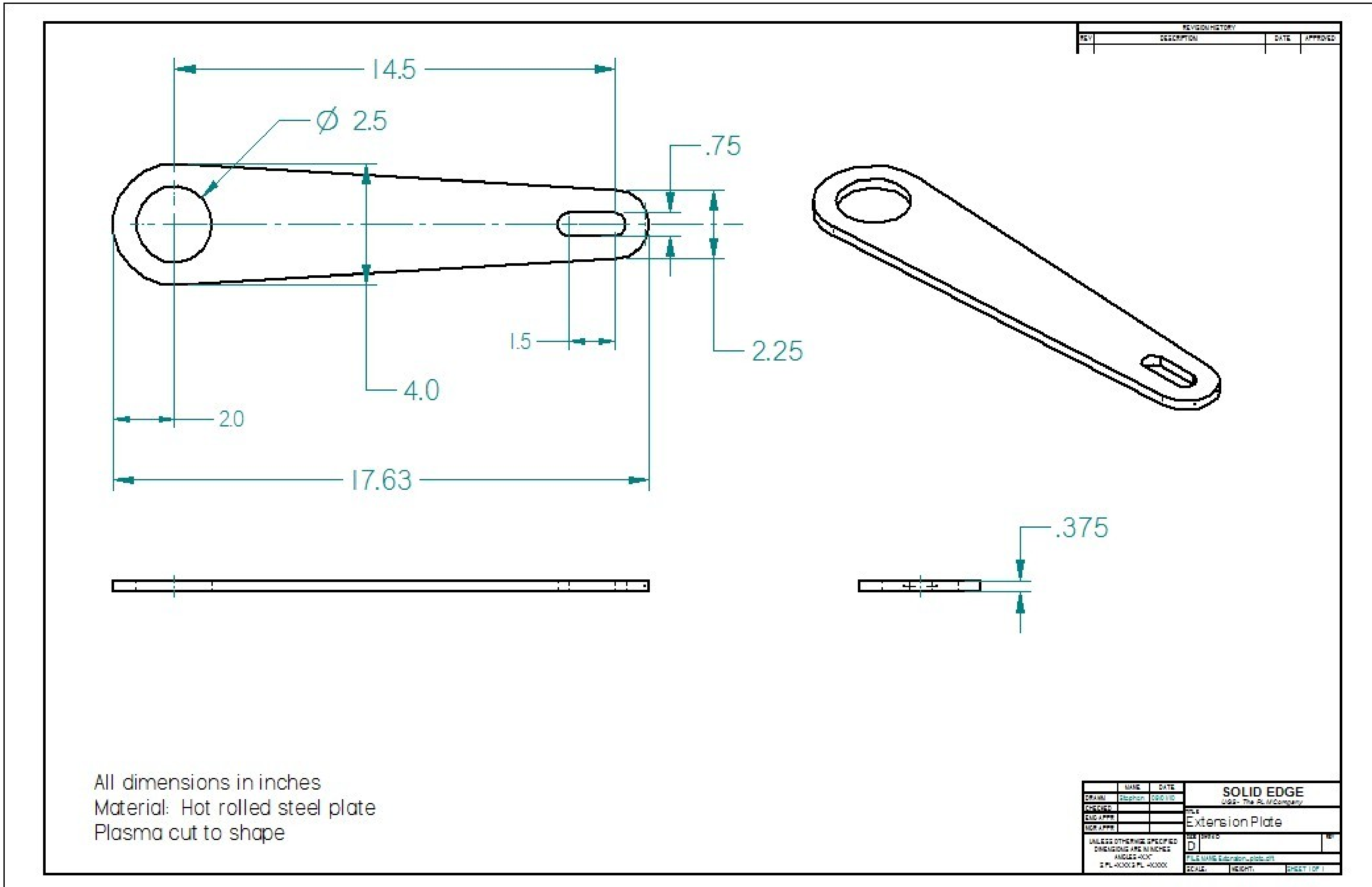
Design Drawings – Adapter plate



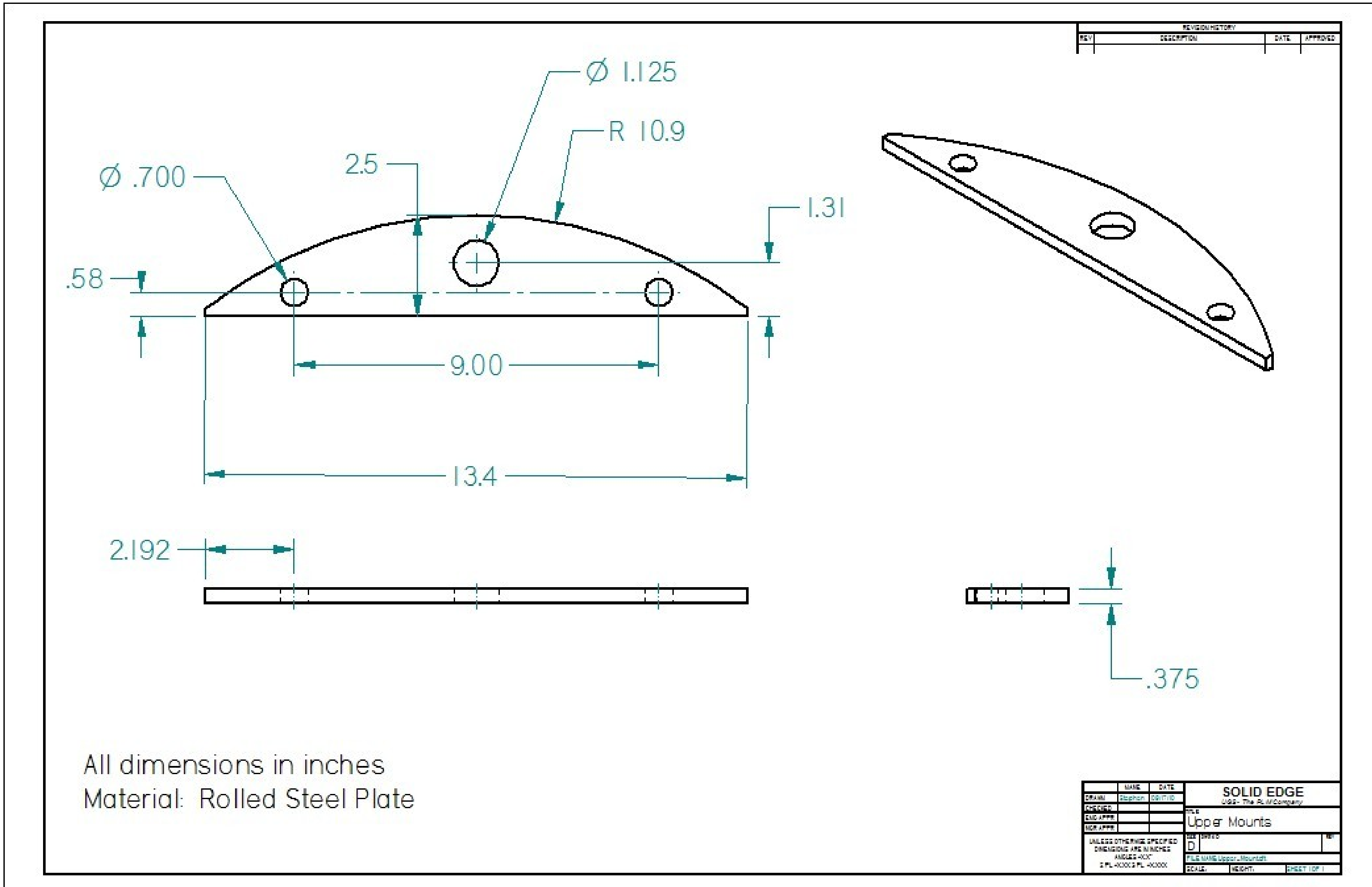
Design Drawings – Adapter bar



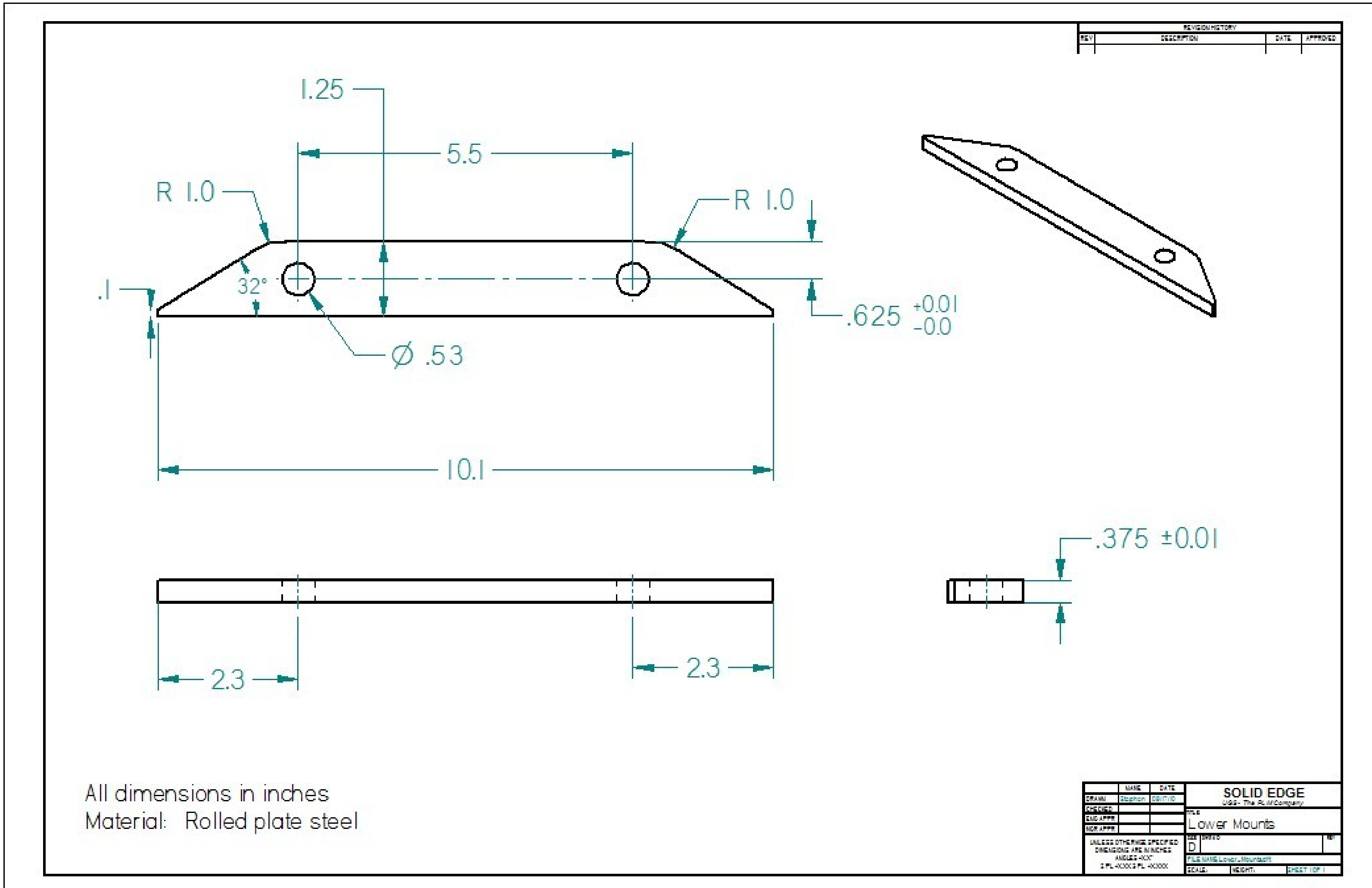
Design Drawings – Ext. Plate



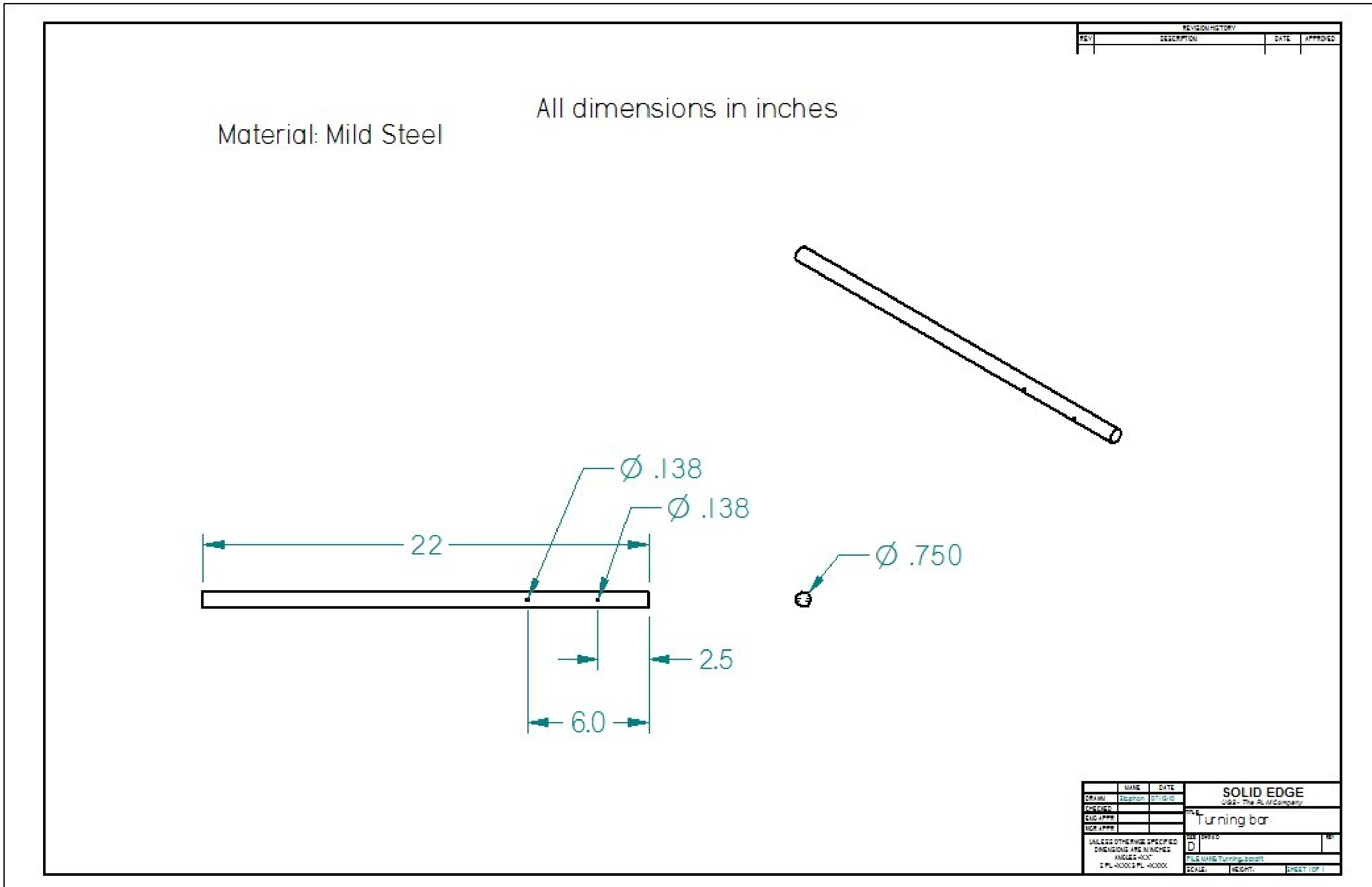
Design Drawings – Upper Mts.



Design Drawings – Lower Mts.



Design Drawings – Turning bar



Technical Analysis

Nastran FEA Results

These are the results for the simple 1-D analysis of just an I beam under two different load cases.

Fork-truck loading

- Maximum stress of 3760 psi compared to hand calculation of 3755 psi
- Percent diff. of 0.1%
- Maximum deformation of 0.025 in

Engine hoist loading

- Maximum stress of 4780 psi compared to hand calculation of 4769 psi
- Percent diff. of 0.2%
- Maximum deformation of 0.026 in

Technical Analysis

C-Channel Beam Rev. A

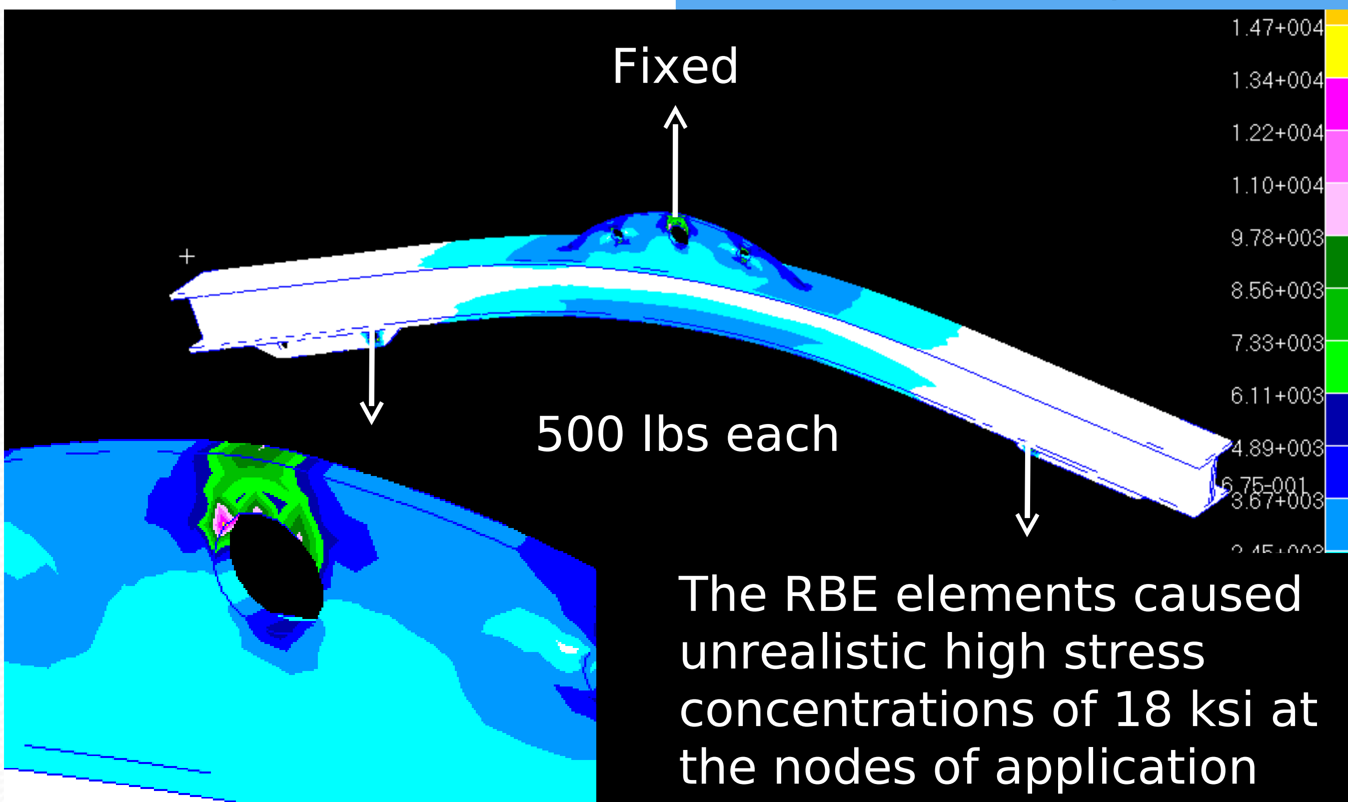
- A special Solid Edge Model was created to mimic the welded geometry in order to analyze the new spreader beam weldment.
- Rigid body elements were then used to constrain the large hole where the hook is placed and to apply forces to the holes in the lower mounts.

Technical Analysis

Engine Hoist Loading

The green stresses of approx. 10 ksi near the hook hole are most likely near realistic values.

The med. Blue areas compare closely to the values obtained with the 1-D analysis



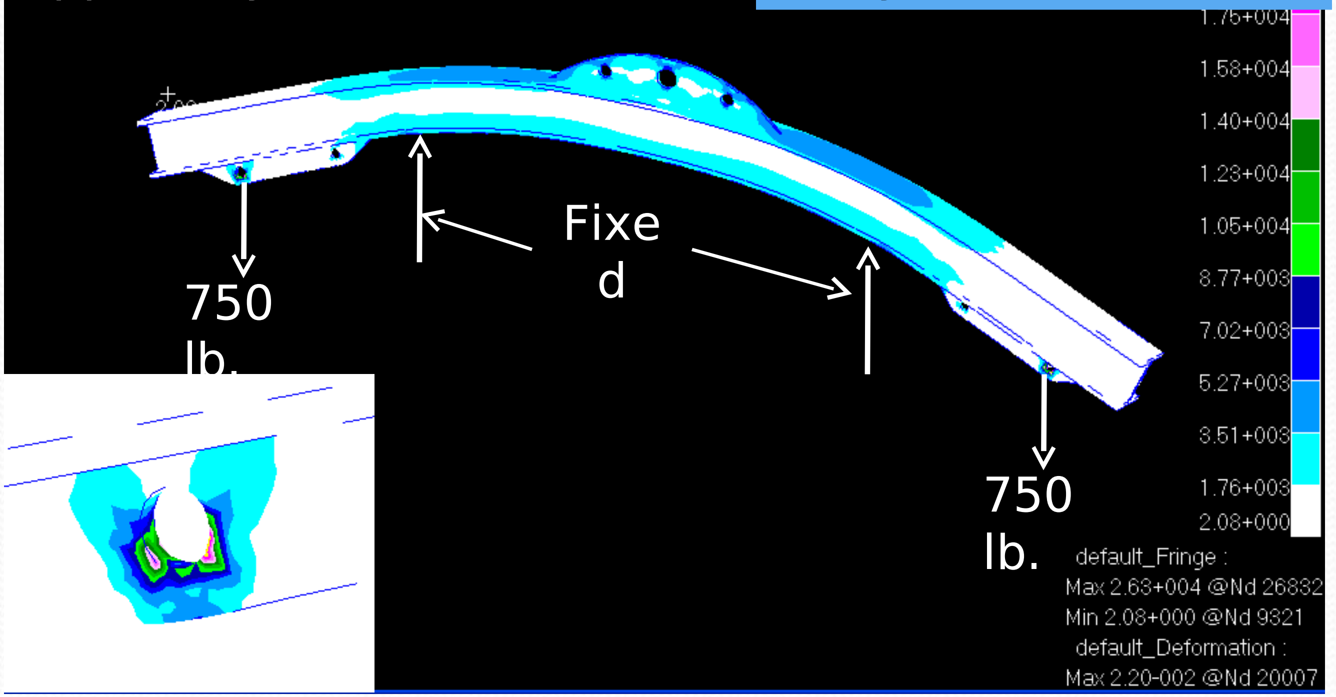
The RBE elements caused unrealistic high stress concentrations of 18 ksi at the nodes of application

Technical Analysis

Fork truck Loading

This model also had unrealistic high stress concentrations of 26 ksi where the 750 lb forces were applied by RBE elements.

The med. Blue areas also compare closely to the values obtained with the 1-D analysis



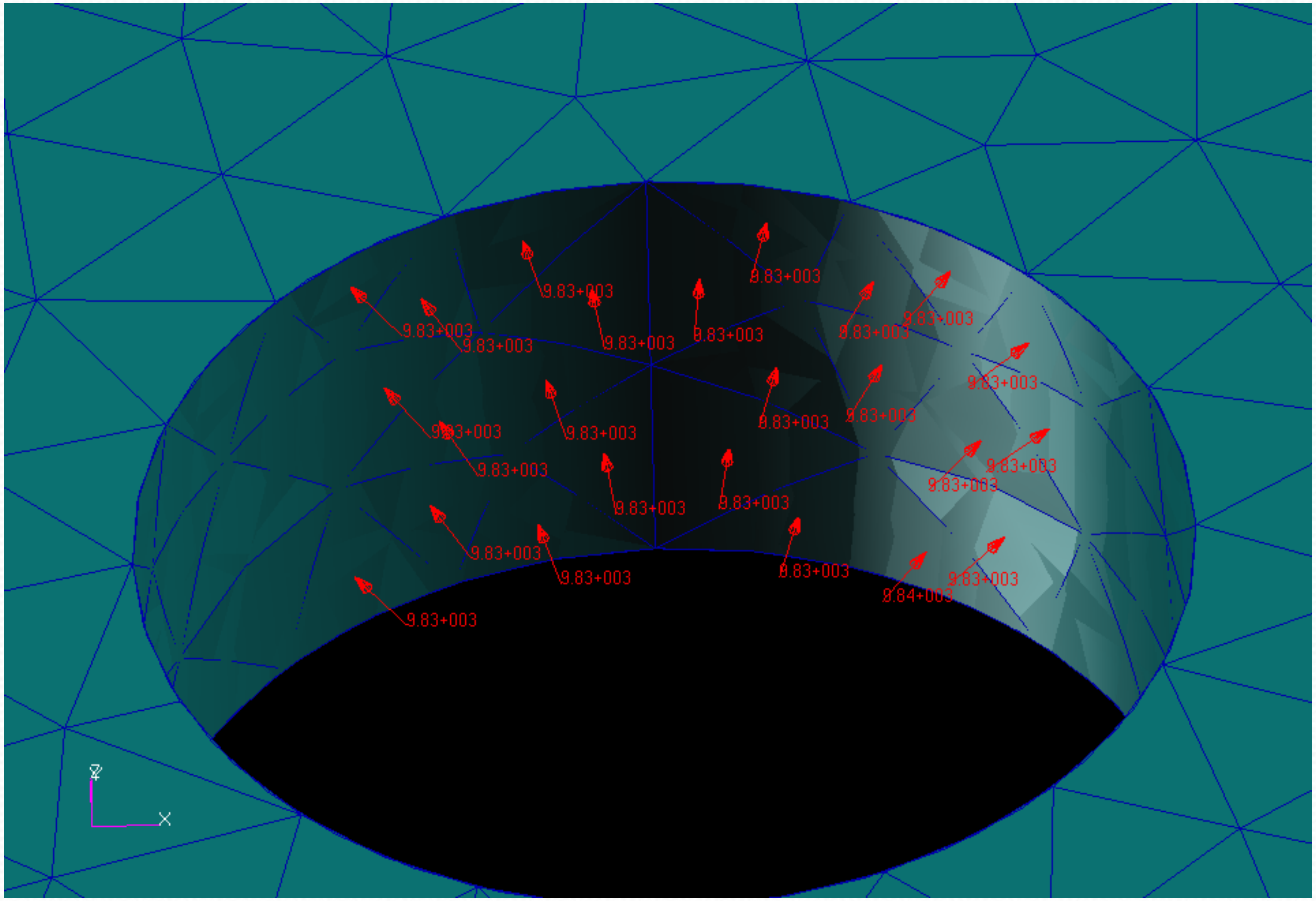
Technical Analysis

Mounting plates

- In order to better represent the loads imposed at the hole locations of the upper and lower mounting plates, separate FEAs were done using load application by pressure instead of point force methods.
- After meshing the model, the actual size of individual elements was used to create a pressure function that could be applied to the contact surfaces inside the holes.
- Both models were constrained by fixing the areas that were to be welded to the beam.

Technical Analysis

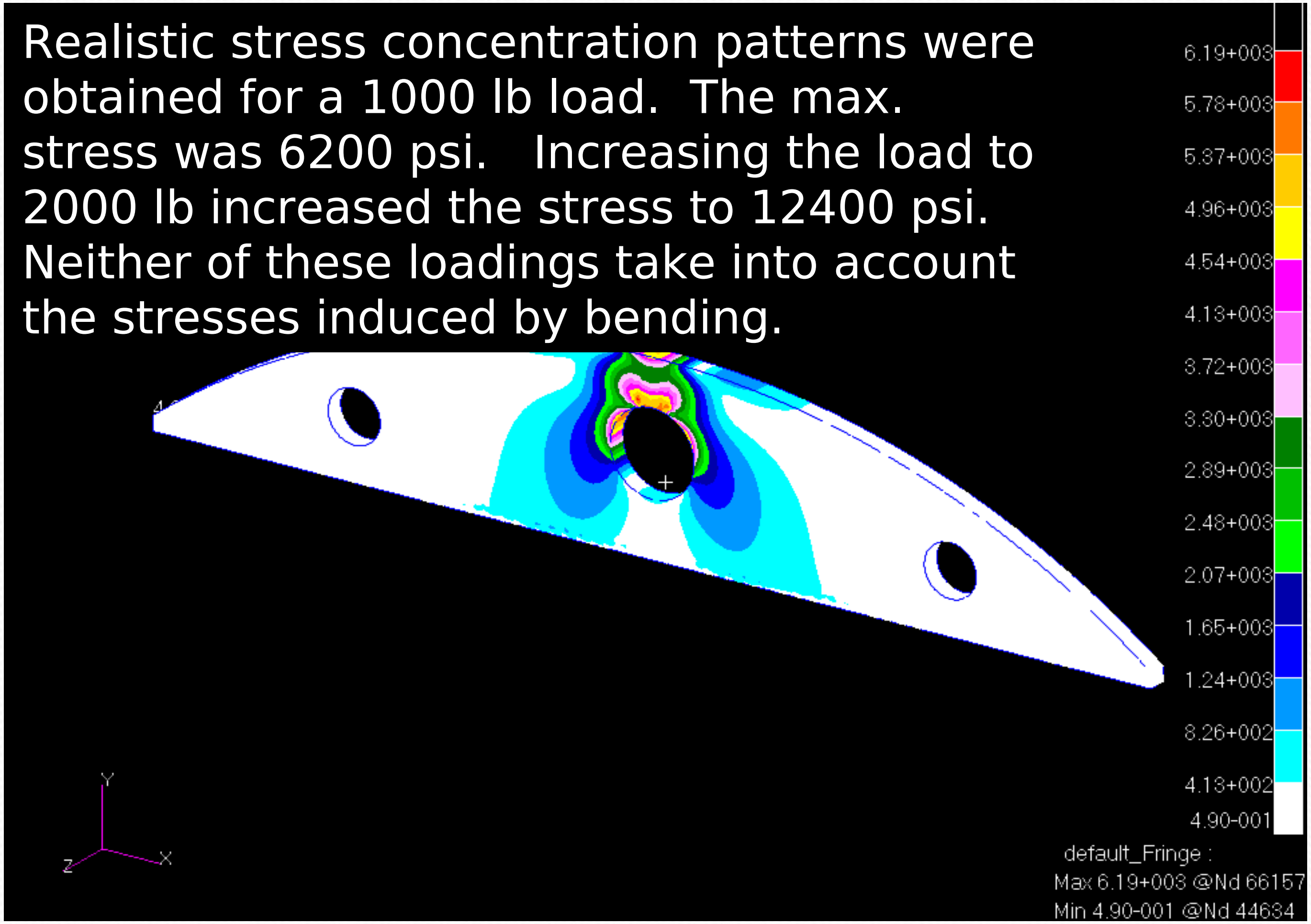
Typical Pressure Load Application



Technical Analysis

Upper Mount (Engine Hoist Loading)

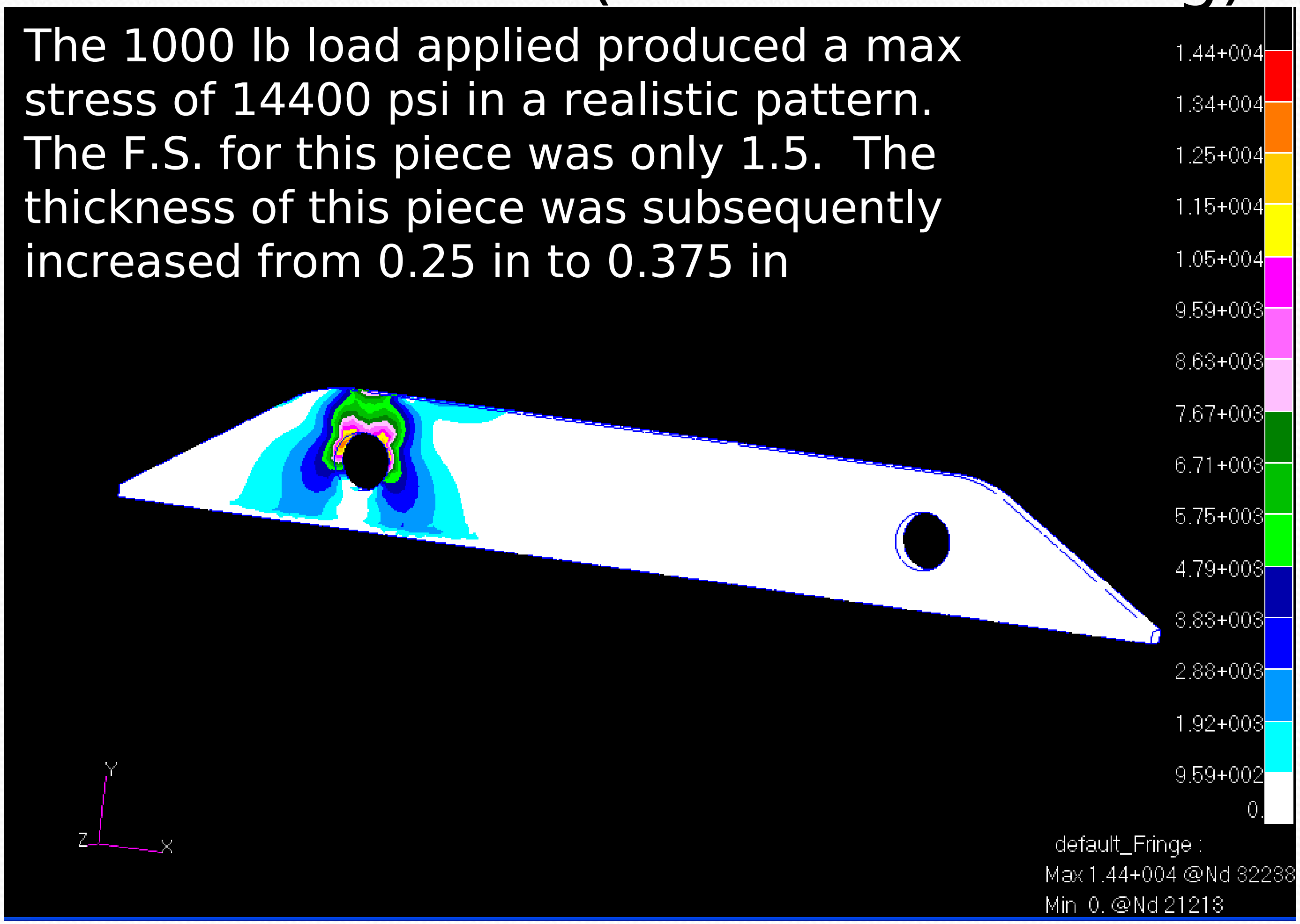
Realistic stress concentration patterns were obtained for a 1000 lb load. The max. stress was 6200 psi.   Increasing the load to 2000 lb increased the stress to 12400 psi. Neither of these loadings take into account the stresses induced by bending.



Technical Analysis

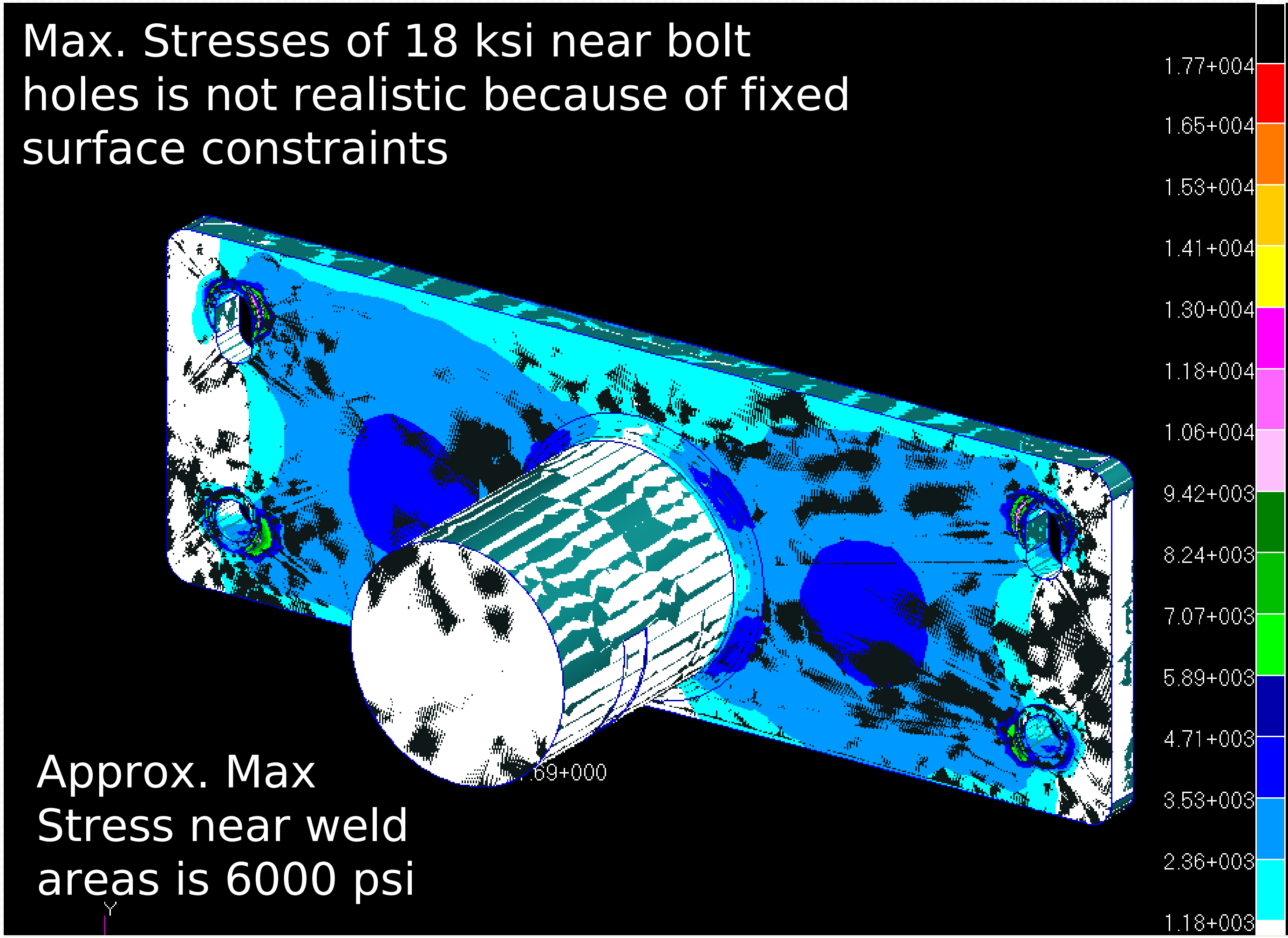
Lower Mounts (Fork Lift Loading)

The 1000 lb load applied produced a max stress of 14400 psi in a realistic pattern. The F.S. for this piece was only 1.5. The thickness of this piece was subsequently increased from 0.25 in to 0.375 in



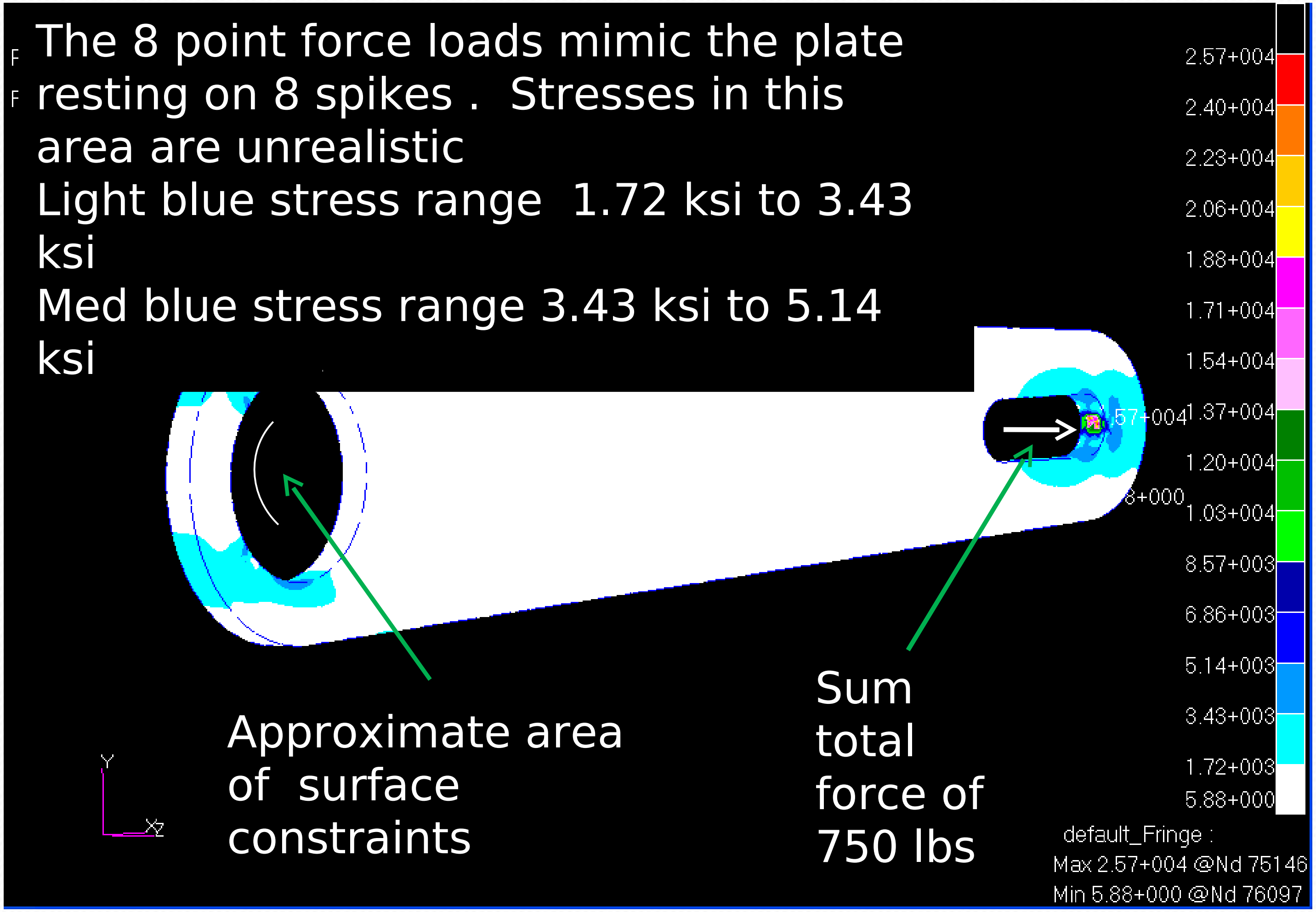
Technical Analysis

Adapters



Technical Analysis

Extension Plates



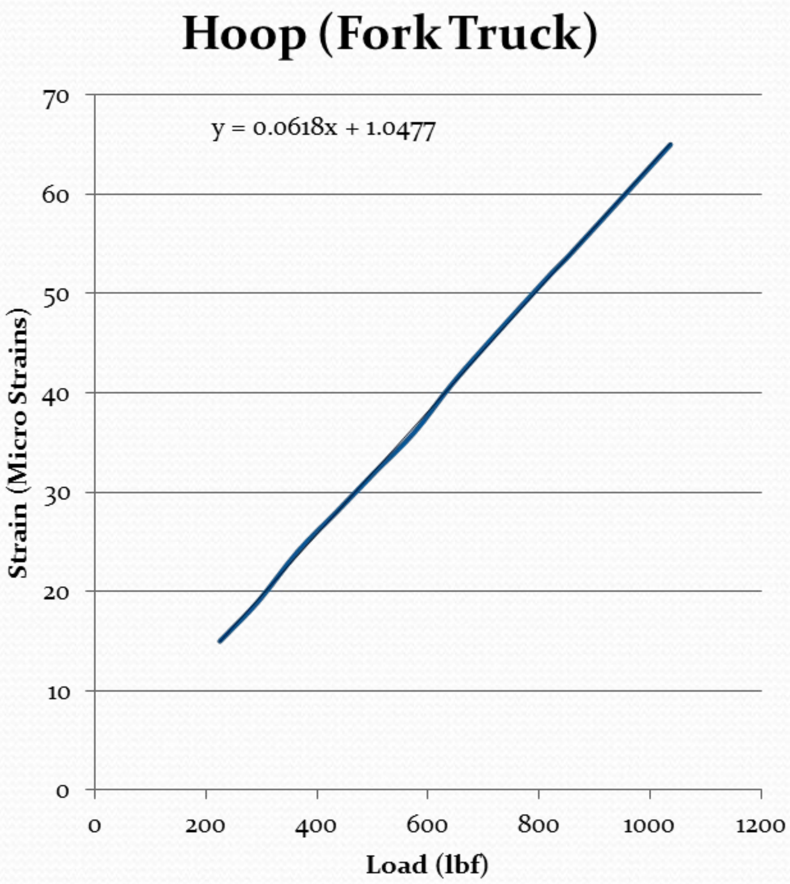
Verification Tests

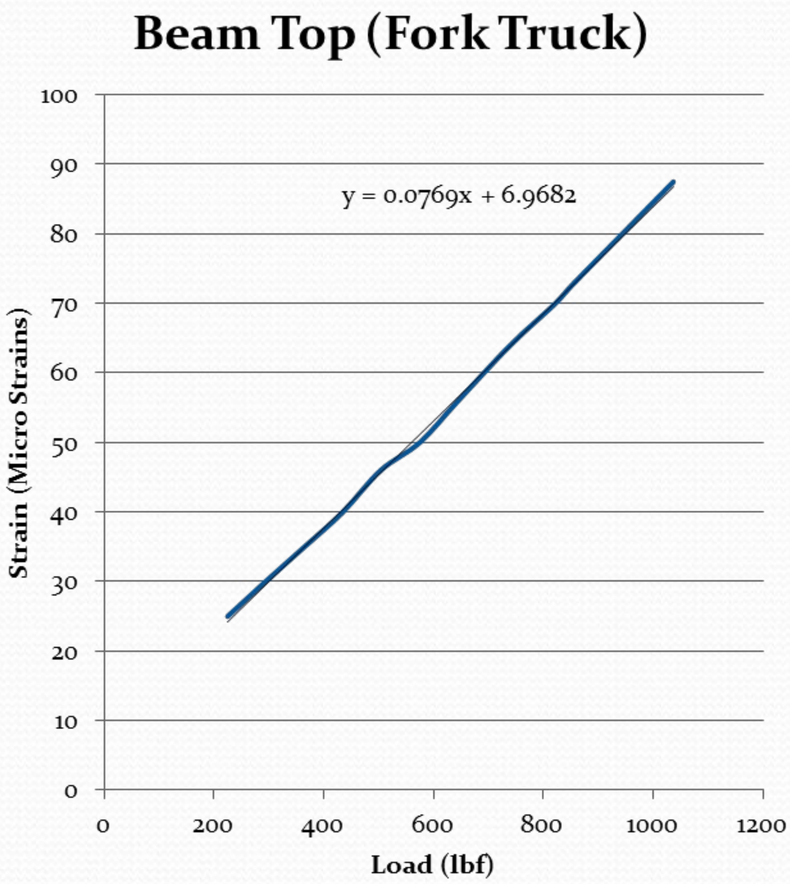
- Verification was performed using strain gauges and loading the beam in a controlled environment.
- The beam was progressively loaded to 1000lbs, recording strain in critical locations determined from FEA analysis.
- A plot of load vs. strain was used to later find the weight of the slide.
- The curve obtained was also used to determine stress in the beam with our 2000 lb maximum load.

Verification Tests

- Hooke's Laws were used to find stress from the strain recorded.
- The reduced equation of $\sigma = E\varepsilon$ gave a maximum stress of 5000 psi along the top surface of the beam. This gives a factor of safety of $FS = \frac{Load_{Max}}{Load} = \frac{36000}{5000} = 7.2$
- The weight found from the data for the large slide was 1130 lbs. This value is much lower than was fond using CAD modeling and is most likely incorrect since the load was applied at an angle in respect to the mounts on the beam during the tests.

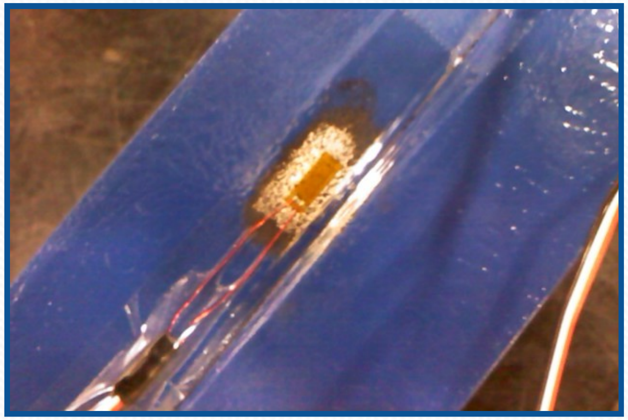
Verification Tests





Verification Tests

Strain Gauges



Loading the beam with 1000 pounds of stuff

Preparing Slides

Bolting Bearings to Slide

Preparing Machine

Cleaning Bearings

Pouring oil For slide channel

Lifting Slides

Slide Lifted and Rotated

Video

Updated Cost Analysis

Cost Analysis							
Materials Cost							
Design type	**Material description**	**Price per unit**	**units**	**Retail Cost**	**Actual Cost**	**Supplier**	**Actual Supplier**
C channel Rev A	3 X 1-3/8 X 3/16 Steel Channel 6 ft. L	$28.26	2	$57	$0	Metal Depot	Stephen Armstrong
	3/8 x 2ft x 2ft flat plate	$77.20	1	$77	$0	Metal Depot	Hubbard and Drake
	3/8 slip hook (5400 lb rating)	$10.58	2	$21	$21	Grainger	Grainger
	3/8 shackle (1700 lb rating)	$5.69	2	$11	$11	Home Depot	Home Depot
	3/8 x 16 x 1.25 in grade 8 bolts	$0.71	8	$6	$6	Home Depot	Home Depot
			Subtotal	$172	$38		
Slide Adapters							
	3/4 in steel round stock (4 ft)	$8.24	1	$8	$0	Metal Depot	Hubbard and Drake
	1/8 quick clips for turning bar	$1.06	4	$4	$4	Lowe's	Lowe's
	2.5 in steel round stock (1 ft)	$27.94	1	$28	$0	Metal Depot	Hubbard and Drake
			Subtotal	$40	$4		
Hardware Cost	**Fork lift Modifications**						
	Hardware description	**Price per unit**	**units**	**Retail Cost**	**Actual Cost**		
	Instrumentation quality flow control	$300	1	$300	0	Parker fittings	Uah Mach shop
	3/8 NPT X 3/8 NPT 90° adapter	$5	1	$5	$5	ACE Hardware	ACE Hardware
	Nipple 3/8 NPT	$2	3	$6	$6	ACE Hardware	ACE Hardware
	Hydralic fluid (gal)	$9	1	$9	$9	O'riellys	O'riellys
	Hex bushing 3/8 by 1/2 NPT	$4	2	$8	$8	ACE Hardware	ACE Hardware
			Subtotal	$328	$28		

Updated Cost Analysis Continued

Labor Costs					
	Labor description	**Labor rate**	**Man hours**	**Retail Cost**	**Actual Cost**
Engineering and design	Engineering research	$80	15	$1,200	$0
	Engineering documentation	$80	37	$2,960	$0
	Preliminary design	$80	8	$640	$0
	CAD	$80	16	$1,280	$0
	FEA analysis	$80	20	$1,600	$0
			Subtotal	$7,680	$0
Manufacturing	Machining (adapter plates)	$40	7	$280	$0
	Drilling (turning bars)	$40	1	$40	$0
	Cutting and shaping of pieces	$30	3.5	$105	$0
	Welding (interior spacers)	$30	2.5	$75	$0
			Subtotal	$220	$0
Testing	Testing equipment turn radius	$30	3	$90	$0
	Lift test of finished beam	$30	3	$90	$0
			Subtotal	$180	$0
Assembly	Assembly of small slide	$30	24	$720	$0
	Assembly of large slide	$30	24	$720	$0
	Modifications of fork lift hydralics	$30	2	$60	$0
			Subtotal	$1,500	$0

Total Cost			
		Retail Cost	**Actual Cost**
Totals	**Channel beam (Design 4)**	$10,120	$71
	Grand total (Hardware and beam)	**$760**	**$71**

This reflects the cost to manufactur the beam with only materials and labor costs

Updated Manufacturing Processes

- Duration

4 weeks (17 actual billable hours)

- Requirements

Cutting, Semi-Complex Machining, Drilling, Fitting, Welding

- Assistance Required

Hubbard & Drake, Team 1, Steve Collins

- Retail Cost - $1,500
- Team Cost - $0

Update Manufacturing Processes

- Manufacturing Location

Hubbard & Drake General Mechanical Contractors

P.O. Box 1867

1002 5th Ave SE

Decatur, Alabama 35602-1867

256.353.9244

www.hubbarddrake.com

- Initiation

Wednesday – September 22, 2010

Problems and Solutions

Problem 1: Original design included chains to wrap around the slide adapters. Special thanks to Scotty Hubbard and Jim Wahoski for pointing out that the chains could become entangled and create a safety hazard.

Solution 1: The chains have been changed to extension plates which will make the entire operation safer and easier.

Problem 2:   Original fittings did not work on the Red lift.

Solution 2:   New fittings were obtained and used to add the flow control valve.

Lessons Learned

- The most important lesson the team learned was to listen to experienced people when they give advice.
- Scottie Hubbard’s advice to use the plates was given near the end of the previous 490 teams project.
- His advice was backed up this semester by Jim Wahoski, who also warned the team about using chains.
- This prompted the team to partially redesign their hardware. This became a big challenge to overcome and still stay on schedule.

Summary

- Going from chains to the extension plates was a positive
- Fabrication of the assembly by Hubbard & Drake was quick and professional.
- Installation of the small slide had a few small hiccups that were resolved with time.
- Installation of the large slide went hiccup free after learning from our mistakes on the small slide
- Team 1 is well pleased with the project outcome.

Acknowledgements

- Thanks to our customer, Mr. Tim Blackwell and the Center for Applied Optics
- Thanks to the shop foreman at Pro Fab fabrication in Hartselle, AL for the suggestion of using two pieces of C channel instead of an I beam.
- We would also like to thank Scottie Hubbard, of Hubbard and Drake General Mechanical Contractors in Decatur, AL, for offering raw materials and use of their shop equipment for this project.