Accessibility and Safety System for Firearm Safes

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by

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ABSTRACT

The purpose of this study was to address storage insufficiencies within the firearm safe industry. As the sales of firearms increases, safe manufactures continue to increase the overall sizes of their safes to accommodate inflated numbers and increase capacities, but neglect to address the fault in their interior storage methods. By researching the market to determine average interior safe sizes, along with standard firearm sizes and weight, this study worked to determine the most efficient method of organizing storage, while maintaining capacity, accessibility, and increasing safety. The results determined that by reorienting the degree in which each firearm is stored, it allows the owner to take up less space with each firearm. Using this method along with our designed application not only increased the organization, safety, and accessibility, but increased the overall stored capacity by 50%.

PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT

The traditional gun safe arrangement/layout does not provide adequate accessibility, organization, visibility, or safety. We are setting out with the intention of creating a single device that a user will be able to retrofit their existing gun safe setup with that will address all of these problems in one mechanical solution.

BACKGROUND

The use of safes can be dated numerous centuries back throughout multiple cultures and nations. The oldest forms of safes have been found in Egyptian temples containing treasures of gold and jewels, as well as, the findings of vaults made of bronze in ancient Greece Ruins. Although this evidence has been recovered the first patented safe was invented in 1835 by Charles Chubb, who went on in the following years to improve his product and creating various designs. Charles was a British inventor and entrepreneur who owned a locksmith firm, and was responsible for the creation of advanced locking mechanisms. These including tumbler locks, which are still used today, and devices called detectors the help with theft protection. Soon he began incorporating fire resistive materials, such as combinations of iron and carbon, and thief resistant designs. Throughout this time these safes were commonly found in banks, businesses, and wealthy family's homes. Theses designs remained consistent until the 1900's, when the rate of safe robberies began to rise. The new models were a combination of increased security and larger sizes.

In the last 50 years, personal safes have become a hot item of development, and manufacturing companies have begun to develop one after the other, totaling over 30 different major manufacturers for safes. Although each company presents a different look and add-on features, many utilize similar designs. A major factor that has played into the rise of personal gun safes has been the introduction of concealed carrying licensing within the United States, as well as, the ability to purchase semi-automatic weapons. By the end of 2017 the United States Government estimates that there will be over 15 million licensed permit holders within our Nation, and this year's analytics report states that there will be over 110 million rifles, 114 million handguns, and 86 million shotguns owned by citizens. The sales for personal gun safes have directly reflected the increase of guns and owners throughout the United States. To the point that some safe manufactures have reported selling up to 500 large sized safes in one day.

The severity of the problem can be seen through a few statistics when it comes to safety. According to the Center for injury Research and Prevention "1.7 million children live with unlocked, loaded guns - 1 out of 3 homes with kids have guns." This shows that any additional safety measures could potentially save lives reduce the number of accidental injuries. "Among children, the majority (89%) of unintentional shooting deaths occur in the home. Most of these deaths occur when children are playing with a loaded gun in their parent's absence."

The rate of sales is not the only thing to rise in the safe industry. The sizes, and holding capabilities have also began to increase. With the larger size comes a much higher cost, with some safes checking out at a staggering six thousand dollars. This is where we have found our issue. With companies creating larger safes capable of storing the rising number of guns being owned they have yet to develop and effective way for storing them. Many safes are accompanied with dividers that are able to be installed, but that requires timely install, and a cluster when it comes to removing a gun that is located in the back of a safe. To put this problem into perspective gun safes capable of holding up to 62 guns are currently hitting the market. The thought having to remove even a third of that quantity to reach the desired gun in the back is baffling. Hence, we have decided to come up with a product that not only effectively stores the guns safely, but maintains the capacity of the safe in an organized accessible manner.

RESEARCH

SCOPE OF THE PROBLEM

At its core the problem that we are setting out to solve is to address the issue of traditional gun safes having a bad design, which leads to poor accessibility, organization, visibility, and ultimately safety. The traditional safe requires the end user, we included, to remove a substantial amount of firearms before we can obtain the desired gun near the rear of the case. The stock storage configurations of gun safes create organizational and ultimately safety issues. We are addresses this problem because our solution will allow for the safer storage of firearms, while providing the end user with a better accessibility and gun capacity at the same time. Safety aside, based on our interviews the want for a more accessible gun storage solution is widely in demand. What makes this project important is that it will allow people to save time, save money, and increase the safety of having a utilized gun safe inside a family setting.

CURRENT STATE OF THE ART

Some companies have begun to develop add on devices for the safes. These include pistol holders that clip onto the shelves, Storage Bags that hang from the door, a multi pistol rack that sits on the shelf, and a swinging gun rack. Each of these have their advantages, but also disadvantages that we plan to build upon in our design. The pistol holder allows the user to store their pistol while also locking the trigger for safety, but takes up a lot of space within the safe. The Bag storage system is only capable of holding small accessories and guns, but risks the damage of guns as they bounce off of the door while opening and closing. The Pistol rack that clips to the shelf stores multiple guns and keeps them out of the way, but does not have a way of locking the triggers or guns to keep them secured safely. The Swinging gun rack allows the user the ability to store weapon and easily move them out of the way to access the row behind them, but requires the user to drill and cut into their new safe for installation. This also only allows the user to access the second row and not the additional firearms behind that, and reduces the safes gun capacity due to taking up large amounts of room. All of the products listed above have improved upon certain areas of the gun safes issues, but with each improvement comes additional issues, and does not fully solve the problem. We plan to incorporate these weaknesses into our design to allow the buyers to get the absolute most fulfillment from an all in one product. All resorting back to efficient, effective storage, which maintains safety and capacity. By researching previously developed products and trends of the industry it has become apparent that there is a better solution that is able to accomplish all of these requirements for not only long guns, but for pistols as well.

As a result, we have developed a product that is easy to install, rotational, safe, supportive, sliding, and creates a well illuminated working environment. Our install will be quick and easy without making any critical altercations to the safe. By making it rotational it will allow for full 360 degrees access to every gun. Achieving safety by locking and holding each gun in place until unlocked and desired to be removes. Supportive by holding each gun tightly to no allow it to move and damage during storage or operation. The sliding will allow for additional access to each gun, and lighting will be to create a safer environment. Each of these features are intended to allowing the customer to get the most out of their safe, which they expect to protect their belongings and have spent a lot of money on.

END USER

Ultimately the end user that will be looking for our solution will be a gun safe owner themselves. The user has the ability to own a number of different types of gun safes ranging from single open unit to shelved/slotted safes. The end user will be a consumer who has the need to either increase the safety of their safes or obtain easier access to their guns. Starting with safety, the end user will be in need of a mechanism that allows for the guns to be restrained in a more secure fashion than was already provided with the case from factory. This can commonly be a problem with gun owners who have children and want to add a level of complexity to their safety tie-ins. The end user might also run into the issue of having an insufficient amount of lighting within their case. This can lead to accidental miss handling of firearms. Our gun safe retrofit will alleviate and or eliminate both of these end user safety requirements. Moving on to accessibility, the typical end sure will most likely be someone who does not have a solution to obtaining a single gun from the case without having to remove and handle multiple other guns at the same time. The end user will want to be handling their guns the least amount of times possible. This is because of the oil residue left on them after being handled by human hands. This also is a time saving trait our end user will greatly appreciate because as with most all products, user like to save on the time required to do a task. The end user will also be requiring a mechanism that does not take away from their available cubic feet inside their case. The end user will want our mechanism to not only keep the same amount of guns prior to the devices insertion, but allow for easy access at the same time. A big user requirement is build quality, fit, and finish. The end user will be looking for a solution that is built with a high level of quality as to match their gun safes. Alongside the sturdy construction the end user will want the appearance to be of the upmost standards and be aesthetically appealing.

This problem was not one that was created as to have a problem to solve. This can be seen by the large number of inferior gun safe accessories that already exist in the market place to a smaller problem that is a part of our own solution. People have been seeking solutions for accessibility, safety, flexibly mounting solutions, and lighting for a very long time, as our above research has demonstrated. We are however finally providing a solution to solve all of these problems and so much more efficiently in one mechanism.

Our design had been narrowed and focused based on this research and by the requirements we have found from our end users.

CONCLUSIONS AND SUMMARY OF RESEARCH

A common reoccurring theme was one of the need for improved accessibility. The end users want a safer solution as well as the existing solution not providing that functionality. The thing that stood out the most was that there are a lot of solutions out in the market today, but each only solves a single problem. This ties into our solution in that our final product/solution will have the flexibility to incorporate all of these solutions into a single mechanism. The specific features that we that were brought to our attention from our research are listed as follows: Accessibility, organization, and flexible mounting solutions. It was determined that our gun safe retrofit would have to have multiple safety constraints put in place to help the end users who have kids and or are unhappy with their current safety solution. Lighting was the next big thing that came up in our research. Most gun safe users who purchase safe do so in well-lit show floor or online through pictures. This creates the problem of not enough lighting when they place the safe in an area with low lighting. There are a lot of forums with users complaining about how they have difficulties reaching a gun near the back of a safe without having to handle their other guns. This is not only an inconvenience, but the handling of guns more frequently cause quicker wear. Our solution has an easy mounting solution that does not require the screwing into or modification of the end users existing gun safe. This is important because our research showed that end users do not want to have to do any major modifications to their potentially new safes. We concluded that since companies are able to sell all of these products in separate configurations, then this would mean that our solution would save end users time, money, and the ability to maintain all of their existing safe space.

CUSTOMER FEATURES

Interview Approach:

Being that we had a clear idea of the problem we wanted to solve, a formal survey was not created. Instead we verbally reached out to all of the friends, family, and coworkers who own gun safes, of which there was a huge number. We would ask and record their answers to questions such as what they felt could be improved with their existing safe. Other questions included whether or not they were satisfied with their accessibility, organization, visibility, and safety. We then described our potential product and asked what they would like to see it perform in the end concept form. We concluded our conversations by asking whether or not they would purchase our product if it was on the market and about how much they would pay for it.

Weighted importance:

Our comprehensive HOQ can be viewed further down within this document, but below is a list of the most highly weighted customer features. They are based on our interviews.

1.) Holds gun Securely (0.20)
2.) Allows access to each gun (0.20)
3.) Easily Slides (0.15)
4.) Easy to install (0.10)
5.) Maintains/Exceeds original safe Capacity (0.10)

PRODUCT OBJECTIVES

- Provide an intuitive solution that will allow for easy access to each and every gun at the same time.
- Come up with a design that helps the end user to keep and or restore organization to their gun safe.
- Provide a design that allows for the viewing all firearms at once.
- Incorporate multiple safety features on top of the ones provided with the traditional safe to ensure there are no accidental discharges during insertion or removal.
- Utilize a vertical mounting configuration to provide even more storage capacity than previously available in the stock case.
- Create a product that is competitively priced with the existing inferior products.
- Create a product that is rigid, long lasting, and has a nice aesthetic to match the end users fine collection.

QUALITY FUNCTION DEPLOYMENT

			Engineering Requirements (units)												Customer Satisfaction Rating (0.00 - 1.00)			
		Importance wt.	Weight(Lbs)	Rolling Resistance(Lbf)	Pulling Force(Lbs)	Firearm Storage(cu ft)	No. of steps to remove gun	Flexs during use(deflecton in")	Gun size adjustablity (yes/no)	Insertion force (ft lbs)	No. of steps for Install							
	Customer Requirements		1	2	3	4	5	6	8	9	10	11	12	14	CP	A	B	C
1	Hold gun securely	0.20				3				9						0.8	0.7	
2	Easy to Install	0.10	1								9					0.7	0.8	
3	Easily slides	0.15	3	9	9											0.9	0.9	
5	Maintains/Exceeds original safe space	0.10				9			3							0.8	0.8	
6	Remains Rigid when in use	0.10						9								0.7	0.8	
7	Allows Access to each gun	0.20				3			9							1	1	
8	Protects against accidental fire	0.05					3			3						0.8	0.7	
9	Fits all Gun types	0.10							9							0.9	0.8	
	Total Importance	1.00																
	Engineering requirement importance																	
Performance	Current Product																	
	competitor A		50	0	0	16	3	0	N	0	1							
	competitor B		65	0	0	12	4	0	Y	0	3							
	competitor C																	
	New Product Targets		45	2	15	18	2	0	Y	5	3							

Interaction Matrix

	Engineering Requirements	Weight(Lbs)	Rolling Resistance(Lbf)	Pulling Force(Lbs)	Firearm Storage(cu ft)	No. of steps to remove gun	Flexs during use(deflecton in")	Gun size adjustablity (yes/no)	Insertion force (ft lbs)	No. of steps for Install	0	0	0
Engineering Requirements		1	2	3	4	5	6	8	9	10	11	12	14
Weight(Lbs)	1		3	3			9						
Rolling Resistance(Lbf)	2			3									
Pulling Force(Lbs)	3												
Firearm Storage(cu ft)	4							1					
No. of steps to remove gun	5							1	3		3		
Flexs during use(deflecton in")	6												
Gun size adjustablity (yes/no)	7												
Insertion force (ft lbs)	8												
No. of steps for Install	9												
0	10												
0	11												
0	12												
#N/A	13												
#N/A	14												

DESIGN

Design Alternatives and selection:

Design Alternative Number 1:

- Shown below in figure A1 is the initial Idea thought up. It would consist of a rotating circular gun stand that would allow the user to easily rotate and select a rifle. The problem that was determined with this design is that since our end product is designed to fit in existing rectangular safes, the corner space of the safe would not be adequately utilized. Ultimately that is why this below design was passed on.

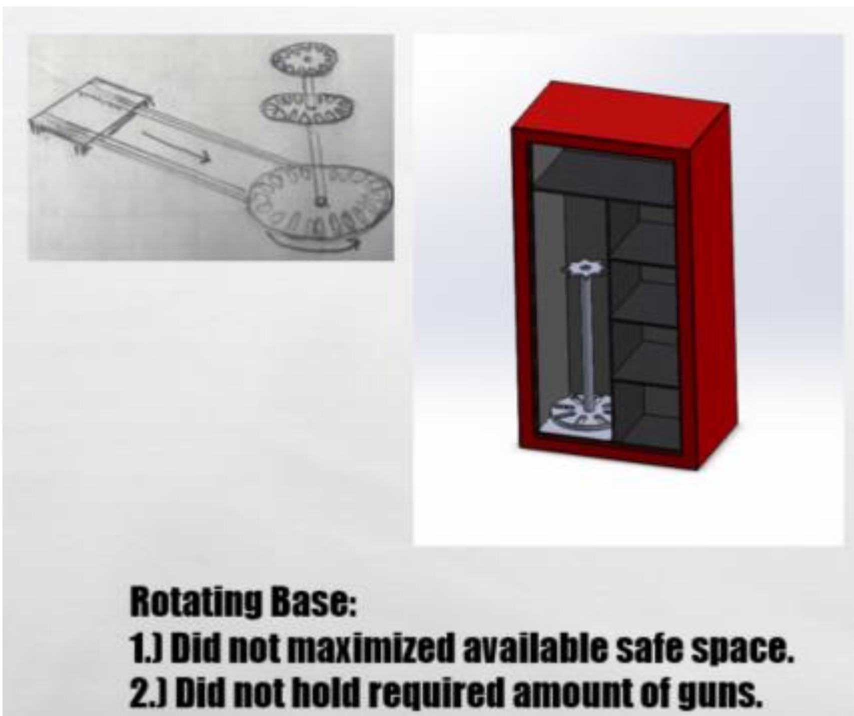


FIGURE A1

Design Alternative Number 2:

- Shown below in figure A2was the second design thought of during the initial design process. It consisted of three gun racks that were mounted to a linear rail system. The center rack would exclusively slide in a single center out direction, while the two outer most racks would have the ability to swing to and open position. The logic behind this was that the swinging outside doors would allow for access to each and every gun simultaneously. The design was not selected as it was determined to be overly complex and would not fit within the ideal gun safe size requirements our research configured.

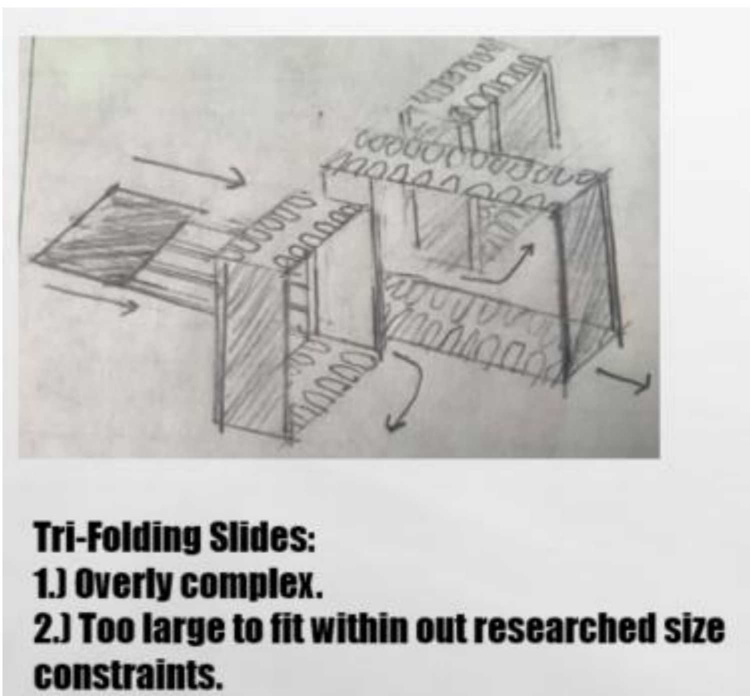


FIGURE A2

Design Alternative Number 3:

- Our third design shown below in figure A3 revision included a dual rack system that would only incorporate the two outer racks. These two outer rack would rotate to the side apart from each other to allow for easy access to each firearm. It would also have been possible to simply pull both racks out in the forward direction retrieve a gun on the outside of either rack. The problem that was determined was that the user might have any sort of items located next to their safe that would interfere with this configuration. This design would have ultimately made the safe form factor wider that originally desired.

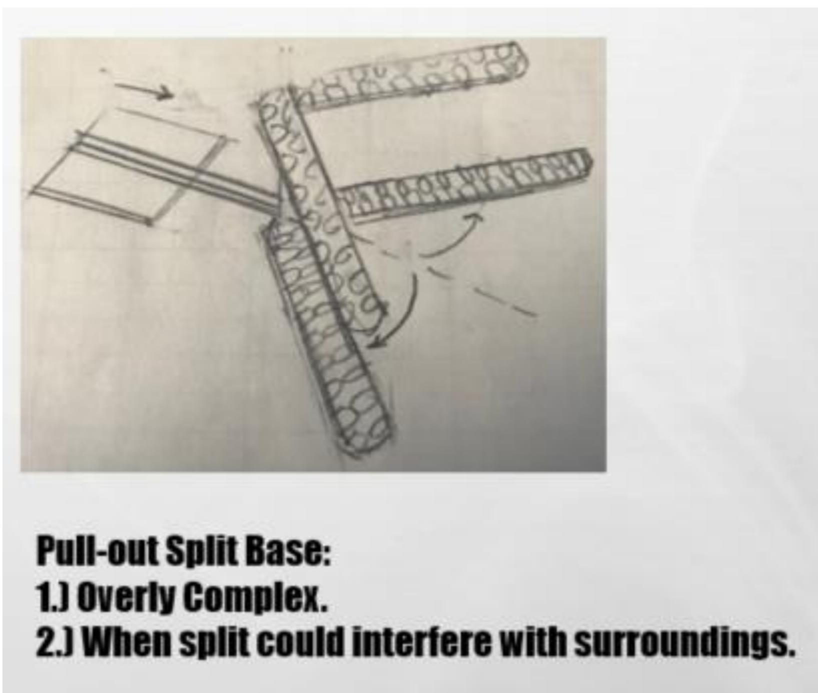


FIGURE A3

Design Alternative Number 4:

- The last design alternative, shown below in figure A4, was the closest to our final design. This design incorporated a single sliding rack that holds guns on either side. Each gun would have its butt placed on the bottom of the rack and the barrel at the top. This would mean that the gun would be stored at a 45 degree angle. This was determined to be a problem because it was a poor use of space. When a rifle stored at a 45 degree angle it reduces the amount of guns that are capable of stored within the allotted space.

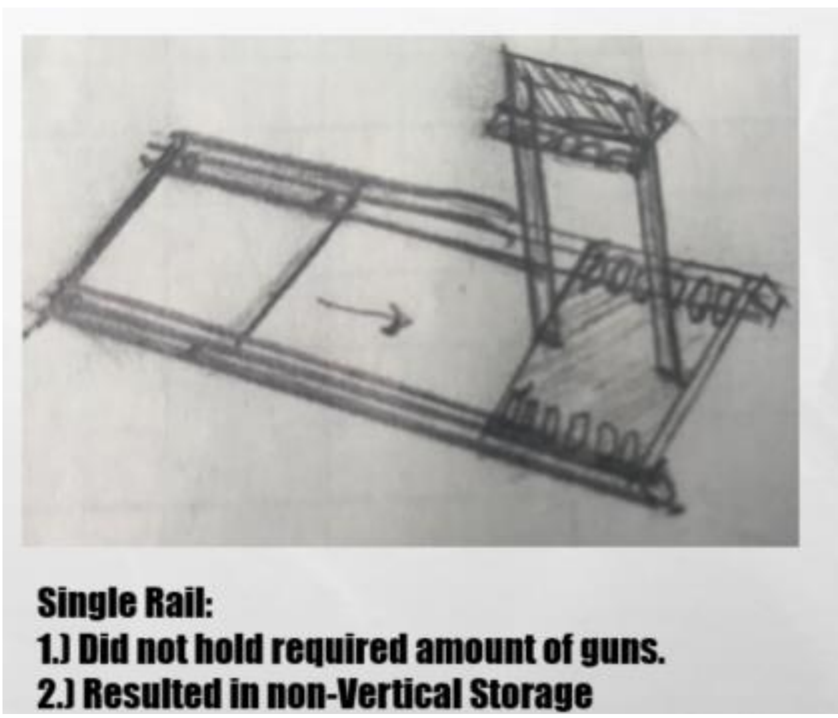


FIGURE A4

Our Solution:

Our solution can be seen in the figure to the right. It incorporates two sliding racks and a pressure based mounting solution. Our design allows for the safe storage and access of 16 long rifles. The unit is assembled into two main components, the racks and the base mounting unit. The end user will place the mounting box onto the floor of their safe. They will then rotate the hex nut attached to the main ball screw mechanism. This will in turn move the pressure plate up against the rear of the safe and the two from rubber feet into the front flange. This pressure along with the box material weight acting as a counterweight itself allows for the safe sliding out of one or both racks simultaneously.

The racks are designed to hold 16 long rifles, of all styles and lengths. It is able to do this by utilizing 16 opposing slots, eight on each rack. The bottom slots are slightly wider than the upper slots to accommodate for the extra width of rifles butt-stocks. The top and bottom of the racks are made from a black Delrin material. This is to ensure that no damage is done to the barrel or stock of the rifles during insertion or removal. The front and rear of the racks are made from aluminum to aid in weight reduction and ensure a secure mounting for the collapsible handles. The handles on the front of the racks are to aid in the sliding of the racks when loaded and reduce the overall depth of our mechanism. There are 0.25” x 0.25” Delrin retention brackets on top of the upper Delrin piece. These pieces can articulate up to 120 degrees to allow for the removal and insertion of rifles. Each individual retention bracket has an in-laid set screw that get magnetically connected to an in-laid magnetic in the upper Delrin piece. This ensures no rifle falls out of its slot during the handling of other rifles near it on the same rack.

KEY FEATURES & HIGHLIGHTS

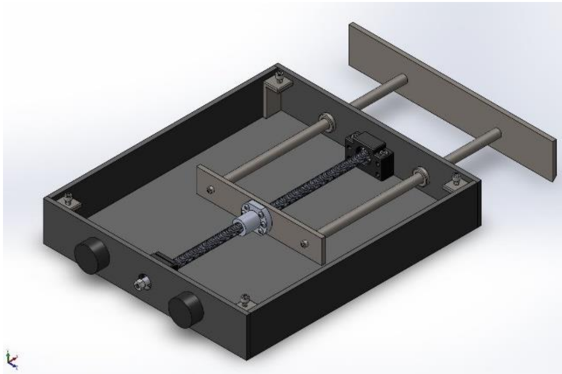
- Mechanism utilizes a ball screw fed pressure plate mounting solution. This means the end user does not have to modify their existing safe in any manor due to the existing front flange utilization
- Utilizes two sturdy racks to hold/secure eight rifles each
- Single rack can be removed or both simultaneously.
- Utilizes Delrin retention latches with set screws contacting in-laid magnets on the rack to secure guns

- Racks have ability to slide out, using aluminum telescopic slides, to ensure access and visibility of all guns in safe
- Easy installation / soft closing
- Universally sized for most standard safe sizes.
- Rubber front feet to protect safe and provide adjustable front rack face positioning.
- Fold flat handles to aid in minimizing form factor and ease the pulling out of racks.

Mounting solution

How it Works:

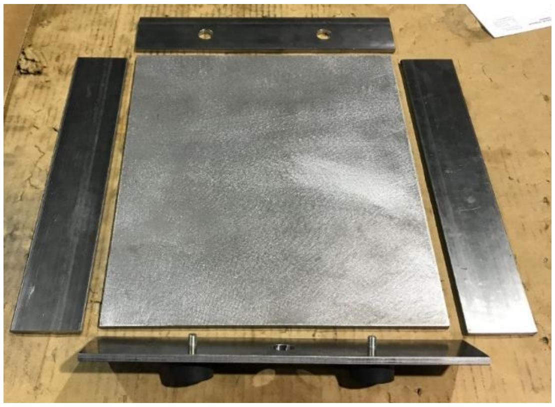
The mounting box, shown to the right, is made up of five steel panels welded together. The top lid is also constructed of steel, but is attached through the use of four M6 bolts. Inside the box is a 1204 ball screw mechanism fitted with a 1204 ball screw nut. Attached to the ball screw nut is a steel center plate. Attached to this center plate is two half inch steel rods that run through flanged press fit bushing to attach to a rear pressure plate. There are two adjustable length rubber feet at the front of the mounting box. The user will rotate the ball screw through the use of a welded hex nut on the front of the ball screw. This rotating action will cause the center plate to push the rear pressure plate into the rear of the gun safe. The front two rubber feet will then contact the front flange of the safe and create opposing pressure within the assembly. Once adequate pressure is being applied the user will utilize a 6mm set screw inside the ball screw nut to keep the nut from experiencing any backlash. Between this and the weight of the box unit itself, the two racks can be slide out one at a time or both simultaneously.



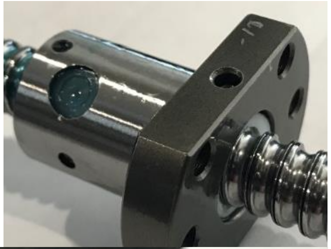
Mounting Box components & Materials:

- 50A durometer rubber feet allow for maximized grip in safe while ensuring no damage is done to safe interior (Feet can withstand 390 lbs static load each)

- Steel 1018 used for box and rack mounting brackets due to low cost, ease of fabrication, and high availability.
- Weight of Box also acts as a counterweight, reducing the work needed to be done by the pressure plate mechanism



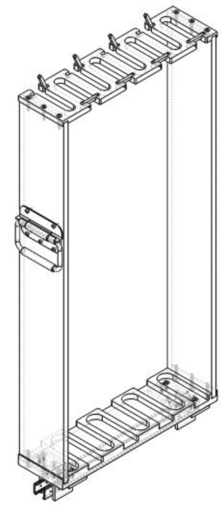
- 1204 ball screw used for high axial strength capabilities.
- Recirculating ball screw nut for smooth travel along ball screw rod and high load capacity.
- - BK10 & BF10 end bearing supports for high load capacity and low cost. (2.78kN or 625Lbf static load rating on bearings)



- Center Plate, Pressure plate, and Connecting rod made from 1018 steel.

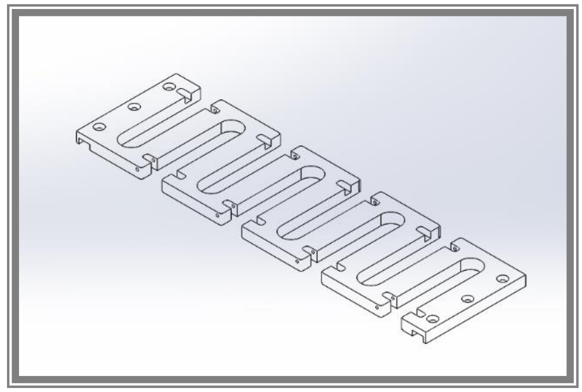
Storage Solution

How it Works:
The storage racks, shown to the right, are each made up of four major components, the top, bottom, front, and back. These four components are constructed together to assemble each individual rack. Once assembled additional parts such as the handle, Delrin slot locks, and magnets are added. The top and bottom of each rack is made up of Delrin plastic which has been CNC’d to a not only have the needed gun and locking slots, but to have slotted pockets at the edges. These pockets allow the front and back to be inserted and gives the assembly increased strength and integrity. The top and bottom are assembled to the sides to utilizing 12 total, 1/4-20 flat head fasteners (6 per top and 6 per bottom). Each rack is equipped with a retractable handle which allows the user to easily extend and close the racks from the safe. Finally, the top piece of the rack is equipped with 8 rare earth magnets which are press fit into the machined holes, along with an individual Delrin locking piece which rotated about a press pin. Each lock includes a recessed steel set screw, which was designed to catch the magnet when each latch is closed to allow for more secure storage of each firearm. Our assembly was designed to hold two of these racks which were attached to the slides using t-brackets that bolt into the bottom piece of the rack. Once fully assembled and equipped into the safe the user will be able to use the handle to pull the rack from the safe. Now that the rack is fully extended they are then able to flip up each desired Delrin latch and insert a firearm into each slot. After the gun is stored the user can return the latch to its closed position, ensuring that the firearm cannot fall out of the slot. The user is then able to return the rack to the closed position by using the handle and applying light inward pressure towards the safe.



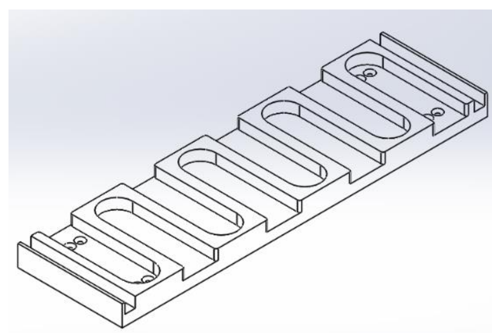
Storage Racks Components & Materials:

- Machined Delrin Plastic Top, which includes 8 slots sized to fit all stand firearms on the market. Each slot contains a delrin lock and rare earth magent for increased safety.



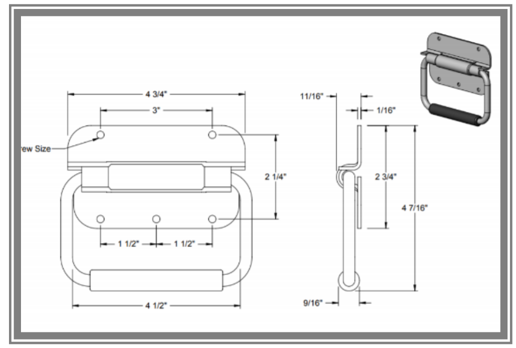
- .25” x .25” Delrin plastic latches. Each latch contains a steel set screw which will be magnetized to the rare earth magnet that is pressed into the top. Each latch is held in and rotates around and 1/8” stainless steel press pin.

- Machined Delrin Plastic bottom, which includes 8 slots machined to the standard sizing for all firearm butt-stocks on the current market. This piece also included the pockets for the sides to secure in to and the countersunk holes for the bottom to fasten to the mounting t-brackets.



- 60601 Aluminum Sides to reduce weight while maintining the structural integrity of the racks. Each pieces was surfaced, and then the ends were drilled and tapped for the assembly fasteners as well as the handles.

- The front of each rack was assembled with a zinc-plated steel, spring loaded pull handle. This allowed for easy manuverying of the racks in and out of the safe, and folded away to save space.

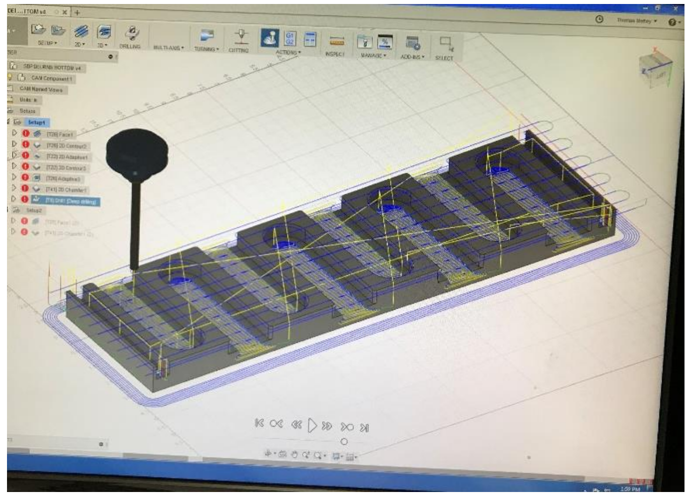


Fabrication:

Fabrication was setup and executed at a local machine CNC machine shop. The materials were purchased direct from a steel and plastics supplier. The shop was able to provide a single 3 axis CNC machine, horizontal lathe, manual drill presses, and a welding station. THe main CNC used was the Okuma Genos M560-V vertical machining center (3 axis, 30HP, 15,000 rpm, 150 ft-lb torque). This CNC machine was used to machine the black Delrin top and bottom rack pieces, aluminum front and rear rack pieces, and all mounting box panels. The machine was fit with two CNC vices and custom fabricated fixtures that were used to hold the pieces in place during operations.
Welding was performed on the slide mounting brackets on top of the upper mounting plate. The pressure plate to connect them to the center plate rods. Welding was also used to hold the upper plate l brackets to the interior of the mounting box.

CNC G-Code Program:

At the local CNC shop a program called Fusion was utilized. This program was able to take a 3D (.STEP) file and auto recognize the features and contours. This would allow it to determine the tooling paths and times for each part automatically. Fusion would then create and write all of the G-code to a file that was directly upload able to the CNC. Fusion was utilized for the derlin pieces and any tapped hole patterns throughout the assembly.



Slide Orientation and Fabrication (Initial):

The initial slide design was created with the two slides mounted close together on the bottom of the double t bracket shown to the right. This design was originally chosen because it allowed for only a single welded tab to come off of the top mounting plate, thus reducing materials and weight.

Problem with Design:

During testing it was discovered that with the slides mounted so close to the center, the rack had excessive swaying back and forth. This was caused by the edges of the double t brackets not have supports directly underneath them.

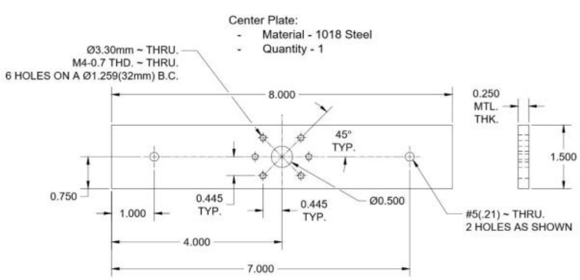
Slide Orientation and Fabrication (Re-design Post Testing):

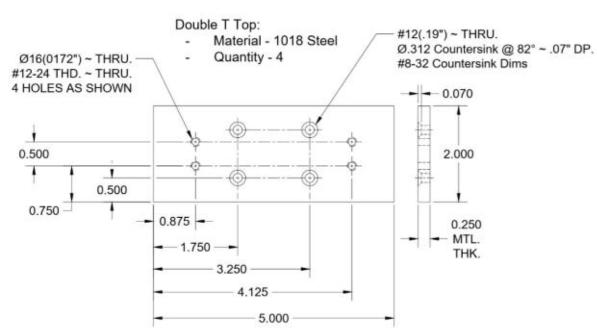
Redesign:
The slide mounting orientation was then updated to reflect the picture shown to the right. The new orientation moved each of the linear rails to the edges of the double t brackets. This allowed for the most of the weight to be held by the upper double t bracket support. The force closest to the edges were now supported directly above the bearing center channels. This meant that the rack now had four to five times less swaying movement than with the initial slide configuration discussed on the previous page.

Painting & Finish of Materials:

The aluminum rack pieces were first sanded by hand with a high grit sand paper. They were then cleaned with a degreaser to remove any surface dust and contaminations that would hinder the paint from sticking. A paint and primer two-in-one was used to ensure no moisture would reach the material surface. All steel pieces were also painted in this same paint and primer.
The mock safe used to display the mechanism at the Cincinnati Tech Expo was constructed out of 2x4 wood and wood screws.

Example Drawings that were provided to the shop for CNC machining:



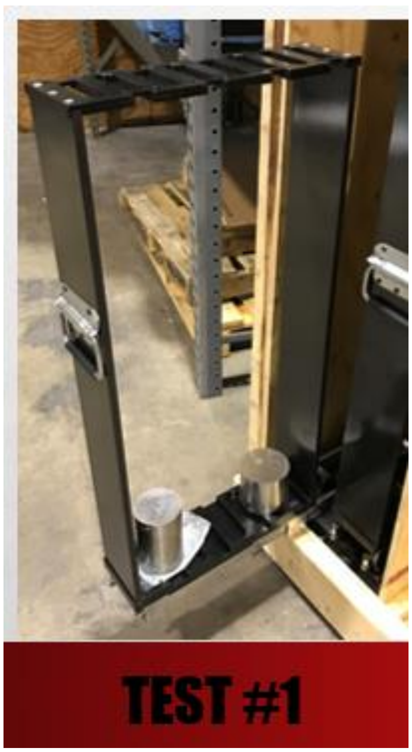


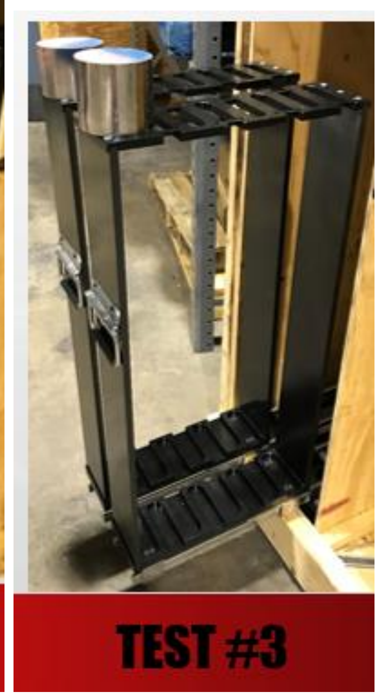
Testing and Results:

Testing was performed by mimicking the expected weight in magnitude and distribution by placing appropriately weighted metal cylinders onto the rack to see how it reacted and or deflected side to side

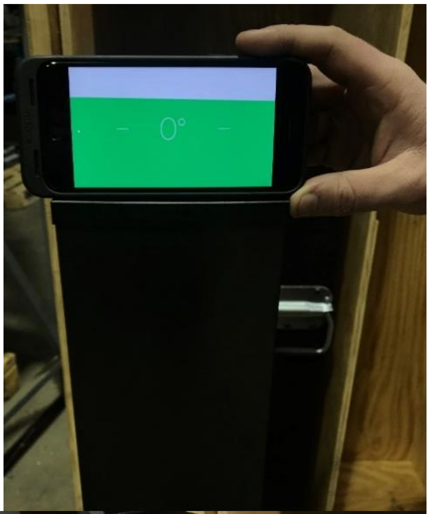
- Three test were performed, pictures can be seen throughout the poster board.

Test #1: Two 40 lbs cylinders were placed onto the front and rear of the Delrin rack base plate. No measureable deflection occurred.
Test #2: Two 40 lbs cylinders were placed onto the front and rear of the Delrin rack top plate. The result of this test was a 1 degree deflection off vertical center.
Test #3: One 40 lbs cylinder was place on top of each of the racks whilst they were in the extended position. The mounting box showed no signs of measureable movement or deflection other than the 1 degree vertical deflection seen in the rack.

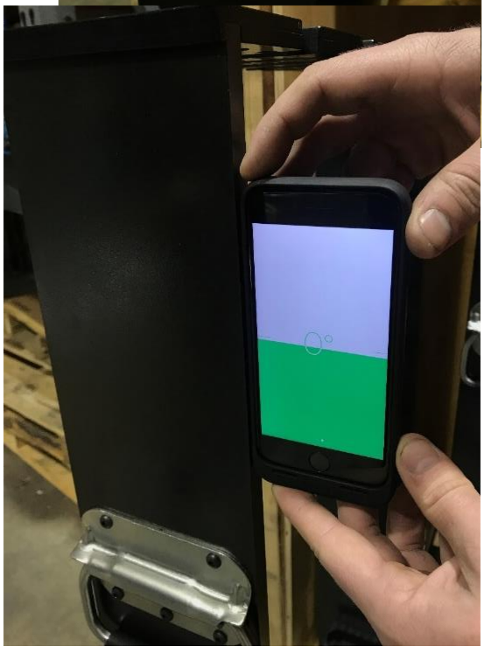




Results:



Post applying our simulated stress test to our mechanism, a full examination was performed to determine if any deformation and or deflection had occurred as a result of the testing. Prior to the entire mechanism being tore down for examination, angular deflection was tested. The results can be seen to the right. The rack angles measured to be perfectly horizontal and vertical post our stress testing. This meant that the rails and support bracketry were able to hold the stress weight without issue.



Post testing the mechanism, the mounting box was disassembled to check for signs of deformation and or cracking. The ball screw itself showed no visible signs of torsional or radial deflection. The metal rod connecting the center plate to the pressure plate also showed no deflection. The rubber feet didn't have any signs of cracking or deformation.

Things to change in retrospect:

Material / Weight Reduction:

- After reviewing the final design and getting to examine it during testing we determined that weight reduction would help with the mechanisms performance. We determined that milling large slots of material out of the aluminum rack panels. This would reduce the torsional forces seen at the based where it connects to the racks. A reduction in weight on the racks would also allow for less force needed to pull a rack out. Another benefit of the rack weight reduction would be a higher retention in the max weight each pair of slides can hold post factoring in the weight of a rack.

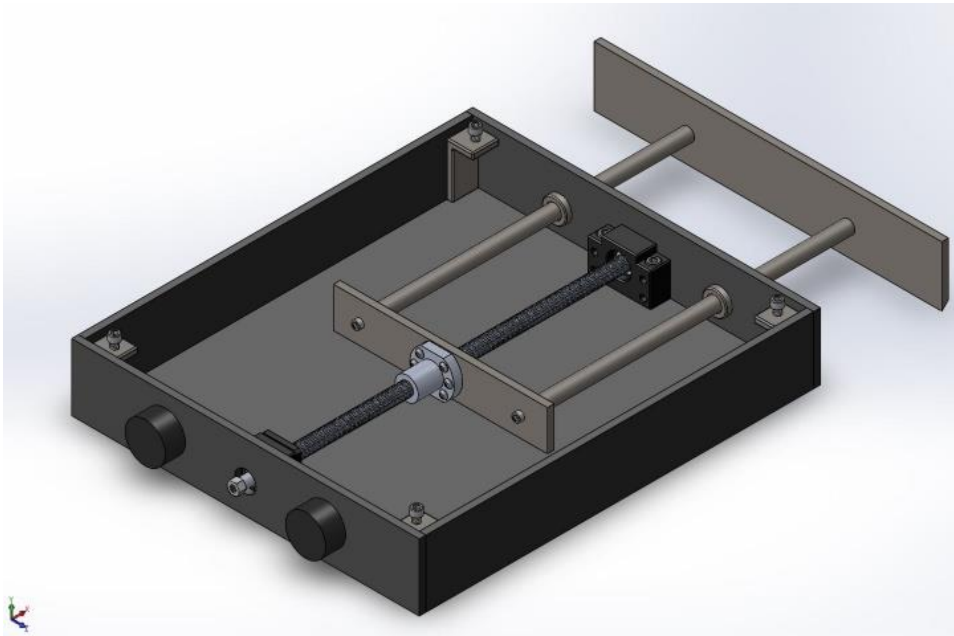
Manufacturing of Delrin Pieces:

- The CNC manufactured delrin pieces proved to be very difficult to machine. During the operation a custom fixture had to be placed onto the work table to stop the workpiece from chattering. In order to make these delrin pieces more easily manufacturable on a high production scale, we plan to have them produced through the process of injection molding. This process has a high initial tooling cost, but a very low cost per production batch post these initial cost.

Provide more Expandability Options:

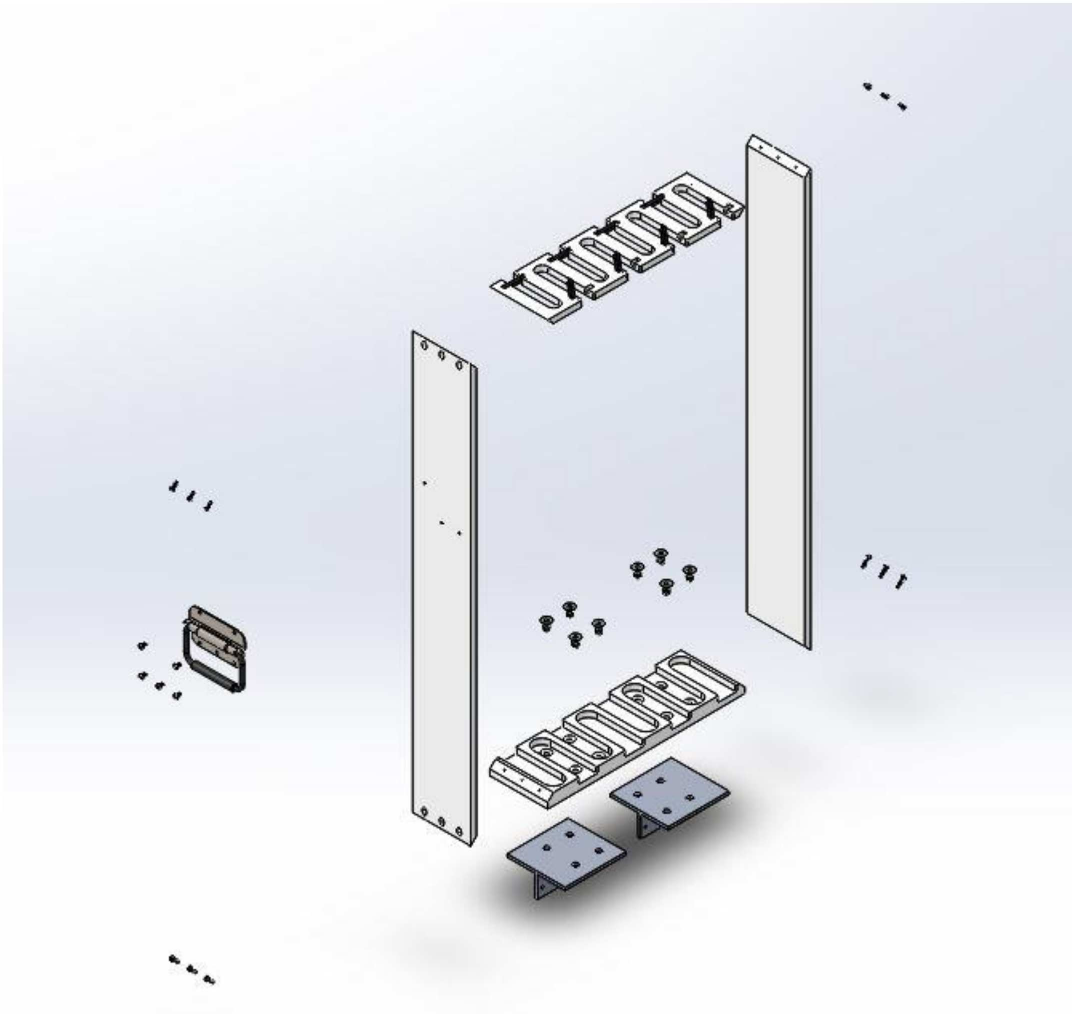
- Though our current design allows for fitment into nearly all current production safe sizes, we would like to reach all markets. This would involve the implementation of an expandable width option in conjunction with the existing depth adjustability. Expandable width would not only allow us to be able to fit more safe but provide the possibility of adding another rack to an existing assembly could now be achieved to provide even more safe and accessible storage.

BOM FOR BASE STRUCTURE:



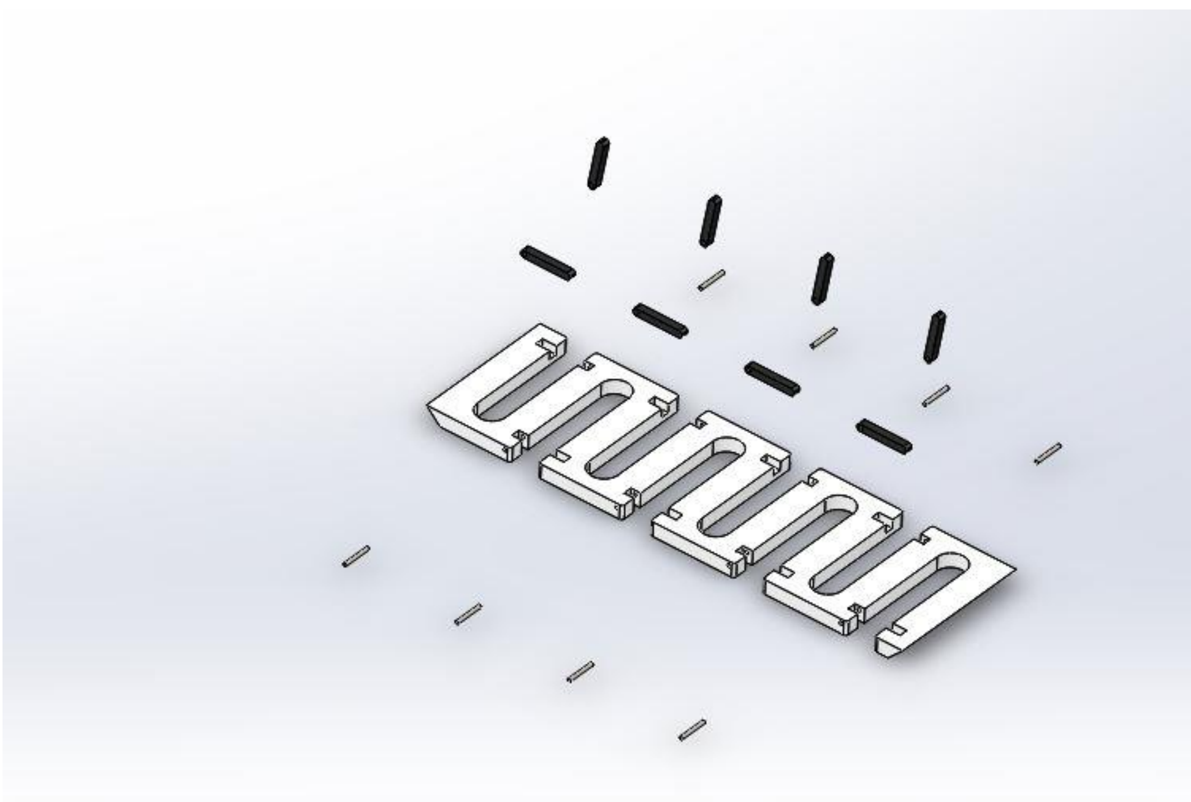
ITEM NO.	PART NUMBER	QTY.
1	Box_Bottom	1
2	8492A038	2
3	95120A111	1
4	Threaded_rod	1
5	1434K6	1
6	Center_Plate	1
7	95036A012	1
8	Rear_Leg	2
9	93115K141	4
10	95412A582	4
11	Front LEG	2
12	8492A214	1
13	94902A105	1
14	98164A266	8

BOM FOR RACK STRUCTURE:



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Rack Side-Front 8 handle		1
2	Rack Side 8		1
3	Top Rack Assem 8		1
4	Sliding Rack Bottom Part 8		1
5	96001A326		6
6	96001A322		6
7	Right_Side_Rail		1
8	92210A640		8
9	Magnetic Disk		4
10	1764A25		1
11	91255A240		5

BOM FOR TOP PLATE STRUCTURE:



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Sliding Rack Top Part 8		1
2	Lock Pin		8
3	Lock Rod		8
4	Magnetic Disk		8

LOADING CALCULATIONS:

SHEAR CALCULATIONS ON BOLTS HOLDING UP RACK SUPPORT T-BRACKET

$$Weight\ on\ Rack = 8(Guns) * 44.4Newtons(per) * 2(SF)$$
$$Weight\ on\ Single\ Rack = 711.7Newtons$$
Two T-Brackets Per Rack = 355.8 Newton’s per
$$A_s = \frac{\pi * D^2}{4}$$
$$A_s = \frac{\pi * 5.5^2}{4} = 23.76\,mm^2$$
$$\tau = \frac{F}{A_s}$$
$$\tau = \frac{355.8N}{47.51mm^2} = 7.47\ MPa$$
$$SF = \frac{207Mpa}{7.47Mpa} = 27.7\ (per\ T - Bracket)$$

Major Loading Conditions

Each rack is capable of holding a vertical load of securely holding 396 lbs. Based on research the highest load anticipated on a single rack is 80 lbs. When this is multiplied by our determined safety factor of 2, each rack is rated to hold at least 160 lbs per.

The above calculations are for the two bolts holding the T-bracket to the linear rail. They are shear calculations demonstrating that the bolts our design team purchased would not shear under max load.

SHEAR CALCULATIONS FOR FOUR BOLTS BASE PLATE LOADS:

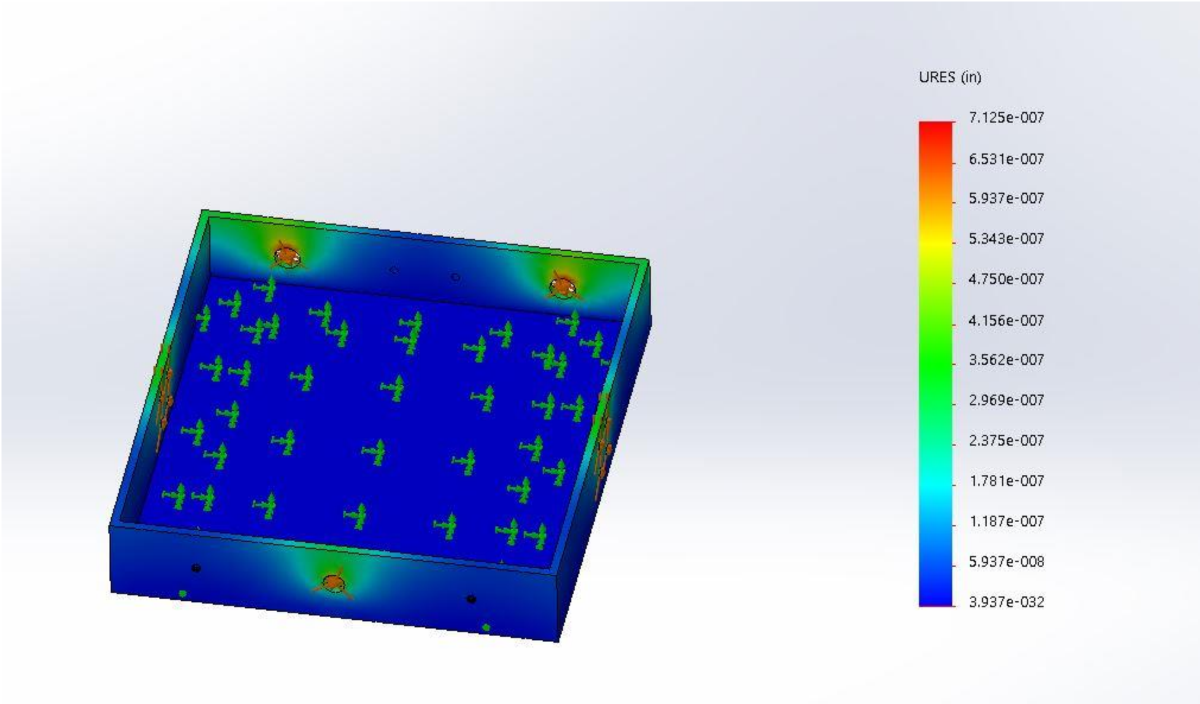
$$A_s = \frac{\pi * D^2}{4}$$
$$A_s = \frac{\pi * 5.5^2}{4} = 23.76\,mm^2$$
$$\tau = \frac{F}{A_s}$$
$$\tau = \frac{355.8N}{95.04mm^2} = 3.74\ MPa$$
$$SF = \frac{207Mpa}{3.74\ Mpa} = 55.34\ (per\ T - Bracket)$$

The above calculations show that when the base is subjected to a full rack load that the bolts holding the top plate on will not shear. The safety is high because we knew that this assembly needed to be very strong to at assume the worst case scenario.

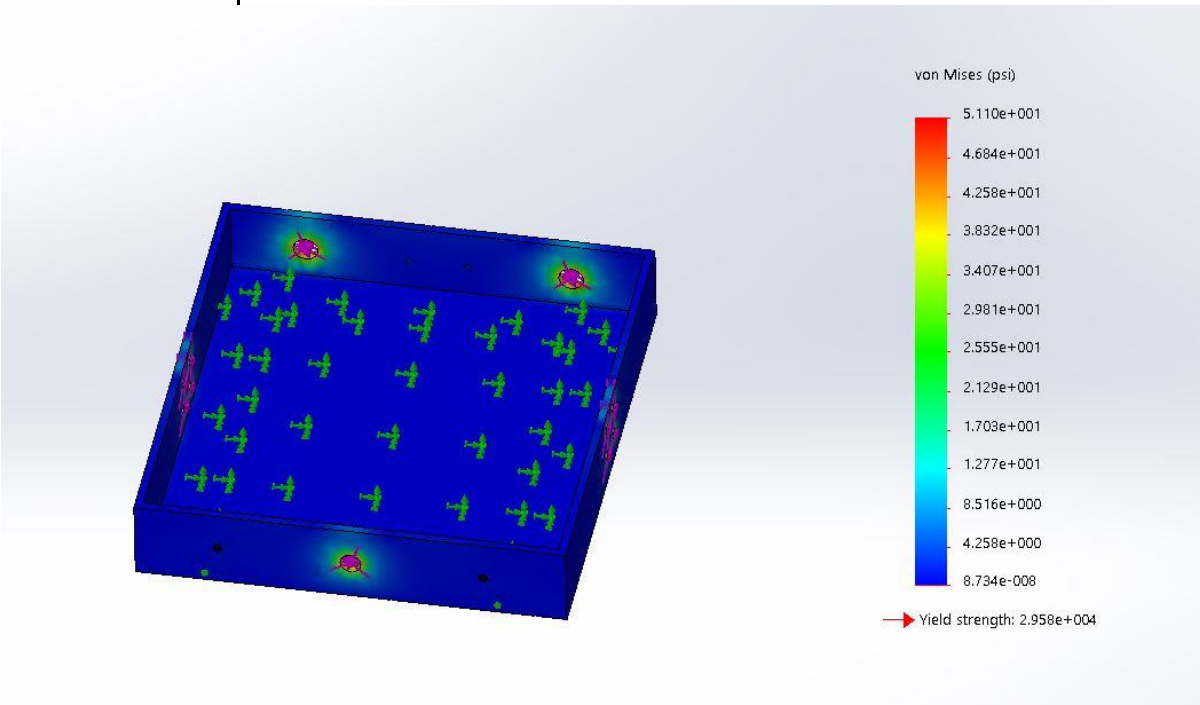
LINEAR RAIL CALCULATIONS EXPLAINATION:

The linear rail that we selected has a load capacity of 396 lbs in the vertical direction. The highest load expected to be seen on the rack is 80lbs. With a safety factor of 2, this translates 160lbs max expected loads. This means that the calculation for whether of not the rail can hold the load not necessary.

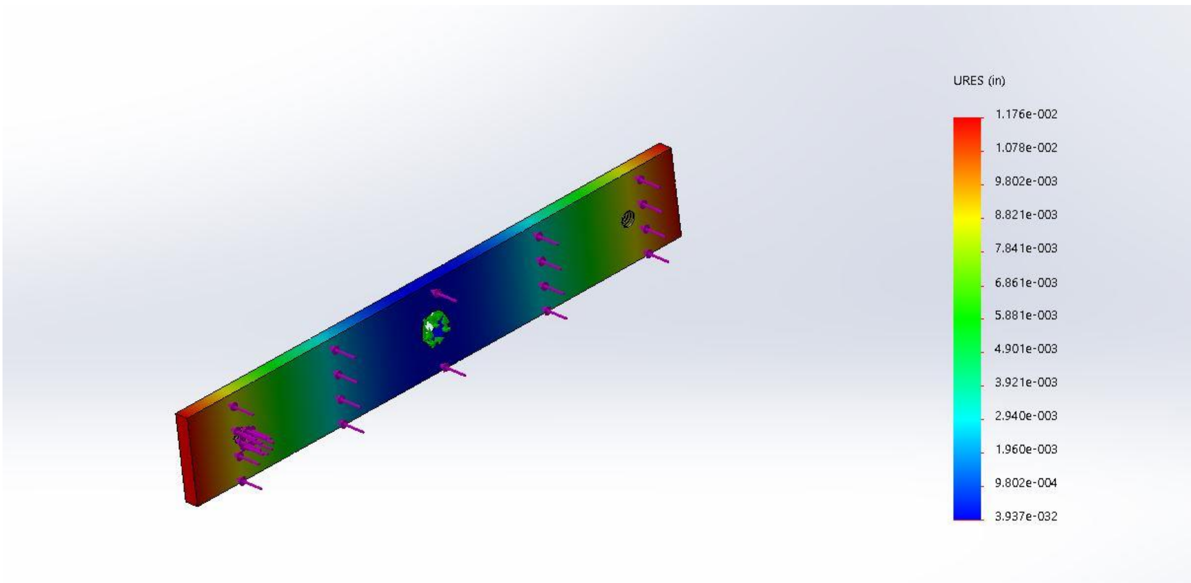
FEA ANALYSIS



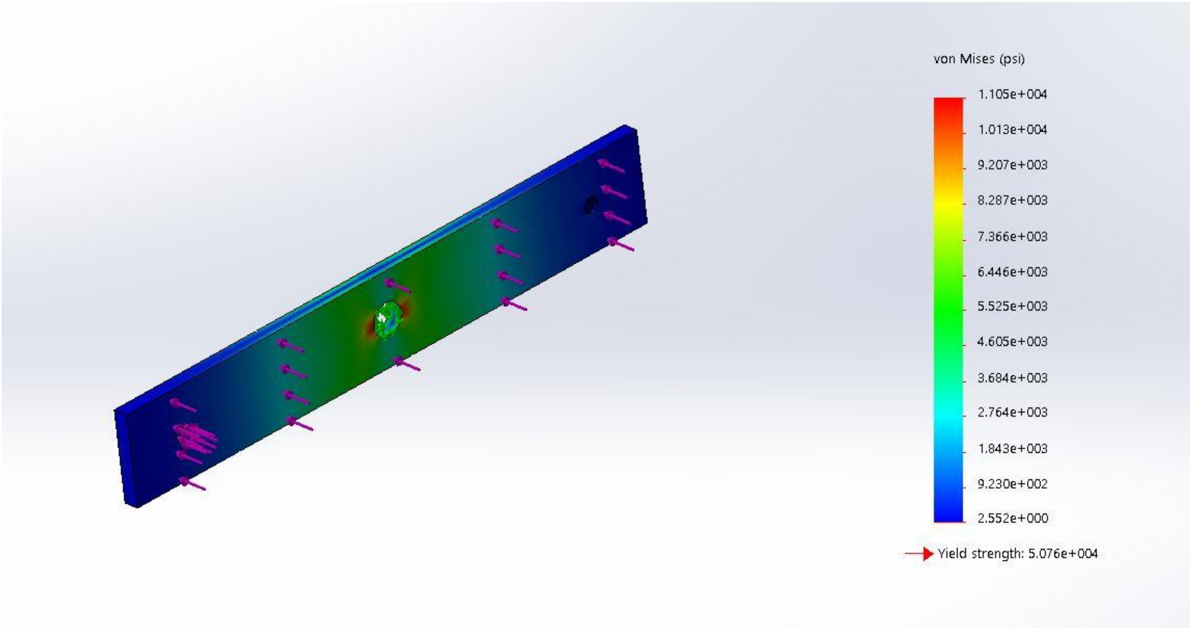
- The above photo shows the base structure displacement in inches. The load represented is that of having a safety factor of two as specified earlier in this document.



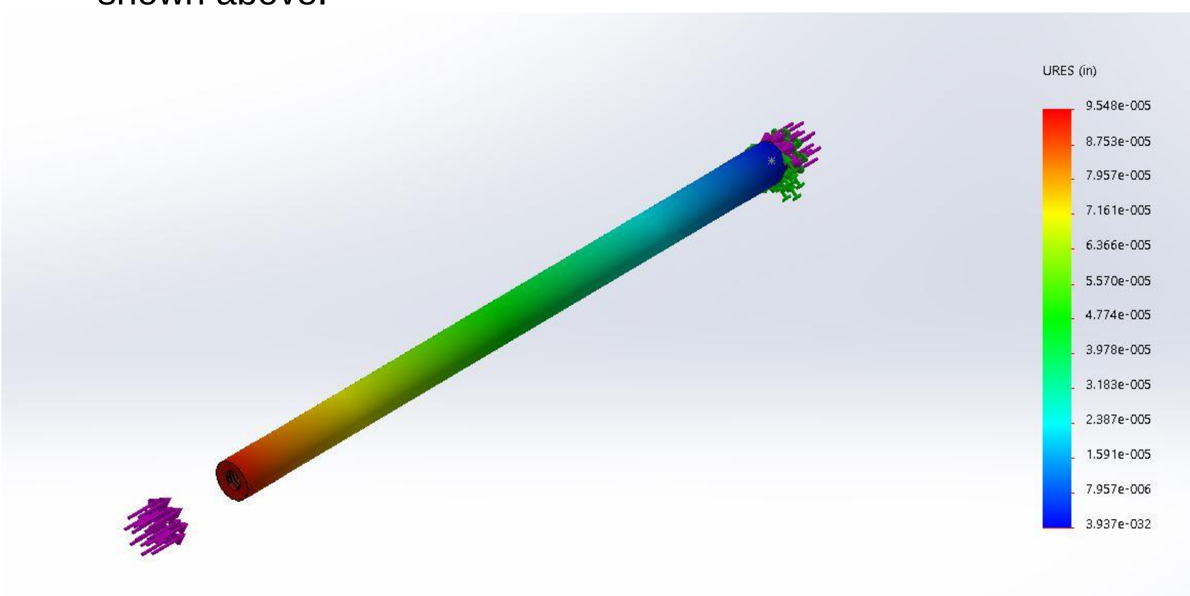
- The above image shows the von mises stress for the Base mounting unit as with a load representing a safety factor of two.

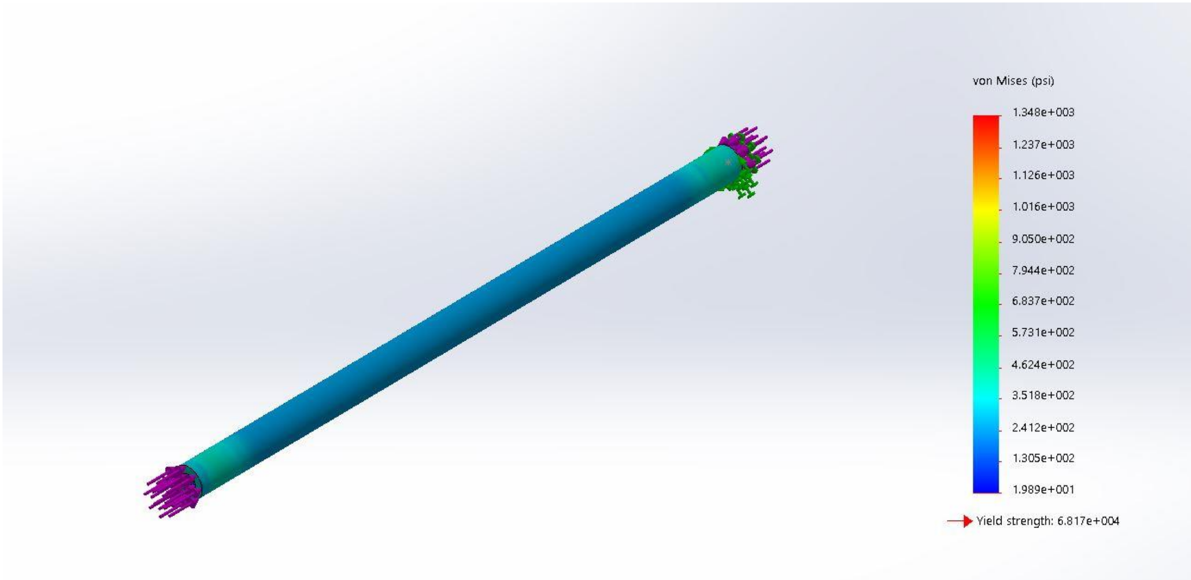


- The above image shows the displacement of the center plate. This deformation is critical to the design holding its capacity when under full load. The loads are represented at each of the two outer most holes as force loads. The center is fixed as it will be in the final design. The center hole will be mounted to the flanged lead screw nut.

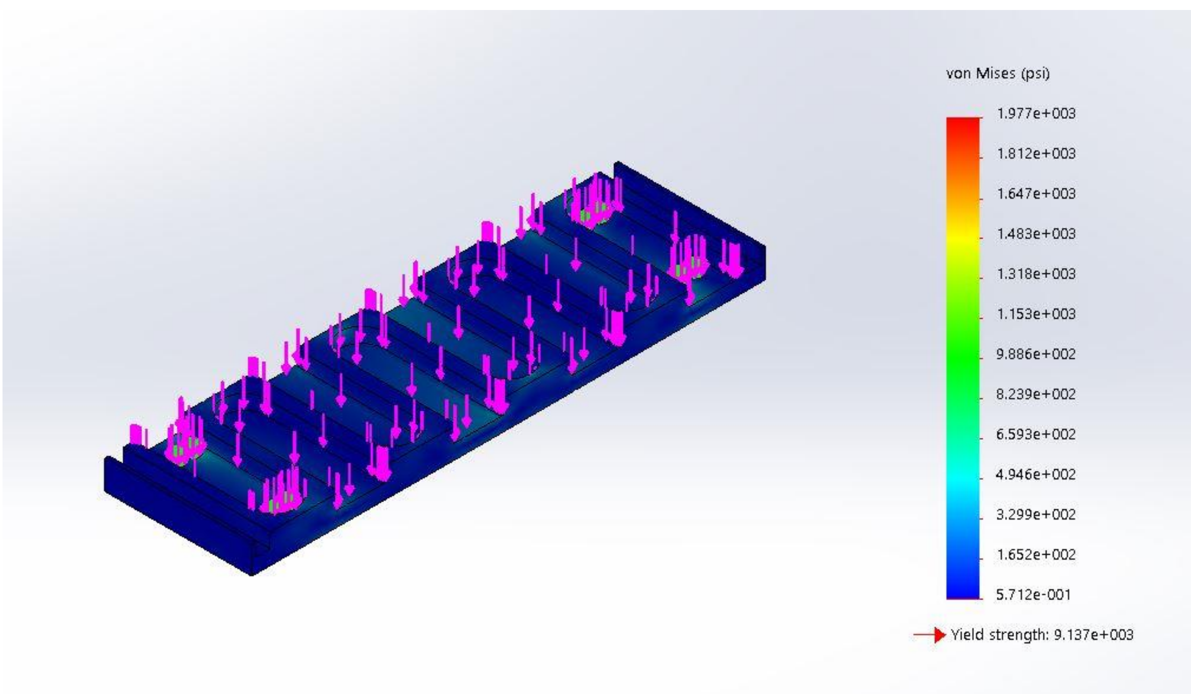


- The above image represents the stresses seen on the center plate under the same constraints as the displacement configuration shown above.





- The above image shows the stresses that will be seen on the rear legs of the base mounting structure. The leg shows a safety factor of nearly three times what is needed.



- The above picture shows the expected load with safety factor on the bottom delrin pieces. This piece would come into contact with the buttstocks of the long rifles.

Component Selection:

Linear Rails: These aluminum linear rails were selected for their lightweight constructed, yet high holding capacity. One rail is utilized for Rack as their 180kg load capacity meant that each was more than capable of handling the expected load including safety Factor. The rails have a installation length of 400mm and have an extension length of 435mm. This allows for our rack to being fully retracted from the safe with our fixed front length.

Safe used to test product: We decided upon using one of our own personal safes to test our design. This is because after our research was completed we determined that our personal safe was within the standard range of safes that we can expect to see our design implemented into.

Mock safe: This safe will be constructed out of plywood to serve as a display stand for the tech expo. Although the actual strength testing will be performed inside an actual Redwing safe, this will allow for a sizing visual at the show.

Threaded Lead Screw Rod & Nut: We decided upon a half inch threaded lead screw for the FEA and hand calculations showed that this would hold up under the safety factor load. This design also allows for the extension and retraction of the rear feet. The rear feet are responsible for holding the base mounting system for the safe in place.

Rubber Feet: These rubber feet were chosen due to their strong construction and high load capacity. The stud material and metal interior force plate are made out of steel. This provides the 50A durometer rubber feet with a high load rating of 390 Lbs. This exceeds the strength requirement calculated by a safety factor of 3.3.

Collapsible Handle:

During the design process, we felt that the ability of the user to easily maneuver the racks in and out of the safe was a necessity for desirable operation. We also wanted to make sure that this handle was capable of withstanding the force that a grown human would be placing on it, while also not taking up a lot of unneeded space. While researching methods of accomplishing this we came upon our handle which is a spring loaded zinc-plated steel pull handle. We choose this product because not only does it well exceed the forces we expect it to be exposed to, but also due to its' spring loaded design. This allows the handle to fold itself back into its storage position when not being used.

Locking Latches:

One of the elements we wanted to accomplish with our design is to increase the safety of storing the weapons. To accomplish this we incorporated a locking system that is made up of a latch pivoting on a metal rod. These latches secure themselves in the storage position by incorporation a magnetic disk that is implanted in latches raceway. This will allow the user to flip the latch down when their guns are in place and feel confident that they are adding another layer of security to their gun storage. To ensure no risk of damage is done to the barrels we plan to coat them in a rubberized finish that will keep from scratching the gun barrels.

Rack Component Material:

Being as the rack was one of the largest component on the overall design we wanted to ensure we were still being conscious of the weight of our device. We ran through some of the load numbers and FEA tests using different materials selections and determined that using delrin plastic would be our best option for maintaining structural integrity and reducing the weight as much as possible. By utilizing this material instead of the original determined metal we were able to reduce the weight of the racks by over 60%, while also reducing the overall cost.

PROJECT MANAGEMENT

BUDGET, PROPOSED

Item	*Cost*
Raw materials (Metal)	$300.00
Bearings & Fittings	$100.00
Miscellaneous Assembly Pieces	$75.00
Labor Cost	$2500.00
Machining Cost	$5000.00
Material Treatment Cost	$200.00
Shipping	$100.00
Display (Safe)	Zero Using Own Safe
Miscellaneous Expenses	$1000.00
Total Cost:	$9275.00

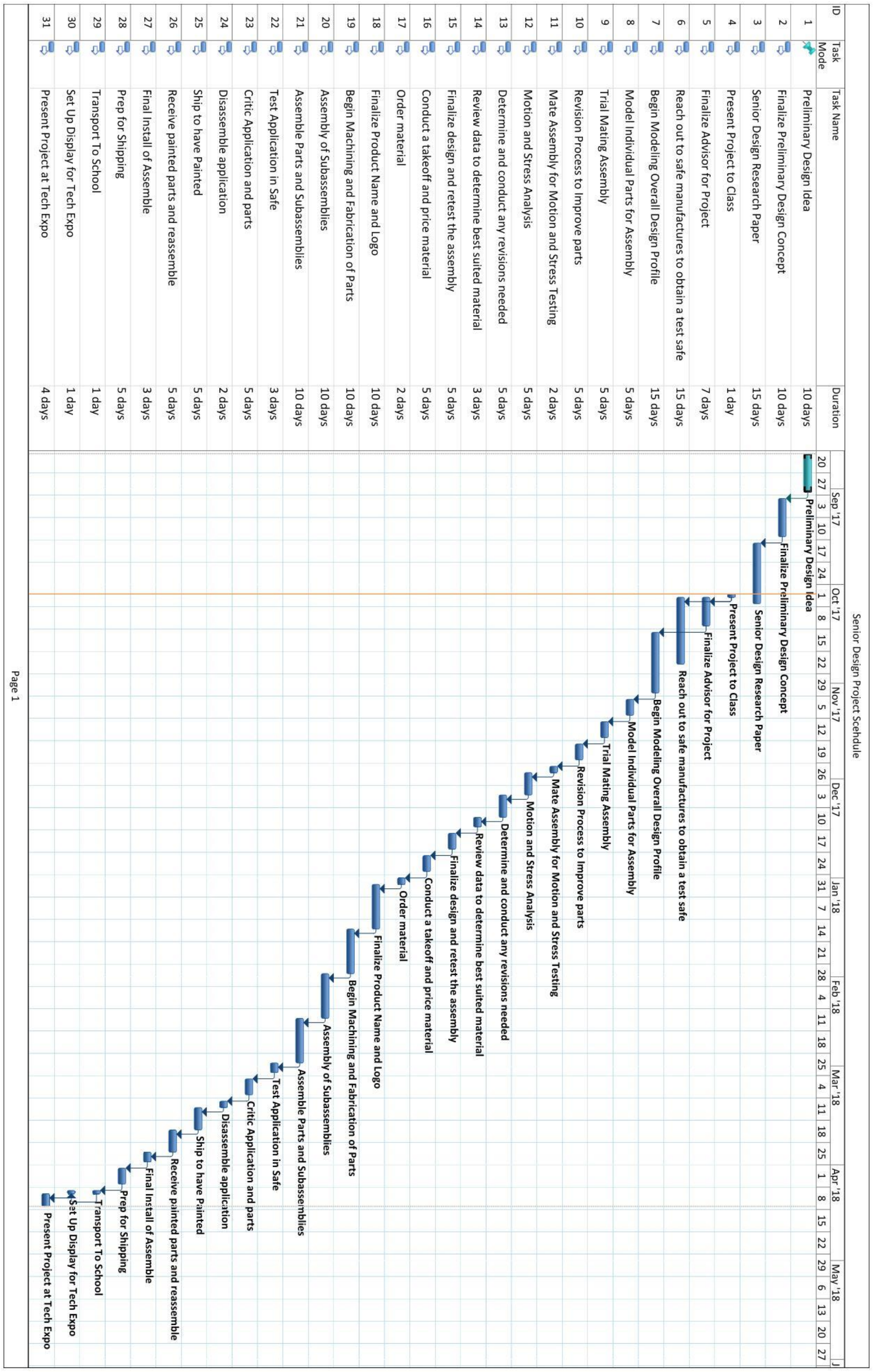
BUDGET, ACTUAL

Description	**Cost**
Raw materials	**$700.00**
Purchase Parts	**$200.00**
Hardware	**$60.00**
Machining Cost	**$2,300.00**
Total Cost:	**$3,260.00**

The table above is a general breakout of the final budget that was used during the procurement and fabrication phase of this project. All material was purchased through material venders local to Cincinnati. The fasteners and hardware were procured variously throughout the internet as the best prices were found to keep cost as low as possible. As you can see from the above table the greatest cost for the project was the amount of machining time it took to create this one-off prototype. Although in the end this amount and work was donated to us for free we were still able to have it priced to include in the budget for reference. Overall this budget seems higher than we would prefer if we were to manufacture and try to sell, but we are confident that we have generated methods of reducing the overall cost per unit if alterations were made. These suggestions can be referenced in the “Things to Change” section to follow.

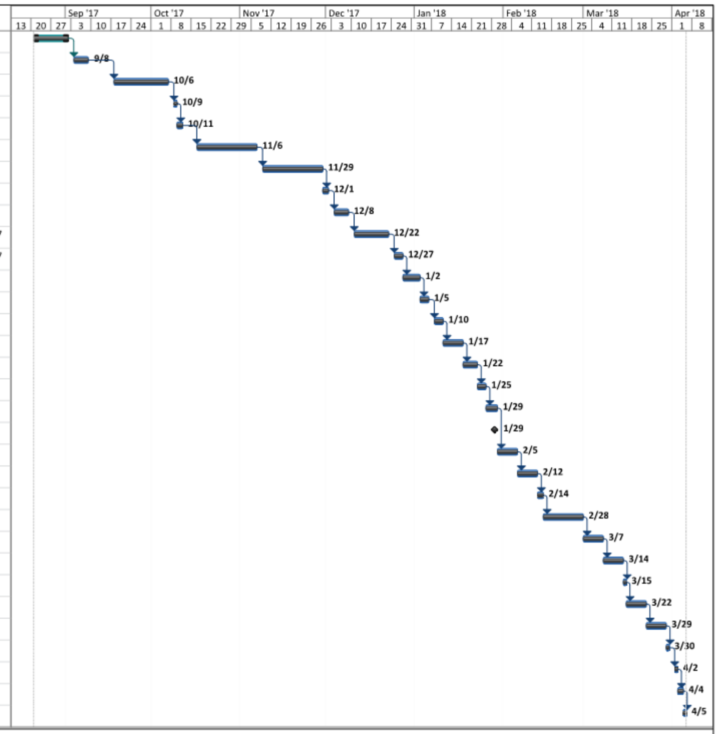
SCHEDULE, PROPOSED

Proposed Schedule:



SCHEDULE, ACTUAL

ID		Task Mode	Task Name	Duration	Start
1	✓		Preliminary Design Idea	10 days	Mon 8/21/17
2	✓		Finalize Preliminary Design Concept	5 days	Mon 9/4/17
3	✓		Senior Design Research Paper	15 days	Mon 9/18/17
4	✓		Present Project to Class	1 day	Mon 10/9/17
5	✓		Finalize Advisor for Project	2 days	Tue 10/10/17
6	✓		Reach out to safe manufactures to obtain a test safe	15 days	Tue 10/17/17
7	✓		Begin Modeling Overall Design Profile	15 days	Thu 11/9/17
8	✓		Determine Market Accessibilty for parts	2 days	Thu 11/30/17
9	✓		Incorperate Prefabricated Parts/Standards	5 days	Mon 12/4/17
10	✓		Model Individual Parts for Assembly	10 days	Mon 12/11/17
11	✓		Trial Mating Assembly	3 days	Mon 12/25/17
12	✓		Revision Process to Improve parts	4 days	Thu 12/28/17
13	✓		Mate Assembly for Motion and Stress Testing	3 days	Wed 1/3/18
14	✓		Motion and Stress Analysis	3 days	Mon 1/8/18
15	✓		Determine and conduct any revisions needed	5 days	Thu 1/11/18
16	✓		Review data to determine best suited material	3 days	Thu 1/18/18
17	✓		Finalize design and retest the assembly	3 days	Tue 1/23/18
18	✓		Prepare for Project Presentation	3 days	Fri 1/26/18
19	✓		Present Project Design to Advisors	0 days	Mon 1/29/18
20	✓		Conduct a takeoff and price material	5 days	Tue 1/30/18
21	✓		Order material	5 days	Tue 2/6/18
22	✓		Finalize Product Name and Logo	2 days	Tue 2/13/18
23	✓		Begin Machining and Fabrication of Parts	10 days	Thu 2/15/18
24	✓		Assembly of Subassemblies	5 days	Thu 3/1/18
25	✓		Assemble Parts and Subassemblies	5 days	Thu 3/8/18
26	✓		Test Application in Safe	1 day	Thu 3/15/18
27	✓		Critic Application and parts	5 days	Fri 3/16/18
28	✓		Final Install of Assemble	5 days	Fri 3/23/18
29	✓		Prep for Shipping	1 day	Fri 3/30/18
30	✓		Transport To School	1 day	Mon 4/2/18
31	✓		Set Up Display for Tech Expo	2 days	Tue 4/3/18
32	✓		Present Project at Tech Expo	1 day	Thu 4/5/18



Page 1

The original schedule was built with the end date estimated to be 4/28. As further details of presentations were released, the project was to be presented on 4/5. This resulted in a more aggressive approach at fabricating and assembling the product to allow for adequate time to test and improve any issues that arose. In the end this decision payed off and allowed the project to be properly tested, design altercations to occur, and finalized assembly prior to presenting the project on 4/5.

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History of Safes: The Evolution of a Box. (n.d.). Retrieved September 15, 2017, from http://gunsafehaven.com/history-of-safe/

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APPENDIX A

Purchase Part Drawings:

Black-Oxide Alloy Steel Socket Head Screw

M5 x 0.8 mm Thread, 10 mm Long

Packs of 100

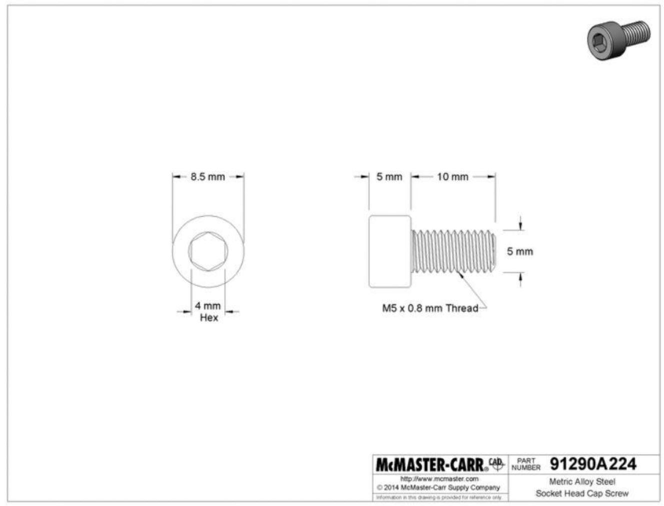
ADD TO ORDER

In stock
$9.84 per pack of 100
91290A224

Thread Size	M5
Thread Pitch	0.8 mm
Length	10 mm
Threading	Fully Threaded
Head Diameter	8.5 mm
Head Height	5 mm
Drive Size	4 mm
Material	Black-Oxide Alloy Steel
Fastener Strength Grade/Class	Class 12.9
Hardness	Rockwell C37
Tensile Strength	170,000 psi
Thread Type	Metric
Thread Spacing	Coarse
Thread Fit	Class 5g6g
Thread Direction	Right Hand
Head Type	Socket
Socket Head Profile	Standard
Drive Style	Hex
Specifications Met	DIN 912, ISO 4762
System of Measurement	Metric
RoHS	Compliant

These screws are made from an alloy steel that's stronger than Grade 8 steel. Length is measured from under the head.

Black-oxide steel screws are mildly corrosion resistant in dry environments.



The information in this 3-D model is provided for reference only. Details

316 Stainless Steel Button Head Hex Drive Screw

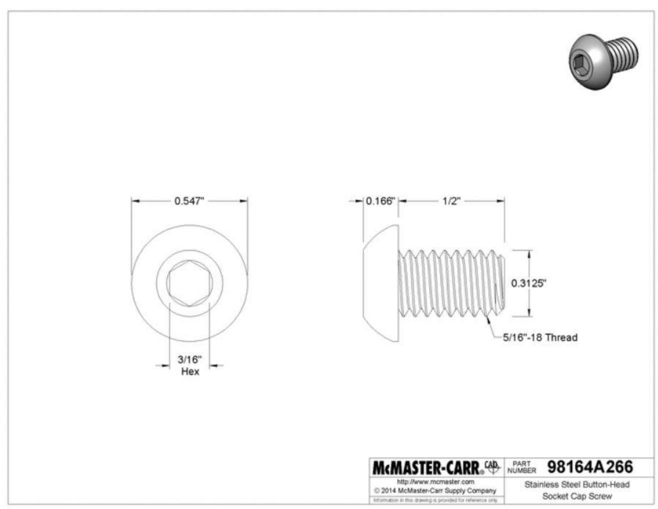
Super-Corrosion-Resistant, 5/16"-18 Thread Size, 1/2" Long

Packs of 10

ADD TO ORDER

In stock
$6.33 per pack of 10
98164A266

Thread Size	5/16"-18
Length	1/2"
Threading	Fully Threaded
Head Diameter	0.547"
Head Height	0.166"
Drive Style	Hex
Drive Size	3/16"
Material	316 Stainless Steel
Finish	Passivated
Hardness	Rockwell B55
Tensile Strength	70,000 psi
Screw Size Decimal Equivalent	0.313"
Thread Type	UNC
Thread Spacing	Coarse
Thread Fit	Class 3A
Thread Direction	Right Hand
Head Type	Rounded
Rounded Head Style	Button
Rounded Head Profile	Standard
System of Measurement	Inch
Specifications Met	ASME B18.3, ASTM F837
RoHS	Compliant



The information in this 3-D model is provided for reference only. Details

932 Bearing Bronze ACME Flange Nut

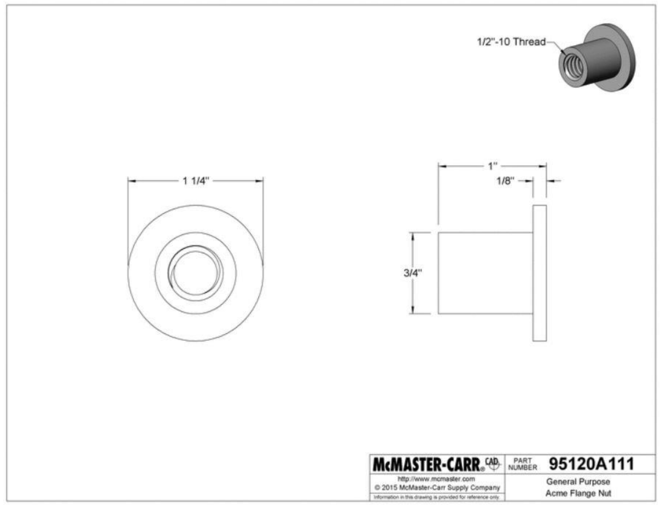
Right Hand, 1/2"-10 Thread Size

Each

ADD TO ORDER

In stock
$95.70 Each
95120A111

Material	932 Bearing Bronze
Component	Nut
Nut Type	Flange
Thread Size	1/2"-10
Height	1"
Diameter	3/4"
Speed Ratio	1:1
Number of Thread Starts	1
Travel Distance per Turn	1/10"
Flange	
Thickness	1/8"
Diameter	1 1/4"
Material	932 Bearing Bronze
Hardness	Not Rated
Thread Direction	Right Hand
Thread Type	Acme
Thread Fit	Class 2G
Hardness	Not Rated
Tensile Strength	Not Rated
System of Measurement	Inch
RoHS	Not Compliant



The information in this 3-D model is provided for reference only. Details

High-Strength Steel Flange Nut

Grade 8, Black-Phosphate, 1/2"-20 Thread Size

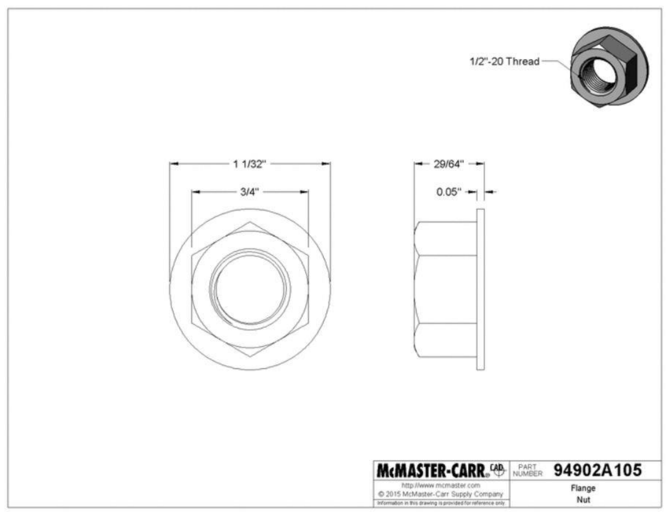
Packs of 25

ADD TO ORDER

In stock
$7.83 per pack of 25
94902A105

Material	Black-Phosphate Steel
Fastener Strength Grade/Class	Grade 8
Thread Size	1/2"-20
Thread Type	UNF
Thread Spacing	Fine
Thread Fit	Class 2B
Thread Direction	Right Hand
Width	3/4"
Height	29/64"
Flange	
Diameter	1 1/32"
Thickness	0.05"
Drive Style	External Hex
Nut Type	Flange
Hex Nut Profile	Standard
System of Measurement	Inch
RoHS	Compliant

A flange distributes pressure where the nut meets the material surface, eliminating the need for a separate washer. Made from Grade 8 steel, these nuts are about 25% stronger than medium-strength steel flange nuts. All have a finish that resists corrosion in wet environments. Height includes the flange.



The information in this 3-D model is provided for reference only. Details

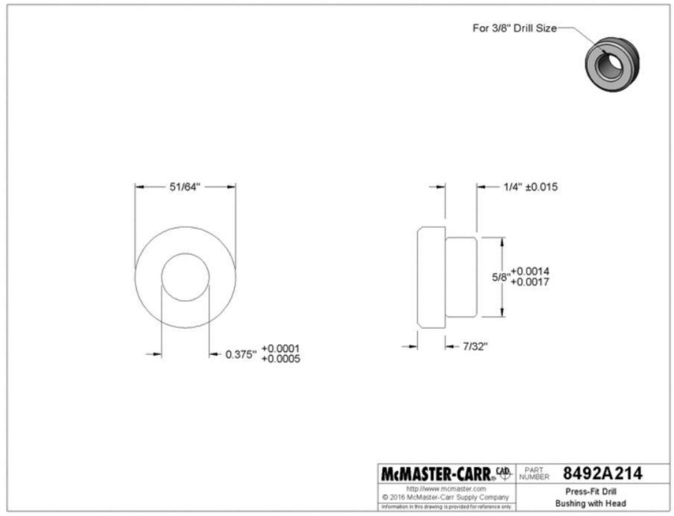
Press-Fit Drill Bushing with Head

0.375" ID, 5/8" OD, 1/4" Long

Each

ADD TO ORDER

In stock
1-5 Each $8.82
6-11 $7.49
12 or more $6.60
8492A214



Installation Type	Permanent
Drill Bushing Style	Smooth
ID	0.375"
OD	5/8"
Length	1/4"
For Drill Bit Size	3/8"
For Drill Bit Size Decimal Equivalent	0.375"
Head	
OD	51/64"
Thickness	7/32"
Tolerance	
ID	0.0001" to 0.0005"
OD	0.0014" to 0.0017"
Length	-0.015" to 0.015"
Drill Bushing Type	H
Material	Steel
Hardness	Rockwell C61
RoHS	Not Compliant

The information in this 3-D model is provided for reference only. Details

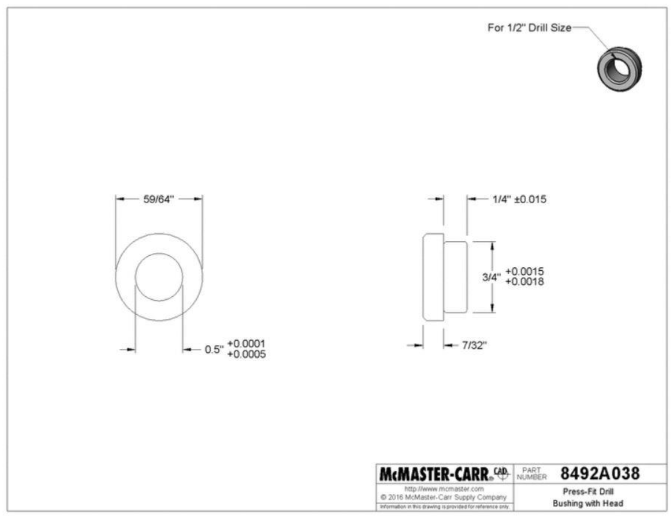
Press-Fit Drill Bushing with Head

0.5" ID, 3/4" OD, 1/4" Long

Each

ADD TO ORDER

In stock
1-5 Each $9.22
6-11 $7.85
12 or more $6.91
8492A038



Installation Type	Permanent
Drill Bushing Style	Smooth
ID	0.5"
OD	3/4"
Length	1/4"
For Drill Bit Size	1/2"
For Drill Bit Size Decimal Equivalent	0.5"
Head	
OD	59/64"
Thickness	7/32"
Tolerance	
ID	0.0001" to 0.0005"
OD	0.0015" to 0.0018"
Length	-0.015" to 0.015"
Drill Bushing Type	H
Material	Steel
Hardness	Rockwell C61
RoHS	Not Compliant

The head prevents these bushings from being pushed through the jig when drilling pressure is extreme. The head sits above the jig plate or can be mounted flush by installing in a counterbored hole. Drill bushings can also be used as spacers, shims, and machinery bushings.

Don't see the size you need? Additional sizes are available.

The information in this 3-D model is provided for reference only. Details

Zinc Yellow-Chromate Plated Hex Head Screw

Grade 8 Steel, 1/4"-20 Thread Size, 1/2" Long

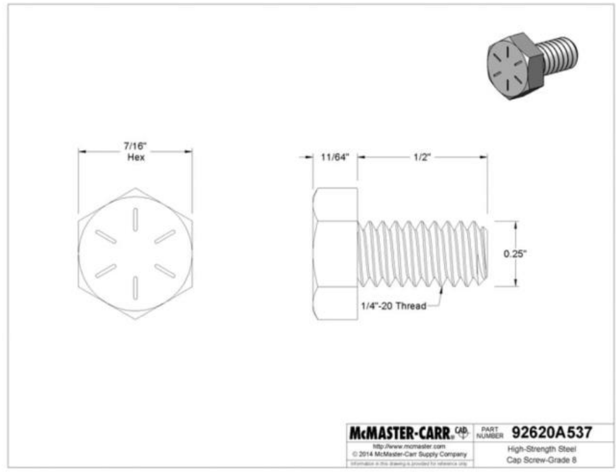
Packs of 100 | In stock
$11.73 per pack of 100
92620A537

ADD TO ORDER

Thread Size	1/4"-20
Length	1/2"
Threading	Fully Threaded
Head Width	7/16"
Head Height	11/64"
Material	Zinc Yellow-Chromate Plated Steel
Fastener Strength Grade/Class	Grade 8
Hardness	Rockwell C33
Tensile Strength	150,000 psi
Screw Size Decimal Equivalent	0.250"
Thread Type	UNC
Thread Spacing	Coarse
Thread Fit	Class 2A
Thread Direction	Right Hand
Head Type	Hex
Hex Head Profile	Standard
Drive Style	External Hex
Specifications Met	ASME B18.2.1, SAE J429
System of Measurement	Inch
RoHS	Not Compliant

Good for demanding applications such as suspension systems, these screws are at least 25% stronger than medium-strength steel screws. Length is measured from under the head.

Zinc yellow-chromate plated steel screws resist corrosion in wet environments.



The information in this 3-D model is provided for reference only. Details

Rubber Load-Rated Bumper

5/16"-18 Thread 5/8" Long Steel Stud, 1-1/2" OD, 3/4" High

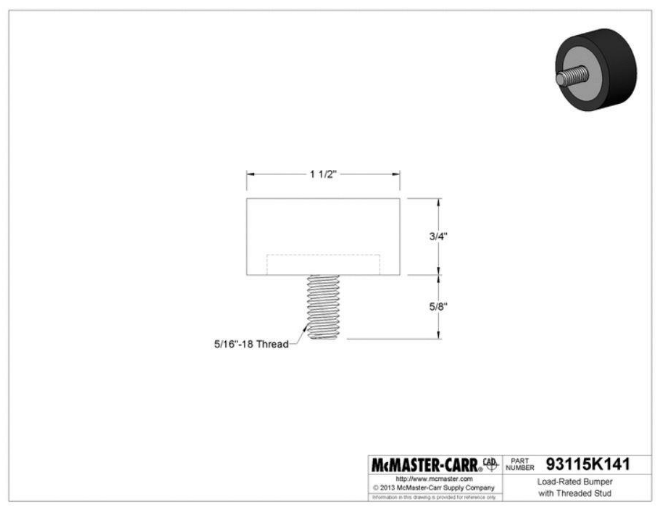
Each | In stock
$9.01 Each
93115K141

ADD TO ORDER

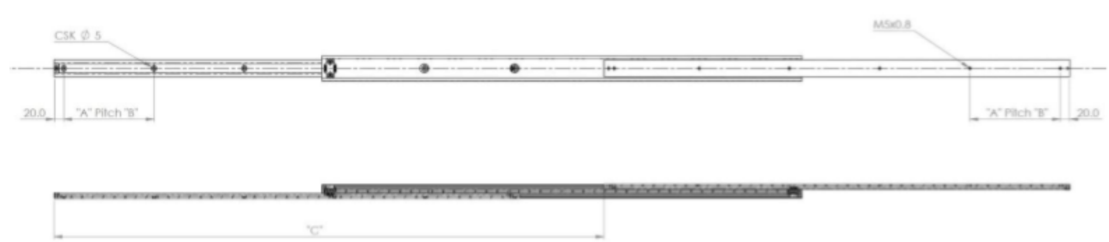
Shape	Round
Mount Type	Threaded Stud
Material	Rubber
Reinforcement Type	Base Plate
Base Plate Material	Steel
Thread	
Size	5/16"-18
Length	5/8"
OD	1 1/2"
Height	3/4"
Maximum Load	390 lbs.
Temperature Range	-10° to 150° F
For Use Outdoors	No
Hardness Rating	Medium Hard
Hardness	Durometer 50A
Nonmarking	No
Color	Black
Stud Material	Steel
RoHS	Compliant

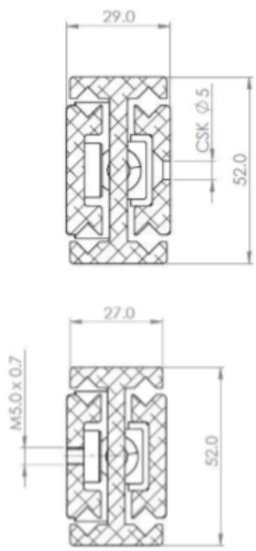
A built-in stud eliminates the need for an additional fastener. Use these bumpers to dampen vibration and shock in applications that require load ratings. They have a steel base plate for added strength and reinforcement.

Rubber bumpers are abrasion resistant.



The information in this 3-D model is provided for reference only. Details

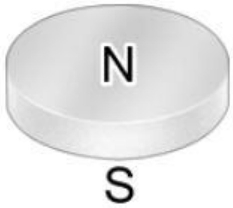




Configuration Table					
Part Number	Installation Length "L"	Extension Length "C"	Load Per Pair (kg)	Drill Table "A"	Drill Table "B"
4013.5229.0300	300	305	175	120	3
4013.5229.0350	350	405	177	145	3
4013.5229.0400	400	435	180	113	4
4013.5229.0450	450	465	185	130	4
4013.5229.0500	500	565	190	110	5
4013.5229.0550	550	525	195	122.5	5
4013.5229.0600	600	625	200	135	5
4013.5229.0650	650	585	220	118	6
4013.5229.0700	700	685	200	128	6
4013.5229.0750	750	785	185	138	6
4013.5229.0800	800	885	175	148	6
4013.5229.0850	850	845	165	158	6
4013.5229.0900	900	945	155	168	6

High-Pull Rare Earth Magnetic Disc

Nickel-Plated Neodymium, 1/8" Thick, 0.7 lbs. Maximum Pull



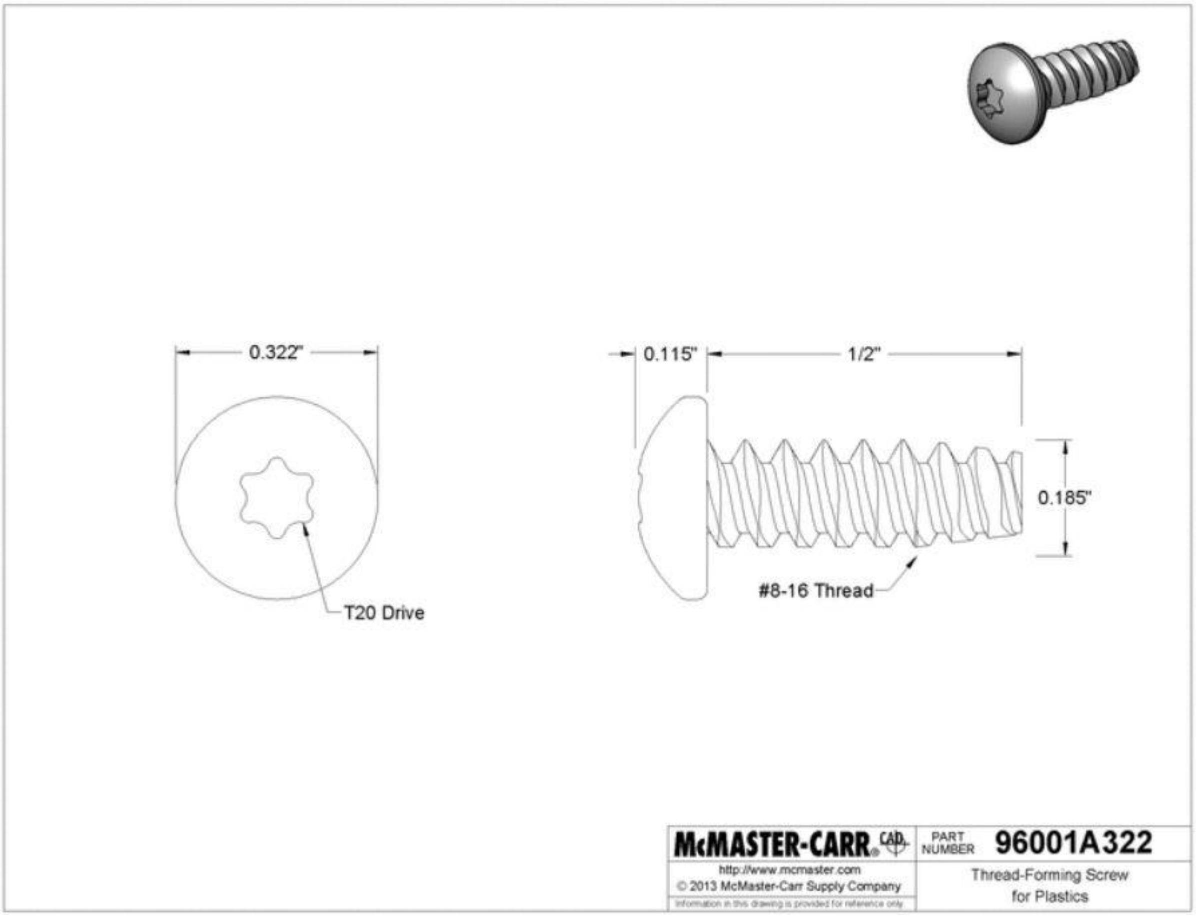
Each	In stock
ADD TO ORDER	1-49 Each $2.27
	50 or more $1.70
	5862K61

Thickness	1/8"
Diameter	1/8"
Maximum Pull	0.7 lbs.
Number of Faces with Holding Power	2
Thickness Tolerance	-0.005" to 0.005"
Diameter Tolerance	-0.005" to 0.005"
Min. Temperature	Not Rated
Maximum Temperature	300° F
Machinable	No
Material	Nickel-Plated Neodymium
Grade	N35SH
Color	Silver
Shape	Disc
Additional Specifications	SDS
RoHS	Compliant
Shipping	Regulated by the U.S. Department of Transportation

Made of neodymium (neodymium-iron-boron), these magnetic discs have five times the holding power of ceramic (ferrite) magnets and resist demagnetization. Nickel-plated magnets are more corrosion resistant than plain magnets.

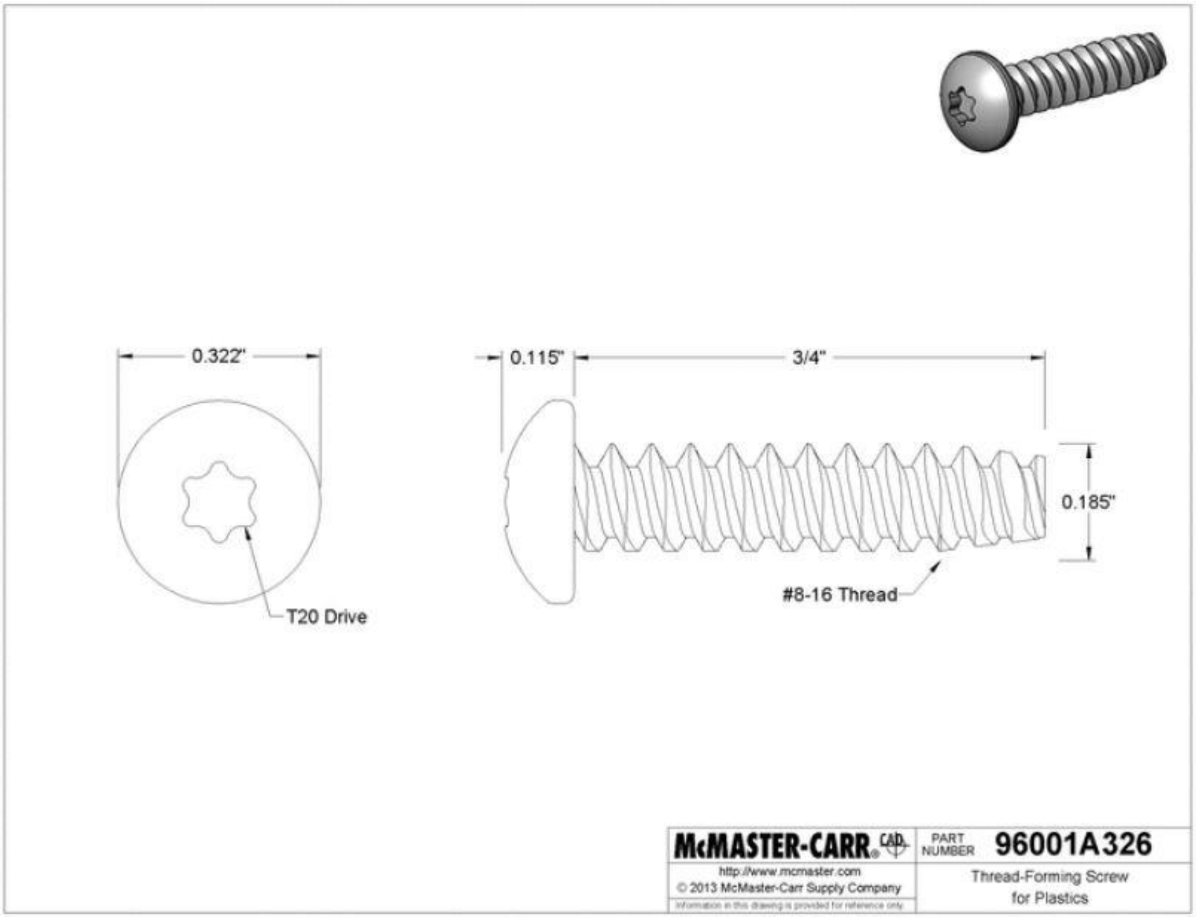
Warning: Maximum pull ratings are based on direct contact with rust-free and unpainted iron plate. Variations in material condition will significantly reduce these ratings. Do not use for lifting over people.

Material	18-8 Stainless Steel
Screw Size	No. 8
Screw Size Decimal Equivalent	0.164"
Length	1/2"
Head	
Diameter	0.322"
Height	0.115"
Drive Size	T20
Drive Style	Torx
Drill Bit Size	No. 29
Drill Bit Size Decimal Equivalent	0.136"
Approximate Threads per Inch	16
Thread Direction	Right Hand
Threading	Fully Threaded
Tapping Method	Thread Forming
Tapping Screw Type	TRS
Head Type	Rounded
Rounded Head Profile	Standard
Rounded Head Style	Pan
Tip Type	Blunt
Shank Cross Section	Tri-Lobe
System of Measurement	Inch
For Use In	Plastic
RoHS	Compliant

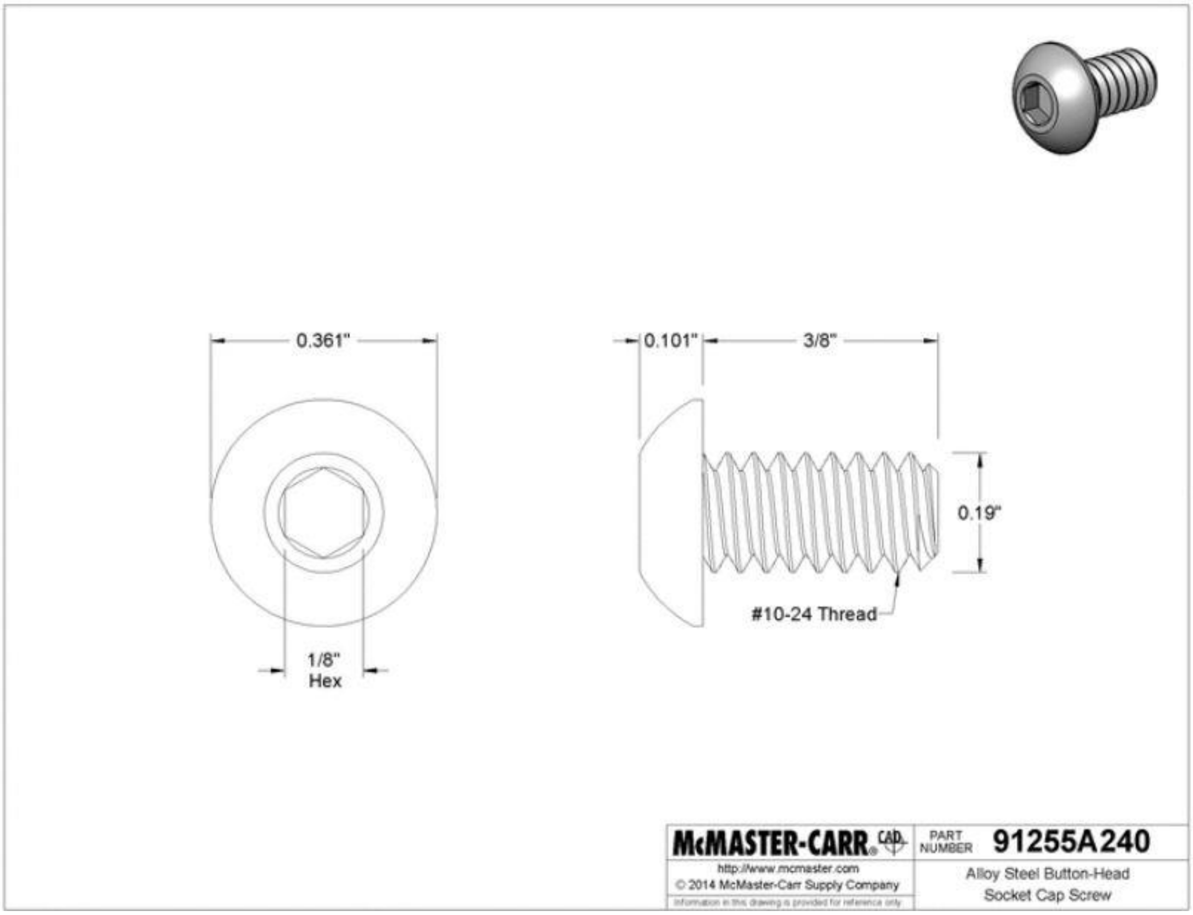


0.322"
T20 Drive
0.115"
1/2"
0.185"
#8-16 Thread
McMASTER-CARR
PART NUMBER
96001A322
http://www.mcmaster.com
© 2013 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
Thread-Forming Screw for Plastics

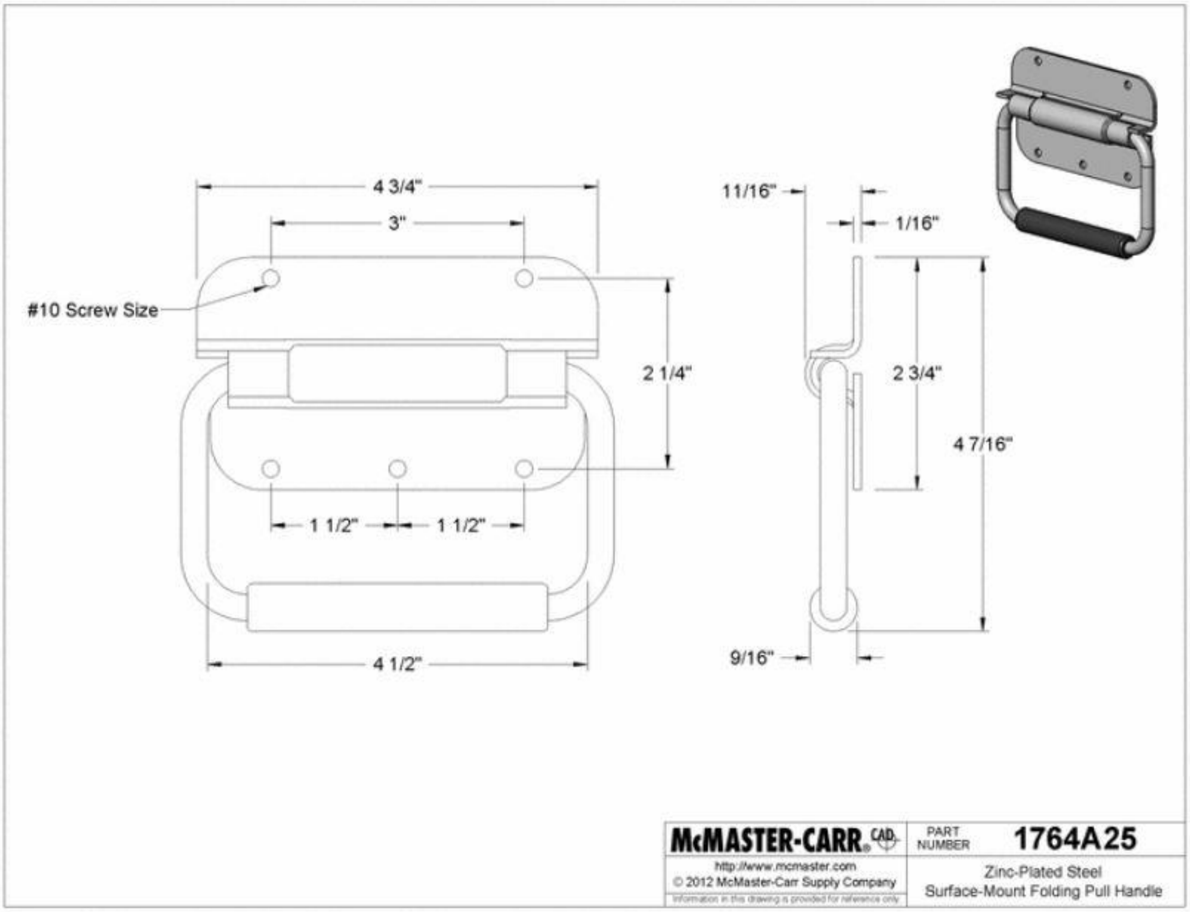
Material	18-8 Stainless Steel
Screw Size	No. 8
Screw Size Decimal Equivalent	0.164"
Length	3/4"
Head	
Diameter	0.322"
Height	0.115"
Drive Size	T20
Drive Style	Torx
Drill Bit Size	No. 29
Drill Bit Size Decimal Equivalent	0.136"
Approximate Threads per Inch	16
Thread Direction	Right Hand
Threading	Fully Threaded
Tapping Method	Thread Forming
Tapping Screw Type	TRS
Head Type	Rounded
Rounded Head Profile	Standard
Rounded Head Style	Pan
Tip Type	Blunt
Shank Cross Section	Tri-Lobe
System of Measurement	Inch
For Use In	Plastic
RoHS	Compliant


0.322"
T20 Drive
0.115"
3/4"
0.185"
#8-16 Thread
McMASTER-CARR
CAD
PART NUMBER
96001A326
http://www.mcmaster.com
© 2013 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
Thread-Forming Screw
for Plastics

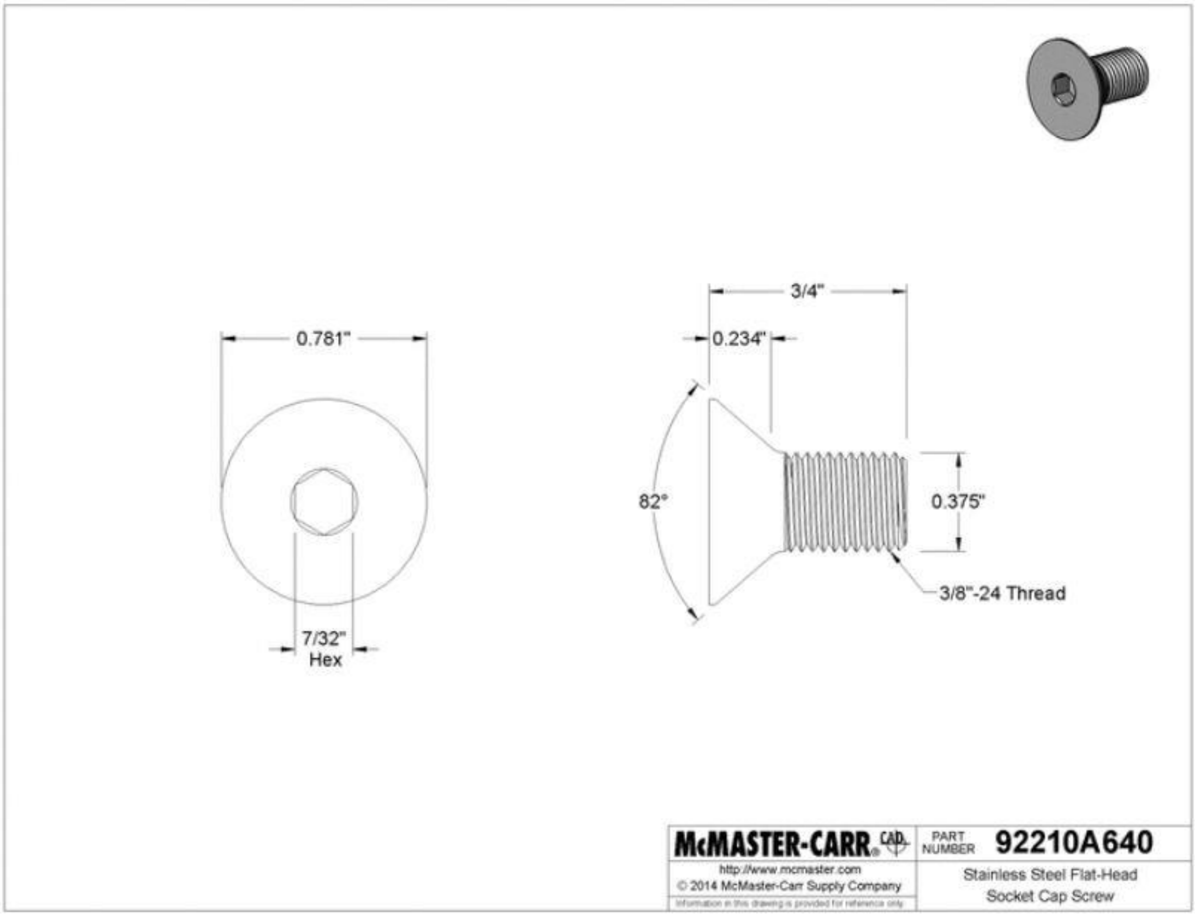
Thread Size	10-24
Length	3/8"
Threading	Fully Threaded
Head Diameter	0.361"
Head Height	0.101"
Drive Style	Hex
Drive Size	1/8"
Material	Black-Oxide Alloy Steel
Hardness	Rockwell C37
Tensile Strength	120,000 psi
Screw Size Decimal Equivalent	0.190"
Thread Type	UNC
Thread Spacing	Coarse
Thread Fit	Class 3A
Thread Direction	Right Hand
Head Type	Rounded
Rounded Head Style	Button
Rounded Head Profile	Standard
System of Measurement	Inch
Specifications Met	ASME B18.3, ASTM F835
RoHS	Compliant


0.361"
1/8"
Hex
0.101"
3/8"
0.19"
#10-24 Thread
McMASTER-CARR® CAD
http://www.mcmaster.com
© 2014 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
PART NUMBER 91255A240
Alloy Steel Button-Head
Socket Cap Screw

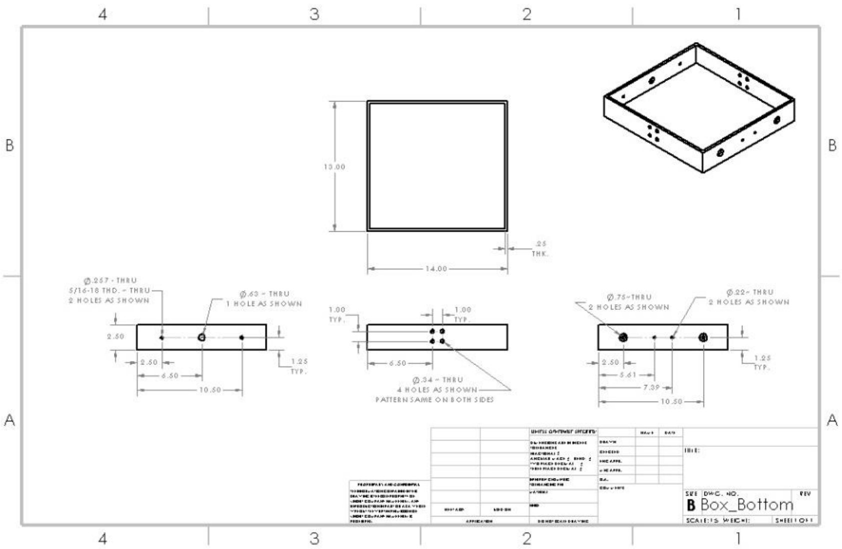
Mounting Plate	
Height	2 3/4"
Width	4 3/4"
Thickness	1/16"
Projection	3 1/16"
Handle Width	4 1/2"
Folding Angle	90°
Grip	
Diameter	9/16"
Cross Section Shape	Round
Material	Rubber
Material	Zinc-Plated Steel
Appearance	Dull
Fabrication	Stamped
Temperature Range	-40° to 240° F
Mounting Fasteners Included	No
Number of Mounting Holes	5
Mounting Screw Size	No. 10
Features	Spring-Loaded Hinge
Mounting Style	Unthreaded Through Hole
Handle Style	Folding

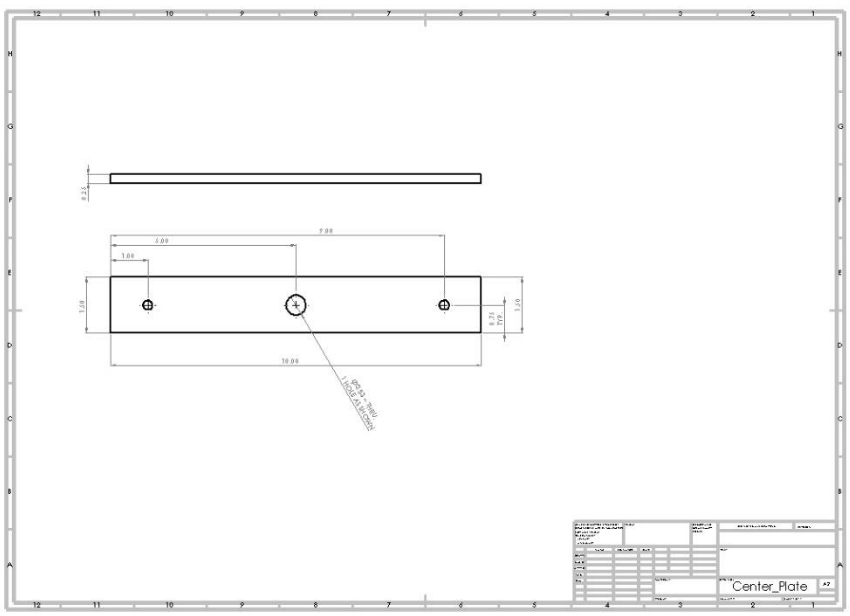

4 3/4"
3"
#10 Screw Size
2 1/4"
1 1/2"
1 1/2"
4 1/2"
11/16"
1/16"
2 3/4"
4 7/16"
9/16"
McMASTER-CARR
PART NUMBER
1764A25
http://www.mcmaster.com
© 2012 McMaster-Carr Supply Company
Zinc-Plated Steel
Surface-Mount Folding Pull Handle

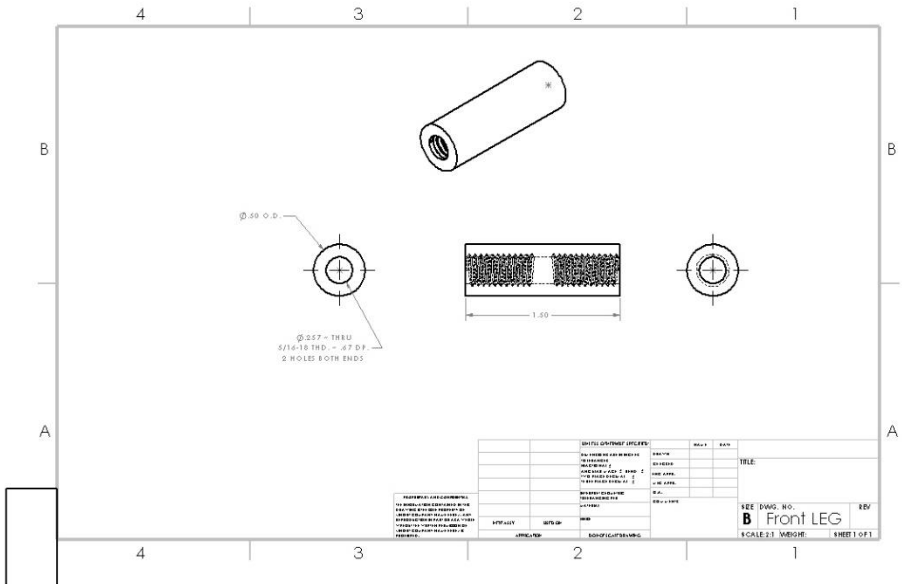
Thread Size	3/8"-24
Length	3/4"
Threading	Fully Threaded
Flat Head Profile	Standard
Head Diameter	0.781"
Head Height	0.234"
Countersink Angle	82°
Drive Style	Hex
Drive Size	7/32"
Material	18-8 Stainless Steel
Finish	Passivated
Hardness	Rockwell B55
Tensile Strength	70,000 psi
Screw Size Decimal Equivalent	0.375"
Thread Type	UNF
Thread Spacing	Fine
Thread Fit	Class 3A
Thread Direction	Right Hand
Head Type	Flat
System of Measurement	Inch
Specifications Met	ASME B18.3
RoHS	Compliant

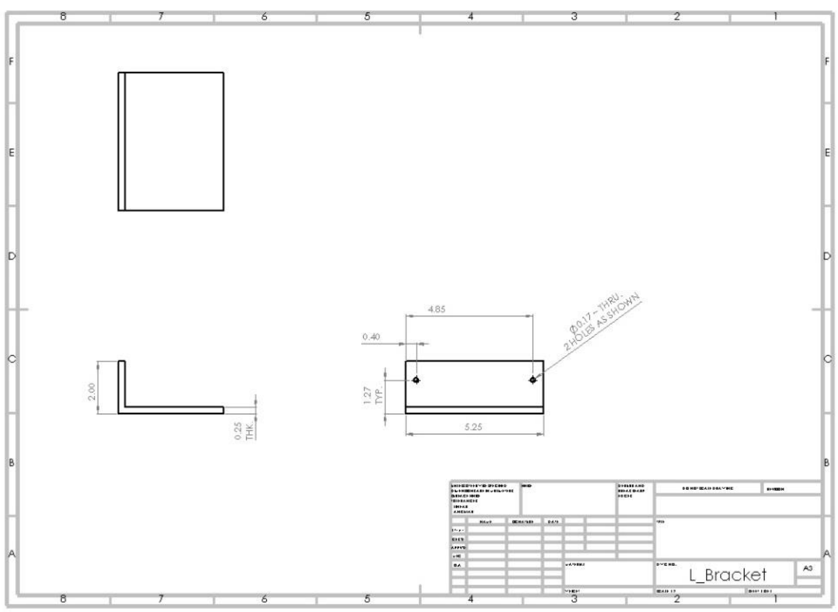


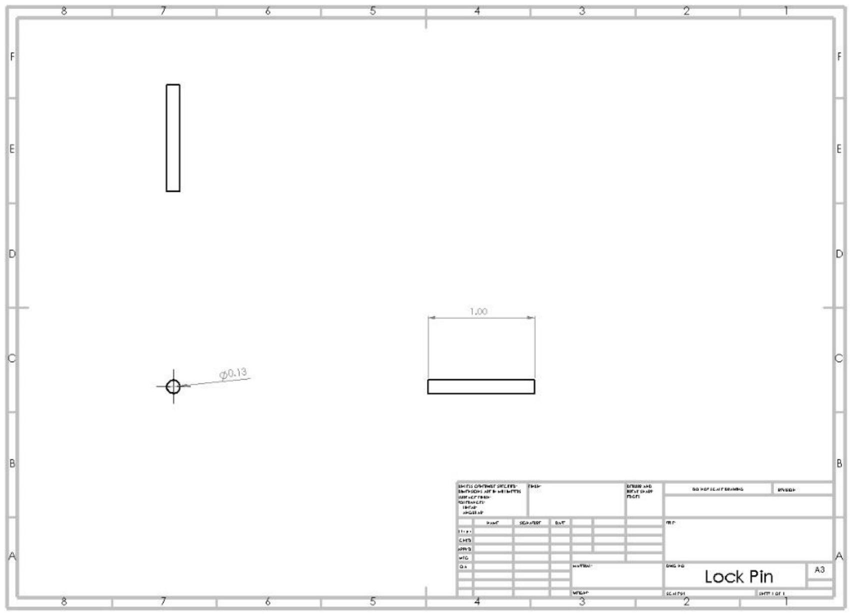
Fabricated Part Drawings:

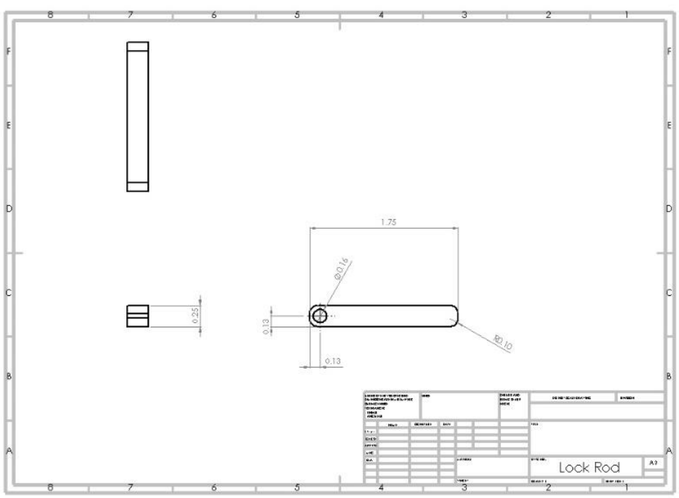

14.00
13.00
.25 THK.
Ø.257 - THRU
5/16-18 THD. - THRU
2 HOLES AS SHOWN
Ø.60 - THRU
1 HOLE AS SHOWN
Ø.34 - THRU
4 HOLES AS SHOWN
PATTERN SAME ON BOTH SIDES
Ø.75-THRU
2 HOLES AS SHOWN
Ø.22- THRU
2 HOLES AS SHOWN
B Box_Bottom

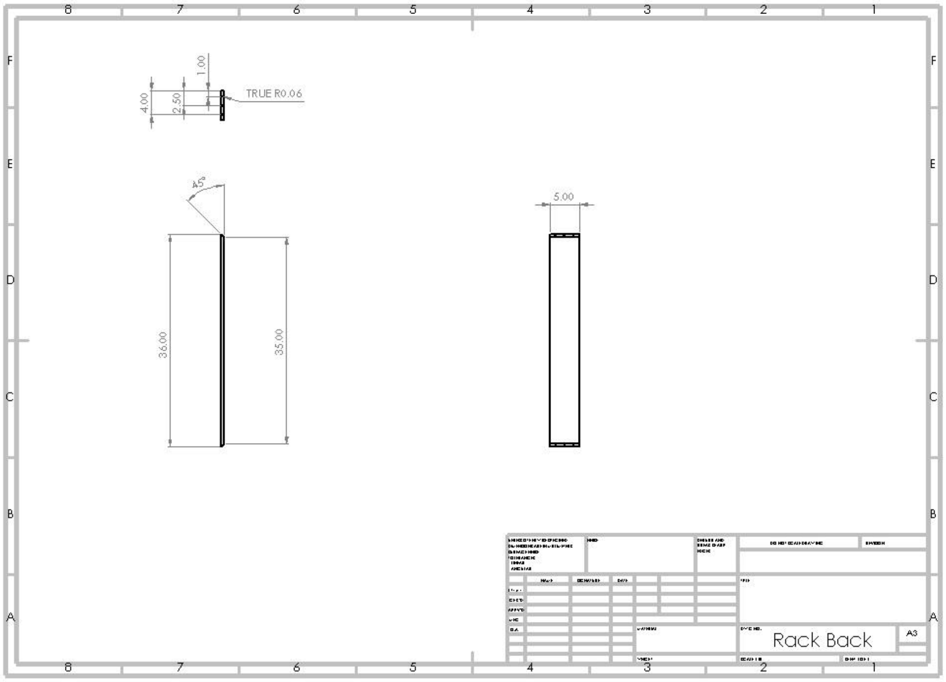

Center_Plate

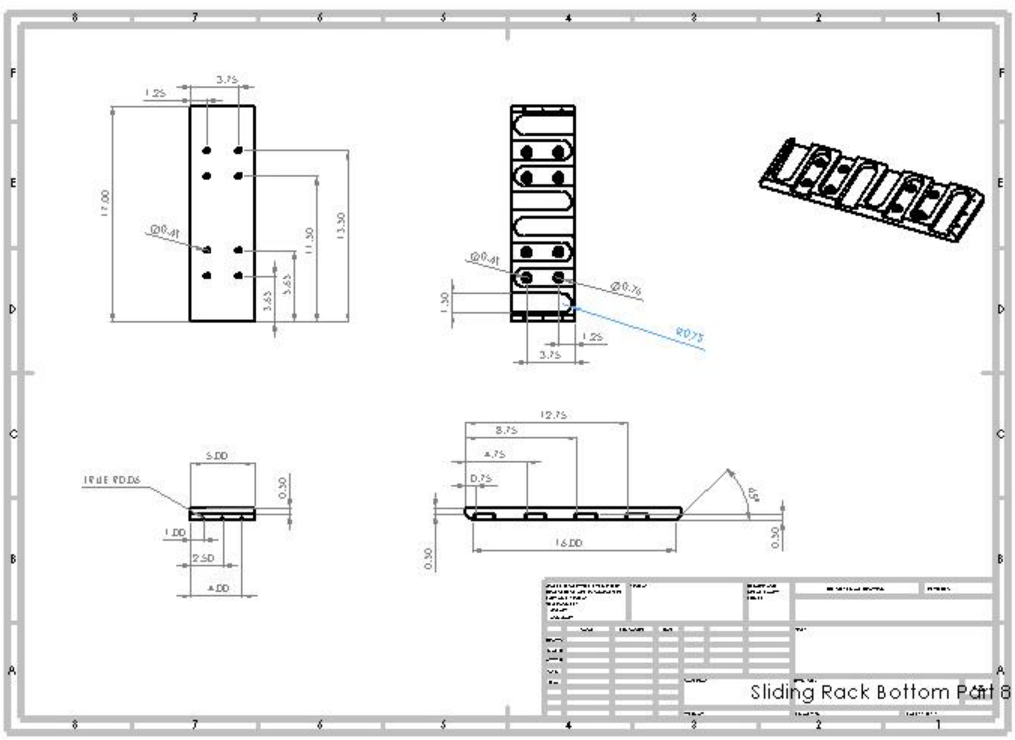

Ø.50 O.D.
Ø.257 – THRU
5/16-18 THD. – .67 DP.
2 HOLES BOTH ENDS
1.50
TITLE:
SIZE DWG. NO.
REV
B
Front LEG
SCALE:2:1 WEIGHT:
SHEET 1 OF 1

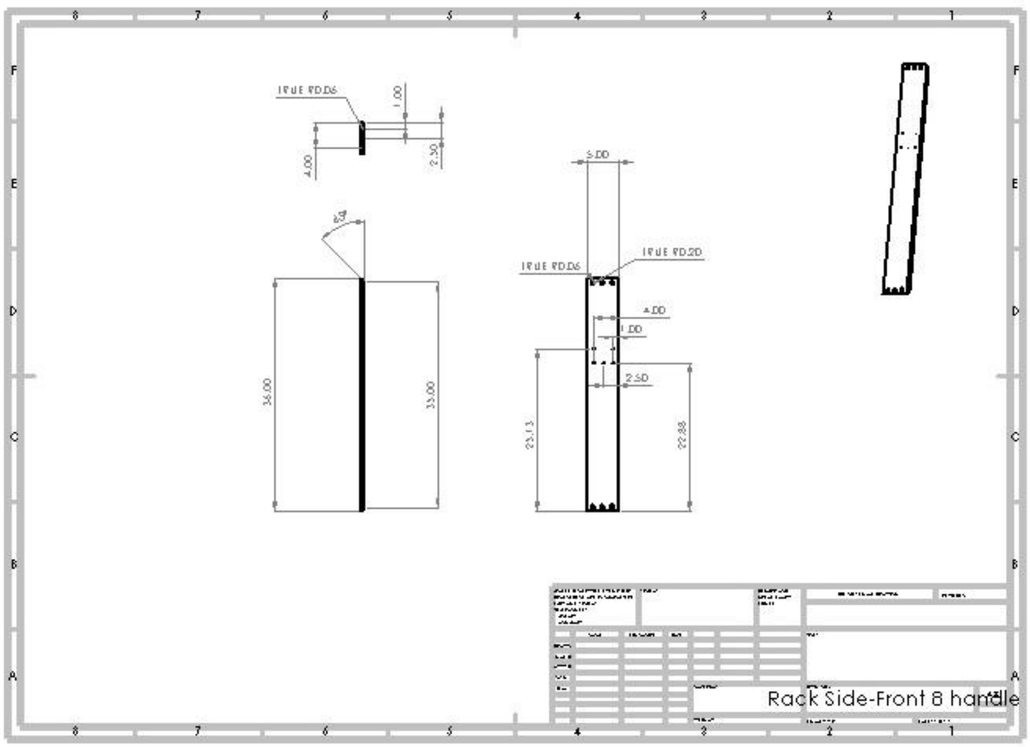

4.85
0.40
Ø0.17 – THRU,
2 HOLES AS SHOWN
2.00
1.27
TYP.
5.25
0.25
THK
L_Bracket
A3

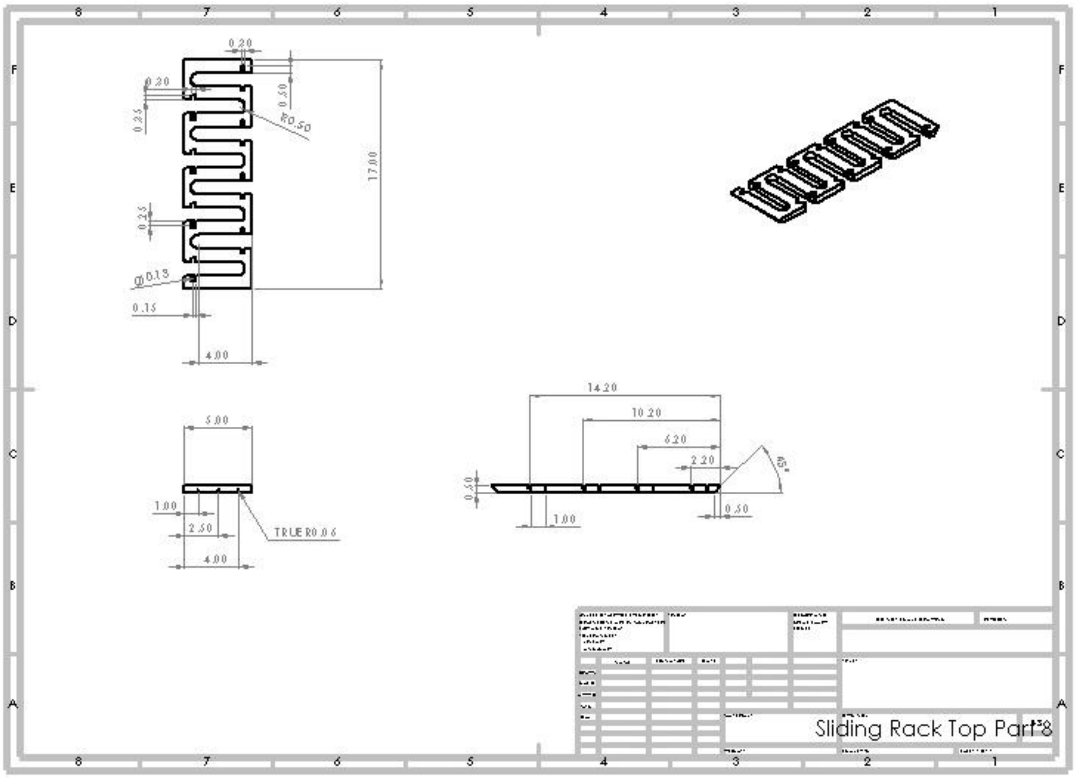

1.00
Ø0.13
Lock Pin
A3


1.75
Ø0.16
0.25
0.13
0.13
R0.10
Lock Rod
A3

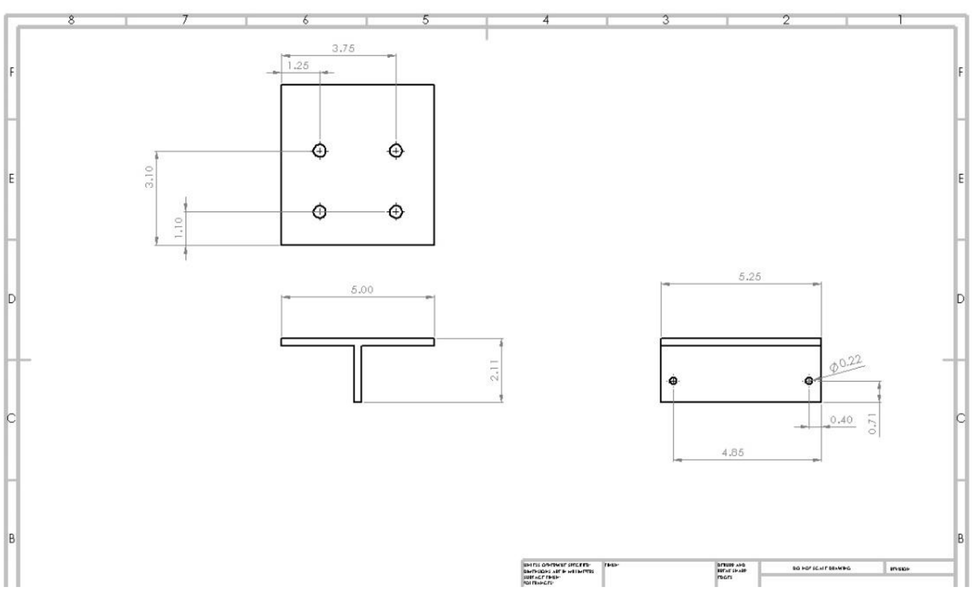

TRUE R0.06
1.00
2.50
4.00
45°
5.00
36.00
35.00
Rack Back
A3


3.75
1.25
17.00
13.30
11.30
3.63
3.63
Ø0.41
Ø0.76
R0.75
1.30
1.25
3.75
12.75
8.75
4.75
0.75
5.00
TRUE R0.06
0.30
1.00
2.50
4.00
16.00
0.30
0.30
45°
Sliding Rack Bottom Part 8

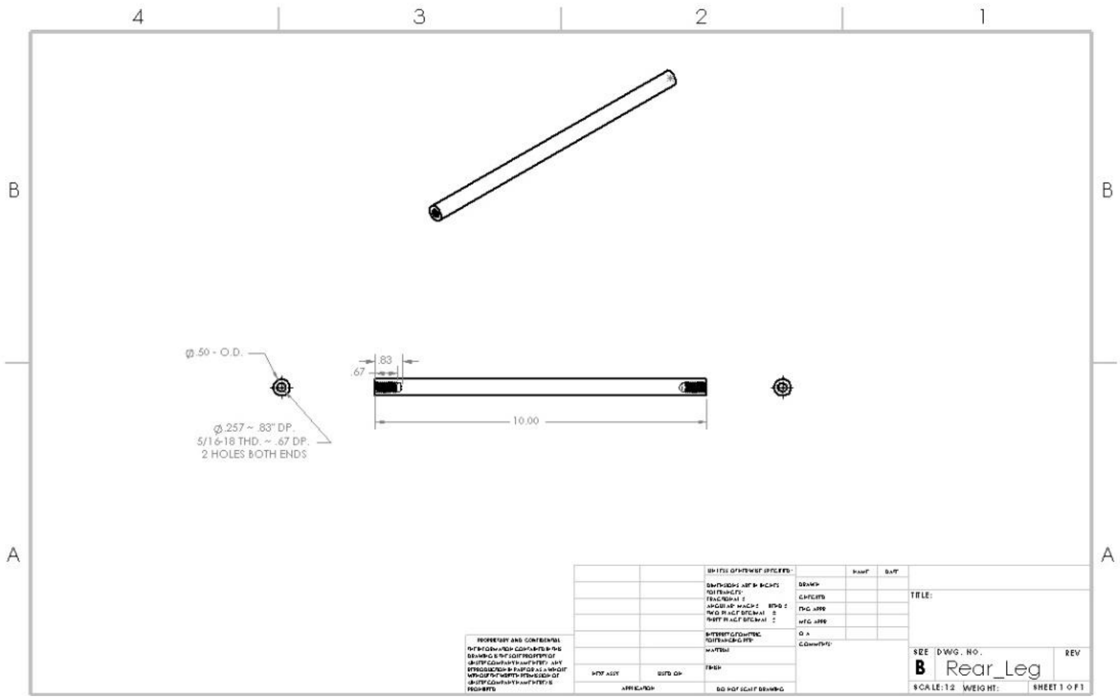

TRUE R0.06
1.00
4.00
2.50
5.00
84
TRUE R0.20
TRUE R0.06
4.00
1.00
2.50
36.00
35.00
25.13
22.88
Rack Side-Front 8 handle



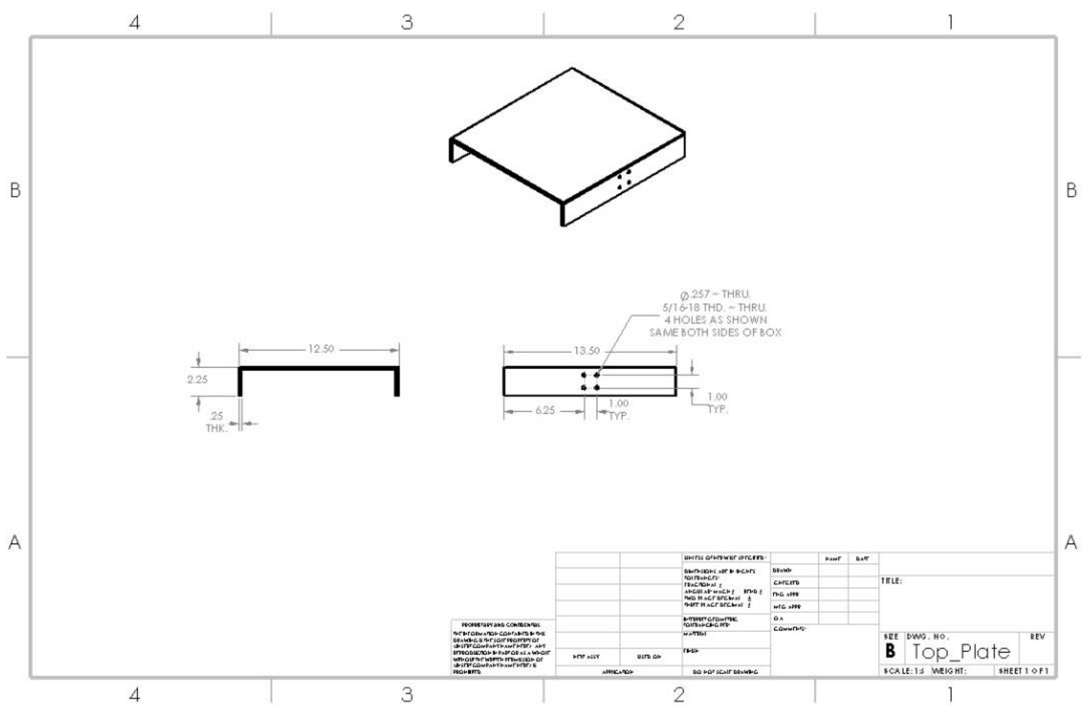
0.20
0.20
0.25
0.50
R0.50
17.00
0.25
Ø0.13
0.15
4.00
14.20
10.20
6.20
2.20
45°
5.00
0.50
1.00
2.50
TRUE R0.06
4.00
1.00
0.50
Sliding Rack Top Part8



3.75
1.25
3.10
1.10
5.00
2.11
5.25
Ø0.22
0.40
0.71
4.85



Ø.50 - O.D.
.83
.67
10.00
Ø.257 ~ .83" DP.
5/16-18 THD. ~ .67 DP.
2 HOLES BOTH ENDS
TITLE:
SIZE DWG. NO. REV
B Rear_Leg
SCALE:1:2 WEIGHT: SHEET 1 OF 1



Ø.257 ~ THRU.
5/16-18 THD. ~ THRU.
4 HOLES AS SHOWN
SAME BOTH SIDES OF BOX
12.50
2.25
.25
THK.
13.50
6.25
1.00
TYP.
1.00
TYP.
TITLE:
SIZE DWG. NO. REV
B Top_Plate
SCALE:1:5 WEIGHT: SHEET 1 OF 1