Model Block Press

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Abstract

The Center for Vocational Building Technology came to the Mechanical Engineering department at Cal Poly, San Luis Obispo with a project to create a new, less expensive model block press than their current BP9 design. This press would produce ¼ scale model compressed earth blocks to be sold as souvenirs and used in demonstrations for constructing buildings. After analyzing the design of the current block presses, JCM came up with the BP10 design. The BP10 operates similarly to the larger block presses, but will cost significantly less to produce and will have some of the design features enhanced to make it easier to use.

Chapter 1. Introduction

The CVBT (Center for Vocational Building Technologies) requests a new working scale model of their Compressed Earth Block Press which will create ¼ scale compressed earth blocks. The full size Compressed Earth Block Press uses a mixture of soil and cement to form compressed earth blocks that are used as building materials. The press is used mainly in rural Thailand, where many of the working villagers would have to migrate to larger cities to find work during seasons when they cannot grow food. The press is just one way that the CVBT has been able to keep those people employed and able to stay with their family during off seasons. In this project, the main stakeholder is the CVBT, and secondarily, people who buy model block presses for themselves.

A model block press that creates ⅓ scale blocks, called the BP9, already exists. It creates smaller compressed earth blocks, used primarily to build model houses or sell as souvenirs. An added bonus to the block press is that it can be used to demonstrate the process of making earth blocks.

However, this block press has problems. The cost to make a block press is currently 8500 Baht, or approximately 250 USD, which is too high. The second problem with the model block press is the efficiency. Through the different bearings, levers, and during block ejection, a lot of friction is produced, making it harder to use. Finally, it also has multiple weak points that need to be reinforced.

Multiple causes result in these problems. One is that the design of the BP9 is extremely similar to that of the actual block press. By keeping the design so similar, less consideration is made to how different loads affect the integrity of the press. This would lead to weak points in the components, making the press harder to use. The high price can be traced back to the materials and manufacturing process of the model block press. By using materials that are excessive in strength and designing parts that are more difficult to machine, a lot of money is wasted producing the block press.

Our goal is to come up with a new model compressed earth block press. This will be done through the use of 3D modeling, static and dynamic analysis of the working parts, machining

and putting together the model, and reiterating this process if something is wrong. While we have creative reign over this process, the model we will make should resemble and work similar to how the full sized block press works.

The new model block press will be completed before the end of the calendar year 2014. From there, the goal is to have a few of these produced to either keep as block-making tools or sell to the public. This new press will be a much more cost-effective way to produce ¼ scale compressed earth bricks that are well-suited to build model houses. The new model can also serve as a demonstration tool for the process of making compressed earth blocks.

Chapter 2. Background Information

The compressed earth method for building blocks has been applied in many different places, and there are multiple solutions available. A little bit of background research shows that people have been trying to find a cheap, efficient solution to this problem for some time. All of the block presses that we found, however, have very similar functionalities and forms. All of these block presses, with pictures, drawings, and detailed specifications can be found in Appendix A. The sources that provided this information can be found in the References section.

The CINVA-Ram block press was developed by Raul Ramirez at the Inter-American Housing Center, and is a good example of a standard solution for making compressed earth blocks. It is made completely out of steel, and compresses a slightly moistened mixture of soil and cement or soil and lime to make blocks. The CINVA-Ram is able to be transported to make blocks anywhere. It takes about 2500 blocks from the CINVA-Ram to build a two-room house. Some benefits to the CINVA-Ram is that the curing process for its blocks does not include baking, and it is relatively cheap (175 USD, or about 5800 Baht). More specifications are listed in Appendix A1.

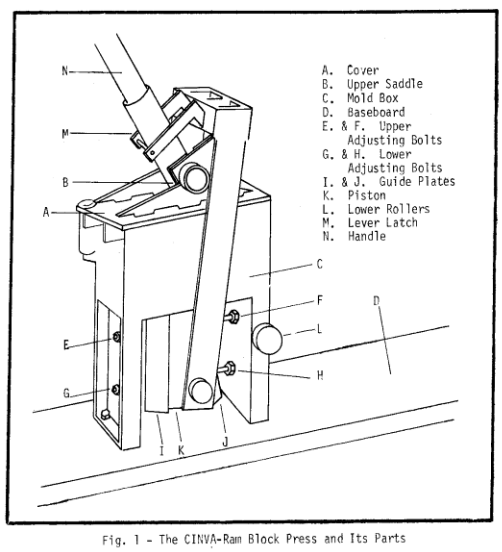


Figure 2-1. The CINVA-Ram Block Press

In 1970, the TEK-Block press was developed by the Department of Housing and Planning Research, Faculty of Architecture at the University of Science and Technology in Kumasi, Ghana. The goal of this development was to modify the CINVA-Ram to suit local requirements. The end result is a little bit cheaper than the CINVA-Ram (173 USD, or about 5700 Baht) and there are a few differences to the design. First of all, the lever arm is a wooden handle that is placed into a hole for leverage. The reason for this is that it makes the press cheaper, and if there is too much force being exerted on the machine the lever will be the first thing to break. This makes for a much less expensive repair, because the press itself does not break. Another difference to the CINVA-Ram is that the lever is connected to the mould cover, so when the lever comes away from the press so does the cover. The TEK-Block press is also a stand-alone press; it does not need to be bolted to the ground for support (*TEK- Block Press, Appendix A*).

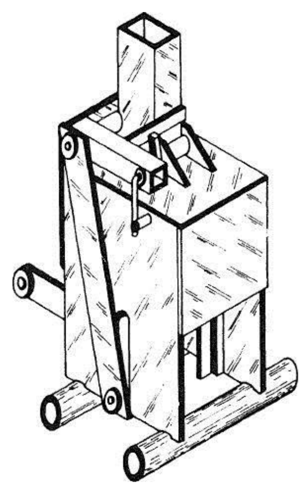


Figure 2-2. The TEK-Block Press

Another block press that pertains to this project is the Fernco MP-612. The MP-612 is portable and produces blocks that are 6 x 12 x 3.5 inches. It has two six-foot rails that extend out as feet to help keep the machine from tipping over during operation. The rails, as well as the six-foot handle, can be detached for easy transport or storage. It also has an optional wheel kit that makes it easier to move around the job site. The MP-612 costs 2,015 USD (about 66,500 Baht), so it is relatively expensive (*Fernco Metal Products, Appendix A*).

Figure 2-3. The Fernco MP-612 Block Press

The block press that most directly pertains to this project is the BP9 Mini Block Press. This press is currently used by the CVBT, and the project is specifically aimed at replacing this press with a cheaper, more efficient and easy to use machine. The BP9 makes blocks at ⅓ scale of the full size BP6 press, or 10 x 5 x 3.33 cm, using regular compressed earth block mix. It can make full and half blocks, and these can be stacked up to make a model home. The BP9 costs 8500 Baht, or about 258 USD.

Figure 2-4. The BP9 Mini Block Press

More information and research on existing block presses can be found in Appendix A.

In December 2012, a Cal Poly student named Nicholas Herskedal completed a thesis on the strength of compressed earth block walls. In this document there is a section on materials needed to make compressed earth blocks, and he goes into detail about the process and the testing of the blocks. The materials he used for compressed earth blocks are soil, sand, and cement (*Herskedal, Appendix 3*).

Since our project is for a small-scale model press, there are no existing codes or standards that need to be met. There were no products or patents out there for a miniature block press, aside from the one used at the CVBT.

Using the BP9

In order to familiarize ourselves with the block creating process and the forces needed to do so, the team spent a few days using the BP9. One challenge while using the BP9 is that the one on Cal Poly Campus is missing the bottom plate. This bottom plate creates the female dowels in a block and also helps completely eject the block. Without the plate, the bottom of the blocks are not smooth and easily chip away. When pulling the block out, the bottom part sits inside the compression chamber because it doesn't have the extra height of the bottom plate to eject it all the way out. Regardless of this missing piece, creating blocks was still a valuable experience to learning how the press worked.

Figure 2-5. Michael sifting soil to create a good mixture

Figure 2-6. Connor mixing the charge

Figure 2- 7. Some blocks created during this process

After creating a few blocks, we decided to analyze how much force was required to compress the mixture and then how much force was required to eject the block from the housing. A handheld force-meter was acquired and attached at the handle of the BP9. Data was collected for two trials. The results can be found in table 2-1. These likely aren't the most accurate of data, but they give us a general sense of what is needed to create blocks.

Table 2-1. Forces required for block making

Trial	Compression Force (lbf)	Ejection Force (lbf)
1	9.5	25
2	9.2	28
Rounded Estimate	10	30

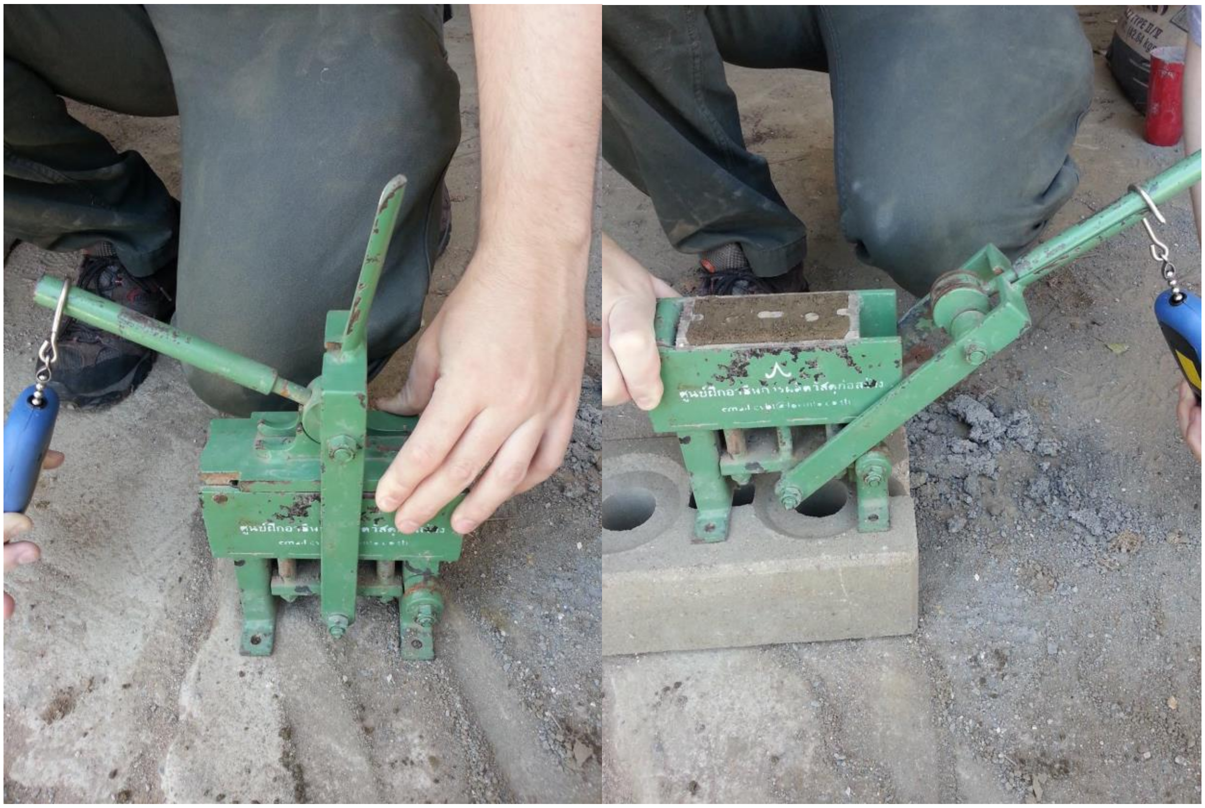


Figure 2-7. Finding the force for compressing and ejecting a block

Objectives

The primary goal for this project is to have a working model block press by October, 2014. This block press will meet all of the customer requirements that are detailed in this section in the formal engineering specification table.

We started our formal design process by putting together a QFD, or House of Quality. This table which is attached in Appendix B relates the main customers of this project, their requirements, the specifications of a solution, the competing solutions, and our solution. Requirements are listed on the left and weighted by importance for each of the customers. Then, in the middle the specifications are rated by relevance to these requirements, and on the right the competing products are rated by how they meet these requirements. On the bottom, targets values are listed for the specifications, and our solution and the competing solutions are rated again on how they meet those target values. Also on the top of the chart, the specifications are compared to each other to identify relationships and redundancies. From this chart, we were able to determine which specifications would be most important for us to focus on.

To meet these requirements, a list of engineering specifications has been made that allows us to fully test the design of our product. These requirements are organized on Table 2-2 found on the following page. Under risk, ‘H’, ‘M’, and ‘L’ indicate high, medium, and low risk of achieving that requirement. Those assigned with higher risk will be harder to attain. The compliance section is a quick way of identifying what criteria will be used to see if the specification is met. ‘A’ is for analysis, ‘T’ test, and ‘I’ is inspection.

Table 2-2. Formal Engineering Specifications

Spec. #	Parameter Description	Requirement or Target	Tolerance	Risk	Compliance
1	Price	1500 baht	Max	H	A
2	Target block density measured with a penetrometer	5 ksc	0.5 ksc	M	A, T
3	Time to Produce a Block	30 blocks an hour	5 blocks	M	T
4	Press Length	10 cm	-2 cm + 4 cm	L	I
5	Press Width	6 cm	-2 cm + 4 cm	L	I
6	Press Height	15 cm	±5 cm	L	I
7	Maximum Force Applied to the Handle	1.05 kN*	±0.05 kN	M	A, T
8	Block Length	7.5 cm	±0.05 cm	L	I
9	Block Width	3.75 cm	±0.05 cm	L	I
10	Block Height	2.5 cm	±0.05 cm	L	I
11	Force required to push over (applied at top)	11 N**	+2 N	L	A, T
12	Ability to remain upright during use	Yes	N/A	M	A, T

* Weight based on the mass of an average human (70 kg according to Hyper Textbook http://hypertextbook.com/facts/2003/AlexSchlessingerman.shtml) and using a safety factor of 1.5.

** Force based on 1/10th of max force exerted by an average human during work with just arms (Canadian Center for Occupational Health and Safety http://www.ccohs.ca/oshanswers/ergonomics/push1.html)

Chapter 3. Design Development

Concept Creation

To begin our ideation process, we came up with a list of functions that the press must be able to perform and maximize in order to be a good design. The three functions that we believe are at the core of the new model block press are: compression of the charge, ejection of the block, and reduced friction between parts and the block.

By having these main functions as the focus for our ideation, we began to develop solutions to them. This was done over the span of about two weeks as we set out to find the idea that would best meet those criteria. Once we had a significant number of ideas, we created three Pugh matrices. A Pugh matrix is a way of comparing ideas to see which are the best, while at the same time providing feedback to see what can be improved in some ideas. The ideas are matched up against more specific criteria for the press and are assigned either a '+' if the design meets the criteria better than the existing model, a '-' if the design meets the criteria worse than the existing model, or an 'S' if the design meets the criteria similarly to the existing model. The Pugh Matrices that were produced are listed on the next page.

There were multiple ideas that we included in the Pugh matrices. The cookie cutter idea would be a way to compress blocks by have a hinge that held a sheet of metal with the design for the bock. The sheet would come down onto the block mixture and compress it into blocks. Multiple blocks could be done at once. The Lobster Shell opener would be a hand held compressed earth block press. The blocks would be compressed in a device similar to a shell opener. The Stamp design would be manufactured so that mixture could be put into a housing that looks similar to a stamp. Then to compress it the operator would push it against a surface.

Table 3-1. Concepts for Compressing the Charge

Customer Requirements	BP9	Power Screw	Gear & Rack	Cookie Cutter	Lobster Shell Opener	The Stamp
Low Cost	Datum	-	-	+	+	-
Compact	Datum	+	S	-	-	+
Builds Blocks	Datum	S	S	+	S	S
Easy to use	Datum	+	+	+	+	-
Similar to Actual Press	Datum	-	-	-	-	-
Makes Different Block Shapes	Datum	S	S	S	S	S
Quickly Makes Blocks	Datum	-	-	+	S	-
Stand Alone	Datum	+	+	+	+	+
Durable	Datum	-	-	+	+	S
Σ+	0	3	2	6	4	2
Σ–	0	4	4	2	2	4
Σ+/–	0	-1	-2	4	2	-2

Table 3-2. Concepts for Ejecting the Block

Customer Requirements	BP9	Removable bottom	Sliding shell	Four hinged walls	Sliding door and press
Low Cost	Datum	+	+	S	+
Compact	Datum	–	+	–	S
Easy to use	Datum	–	–	+	+
Similar to actual press	Datum	–	–	–	S
Varied block shapes	Datum	S	S	S	S
Stand alone	Datum	S	+	+	S
Durable	Datum	+	+	–	+
Σ+	0	2	4	2	3
Σ–	0	3	2	3	0
Σ+/–	0	–1	+2	–1	+3

Table 3-3. Concepts to Reduce Friction

Customer Requirements	BP9	Double-Shell	Lowered Peg	Non-Rotating Peg (Frictionless)	Lubrication
Low Cost	Datum	S	S	+	-
Compact	Datum	+	S	+	S
Easy to use	Datum	S	+	+	-
Similar to Actual Press	Datum	+	+	-	S
Quickly Makes Blocks	Datum	-	S	S	+
Durable	Datum	-	S	S	S
Σ+	0	2	2	3	1
Σ–	0	2	0	1	2
Σ+/–	0	2	4	2	3

Once we had these matrices, the next step was to see which items could be eliminated and which could be modified. We eliminated the “removable bottom” ejection concept because it had big problems with friction, which it couldn’t be modified without making it too complicated or making it similar to another concept. The “sliding shell” concept was eliminated for the same reason. The “four hinged walls” and “sliding door and press” concepts were both modified.

Most of the compression concepts were eliminated. The “gear and rack” and “power screw” concepts were too complex and expensive, the “cookie cutter” would be too big, the “lobster shell opener” would be too different from the original, and the “stamp” would be difficult to add an ejection mechanism to. The original BP9 compression method is used for two of the final concepts, and a new design was created for the third final concept.

The first idea that we considered is the “BP10.” This will be just a scaled version of the BP9, which is the current model block press that is being used. There will be minor tweaks to try and make it more efficient and easier to use, such as lowering the fulcrum pin used to generate torque to eject the block. The lower it is, the more easily a person can apply a perpendicular force downward. It would also be revamped to use cheaper materials and less machining time in order to make it cost less than the BP9 counterpart. With enough small tweaks, it could theoretically meet all of our specifications.

The second model that we are considering is what we call the “Double-Shell” concept. As shown in the following sketches, the charge is loaded into an interior compartment with four hinged walls, and that interior compartment rests inside an exterior shell. After the block is compressed, the interior part is ejected, and the hinged walls are pulled away to reveal the block. This eliminates the problem of friction between the completed block and walls during the ejection process while still maintaining the original shape and look of the original press. A quick 3D model of it can be seen in Figure 3-1 and 3-2.

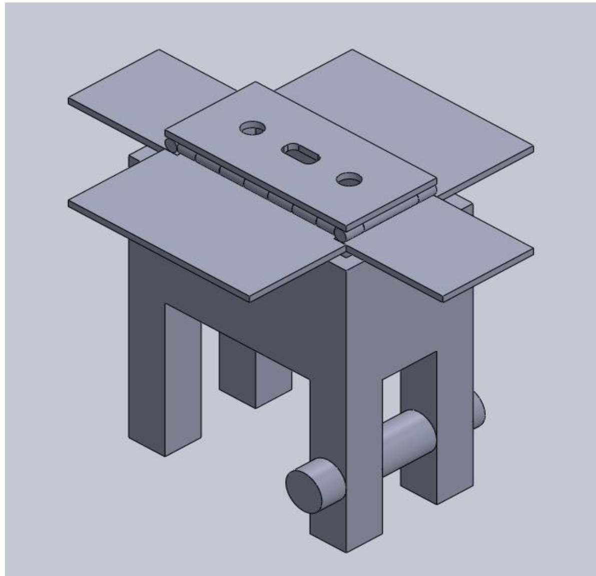


Figure 3-1. The Double-Shell fully ejected

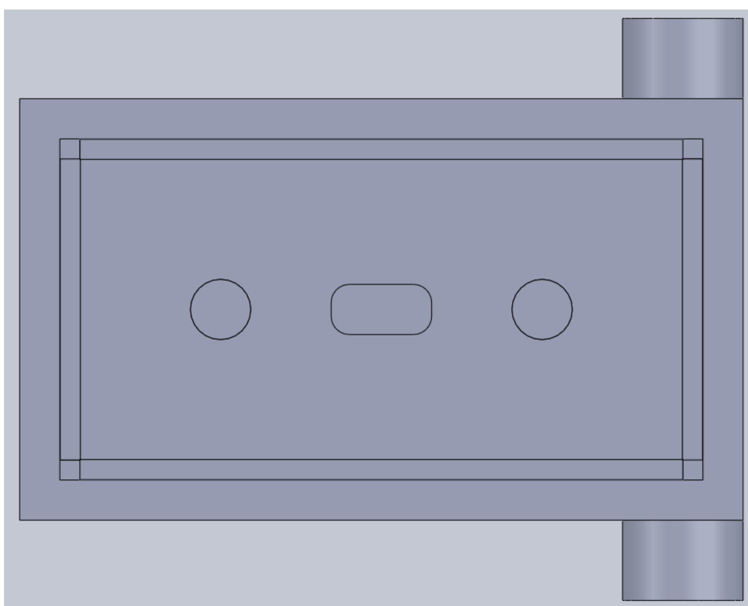


Figure 3-2. A top down view of the Double-shell when inside the main case

The final design that we came up with is the “Swivel”, shown in Figure 3-3. The Swivel is the most unique design. The design can rotate between two modes; one for loading material, and one for compressing and ejecting the block. In the loading mode, the sliding door is opened, and charge is loaded into the box. Then, it is rotated 180° into compression mode. The lid on top has a lever and is connected to the interior ram by a 4-bar mechanism. The lever is pulled down to a certain marked point to compress the block, and then the sliding door is opened and the lever is pulled down all the way to eject the block. We believe that this design is less complex than the BP9 and has the potential to be inexpensive to produce, and the simple lever arm motion will make block ejection easier for the user. An example of the swivel can be seen in Figure 3-3 on the next page. A full set of pictures of the Swivel design are shown in Appendix D, demonstrating the full process of creating a block with the device.

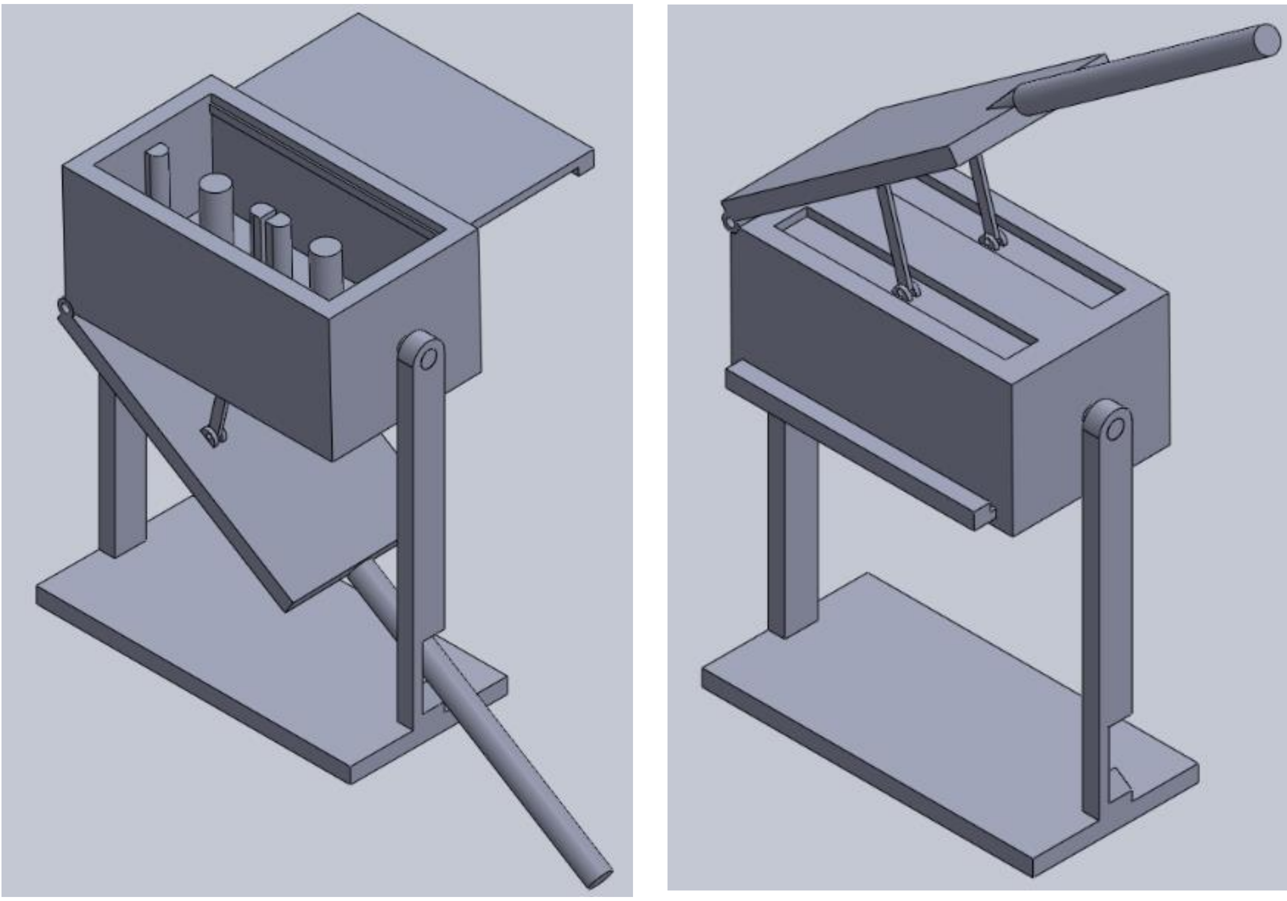


Figure 3-3. The Swivel design in loading mode (left) and compression mode (right)

With these three main concepts, our next objective was to create a decision matrix in order to see which design succeed the most at satisfying our different requirements. For the criteria, we used a mix of engineering specifications we have listed in Table 2-2 of the Objectives section and other customer requirements in order to best encapsulate everything the model should do. The top portion of the matrix reflects those criteria while the left side lists our models. Each of the criteria were given a weighting factor that all summed to 1. The concepts were then graded for each criteria on a scale of 1-10. The product of that grading and the weighting for each criteria was then summed at the end. The concept with the highest value was the one that most adequately meets all of our requirements and should be the focus for the project. This decision matrix can be found in Appendix B.

The results of this decision matrix were very close. The design with the highest score was the Swivel at 6.95, followed closely by the BP10 at 6.725 and the Shell at 6.425. While the Swivel scored the highest, we still had one more consideration to take into account. This consideration was time and ability required to fix any malfunctions on the designs we created if they come up. The BP10 is very similar to the existing model, and therefore if a problem would occur, there would likely be an available solution. Because the Swivel and Shell are so radically different, a problem could take weeks to solve. Since all of them scored so similarly, we decided to pursue the BP10 as our final design choice, as it is nearly tied with the other designs in terms of the decision matrix, and the design will be easier to fix if any major problems arise in testing.

Chapter 4. Description of the Final Design

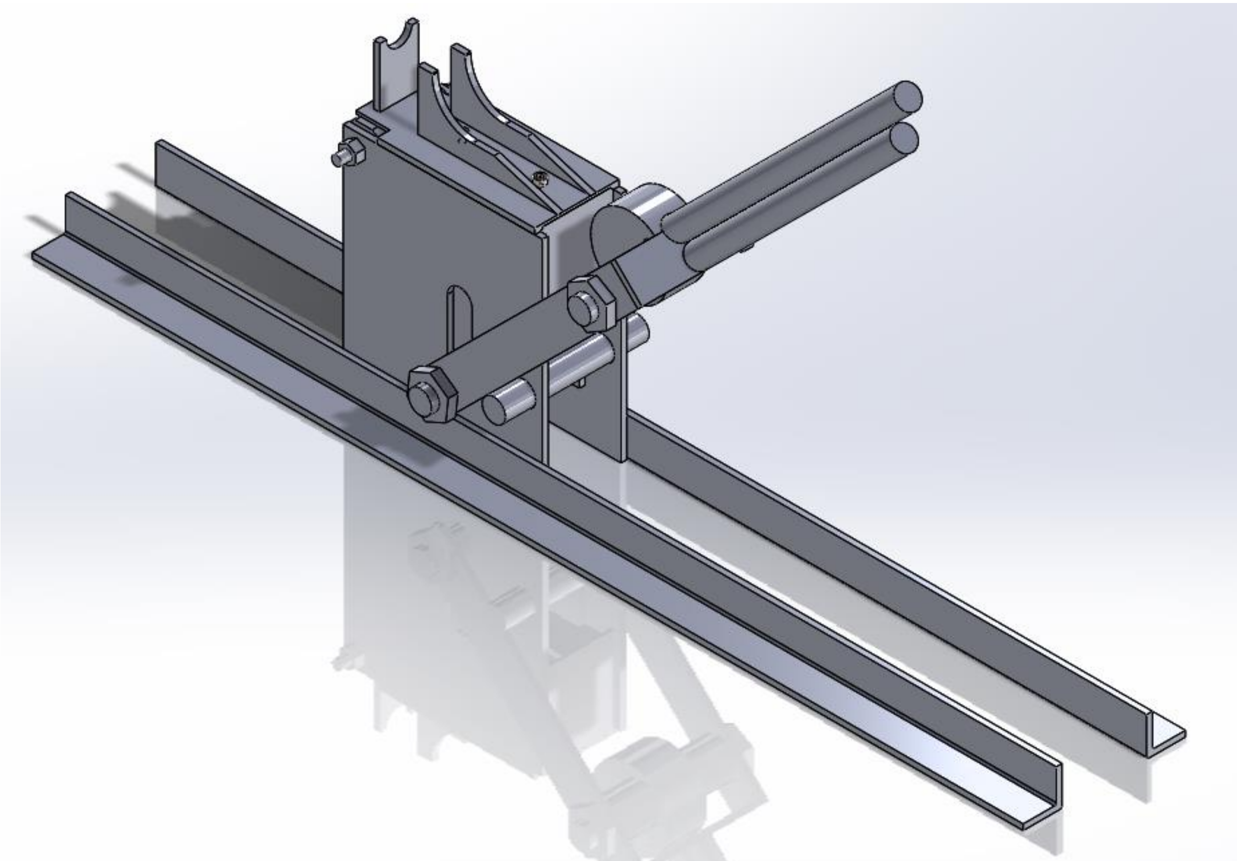


Figure 4-1. Isometric view of the final BP10 design

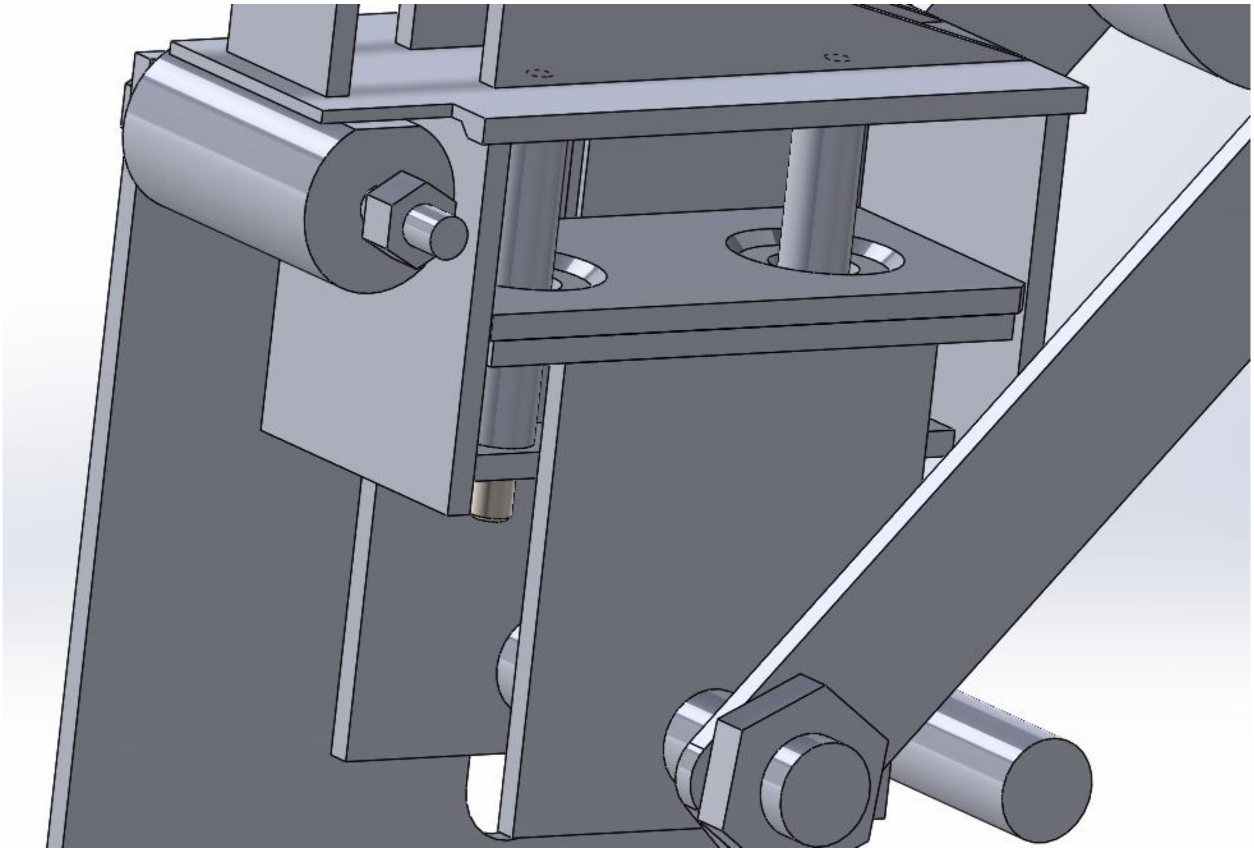


Figure 4-2. View of the Inside of the BP10.

Overview of the Design

The final design that we decided to develop was the BP10. This design is a scaled model of the BP9 with some choice differences.

The first difference between the BP10 and the BP9 is the placement of the pivot point for ejection. We have chosen to lower it from its original position in the BP9. This is to help create a better moment arm for the user when they are ejecting the block.

Another difference made is the sides of the housing. In the BP9 design, there is the charge housing and then additional parts to create the legs for the press. In our design, we have decided to make this all out of a 4-walled box. The side of the charge housing extends all the way to the ground, and contains a slot for the ram-lever fastener to extend into. We feel that this will require less machining than the previous version and make the assembly easier to conduct.

One of the biggest changes we made was the addition of feet to the press. One of our design considerations was to create a block press that would be able to stand on its own during operation. The BP9 currently has to be bolted down to a surface in order to be used, which limits where a person can create blocks. The feet that we have added extend the area that the press sits on. The intended goal is that the feet will create a counter-moment to prevent tipping caused by the compression or ejection stroke.

As we prepared to prototype the design, a few more changes were made. A small plate was added to the lid that catches the compression handle at the bottom of its stroke, keeping it from being pulled too far. The bolts holding the shaped dowels on the lid were flipped back around to have the heads on top, with the dowels threaded. This was to prevent the bolt heads sticking out of the bottom of the lid from damaging the block as the lid was opened after compression. Also, the L-bracket "feet" were changed to be a store-bought component instead of bent from stock plate metal. Finally, the plate thickness throughout the whole press was standardized to 3 mm, as opposed to a mix of 3, 5, and 7 mm.

Detailed Analysis

The easiest way for the BP10 to fail is when its parts experience excessive shear stress or bending stresses, which are only induced during operation. Our main objective when considering the stress on the machine was to make sure that they all had sufficient strength to withstand our maximum design load, which is 1.05 kN (found in Table 4-1). If the machine is strong enough to endure more than the full weight of an average human, then it will be ready for use.

The primary areas of concern were the eccentric fastener, the ram-lever fastener, the rotation peg, and the ram sides. All the analysis done can be found in Appendix E. For these analyses we used the design load of 1.05 kN to determine the size of fasteners or if the component could stand up to the stress. The only problem we encountered was the eccentric fastener. Under the load of 1.05 kN, the fastener would fail unless it had an absurdly large diameter. So instead, we continued analysis to see if it could withstand the load that is needed to compress a block in the BP9. When we did that, the fastener was able to stand up against that load very well. This means that during compression, we will need to warn the user that excessive weight can break the fastener.

Another part of the analysis was to see at what point the device would tip over during operation. As seen in the drawings, we had to provide it with stabilizing feet. To calculate the length of those legs, we did a static analysis of the machine during ejection and compression. Since more force is applied to the lever during ejection, this is when the machine is most likely to tip over. The length of the feet was calculated so that they would be long enough to prevent this from happening.

The calculations for these detailed analysis can be found in Appendix E.

Calculation	Safety Factor	Value Used
Force applied to handle	1.5	1.05 kN

Table 4-1. Safety Factor Table.

Cost Analysis

To begin analyzing the cost of producing a BP10 press, we created a list of parts; some for manufacture, and some to be bought from vendors. A full list of these parts can be found in Appendix C, and material pricing can be found in Appendix D. Many of the parts are made of 0.5 cm thick plate metal, some are made of varying diameters of cylindrical stock, and several are off-the-shelf parts. The following tables show the cost analysis for the parts for a US-based prototype, both manufactured and off the shelf.

Table 4-2. Cost analysis of materials for a single prototype press

Desired Material	Amount	Vendor	Available Material	Price
0.3 cm HR steel plate	523.675 cm^2	OnlineMetals	12''x24'' 0.125'' HR steel plate	$31.06
1.2 cm diameter steel pipe	32 cm	OnlineMetals	24'' 0.5'' diameter HR pipe	$2.78
0.8 cm diameter steel tube	10.85 cm	OnlineMetals	10''-12'' 0.3125 OD x 0.049'' wall Stainless tube	$4.18
2 cm diameter steel barstock	5.23 cm	OnlineMetals	10''-12'' 0.875'' diameter HR pipe	$3.77
4 cm diameter steel barstock	2 cm	OnlineMetals	10''-12'' 1.75'' diameter HR barstock	$15.54
2 cm x 2 cm x 0.3 cm steel angle	102 cm	OnlineMetals	48'' 0.75'' x 0.75'' x 0.125'' HR steel angle	$4.80
			Total	$62.13

Table 4-3. Cost analysis of off-the-shelf parts (from BoltDepot)

Part	Quantity	Part #	Price per unit
M12-1.75 x 80mm Hex Bolt	2	5855	\$2.26
M5-0.8 x 50mm Socket Cap Screw	2	15013	\$2.57
M5-0.8 x 50mm Hex Bolt	1	6208	\$0.28
M5-0.8 x 20mm Socket Cap Screw	2	9513	\$2.29
M12-1.75 Hex Nut	2	4780	\$0.32
M5-0.8 Hex Nut	3	4775	\$0.05
M12 Washer	6	4520	\$0.19
M5 Washer	3	4515	\$0.05
3/16’’ x 1-1/2’’ Cotter Pin	1	14586	\$0.37
		Total	\$16.97

As seen in the preceding tables, the cost of materials for a prototype press adds up to \$59.17. The cost is high due to the inefficiency of buying materials for such a small application. For example, only 2 cm of 4 cm diameter cylindrical stock is needed for a single press, but the smallest length that can be bought is 10-12 cm.

The next set of tables show the price analysis for a full manufacturing run. For these calculations, it is assumed that 5 presses will be produced. The table uses a cost estimate from MRT Steel, a Thailand-based steel company, for the price of the steel plating. However, MRT does not supply prices for their cylinder stock, so estimates from OnlineMetals.com are currently being used.

Table 4-4. Cost analysis of materials for 5 presses

Desired Material	Amount	Vendor	Available Material	Price
0.3 cm HR steel plate	2618.375 cm^2	MRT Steel	0.3 cm 3' x 6' HR steel plate	$40.00
1.2 cm diameter steel barstock	160 cm	OnlineMetals	8' 0.5'' diameter HR barstock	$8.12
0.8 cm diameter steel tube	54.25 cm	OnlineMetals	24’’ 0.3125 OD x 0.049’’ wall Stainless tube	$8.93
2 cm diameter steel barstock	26.15 cm	OnlineMetals	1' 0.875'' diameter HR barstock	$4.19
4 cm diameter steel barstock	10 cm	OnlineMetals	10''-12'' 1.75'' diameter HR barstock	$15.54
2 cm x 2 cm x 0.3 cm steel angle	510 cm	OnlineMetals	18 ft 0.75’’ x 0.75’’ x 0.125’’ HR steel angle	$19.90
Total				$96.68

Using the total material cost for 5 presses along with 5 times the cost of off-the-shelf parts from Bolt Depot, the total part cost for 5 presses adds up to $181.53, or $36.31 per press.

Using the software “DFM Concurrent Costing” and “DFA Product Simplification” available in Cal Poly’s IME department computer lab, we estimated a cost of production for a press. We first used the DFM software to create individual cost analysis files for each machined part. The software generated a material cost based on the basic dimensions of the part, and the time spent on various machining and handling processes. Then, these files were combined using the DFA software, while also adding in store-bought hardware parts and the program’s estimated cost of all the welds and other various handling needed to assemble the press. After the analysis was complete, the program generated the following prices.

Table 4-5. Production costs estimated by DFA Product Simplification

Item Cost (Includes the total prices of all the machined parts, including their machining processes, and the store-bought parts)	$111.60
Process Cost (Includes welding processes, and handling and basic assembly)	$11.37
Total Cost	$122.97

The generated cost is much higher than previously anticipated, and it is not certain that this is an accurate estimate of production costs in Thailand. The software was also set to use a production run size of only 5 presses, which may have elevated the cost significantly.

Material Choices

The BP10 is comprised exclusively of low-carbon steel. The steel will comprise everything except for the screws and nuts. The reason for choosing low-carbon steel is because it is fairly inexpensive and easily accessible in Thailand, but still has high enough strength for this application, as seen in the stress analysis in Appendix F.

Safety Considerations

In order to make the machine safe for use, many of the corners in the metal have been rounded to prevent lacerations from handling the BP10.

Most of the BP10 parts are designed to withstand a load caused by 1.05 kN applied to the lever, although it is not advised to apply this much force. The one part that does not meet this design criteria is the eccentric bolt, but this part still has a high safety factor compared to how much force is needed to operate the press.

Chapter 5. Product Realization

Manufacturing

With our final design finished and parts in our possession, we began the task of manufacturing a BP10. For the prototype we decided to machine all of the custom parts ourselves and have other people handle the welding. A summary table of how parts were machined are listed in Table 5-1.

The first thing we did was cut out most of the parts out of the sheet of steel that we had. A plasma cutter was used to do the cutting. The plasma cutter we used had options for automatic jogging, or cutting in a straight line along the given direction. This allowed us to cut in reasonably straight lines, which was beneficial as most of the parts are rectangular in shape. The one object that would require a lot of working was the eccentric receiver, as it has a curved edge that needs to be very close to tolerance. To machine that part we first cut it out in a triangle and then worked in the curve using a hand held grinder.

With most of the rough cuts done, we then worked on making the edges within tolerance and smooth. A grinding wheel was used to get rid of the melted steel and then all of the edges were milled to the given dimension.

Figure 5-1. Milling One of the Pieces

With the pieces milled to the correct dimension, a drill press bored the multitude of holes needed in each of the pieces. To get the slot in the side walls, we used a drill press to bore a hole and the top and bottom of the slot. Then we took the mill and milled out the material in between those holes.

For the circular and shaft pieces, we cut off sections of bar stock to the near length that they needed to be. Then those pieces were put on the lathe for be faced and turned to the correct dimension. The eccentric toggle then placed on the drill press so that we could place all of the holes in it.

Figure 5-2. Most of the Pieces for the Press Laid Out after Machining

Once all of the parts were machined, we went to Kevin Williams and Brett Johnson for welding. Most of the welds were done with TIG, while MIG welding was used to secure the legs to the main housing. During welding, the parts were secured in fixtures to maintain correct angles.

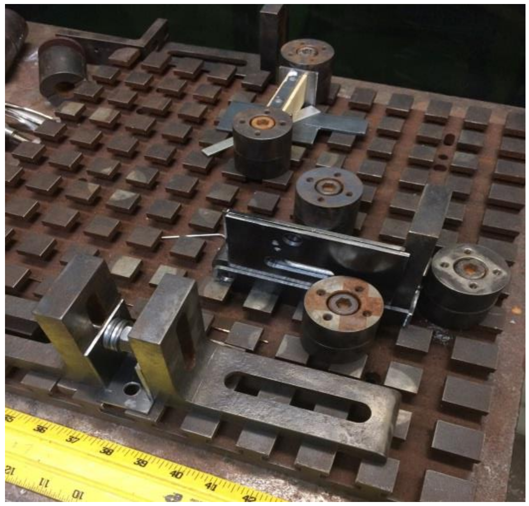


Figure 5-3. Parts in Fixtures to be Welded

After all of the parts were welded correctly, the prototype was assembled. The assembly is quick and easy. Bolts are placed through their given holes, with washers and nuts to keep them in place. The primary handle is secured in the eccentric toggle with a cotter pin.

Figure 5-4. Assembling the BP10 and the Finish Prototype

Table 5-1

Part	Manufacturing Processes
All main housing pieces	Plasma cutting, milling, grinder
Rectangular lever pieces	Plasma cutting, milling, grinder
Eccentric	Band saw, lathe, center drill
Eccentric receiver	Plasma cutting, milling, hand grinder
Male Dowels	Band saw, lathe, center drill, tap, hand grinder
Various cylindrical parts	Band saw, milling
Support legs	Band saw

Difference between the Prototype and Final Product

There are few differences between the prototype and the final product. While the team was making the BP10, the machines we were working with were all based in the English system of measurement. Because of this, we used drill bits and bolts that most closely matched the metric measurements. This did not result in an issue with the dimensions, and the prototype still reflects what is on the drawings.

Recommendations for Future Manufacturing

In order to make manufacturing go more smooth, there a few things that could be done before hand. One of the most complicated parts to machine is the toggle rest. In order to get the correct dimensions for it, a lot of time has to be spent hand grinding the metal. We can improve the speed of this step by using a guided plasma cutter. During our manufacturing, the available plasma cutter had the option to trace along lines in order to cut a desired shape. However, it was not working when we went to use it. We believe it would be a very useful machine to have during manufacturing, especially when doing a production run of multiple BP10's.

Another way to make manufacturing more efficient would be to create welding fixtures that place the parts in the proper angles. During prototyping, we did not create a fixture for the parts, but did use many clamps to get the parts into place. Making multiple BP10's would benefit from having dedicated fixtures to allow the welding to go much more quickly.

Chapter 6. Design Verification Plan

With the BP10, there are three major things that were tested for. These are the price to produce one, the quality of the blocks created, and how well it handles different stresses. For a summary of the results, the full design verification plan can be found in Appendix H.

The cost to produce one of the BP10's was calculated by using determining how much the materials cost and then finding out how much the different machining and welding processes would cost. We found our materials cost about 80 USD. However, this is for making one press. It is higher than what we wanted it to be, but if this were a production run of multiple BP10's the material cost would decrease because we bought a lot of excess material for the prototype. The total cost estimated by the DFA software including its own estimate of material cost for a run of 5 presses was approximately $120. This is also higher than we anticipated, but it's hard to tell if the software's estimate is accurate for such a small scale production.

Testing the quality of the blocks required us to finish the prototype and come up with a mixture that we found suitable for the blocks. We settled on a mixture that was comprised of 90% soil and 10% cement. We found that this created solid blocks that cured well. With the mixture decided upon, we began making blocks. During testing, we produced 100 blocks to see if the blocks themselves were of usable quality and if the machine would operate reliably. The BP10 worked fine during the production run. It needed to be cleaned out a few times with water. After rinsing it with water, a few parts slightly rusted. This could be prevented if we had painted the parts with a protective coat. Our solution to the rust was just to use an oil lubricant to make the parts slide easily once again. Once lubricated, it operated fine and was able to make the blocks.

The blocks themselves met our specifications, but had one defect. The blocks made had a slight angle that caused one end of the block to be slightly above the other side. Upon further inspection of the press, we determined that this was a defect formed due to our manufacturing job. Because of the position of the slot in the main walls relative to the chamber, the compression ram sits just slightly crooked. If a more experienced machinist had made the prototype, we are confident that this defect wouldn't be present.

Originally we had planned to conduct fatigue testing on the machine. However, we lacked the proper set up to test the BP10 in this way. In order to do this, the team would have had to

create a fixture to attach to an actuator and then let it run multiple cycles for both the compression and ejection motions. Instead of performing this test, we decided that making 100 blocks would give us sufficient information if the BP10 could handle the normal stresses of use. As mentioned previously, the only trouble came with rust and dirt causing friction between the parts, which can be remedied with regular cleaning and application of a lubricant like WD-40. Aside from that, the BP10 was able to withstand the normal forces that it would experience. We decided against seeing what the maximum force it could withstand, as the destructive testing would mean we would need to make multiple prototypes. With the factor of safety that we included in our design calculations, we are confident that it will not break unless put under extreme loading conditions, which would be a force that is more than the weight of an average person.

Chapter 7. Project Management Plan

For this project, Just Clever Mechanics had three undergraduate mechanical engineers working on coming up with a solution to the CVBT's problem. Table 6-1 gives an overview on who they are.

Table 7-1: List of students working on this project, along with relevant experience and role in the group

Name	Experience	Role
Jordan Brown	SolidWorks, static and dynamic design analysis, Matlab, material analysis	Document and meeting organizer
Connor Morrow	SolidWorks, static and dynamic design analysis, material analysis, Matlab	Fiscal overseer
Michael Evans	SolidWorks, technical writing, static and dynamic design analysis, Matlab	Communication Lead

We also came up with a Gantt chart for this project, in order to set expectations and deadlines for specific milestones. This Gantt chart can be found in Appendix F.

Chapter 8. Conclusions and Recommendations

This project progressed very well. As a team we are pleased with how our final product turned out. There were a few hiccups and difficult goals to accomplish, but overall they were handled well. We believe we have met all of the expectations of the project to some degree.

Making a block press that produced scale models was the easiest expectation to meet, as it meant just reducing the size of any chamber to match the design lengths for the correct size blocks.

The second easiest obstacle to overcome was solving the problem of the machine tipping over. Many ideas were thought of on how to solve this, but when we needed to implement a final decision, the addition of feet was the simplest idea. It adds little to the cost of materials. The only downside to the feet is that it makes the machine much longer. This could possibly interfere with storage and makes it so that the BP10 can only be used in a space that allows for the entire length of the feet. However, this is preferable to having to find an area to bolt it down, like the BP9 needs.

One goal we had difficulty with was the cost to produce the machine. Originally we wanted to make it cost around 45 dollars. We planned on doing that by ordering materials in bulk and cutting down on machining processes. While that was still the goal, after ordering our initial parts, we realized that making it $45 was going to be impossible. The parts alone cost around $30, so that would mean that the machining would have to be less than $10 to produce. That is an impossible goal. However, if all of the machining is done by the CVBT, then that cost can certainly go down. Based off our estimates, however, the machining will cost around $100.

This informs the most difficult aspect of this project: the machining. No one on the team was adept at machining, but all had some experience. Because we did have some knowledge of machining processes, we decided to tackle it ourselves, and have someone else do the welding for us. However, machining proved to be much more difficult than expected, and delayed us by several weeks. Working with mild carbon steel was much more difficult than working with aluminum, which is what we had experience in. However, we were able to finish all of the machining, albeit with tolerances that were a little off. We still believe that the way we designed the product will be easy for an experienced machinist to pull off, but for us it was a challenge.

Appendices

Appendix A: Background Research

This appendix contains a majority of the background research that was done before initial concepts were created for this project. Most of the information revolves around the different types of compressed earth block presses. Some of them heavily influenced our design choices.

A1. CINVA-Ram Block Press

Developed by Raul Ramirez at the Inter-American Housing Center, the CINVA-Ram block press is made entirely out of steel and is transportable. It compresses a mixture of slightly moistened soil and cement or lime, like a typical compressed earth block press would.

It has the following specs:

- 140 lbs (63 kilos)
- 10inx16inx26in
- application force of lever: 80 lbs (36 kilos)
- 300-500 tiles per day by 2 people
- about 150 blocks per 100 lbs of cement
- costs 175 USD

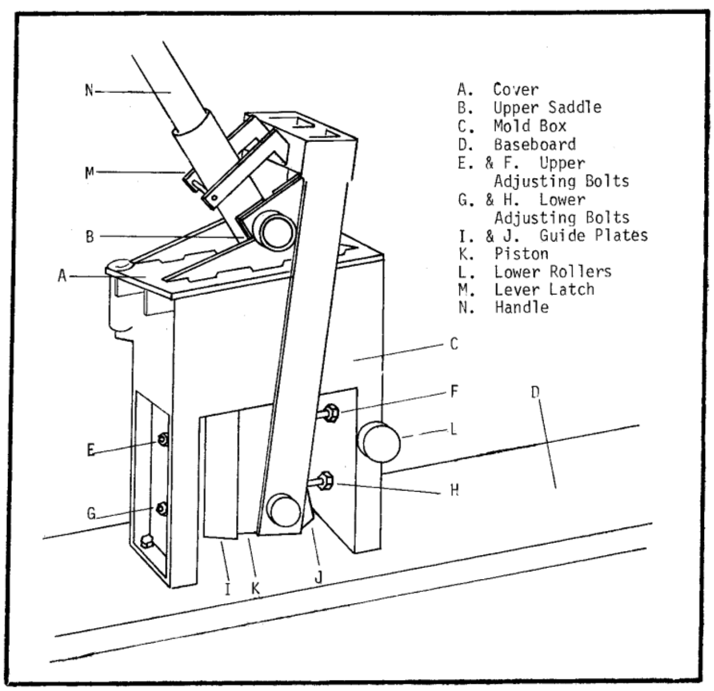


Fig. 1 - The CINVA-Ram Block Press and Its Parts

Figure A-1. The CINVA-Ram Press

A2. TEK-Block Press

The TEK Block press was developed in 1970 by the Department of Housing and Planning Research. The goal was to modify the CINVA-Ram to suit local requirements. The lever arm is made out of wood which serves a dual purpose. The first is to make the press cheaper. It also serves as a fail-safe; if too much force is applied, the lever will break before any damage is done to the machine.

The TEK-Block Press has the following specs:

- Size of Machine: 32 x 23 x 79 cm
- Weight of Machine: 85 kg
- Standard Block Size: 29 x 21.5 x 14 cm
- Price: $173 USD
- Output Rate: 50 blocks per hour

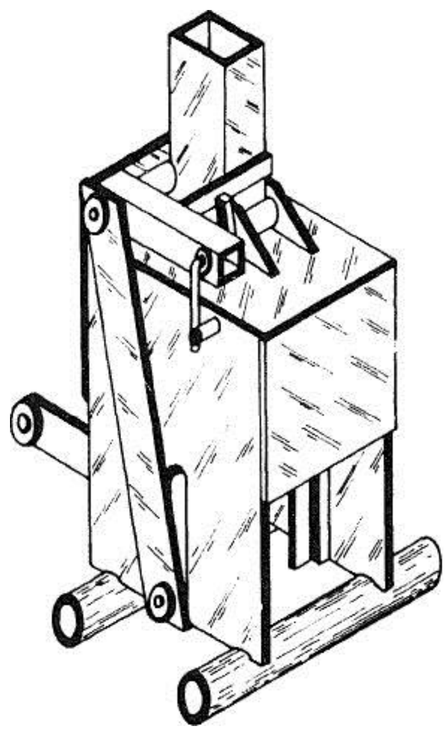


Figure A-2. The TEK-Block Press

A3. Links to Informative Websites

The following links will lead to websites with details on block presses or compressed earth blocks themselves.

1. CINVA-Ram Block Press
   http://www.cd3wd.com/cd3wd_40/vita/cinvaram/en/cinvaram.htm
   accessed 1/23/14
2. TEK-Block Press
   http://collections.infocollections.org/ukedu/uk/d/Jh2380e/6.7.4.html#Jh2380e.6.7.4
   accessed 1/23/14
3. Video of Ceta Ram Block Press During Compression and Ejection
   http://www.youtube.com/watch?v=R_3xGySdfNg&list=PLEU-v0sCVSix_rBtMVOx_a6Ird2CpVAV_
   accessed1/22/14
4. Fernco MP-612
   http://www.ferncometal.com/products.htm
   accessed 1/23/14
5. Soeng Thai Interlocking Compressed Earth Block Press Model BP6
   http://cvbt-web.org/?q=Equipment
   http://www.cvbt-web.org/uploads/Equip/Ad-BP5e3.pdf
   accessed: 1/23/14
6. Interlocking Compressed Earth Block (ICEB)
   http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1965&context=theses
   accessed 1/23/14
7. BP9 Mini Block Press
   http://cvbt-web.org/?q=BP9-MINI-BLOCK-PRESS
   accessed: 1/23/14

Appendix B: QFD and Decision Matrices

B1. Original requirements from the sponsor

- The production cost of the press should be under 1500 baht
- The press should produce blocks that are 7.5 x 3.75 x 2.5 cm
- The press should be free-standing
- Modes for half-size and full-size blocks
- Green color

B2. Quality Function Deployment Matrix

The QFD on the next page expands on the original requirements from the sponsor and includes possible requirements of secondary customers. Based on the requirements, we came up with technical specifications that can be measured to test how the product meets the customer needs.

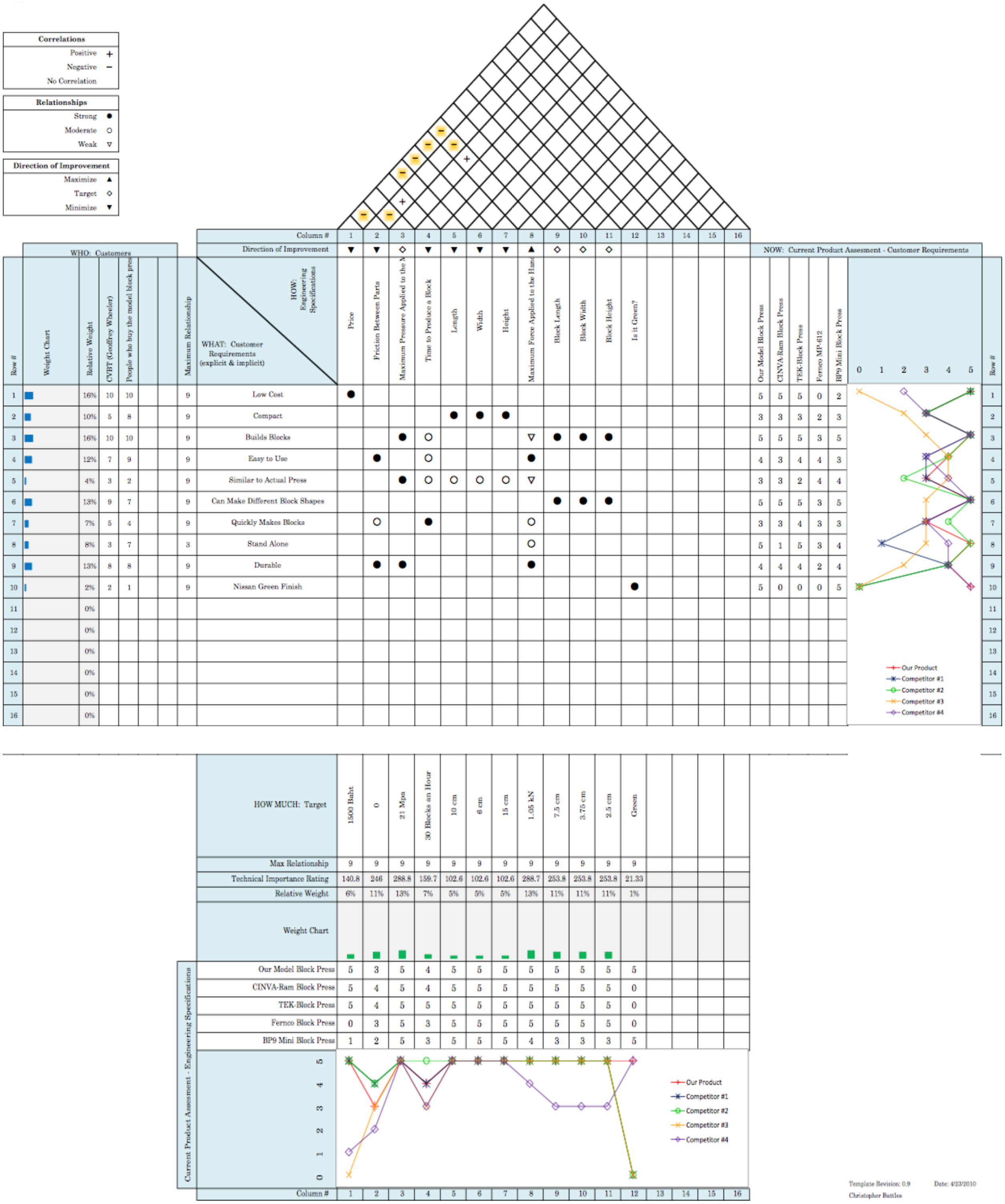


Figure B1: Quality Function Deployment (QFD) matrix for the block press

B3. Decision Matrix

	Criteria	Price	Compact	Achieves Target Block Density	Easy to Use	Similar to Actual Press	Can make Different Block Shapes	Quickly Makes Blocks	Stand Alone	Durable	Maximum Force Applied to the Handle	Sum
Design	**Weighting**	0.25	0.05	0.15	0.15	0.025	0.05	0.025	0.15	0.1	0.05	1
Swivel	Score	6	7	10	8	5	10	5	6	6	3	
	Weighted Score	1.5	0.35	1.5	1.2	0.125	0.5	0.125	0.9	0.6	0.15	6.95
Shell	Score	4	6	10	8	9	10	6	4	5	9	
	Weighted Score	1	0.3	1.5	1.2	0.225	0.5	0.15	0.6	0.5	0.45	6.425
BP10	Score	5	6	10	6	10	10	7	4	8	9	
	Weighted Score	1.25	0.3	1.5	0.9	0.25	0.5	0.175	0.6	0.8	0.45	6.725

Figure B1: Decision matrix for three block press concept

B4. Pictures of “Swivel” concept design model

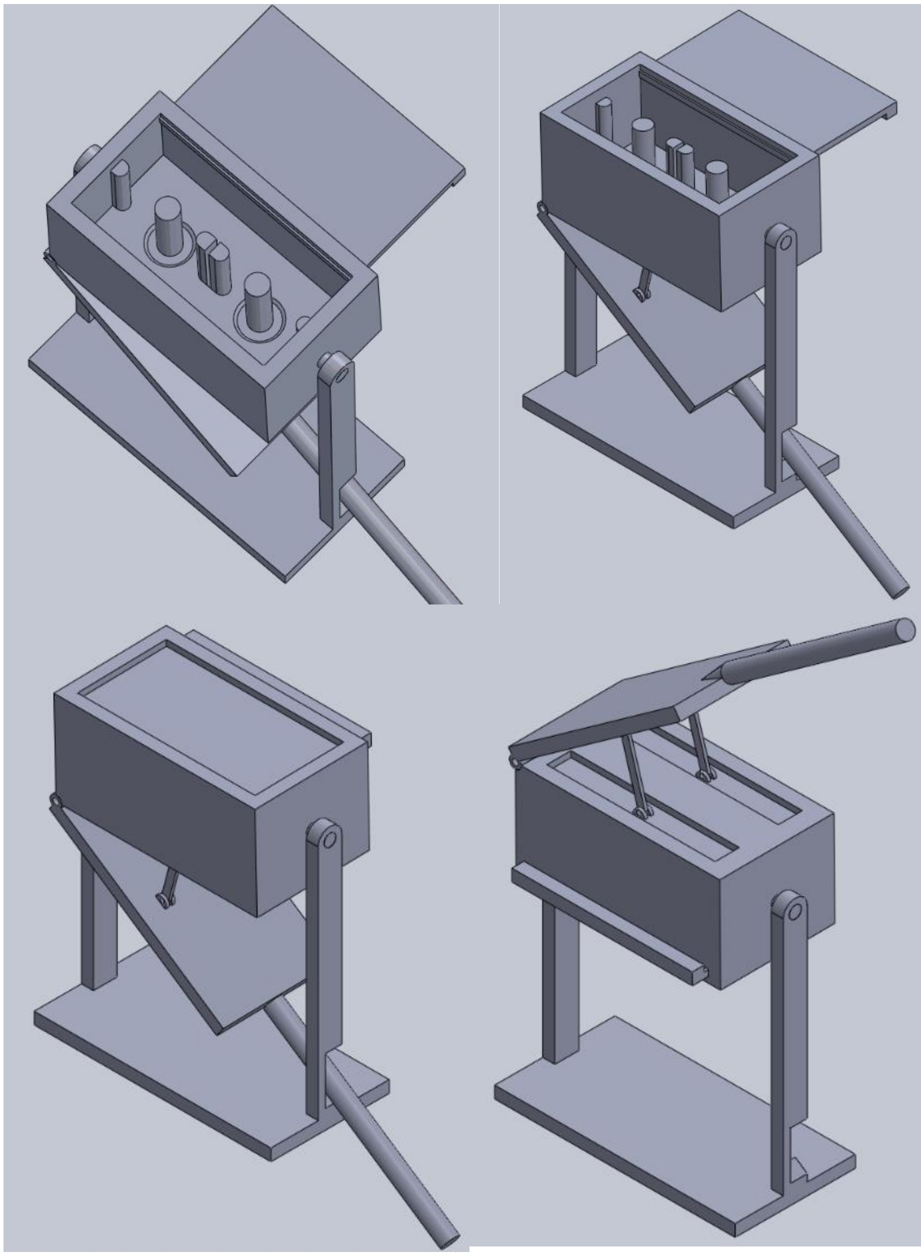


Figure B1: The Swivel concept design in loading mode (top two), transitioning to compression mode (bottom left) and in compression mode (bottom right)

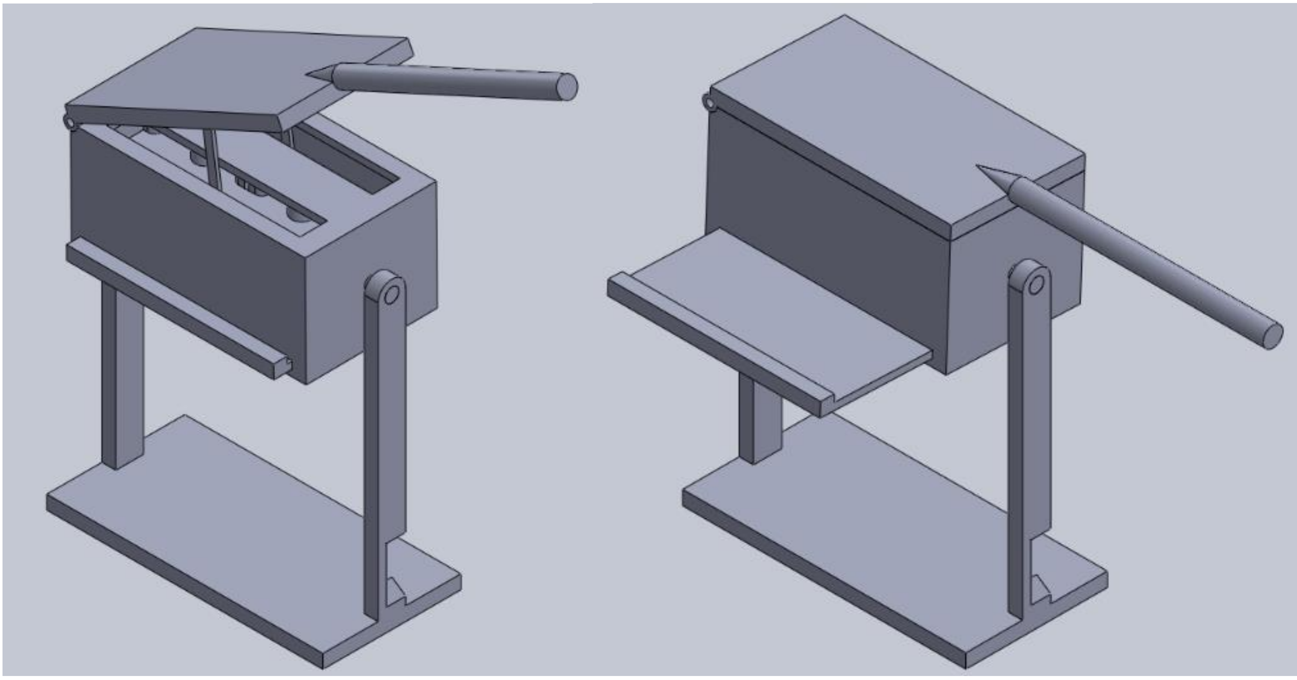
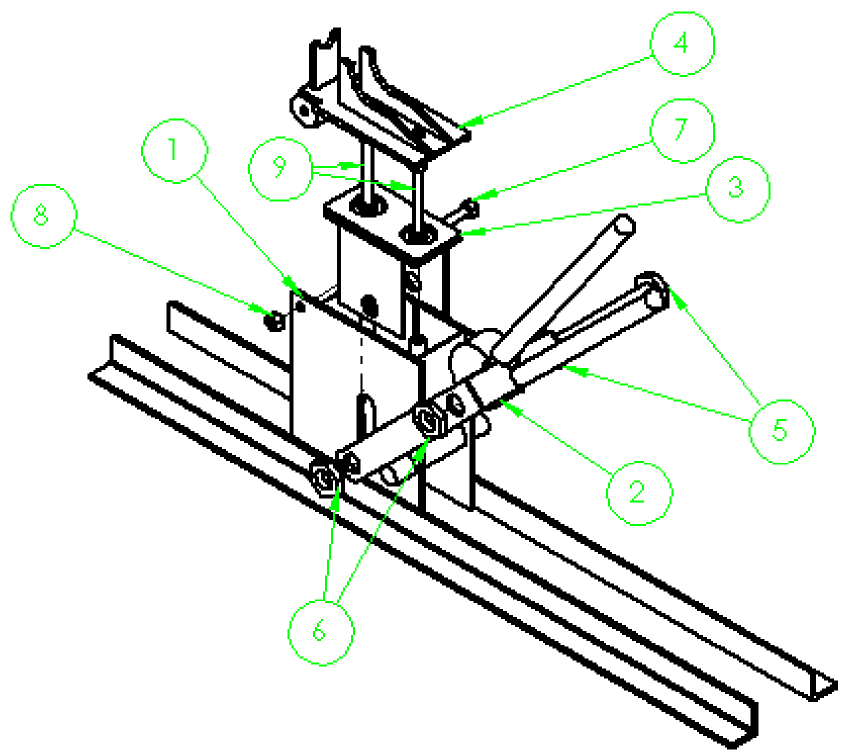


Figure B2: The Swivel concept design in the process of compression (left) and ejecting a completed block (right)

Appendix C: Drawing Packet (Assemblies with Bill of Materials, Detailed Part Drawings, Process and Instrumentation Drawing)



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1100	BASE ASSEMBLY	1
2	1200	HANDLE ASSEMBLY	1
3	1300	RAM ASSEMBLY	1
4	1400	LID ASSEMBLY	1
5	5854	M12x1.75x75 HEX BOLT	2
6	4780	M12x1.75 HEX NUT	2
7	5820	M8x1.25x55 HEX BOLT	1
8	4778	M8x1.25 HEX NUT	1
9	5804	M5x1.75 HEX BOLT	2

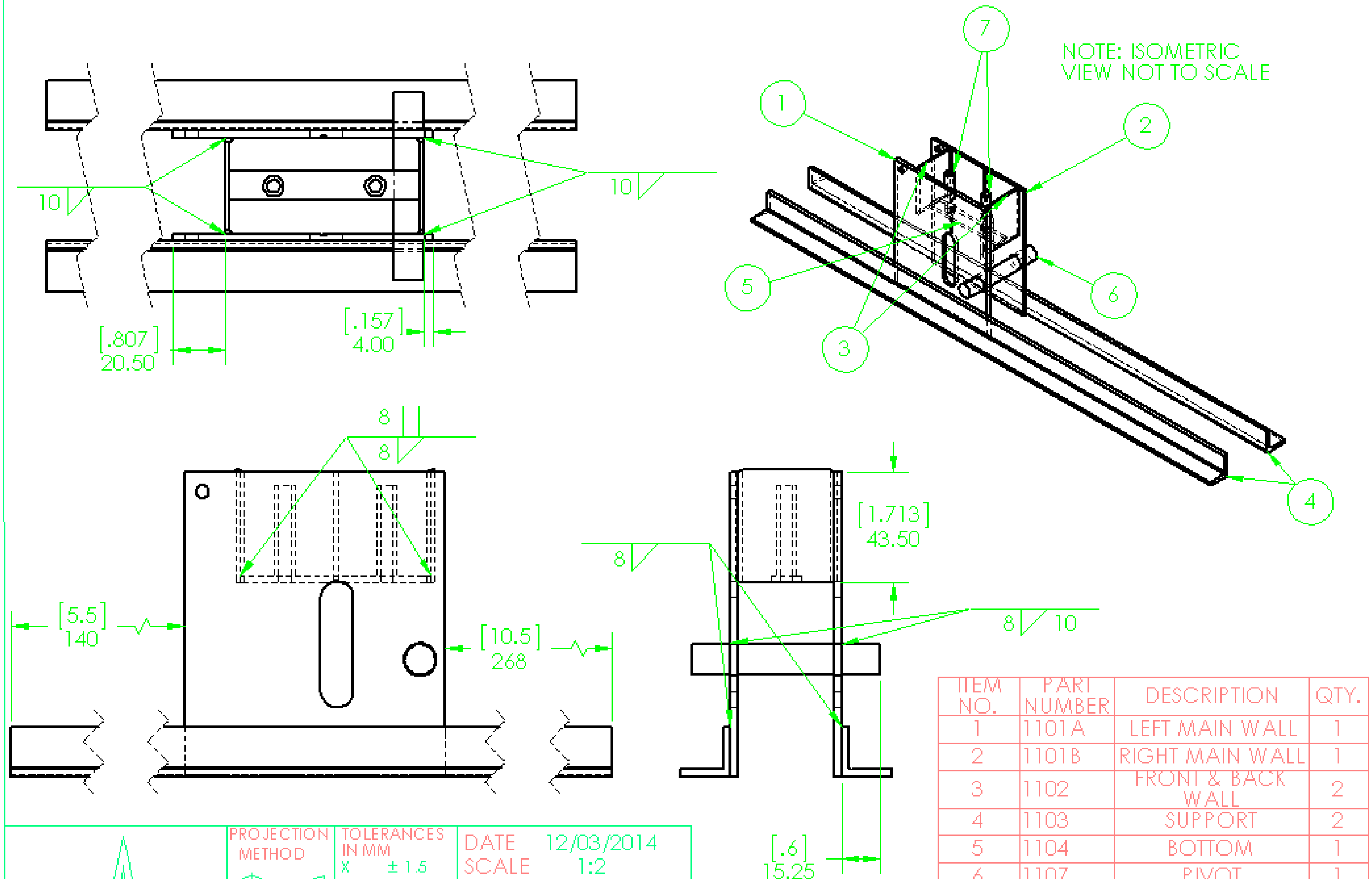
C.V.B.T.

PROJECTION METHOD

TOLERANCES IN MM
X ± 1.5
X.X ± 0.5
X.XX ± 0.25

DATE 12/05/2014
SCALE 1:4
WT. 2.696 KG.
UNITS ARE MILLIMETRES [INCHES]

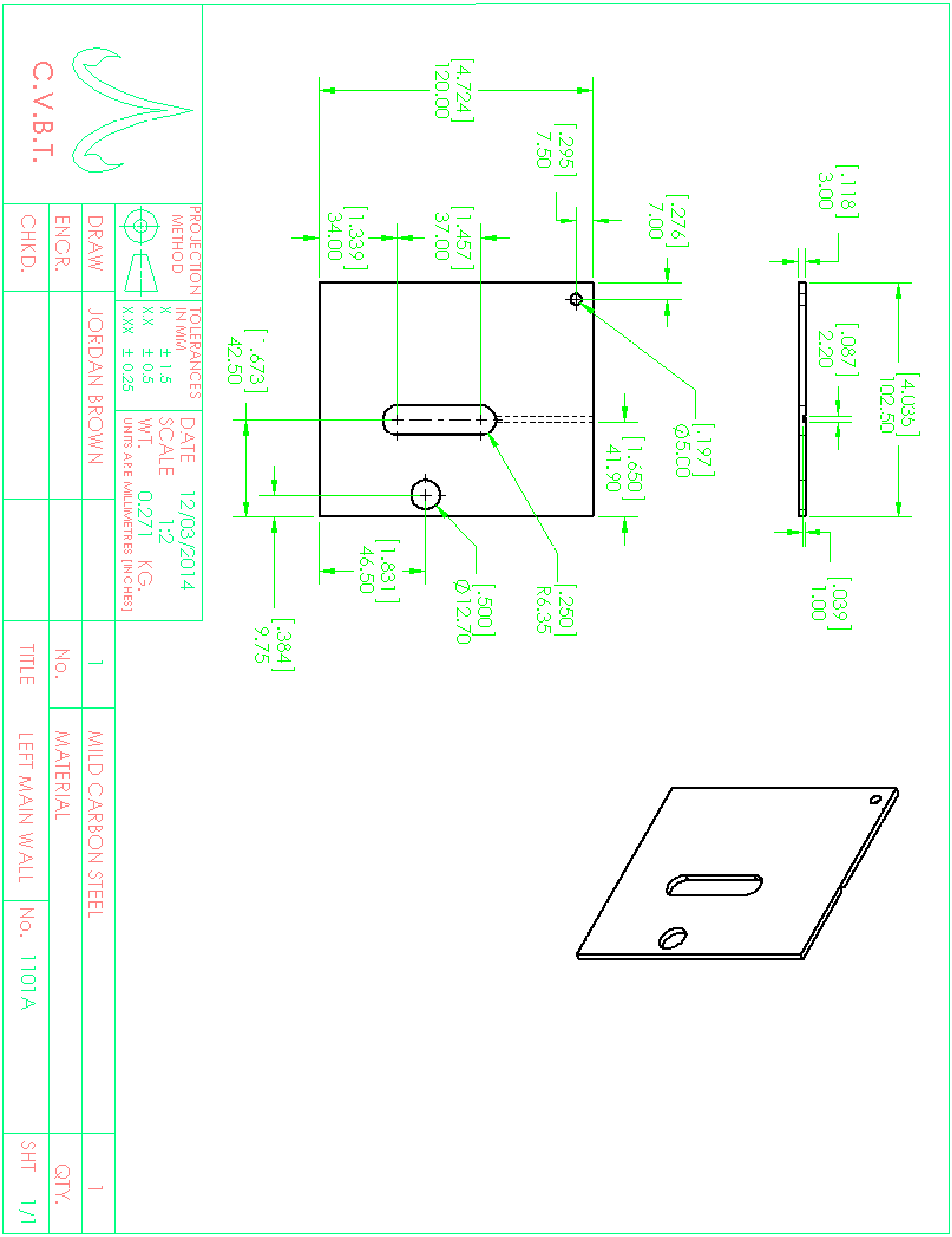
DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
ENGR.			No.	MATERIAL	QTY.
CHKD.			TITLE	FULL ASSEMBLY — No. 1000	SHT 1/1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1101A	LEFT MAIN WALL	1
2	1101B	RIGHT MAIN WALL	1
3	1102	FRONT & BACK WALL	2
4	1103	SUPPORT	2
5	1104	BOTTOM	1
6	1107	PIVOT	1
7	1105	CYLINDER	2

C.V.B.T.

PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:2 WT. 1.575 KG. UNITS ARE MILLIMETRES [INCHES]		
DRAW	MICHAEL EVANS	1	MILD CARBON STEEL	1
ENGR.		No.	MATERIAL	QTY.
CHKD.		TITLE	BASE ASSY — No. 1100	SHT 1/1


C.V.B.T.
PROJECTION METHOD
TOLERANCES IN MM
X ± 1.5
X.X ± 0.5
X.XX ± 0.25
DATE 12/03/2014
SCALE 1:2
WT. 0.271 KG.
UNITS ARE MILLIMETRES [INCHES]
DRAW JORDAN BROWN
ENGR.
CHKD.
No. 1
MILD CARBON STEEL
MATERIAL
TITLE LEFT MAIN WALL
No. 1101A
QTY. 1
SHT 1/1
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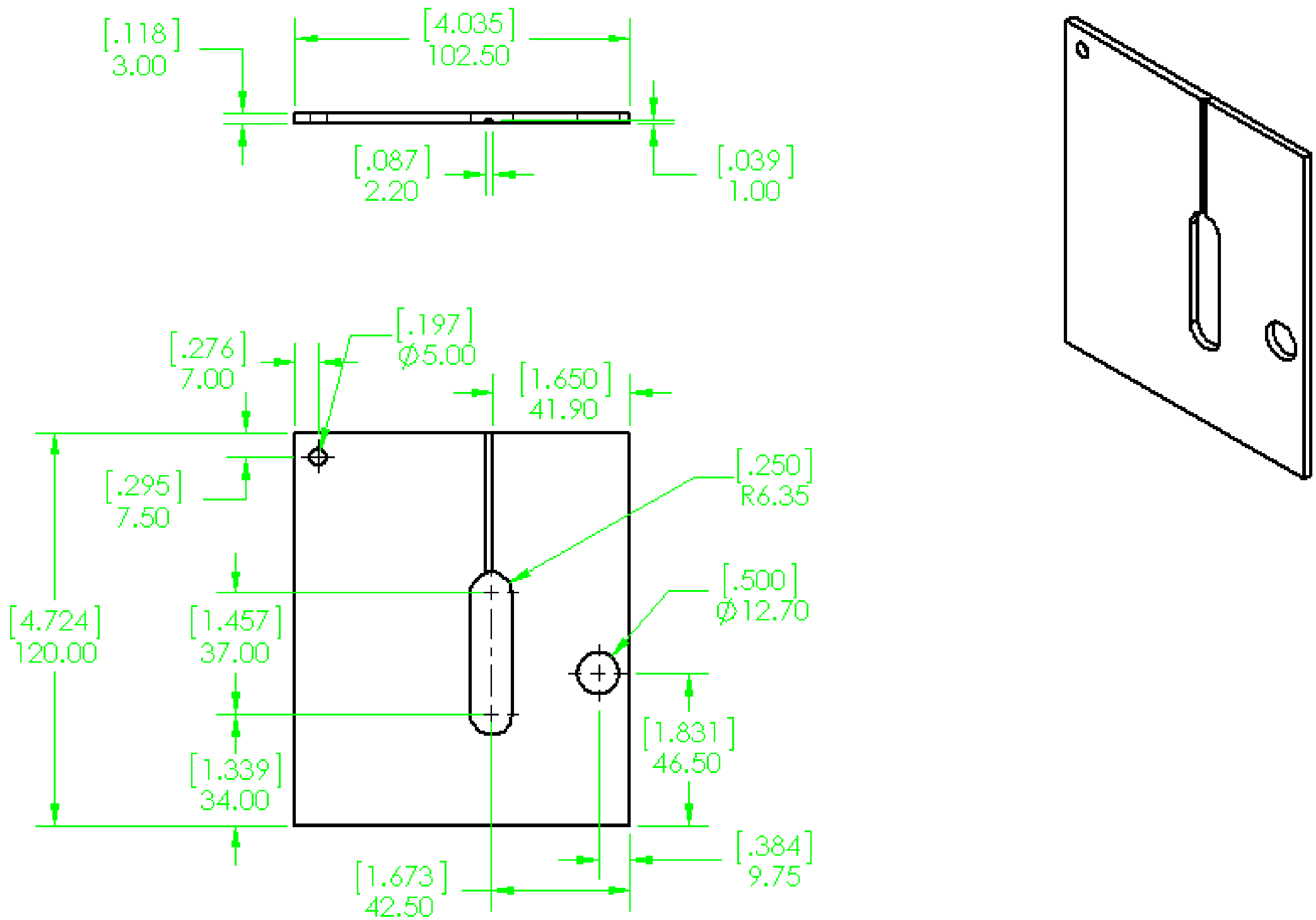
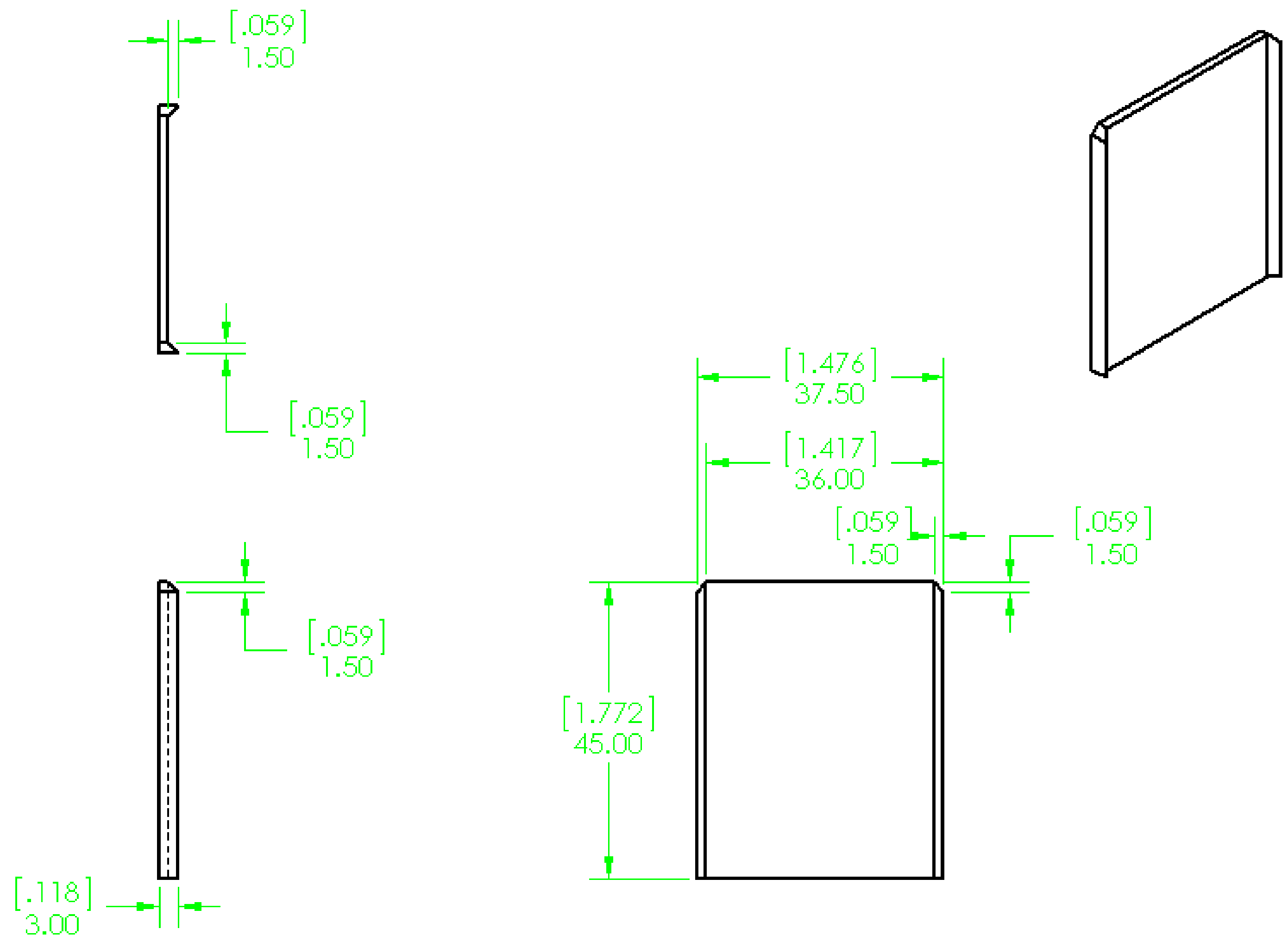
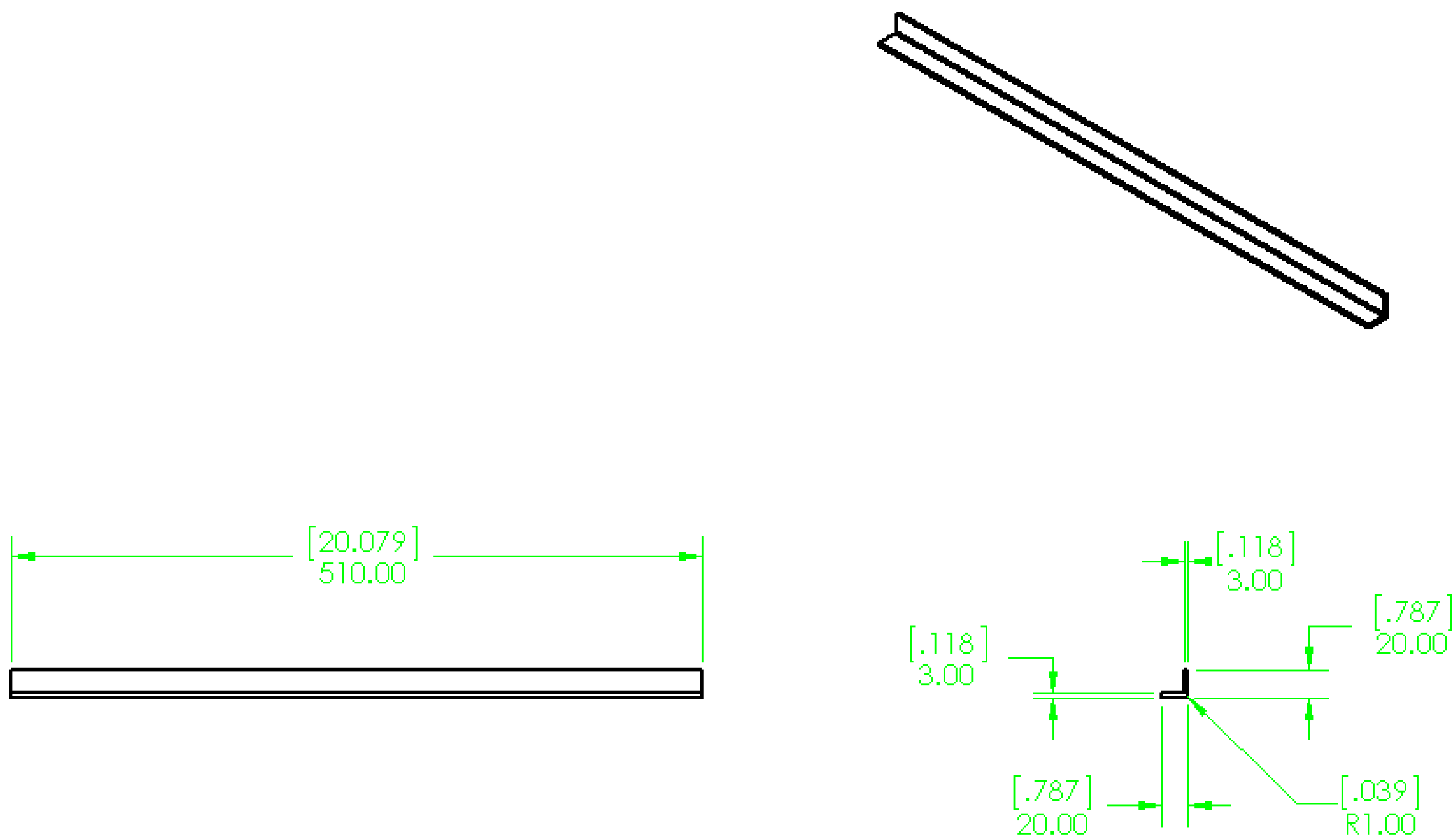
[.295] 7.50
[.276] 7.00
[.118] 3.00
[1.339] 34.00
[1.457] 37.00
[1.673] 42.50
[.087] 2.20
[4.035] 102.50
[.197] Ø5.00
[1.650] 41.90
[1.831] 46.50
[.500] Ø12.70
[.250] R6.35
[.039] 1.00
[.384] 9.75



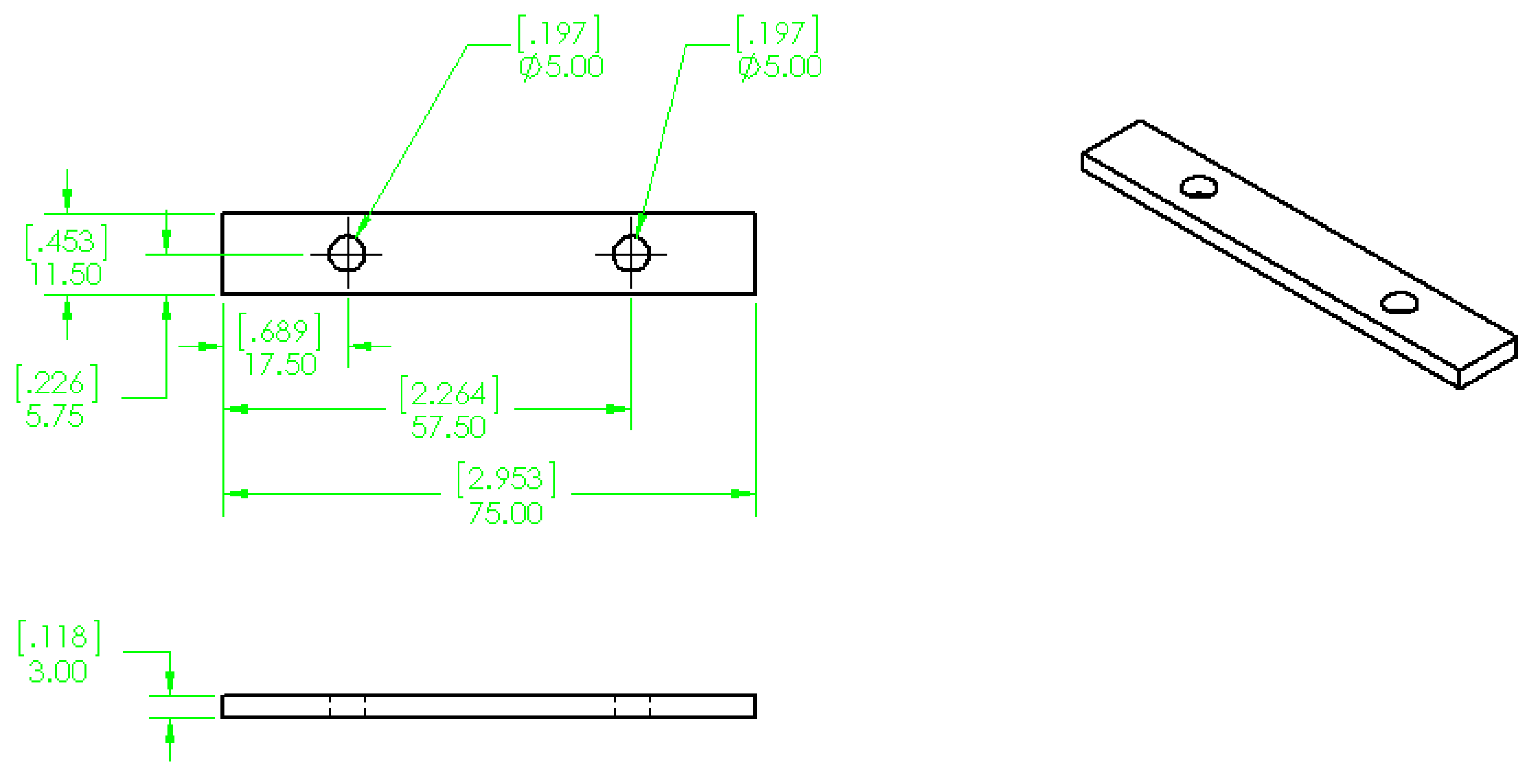
C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:2 WT. 0.271 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN	1	MILD CARBON STEEL		1
	ENGR.		No.	MATERIAL		QTY.
	CHKD.		TITLE	RIGHT MAIN WALL	No. 1101B	SHT 1/1



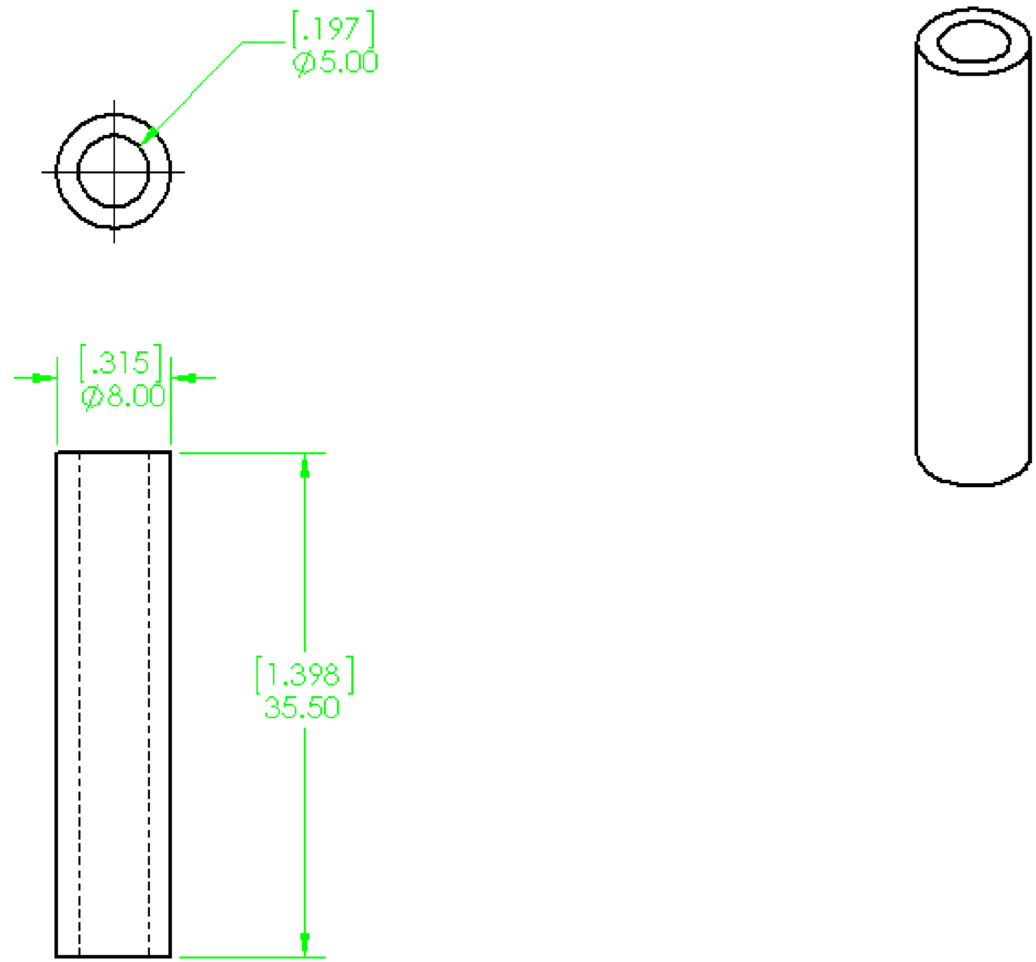
C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.021 KG. UNITS ARE MILLIMETRES [INCHES]				
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL		2
	ENGR.			No.	MATERIAL		QTY.
	CHKD.			TITLE	FRONT AND BACK WALL	No. 1102	SHT 1/1



C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:5 WT. 0.444 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL	2
	ENGR.			No.	MATERIAL	QTY.
	CHKD.			TITLE	SUPPORT No. 1103	SHT 1/1

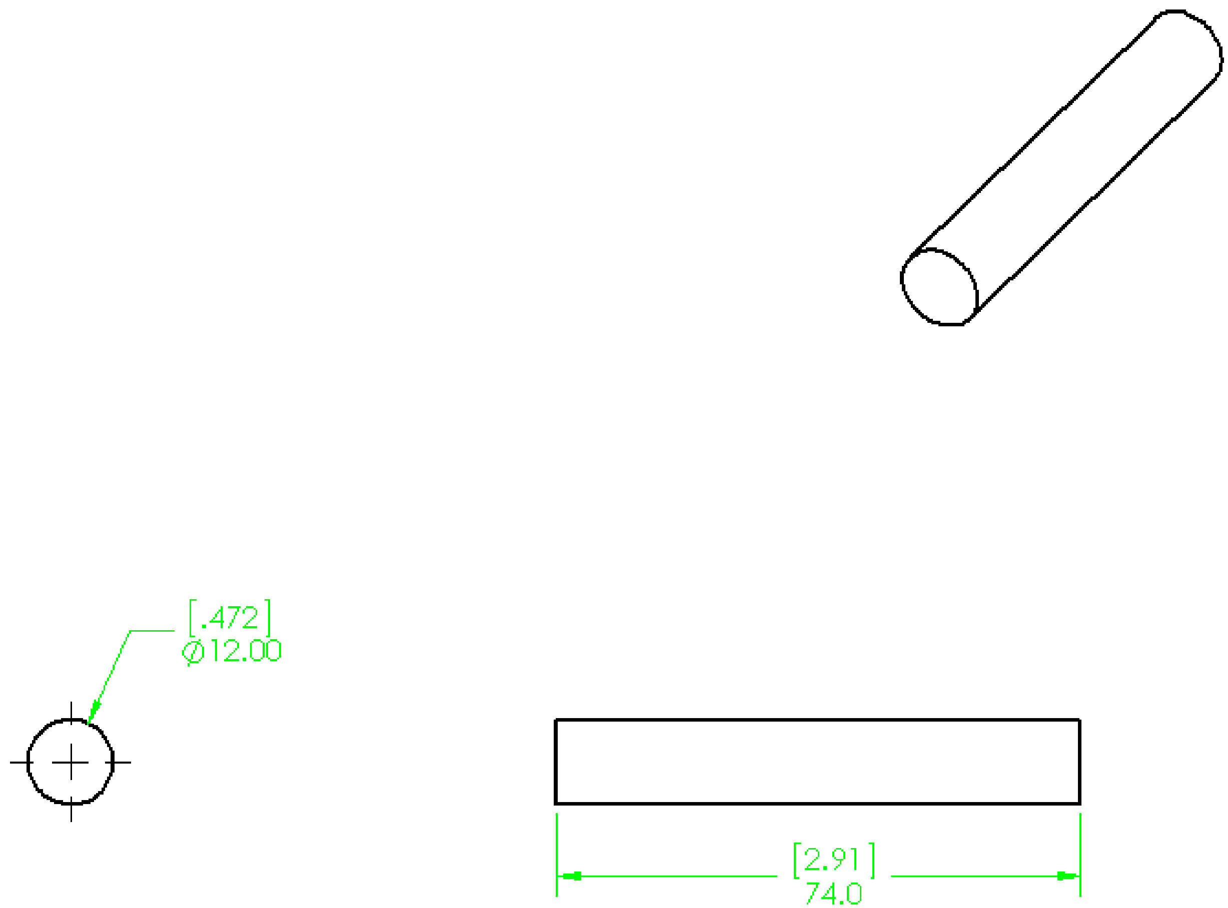


C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.020 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
	ENGR.			No.	MATERIAL	QTY.
	CHKD.			TITLE	BOTTOM / No. 1104	SHT 1/1

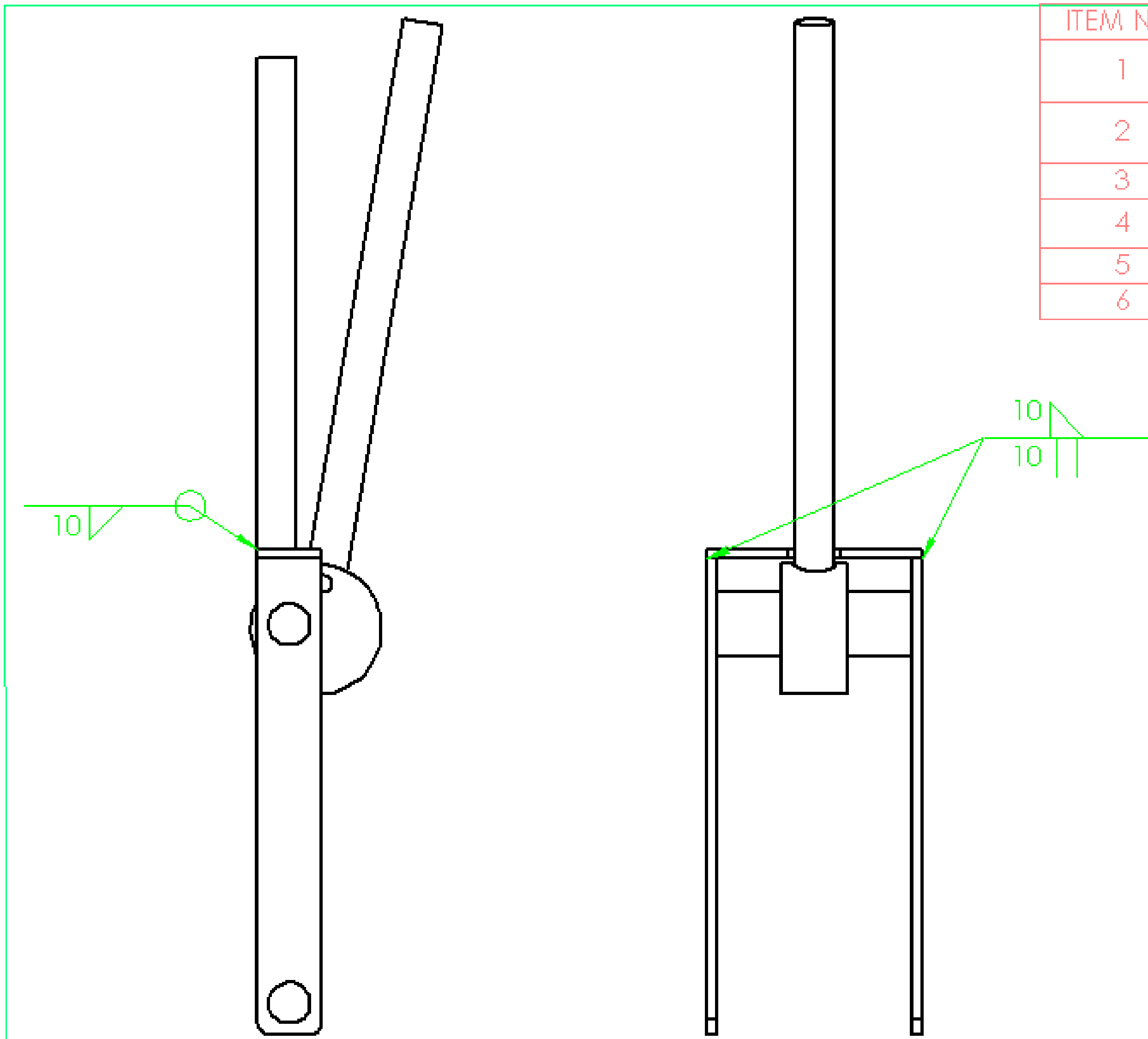


C.V.B.T.

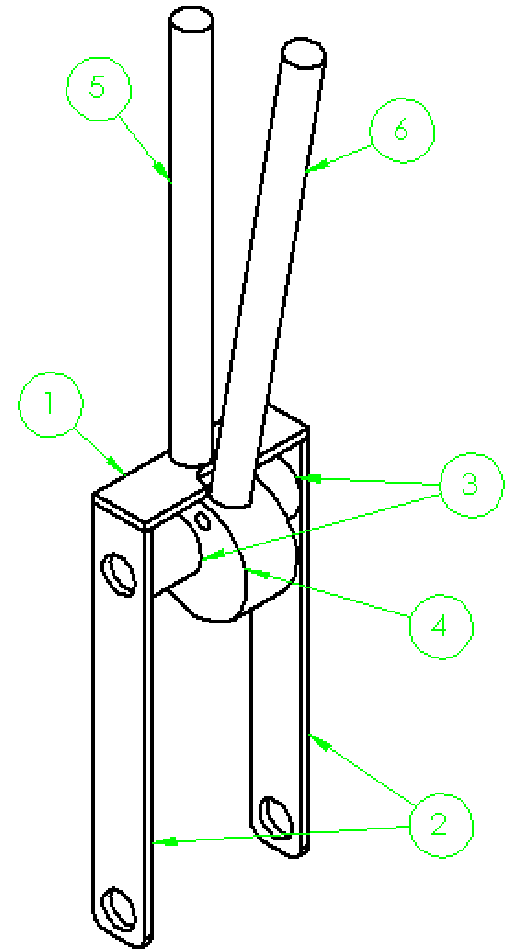
PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 2:1 WT. 0.009 KG. UNITS ARE MILLIMETRES [INCHES]				
DRAW	JORDAN BROWN		1	MILD CARBON STEEL		2
ENGR.			No.	MATERIAL		QTY.
CHKD.			TITLE	CYLINDER	No. 1105	SHT 1/1



C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.066 KG. UNITS ARE MILLIMETRES [INCHES]				
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL		1
	ENGR.			No.	MATERIAL		QTY.
	CHKD.			TITLE	PIVOT	No. 1107	SHT 1/1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1201A	CONNECTOR TOP	1
2	1201B	CONNECTOR SIDE	2
3	1205	SPACER	2
4	1203	ECCENTRIC TOGGLE	1
5	1202	EXTRA HANDLE	1
6	1204	HANDLE	1



C.V.B.T.

PROJECTION METHOD	TOLERANCES IN MM	DATE 12/03/2014
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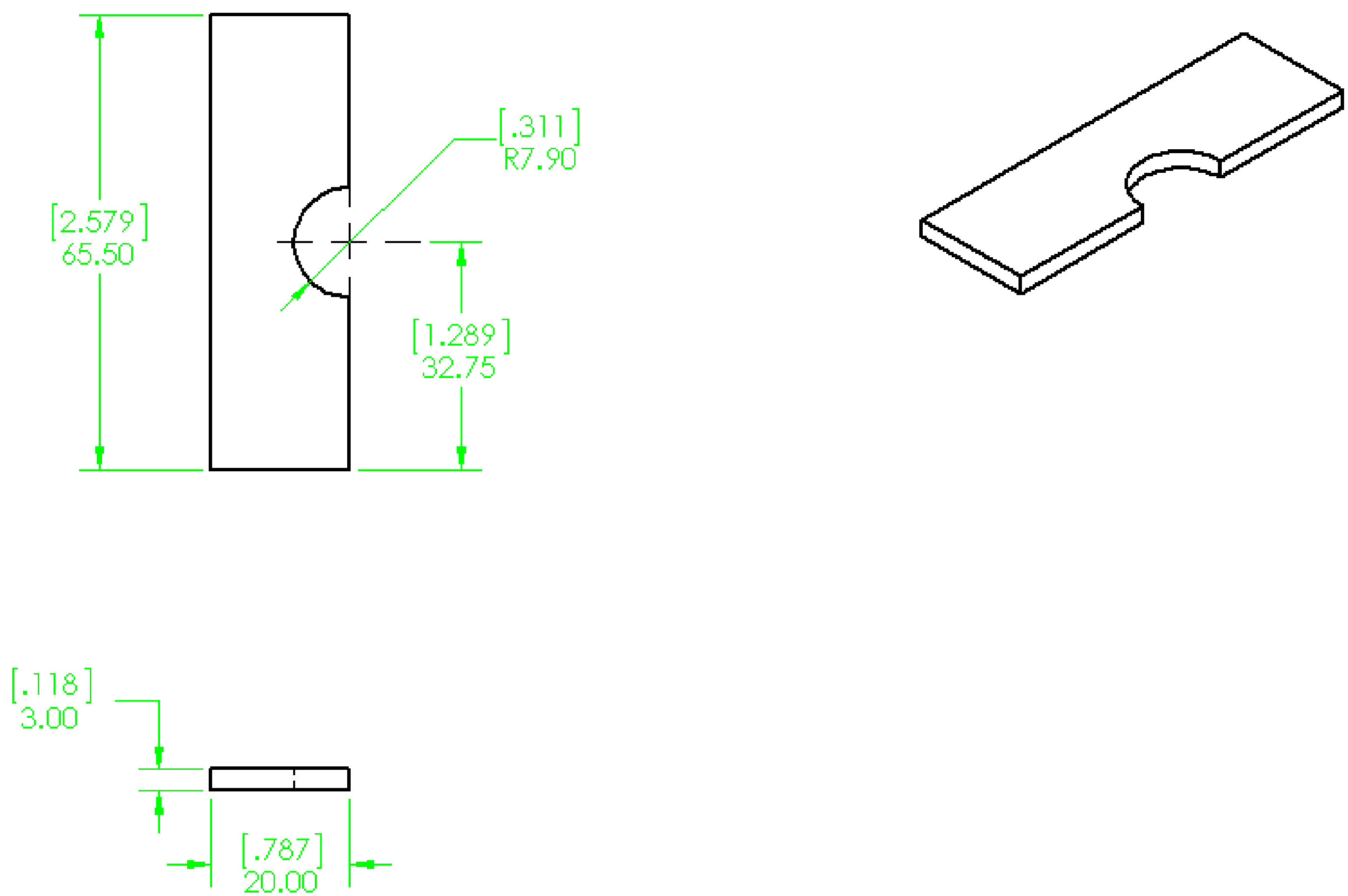
	X.X ± 0.5	WT. 0.665 KG.
	X.XX ± 0.25	UNITS ARE MILLIMETRES [INCHES]

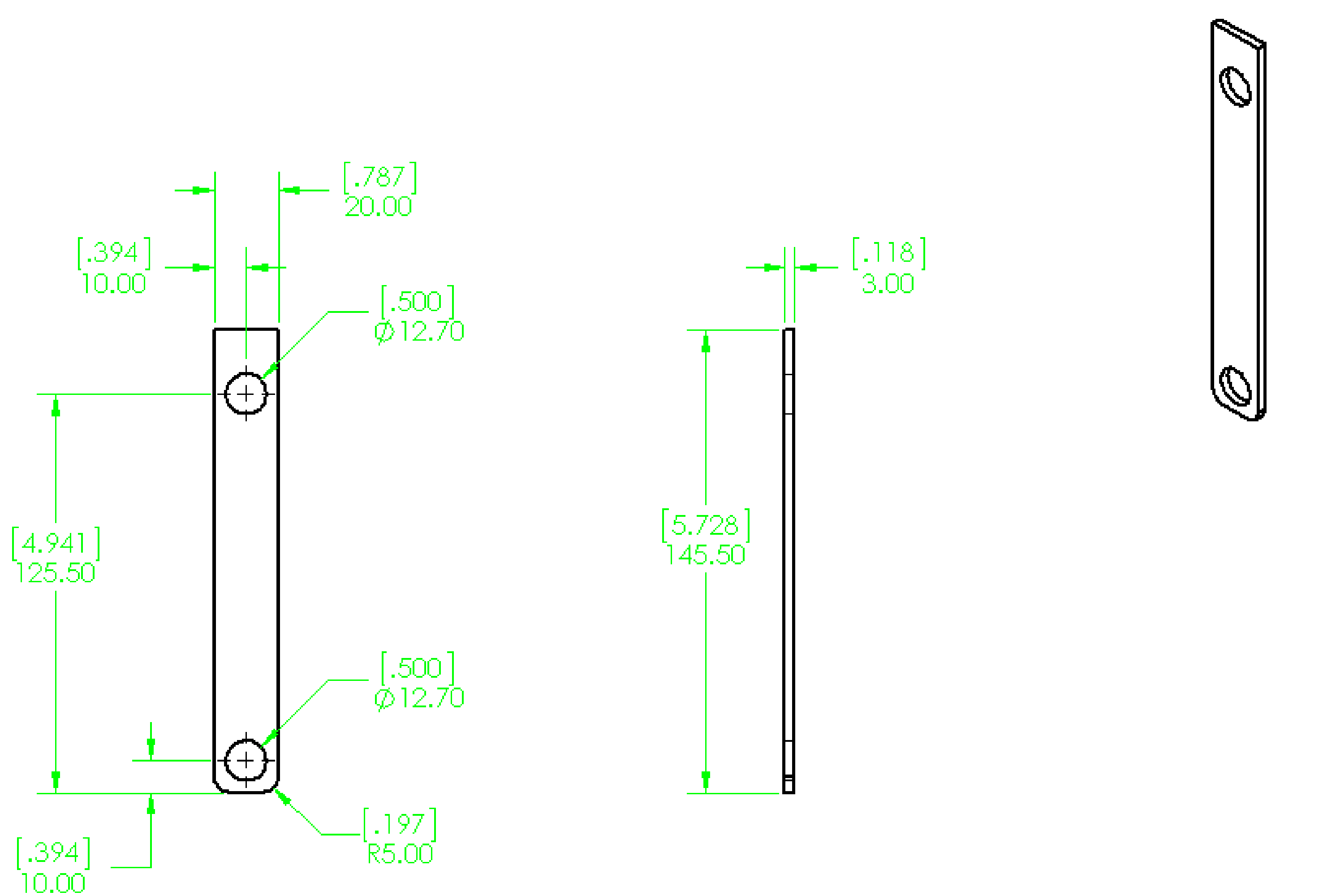
DRAW	MICHAEL EVANS	1	MILD CARBON STEEL		1
ENGR.		No.	MATERIAL		QTY.
CHKD.		TITLE	HANDLE ASSY	No. 1200	SHT 1/1



C.V.B.T.

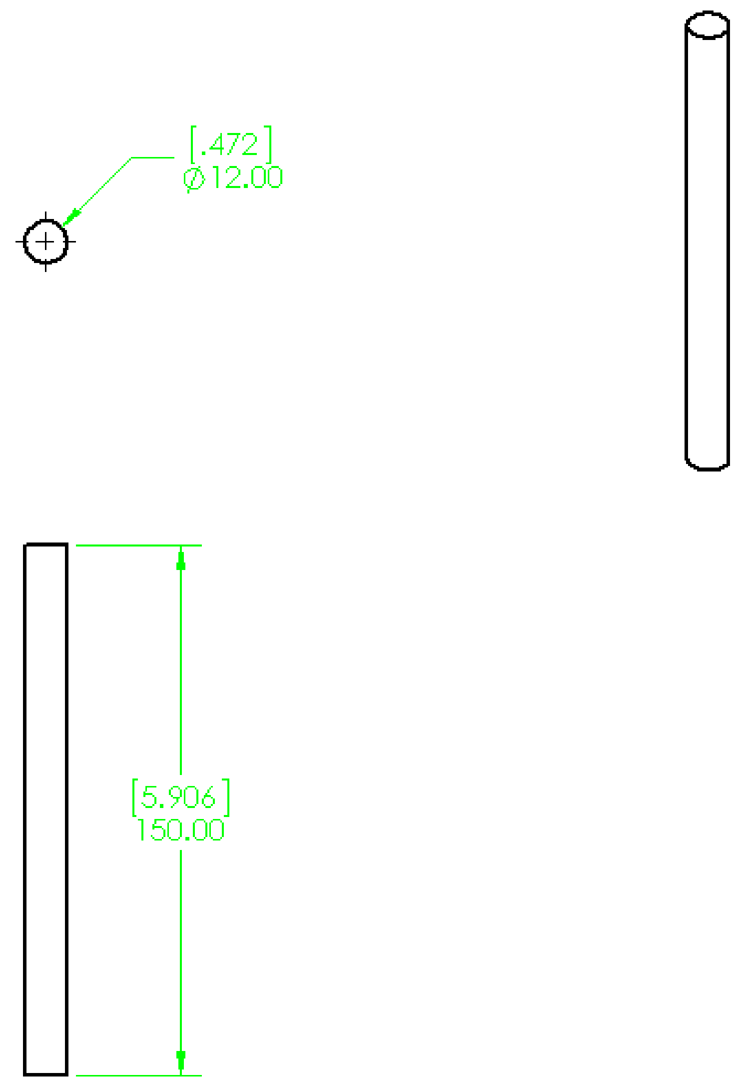
PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.029 KG. UNITS ARE MILLIMETRES [INCHES]	

DRAW	JORDAN BROWN		1	MILD CARBON STEEL		1
ENGR.			No.	MATERIAL		QTY.
CHKD.			TITLE	CONNECTOR TOP	No. 1201A	SHT 1/1



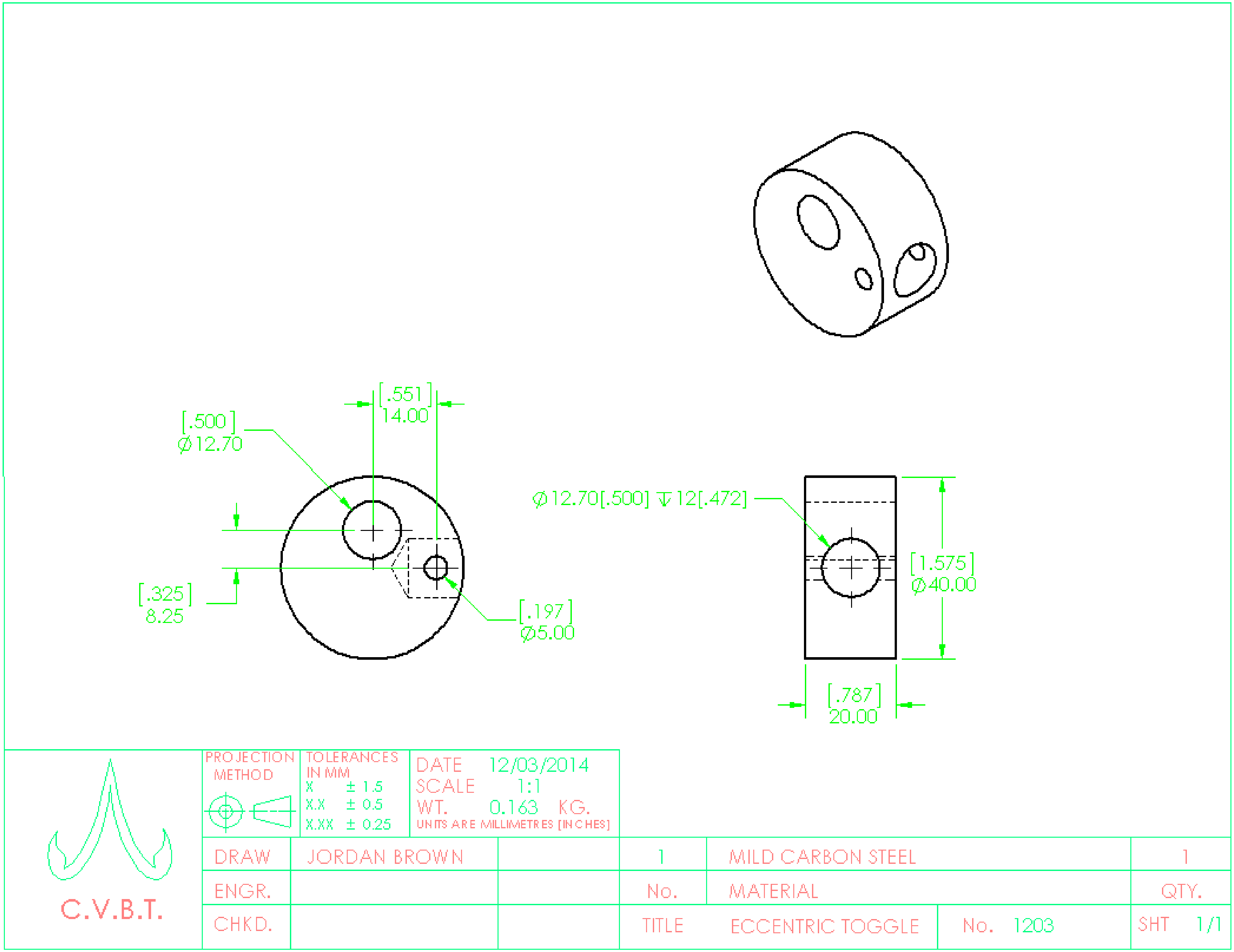
C.V.B.T.

PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:2 WT. 0.062 KG. UNITS ARE MILLIMETRES [INCHES]			
DRAW	JORDAN BROWN		1	MILD CARBON STEEL	2
ENGR.			No.	MATERIAL	QTY.
CHKD.			TITLE	CONNECTOR SIDE No. 1201B	SHT 1/1



PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:2 WT. 0.133 KG. UNITS ARE MILLIMETRES [INCHES]			
DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
ENGR.			No.	MATERIAL	QTY.
CHKD.			TITLE	EXTRA HANDLE No. 1202	SHT 1/1

C.V.B.T.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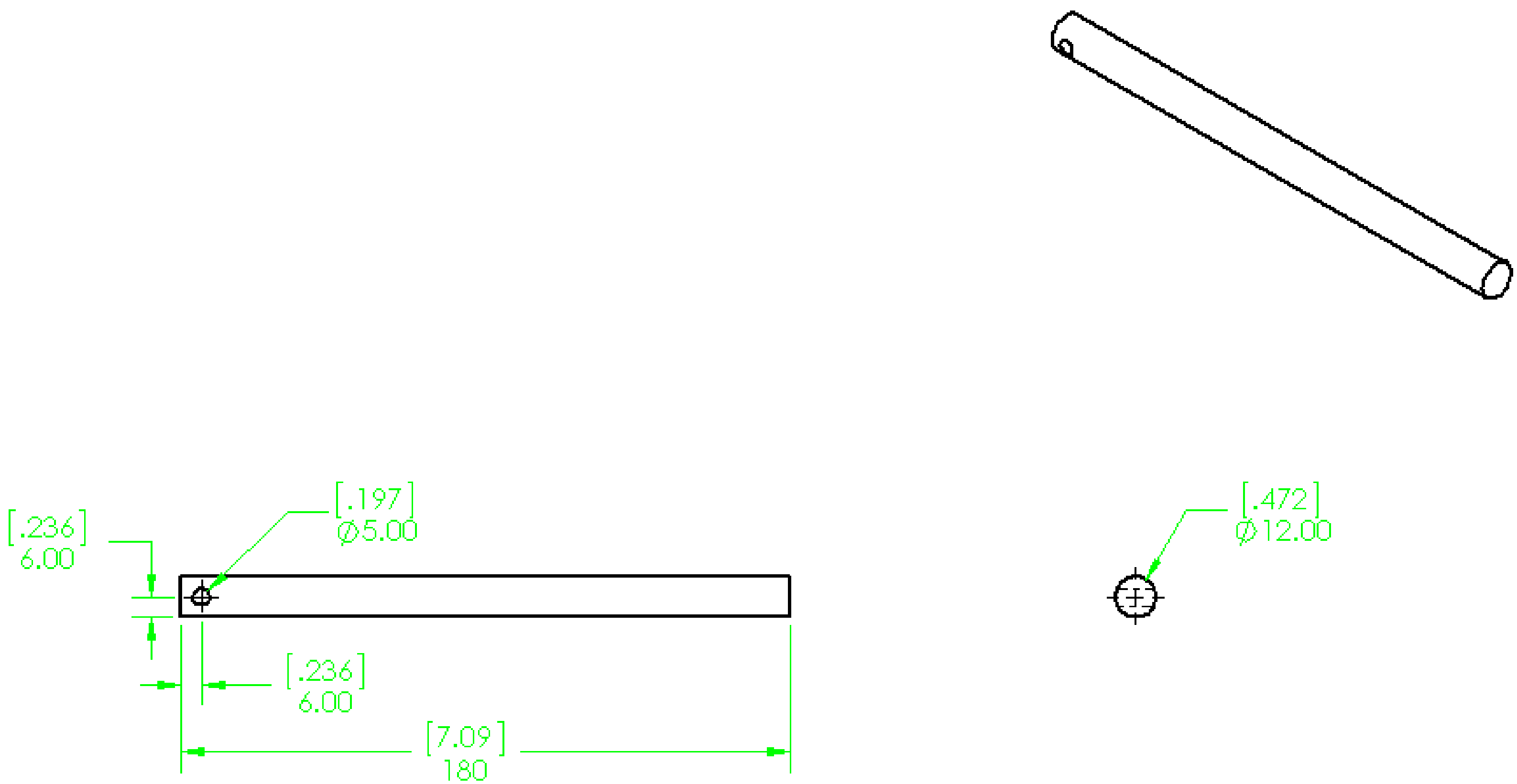
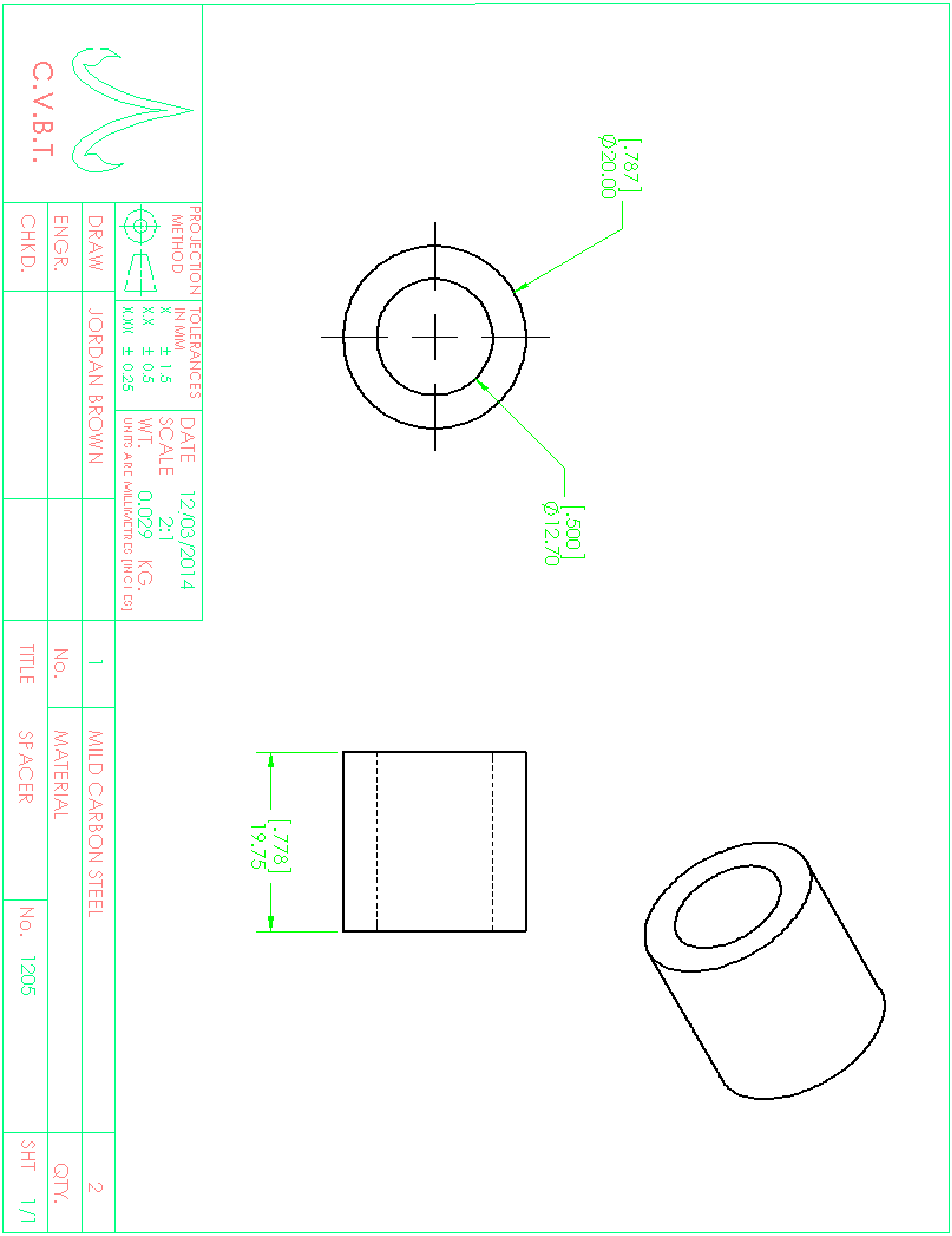
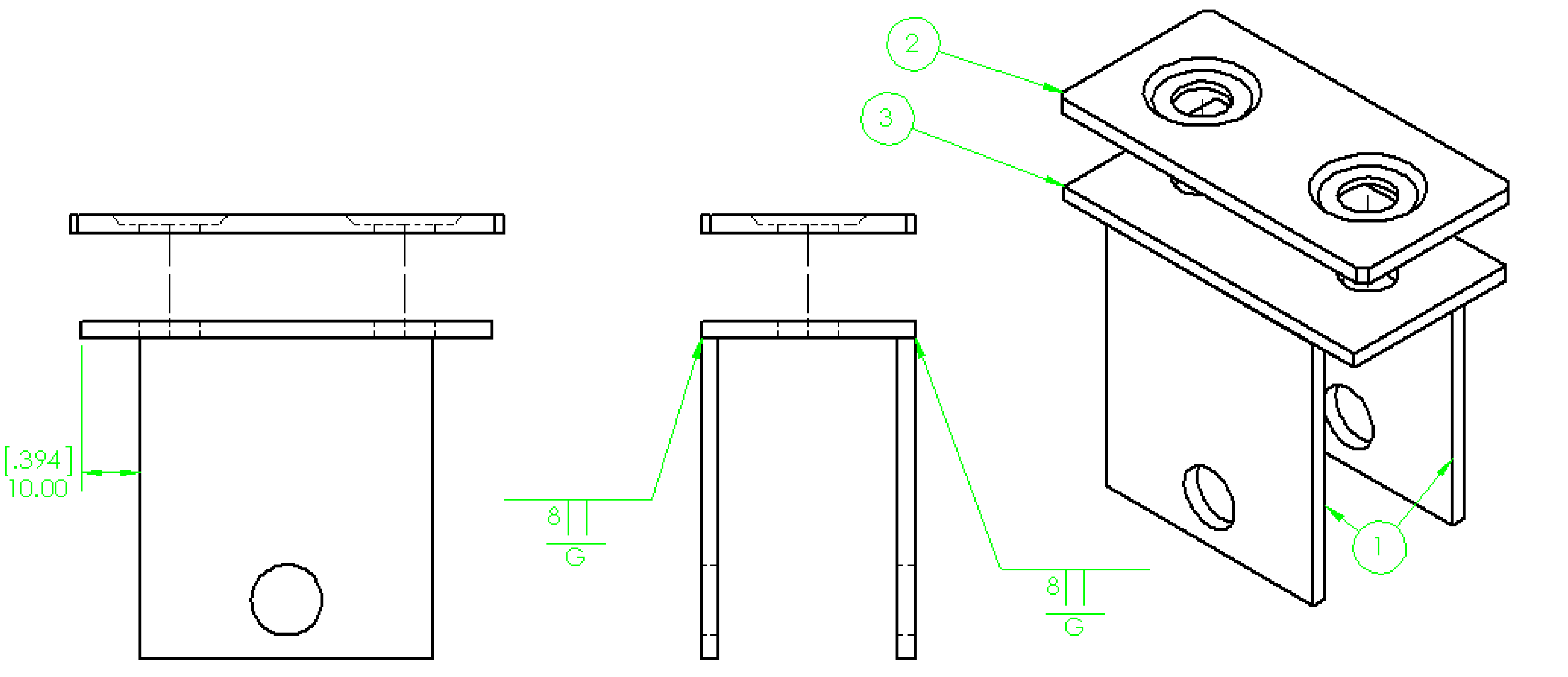
[.551]
14.00
[.325]
8.25
[.197]
Ø5.00
Ø12.70[.500] ↧12[.472]
[1.575]
Ø40.00
[.787]
20.00
C.V.B.T.
PROJECTION METHOD
TOLERANCES IN MM
X ± 1.5
X.X ± 0.5
X.XX ± 0.25
DATE 12/03/2014
SCALE 1:1
WT. 0.163 KG.
UNITS ARE MILLIMETRES [INCHES]
DRAW
JORDAN BROWN
ENGR.
CHKD.
1
No.
TITLE
MILD CARBON STEEL
MATERIAL
ECCENTRIC TOGGLE
No. 1203
1
QTY.
SHT 1/1



C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:2 WT. 0.158 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
	ENGR.			No.	MATERIAL	QTY.
	CHKD.			TITLE	HANDLE / No. 1204	SHT 1/1



C.V.B.T.
PROJECTION METHOD
TOLERANCES IN MM
X ± 1.5
X.X ± 0.5
X.XX ± 0.25
DATE 12/03/2014
SCALE 2:1
WT. 0.029 KG.
UNITS ARE MILLIMETRES [INCHES]
DRAW JORDAN BROWN
ENGR.
CHKD.
No. 1
MILD CARBON STEEL
MATERIAL
TITLE SPACER
No. 1205
QTY. 2
SHT 1/1
Ø20.00 [.787]
Ø12.70 [.500]
19.75 [.778]

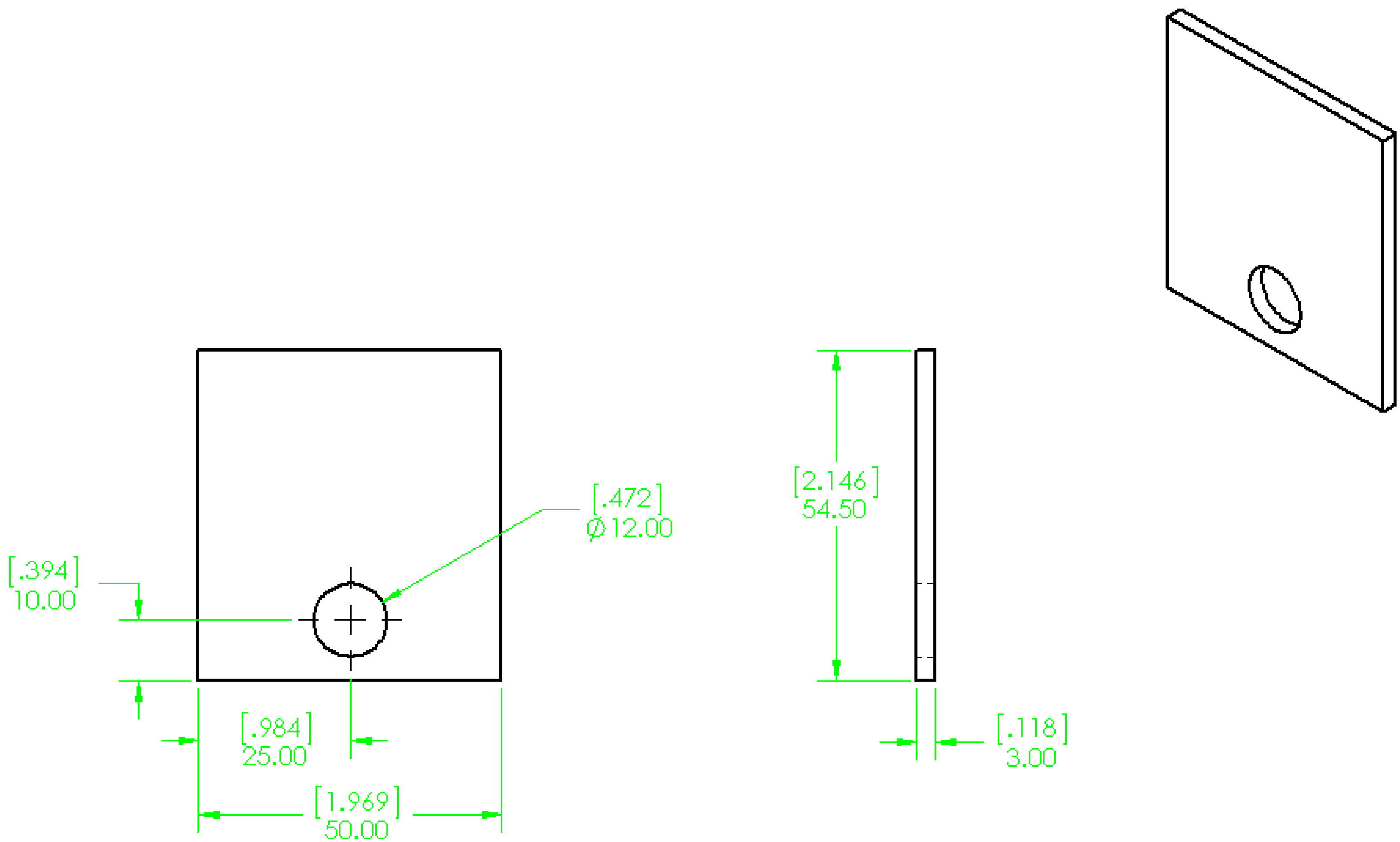


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1301	CONNECTOR PLATE	2
2	1302	PRESS PLATE	1
3	1304	TOP PLATE	1

C.V.B.T.

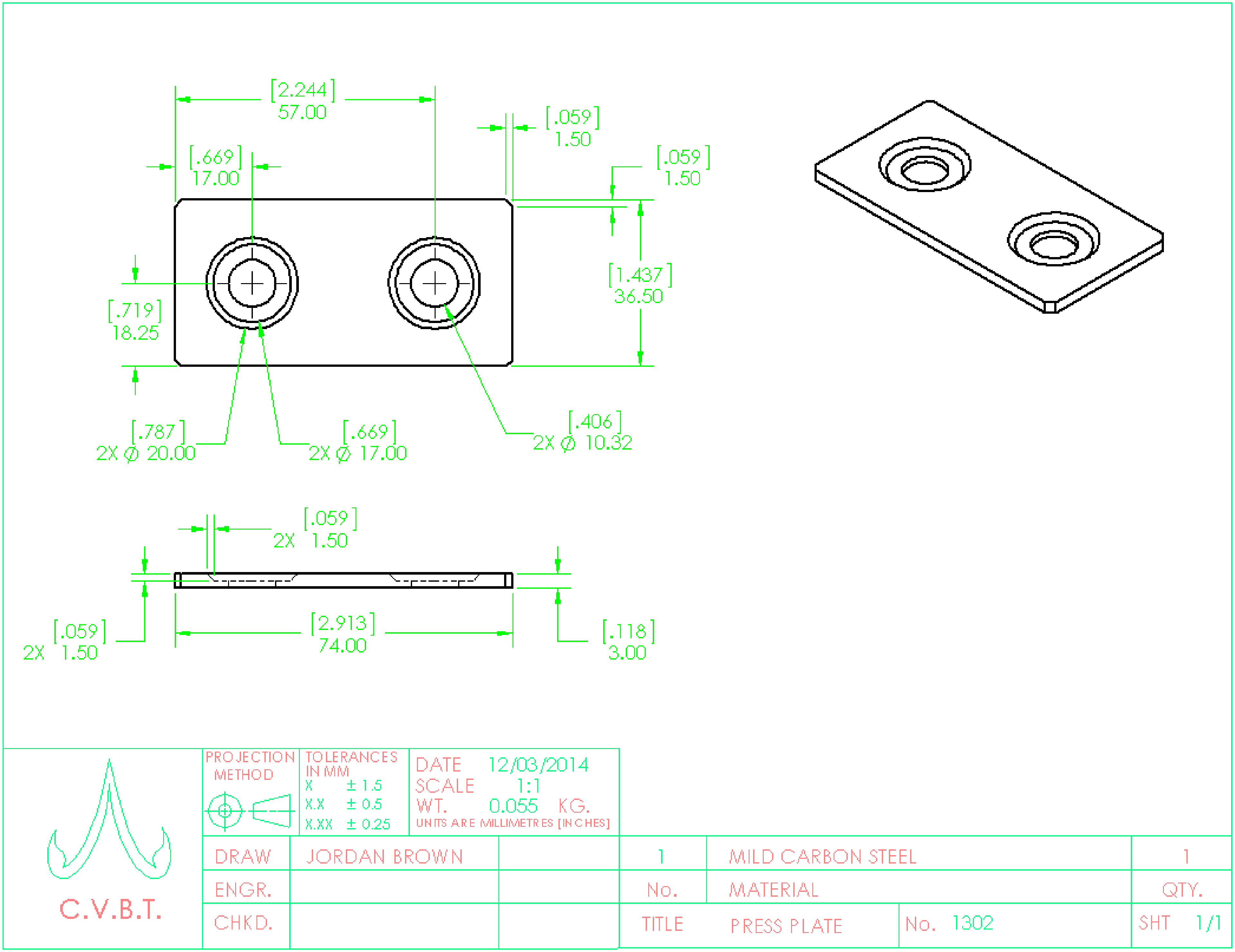
PROJECTION METHOD	TOLERANCES IN MM	DATE 12/04/2014
	X ± 1.5	SCALE 1:1
	X.X ± 0.5	WT. 0.234 KG.
	X.XX ± 0.25	UNITS ARE MILLIMETRES [INCHES]

DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
ENGR.			No.	MATERIAL	QTY.
CHKD.			TITLE	RAM ASSEMBLY	No. 1300	SHT 1/1



C.V.B.T.

PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.062 KG. UNITS ARE MILLIMETRES [INCHES]		
DRAW	JORDAN BROWN	1	MILD CARBON STEEL	2
ENGR.		No.	MATERIAL	QTY.
CHKD.		TITLE	CONNECTOR PLATE · No. 1301	SHT 1/1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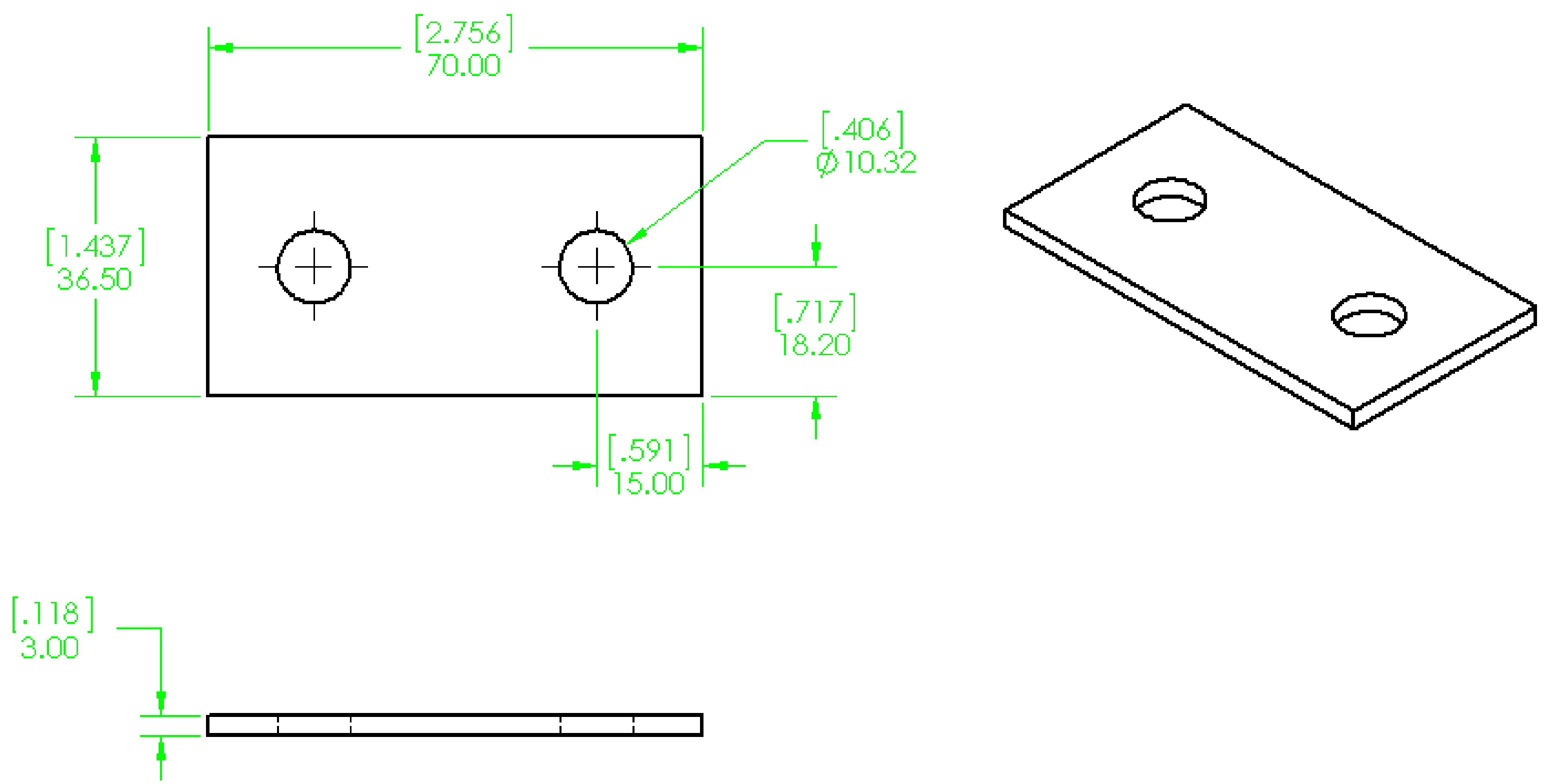
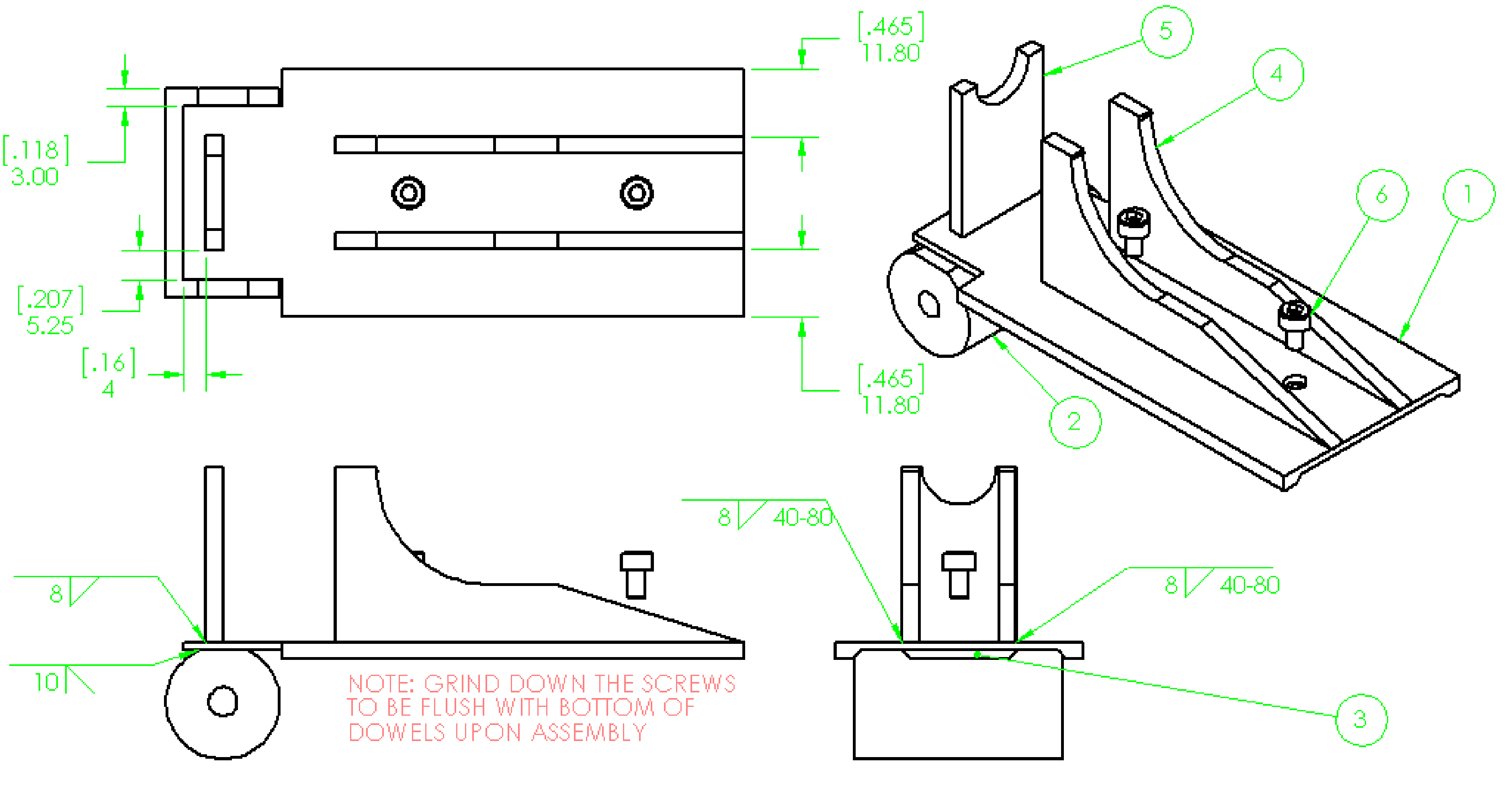
36.50
[.787]
2X Ø 20.00
[.669]
2X Ø 17.00
[.406]
2X Ø 10.32
[.059]
2X 1.50
[.059]
2X 1.50
[2.913]
74.00
[.118]
3.00
C.V.B.T.
PROJECTION METHOD
TOLERANCES IN MM
X ± 1.5
X.X ± 0.5
X.XX ± 0.25
DATE 12/03/2014
SCALE 1:1
WT. 0.055 KG.
UNITS ARE MILLIMETRES [INCHES]
DRAW JORDAN BROWN
ENGR.
CHKD.
1
No.
MILD CARBON STEEL
MATERIAL
1
QTY.
TITLE PRESS PLATE
No. 1302
SHT 1/1



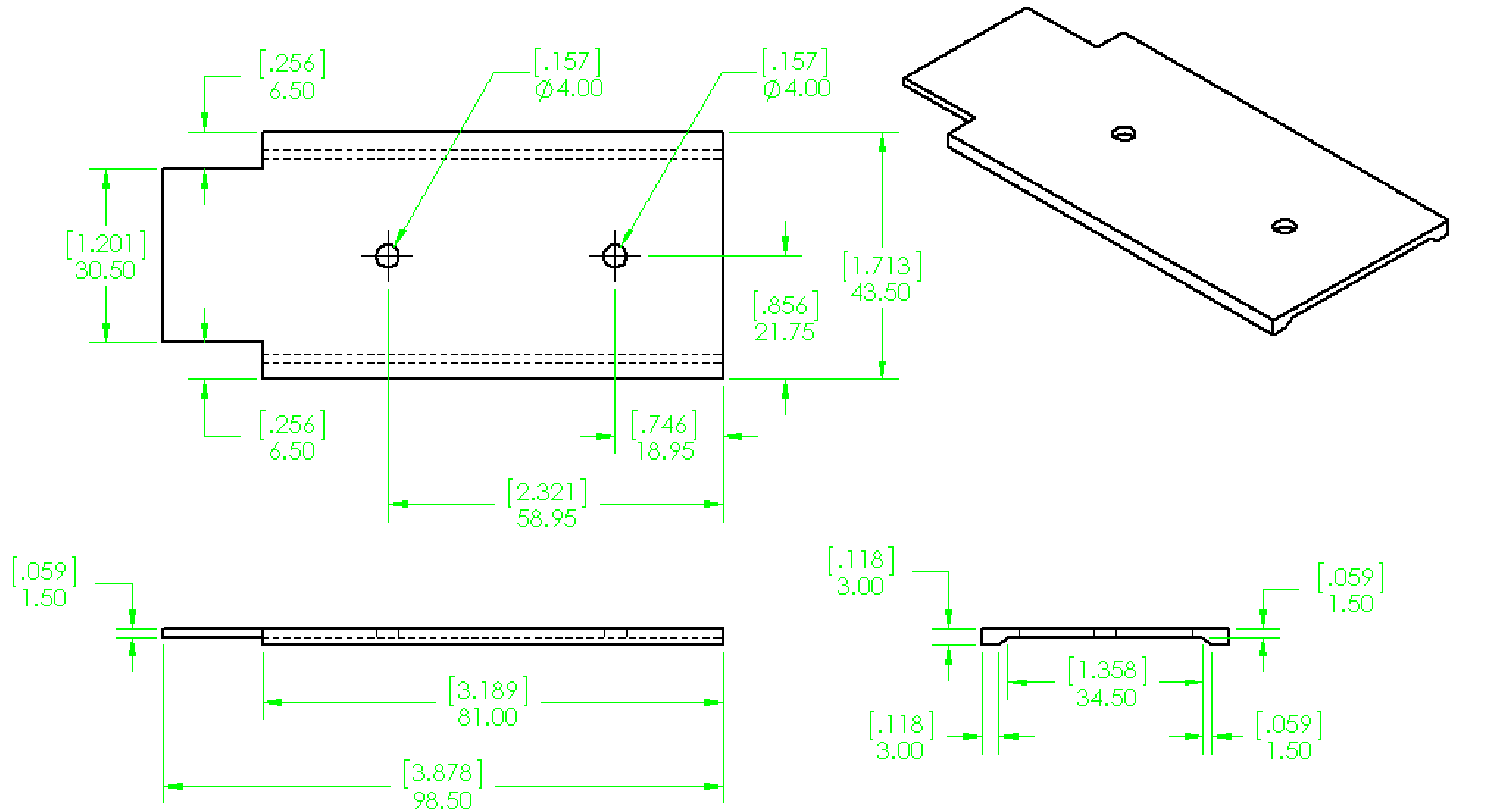
C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.056 KG. UNITS ARE MILLIMETRES [INCHES]			
DRAW	JORDAN BROWN		1	MILD CARBON STEEL		1
ENGR.			No.	MATERIAL		QTY.
CHKD.			TITLE	TOP PLATE	No. 1304	SHT 1/1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1401	LID	1
2	1402	LID CYLINDER	1
3	1405	MALE DOWEL	2
4	1406	TOGGLE REST	2
5	1407	HANDLE STOP	1
6	M3 x 0.5 x 5 HEX	HEX SCREW	2

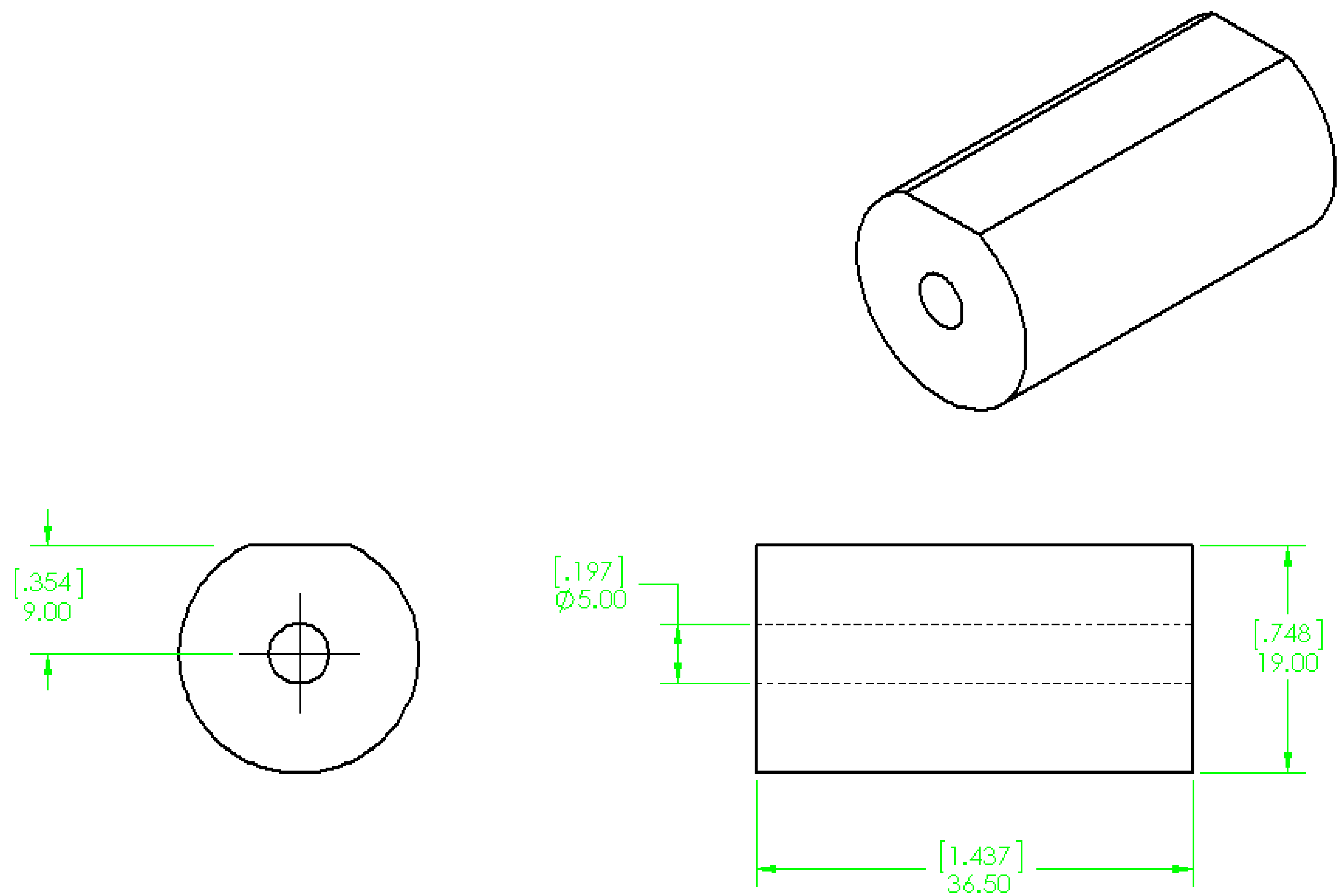
C.V.B.T.

PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/04/2014 SCALE 1:1 WT. 0.194 KG. UNITS ARE MILLIMETRES [INCHES]				
DRAW	JORDAN BROWN		1	MILD CARBON STEEL		1
ENGR.			No.	MATERIAL		QTY.
CHKD.			TITLE	LID ASSEMBLY	No. 1400	SHT 1/1

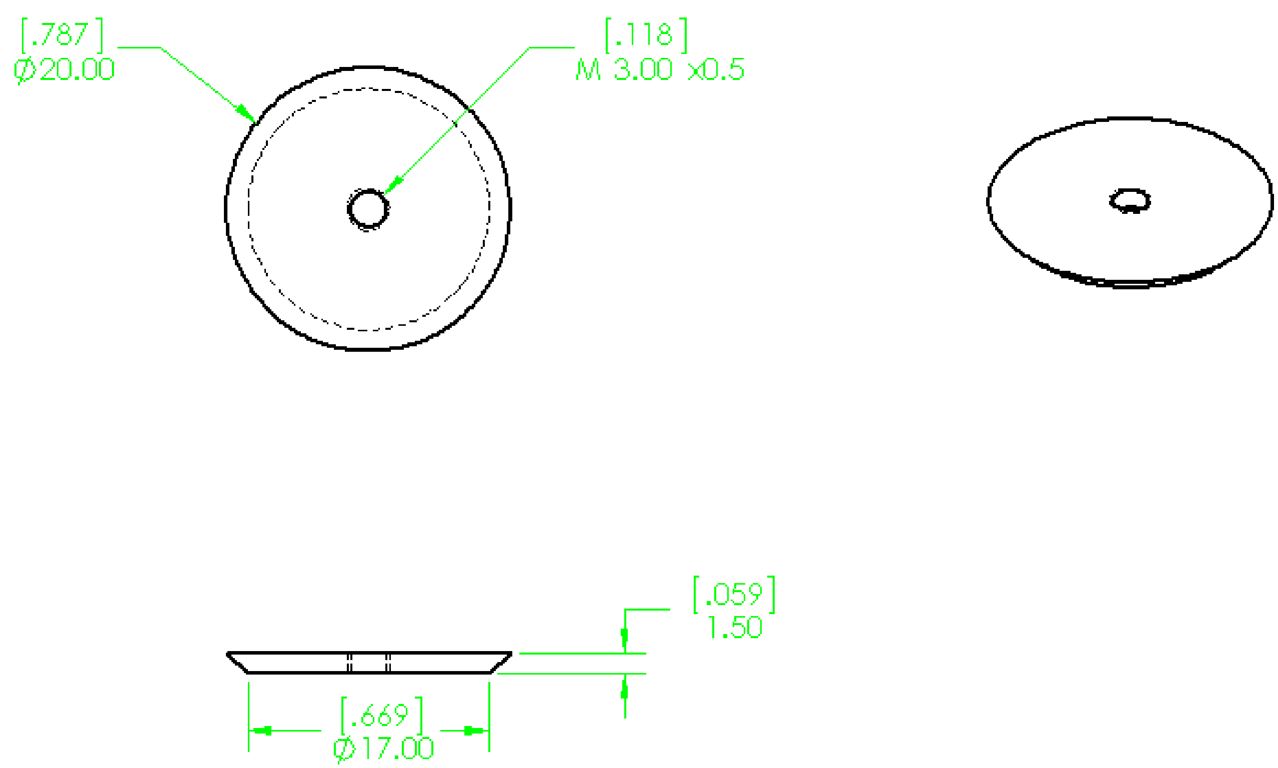


C.V.B.T.

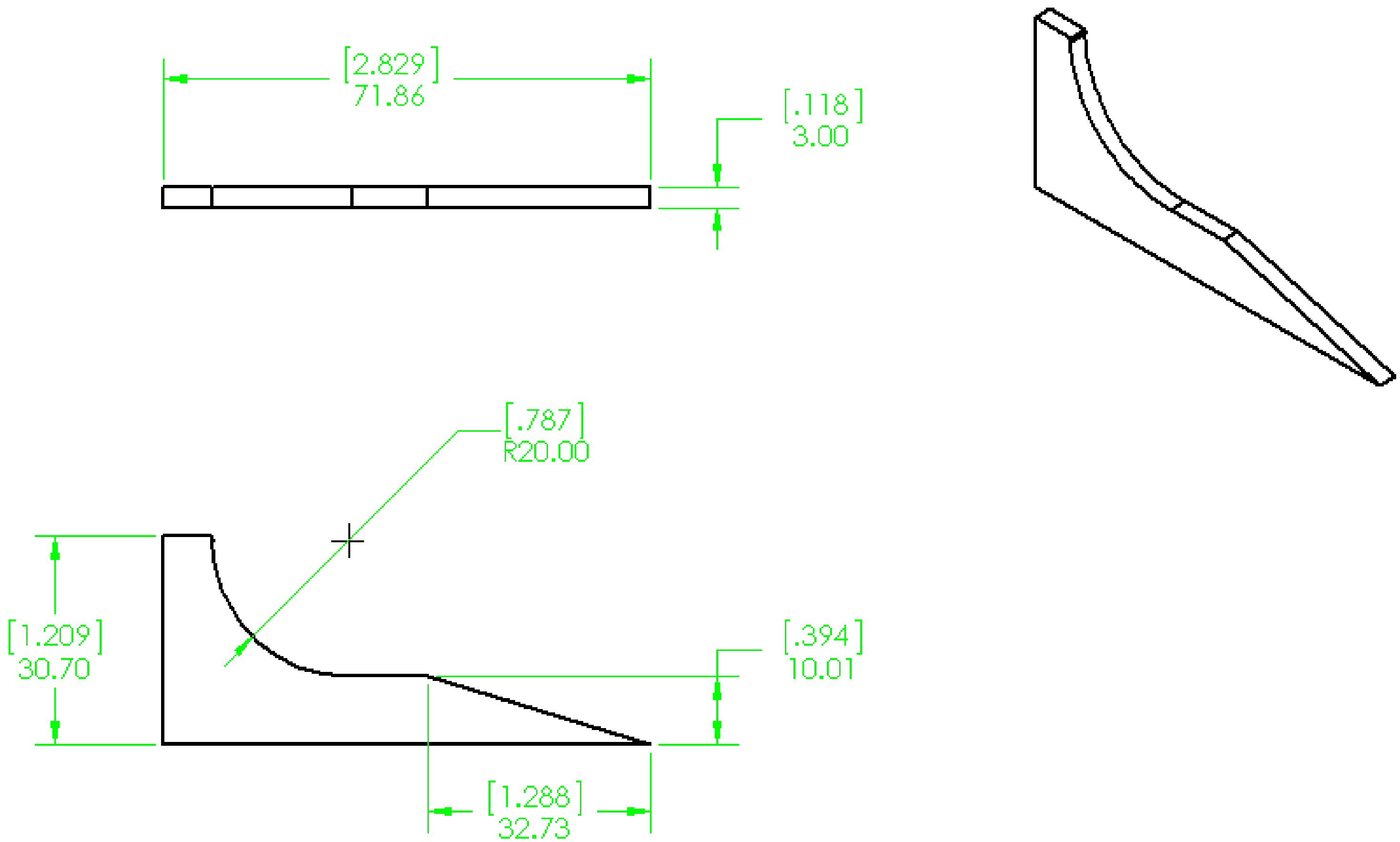
PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.055 KG. UNITS ARE MILLIMETRES [INCHES]			
DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
ENGR.			No.	MATERIAL	QTY.
CHKD.			TITLE	LID No. 1401	SHT 1/1



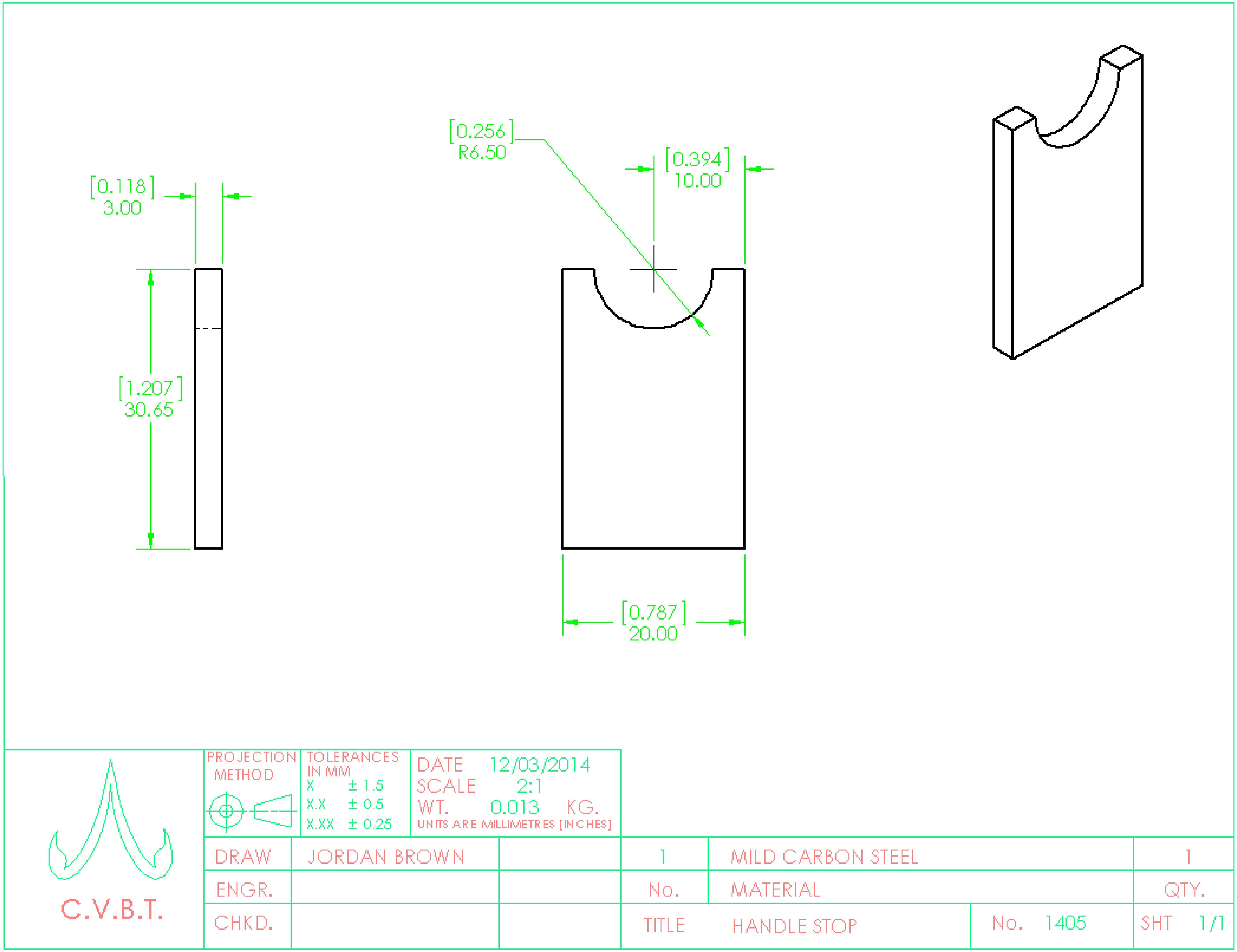
C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 2:1 WT. 0.083 KG. UNITS ARE MILLIMETRES [INCHES]				
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL		1
	ENGR.			No.	MATERIAL		QTY.
	CHKD.			TITLE	LID CYLINDER	No. 1402	SHT 1/1



C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 2:1 WT. 0.003 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL	2
	ENGR.			No.	MATERIAL	QTY.
	CHKD.			TITLE	MALE DOWEL No. 1403	SHT 1/1



C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 1:1 WT. 0.019 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL	2
	ENGR.			No.	MATERIAL	QTY.
	CHKD.			TITLE	TOGGLE REST No. 1404	SHT 1/1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3.00
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30.65
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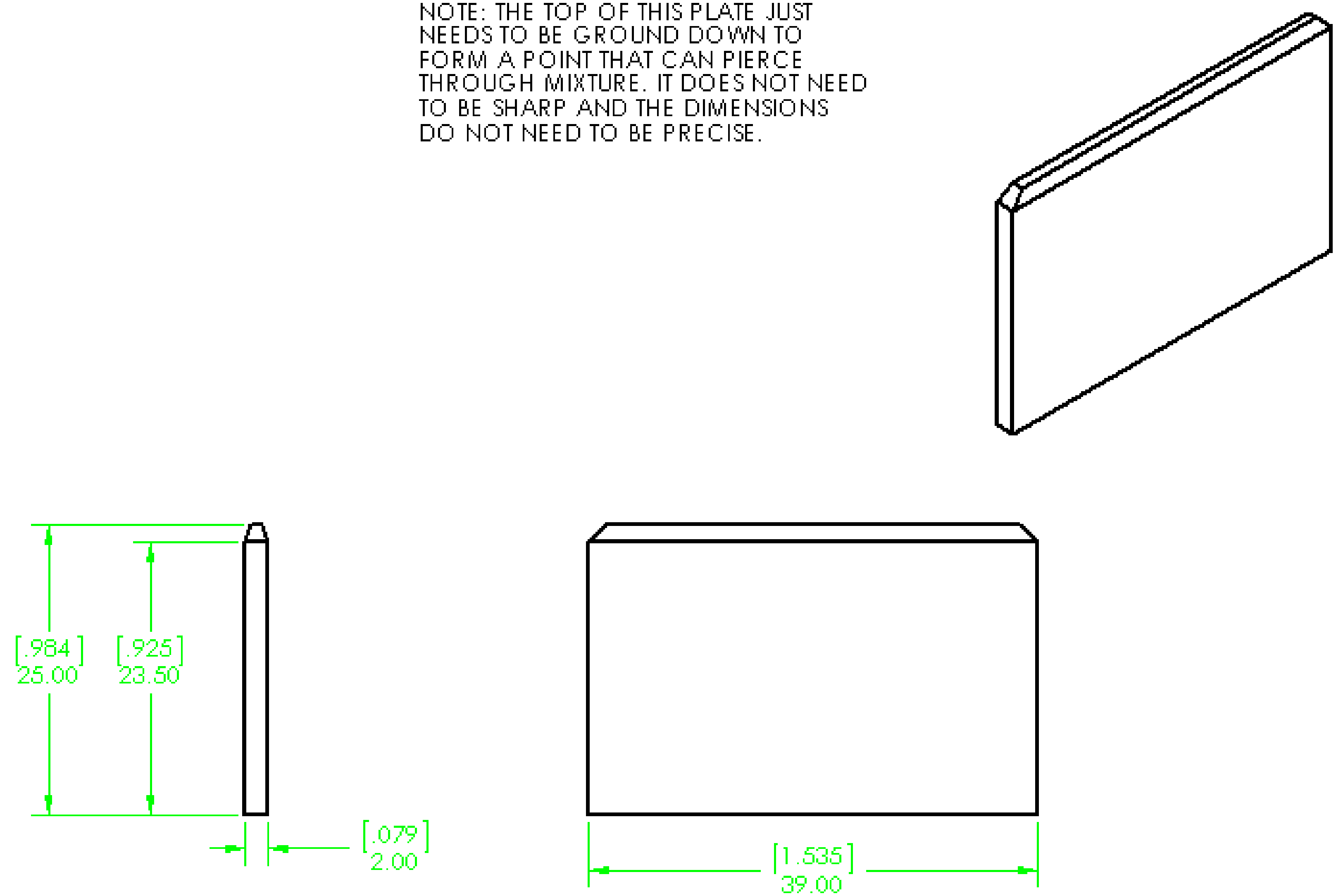
R6.50
[0.394]
10.00
[0.787]
20.00
C.V.B.T.
PROJECTION METHOD
TOLERANCES IN MM
X ± 1.5
X.X ± 0.5
X.XX ± 0.25
DATE 12/03/2014
SCALE 2:1
WT. 0.013 KG.
UNITS ARE MILLIMETRES [INCHES]
DRAW JORDAN BROWN
ENGR.
CHKD.
1
No.
TITLE
MILD CARBON STEEL
MATERIAL
HANDLE STOP
No. 1405
1
QTY.
SHT 1/1

NOTE: THE TOP OF THIS PLATE JUST NEEDS TO BE GROUND DOWN TO FORM A POINT THAT CAN PIERCE THROUGH MIXTURE. IT DOES NOT NEED TO BE SHARP AND THE DIMENSIONS DO NOT NEED TO BE PRECISE.



C.V.B.T.	PROJECTION METHOD	TOLERANCES IN MM X ± 1.5 X.X ± 0.5 X.XX ± 0.25	DATE 12/03/2014 SCALE 2:1 WT. 0.015 KG. UNITS ARE MILLIMETRES [INCHES]			
	DRAW	JORDAN BROWN		1	MILD CARBON STEEL	1
	ENGR.			No.	MATERIAL	QTY.
	CHKD.			TITLE	SEPARATOR PLATE No. 1003	SHT 1/1

Appendix D: List of Vendors, Contact Information and Pricing

Vendor	Country	Phone	Email
OnlineMetals	US	206-285-8603	sales@onlinemetals.com
Bolt Depot	US	1-866-337-9888	info@boltdepot.com
MRT Steel	Thailand	+(66) 2897-2610-5	sale@mrt-steel.com

Appendix E: Detailed Supporting Analysis

Tipping Analysis

1

Static Analysis : Tipping

The purpose of this calculation is to find the length of "feet" necessary to prevent the press from tipping during the compression stroke and ejection stroke.

L_W = length of "feet," from center of mass to tip

W = weight of press

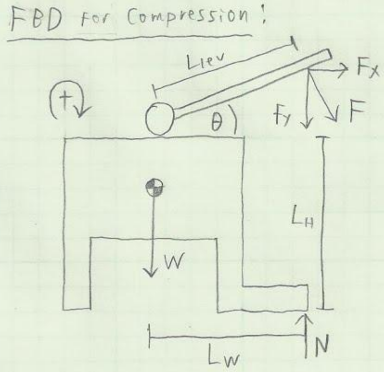
L_{lev} = Length of lever

F = Applied Force

L_p = Distance from center of mass to lever pivot

L_H = Height from ground to lever pivot

FBD for Compression:



$$F_x = F\sin\theta$$
$$F_y = F\cos\theta$$

Analysis for Compression:

$$\Sigma M = 0 = F_x(L_H + L_{lev}\sin\theta) + F_y(L_{lev}\cos\theta - L_w) - WL_w$$

$$0 = F\sin\theta(L_H + L_{lev}\sin\theta) + F\cos\theta(L_{lev}\cos\theta - L_w) - WL_w$$

$$0 = F\sin\theta L_H + FL_{lev}\sin^2\theta + FL_{lev}\cos^2\theta - F\cos\theta L_w - WL_w$$

$$0 = F(\sin\theta L_H + L_{lev}) - L_w(F\cos\theta + W)$$

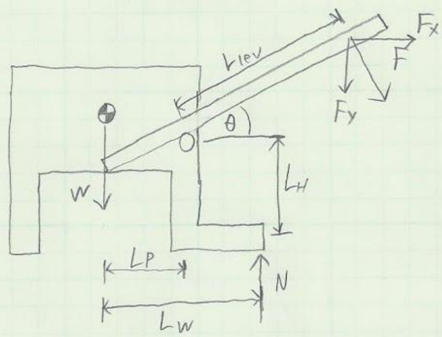
Tipping Analysis cont.

2

$$\boxed{L_w = \frac{F(\sin\theta\, L_H + L_{lev})}{F\cos\theta + W}}$$

FBD for Ejection:

Assuming lever doesn't slide on pivot, only rotates



$F_x = F\sin\theta$

$F_y = F\cos\theta$

Analysis for ejection:

$$\Sigma M = 0$$

$$0 = F_x(L_H + L_{lev}\sin\theta) + F_y(L_{lev}\cos\theta + L_p - L_w) - WL_w$$

$$0 = F\sin\theta(L_H + L_{lev}\sin\theta) + F\cos\theta(L_{lev}\cos\theta + L_p - L_w) - WL_w$$

$$0 = FL_H\sin\theta + FL_{lev}\sin^2\theta + FL_{lev}\cos^2\theta + FL_p\cos\theta - FL_w\cos\theta - WL_w$$

$$0 = F(L_H\sin\theta + L_{lev} + L_p\cos\theta) - L_w(F\cos\theta + W)$$

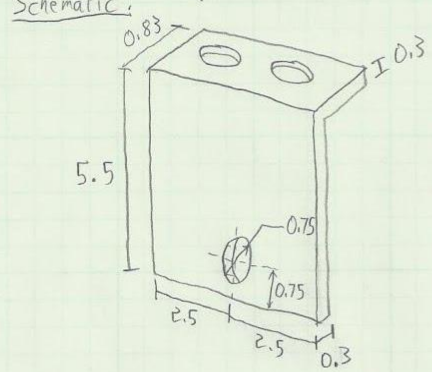
$$\boxed{L_w = \frac{F(L_H\sin\theta + L_{lev} + L_p\cos\theta)}{F\cos\theta + W}}$$

Connector Plate Analysis

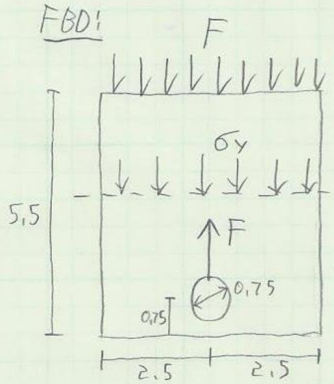
1

Stress Analysis: Ram Carriage Plate

Schematic: Dimensions in cm



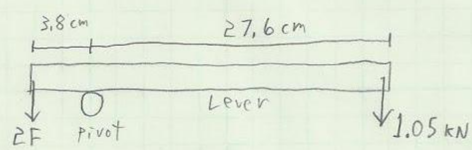
FBD:



Analysis:

Here two methods will be used to determine whether or not the ram support plates will fail under compressive stress.

- Finding force applied to ram carriage



F = Force applied to one plate
Our design load is 1.5 × the weight of a human, which is 1.05 kN

$$2F(3.8\,cm) = (1.05\,kN)(27.6\,cm)$$

$$F = 3.81\,kN$$

- Finding compressive stress using cross sectional area

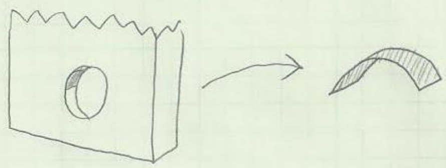
$$A = (0.3\,cm)(5\,cm) = 1.5\,cm^2$$

$$\sigma_{y_1} = \frac{F}{A} = \frac{3.81\,kN}{1.5\,cm^2} = \frac{3810\,N}{1.5\times10^{-4}\,m^2} = \boxed{25.4\,Mpa}$$

$$S_y \text{ for steel} = 370\,Mpa$$

2

• Finding Compressive stress using hole area



$$A = \frac{\pi D}{2} \cdot t = \frac{\pi(0.75\text{ cm})}{2} \cdot 0.3\text{ cm} = 3.53 \times 10^{-5}\ m^2$$

$$\sigma_{y_2} = \frac{F}{A} = \frac{3810\ N}{3.53 \times 10^{-5}\ m^2} = \boxed{107.93\ MPa}$$

Conclusion:

$\sigma_{y_1} = 25.4$ Mpa

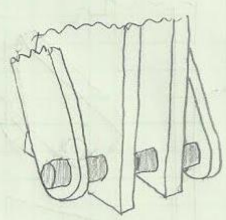
$\sigma_{y_2} = 107.93$ Mpa

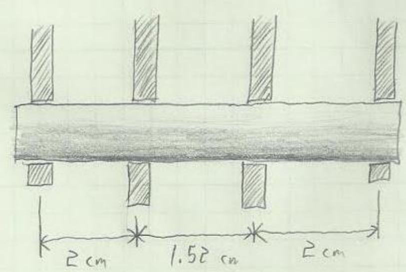
$S_{y\,steel} = 370$ Mpa

Since $S_{y\,steel} > \sigma_{y_1}$ and $S_{y\,steel} > \sigma_{y_2}$, it is safe to assume that the ram carriage plate meets our design criteria.

Stress Analysis: Ram Pin

Schematic:



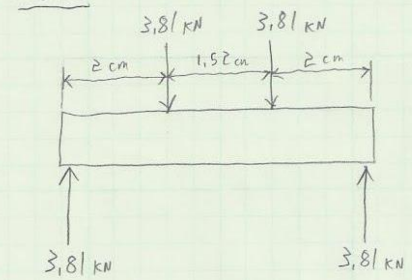


The Force on each contact point along the pin, from the previous analysis, is 3.81 kN

Lever-Ram Fastener

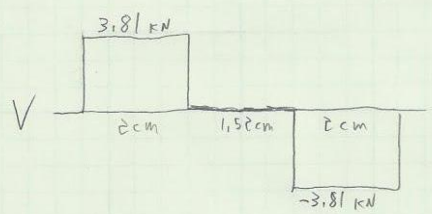
3

FBD:

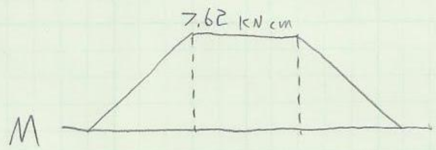


Analysis:

This bending member will be analyzed to find the necessary diameter to avoid failure, using shear and moment diagrams.



$(3.81\ kN)(2\ cm) = 7.62\ kNcm$



$7.62\ kNcm = 76.2\ Nm$

$$\sigma = \frac{Mc}{I} = \frac{(76.2\ Nm)(r)}{\left(\frac{\pi (2r)^4}{64}\right)} \leq S_{y\,steel} = 370\ Mpa$$

$$\frac{97.0208\ Nm}{r^3} = 370\ MPa$$

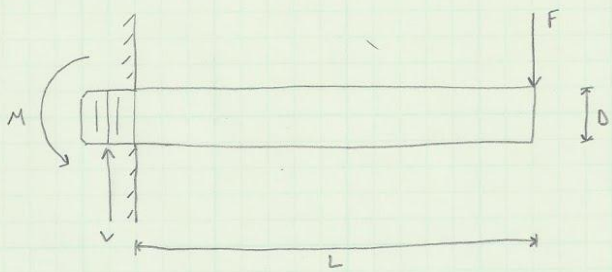
$$r \geq 6.40\ mm \Rightarrow \boxed{D \geq 1.28\ cm}$$

Conclusion: The design diameter of the ram carriage pin should be 1.2 cm.

Handle Analysis

1/1

Stress Calculation of Handle



This calculation is solving for the diameter of the handle.

$F = 1.05\ kN$ (Design choice)

$L = 5\ cm$

For low-carbon steel: $\sigma_y = 370\ MPa$

$$M_{max} = FL = 1.05\ \cancel{kN}\ (5\ \cancel{cm})\left(\frac{1000N}{1\ \cancel{kN}}\right)\left(\frac{m}{100\ \cancel{cm}}\right) = 52.5\ N\cdot m$$

$$\sigma_{bend} = \frac{M\,y}{I}$$

$$y = r$$

$$I_{cyl} = \frac{\pi}{4} r^4$$

$$\sigma_{bend} = \frac{M\,\cancel{r}}{\frac{\pi}{4} r^{\cancel{4}\,3}}$$

$$\left(\frac{N/m^2}{\cancel{Pa}}\right)\left(\frac{10^6\ \cancel{Pa}}{\cancel{MPa}}\right)370\ \cancel{MPa} = \frac{52.5\ \cancel{N}\cdot m}{\frac{\pi}{4}\ r^3}$$

$$r^3 = \frac{52.5\ m^3\ (4)}{\pi\ (370 \times 10^6)}$$

$$r^3 = 1.807 \times 10^{-7}\ m^3$$

$$\boxed{r = .0057\ m}$$

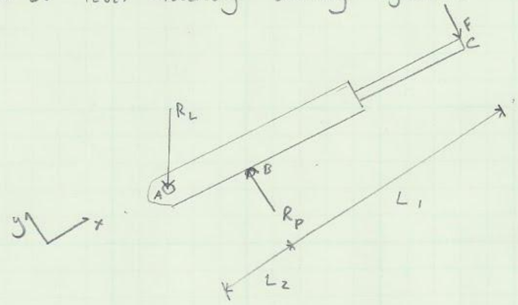
Choose a cylinder with 1.2 cm diameter

Rotation-Peg Analysis

1/3

Stress Calculation of the Peg

FBD of lever Assembly during ejection:



$F = 1.05\ kN$
$L_1 = 18\ cm$
$L_2 = 2.7\ cm$

$$\Sigma M_A = 0$$

$$R_p(L_2) - F(L_1 + L_2) = 0$$

solve for R_p, the force on the peg, in order to calculate the shear stresses in it

$$R_p(2.7\,cm) - 1.05\ kN(18\,cm + 2.7\,cm) = 0$$

$$R_p(2.7) = 1.05\ kN(20.7)$$

$$R_p = 8050\ N$$

Rotation-Peg Analysis cont.

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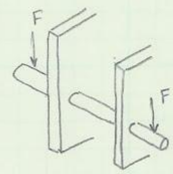
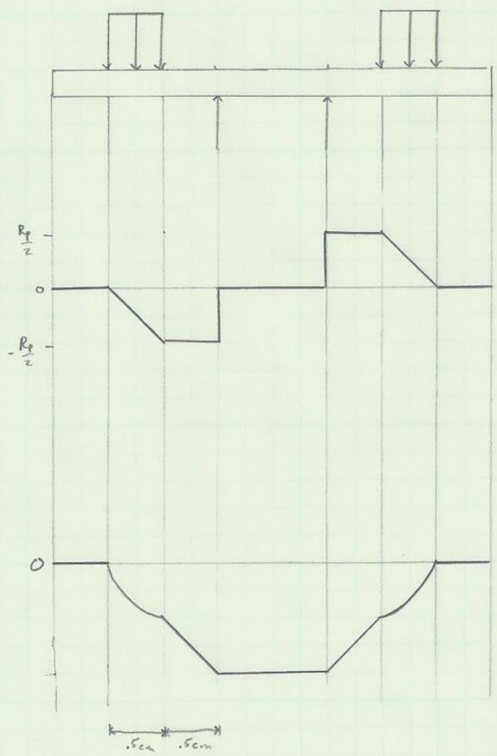
Now with the force on the peg acquired, lets look at beam stresses. The force is applied on two sides of the peg cylinder



$F = \frac{R_p}{2}$

The force is also distributed along the width of the contact area



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$$M_{max} = \frac{R_p}{2}(.5cm) + \frac{R_p}{2}(.5cm)$$

$$M_{max} = R_p(.5cm)$$

$$= 8050\,N(.5cm)\left(\frac{m}{100cm}\right)$$

$$M_{max} = 40.25\ N\cdot m$$

$$\sigma_{bend} = \frac{My}{I}$$

$$y = r$$

$$I_{cyl} = \frac{\pi}{4}r^4$$

$$\sigma_{bend} = \frac{M\cancel{r}}{\frac{\pi}{4}r^{3}}$$

$$\left(\frac{N/m^2}{Pa}\right)370\times10^6\,Pa = \frac{40.25\ N\cdot m}{\frac{\pi}{4}r^3}$$

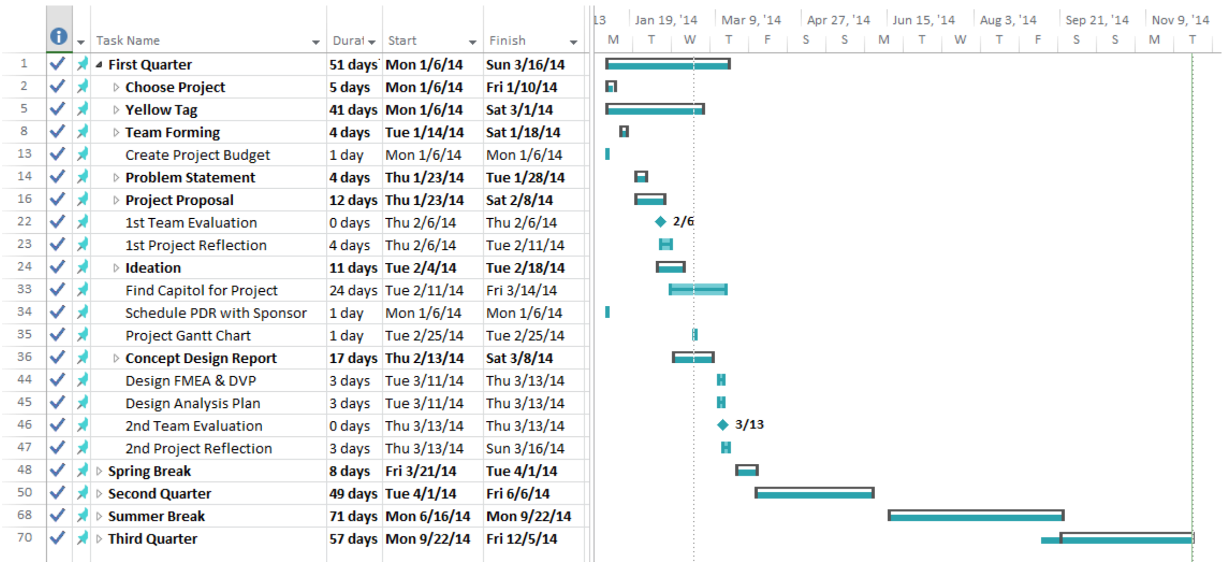
$$r^3 = 1.385\times10^{-7}\,m^3$$

$$r = .0052\,m$$

$$\boxed{r = .52\ m}$$

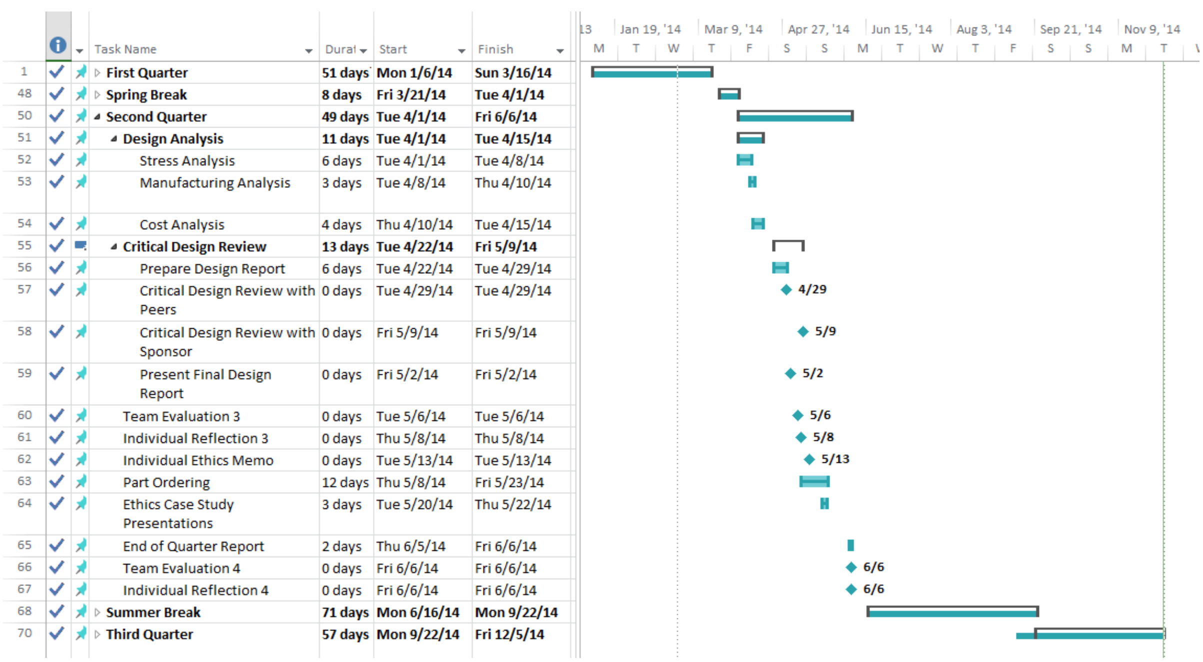
Choose a cylinder with diameter = 1.2 cm

Appendix F: Gantt Chart



ID	Task Name	Duration	Start	Finish
1	**First Quarter**	**51 days**	**Mon 1/6/14**	**Sun 3/16/14**
2	**Choose Project**	**5 days**	**Mon 1/6/14**	**Fri 1/10/14**
5	**Yellow Tag**	**41 days**	**Mon 1/6/14**	**Sat 3/1/14**
8	**Team Forming**	**4 days**	**Tue 1/14/14**	**Sat 1/18/14**
13	Create Project Budget	1 day	Mon 1/6/14	Mon 1/6/14
14	**Problem Statement**	**4 days**	**Thu 1/23/14**	**Tue 1/28/14**
16	**Project Proposal**	**12 days**	**Thu 1/23/14**	**Sat 2/8/14**
22	1st Team Evaluation	0 days	Thu 2/6/14	Thu 2/6/14
23	1st Project Reflection	4 days	Thu 2/6/14	Tue 2/11/14
24	**Ideation**	**11 days**	**Tue 2/4/14**	**Tue 2/18/14**
33	Find Capitol for Project	24 days	Tue 2/11/14	Fri 3/14/14
34	Schedule PDR with Sponsor	1 day	Mon 1/6/14	Mon 1/6/14
35	Project Gantt Chart	1 day	Tue 2/25/14	Tue 2/25/14
36	**Concept Design Report**	**17 days**	**Thu 2/13/14**	**Sat 3/8/14**
44	Design FMEA & DVP	3 days	Tue 3/11/14	Thu 3/13/14
45	Design Analysis Plan	3 days	Tue 3/11/14	Thu 3/13/14
46	2nd Team Evaluation	0 days	Thu 3/13/14	Thu 3/13/14
47	2nd Project Reflection	3 days	Thu 3/13/14	Sun 3/16/14
48	**Spring Break**	**8 days**	**Fri 3/21/14**	**Tue 4/1/14**
50	**Second Quarter**	**49 days**	**Tue 4/1/14**	**Fri 6/6/14**
68	**Summer Break**	**71 days**	**Mon 6/16/14**	**Mon 9/22/14**
70	**Third Quarter**	**57 days**	**Mon 9/22/14**	**Fri 12/5/14**

Figure F1: Gantt chart for the First Quarter



ID	Task Name	Duration	Start	Finish
1	**First Quarter**	**51 days**	**Mon 1/6/14**	**Sun 3/16/14**
48	**Spring Break**	**8 days**	**Fri 3/21/14**	**Tue 4/1/14**
50	**Second Quarter**	**49 days**	**Tue 4/1/14**	**Fri 6/6/14**
51	**Design Analysis**	**11 days**	**Tue 4/1/14**	**Tue 4/15/14**
52	Stress Analysis	6 days	Tue 4/1/14	Tue 4/8/14
53	Manufacturing Analysis	3 days	Tue 4/8/14	Thu 4/10/14
54	Cost Analysis	4 days	Thu 4/10/14	Tue 4/15/14
55	**Critical Design Review**	**13 days**	**Tue 4/22/14**	**Fri 5/9/14**
56	Prepare Design Report	6 days	Tue 4/22/14	Tue 4/29/14
57	Critical Design Review with Peers	0 days	Tue 4/29/14	Tue 4/29/14
58	Critical Design Review with Sponsor	0 days	Fri 5/9/14	Fri 5/9/14
59	Present Final Design Report	0 days	Fri 5/2/14	Fri 5/2/14
60	Team Evaluation 3	0 days	Tue 5/6/14	Tue 5/6/14
61	Individual Reflection 3	0 days	Thu 5/8/14	Thu 5/8/14
62	Individual Ethics Memo	0 days	Tue 5/13/14	Tue 5/13/14
63	Part Ordering	12 days	Thu 5/8/14	Fri 5/23/14
64	Ethics Case Study Presentations	3 days	Tue 5/20/14	Thu 5/22/14
65	End of Quarter Report	2 days	Thu 6/5/14	Fri 6/6/14
66	Team Evaluation 4	0 days	Fri 6/6/14	Fri 6/6/14
67	Individual Reflection 4	0 days	Fri 6/6/14	Fri 6/6/14
68	**Summer Break**	**71 days**	**Mon 6/16/14**	**Mon 9/22/14**
70	**Third Quarter**	**57 days**	**Mon 9/22/14**	**Fri 12/5/14**

Figure F2: Gantt Chart for the Second Quarter

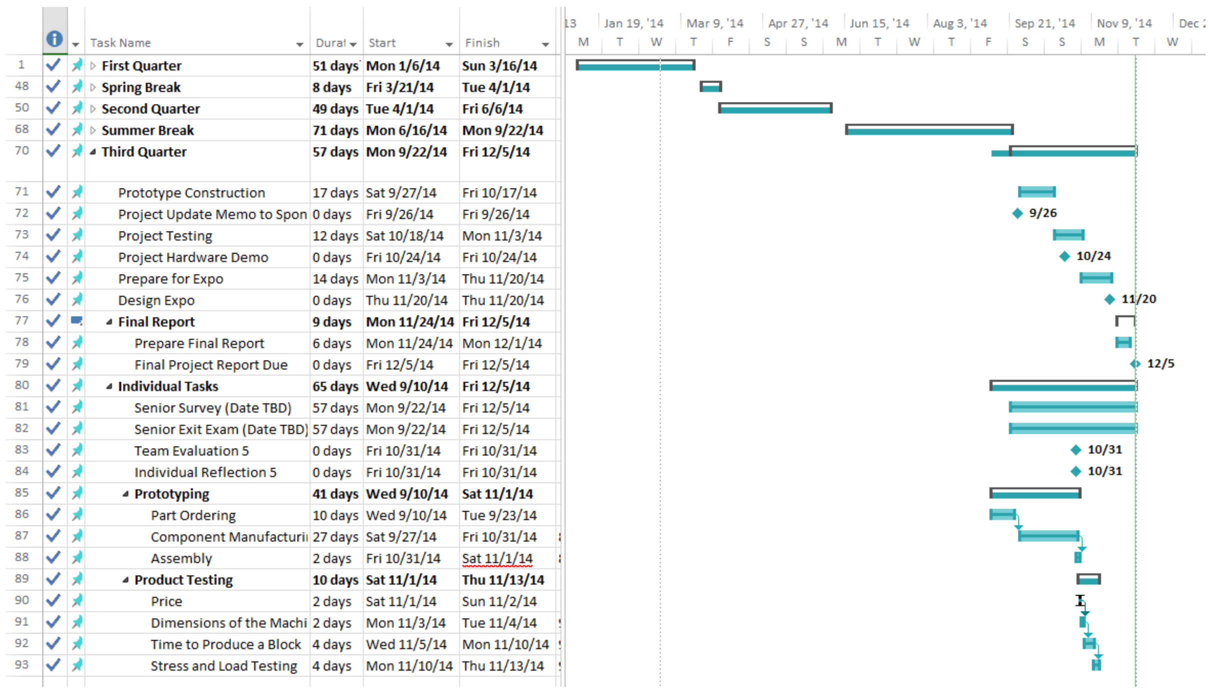


Figure F3: Gantt Chart for the Third Quarter

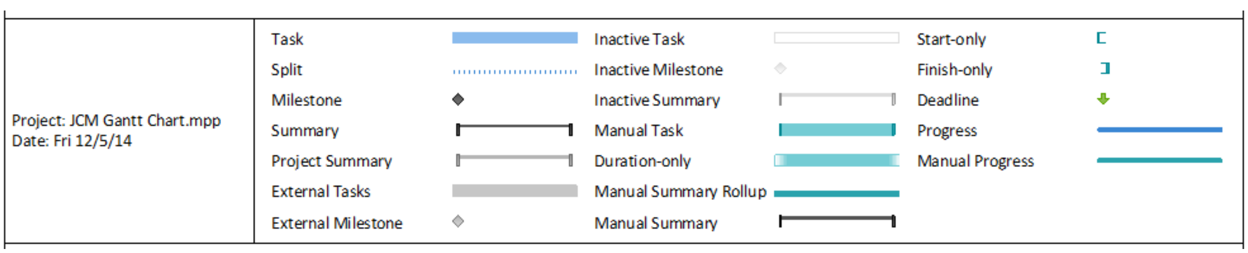


Figure F6: Gantt Chart Legend

Appendix G: Operators Manual

Operating the BP10

The BP10's operation follows the same 7-part process as the BP9. The steps are:

1. Load the mixture into the main housing. The mixture found to be best for the BP10 was 90% soil, 10% cement, and enough water content to make the mixture break into several clumps in a drop test. The amount of mixture used for one block is approximately 125 g. Fill the chamber to the brim with the mixture and press it down manually with fingers, then add the rest of the mixture.

Figure G1. Initial Loading Position

2. Making sure the tops of the cylinders and the edges of the lid and walls are clear of mixture, close the lid and move the lever-assembly into position.

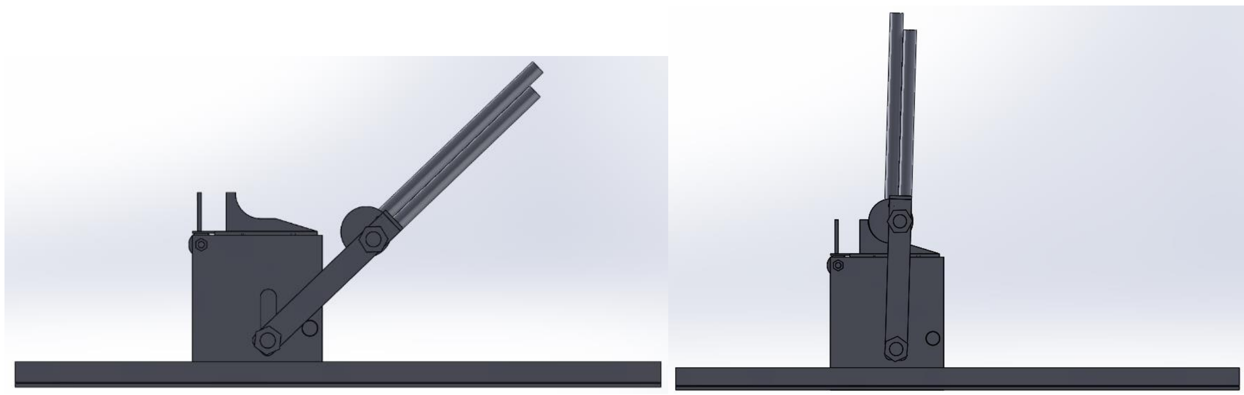


Figure G2. Closing the Lid and Moving the Lever Assembly into Position

3. Pull down on the sub-lever until it is fully horizontal and touching the lever stop.

Figure G3. Compressing the Contents

4. Move the lever-assembly back into its original position, and open the lid.

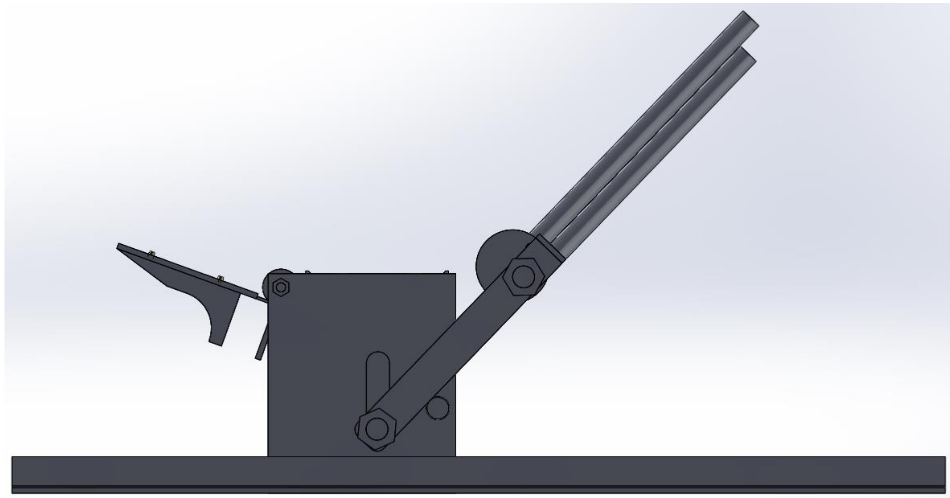


Figure G4. Returning the Assembly to its original position

5. Push down on the lever-assembly to eject the block.

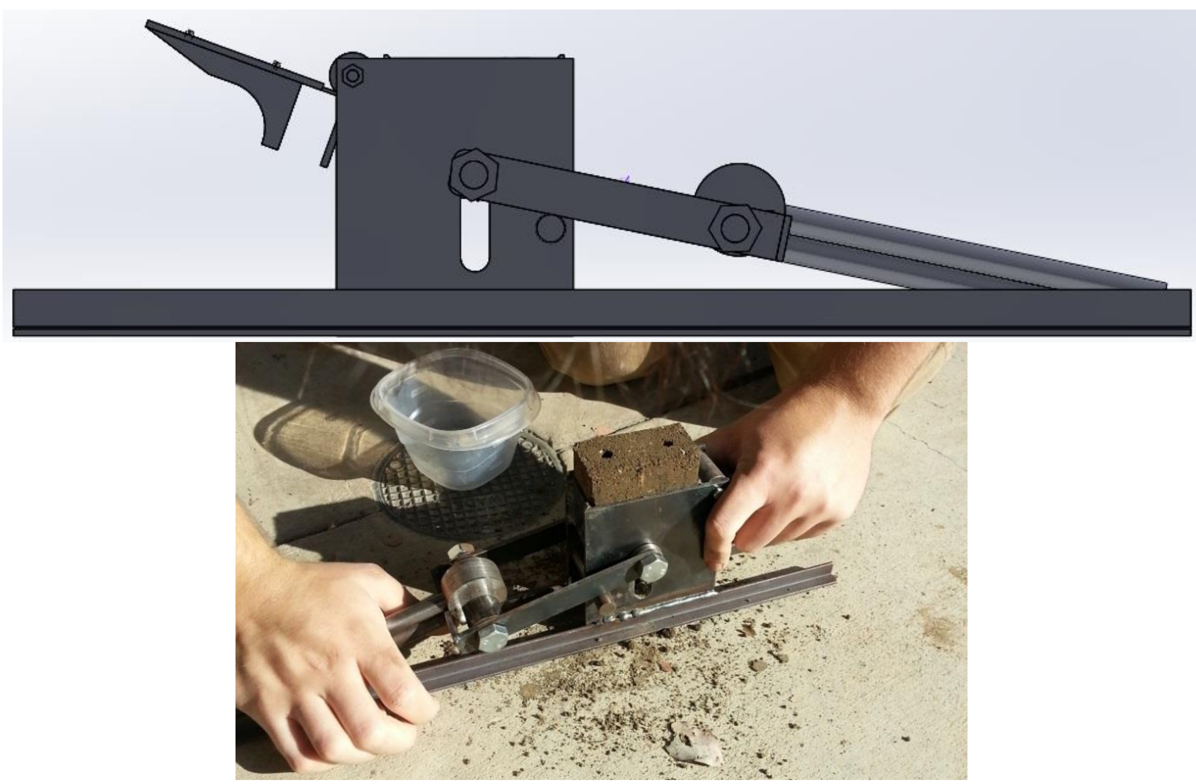


Figure G5. Ejecting the Block

6. Remove the compressed earth block from the chamber. It is likely that the press plate will stick to the block after ejecting. To remove the press plate from the block, pinch the sides between your thumb and fingers, and gently pull it off with a rocking motion.

7. Return the lid and lever-assembly into its original position.

Maintenance

The biggest issue with the BP10 is that it will often get the soil mixture stuck in between moving surfaces. This creates added friction and makes block ejection difficult. In order to combat this, the machine should be washed with water about every 25-50 blocks.

Another thing to keep in mind is that when it starts binding up, lubrication should be applied liberally to surfaces that move and rotating parts. If it is not lubricated and is difficult to use, the excess force could damage the parts.

Appendix H: DVP&R

DVP&R

				DVP&R								Jordan Brown	
												Connor Morrow	
Report Date:	3/11/2014	Sponsor:	CVBT					Component/Assembly:	BP10	REPORTING ENGINEER:	JCM Team	Michael Evans	
Item No	Specification or Clause Reference	Test Description	Acceptance Criteria	Test Responsibility	Test Stage	SAMPLES TESTED		TIMING		TEST RESULTS			NOTES
						Quantity	Type	Start date	Finish date	Test Result	Quantity Pass	Quantity Fail	
1	Price	Calculate how much the model will cost.	1500 Baht	Team	CV	1	Detailed drawing	4/12/2014	5/2/2014	4045		X	
2	Target Block Density	Use a penetrometer	5 ksc	Team	DV	30	Product output	10/6/2014	11/3/2014	DID NOT TEST	N/A	N/A	Could not find a penetrometer
3	Time to produce a block	Time ourselves compressing a block	30 blocks per hour	Team	DV	30	Prototype	10/6/2014	11/3/2014	26		X	
4	Dimensions of the Block	Measure the length, width, and height of a block produced from our model	7.5 x 3.75 x 2.5 cm	Team	DV	30	Product output	4/12/2014	4/19/2014	7.5 x 3.75 x 2.5 cm	X		
5	Maximum force applied to the handle	Perform a stress test on the machine	1.05 Kn	Team	DV	30	Prototype	10/6/2014	11/3/2014	Qualitatively Passed (without spring scale)	X		
6	Dimensions of the Machine	Measure the length, width, and height of our model	10 x 6 x 15 cm	Team	DV	1	Detailed drawing	4/26/2014	5/1/2014	90 x 17 x 45 cm		X	
7	Force required to push over	Pull it over with a spring scale	11 N	Team	DV	10	Prototype	10/6/2014	11/3/2014	Qualitatively Passed (without spring scale)	X		
8	Ability to remain upright during use	Perform a full cycle of block compression and ejection	Y/N	Team	DV	30	Prototype	10/6/2014	11/3/2014	Y	X		
9	Failure of Components during ejection	Eject a completely compressed earth block. Apply a large load at the end of the compression test to identify if the rotation peg can handle the loading	Components do not fail during ejection	Team	DV	30	Prototype	10/6/2014	11/3/2014	PASS	X		
10	Failure of Components during compression	Apply max handle force and observe components	Components do not fail under max handle force	Team	DV	30	Prototype	10/6/2014	11/3/2014	PASS	X		
11	Failure of components after a shock (falling over)	Drop press from 3 feet at mutliple angles	Components do not fail under shock due falling 3 feet	Team	DV	10	Prototype	10/6/2014	11/3/2014	PASS	X		