

**DESIGN AND CONSTRUCTION OF A FEEDING SYSTEM FOR A PELLET MILL**

**by**

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I would like to thank my parents for all the love and support they have shown me over the years. Next, I would like to thank Dr. Holtz for his assistance on my senior project.

## **ABSTRACT**

Currently Petaluma Farms has no cost effective way to get rid of the chicken manure generated on the ranch. The goal of this project is to lay out a facility to pelletize manure. The Pellet Mill that has been obtained for this project is a Farmer Automatic Pelletizer H P K 01. This mill does 500 lb/h of manure. This machine will be fed through an auger. The auger must allow for the future expansion to three mills so it must be sized to provide at least 1500 lb/h. This report includes the auger sizing as well as the appropriate sized motors to operate it. The only construction that will take place on this project is the chute that will feed material into the mills.

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## INTRODUCTION

### **Background**

In many areas of the United States that have high concentrations of poultry production getting rid of the on-farm waste in an economically and environmentally feasible way can be problematic. Currently many farms try to dispose of the manure by spreading it on fields surrounding the production facilities. This method can be very beneficial to the surrounding areas and crops because it will fertilize the land. Also according to Bernhart et. al. (2009) chicken manure in particular is the most valuable of all manures. The litter is typically made up of chicken manure, bedding material, and feathers. This combination is very beneficial to the soil because it has high nitrogen levels as well as phosphorous and potassium.

The problem with spreading the manure on the surrounding lands is production facilities are typically concentrated in central areas in order to decrease production costs (Ndegwa et. al., 1991). As urban encroachment continues the land available to spread manure on decreases, which leads to more problems from odor and flies (Petric et. al., 2009). This will lead to those areas having high levels of nitrogen and phosphorus (Kingery et. al., 1994). This has created groundwater and surface water problems as excess nutrients run off or leach into the groundwater (Moore et. al., 1998).

This environmental problem is directly related to the poultry manure having a very low density. Since the material has a low density this causes it to have a high cost of transportation. Collins et al. (1988) suggested that hauling the manure about 200 km would cost around \$18 to \$20 a ton. The nutrient value of the litter was only valued at \$17 per ton. Since the transportation cost of the manure is greater than the cost of the nutrients it is not a good economic option to haul the manure. In order to decrease the cost of transportation of the manure an option is to increase the density of the litter. A good way to do this is through compaction.

Poultry litter originally has a bulk density of about 500 kg/m<sup>3</sup> (Bernhart and Fasina, 2008). Usually this is improved by compacting the material into pellets, cubes, and bales (Bernhart et. al., 2009). The form that this project will look at is forming the litter into pellets.

In addition there is also a potential political benefit to pelletizing manure. Along with reducing volume, drying and pelletizing manure will also help reduce offensive odors (Lopez-Mosquera et. al., 2007). This could help prevent unwanted complaints and publicity to a ranch because in the U.K. 25% of agriculture odor problems are due to chicken manure (MAFF, 1992).

## LITERATURE REVIEW

For this project the pelletizer that has been selected is a Farmer Automatic Pelletizer H P K 01. This pelletizer falls under the category of a disk pelletizer. It works by first feeding the manure between the two disks. Then as the disks turn, it forces the manure into the dies that make the pellets. The diagram for this is shown in Figure 1. The benefit of this machine is that it doesn't get clogged because the rollers will grind down the compost. The disadvantage is that any hard foreign matter can cause damage to the dies.

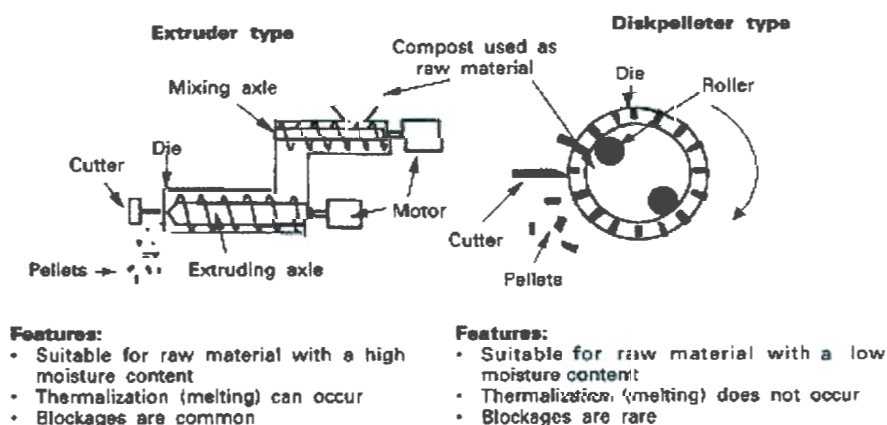


Figure 1. Diagram of Pellet Mill Operation (Hara, 2004).

The goal of this project is to develop a surge hopper for material entering the pellet mill along with looking at possible ways to load it. In order to figure out the hopper design certain flow properties of chicken litter must be examined.

In order to make to begin making pellets, certain properties of the manure had to be researched. This is also important because the flow properties of the manure will help dictate what equipment will be the best fit. These Flow properties are used to do three things. First, they are used to design and retrofit existing bins, hoppers, and feeders. Secondly, they also help to determine the cause of flow problems. Lastly, they help figure out the different bulk materials or different grades of the same material (Bernhart et. al., 2009). Flow properties are measured by the flow index, cohesion, and angle of internal friction.

From Table 1, it is possible to see how different metals affect the flow properties of the manure. From the flow index it is possible to find out the flowability of the litter. Flowability is defined as the capability of powders and granular solids to flow (Ganesan et. al., 2008). The classifications are shown in Table 2.

Table 1. Adhesive Strength and Angle of Wall Friction of Poultry Litter (Bernhart and Fasina, 2008).

Surface	Flow index	Adhesive strength (kPa)	Angle of wall friction (degrees)
Stainless steel 304-2B	2.6	1.29	35.8
Mirror-finished stainless steel	9.2	0.79	33.9
Galvanized steel	11.90	0.53	29.2

Table 2. Classification of Powder Flowability by Flow Index (Jenike, 1964).

Flowability	Very cohesive	Cohesive	Easy flowing	Free flowing
Flow index (FI)	$FI < 2$	$2 < FI < 4$	$4 < FI < 10$	$FI > 10$

One of the most important factors in making good pellets is the moisture content of the manure. The pressure used to create a pellet as well as the moisture content will significantly impact the density of the pellets. It will also affect the energy required to create them (Bernhart et. al., 2009). The results of a study conducted on the effect of moisture content of poultry litter, indicated that with an increase in moisture content, it would reduce the bulk density, particle density, and flow ability of the litter (Bernhart et. al., 2009). The study also went on to predict that poultry litter would have a maximum stability at a moisture content of 5.5% (wb). The article also suggested that this study results could change depending on the composition of the poultry litter. The litter can have lots of variability in it as a result many factors such as spilled feed and feathers. In Table 3 it shows the flow index at various moisture contents.

Table 3. Flow Indices for Poultry Litter (Bernhart and Fasina, 2008).

Moisture content (% wb)	Flow index	Classification (see Table 1)
10.3	10.01	Free flowing
18.0	4.93	Easy flowing
22.1	3.56	Cohesive
30.9	2.16	Cohesive

## **Handling**

On the ranch pellets will be exposed to various environmental conditions that can affect the integrity of the pellets. The greatest factor when determining the durability of the pellets is moisture content. A study by McMullen et. al. (2005) concluded that increasing the moisture content of the pellets would usually result in less force being required to rupture them. A graph of some of the data is shown in Figure 2. The study also concluded that pelleting would increase the bulk density by up to four times.

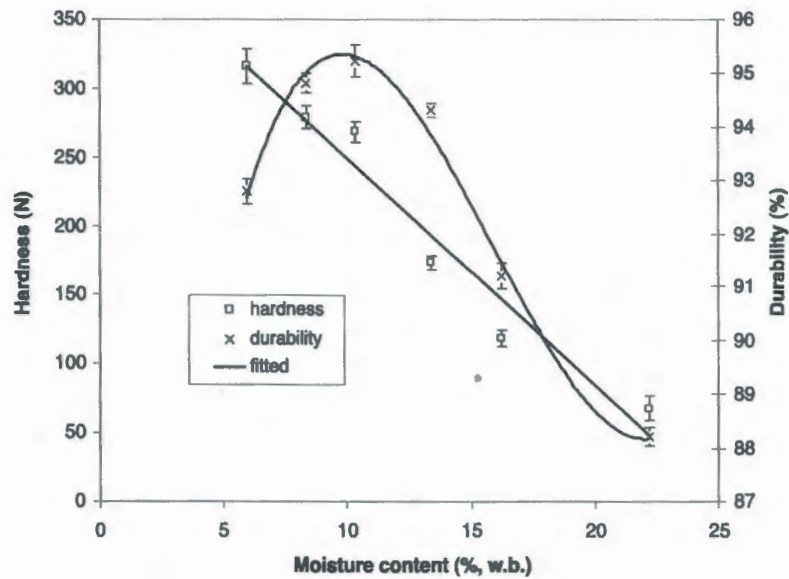


Figure 2. Effect of moisture content on hardness and durability of poultry litter pellets (McMullen et. al., 2005).

### Conveyance

The manure will be brought into the building from outside. The goal is to use an auger that is made by Chore-Time to transport it. The auger is made to transport chicken feed out of the feed bin to inside the chicken house. The auger is shown in Figure 3 and it has an auger flighting that turns inside a specially compounded PVC tubing. Some testing will have to be conducted to see if this auger will successfully transport the litter. If the results are successful some sizing charts that could be adapted for manure are shown in Table 4.



Figure 3. Chore Time Flex Augers (Chore-Time, 2014).



Table 4. Flex Auger Specification (Chore-Time, 2014).

	Model 75	Model HMC	Model 90 (Standard)	Model 90 (High Speed)	Model 90 (High Speed)	Model 108 (Standard)	Model 108 (High Speed)
Feed Delivery Rate per Minute*	50 pounds (20 kg)	50 pounds (20 kg)	100 pounds (45 kg)	120 pounds (55 kg)	170 pounds (75 kg)	220 pounds (100 kg)	250 pounds (110 kg)
Power Unit RPM:	348	348	348	425 (60 Hz only)	584	348	425 (60 Hz only)
Outside Diameter of Tube	3 inches (75 mm)	3.5 inches (90 mm)	3.5 inches (90 mm)	3.5 inches (90 mm)	3.5 inches (90 mm)	Steel – 4.25 inches (108 mm) PVC – 4.5 inches (115 mm)	Steel – 4.25 inches (108 mm) PVC – 4.5 inches (115 mm)
Corner Radius	5 feet (1.5 meters)	5 feet (1.5 meters)	5 feet (1.5 meters)	5 feet (1.5 meters)	5 feet (1.5 meters)	5 feet (1.5 meters)	5 feet (1.5 meters)
Recommended Motor at Maximum Length	1 HP	1 HP	1 HP	1 HP	1.5 HP	1.5 HP	2 HP
Maximum Length	200 feet (60 m)	150 feet (45 m)	150 feet (45 m)	120 feet (35 m)	120 feet (35 m)	150 feet (45 m)	150 feet (45 m)
Standard Extension**	245 feet (75 m)	185 feet (55 m)	185 feet (55 m)	150 feet (45 m)	N/A	185 feet (55 m)	185 feet (55 m)
Typical Applications	Broiler and turkey production or hog grow and finish houses	Dairy cattle feeding or large particle feeds	Broiler, breeder, turkey or layer houses; or large hog buildings	Broiler, breeder, turkey or layer houses; or large hog buildings	Broiler breeder houses only	Broiler, breeder or layer houses; bin filling, grain moving or stationary mills	Breeder or layer houses; bin filling, grain moving or stationary mills

## Hopper Design

The goal of the surge hopper design is to have mass flow through the hopper. Mass flow in a hopper is beneficial because it means that all of the material in the hopper is moving as it empties. This ensures that there is no dead zones in the hopper where material gets stuck and never empties. Funnel flow is what happens when the material only empties in the middle of the hopper. A diagram showing the difference between the two is shown in Figure 4.

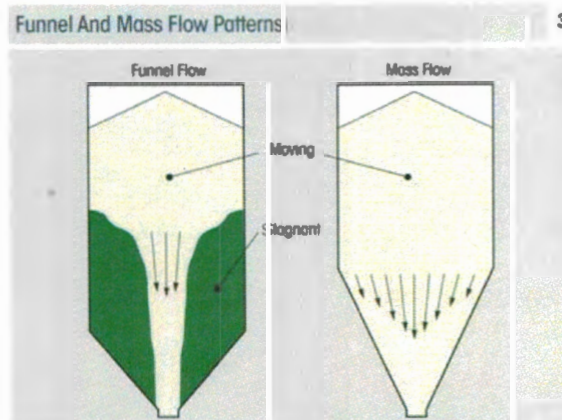


Figure 4: Diagram of Mass vs. Funnel Flow.

Depending on numerous factors such as moisture content, angle of repose, and sidewall material there could be ratholing, bridging, or funnel flow. These are undesirable characteristics that may need a flow aid to correct. Most of these factors will have to be discovered through testing. The hopper will probably be similar to the hopper shown below in Figure 5 and then subjected to testing.



Figure 5: Possible Hopper Design.

## PROCEDURES AND METHODS

### Design Procedure

The initial design needs to have the bottom of the hopper converge to an 8.5" by 8.5" square flange. A picture of it is shown below in Figure 6. The initial plan was to have a surge hopper above this inlet in order to allow the auger not to run all the time. This plan was discarded when it was discovered that the Chore-Time Flex Auger would not provide enough flow for the future expansion to three mills.

**Customer Constrains.** Steve Mahrt on behalf of Petaluma Farms wanted the system to be able to accommodate future expansion to three pellet mills. Various ideas on how to



Figure 6. Manure Inlet into Pellet Mill.

provide this flow rate were discussed. One option was to use three individual auger to feed the mills. This idea was rejected because it was deemed too expensive. A single auger from McMaster-Carr would cost \$300, and individual augers would cost \$188 each. This cost also does not take into account the added cost of additional motors, hoppers, and all of the wiring to go with it. The second option was to line the three mills up in order to feed them with one auger. This auger needed to be sized in order to ensure that it would deliver enough manure to keep all of the mills full.

This auger would get manure from an existing hopper shown in Figure 7 below. This hopper will be fed manure from a rotating screen that will take out anything in the manure that is too big to pass through the mill. This screen will also help break up any big chunks of manure that could clog the system later on.





Figure 7. Existing Hopper.

The hopper is emptied by an auger in the bottom. There is currently a five inch auger in the bottom, but this will have to be modified in order to accommodate a larger auger. The hopper will also have to be raised into the air in order for the material in the auger to feed the mill.

**Auger Sizing.** The first step in deciding how big to size the augers was to determine the density of the manure. In order to determine this a .67 ft<sup>3</sup> bucket was filled with manure out of the chicken house and weighed on a scale. The weights are shown below in Table 5.

Table 5. Manure Weights and Avg. Density.

Weight (lbs)	Density (lbs/ft <sup>3</sup> )
23.4	35.0
23	34.4
24	35.9
24	35.9
23.8	35.6

Average= 35.4

The auger sizing chart in Appendix B was developed by estimating the flow rate through an auger. First, the total area of the auger was computed. Then, the area of the shaft and an estimation of the area lost due to the flighting was subtracted from the total area of the auger. Next, the total area left was multiplied by the length of the auger in order to get the total volume of the auger in cubic feet. Then, the volume was multiplied by the manure density to come up with the weight of manure the auger could hold. From there, a table was



made that contained many different pitch sizes. Using the different pitches allowed the number of coils per auger to be computed. After this the flow rate per revolution of the auger was determined. It was then multiplied by the revolutions per minute of the auger in order to get pounds per minute of manure. The last step was to convert this number to pounds per hour of manure the auger could deliver.

From measurements taken on the existing auger in the hopper it has 5 coils of flighting in 25 inches. This gives it a pitch of 5 inches. This auger was sized by Farmer Automatic to deliver 500 lb/h. From the auger flow rate chart shown in Appendix B, it was determined that if it only supplied 500 lb/h, then it was assumed that the auger was only running 10% full.

In order to size the new auger it was again assumed that the auger would only run at 10% of capacity. Again from the auger flow rate chart in Appendix B, it was determined that if only using standard pitches an 8 inch auger was the correct size. A standard pitch is when the pitch is equal to the auger diameter as seen in Figure 8. It was decided to use a standard pitch because they can convey a wide range of materials and are very common if replacement is needed. This would supply approximately 2100 lb/h. The extra material that is supplied to the mills will be returned to the main hopper through a return hopper to ensure that the mills always have enough material.

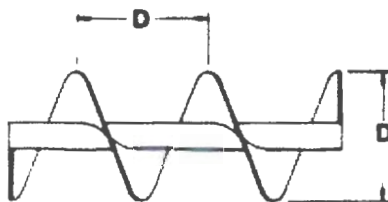


Figure 8. Illustration of Standard Pitches (Kase, 2014).

The initial design for the auger is shown below in Figure 9. This original design was changed to more of a trough design which is shown in Figure 10 for a number of reasons. The first reason is that it can be mounted with a bearing on both sides which leads to a longer service life. They are also easier to service, repair, and material can be added at any point along the conveyor (Bloome et. al., 2005).

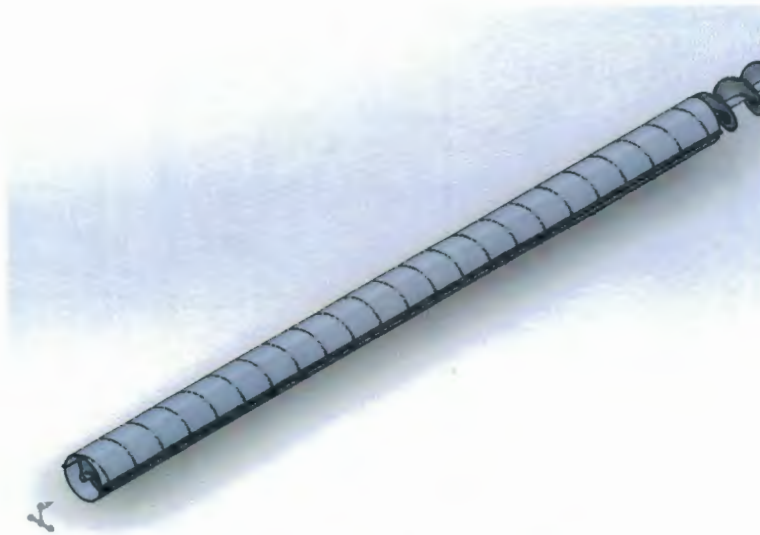


Figure 9. Original Auger Design.

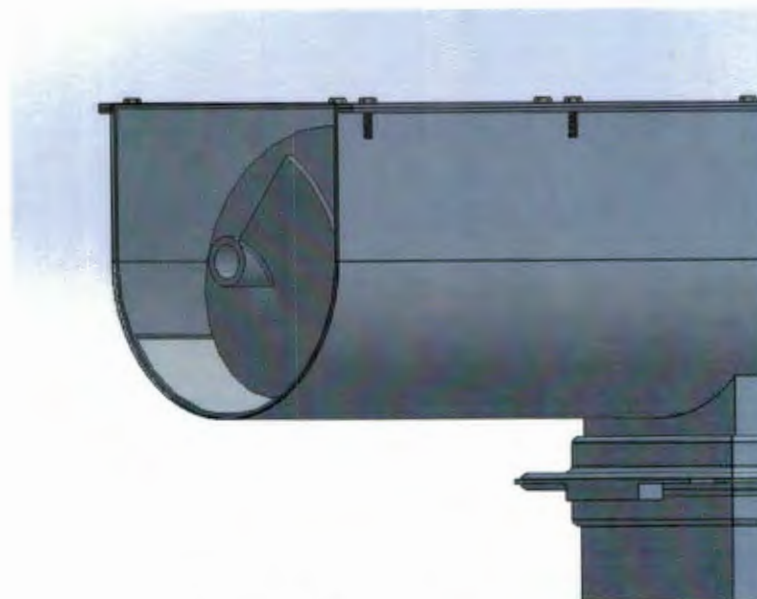


Figure 10. Final Hopper Design.

**Design of Feeder Tube.** A 6 inch square hole was cut out of the bottom of the auger housing. This hole will allow the material to fall out of the auger and into the square feeder tube. The initial design had a slider that controlled the flow rate on the bottom of the auger housing as shown in Figure 11. This design was changed because it would be hard to fabricate correctly, which could make the slider harder to adjust under operation.

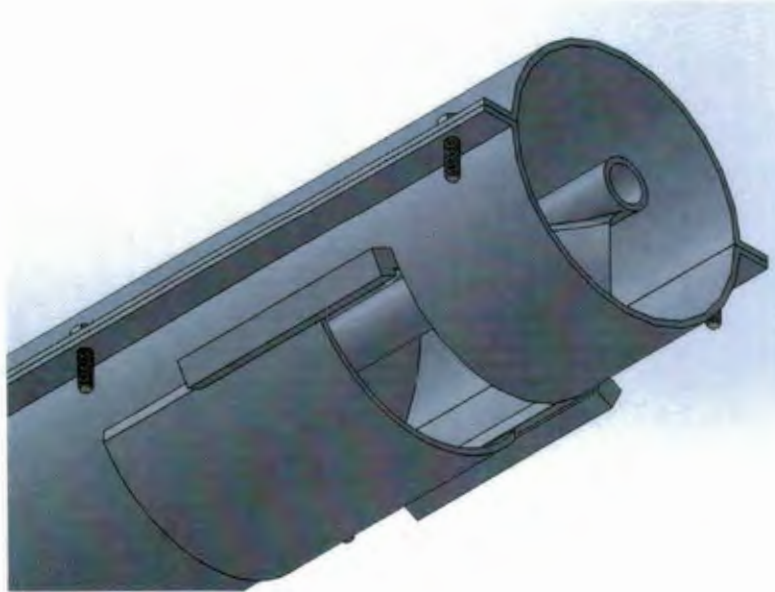


Figure 11. Initial Flow Rate Slider Design.

The final design is shown in Figure 12. This design has the flow rate adjuster located 3 inches below the bottom of the auger housing. The slider will function primary as an on/off gate. The slider rests in between a flange made out of 1/8" angle iron with a gap in the middle in order for it to move. This design is much easier to fabricate and will allow for easy shut down of a mill.

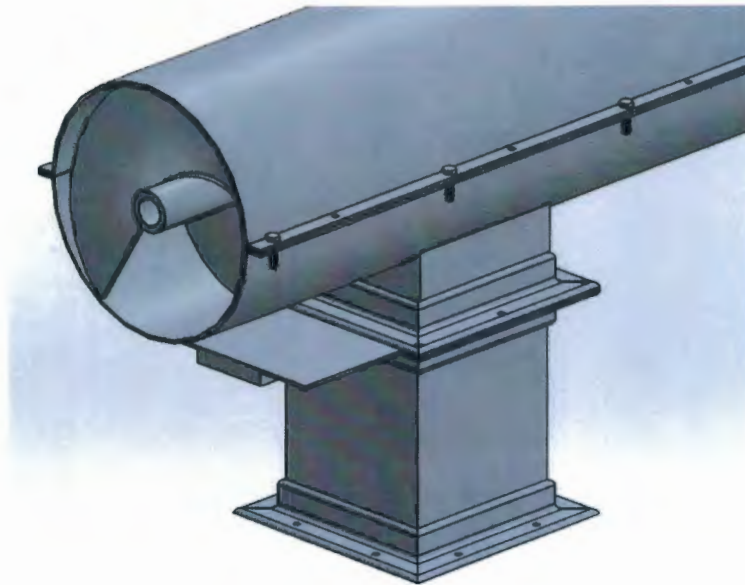


Figure 12. Final Feeder Tube Design.

**Design of Return Auger.** The return auger that will bring the material will dump material into the top of the main hopper. This will be a five inch auger in order to allow one mill to be able to shut down for maintenance and still be able to operate the remaining two. This auger will have to lift the material at least 79 inches in order to clear the top of the hopper. The initial design is shown in Figure 13.

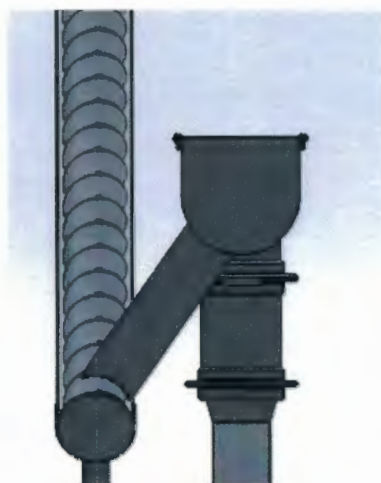


Figure 13: Initial Return Chute Design.

This design was rejected by the client because the angle of the chute feeding the return auger was not steep enough for the manure to flow. The final design is shown in Figure 14 and it has the chute as close to vertical as possible. Making the chute completely vertical was not possible because the return auger would come into contact with the main feed auger if it was any steeper of an angle. An excess door was added to the chute in order to allow access to the interior for cleaning and in case of potential clogs.

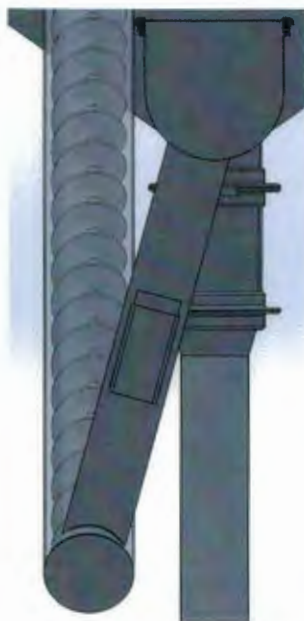


Figure 14: Final Return Chute Design.



### Construction Procedure

**Feeder Tube.** The only part of this project that is going to be constructed is the feeder tube shown in Figure 15.

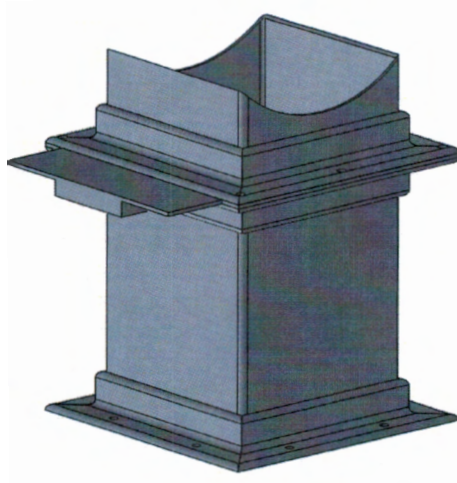


Figure 15: Feeder Tube.

The top of feeder tube that will be in contact with the auger trough will be cut out of a sheet of 12 gauge flat stock using the CNC Plasma. The part was cut out in two separate pieces. Then each individual piece was bent 90° on the press brake. The two cut pieces can be seen in Figure 16.



Figure 16: Pieces Cut on CNC Plasma.

The lower portion of the feeder tube below the flange was cut out in two pieces of 12 gauge flat stock on the Pexto Shear. Then it was bent 90° on the press brake. The bent pieces are

shown put together in Figure 17. Then the seams of the two pieces were MIG welded together.



Figure 17: Lower Feeder Tube Tacked Together.

The next portion of the construction was the flange. The flange was made out of  $1\frac{1}{2}$ "x $1\frac{1}{2}$ "x $\frac{1}{8}$ " angle iron. The metal was cut at a  $45^\circ$  angle on the bandsaw and then welded together. The welded flange is shown in Figure 18. The next step was to drill the holes for the bolts that would hold everything together. The both the top and bottom flange along with

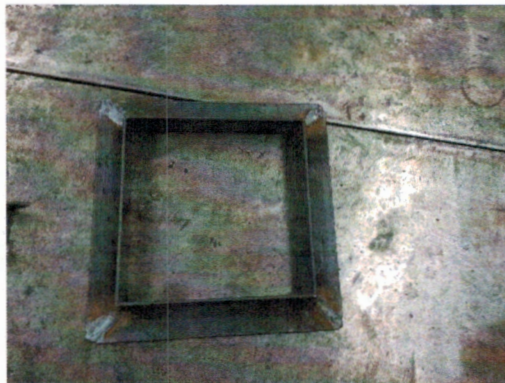


Figure 18: Welded Flange.

the spacer for the flow control slider were drilled out together to ensure everything would line up for assembly. The bolts used in the flange are  $\frac{1}{4}$ "x1" hex bolts. The holes are drilled out to  $\frac{5}{16}$ " to ensure the bolts would fit. Once all of the holes were drilled, one flange was welded to both the top and bottom pieces of the feeder tube.

The last portion that needed to be built was the slide gate. This piece was cut out of 12 gauge flat stock on the Pexto Shear. Then a piece of  $1\frac{1}{2}$ "x $1\frac{1}{2}$ "x $\frac{1}{8}$ " angle iron was welded to one side of it as a handle.

## RESULTS AND DISCUSSION

The finished design is shown in Figure 19. This design will be tried on a smaller scale using only one pellet mill at first, in order to test its functionality. If everything works as intended, then the final product will be assembled once Petaluma Farms finds all of the necessary parts.

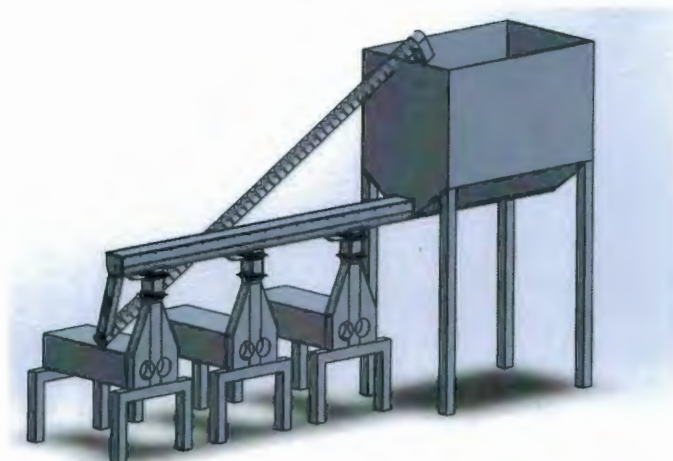


Figure 19: Overall Hopper Design.

The finished feeder tube is shown in Figure 20. Some of the dimensions were slightly different than the Solidworks drawings. This was because the bend radius for the brake in Lab 6 was different than the radius used in the construction of the drawing. This was corrected by cutting the angle iron pieces that make up the flange  $3/16$ " longer than the original drawing specified.



Figure 20: Finished Feeder Tube.

## RECOMMENDATIONS

Further calculations on the system will involve sizing the motor that will turn the auger. In between this motor there will be a gear box in order to reduce the motor speed down to 45 rpms. Depending on the gear box selected this will change the necessary motor horsepower. This was not incorporated into the design because accurate numbers on how much torque is required to turn the auger in order to deliver the manure could not be determined. This will be tested on the small scale version, and using the data acquired the final motor will be sized.

In order to help facilitate flow and prevent clogging in certain parts of the system some sort of flow aid may need to be incorporated. This flow aid would be placed on the feeder tube and would help material fall out of the auger and into the feeder tube. The only way to determine if this is needed is after the system is built and the initial design is tested. A flow aid such as the one shown in Figure 21 is recommended. This vibrator is operated by air at 80 psi and delivers 75 lb vibrations at 10,500 vpm.



Figure 21: Pneumatic Vibrator (Grainger, 2014).

Another future consideration is how to cool the pellets once they are made. When the pellets are made the dies in the mill will compress the manure to a density and length that depends on the dies being used. This process creates a lot of heat and the pellets can reach temperatures of 200 °F. The pellets come out very soft, and must be cooled before they are stored in order to harden them. When the testing of the design is done on the first mill different cooling methods will be looked at. The current idea is to take the pellets away on a twenty-one foot open faced conveyor. Along this conveyor some 24 inch fans will be placed to help cool the pellets. A potential fan is shown in Figure 22.



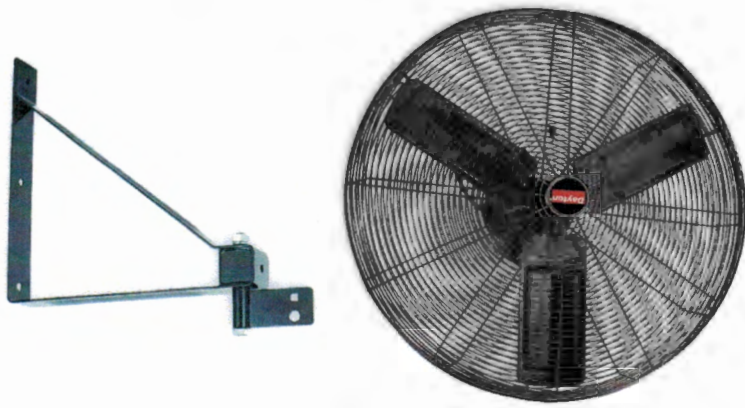


Figure 22: Cooling Fan (Grainger, 2014).

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## **APPENDIX A**

### **How Project Meets Requirements For The BRAE Major**

## **Major Design Experience**

The BRAE senior project must incorporate a major design experience. The design process usually involves the fundamental elements as outlined below.

**Establishment of Objectives and Criteria.** Project objectives and criteria are established to meet the needs of Petaluma Farms.

**Synthesis and Analysis.** The project developed a chart in order to estimate the flow rate of augers based on different densities and rpms.

**Construction, Testing, and Evaluation.** This project will be designed to meet the needs of Petaluma Farms. The only part of this design that will be built is the feeder tube that brings material from the auger to pellet mill. There will be no testing done on this project.

**Incorporation of Applicable Engineering Standards.** The final design will be wired according to NEC code.

**Capstone Project Experience.** The project will incorporate many concepts that were introduced in previous engineering classes. The project will also utilize many concepts that had to be researched further. The relevant classes include: BRAE 129, BRAE 133, BRAE 152, BRAE 234, BRAE 320, ENGL 149 and BRAE 216.

**Design Parameters and Constraints.** This project addresses a significant number of the categories of constraints listed below.

### **Physical**

The system must be capable of feeding 1500 lb/h to three different pellet mills.

### **Economic**

The process should be designed to reduce costs when built in order to maximize the profit made from the sale of the pellets.

### **Environmental**

Will reduce the smell of manure from being spread on nearby fields.

### **Ergonomical**

N/A

### **Manufacturability**

N/A (This design will produce a one of a kind machine)

**Health and Safety**

The design will incorporate the necessary guards to keep people's fingers away from pinch points.

**Ethical**

N/A

**Political**

N/A

**Productivity**

This design will need to be able to operate for hours at a time with no operator.

**APPENDIX B****Auger Sizing Table**

Auger dia (in)	Area (in^2)	Shaft Dia (in)	Area (in^2)	Total Area (in^2)	Total Area (ft^2)	Auger Length (ft)	Auger Volume (ft^3)	Area lost from flighting (ft^2)	Manure in Auger (lbs)
5	19.6	1.5	1.767	17.3	0.12	20	2.4	0.60	84.8
6	28.3	1.5	1.767	25.6	0.18	20	3.6	0.87	126.0
7	38.5	1.5	1.767	35.5	0.25	20	4.9	1.18	174.6
8	50.3	1.5	1.767	47.0	0.33	20	6.5	1.54	230.7
9	63.6	1.5	1.767	59.9	0.42	20	8.3	1.95	294.2
10	78.5	1.5	1.767	74.4	0.52	20	10.3	2.41	365.3

Want to deliver 1500 lbs/hr

Auger Speed=

45 rpm

Weight (lbs)	Volume (gal)	Volume (ft^3)	Density (lbs/ft^3)
23.4	5	0.67	35.0
23	5	0.67	34.4
24	5	0.67	35.9
24	5	0.67	35.9
23.8	5	0.67	35.6

Average= 35.4

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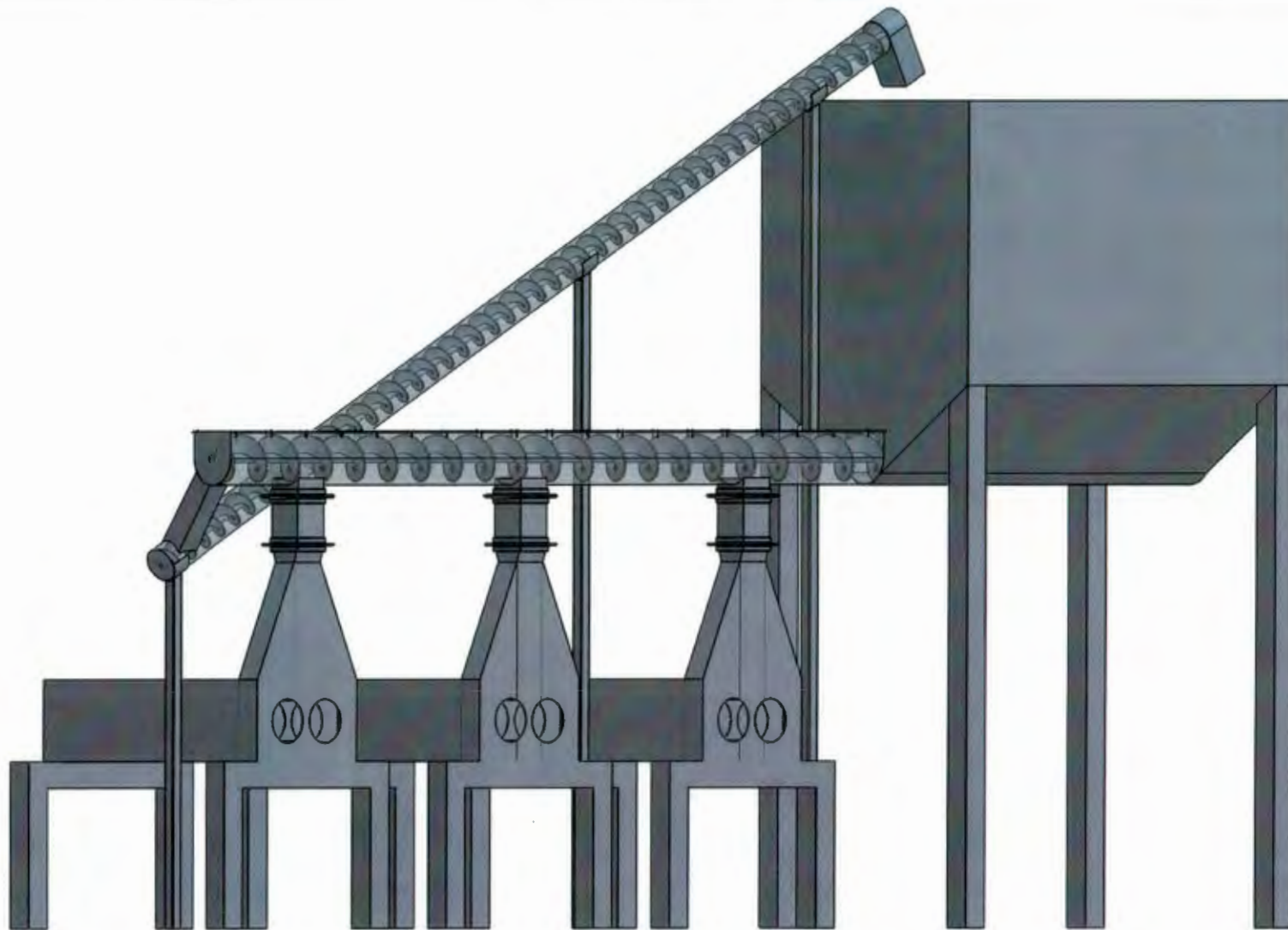
% of Auger Full= 10%		Only Consider Standard Pitches					
Pitch (in)	Threads per auger	Flow Rate (lbs/hr) 5 in	Flow Rate (lbs/hr) 6 in	Flow Rate (lbs/hr) 7 in	Flow Rate (lbs/hr) 8 in	Flow Rate (lbs/hr) 9 in	Flow Rate (lbs/hr) 10 in
1.13	211.67	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.20	200.00	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.29	186.67	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.42	169.33	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.44	166.67	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.50	160.00	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.60	150.00	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.70	141.12	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.80	133.33	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
1.98	120.95	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.00	120.00	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.25	106.67	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.27	105.83	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.40	100.00	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.55	94.07	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.57	93.33	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
2.83	84.67	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
3.00	80.00	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
3.27	73.33	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
3.40	70.55	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
3.60	66.67	Too Small	Too Small	Too Small	Too Small	Too Small	Too Small
3.97	60.48	Too Small	Too Small	Too Small	Too Small	Too Small	1631
4.00	60.00	Too Small	Too Small	Too Small	Too Small	Too Small	1644
4.24	56.67	Too Small	Too Small	Too Small	Too Small	Too Small	1741
4.25	56.45	Too Small	Too Small	Too Small	Too Small	Too Small	1747
4.50	53.33	Too Small	Too Small	Too Small	Too Small	Too Small	1849
4.54	52.92	Too Small	Too Small	Too Small	Too Small	1501	1864
4.80	50.00	Too Small	Too Small	Too Small	Too Small	1589	1973
5.10	47.03	Too Small	Too Small	Too Small	Too Small	1689	2097
5.14	46.67	Too Small	Too Small	Too Small	Too Small	1702	2114
5.33	45.00	Too Small	Too Small	Too Small	Too Small	1765	2192
5.54	43.33	Too Small	Too Small	Too Small	Too Small	1833	2276
5.67	42.33	Too Small	Too Small	Too Small	Too Small	1877	2330
6.00	40.00	Too Small	Too Small	Too Small	1557	1986	2466
6.55	36.67	Too Small	Too Small	Too Small	1699	2167	2690
7.09	33.87	Too Small	Too Small	Too Small	1839	2346	2912
7.20	33.33	Too Small	Too Small	Too Small	1868	2383	2959
7.58	31.67	Too Small	Too Small	Too Small	1967	2509	3115
8.00	30.00	Too Small	Too Small	1571	2076	2648	3288
8.51	28.22	Too Small	Too Small	1670	2207	2816	3496
9.00	26.67	Too Small	Too Small	1768	2336	2979	3699
9.92	24.18	Too Small	Too Small	1949	2575	3285	4079
10.29	23.33	Too Small	Too Small	2020	2669	3405	4227
11.08	21.67	Too Small	1570	2175	2875	3667	4552

11.34	21.17	Too Small	1607	2227	2942	3753	4660
12.00	20.00	Too Small	1700	2357	3114	3972	4932
12.52	19.17	Too Small	1774	2459	3249	4145	5146
13.09	18.33	Too Small	1855	2571	3397	4333	5380
14.17	16.93	Too Small	2008	2784	3678	4692	5825
14.40	16.67	Too Small	2040	2828	3737	4767	5918
16.00	15.00	1527	2267	3142	4152	5296	6576
17.00	14.12	1622	2409	3339	4412	5628	6987
18.00	13.33	1718	2551	3535	4671	5959	7397
19.83	12.10	1893	2811	3895	5147	6566	8151
20.57	11.67	1963	2915	4040	5338	6810	8454
22.68	10.58	2164	3213	4454	5885	7507	9320
24.00	10.00	2290	3401	4713	6228	7945	9863
25.53	9.40	2436	3618	5014	6626	8452	10493
28.35	8.47	2705	4017	5567	7356	9384	11650
28.80	8.33	2748	4081	5656	7474	9534	11836
31.17	7.70	2974	4417	6121	8088	10318	12809
32.00	7.50	3053	4534	6285	8304	10593	13151
34.04	7.05	3248	4824	6686	8834	11269	13991
36.00	6.67	3435	5101	7070	9342	11917	14795
48.00	5.00	4580	6802	9427	12456	15889	19727
72.00	3.33	6870	10202	14140	18684	23834	29590

**APPENDIX C**

**PART DRAWINGS**

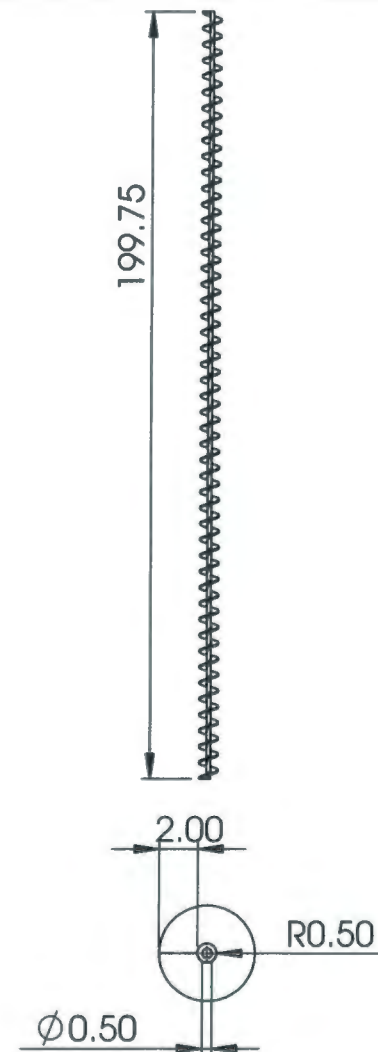
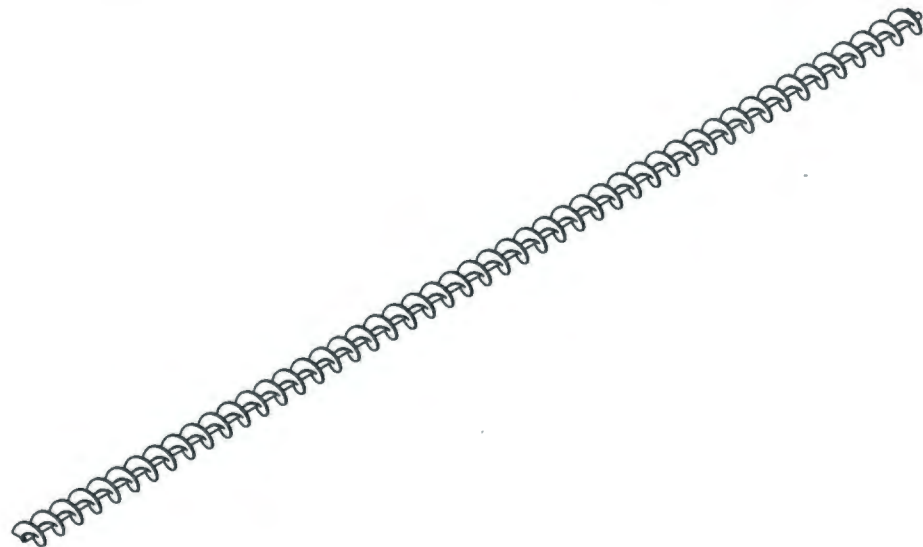




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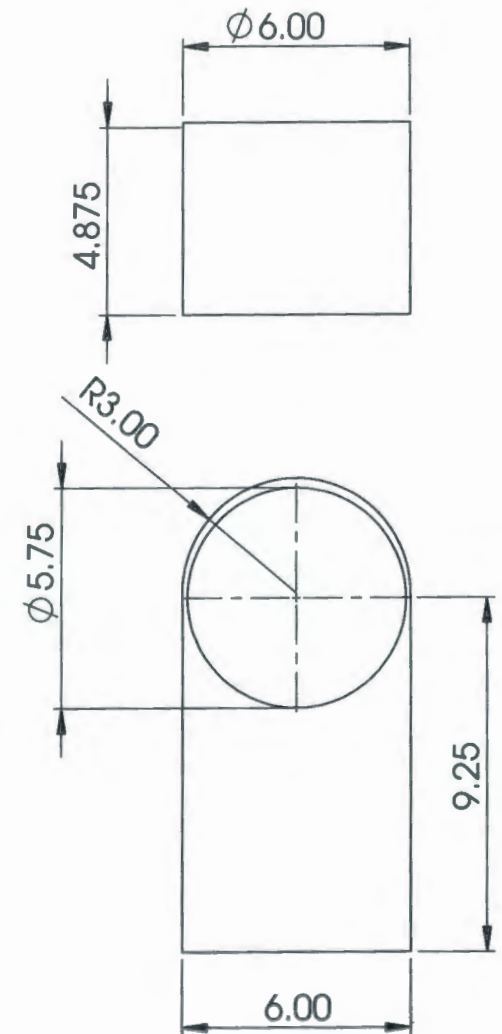
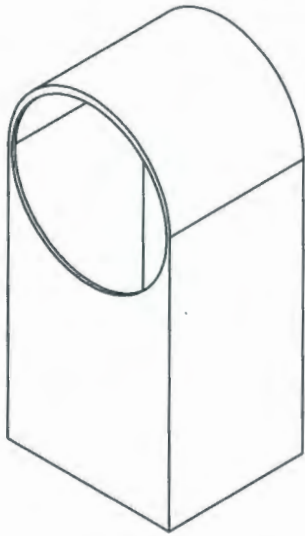
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Pellet Mill System		
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		SHEET 1 OF 1



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				CHECKED			
				ENG APPR.			
				MFG APPR.			
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NEXT ASSY	USED ON						
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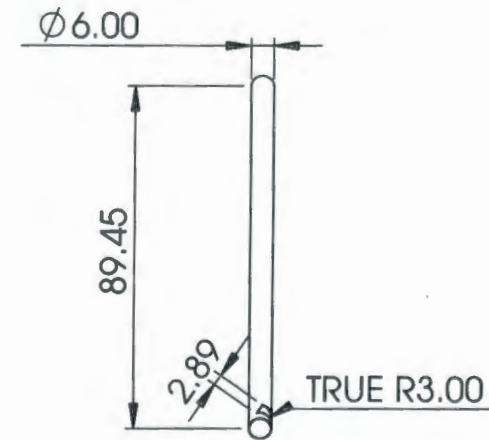
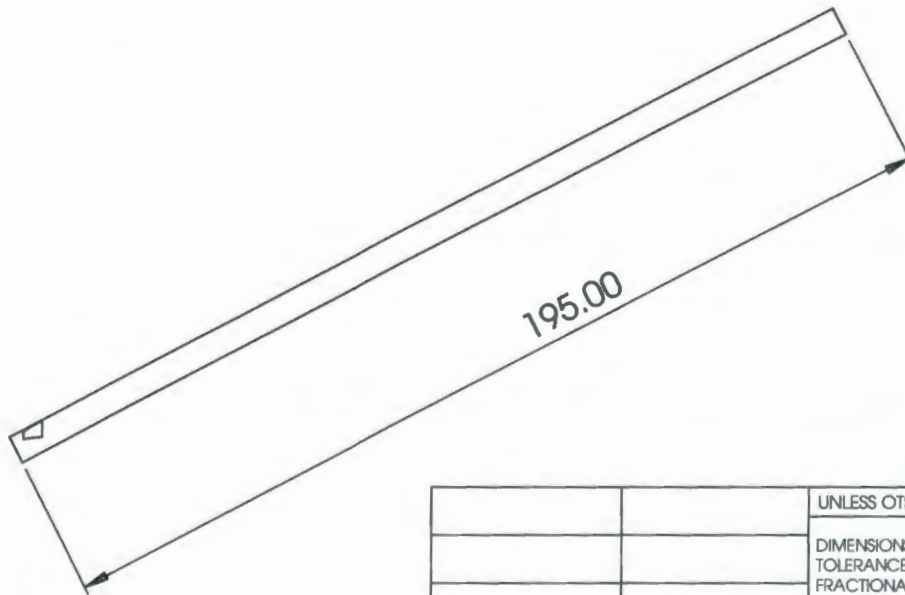
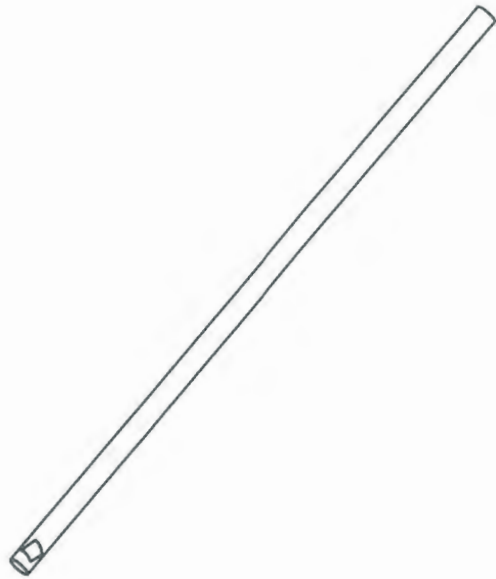


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		INTERPRET GEOMETRIC		All dimension's in inches	
		TOLERANCING PER:			
		MATERIAL			
		FINISH		SIZE	DWG. NO.
NEXT ASSY		USED ON		<b>A</b>	
APPLICATION		DO NOT SCALE		SCALE: 1:5	WEIGHT:
		DRAWING		REV	
				EET 1 OF 1	

**TITLE:**  
Return auger Dump

SCALE: 1:5 WEIGHT: EET 1 OF 1

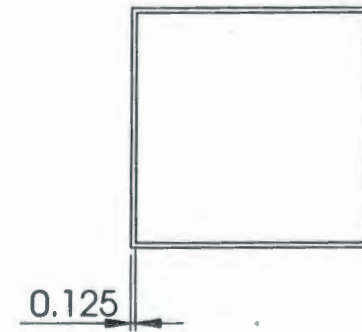
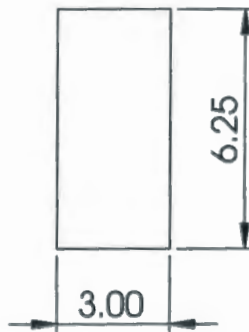
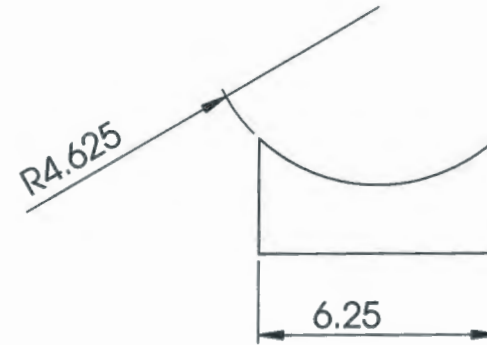
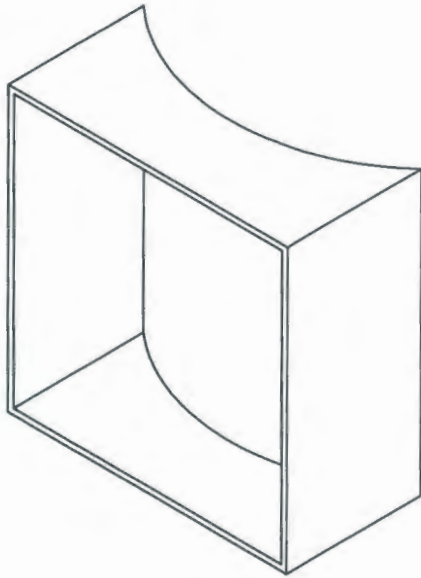


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		INTERPRET GEOMETRIC		All Dimension's in inches			
		TOLERANCING PER:					
		MATERIAL					
		FINISH					
NEXT ASSY		USED ON					
APPLICATION		DO NOT SCALE		DRAWING			

TITLE: <b>Return Auger Housing</b>		
SIZE <b>A</b>	DWG. NO.	REV
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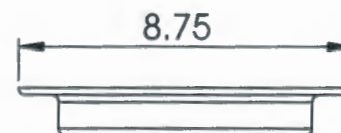
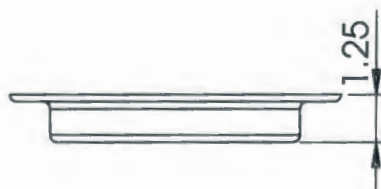
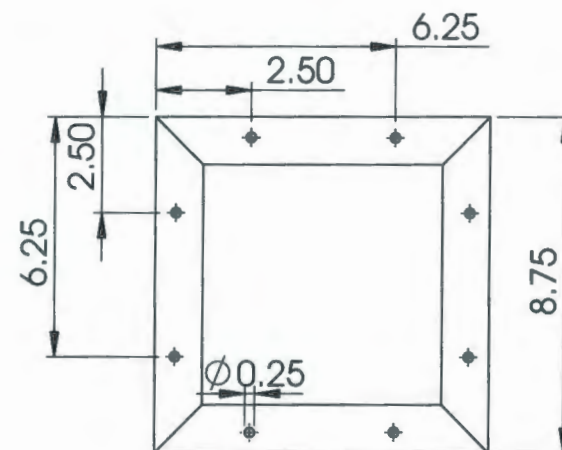
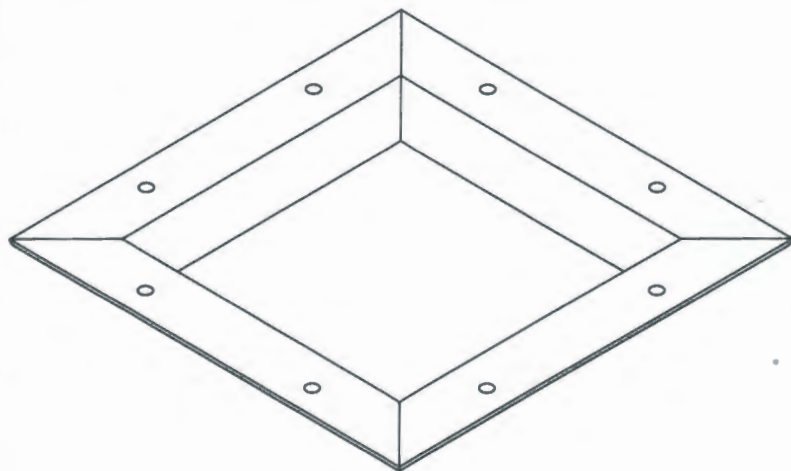




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		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	<b>TITLE:</b> <h1>Auger feeder tube</h1>	
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		TOLERANCES:		CHECKED			
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		ANGULAR: MACH ± BEND ±		MFG APPR.			
		TWO PLACE DECIMAL ±		Q.A.		<b>SIZE</b> <b>DWG. NO.</b> <b>REV</b>	
		THREE PLACE DECIMAL ±		COMMENTS:		<b>A</b>	
		INTERPRET GEOMETRIC TOLERANCING PER:		All Dimension's in inches		SCALE: 1:2 WEIGHT: SHEET 1 OF 1	
		MATERIAL					
		FINISH					
NEXT ASSY	USED ON	DO NOT SCALE	DRAWING				
APPLICATION							

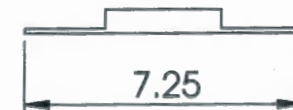
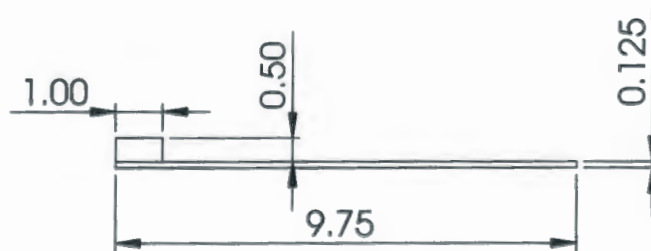
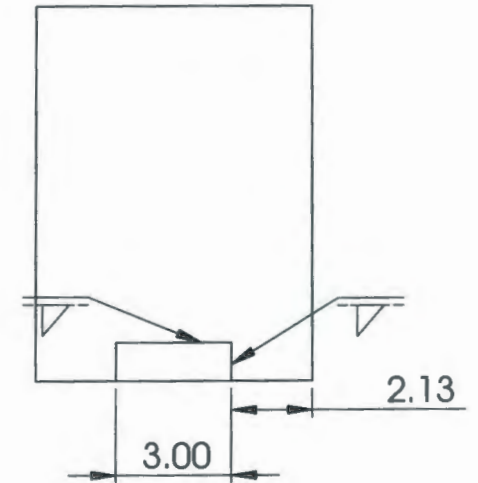
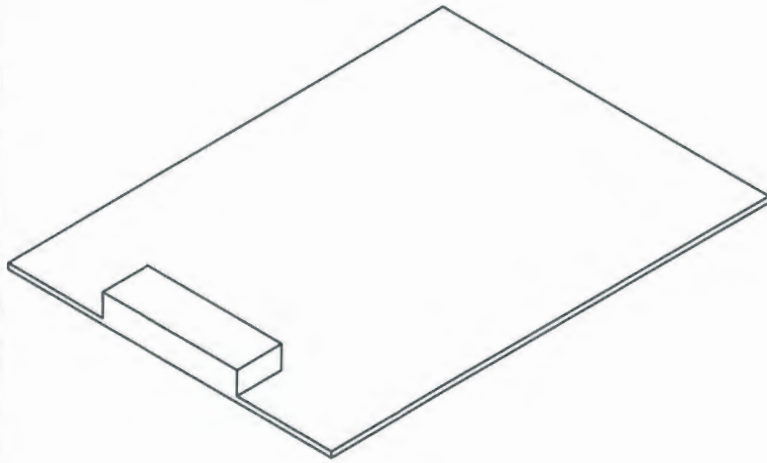




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				CHECKED			
				ENG APPR.			
				MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:		Q.A.			
		MATERIAL		COMMENTS:  All Dimension's in inches			
		FINISH					
NEXT ASSY		USED ON		SIZE <b>A</b> DWG. NO. REV SCALE: 1:5 WEIGHT: SHEET 1 OF 1			
APPLICATION		DO NOT SCALE DRAWING					

**TITLE:**  
**Pellet mill Flange**

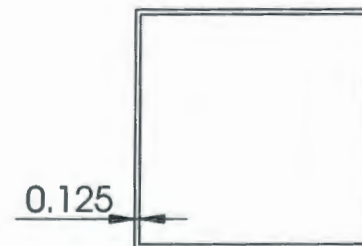
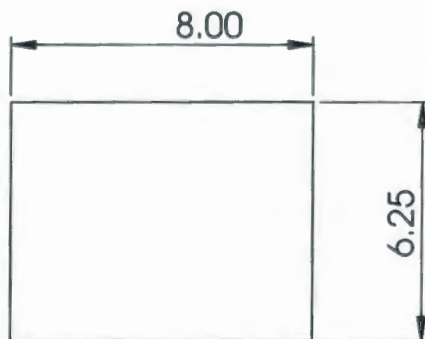
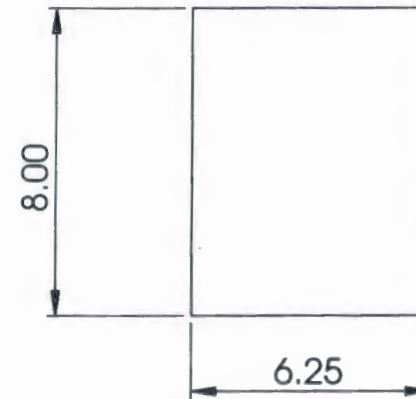
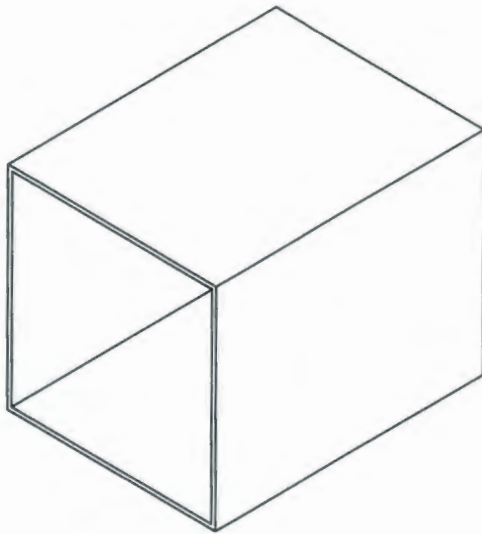


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		THREE PLACE DECIMAL ±		COMMENTS:			
		INTERPRET GEOMETRIC TOLERANCING PER:		All dimension's in inches			
		MATERIAL					
		FINISH					
NEXT ASSY		USED ON		SIZE		DWG. NO.	
APPLICATION		DO NOT SCALE		A		REV	
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**TITLE:**  
Flow Rate Adjustment Slider

SCALE: 1:5 WEIGHT: SHEET 1 OF 1



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		UNLESS OTHERWISE SPECIFIED:		NAME	DATE				
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		TOLERANCES:		CHECKED					
		FRACTIONAL ±		ENG APPR.					
		ANGULAR: MACH ± BEND ±		MFG APPR.					
		TWO PLACE DECIMAL ±		Q.A.		SIZE	DWG. NO.		
		THREE PLACE DECIMAL ±		COMMENTS:  All Dimensions in inches		<b>A</b>	REV		
		INTERPRET GEOMETRIC TOLERANCING PER:					SCALE: 1:5	WEIGHT:	SHEET 1 OF 1
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NEXT ASSY	USED ON								
APPLICATION		DO NOT SCALE							

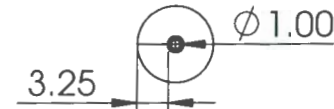
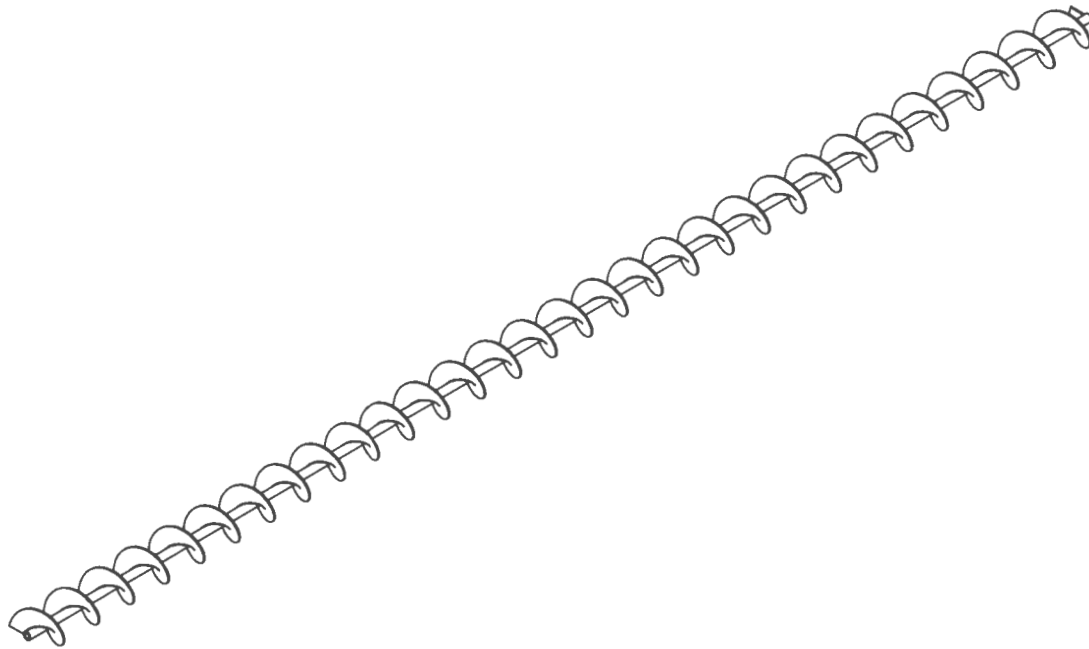
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3

2

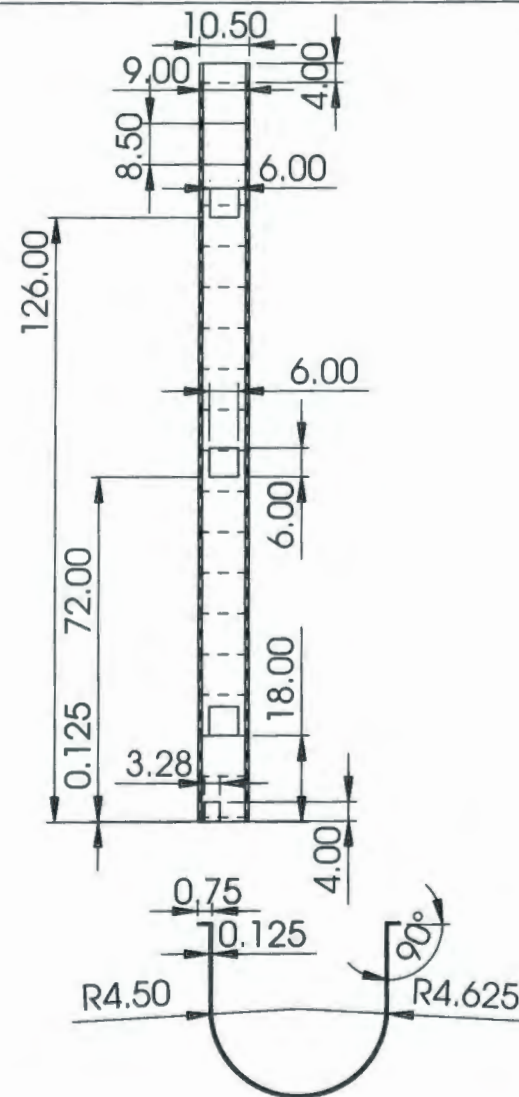
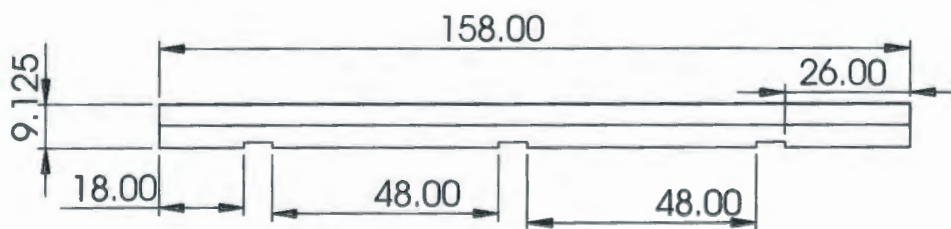
1



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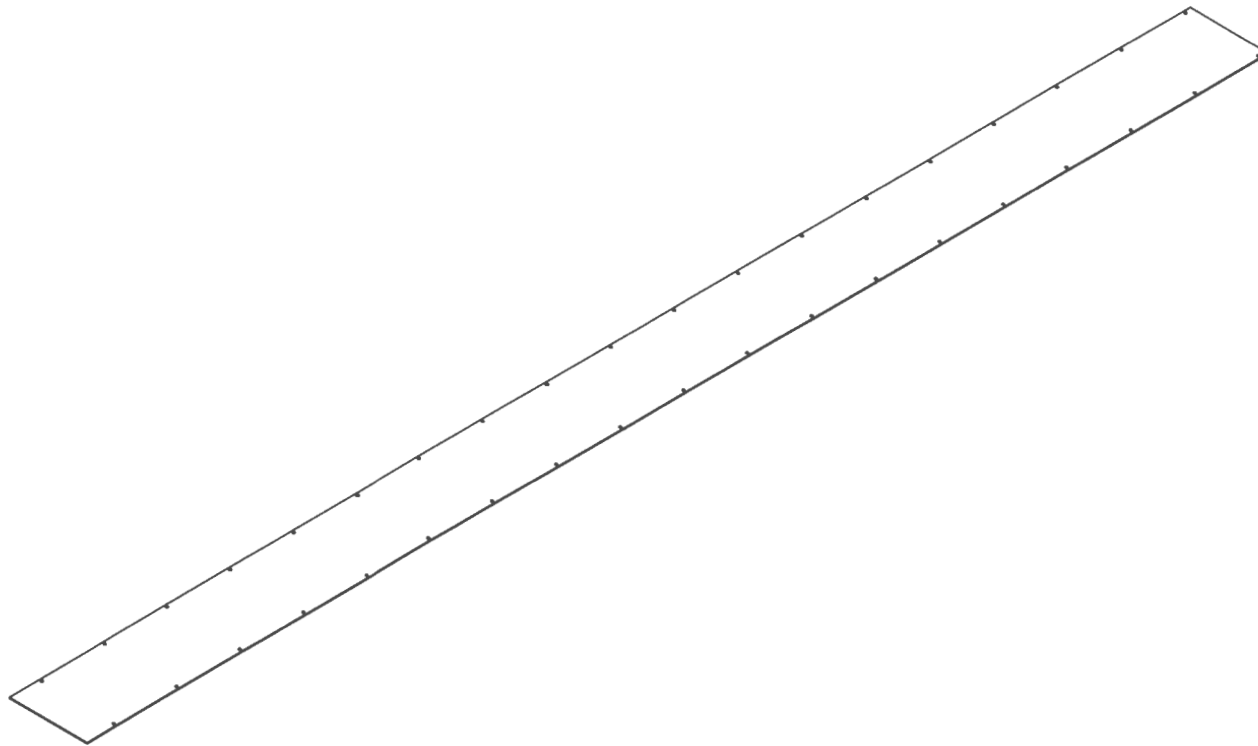
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		DIMENSIONS ARE IN INCHES		DRAWN			
		TOLERANCES:		CHECKED		TITLE:	
		FRACTIONAL ±		ENG APPR.		Feed Auger	
		ANGULAR: MACH ± BEND ±		MFG APPR.			
		TWO PLACE DECIMAL ±		Q.A.			
		THREE PLACE DECIMAL ±		COMMENTS:		SIZE	DWG. NO.
		INTERPRET GEOMETRIC TOLERANCING PER		All Dimensions in inches Auger Pitch is 8 in		A	REV
		MATERIAL					
		FINISH					
NEXT ASSY	USED ON						
APPLICATION		DO NOT SCALE		DRAWING		SCALE: 1:100	WEIGHT: ( )



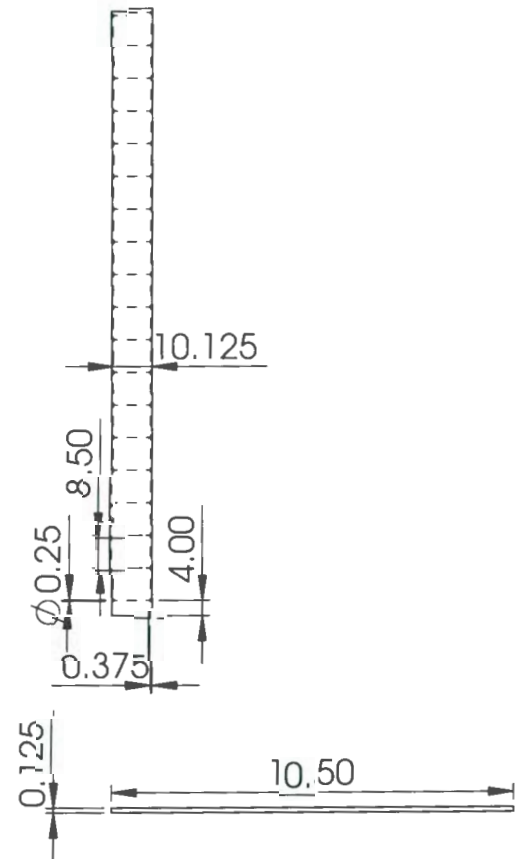
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		UNLESS OTHERWISE SPECIFIED:		NAME		DATE	
		DIMENSIONS ARE IN INCHES		DRAWN			
		TOLERANCES:		CHECKED			
		FRACTIONAL ±		ENG APPR.			
		ANGULAR: MACH ± BEND ±		MFG APPR.			
		TWO PLACE DECIMAL ±		Q.A.			
		THREE PLACE DECIMAL ±		COMMENTS:			
		INTERPRET GEOMETRIC TOLERANCING PER:		All Dimension's in inches			
		MATERIAL					
		FINISH					
NEXT ASSY		USED ON					
APPLICATION		DO NOT SCALE		DRAWING			

TITLE: <b>Auger Trough bottom</b>		
SIZE <b>A</b>	DWG. NO.	REV
SCALE: 1:50		WEIGHT:
		SHEET 1 OF 1



158.00



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		UNLESS OTHERWISE SPECIFIED:	NAME	DATE
		DIMENSIONS ARE IN INCHES	DRAWN	
		TOLERANCES:	CHECKED	
		FRACTIONAL ±	ENGINE APPR.	
		ANGULAR: MACH ± BEND ±	MFG APPR.	
		TWO PLACE DECIMAL ±	Q.A.	
		THREE PLACE DECIMAL ±	COMMENTS:	
		INTERPRET GEOMETRIC TOLERANCING PER	All Dimension's in inches	
		MATERIAL		
		FINISH		
NEXT ASSY	USED ON	DO NOT SCALE	DRAWING	
APPLICATION				

TITLE:

Feed Auger Top

SIZE  
**A**

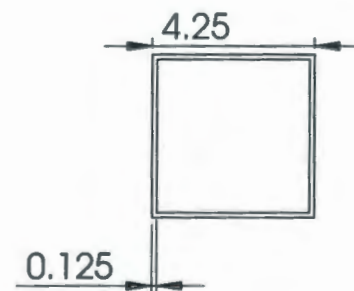
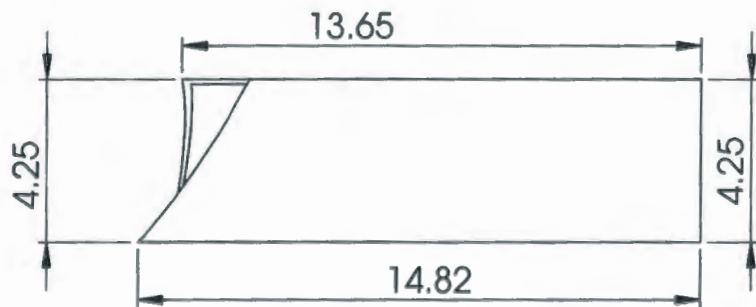
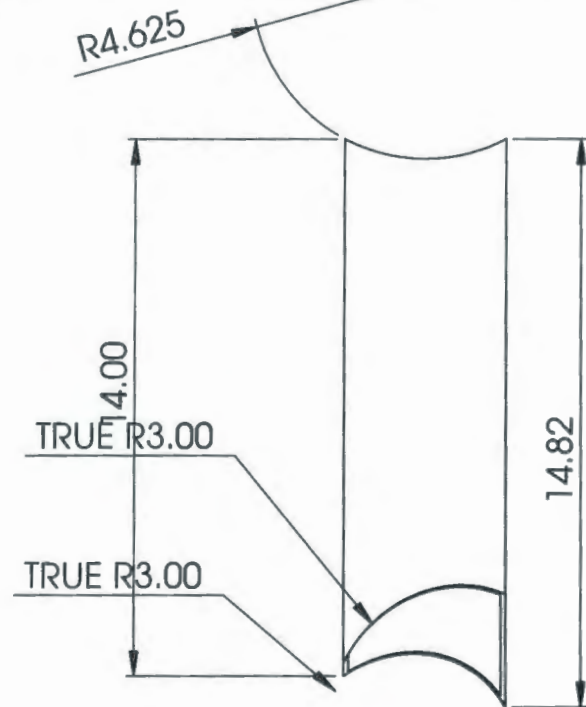
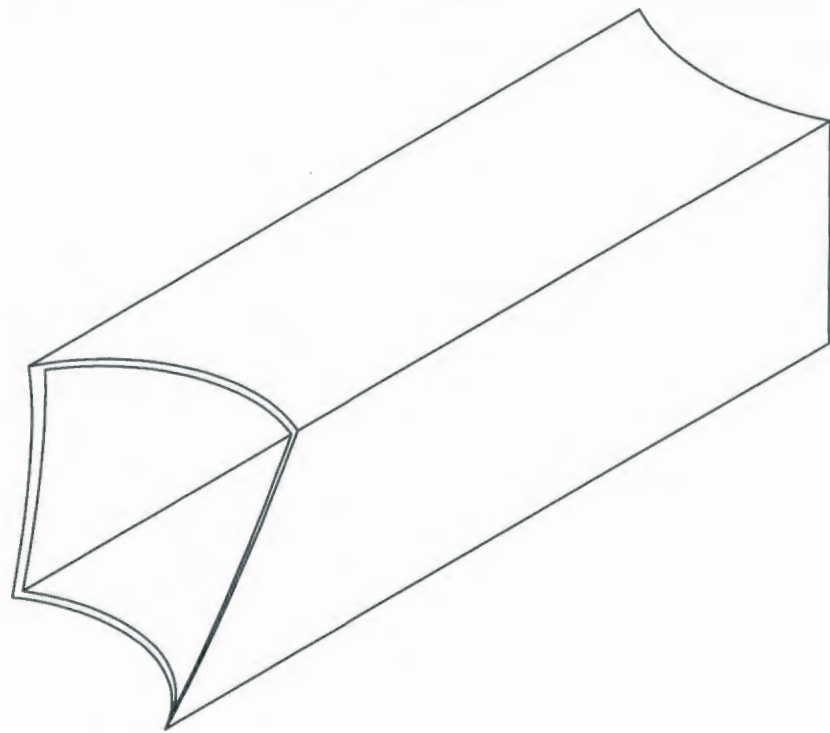
DWG. NO.

REV

SCALE: 1:50 WEIGHT:

SHEET 1 OF 1





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		UNLESS OTHERWISE SPECIFIED:		NAME		DATE	
		DIMENSIONS ARE IN INCHES		DRAWN			
		TOLERANCES:		CHECKED			
		FRACTIONAL ±		ENG APPR.			
		ANGULAR: MACH ± BEND ±		MFG APPR.			
		TWO PLACE DECIMAL ±		Q.A.			
		THREE PLACE DECIMAL ±		COMMENTS:			
		INTERPRET GEOMETRIC TOLERANCING PER:		All dimension's in inches			
		MATERIAL					
		FINISH					
NEXT ASSY		USED ON		TITLE: Return Auger Feeder Tube			
APPLICATION		DO NOT SCALE		RAWING		SIZE DWG. NO. REV	
						SCALE: 1:5 WEIGHT: EET 1 OF 1	