Final Design Report
Farm Grade Distributor Redesign & Cost Savings
Client: AGI-VIS

MECH 4860: Engineering Design

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Letter of Transmittal

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Professor Paul Labossière
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Dear Dr. Paul Labossière,

The attached report, "Farm Grade Distributor Redesign & Cost Savings" is submitted in accordance with the requirements set by Professor Paul Labossière in the MECH 4860 Engineering Design Course.

The purpose of our report is to explain the final design and demonstrate how our proposed design meets our customer's design criteria. The report includes an overview of the final design, manufacturing process, cost analysis, preliminary engineering drawings, and bill of materials.

We would like to acknowledge our advisor Vern Campbell for providing feedback throughout the course project and Aidan Topping for helping us to better structure our reports. If you have any questions, please do not hesitate to contact our team.

Best Regards,

Zerlina Abhazim
Team 29 Project Manager

Executive Summary

AGI-VIS is a supplier of commercial agricultural equipment and is in the early stages of expanding its product line to include farm grade equipment. AGI-VIS tasked our team to design a farm grade version of their distributors. The company has failed to sell many distributors in the past two years due to large manufacturing costs as a result of long labour hours. On average, a mild steel distributor with eight outlets has a total manufacturing cost of $10360 (Material Cost of $4364 and Labor Cost of $5996) and takes 92 hours to assemble. The goal of this project is to design a farm grade distributor with a total manufacturing cost of $7770, which is 25% less than the commercial version.

In the concept generation phase of this project, a total of six main concepts were generated with a focus on different body shell types. The chosen body shell for the final design involves significantly less forming due to the octagonal geometry, an angled lower section that coincides with the required 50-degree product discharge angle, and eight outlet spouts. The angled nature of the new distributor body concept allowed for a simplified outlet spout design made from standard 12-inch, 10-gauge mild steel tubing that is cut to length with welded round flanges. Similarly, the inlet and internal swing spout will use the same standard tubes and flanges which allow for the parts to be assembled simultaneously. A significant change from the commercial version is that the farm grade distributor, except for a few components (outlets, swing spout, service door and drive assembly) will be composed of galvanized steel. The use of galvanized steel will allow for many distributor components to be bolted, simplifying the overall distributor assembly process and making replacing parts more feasible. The final design also includes features such as an air vent, drip tray, cleanout holes, outlet spout covers, lifting lugs built into the body shell flanges, a 12-inch to 11-inch diameter bolt-on swing spout transition, hanger supports, an inspection window and shipping legs.

Finally, the main project objective of developing a farm grade distributor with a 25% reduction of total manufacturing cost and less assembly time was achieved. The new design has a projected total manufacturing cost of $7828 with material and labour costs of $3700 and $4128 respectively. For the assembly process, the required labour hours were reduced by 28.5 hours to 63.5 hours.

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1 Introduction

AGI-VIS is an agricultural equipment supplier based in Oak Bluff, Manitoba that specializes in manufacturing material handling and bulk storage equipment that is specifically engineered for commercial applications. The company product line includes equipment such as bucket elevators, overhead bin systems, spouting, distributors, control (slide) gates, various types of conveyor systems used for grain storage purposes.

This report focuses on AGI-VIS distributors, a product line that our team was tasked with redesigning for farm grade applications. Included in this report is a definition of the project, a detailed overview of the final design, its fabrication process and total manufacturing cost.

1.1 Project Background

AGI-VIS distributors are designed for material handling applications to convey materials such as grain, fertilizer, and feed to bulk storage bins. With an electrically operated rotating internal swing spout that mates with the external outlet spouts (via position sensors), the distributor can accurately direct product to a chosen storage bin. Currently, the distributor is available in mild steel or stainless-steel options and have other customer-specific configurations such as spouting size (Ø10”-16”), the number of outlets (4-24), spout liners, and body type (full round or flat back). A stainless-steel distributor is shown in Figure 1 and has a full round body type with six outlets.

Figure 1: AGI-VIS Stainless Steel Distributor *[1]*

AGI-VIS products including the distributors have been designed for commercial use only. However, the company has recently invested in a new product development department and plans to expand its current offerings by developing a new farm grade product line. At the top of the list are their distributors that currently have a total manufacturing cost of $10360 (material cost of $4364 and labour cost of $5996). These distributors are of reliable design, but poor sales indicate that they are too expensive in today's marketplace. Only nine distributors were sold in the last two years. As a result, AGI-VIS is targeting farmers who have a high demand for this product but, historically in most cases, are not willing to pay the high price of commercial distributors. With a new and more affordable farm grade version, the company hopes that it will lead to a continual increase in distributor sales and improve their overall earning potential.

1.2 Project Objective

The objective of this project is to design a farm grade distributor with a total manufacturing cost of $7770 (a 25 percent cost reduction from the current commercial version, $10360) by December 4, 2019.

1.3 Project Scope

The scope of this project covers the design of a single configuration of a farm grade distributor. The chosen configuration to be used as a baseline for this project includes 12-inch inlet and outlet spouting, eight outlet spouts and a 50-degree discharge angle. Additionally, the body-shell is not limited to the current flat-back and full round types. Further details on the project are highlighted in the project charter shown in Appendix A.

The project scope includes potential cost savings from the following areas:

- Design changes to an existing commercial distributor
- Process improvements to manufacturing and assembly for labour time reduction
- Design of new tooling and/or fixtures

Any process improvements are required to be within the company's current manufacturing capabilities and are limited from the point where the individually processed distributor components arrive at the assembly cells, up to the point where the distributor is fully assembled, painted, tested and ready for shipping.

Items out of the scope include modifications to the shop layout, the design of the transition from the grain elevator to the distributor inlet, electrical and control aspects, creating prototypes, and any overhead costs.

Deliverables for this project include the following:

- 3D SolidWorks models and assembly drawings using AGI-VIS SolidWorks templates
- Bill of Materials (BOM) and Standard Routing Reports using AGI-VIS MRP (Material Requirements Planning) software, Made2Manage
- Final Design Report and Project Poster

1.4 Constraints and Limitations

The following outlines the constraints and limitations of the project that are not within the control of the project team and limit the methodology to accomplish tasks within the project.

1.4.1 Constraints

- The layout of the manufacturing shop cannot be changed
- All parts must be made with the existing tooling in AGI-VIS' manufacturing shop
- Discharge angle of the outlet spouts set to 50° cannot be changed
- The drive assembly stays the same, adding a base cost of $3457.74 to the new design when the material and labour costs are added together.

1.4.2 Limitations

- Lack of information from competitors restricts the ability to fully benchmark other distributors on the market
- A lack of scheduled distributor jobs at VIS that prevents conducting future time studies and testing (results rely on old data),
- All parts must be cut on standardized sheet metal sizes (4 feet x 10 feet or 5 feet x 10 feet)
- The assembly process will be limited to only two assemblers, therefore additional assemblers cannot be added to fast track the assembly process.

1.5 Customer Needs

Customer needs were assessed from the perspective of the client, AGI-VIS, and the target consumer of the product, grain farmers. An initial priority was given to each need ranging from 1 to 5, with 5 being the highest priority. Customer needs are summarized in TABLE I below.

TABLE I: CUSTOMER NEEDS

#	Target consumer of the product – Farmers	*Priority
1	Reliable swing spout - The grain goes in a correct bin	5
2	Reliable swing spout - Ensure swing spout does not get stuck	5
3	Inexpensive	4
4	Easy maintenance	4
5	Airtight	4
6	Internal parts easily accessible and can fit through the door	3
7	Easy to operate	2
8	Corrosion resistant	2
9	Wear resistance on the inside of distributor from grain	2
10	Self-cleaning	1
11	Light weight	1
#	Client Needs – AGI-VIS	*Priority
12	Total assembly labour hours reduce	5
13	Inexpensive	5
14	Minimize the total quantity of parts to be assembled	4
15	Minimize the amount of forming on the brake (sheet metal bends)	4
16	Uses hardware and fasteners	2
17	Focus on a single size distributor	1

The design of the distributor focused to address needs with priority values of 2 to 5. The highest priority items are to ensure the swing spout does not get stuck during operation, the grain deposits into the correct bin, and reliability for the farmer. For AGI-VIS, the focus will be to reduce the total labour hours and the total manufacturing cost.

1.6 Design Methodology

Key problems were identified with the current design and manufacturing process using the current process flowchart shown in Appendix B.5. Various design concepts were generated to address each problem using the functional decomposition method shown in TABLE II.

TABLE II: FUNCTIONAL DECOMPOSITION

Process	Problem	Proposed Solution
Hammering flange to the bottom plate	Time-consuming, critical path item	Incorporate tolerances into the design to ensure a perfect fit
Body forming 100-150 bends	Time-consuming	Reduce the number of bends to have one bend per outlet
Additional and Removal of stiffener	Time-consuming	A thicker gauge of metal for the bottom plate
Cut flange 1.5-2" deep centred between each bolt	Time-consuming	Change circular to the bent body. The flange can be bent on flat body panel pieces.
Paint on Mild steel	Painting adds waiting time	Select galvanized steel which doesn't require paint
Stainless steel material selection	Expensive Unnecessary for farm grade application	Galvanized steel is inexpensive and offers the durability required for farm-grade cycles of use
Cut out inspect door hole	Time-consuming	Precut door opening before the part is formed with water jet/laser cutter
Door opening	A lot of maintenance is required after installation of distributors in the winter, access to the internal part must be more easily accessible	To have a larger door would need to bolt components rather than to weld. A larger hole would be subject to warping during welding.
Door opening	Due to a small door opening, a lot of assembling of parts must be done when inside the distributor in a highly confined space.	Introduce a port through the bottom for easy removal of parts and
Door location: elevated on the center of the sidewall	Tripping hazard	Design door opening to be flush with a bottom surface

Process	Problem	Proposed Solution
Double inlet assembly, deadhead. Additional inlet piece to take the wear and be easily replaced	Farm grade distributor will not be subject to as much wear.	Use a removable liner or thicker piece of sheet metal for the internal inlet.
Bending outlets to the tapered tube.	An expensive and long process	Buy fixed diameter tubing and laser cut
Assembly bent door to the body	The piece must be stepped on to reform correctly to attach to the body. Poor fit leads to a risk of leakage and moisture entering the distributor	Rectangular elevated box door. Easier assembly to the body panel. The door is flat, therefore no reforming or leakage

The main problems addressed reducing assembly time and eliminating non-value-added steps. The proposed solutions column aimed to reduce labour time and change materials to meet the less demanding needs of a farm grade distributor.

After functional decomposition, concepts were generated during brainstorming. The top five generated concepts were screened against the voice of the customer by establishing a quantifiable weighted criterion. A Criteria Weighting Matrix (CWM) was used to quantify the weighted importance of each decision criteria. Each parameter was compared with one another and the criteria of greater importance were recorded. The number of times the criteria were selected as the higher importance was tallied to determine the total hits. The total hits were divided by the amount of hit possible to determine the weight for that criterion. Each team member filled out the CWM independently and the totals were averaged. The resulting relative weights for the criteria are shown in TABLE III below as a percentage.

The detailed descriptions of each criteria are also shown in TABLE III in order of highest to lowest importance. The decision criteria matrix indicates that the cost, lack of product build-up and reduce labour time are of the highest importance in the design of the distributor. The internal space and tolerancing parts proved to be of the least importance in the final design of the distributor. All weighted criteria were applied to the selection of the distributor's body shell design and adjusted for the remaining features. The criterion addressed all the customer needs to be established by the client in TABLE I with a priority of two or higher in greater detail.

TABLE III: WEIGHTED CRITERIA MATRIX

Criteria		Weight	Description
Cost	↓	13.8%	• Reduce material and labour cost
Product Build Up	↓	12.5%	• Minimize product (rain, snow, and grain) build up on the exterior/interior of the distributor
Labour Time	↓	10.9%	• Reduce labour time to enable the full assembly to be able to be completed in a single workweek
Easy Maintenance	-	10.0%	• The parts are durable and easy to be maintained during monthly maintenance checks
Airtight	-	10.3%	• Any moisture can damage the product and clog the distributor causing build-up. • The container must be sealed.
Lifecycle	↑	9.3%	• The distributor must last 15-20 years before failure
Ventilation	-	8.7%	• Must be a ventilation system in place to remove any moisture in the air that enters the distributor and adjacent spouting
Easy entrance and exit into confined space	-	8.3%	• Minimize tripping hazards • Ensure the door can be opened easily from the interior or exterior • The opening is large enough to fit an average-sized technician (approx. 200 lbs) during initial assembly and maintenance.
Wear Resistant	-	7.4%	• Resistance from wear as the grain will significantly erode single side of the spout on entry into the distributor
Number of Steps	↓	5.8%	• Reduce the number of steps for assembly <60 steps
Number of Parts	↓	4.2%	• Reduce the number of parts for the whole assembly
Tolerance	-	3.8%	• Parts should have a tolerance of 1/16 inch to save time during assembly and reduce the amount of re-forming parts
Internal Space	↑	2.6%	• Increase the amount of internal space in the distributor for easy maintenance.

1.6.1 Target Specifications

Each of the metrics in TABLE IV correlates with at least one weighted criterion identified in TABLE III and function to address the customer needs, established in TABLE I, to design a distributor that is reliable, inexpensive and easy to maintain. The marginal values indicate the lowest value that would still manage to meet the needs of the client, however, the design aimed to meet the ideal values listed below.

TABLE IV: METRICS WITH MARGINAL AND IDEAL VALUES

Spec. #	Specifications	Unit	Marginal values	Ideal values
1	Cost per distributor	$	7,770-10,300	7,770
2	Horizontal surface area	ft^2	3-4	<3
3	Total labour time	hours	60-70	<60
4	Airtight	Yes/No	-	Yes
5	Lifecycle	years	15-20	20
6	Ventilation system	Yes/No	-	Yes
7	Door opening	ft^2	3.5-4	4
8	Wear resistant features	Yes/No	-	Yes
9	Number of steps involved to assemble a distributor	steps	39-30	<30
10	Number of parts required to build a distributor	#	40-60	<40
11	Tolerances	inch	-	1/16
12	Internal Space	ft^3	35-40	>40

Each target specification from TABLE IV has a quantifiable metric detailed below:

- Metric 1: Total manufacturing cost of the distributor including materials and labour ($)
- Metric 2: Minimize the horizontal surface area to ensure that the product does not build upon the distributor such as snow, water, grain, and bird nests. [ft^2]
- Metric 3: Total labour time required to assemble the distributor, not including the control box or fasteners. (hours)
- Metric 4: All seams in the distributor designed are sealed and airtight to prevent moisture from entering the system and contaminating the quality of the product [Yes/No]
- Metric 5: Lifecycle of the distributor till failure (years)
- Metric 6: A ventilation system is provided to release any moisture that enters the system [Yes/No]
- Metric 7: Door opening can fit average-sized technician to enable easy entrance, removal and maintenance of the internal components [ft^2]
- Metric 8: Components is the assembly can resist wear or are easily replaceable [Yes/No]
- Metric 9: Number of steps involved to make a distributor (steps)
- Metric 10: Number of parts required to build a distributor (parts)
- Metric 11: The tolerance between the interconnecting parts within the distributor assembly to ensure uninterrupted rotation of the swing spout and minimize rework during assembly (inch)
- Metric 12: Volume of internal space can fit an average sized technician to enable easy entrance, removal, maintenance, and assembly while within the distributor [ft^3]

The House of Quality shown in Appendix C related the relationship between customer needs and target specifications and metrics. AGI-VIS competitors including GSI, Lambton, Schagel, Honeyville, and Hayes & Stolz were also compared to the customer needs from the client to see how the current AGI-VIS distributor design compared to the competitors and reiterated the main needs the current design failed to address.

2 Details of the Final Design

This section outlines the final design, its operation and its design features that met the customer needs previously outlined.

2.1 Final Design Overview

The final design of the farm grade distributor shown in Figure 2, was designed to use the same operational methodology as the original commercial distributor where an internal swing spout rotates within the distributor body on a central shaft. The central shaft is driven by an electric drive assembly which includes position sensors that allow the swing spout to accurately stop at the outlet spout of the user's choosing. The product can then be fed into the inlet of the distributor from a grain elevator and discharge into a select grain storage bin.

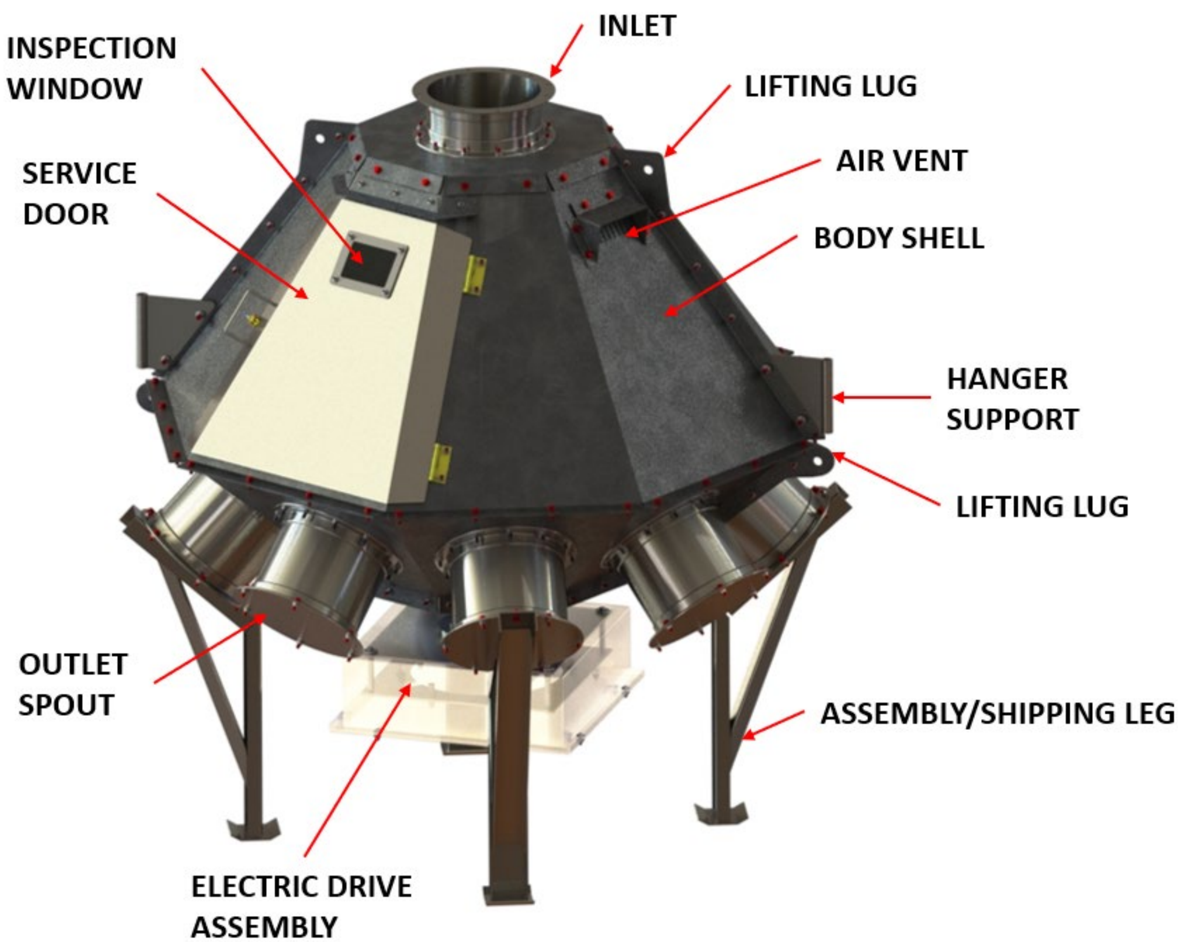

Figure 2: Isometric View of the Farm Grade Distributor

The new design as shown in Figure 3 has an octagonal geometry to coincide with the eight outlet spouts, a 50-degree product discharge angle and 12-inch diameter tubing (10-gauge HRMS) for the inlet, internal swing spout and outlets. Major changes (discussed in more depth in later sections) featured in the farm grade distributor include the switch from mild steel construction to galvanized steel construction, more bolting over welding, an angled bottom section rather than a flat one, and a simpler outlet spout design.

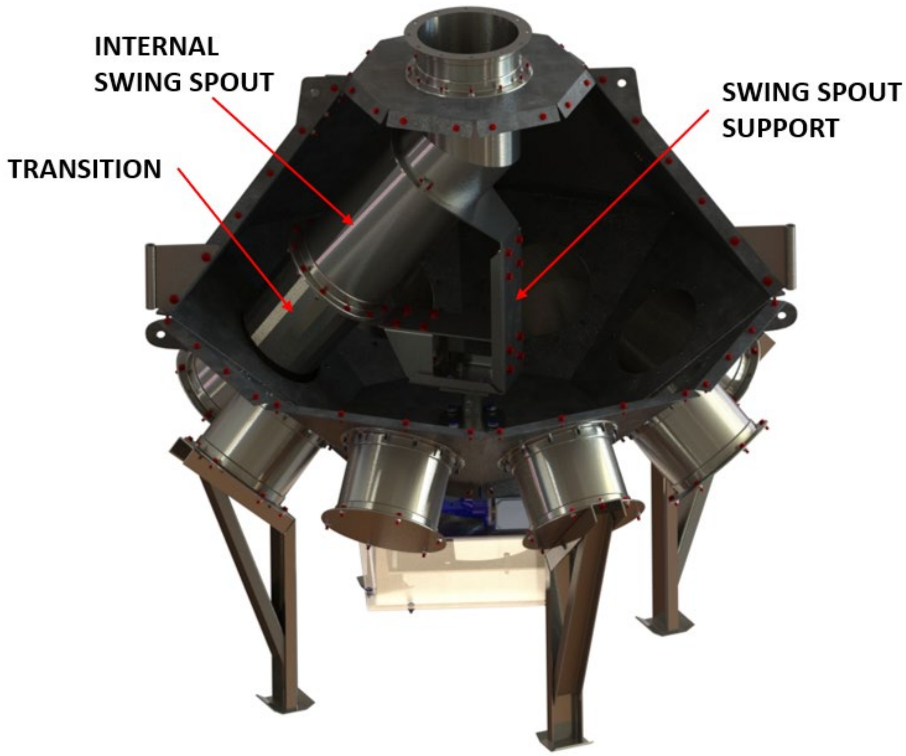

Figure 3: Inside View of Farm Grade Distributor (Top Body Panel Hidden)

Overall, the new distributor design comprises of six main subassemblies that are discussed in further detail in the following sections. These subassemblies are:

1. Distributor Body Shell
2. Outlet Spouts
3. Internal Swing Spout
4. Spout Transition
5. Shipping/Assembly Legs
6. Electrical Control Unit

2.2 Distributor Body Shell

The body shell, shown in Figure 4, is the housing component of the distributor where the material is handled. The shell covers the internal spout sub-assembly where grain travels through and is deposited into outlets located along the lower bottom half of the shell.

Figure 4: Body Shell with all features

Features on the body include the main body shell, a product inlet, service door, hanger supports, ventilation cover, drip tray, and clean out covers which are all attached to the four main body panels.

2.2.1 Body Shell

Shown in Figure 5, the body shell is the main structure of the body sub-assembly and is a major structural component that holds all parts together.

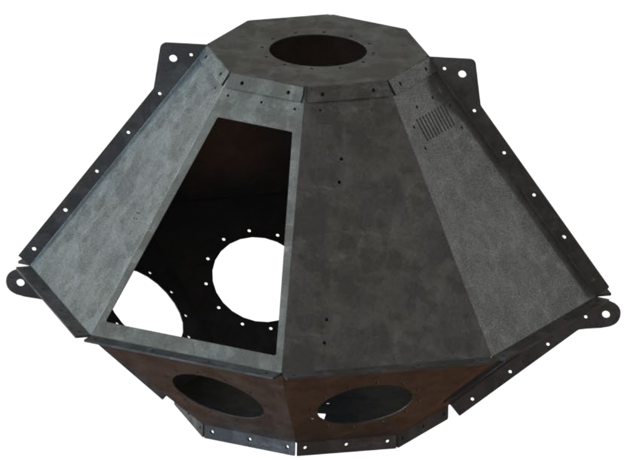

Figure 5: Body panels that make up the body shell

The new design consists of six parts: four body panels, top, and bottom caps that are all bolted together by flanges. The flanges contain built-in lifting lugs, shown in Figure 6 and Figure 7 so that the distributor can be moved with overhead cranes. The upper body panels, top and bottom cap are 12-gauge and the lower body panels are 10-gauge galvanized steel.

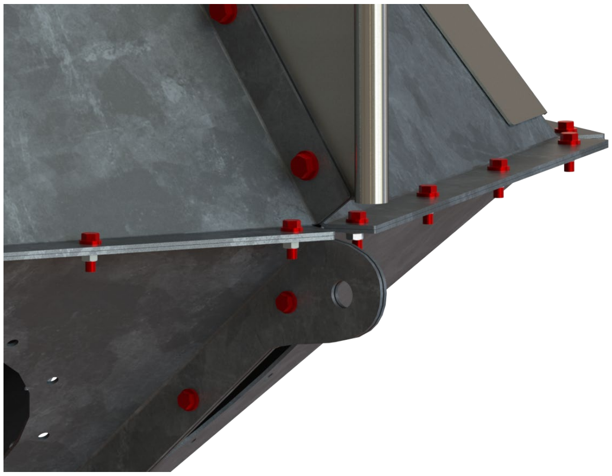

Figure 6: Upper lifting lugs

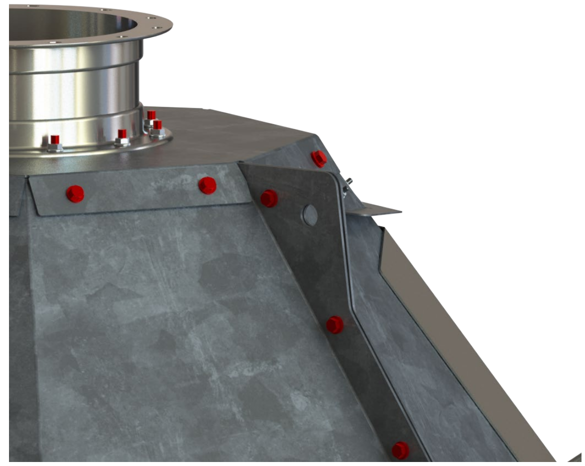

Figure 7: Lower lifting lugs

Attached to the bottom plate, the distributor contains cleanout covers that can be removed to empty built-up product. This additional feature allows for easy cleaning and improved maintenance.

Compared to the previous design, the body shell parts have a separate assembly process due to changed design features. The old design had multiple formed bends and consisted of mild steel that required painting to avoid corrosion. In addition, these panels were welded together.

To achieve a lower costing farm grade application, galvanized steel allows for lesser labour costs over mild steel. Benefits in using galvanized steel include lack of painting parts and less welding in the fabrication process. Since the steel is purchased with a galvanized coating, the metal is less susceptible to corrosion and does not need a paint coating in the assembly process. Also, galvanized steel has excellent mechanical properties and life expectancy of up to 50 years [2].

With bolted parts, warpage and weak points are not a problem in the design. Since welding requires melting metal, cooling after welding adds downtime to the total assembly time and painting is required to ensure that the welded metal does not corrode.

With the new features on the body shell, the target specifications earlier discussed highlight low fabrication costs that include material and labour, fewer steps and parts involved in the assembly process, proper ventilation during the application, and a fair sales costs that achieve customer needs. The numbers for costs will be discussed in Section 4.4.

2.2.2 Inlet

The inlet is the top section of the body shell that feeds product into the distributor shown in Figure 8. The inlet consists of three parts: one cut tube and two flanges welded on one end and a 7” distance from the lower half. The clearance allows for the UHMW ring on the internal spout to fit onto the inlet. More detail of flange locations is specified in the Body Shell Drawing found in Appendix D.

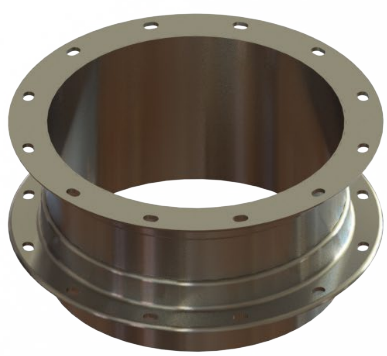

Figure 8: Inlet

The inlet material is 10-gauge mild steel tubing and two purchased flanges. Since the inlet is more prone to wear during the application, the bolted configuration allows for a replaceable part for easy maintenance.

Compared to the old design, the new design has fewer parts and fabrication steps. The old design had sheet metal flanges that were not designed to any standard; furthermore, two sheet metal rolled plates were welded down the sides to form a non-standard tube. Working with no standards can increase errors in fabrication and adds room for rework. The new inlet accounts for tolerances of the purchased flanges and is properly fitted to the tubing to decrease labour time significantly.

2.2.3 Service Door

The service door is a component that provides access to the internal distributor components. Shown in Figure 9, features of the door include a handle, hinged clamp, door hinges, and a window.

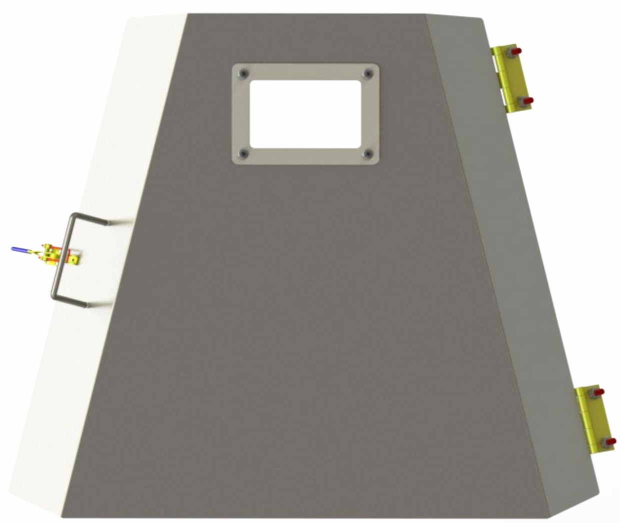

Figure 9: Door

The door is made of 12-gauge mild steel for components to be welded. The window, hinges and clamp are purchased parts that allow for ease of assembly during fabrication. Most component features allow for the door to be bolted to the body.

The window is an additional feature that is made of lexan glass. The window provides a visual of the internal components for improved maintenance. Another additional feature of the door is the drip tray cover located above the door that is bolted onto the body. The drip tray helps with water runoff that could leak into the distributor. This feature meets customer needs by reducing humidity and water contaminating the grain inside the distributor.

Like the old design, the new door is made of a sheet metal part that covers a cutout in the body shell. However, the cutout for the door is already laser-cut during table processing. As a result, rework in the overall body is eliminated decreasing fabrication costs. Likewise, the door design is sufficient to the target specifications and meets customer needs by improving cost, inspection, and assembly.

2.2.4 Hanger Supports

The hanger supports allow the distributor to be held in place while suspended above the bins. Two hanger supports are attached to the body shell flanges on opposite sides of the structure as shown in Figure 10.

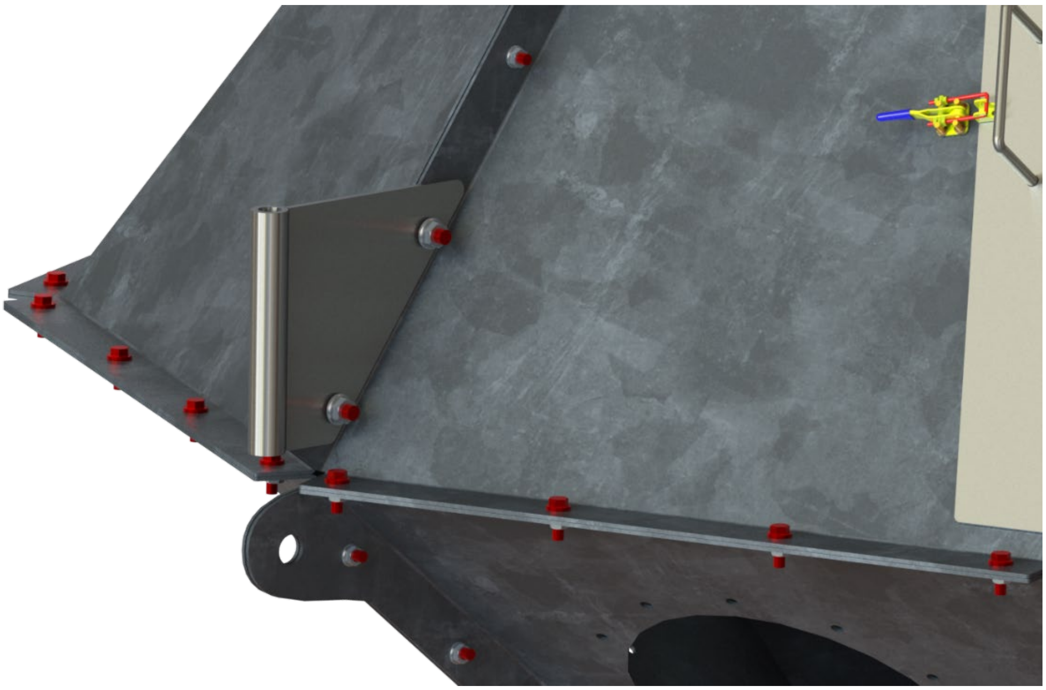

Figure 10: Hanger supports

The hanger support design is different from the old design because it is bolted instead of welded. The material of the hanger supports consist of ¼-inch mild steel sheet metal and a 3/4-inch pipe schedule 40, mild steel pipe.

Although there is still welding involved in the design, the support is bolted onto the body. As discussed, reduced welding improves the fabrication process. In addition, the hanger support is an optional feature in case the customer does not need it for their grain application.

2.2.5 Ventilation Cover

The ventilation cover shown in Figure 11 is an additional feature of the body used to ensure water does not leak through the vent and into the distributor.

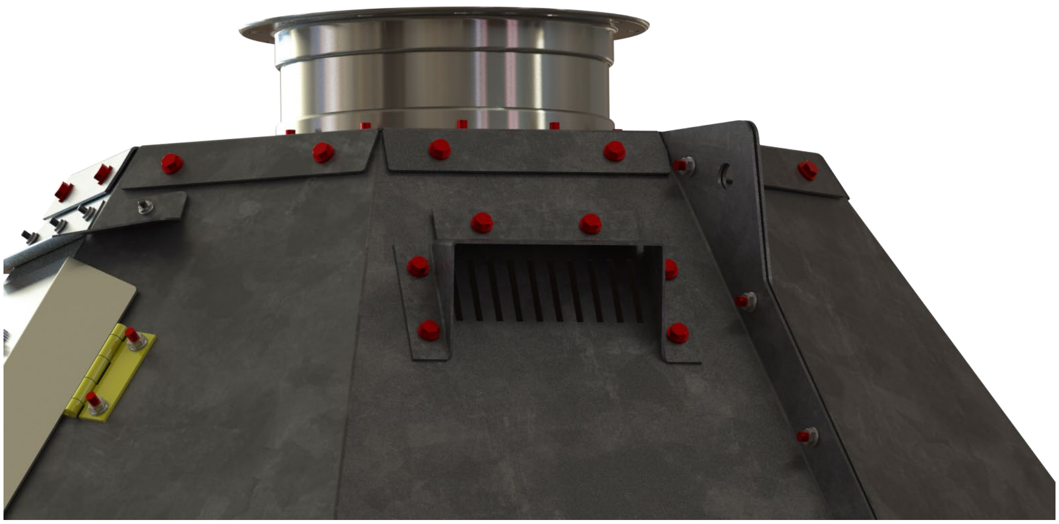

Figure 11: Ventilation Cover

Ventilation is up to customer need that helps prevent condensation inside of the distributor when humidity levels increase. Although it is an additional component that adds to the original design, it eliminates the previous ventilation system composed of unnecessary components. As a result, the overall cost decreases.

2.3 Outlet Spouts

The outlet spouts expel and direct product from the internal swing spout to the desired grain storage bin. A total of eight outlets are included in this design and are bolted to the lower half of the distributor body. Figure 12 shows the outlet spouts that are made of mild steel so that round flanges can be welded onto each end. Each outlet has an outer diameter of 12-inch and has a thickness of 10-gauge. In addition to each outlet is a thin outlet spout cover made of 14-gauge HRMS as shown in Figure 13. These covers will allow the farmer to close off any unused outlets and prevent dust from entering the distributor.

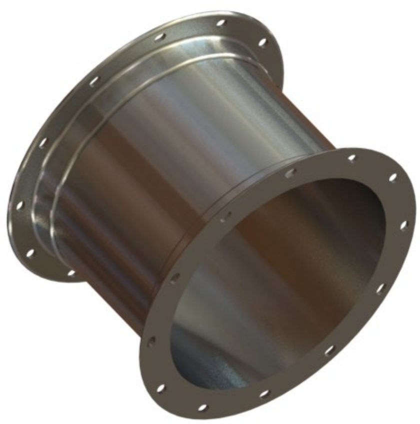

Figure 12: Outlet Spout

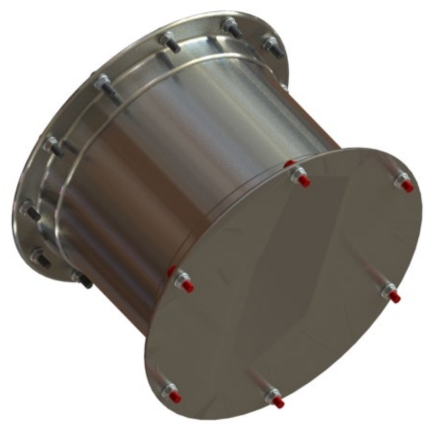

Figure 13: Outlet Spout with Spout Cover

Figure 14 shows the original outlet spout design of the commercial distributor which involves a tedious and time-consuming manufacturing process. This process involves cutting the sheet metal parts on the water jet, forming these sheets on the brake press, welding the parts together with a round flange on the end to create the tapered shape, and ultimately welding the entire outlet spout to the distributor. In total, the assembly and installation of these outlets take on average three to four hours. However, according to the distributor assemblers, it often takes much longer than this as the formed sheets often don't fit snug into the round flange and require rework at the brake press.

Figure 14: Tapered and Welded Outlet Spouts (Old Design)

The new design, on the other hand, will save assembly time as it has a much simpler manufacturing and installation process. It only requires two assembly steps which are cutting the spouting to length from standard 12-inch diameter tubes and then welding round flanges that easily slip on to the ends of the spouting. Afterwards, they are bolted on to the body through the round flanges.

2.4 Internal Swing Spout Assembly

The internal swing spout assembly is critical to the functionality of the distributor as it facilitates the material flow of the product (grain) into the various grain storage bins. Shown in *Figure 15* and *Figure 16*, the new swing spout design possesses similar aspects to the original commercial design, but now incorporates a bolt-on transition spout (discussed further in Section 2.5) in place of the sleeve and UHMW (polyethylene) glide plate.

Like the original commercial spout, the farm grade spout will also be constructed of mild steel due to the spout being completely enclosed within the distributor body and protected from harsh and corrosive conditions. As such, the swing spout does not require any protective coating or painting which further generates cost savings for the client. This is because mild steel construction without painting would be less expensive than using galvanized steel due to a greater cost per square foot.

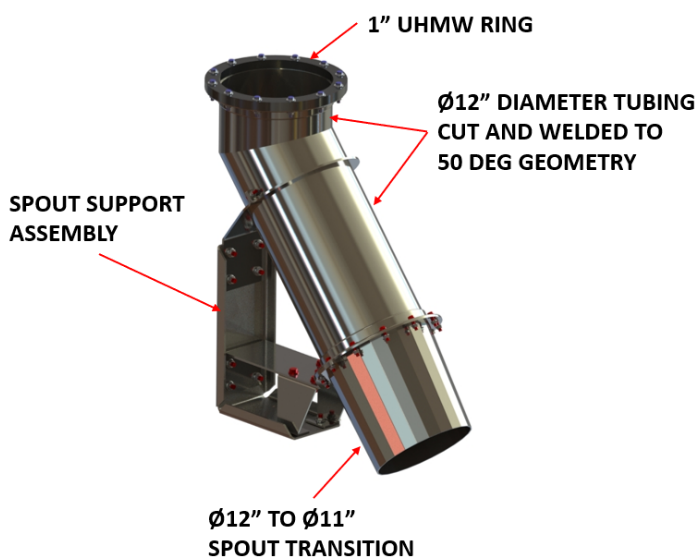

Figure 15: Modified Swing Spout

Figure 16: Original Swing Spout (For a Larger Sized Distributor)

2.4.1 Main Spout

The main spout seen in *Figure 17*, is designed to discharge at 50-degrees as requested by the client. Since grain has an angle of repose of 28 degrees, the grain should flow without issue as the minimum angle required for dry grain to flow reliably is 45-degrees [3]. Implementing a larger discharge angle will only ensure that the chances of product building up and plugging the distributor are minimized.

Figure 17: Main Spout

Just like the newly designed outlet spouts the spouting will be cut to length from standard 12-inch diameter tubing with round flanges welded on the ends. The new spout design eliminates the extra unnecessary and time-consuming processes involved in the original design. These processes include cutting the required part on the water or plasma jet, rolling it and then welding it to form the tube.

2.4.2 Swing Spout Support

Figure 18 and Figure 19 show the spout support assembly for which was not drastically redesigned in this project, but rather modified to integrate well with the other design changes to the distributor. First, the large formed L-Bracket was elongated by approximately six inches since the drive assembly and mounting plate connected to the support was lowered as a result of the new body shell. Gusset plates were then added to provide additional support to the L-Bracket since structural parts weaken as they increase in length.

Figure 18: Support Assembly with Fasteners

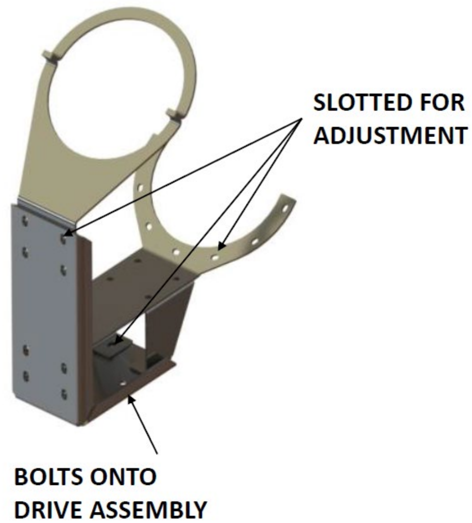

Figure 19: Support Assembly without Fasteners

The next modification was to the bottom ring bracket which will now be bolted onto the round flange and transition connection, all of which will share the same fasteners. Overall, the entire assembly was designed to bolt together for easy maintenance and replacement of parts in the field. Beyond that, the support parts are all slotted to allow for adjustment during the overall installation of the swing spout assembly into the distributor.

2.4.3 UHMW Ring

Bolted onto the top of the round flange of the internal spout will be a 1-inch thick UHMW ring shown in Figure 20. The purpose of this piece is that it will help keep the entire swing spout centered and prevent the product from falling out of the swing spout when the distributor is fully assembled and in service. Since the 12-inch diameter inlet will go through the top cap and into the body, the inlet spouting can be inserted into the UHMW ring and act as a guide as it rotates with the central shaft.

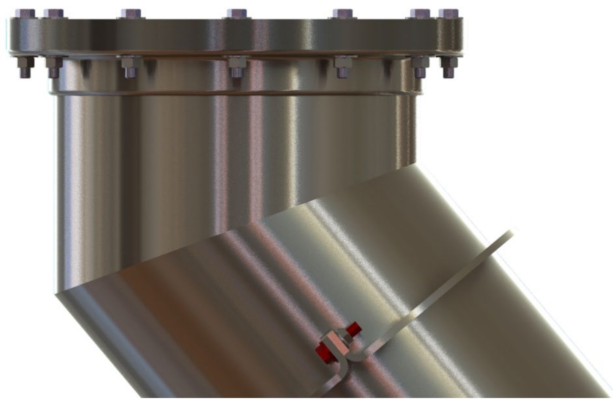

Figure 20: UHMW Ring

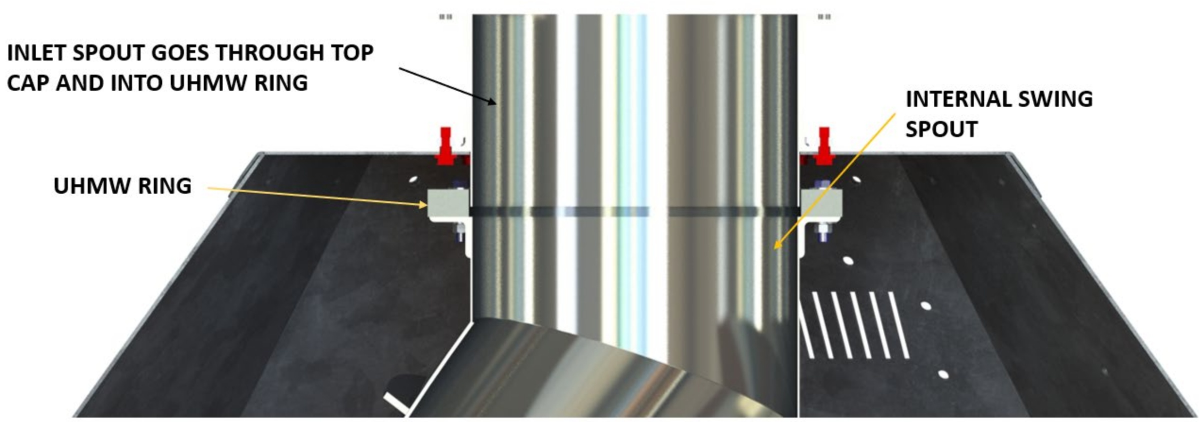

Figure 21: Section View of the Inlet Inside of the UHMW Ring

The internal diameter of the UHMW piece was designed to have an internal diameter that is 1/16 of an inch larger than the outer diameter of the inlet spout tubing for added tolerance and ease of swing spout rotation as shown in Figure 21. UHMW was chosen for this piece because it has outstanding resistance to abrasion, low moisture absorption, high corrosion resistance and better strength for a thermoplastic [4]. Furthermore, UHMW plastic is durable and inexpensive.

2.4.4 Spout Transition

A significant change that was made to the swing spout assembly is that it now requires a bolt-on round transition (12-inch to 11-inch diameter) spout that attaches to the end of the main spout as seen in Figure 22.

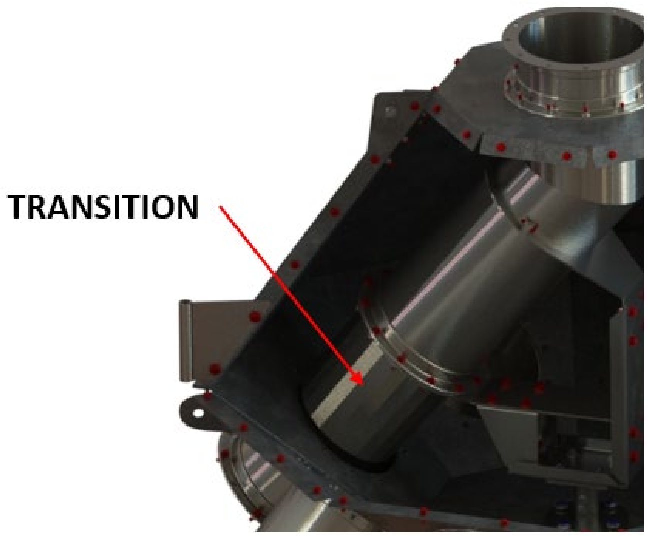

Figure 22: Transition Mating with Discharge Hole

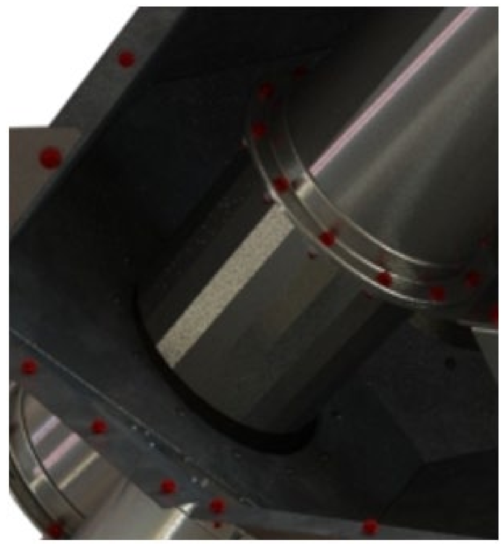

Figure 23: Transition – Discharge Closeup View

The transition spout addressed one of the higher priority projects for the grain product to precisely discharge into the outlet spouts. As previously mentioned, there is no longer a flat bottom plate, rather an angled body panel with 12-inch diameter round discharge openings. As such, the swing spout can no longer glide on a flat surface like the commercial-grade distributor and create a sealed connection with the discharge holes. To ensure a sealed connection and minimize the collection of products inside of the distributor the following three design features were established:

- The transition spout will be installed with the smaller 11-inch diameter end facing the discharge holes so that the grain expels into an oversized 12-inch diameter hole as seen in Figure 24.
- The clearance between the transition and the angled body panel is minimized by approximately 1-inch to safely clear the fasteners.

- The positioning of transition was optimized so that the top of the transition is tangent with the top of the discharge holes to create extra room for the grain to fall into.

When the distributor is in service, the flow of the grain (created by the 50-degree discharge angle), the oversized opening, the transition to body panel clearance, and the optimized positioning of the transition spout, the risk of grain spilling out is minimized. More importantly, with oversized discharge holes, there is 1-inch of tolerance in the event the swing spout stops too late or too early.

In addition to the bolt-on transition, there are optional features designed that can be attached to the transition spout if the customer chooses. These options include a bolt-on flexible neoprene rubber boot and a clamp-on brush option as shown in Figure 24 and Figure 25.

Figure 24: Transition with Neoprene Boot Attachment

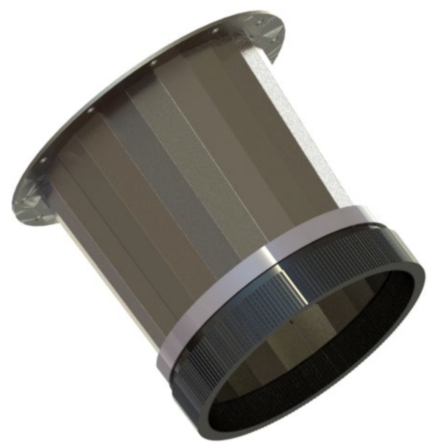

Figure 25: Transition with Brush Spout Attachment

The bolt-on neoprene boot provides an extension to the transition spout that can glide along the distributor body and fasteners without causing mechanical damage. Due to its soft texture and flexible behaviour over a wide range of temperatures, the neoprene boot is a feasible option all year long. The brush spout option, on the other hand, is attached to the end of the transition using a hose clamp and will allow for an improved sealed connection with the discharge hole. At the same time, the self-cleaning brush will remove unwanted product build-up.

2.5 Shipping/Assembly Legs

The farm grade distributor will come with a total of four shipping/assembly legs shown in Figure 26 that are made from three 3/16-inch thick mild steel pieces that are formed and welded together. The top piece of each shipping leg attach to the outlet flanges.

Figure 26: Shipping/Assembly Legs Installed on Outlet Spouts

Essentially, these legs serve two main purposes. The first is that they are required during manufacturing when assemblers are putting the distributor together. The assembly process (Section 4.3) involves many steps where the distributor must be elevated from the ground. Secondly, the legs protect the drive assembly during installation and when the finished distributor is shipped to the customer. Otherwise, the entire weight of the distributor will act on the drive assembly, stressing the central shaft and possibly causing it to fail. The strength of these shipping legs is analyzed in Section 3.

2.6 Electrical Control Unit

The electrical control unit [5] [6] shown in Figure 27 and Figure 28 was left out of the scope for this project and therefore not redesigned. Additionally, since the operational and capacity requirements are the same as the original, the entire assembly will be reused and integrated accordingly into the farm grade distributor.

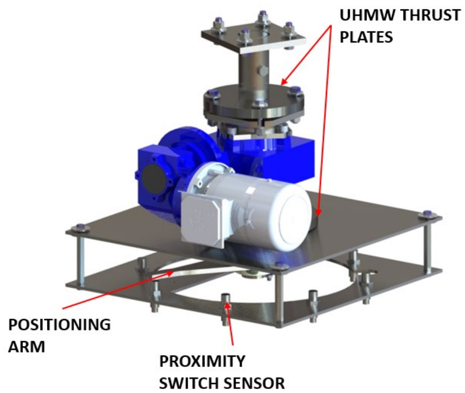

Figure 27: Drive Assembly without Sensor Box

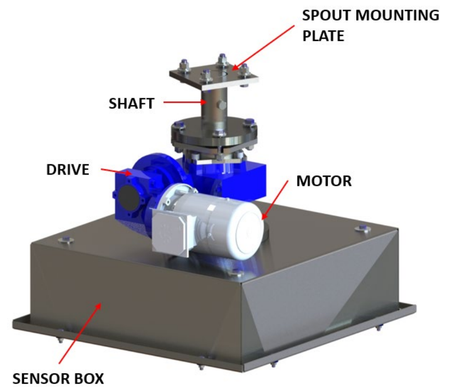

Figure 28: Drive Assembly with Sensor Box

Shown in Figure 29 the control unit is installed underneath the distributor body with the shaft going through the bottom plate and into the body. On the end of the shaft, a welded mounting plate contains a connection with spout support assembly. This connection allows the swing spout to rotate with the central shaft. To ensure that the swing spout is positioned correctly during service, the spout is synced during final testing to stop when the positioning arm hovers over top of the magnetic position sensor of the chosen outlet spout.

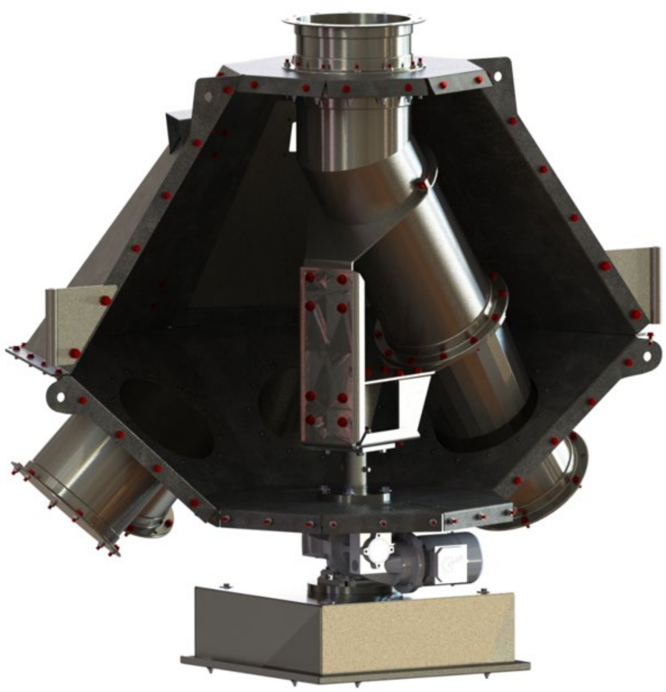

Figure 29: Drive Assembly Installed (Section View)

As nothing changed in the design of the electrical control unit the installation procedure also remains the same. However, the spout mounting plate position was lowered due to the change in the location of the bottom body panel. In this case, rather than extend the shaft to reach the spout support the L-Bracket was elongated in the spout support instead. Otherwise, by extending the length of the shaft, the shaft would ultimately become weaker.

2.7 Final Design Relating to the Voice of the Customer

Table V below summarizes the design features implemented to the new design addressing the voice of the customer.

TABLE V: DESIGN SUMMARY

Voice of the Customer (Target Specifications or Project Needs)	Targets or Customer Need met? (Yes/No/Somewhat)	Design Feature
Discharge Angle (50 Degrees)	Yes	- New distributor designed to discharge specifically at 50-degrees
Reliable Spout – (Grain discharges into the correct discharge hole)	Yes	- Position sensors ensure the spout stops at the correct hole - Oversized discharge openings just in case the spout stops too late or too early
Reliable Spout (Spout will not get stuck)	Yes	- 1-inch clearance between the transition and body panel ensures spout does not catch on fasteners - Spout support and the connection between the inlet and UHMW ring keeps spout centered with the body
Cost Reduction of 25% from the commercial version ($7770)	Yes	- The total cost savings including material and labour costs are $2532.86 or 24.5% respectively (described in Section 5).
Minimize Product Build up (Snow, water, dust, etc.) (Horizontal surface area 3 - 4 ft^2)	Somewhat	- The distributor body shell is angled so any unwanted product slides off the distributor - Flat surfaces were minimized as much as possible but are still present on the top cap and body connection flanges (5.6 ft^2)
Reduce labour time (60-70 hours)	Yes	- The projected labour-time of the new distributor is 63.5 hours which is a 28.5-hour improvement from the commercial version, 92 hours (highlighted in Section 5)
Easy Maintenance	Yes	- More bolted components and less welded components allow for easy replacement of parts - Service door allows for access to internal components - Product cleanout holes for removing product buildup at the bottom of the distributor - Inspection window to easily see the internal features
Airtight	Somewhat	- The distributor is now bolted together through flanges, creating more small crevices for potential leakage - Assembly instructions include applying silicone and gaskets to seal crevices
Life Cycle (15 – 20 years)	Yes	- The body is constructed of galvanized steel which has excellent mechanical properties and life expectancy of up to 50 years [2]. - Most of the parts are now bolted and are easily replaceable. - Product cleanout holes, spout covers, and an inspection window will help facilitate proper maintenance to ensure a long product life.
Ventilation	Yes	- A vent was designed into the distributor body and is complimented with a vent cover.
Easy entrance and exit into confined spaces (Door Opening 3.5 - 4 ft^2)	N/A	- Service door allows for access to internal components (3.9 ft^2) - Will be confirmed when a prototype is created
Wear resistance	Somewhat	- The use of galvanized steel and mild steel at an increased gauge will help prevent wear. - UHMW was used on parts that make contact during spout rotation. - Wear resistance could be improved by incorporating liners, however at an increased cost.
Corrosion resistance	Yes	- Galvanized steel has excellent corrosion resistance and will protect the body shell. - The mild steel components except for the internal swing spout are to be painted to protect from corrosion.
Reduce the total number of assembly steps (<30)	Yes	- Total assembly steps reduced from 39 steps to 29 steps
Reduction in the total number of parts required (40 – 60 parts) Note: Part totals do not include fasteners and drive assembly parts	No	- The number of parts decreased from 75 to 68.
Add tolerances to parts to save time during assembly and minimize rework	Yes	- Bolt holes were made 1/16-inch larger than the fasteners. - Large assembly parts were designed with slotted holes.
Sufficient Internal Space (Internal Space > 40 ft^3)	Yes	- Large internal space allows for easy entrance and removal of parts and technicians (46.7 ft^3) - Will be confirmed when prototype is created

3 Design Analysis

The analytical analysis was evaluated on key features of the design to ensure max stresses were below the point of failure by a minimum factor of safety of two. The following sections give a summary of the results from the calculations.

3.1 Distributor Capacity Calculation

Flow rates of grain through the swing spout in Figure 30 was calculated using to determine the overall capacity of the distributor.

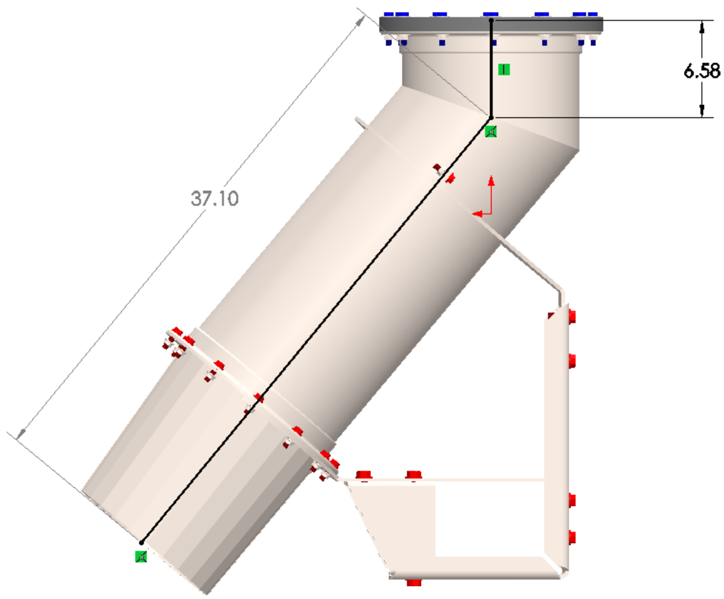

Figure 30: Dimensions of internal swing spout

Q = Volume flowrate $[gpm]$

g = Acceleration due to gravity $[ft/s^2]$

D_h = Hydraulic diameter $[ft]$

A = Effective orifice area $[ft^2]$

$$Q = 0.75A\sqrt{(gD_h)}$$

$$Q = 0.75 * pi\left(\frac{11\ in}{2}\right)^2 \sqrt{(32.40\ ft/s^2 * 11\ in)}$$
$$= 1345\ gpm$$
$$\sim 10700\ ft^3/hour$$

Given a farm grade distributor has an average cycle time of 76 hours per year [7]. The distributor allows for a capacity of approximately 10700 cubic feet per hour of grain.

3.2 Lifting Lug Stress Analysis

Failure Mode 1 is due to shear stress on the plate of the lifting lug leading to catastrophic failure. The portion above the hole is in compression while the portion below the hole is in tension due to the weight of the distributor pulling it down. Figure 31 outlines the area that will be subject to the shear.

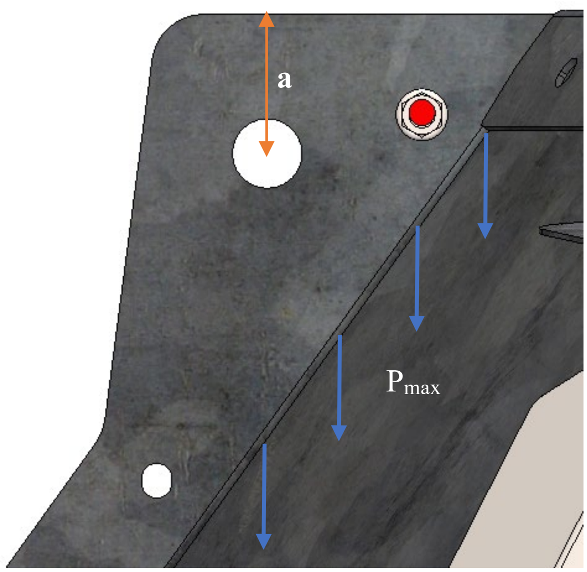

Figure 31: Free Body Diagram of Lifting Lug

P_{max} = Max load the lifting lug will experience due to the weight of the distributor and the internal spout full of grain $[lb_f]$

a = Length from the center the hole to the edge of the plate of the lifting lug $[in]$

t = Thickness of the lifting lug plate $[in]$

σ_{allow} = Maximum allowable stress before failure $[psi]$

The following calculation assumes the plate is tension. The forces acting on the lifting lugs are shown in the schematic below.

$$\sigma_{allow} = \frac{P_{max}}{2at}$$

$$= \frac{(P_{grain} + P_{distributor})}{2 \times 2.00\ in \times (2 \times 0.14\ in)}$$

$$= \frac{1027\ lbf + 137\ lbf}{1.12\ in^2}$$

$$= 1039\ psi$$

The tensile yield strength of galvanized steel is 29600 psi [8]. The calculated stress acting on the lifting lug is 1039 psi due to the maximum weight of the distributor filled with the grain still maintains below the yield stress. With a factor of safety of 25, the lifting lug remains well below to point of failure and proves the proposed is reliable design.

3.3 Hanger Support Strength Analysis

The hanger support is subject to shear stress from the bolts connecting the support to the body shell of the distributor as shown in Figure 32.

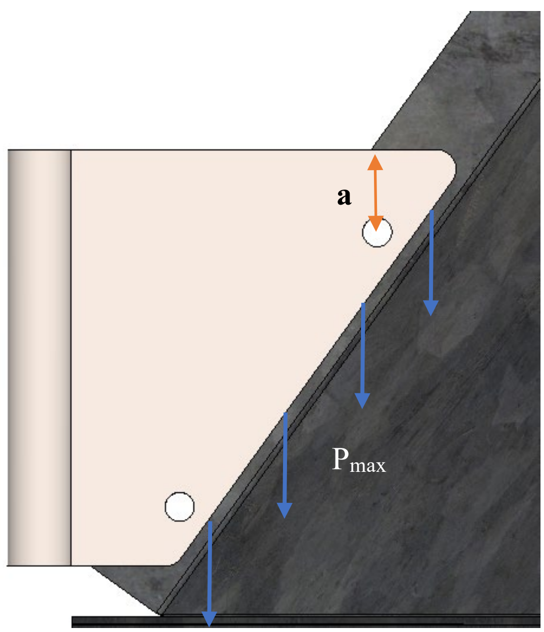

Figure 32: Free Body Diagram of Hanger Support

P_{max} = Maximum load the support hanger will experience due to the weight of the distributor and the internal spout full of grain $[lb_f]$

a = Length from the center the hole to the edge of the plate of the lifting lug $[in]$

t = Thickness of the hanger support $[in]$

$$\sigma_{allow} = \frac{P_{max}}{2at}$$
$$= \frac{(P_{grain} + P_{distributor})}{2 *\times 0.74in \times (0.25\ in)}$$
$$= \frac{1027\ lb_f + 137\ lb_f}{0.37in^2}$$
$$= 3174\ psi$$

Since mild steel's yield strength, 44 000 psi, is less than the applied stress, the part will not fail due to shear stress [8]. The maximum yield strength of the ½-inch 5 grade bolt is 120 000 psi and is well above the maximum stress the part will endure proving the design is safe and reliable [9].

3.4 Stress from Outlet to the Body

The stress from the outlet to the body plate is important when the product is exiting from a 12" outlet to 40' spouting. The normal force acts on the object by an inclined plane shown in Figure 33.

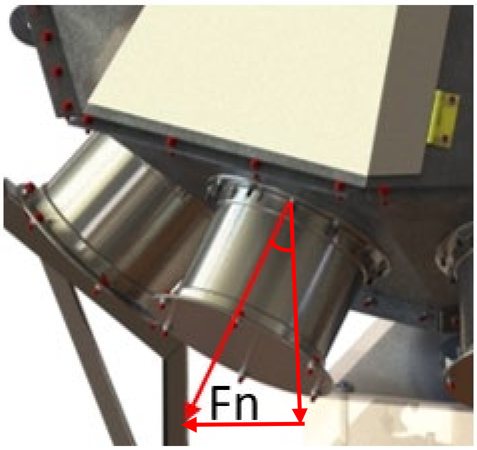

Figure 33: Normal Force from Outlet to the body

There is a normal force pulled away from the 10-gauge galvanized steel body when the product exits the distributor, assuming the 40' spouting filled with the grain is acting on the plate. Therefore, the allowable load (normal force acting on the plate) F_n in lbf can be calculated as,

$$F_n = mgcos\theta$$

Where, m = Mass of the outlet, product exiting, and 40 ft of spouting $[lbs]$

g = Gravitational acceleration $\left[\frac{ft}{s^2}\right]$

θ = Angle of the outlet in the y-direction [°]

$$F_n = (322{,}560 + 6{,}720) \times 32.174 \times \cos(50°)$$

$$F_n = 6{,}809{,}855.67\ lbf$$

Next, the normal stress shown in the immediate equation below is calculated using the area of the plate and the normal force previously calculated. Figure 34 shows the trapezoidal shape of the body plate.

$$\sigma = \frac{F_n}{A}$$

Where, A = Area of the trapezoidal plate $[in^2]$

σ = Normal stress $[psi]$

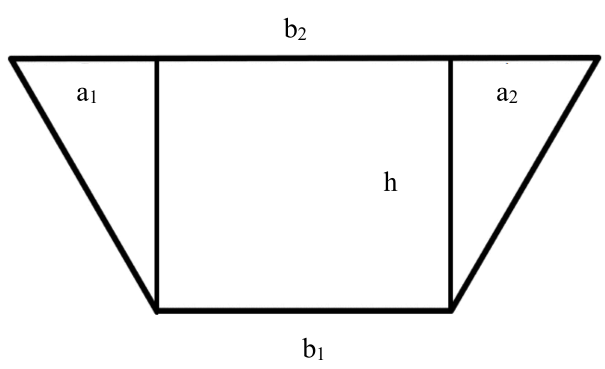

Figure 34: Trapezoidal shape of the body plate

$$A = \frac{1}{2}(b_1 + b_2)h$$

Where, $h = height\ of\ the\ trapezoid\ [in]$

$$b_1 = bottom\ length\ [in]$$

$$b_2 = top\ length\ [in]$$

The height of the trapezoid can be calculated using the right-angle triangle formula [10]. Now, the normal stress can be calculated:

$$\sigma = \frac{F_n}{\frac{1}{2}(b_1 + b_2)h}$$

$$\sigma = \frac{6.81 \times 10^6\ lbf}{\frac{1}{2}(13.04 + 26.72)in \cdot 22.22\ in}$$

$$\sigma = 15{,}416.20\ psi$$

Therefore, a normal stress of $15{,}416.20\ psi$ is acting on the distributor body plate. Altogether, the 10-gauge galvanized steel body can support a normal stress up to $29{,}600\ psi$. From the normal stress calculation, the design will have an overall factor of safety of 2 assuming the 40' spout is full of grain.

3.5 Shipping/Assembly Leg Stress Analysis

The entire weight of the distributor is supported by the shipping legs. In Figure 35, W signifies the weight of the distributor on the shipping leg.

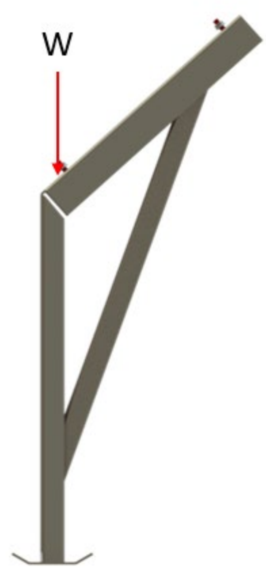

Figure 35: Shipping Leg

The shipping legs act as a column that can fail by buckling when the critical load is reached. This column can be analyzed with the Euler column formula. Therefore, the allowable load F_a in lbf can be calculated as: [11]

$$F_a = \frac{n\,\pi^2 EI}{L^2}$$

Where, n = factor accounting for the end conditions

E = modulus of elasticity $\left[\frac{lb}{in^2}\right]$

I = moment of inertia $[in^4]$

L = length of the column $[in]$

The column is made of a mild steel C-channel with a moment of inertia $I_y = 324.1182\ in^4$. The Modulus of elasticity of mild steel is $30457924.91\ \frac{lb}{in^2}$ and the factor is 4 as the column ends are fixed. The Euler buckling load of the column, F_1, can be calculated as:

$$F_1 = \frac{4\,\pi^2\left(30.4579 \times 10^6\ \frac{lb}{in^2}\right)(324.1182\ in^4)}{324\ in^2}$$

$$F_1 = 1.2029 \times 10^6\ lb_f$$

The support piece attached to the support leg is also in compression. Assuming, the support piece acts as a column, it can fail through buckling when the critical load is reached. This column can be analyzed with the Euler column formula also. Since the C-channel support piece is also made of mild steel, the same factors mentioned above apply. Therefore, the allowable load, F_2, in lbf can be calculated as: [11]

$$F_2 = \frac{4\,\pi^2\left(30.4579 \times 10^6\ \frac{lb}{in^2}\right)(0.3071\ in^4)}{324\ in^2}$$

$$F_2 = 1.1397 \times 10^6\ lbf$$

The force acting on the distributor without the support leg is $33{,}042.7\ lb_f$. Therefore, the support legs, with a critical buckling load of $1.2029 \times 10^6\ lb_f$, will easily withstand the weight of the distributor.

4 Process Analysis

This section will highlight the assembly process of the final design by reviewing the current state process, establishing a target operating condition, explaining the methodology for producing a final process flow and highlighting process changes to proceed with final design implementation. The sections that will be covered include:

1. Baseline Performance
2. Future State Value Stream Map (VSM)
3. Updated Process Flow Chart
4. Assembly Layout

4.1 Baseline Performance

In earlier stages of design development, the process of the current distributor fabrication was analyzed. Current state data in Appendix B including the SIPOC (Suppliers, Inputs, Process, Outputs, and Customers) Table, performance data, Current State VSM, and Value-Added Analysis were used to understand key elements in the manufacturing process. Note that labour costs defined in this section do not include table processing and forming since the scope is narrowed to the distributor assembly only. Evidently, the target operating state described in Figure 38 does not match the cost analysis of the labour described in section 4.4.

Assumptions for the baseline performance include:

- The standard costed BOM and routing reports in the MRP system are the average fabrication costs based on the demand of AGI-VIS customers
- All factual statements are confirmed by interviews by the assemblers and client
- The process scope only covers the point where parts enter the cell to shipping.

Below is a brief description of the current state data described previously:

1. **SIPOC Table**
    - SIPOC was the first step to the lean method: define the process
    - Provided a summary of the manufacturing of the distributor by defining supplier capability, customer needs, inputs, outputs, and the process flow. Further details of the table are in Appendix B.1.

2. **Performance Data**
   - Collected data were timesheets of total distributor assembly times were graphed and analyzed in statistical analysis software, Minitab. Results found in Appendix B.2 were skewed and unreliable because of the lack of variation and bias in the data set.
   - The costed BOM and routing reports provided the proper data needed for the distributor fabrication found in Table D and E from Appendix B.
   - Despite skewed data, the process does not follow any standards and is lagging in the competitor market. Thus, the causes must be determined.
3. **Value-Added Analysis**
   - The second step to understanding the problems that arose in the design was to establish the focus on the current distributor design because the design depended on the fabrication process.
   - The Value-Added Analysis, in Appendix B.3, was used to break down the current process, found in Appendix B.5, to show that the design was long and convoluted. The datum was collected by interviewing process performers because future jobs did not occur in the period of the project deadline. Collecting explicit and clear datum was beyond the team's capability.
4. **Current State VSM**
   - The third step to understanding the problems in the design was examining the current situation.
   - A VSM created a linear model of the current process.
   - The VSM provided information such as low customer demand. In addition, an MRP system was adding unnecessary production control to a simple process flow. The Current State VSM is found in Appendix B.4.

4.2 Future State Value Stream Map (VSM)

Based on the current baseline performance, a Future State VSM shown in Figure 38 was created to establish a target operating condition (TOC) for material and labour costs in manufacturing.

A list of potential process times including setup and cycle times were validated with MRP data and interviews with the process performers. The major design changes modified the overall process flow. As a result, the manufacturing processes created a TOC that help achieve a state with no waste.

The Future state value stream map shows a TOC of 39.2 hours. With a current state of 71 hours from the current VSM, the assembly time is targeted to decrease by 31.8 hours. Although the labour time changes are ambitious, the major changes are a result of distributor design changes that are confirmed only by the assemblers.

Below are insights from the Future State VSM:

- Removal of the MRP system will decrease the corruption that comes with external production control.
- Fewer parts in the process flow results in fewer steps
- The linear process allows for the inputs to continuously flow to produce the output.
- The removal of any WIP that existed in the previous design.
- Design changes result in lower cycle times and the removal of non-value-added steps observed from the current design.

Knowing the process flows, a list of causes to the narrowed focus on long assembly time is summarized in the cause and effect diagram shown in Figure 36.

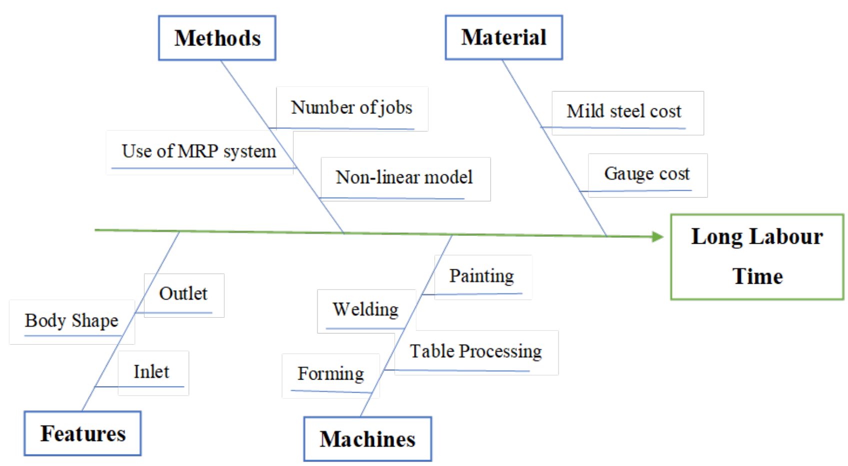

Figure 36: Cause and Effect Diagram with Key Variables for Distributor Fabrication

With the lack of tools for testing, the causes must be analyzed internally to ensure the key variables are true. However, these variables cannot be confirmed because it is beyond the scope of the project. Section 6.1 describes further actions to take to achieve the proposed goal.

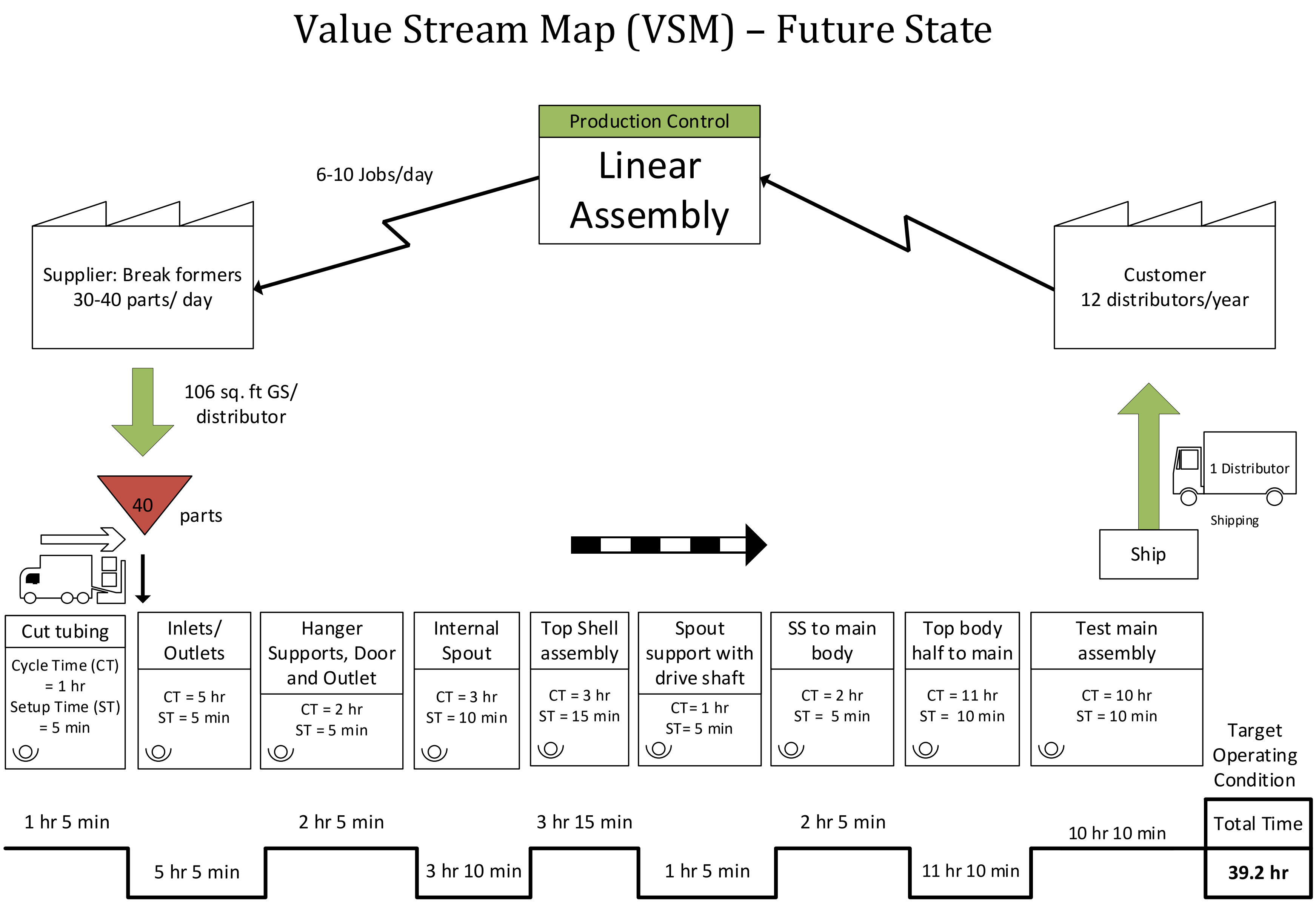

Figure 37: Future State Value Stream Map

4.3 Updated Process Flow Chart

The final design assembly process is defined in Figure 39. The new process flow consists of the small component assembly that is split into two sections for both assemblers. The assemblers combine the small components for the large component assembly.

The major design changes including the inlet, outlets, body, and material have improved the overall process flow. Based on the Future State VSM, the updated process flow was simplified.

Major changes in the final design assembly process include:

- Inlets and outlets have proper tolerances and are easily fitted, decreasing labour time.
- The body shape is octagonal and consists of four body panels with flanges that bolt together.
- Mild steel is replaced with galvanized steel for ease of manufacturing by decreasing welding and painting.
- The assembly is a linear process.
- The total number of steps was reduced to 29 steps.
- Non-value-added steps were removed from the old distributor design.

Tying back to the voice of the customer, the following customer and client needs were considered in the new process flow:

- Low fabrication and sales costs
- Corrosion-resistant
- Easy maintenance

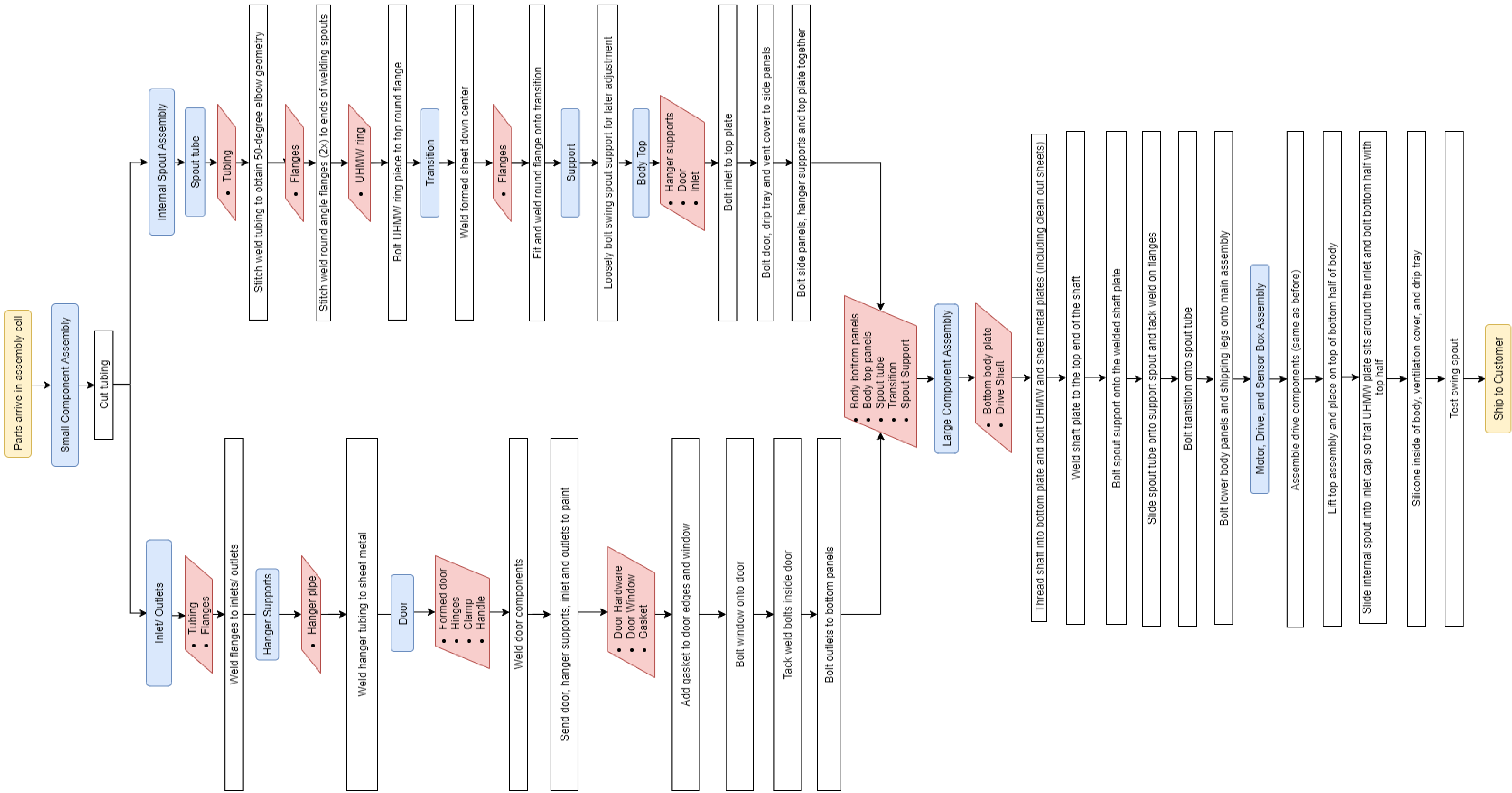

Figure 38: Updated Process Flow Chart

4.4 Assembly Layout

The assembly layout explains the process tools, layout, and locations of where the process takes place.

4.4.1 Work Center Layout

Below in Figure 39 is a layout of the work center where all the components of the distributor are to be assembled.

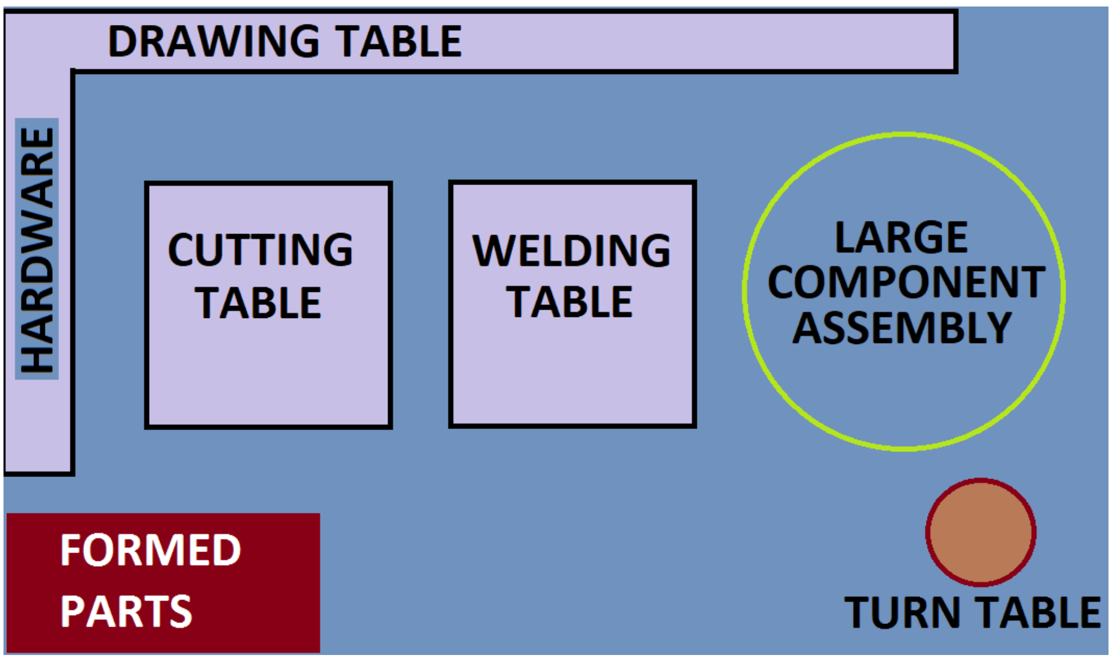

Figure 39: Work center layout

The new distributor assembly work center has a similar layout to the previous design. In the figure above, the work center is separated by a wall along the perimeter of the hardware and drawing table. On the right side, exists a curtain to separate the welding light from other work centers. The main walkway is located at the bottom perimeter of the cell.

The table positions of the physical layout have remained the same, however, specific areas are now labelled for specific tasks. The new process of the distributor design allows for two assemblers to work on separate tables and to complete individual tasks. Tooling and fixtures do not change in the new design process. These include the forklift, pallet jack, turntable and overhead cranes.

4.4.2 Shop Layout

AGI-VIS' manufacturing shop is conveyed in Figure 41. The lighter orange sections are the work centers that components of the distributor pass through. The gray areas are other work centers for various other jobs that include separate material handling equipment. The blue lines are a map of the crane branches and where they can move.

Despite the distance between the routing processes in the layout, it is beyond the team's control to change the location of the work centers. However, the overhead cranes lift the distributor body without the need for external means of transportation within the shop. With the proposed farm grade distributor design, the overall weight has decreased due to lighter material. Evidently, moving the distributor to the shipping bay is deemed feasible.

Although the paint shop is located away from all the work centers, the new design does not contain painted large components. The few mild steel parts that are welded only need paint if they are externally exposed to outdoor conditions that contribute to corrosion. Furthermore, with a galvanized steel body, the distributor process does not contain travel and excess processing. The assemblers can focus on working on the design instead of waiting on painted parts.

The following section will describe the cost analysis that provides a breakdown of the new design and supporting data on the improvements made.

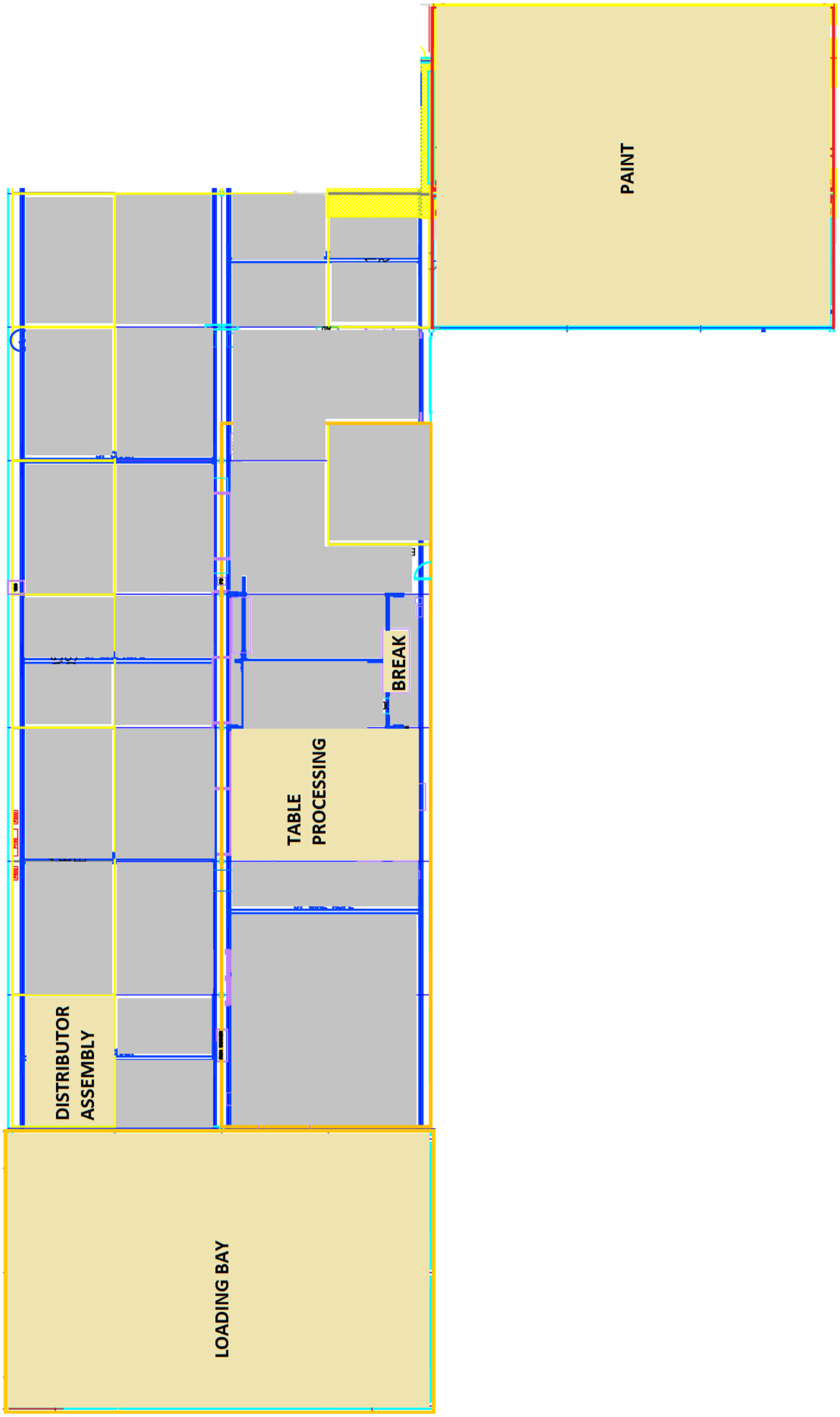

Figure 40: Shop layout to scale

5 Cost Analysis

The total manufacturing cost of the distributor is the total of the material and labour cost. The baseline commercially designed distributor has a total cost of $10360.38 with the material and labour costs at $4364.13 and $5996.25 respectively. For the new farm grade distributor, the total manufacturing cost projects to be $7827.52 with material and labour costs of $3700.02 and $4127.50. Overall, this amounts to a total cost savings of $2532.86 or 24.5% (Material Savings - $664.11 and Labour Savings - $1868.75), just shy of the project objective, 25%. The following sections provide a breakdown of these new costs with a detailed Costed Bill of Materials (BOM) and Standard Routing reports of both the commercial and farm grade distributors found in Appendix E. Explicit details that are not addressed below are found in Appendix F.1 and F.2 for labour and material cost analysis.

5.1 Labour Cost and Routing Hours

Manufacturing at AGI-VIS is broken down into different work centers where similar equipment and operations are grouped together. The relevant work centers for manufacturing the farm grade distributor are summarized in TABLE VI.

TABLE VI: WORK CENTERS FOR THE FARM GRADE DISTRIBUTOR

Code	Work Center	Description
TBLPRO	Table Processing	Sheet metal parts cut on either the plasma or water jet.
FRMPRO	Form Processing	Sheet metal bending on a brake press.
PAINT	Painting	Painting and kiln drying.
AO#	Assembly Cell	Assembly cells for large and small component assembly and testing. Each cell is assigned a specific number (#). AO1 being assembly cell 1 as an example.

The labour costs are directly associated with the number of standard routing hours allocated to each work center using a fixed labour rate of $65/hr. The following TABLE VII summarizes the routing hours allotted to the distributor and its subassemblies.

TABLE VII: SIMPLIFIED ROUTING REPORT SUMMARY

Work Center	Operation Quantity	Production Hours (HR)	Standard Cost (CAD $)
Item: Farm Grade Distributor (FBDTA-08HFR-5012E) - (QTY - 1)			
TBLPRO	1	2	130.00
FRMPRO	1	4	260.00
PAINT	1	1	65.00
AO#	1	18	1170.00
TOTAL	**N/A**	**25**	**1625.00**
Item: Outlet Spout (FBDTA-OUTLET-MS) – (QTY - 8)			
TBLPRO	8	.25	130.00
PAINT	8	.5	260.00
AO#	8	.75	390.00
TOTAL	**N/A**	**12**	**780.00**
Item: Swing Spout (FBDTA-SWING-SPOUT-MS) – (QTY - 1)			
TBLPRO	1	1	65.00
PAINT	1	1	65.00
AO#	1	2	130.00
TOTAL	**N/A**	**4**	**260.00**
Item: Transition Spout (FBDTA-TRANSITION-MS) – (QTY - 1)			
TBLPRO	1	.5	32.50
FRMPRO	1	.5	32.50
PAINT	1	.5	32.50
AO#	1	2	130.00
TOTAL	**N/A**	**3.5**	**227.50**
Item: Shipping Leg (DTA-SHIPLEG) – (QTY - 4)			
TBLPRO	4	.25	65.00
FRMPRO	4	.50	130.00
AO#	4	1	260.00
TOTAL	**N/A**	**7**	**455.00**
Item: Drive Assembly (DTA-DRIVE-E01-08FR) – (QTY - 1)			
TBLPRO	1	2	130.00
FRMPRO	1	2	130.00
AO#	1	8	520.00
TOTAL	**N/A**	**12**	**780.00**
OVERALL TOTAL	**N/A**	**63.5**	**4127.50**

The total assembly time for the farm grade distributor is 63.5 hours which equates to $4127.50 in labour costs. This means that the project objective of decreased labour hours in the new design was successfully fulfilled as the new design will take 28.5 hours less to fully assemble than the commercial version with a total of 92 hours. Note that these numbers include all routing work centers which include a total labour time (different from the defined baseline performance suggested in section 4).

It is important to note that the routing hours allocated to each assembly are estimates since creating prototypes were out of the scope of this project. Therefore, no time studies were conducted. To ensure that these estimated labour times were accurate without any concrete data from the limited capability of performing time studies, the following combination of steps were taken:

- The process performers (assemblers and brake press operators) were interviewed throughout the entire duration of the project. They provided valuable input and logical build time estimates based on their years of experience working on the production floor.
- The routing reports of the commercial distributor and similar jobs were thoroughly analyzed and used to establish assembly times on common tasks.
- An updated step by step process flow chart of the entire distributor assembly was created and documented (Section 3.4). Each step in the new process was given an approximate completion time based on the previous two points in combination with each team member's input and manufacturing knowledge/experiences.
- The updated process flow chart and estimated assembly hours were presented and approved by the client.

5.2 Material Costs

Table VIII outlines the material costs of the entire distributor and its subassemblies. These costs include all the sheet metal, fasteners, and purchased parts required for the new design. In total, the farm grade distributor will require a total material cost of $3700.02, a $664.11 cost reduction from the commercial version ($4364.13).

TABLE VIII: SIMPLIFIED MATERIALS COST SUMMARY

Item	Quantity	Standard Cost (CAD $)
Distributor Body	1	540.72
Outlet Spout	8	337.44
Swing Spout	1	96.52
Transition Spout	1	16.25
Shipping/Assembly Legs	4	31.36
Drive Assembly	1	2677.73
TOTAL	**N/A**	**3700.02**

All the listed material costs were determined by matching the SolidWorks bill of materials (Appendix E) to the standard bill of materials in the company's MRP software, Made2Manage.

6 Recommendations & Future Works

This section highlights an implementation plan and some key insights the team encountered during the project.

6.1 Future Works

To move forward with prototyping and implementation, there are a few suggestions to consider. These include the next actions that need to be performed such as analyzing and acting on the causes, prototyping, studying results, and standardizing.

6.1.1 Analyze the Causes

The Future State VSM shown in Figure 38 stems from the analysis in the Current State VSM described in Section 4.1. Based on the Value-Added Analysis, the current process showed that the model was not linear, the process included Work-In-Progress (WIP) components, and multiple steps were not necessary. A cause and effect diagram discussed earlier in Figure 37 describes various key variables that need to be validated by collected data. AGI-VIS will have to test certain variables in the design to ensure that the causes are explicitly related to long labour times.

Next, the causes can be analyzed by:

- Establishing key variables contributing to the design such as an inlet or outlet design, excessive welding, material choice, and body shape in the fishbone diagram discussed earlier in section 4.2. These are examples of key variables that can be explored.
- Proposing a hypothesis: If the design is improved by eliminating excessive welding, updating the material choice, and changing the body, inlet, and outlet design, then the labour time will decrease by 25%.
- Testing the hypothesis by reviewing routing reports on other jobs with similar design concepts at AGI-VIS that confirm lower labour time rates. Refer to the Future State VSM to reach the TOC.
- Evaluating data to confirm the proposed hypothesis. A detailed cost analysis should be performed internally with the company after prototyping. With exact values, the hypothesis can confirm if the distributor design needs rework or can proceed with acting on the cause.

6.1.2 Act on the Cause

When acting on the proposed causes and analyzing key variables that contribute to the new design, a range of tools should be used to help track the changes. Root cause analysis is key to understanding where and how the process is affected by the changed design. In addition, a series of time studies and referring to customer demand will help strengthen the design and allow for improvements to be effective.

The final steps that follow in lean methodology for the proposed distributor are to study results, standardize, and conclude the changes and improvements made. This consists of a period of reviewing and tweaking the prototype. Optimizing the design will come with the following tasks:

- Collecting explicit time studies of distributor labour hours.
- Revisiting the process flow and design
- Understanding that data and facts must support the decisions made moving forward
- Consult with production to create a change management plan (i.e. new shop layout)
- Standardize the distributor sizes by creating thorough CAD models and assembly and part drawings
- Develop maintenance procedures for farmers highlighting the design features and critical points in the overall design.

6.2 Key Insights

Key insights throughout the project include accurate data recording. A lack of accurate reliable data available at AGI-VIS limited the ability to collect information to determine a baseline performance. In the future, accurate data will allow for further improvement to processes. It is crucial to document information proactively as soon as a task is completed to ensure there are no discrepancies between the true data and remembered times.

Compare various resources to determine different ways to communicate ideas effectively to different audiences. The use of appendix is an effective manner to cater to multiple audiences. Ensure the project is reviewed by external stakeholders if permission granted from the client, to ensure documentation is easily comprehendible and has good cohesion between sections.

The integration of the voice of the customer in each step of the design process is crucial to ensure the customer needs are being met. The frequent visits with the client ensure the design is still within customer needs and addresses any changes from the original intent.

7 Summary

The proposed final design achieves the main project objective set by the project sponsor to design a farm grade distributor with a 25 percent reduced total manufacturing cost from the current commercial version. The distributor configuration that was selected as the baseline for this project was AGI-VIS' mild steel distributor with eight outlet spouts, 12-inch diameter spouting and a 50-degree discharge angle. Including all material and labour, the total manufacturing cost of this baseline commercial distributor is $10360. The proposed farm grade design has a projected cost of $7828 (Material Cost – $3700 and Labour Cost - $4128). This amounts to a 24.5 percent cost reduction from the baseline distributor and an overall material and labour savings of $664 and $1869, respectively. Additionally, the required labour hours for the proposed design is estimated to be 63.5 hours which is a 28.5-hour improvement over the commercial version.

The new farm grade distributor features a design that involves significantly less forming and welding compared to the commercial version and has a much more simplified outlet spout design. All of which were identified earlier on in the project as major contributors of nonvalue-added time in the fabrication process. Overall, six main subassemblies make up the farm grade distributor including a body shell, internal swing spout, transition spout, outlet spouts, drive assembly and shipping legs. The major design changes and modifications include:

- Using galvanized steel instead of mild steel for the body shell to reduce welding and painting
- Bolting most components for easy maintenance and replacement of parts for the product user
- Adding a bolt-on transition to the swing spout and oversized holes in the lower body panel to ensure proper grain discharge
- Using standard 12-inch diameter tubing for the inlet, outlets and swing spout to eliminate time-consuming processes, including water/plasma jet cutting, forming, rolling and welding, that were required in the commercial version

- Built-in lifting lugs into the body shell flanges to reduce components and welding
- Changing the body shell shape to have an angled lower section to facilitate a simplified outlet design and installation
- Using standard round flanges on the tubing for ease of assembly and less rework compared to the original tapered outlet design
- Incorporating the door opening and air vent into the body panel during table processing
- Implementing features such as product cleanout holes, an inspection window and a service door to ensure improve maintenance

The new design satisfied 10 out of the 12 target specifications with values within the acceptable ranges that were established in the project definition phase of the project. These include reduction in cost, number of assembly steps, and total labour time. The lifecycle and tolerance requirements were met. The design is also airtight, corrosion and wear resistant, includes a ventilation system, has a sufficient door opening and internal space for easy entrance and exit in and out of the distributor. Beyond that, other critical project needs including spout reliability and easy maintenance were also successfully addressed with the proposed design.

Lastly, several recommendations were mentioned to further improve the final design of the farm grade distributor. These include:

- Prototyping to identify issues with the design and assembly process
- Analyze causes in the distributor design and process
- Act on the causes by implementing change
- Optimize the distributor by iterating changes between the process and design components
- Track data for improvements and study the results
- Standardize the changes
- Implement the final design as a new farm grade product

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9 Appendices

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Appendix A – Project Charter

Prepared for:

Tristen Gitzel, P. Eng.
AGI-VIS

Vern Campbell, P. Eng., MBA
Center of Engineering Professional Practice and Engineering Education

Dr. Paul Labossiere, P. Eng.
Department of Mechanical Engineering

Aidan Topping, M.A.
Center of Engineering Professional Practice and Engineering Education

AGI VIS University of Manitoba

Project Charter

Project Name: Distributor Redesign and Cost Savings	Project Sponsor: Tristen Gitzel	
Prepared By: Kavan Patel, Mark Marquez, Megan DaCosta, Zerlina Abhazim		Revision: B

PROJECT BACKGROUND

- The current AGI-VIS product line is designed for commercial use only
- New product development department has recently been added to the company with the goal of adding farm grade versions of AGI-VIS products
- The distributor is one product that requires redesign for framers

BUSINESS CASE

- Currently, the company does not sell many distributors because it is overpriced
- To increase number of sales and to increase profit
- Current level of performance impacts the business by increasing the lead time to the customer
- Benefits from the improved performance will allow target customers outside of the competitive market; i.e. farm grade products

PROJECT OBJECTIVES

- Select the most cost-effective approach in designing a farm grade distributor by the end of the course, December 5, 2019
- Total cost of final design, including material and labour, will be reduced by 25% than the current commercial use distributor from approximately $10370 to $7750

PROJECT SCOPE	RESOURCES
- Distributor to be designed for farming applications only	- Time from advisors (Tristen Gitzel and Vern Campbell) for project guidance
- Team will design a single distributor configuration (12" outlet, full round, 8 outlets)	- Time from AGI-VIS shop welders (Provide information on assembly)
- Distributor process flow will start from parts arriving to assembly cell to shipping	- Distributor time sheets, costed bill of materials (BOM), production drawings
- All electrical and control aspects of the design is excluded from scope	- Time from team for AGI-VIS site visits
- Team to provide drafting of individual parts if time permits	- AGI-VIS SolidWorks modelling and drawing templates
- Any overhead costs will not be investigated	- Project budget ($ to be confirmed)
- Cost savings can be from design change, tooling/fixtures, process improvements	

Roster	Role	COMPANY	KEY PROJECT DELIVERABLES	DUE DATE
Zerlina Abhazim	Team Manager	University of Manitoba	Project Charter	09-24-19
Contact Information			Phase I: Project Definition Report	09-30-19
Tasks: Check in on members tasks – help if needed and delegate and develop tasks			Gantt Chart & Phase I Meeting Minutes	10-09-19
Mark Marquez	Point of Contact	University of Manitoba	Phase II: Concept Design Report	10-25-19
Contact Information			Gantt Chart & Phase II Meeting Minutes	10-30-19
Tasks: Maintain communication between team and client			Phase III: Final Report (1st Draft)	11-25-19
Megan DaCosta	Team Secretary	University of Manitoba	Gantt Chart & Phase III Meeting Minutes	11-27-19
Contact Information			Phase IIII: Final Design Report	12-04-19
Tasks: Meeting minutes and other general documentation			SolidWorks 3D Model & Assembly Drawings	12-04-19
Kavan Patel	Team	University of Manitoba	Project Poster	12-04-19
Contact Information				
Tasks: Update schedule and transportation means to and from project site				
Vern Campbell	Project Advisor	University of Manitoba		
Contact Information				
Tristen Gitzel	Project Advisor	AGI-VIS		
Contact Information				

STANDARD TEAM MEETINGS	LOCATION
Tuesday & Thursday: 10:00am - 11:15am	AGI-VIS (140 Parkland Road, Oak Bluff, MB)
Wednesday - 10:30am - 11:20am	University of Manitoba (66 Chancellors Cir, Winnipeg, MB)

RISKS	RISK MITIGATION PLAN
- Losing a team member	- Create a work plan for the team
- Entire team has conflicting schedules	- Set up weekly meetings and keep schedules availble for urgernt meetings
- Lack of scheduled distributor jobs at AGI-VIS	- Interview assemblers and review products with similar fabrication methods

CONSTRAINTS

- Discharge angle, height and bottom plate location cannot be changed from current design
- Lack of accurate time sheets available for assembly time of the distributor
- Entire team has conflicting schedules

PROJECT CHARTER APPROVALS

AGI-VIS New Product Development Manager (Project Sponsor): **Tristen Gitzel**	AGI-VIS Enigneering Manager: **Chris Trenholm**
AGI-VIS General Manager: **Shawn Conway**	

Figure A: Project Charter

Farm Grade Distributor

Appendix B – Process Analysis

Prepared for:

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Dr. Paul Labossiere, P. Eng.
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The process analysis used for the current design is shown in the following sections.

B.1 Suppliers, Inputs, Process, Outputs, and, Customers (SIPOC)

There are five major components in the SIPOC Chart that are critical to understanding the manufacturing process flow: Suppliers, Inputs, Process, Outputs, and Customers. The summary of distributor fabrication is shown in TABLE A.

TABLE A: PROCESS OWNERS AND STAKEHOLDERS

Process Owners and Stakeholders			
Process Owner	Shop Supervisor: Adrien		
Process Performers	Assemblers: Zhong and Juan		
Stakeholders	**Stakeholder**	**Concerns**	
	VIS Team	Change management	
	Capstone Team	Process/ design improvement	
	University of Manitoba	Budget	
	Advisor	Providing time and guidance	
	Distributor assemblers	Too many parts for assembly	
	Machine operators	Number of parts for forming after changes	
	Customers (end user)	Lead times	
Process Purpose and Output			
Purpose	Fabricate the distributor		
Outputs	• Produce a distributor that is functional for farm grade operations • The process includes steps from parts arriving at the work center to the last off step before shipping		
Customers and Needs			
Internal Customers	**Customer**	**Target (Need)**	**Specification**
	Assembler/ Welders	Formed Parts	Match drawing specs.

Process Owners and Stakeholders			
External	Shipping	Variable time for travel	Lead times includes distance traveled for delivery
	End-user	Quality, quantity, time	Meet needs (see House of Quality)
Suppliers and Inputs			
Internal Suppliers	**Supplier**	**Input**	**Capability**
	Machine Operator	Formed Parts	Quality and quantity
External	Premier	Spouting	Meet lead times
	Nord/ WEG	Drive and motor	Meet lead times and functionality
	Muzeen and Blyth	Shaft	Meet lead times and compatibility with drive
	Brunswick Steel	Sheet Metal	Meets size requirements of 4'x10' or 5' x10'
	Uniflight and Cadorath	Round Flange	Meets lead times
	KI Supplier	Hardware	Meets VIS' inventory stalk

TABLE A shows that the process performers are only two workers. Assembly of the distributor is therefore not standardized and only done by two assemblers with experience. The process contains a list of external suppliers. Since most of the parts are important to the process output, it is important to highlight the reasons for specific suppliers and their capabilities. From this, there may be other options for the fabrication of parts and places where problems stem from within the process if further examined.

B.2 Performance Data

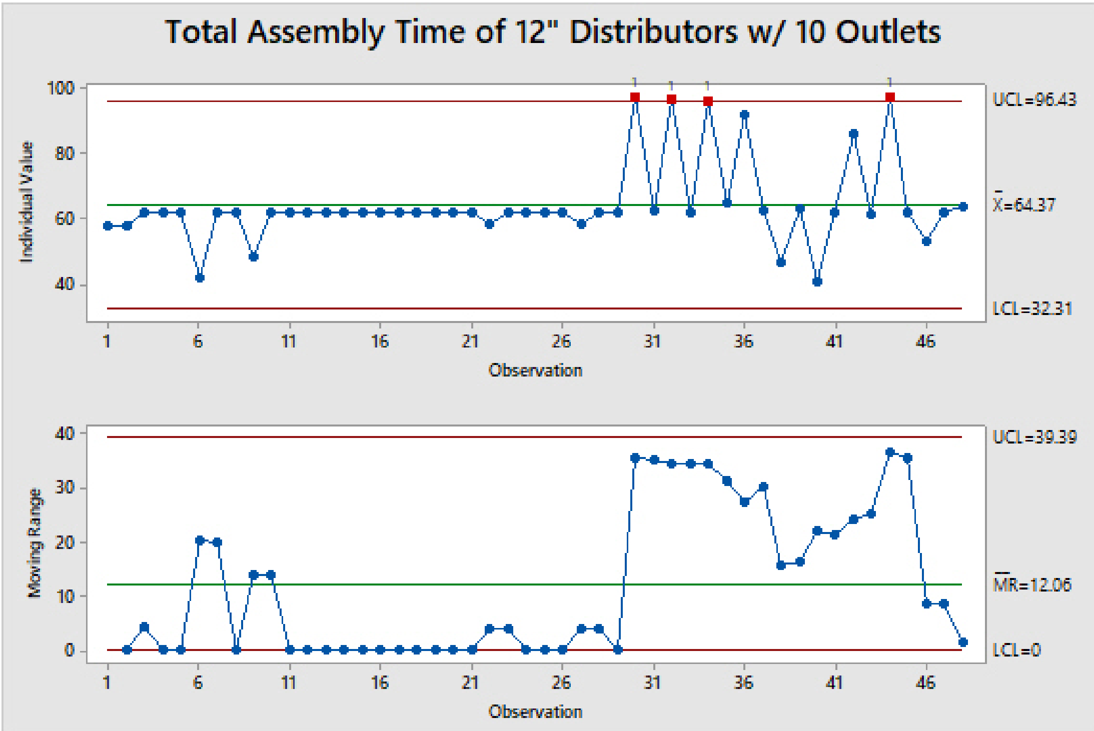

Figure B: Baseline Performance I-MR Chart of Total Assembly Times

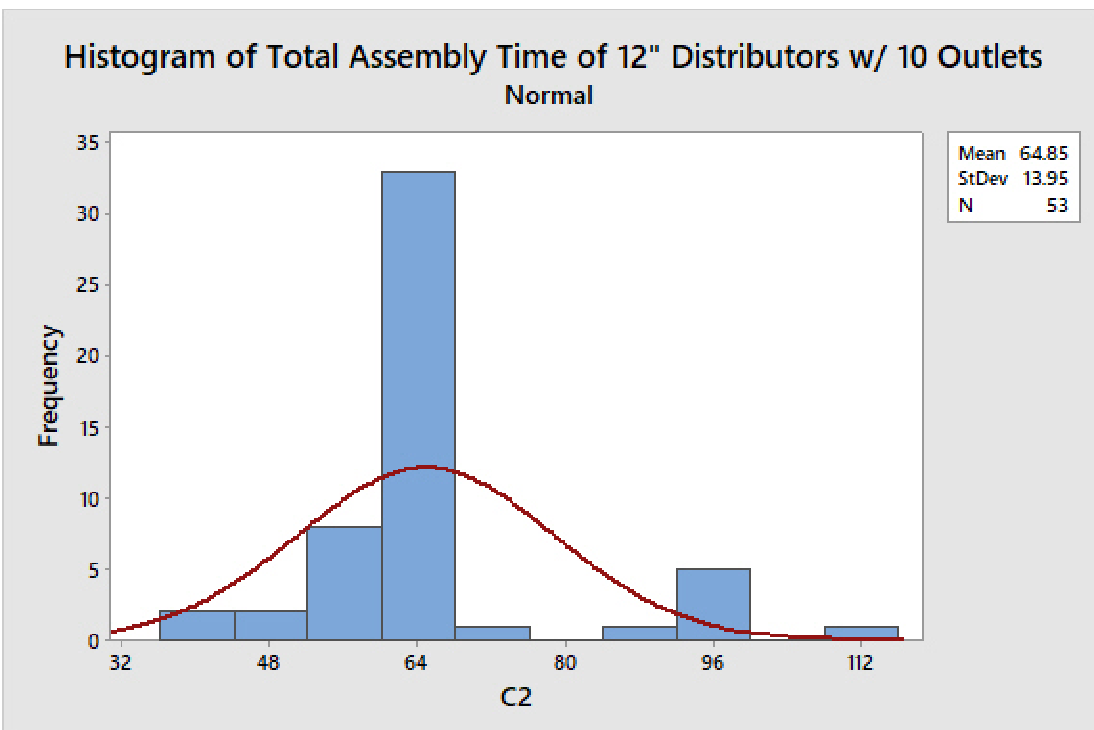

Figure C: Histogram of Total Assembly Times

B.3 Value Add Analysis

TABLE B: VALUE ADD ANALYSIS OF THE DISTRIBUTOR PROCESS FLOW

		Description	Does the customer see the value or be willing to pay for this activity?	Is this activity required if prior activities are done correctly or differently?	Does this activity physically change the product/ service?	Is this activity dictated by policies and regulations?	VA / NVA
Start	1	Parts arrive at assembly cell	Yes	Yes	Yes	No	VA
Inlet Assembly	2	Outer inlet rolled & welded	Yes	Yes	Yes	No	VA
	3	Weld the flange to the inlet	Yes	Yes	Yes	No	VA
	4	**Top cap assembled**	**Yes**	**No**	**Yes**	**No**	**NVA**
	5	Top plate, inner inlet, and ring plate all welded together	Yes	Yes	Yes	No	VA
	6	Paint	Yes	Yes	Yes	No	VA
Outlet Assembly	**7**	**Bend and weld outlet together**	**Yes**	**Yes**	**No**	**No**	**NVA**
	8	**Hammer and tack flange to outlet**	**Yes**	**No**	**Yes**	**No**	**NVA**
	9	Place outlet on turn table and full weld	Yes	Yes	Yes	No	VA
	10	Paint	Yes	Yes	Yes	No	VA
Internal Spout and Control Elements	**11**	**Cut and weld bottom of spinning arm to spinning flange (add UHMW)**	**Yes**	**No**	**Yes**	**No**	**NVA**
	12	**Cut and weld bottom of spinning arm, weld 18" inside and grind off 18" on outside weld**	**Yes**	**No**	**Yes**	**No**	**NVA**
	13	Add bottom to see if it spins easily by hand	Yes	Yes	Yes	No	VA
	14	Cut and weld upper flange assembly on spinning arm	Yes	Yes	Yes	No	VA
	15	Add spinning arm holder in proper placing	Yes	Yes	Yes	No	VA
	16	Assemble, drill half on shaft and weld to plate	Yes	Yes	Yes	No	VA
	17	Wire sensor box	Yes	Yes	Yes	No	VA
	18	**Plug weld hinges on door**	**Yes**	**No**	**Yes**	**No**	**NVA**
Large Component Assembly	**19**	**Bottom plates welded together (2+ pieces)**	**Yes**	**No**	**Yes**	**No**	**NVA**
	20	Bolt flange to bottom plate	Yes	Yes	Yes	No	VA
	21	**Cut flange 1.5"-2" deep, centered between each bolt**	**Yes**	**No**	**Yes**	**No**	**NVA**
	22	Main body tack welded to bottom flange assembly	Yes	Yes	Yes	No	VA
	23	Tack inside of inlet assembly to body	Yes	Yes	Yes	No	VA
	24	**4 welds on holding lugs**	**No**	**No**	**Yes**	**No**	**NVA**
	25	**Weld lift lugs on the top of the assembly**	**Yes**	**No**	**Yes**	**No**	**NVA**
	26	flip	Yes	Yes	Yes	No	VA
	27	**Tack weld stiffener flat bars to bottom plate**	**Yes**	**No**	**Yes**	**No**	**NVA**
	28	**Weld outlets to flat bottom plate**	**Yes**	**No**	**Yes**	**No**	**NVA**
	29	**Remove stiffener**	**Yes**	**No**	**No**	**No**	**NVA**
	30	For less warpage stitch weld all outlets all the way around	Yes	Yes	Yes	No	VA
	31	**Weld body to flange then the cuts**	**Yes**	**No**	**Yes**	**No**	**NVA**
	32	Weld top inlet to the body (flip sideways for welding lugs)	Yes	Yes	Yes	No	VA
	33	**Cut out inspection door on body**	**Yes**	**No**	**Yes**	**No**	**NVA**
	34	Clean inside and silicon edges	Yes	Yes	Yes	No	VA
	35	Assemble internal spout into body assembly	Yes	Yes	Yes	No	VA
	36	Add drive, sensor and motor box, position sensor and bolt to bottom of distributor	Yes	Yes	Yes	No	VA
	37	Add top cap and door	Yes	Yes	Yes	No	VA
	38	Testing Stickers	Yes	Yes	Yes	No	VA
	39	Clean	Yes	Yes	Yes	No	VA

The process flow was split into four sections such that each section can be evaluated more closely. The four sections include:

- Inlet assembly
- Outlet assembly
- Internal spout
- Large component assembly

NVA steps that are bolded in TABLE B have been reconsidered with reasoning shown in TABLE C below.

TABLE C: NVA STEPS

NVA Step	Problem Description
4	Too many parts and too much welding involved
7	Formed parts can create a bottleneck and added inventory
8	This step is time-consuming and design features can be added to eliminate the added labour.
11 **12**	Spinning arm support design can be reconsidered as there are simpler ways to make it with less welding (from competitor designs).
18	Hinges can be bolted to reduce the cost of welding.
19 **21**	Redesign to the octagonal body allows for no extra bottom pieces and no added flange for extra relief cuts.
24 **25**	Welding is not the only option for holding lugs. Holding lugs can be reduced to two.
27 **28** **29**	The above three steps contain sheet metal warpage which is a process with added waste. The problem should be further analyzed.
31	The octagonal body eliminates this step since relief cuts will not be needed in the bottom flange.
33	The octagonal body allows for the door to be programmed in the DXF file since multiple bends are no longer present in the body pieces.

The problem decomposition shown in TABLE C is based on assumptions including:

- A chosen simple design from brainstorming sessions is compared to the current design (i.e. Octagonal body distributer)
- Value-add analysis is subject to change based on the actual design selection

The Value-Add analysis provides a direction on what aspects should be evaluated further. Insights gathered from the Value-Add analysis:

- Welding is time-consuming and excessive in the current design
- There are too many steps in assembling the large component assembly such as the relief cuts on the bottom flange that are welded
- Tolerances are not accounted for in the design phase

B.4 Current State VSM

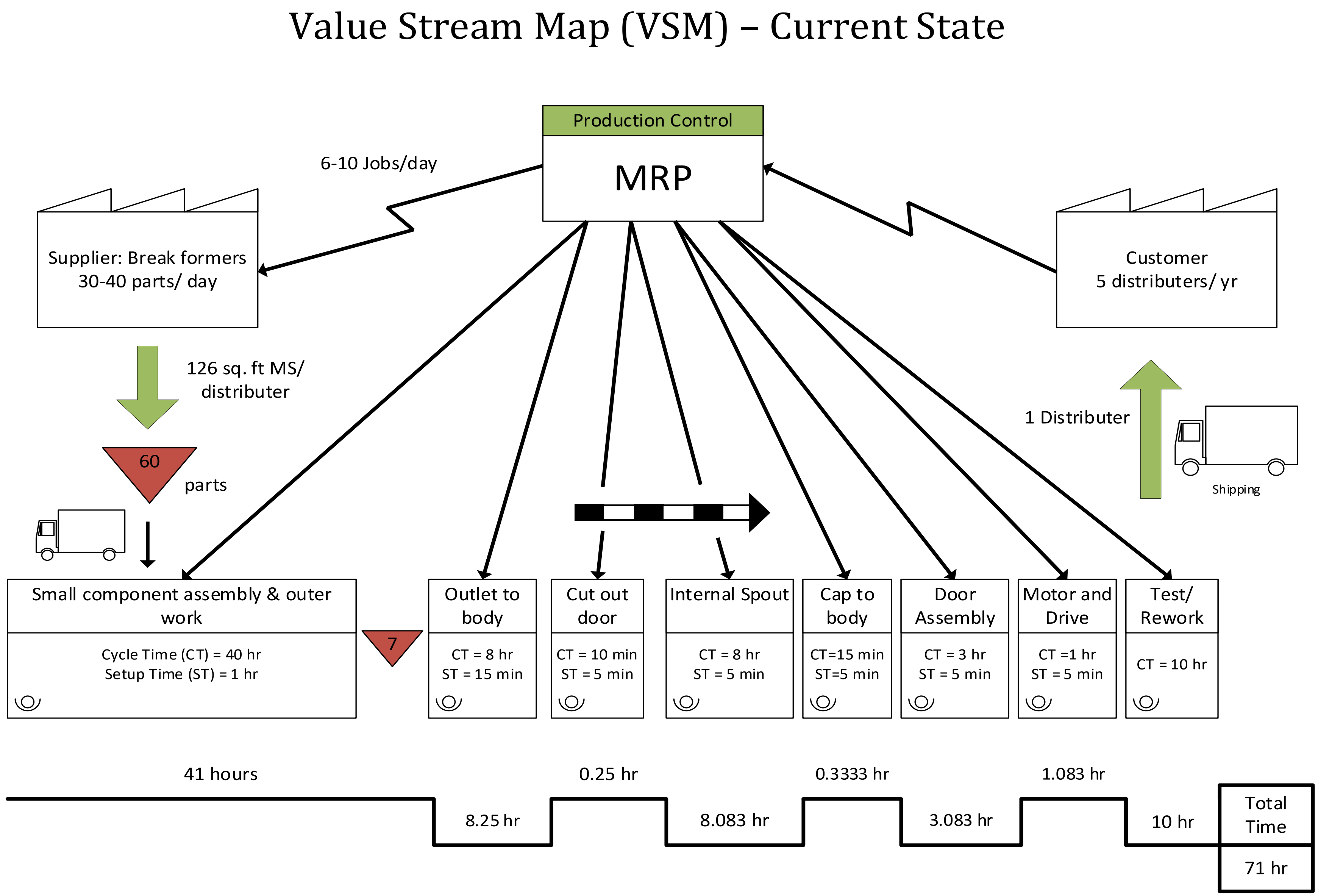

Figure D: Current State Value Stream Map

B.5 Current State Process Flow Chart

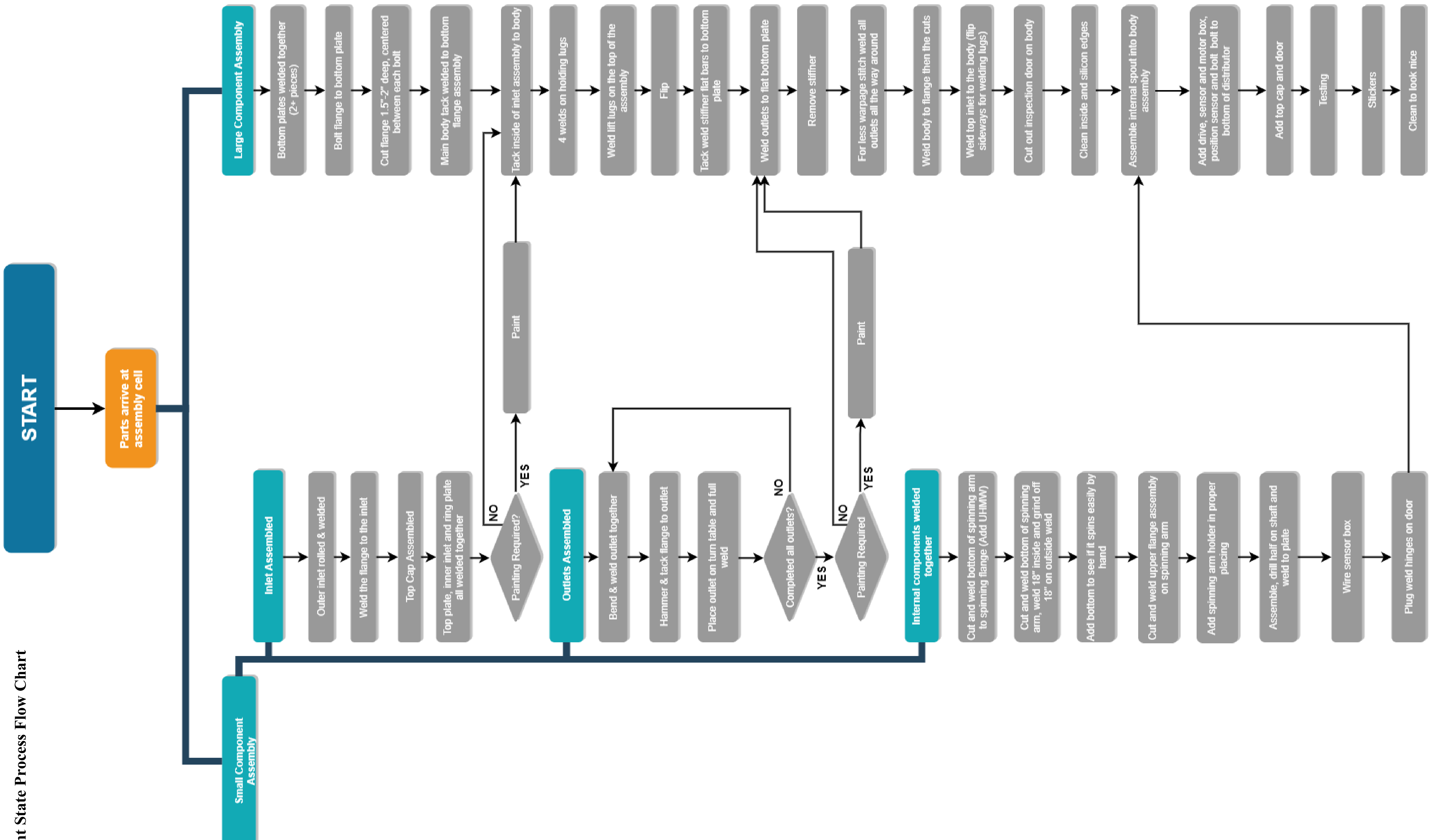

Figure E: Current Process Flow Chart

Farm Grade Distributor

Appendix C – House of Quality

Prepared for:

Tristen Gitzel, P. Eng.
AGI-VIS

Vern Campbell, P. Eng., MBA
Center of Engineering Professional Practice and Engineering Education

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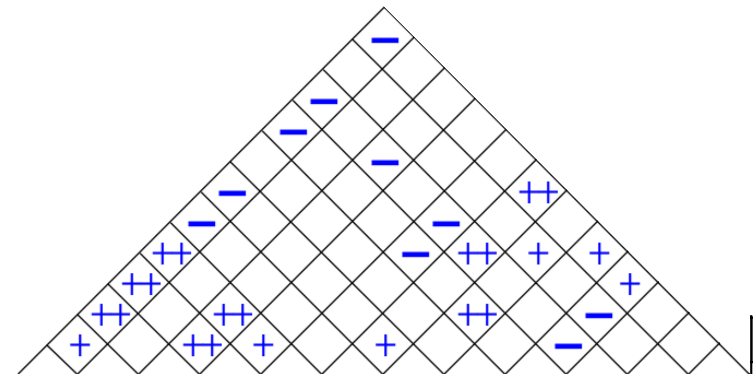
Legend		
Θ	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
−	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
x	Objective Is To Hit Target	



Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	Cost	Internal Space	# of steps to create device	# of Parts	Labour Time	Lifecycle	Tolerance	Horizontal Surface Area	Airtight (Seams are sealed)	Ventilation System	Door Opening	Wear Resistant Features
				Column #	1	2	3	4	5	6	7	8	9	10	11	12
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▼	▼	▼	▼	▼	▲	x	x	x	x	▲	x
1	9	9.1	4.0	Inexpensive	Θ		Θ	Θ	Θ					▲	▲	Θ
2	9	11.4	5.0	Reliability, grain goes in correct spout/swing spout aligns perfectly with outlet to spouting	O						Θ	O				
3	9	11.4	5.0	Reliability, spout does not get stuck during rotation		Θ				O	Θ	Θ	Θ	O		
4	9	9.1	4.0	Easy maintenance		Θ	Θ	Θ	Θ	O		Θ			Θ	
5	9	11.4	5.0	Low total assembly hours	Θ		Θ	Θ	Θ							
6	9	9.1	4.0	Minimize total quantity of parts assembled	Θ		Θ	Θ	Θ							
7	9	9.1	4.0	Minimize the amount of forming on the brake	Θ		Θ	O	Θ		O					
8	9	11.4	5.0	Corrosion/Wear Resistant	O					Θ	Θ		O			Θ
9	9	11.4	5.0	Airtight	Θ				Θ	Θ	O		Θ	Θ	O	
10	9	6.8	3.0	Internal parts easily accessible and can fit through the door		Θ	O		Θ						Θ	
				Target or Limit Value	$7,700 CAD/distributor	>40 ft^2	<30 steps	< 65 parts	< 60 hours	20 years	1/16-inch	<3 ft^2	Yes	Yes	4 ft^2	Yes
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	5	4	3	10	8	5	0	1	1	1	3	5
				Max Relationship Value in Column	9	9	9	9	9	9	9	9	9	9	9	9
				Weight / Importance	518.2	245.5	450.0	375.0	593.2	265.9	368.2	218.2	238.6	145.5	186.4	184.1
				Relative Weight	13.7	6.5	11.9	9.9	15.7	7.0	9.7	5.8	6.3	3.8	4.9	4.9

Competitive Analysis
(0=Worst, 5=Best)

AGI-VIS	GSI	Lambton	Schlagel	Honeyville	Hayes and Stolz
1	5	5	4	3	3
5	5	5	5	5	5
4	5	5	4	5	4
3	4	5	4	5	4
1	4	4	3	2	3
1	4	4	1	1	4
1	4	5	4	4	5
5	3	4	5	5	4
3	5	4	5	4	5
4	4	5	4	5	4

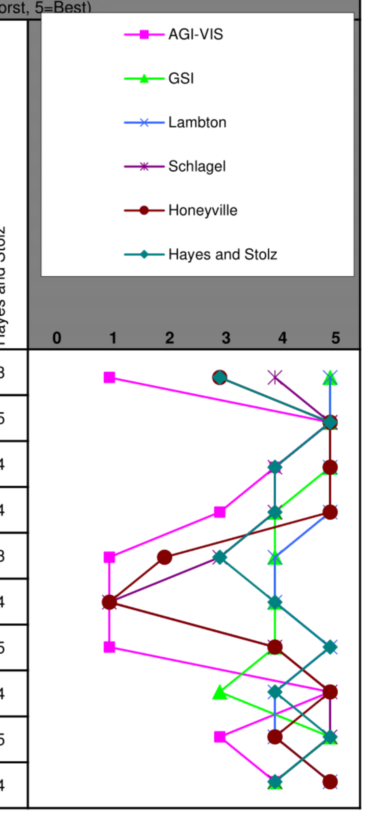


Figure F: House of Quality

The House of Quality shown in Figure B shows the selected metrics that can address every need specified by the client as indicated by the 9 values in the Max Relationship in Column and Row sections. The weighted value for each Demanded Quality was determined by the priority number given in Table 1: Customer Needs. Various metrics have wide coverage and address multiple needs, indicating it is of high importance during the concept and design of the device. The importance of the metric was given a calculated numerical value in the bottom portion of the chart and showed that the cost, labour time, and the number of parts will be crucial technical specifications in the final design to meet the characteristic needs specified and prioritized by the client. The right-hand side of the HOQ compares AGI-VIS's current model distributor to competitor's standards with relation to the identified needs. In terms of reliability and functionally, the current device measures on par with the competitors. However, the labour time and price of AGI-VIS' current commercial grade distributor poorly compares to the competitor market distributors.

Farm Grade Distributor

Appendix D – Assembly Drawings

Prepared for:

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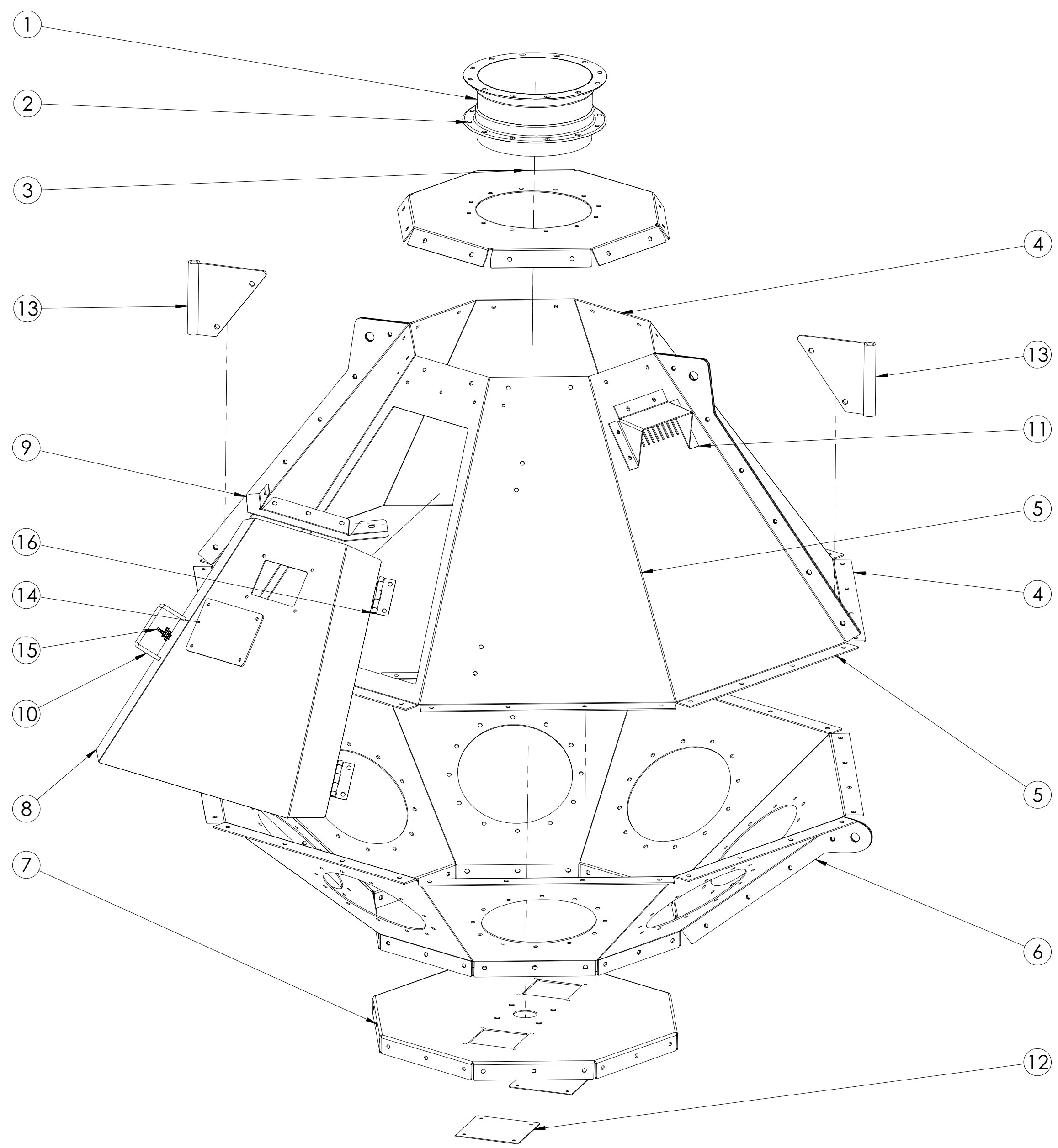
U:\Capstone\final design\NOVEMBER 20 2019\NOVEMBER 20 2019\BODY SHELL\FBDTA-BODY



DIMENSIONS ARE IN INCHES. TOLERANCE ±0.063" UNLESS NOTED.

BILL OF MATERIALS

ITEM	QTY	PART NUMBER	DESCRIPTION	MTL	LBS
1	1	FBDTA-INLET-TUBE	12 VIS SPOUT, 12in Cut Length	10ga HRMS	5.0
2	2	FLA-RO-ANG-12	FLANGE ROUND ROLLED ANGLE ∅ 12" ID L2		5.823
3	1	FBDTA-TOP-PL-GA	TOP PLATE	12ga GALV	18.0
4	1	FBDTA-BODY-SIDE	SIDE BODY PANEL	12ga GALV	118.9
5	1	FBDTA-BODY-SIDE-DOOR	SIDE BODY PANEL W/ DOOR	12ga GALV	99.6
6	2	FBDTA-BODY-BOT	BOTTOM BODY PANEL	10ga GALV	67.9
7	1	FBDTA-BOT-PL	BOTTOM PLATE	10ga GALV	36.2
8	1	FBDTA-DOOR-PANEL	DOOR PANEL	12ga HRMS	23.3
9	1	FBDTA-DRIPTRAY	DOOR DRIP TRAY	12ga GALV	1.3
10	1	FBDTA-DOOR-HANDLE	DOOR HANDLE	44W	0.34
11	1	FBDTA-VENT-COVER	VENTILATION COVER	12ga GALV	2.04
12	2	FBDTA-CLEANOUT-COV	CLEANOUT COVER	14ga GALV	1.09
13	2	FBDTA-HANGER-SUPPORT	HANGER SUPPORT		4.4
14	1	FBDTA-LEXAN-WINDOW	DOOR INSPECTION WINDOW - LEXAN GLASS	LEXAN GLASS	0.3
15	1	CLA-JE-71040-SS	CLAMP JERGENS 71040 STAINLESS STEEL		0.02
16	2	HINGE-BUTT-4x3-SS	BUTT HINGE - 4" LONG x 3" WIDE - SS	SS	0.60
17	4	BOLTMACH10-24X075	10-24 x 3/4" Machine Screw - Plated	MS	0.01
18	4	NUTMACH10-24	No. 10-24 Machine Nut - Grade 5 Plated	MS	0.00
19	17	BOLTBH025X075	1/4 x 3/4 Button Head Bolt gr 5 plated	MS	0.01
20	17	NUTFLANGE025	1/4 Flange Nut - Grade 5 Plated	MS	0.01
21	110	BOLTFL038X100	3/8 x 1 Flanged Bolt - Grade 5 plated	MS	0.07
22	110	NUTFLANGE038	3/8 Flange Nut - Grade 5 Plated	MS	0.02
23	4	BOLTFL050X150	1/2 x 1 1/2 Flanged Bolt - Grade 5 plated	MS	0.16
24	4	NUTFLANGE050	1/2 Flange Nut - Grade 5 Plated	MS	0.06

MODEL SPECIFICATION

APPLICATION	GRAIN
DENSITY (LB/CF)	48 LB/CF
FEED TYPE	METERED
DESIGN CAPACITY	10000 CF/HR
PRIMER	GREY SHOP PRIMER
PAINT	CUSTOMER TO CONFIRM FOR MS

REVISIONS

REV.	DESCRIPTION	DATE	BY
0	INITIAL RELEASE	20-NOV-2019	TEAM 29

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PRELIMINARY
FOR REVIEW

CLIENT: AGI-VIS	SITE LOCATION: OAK BLUFF, MANITOBA			SO#:
TITLE: DISTRIBUTOR BODY SHELL	TITLE: ASSEMBLY DETAILS			WEIGHT (LBS): 475.8
DWG NO: DTAFB-BODY-12-GALV	SHEET: 1 OF 2	REV: 0	BY: TEAM 29	DATE: 11/27/2019

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Figure G: Farm Grade Distributor Exploded View

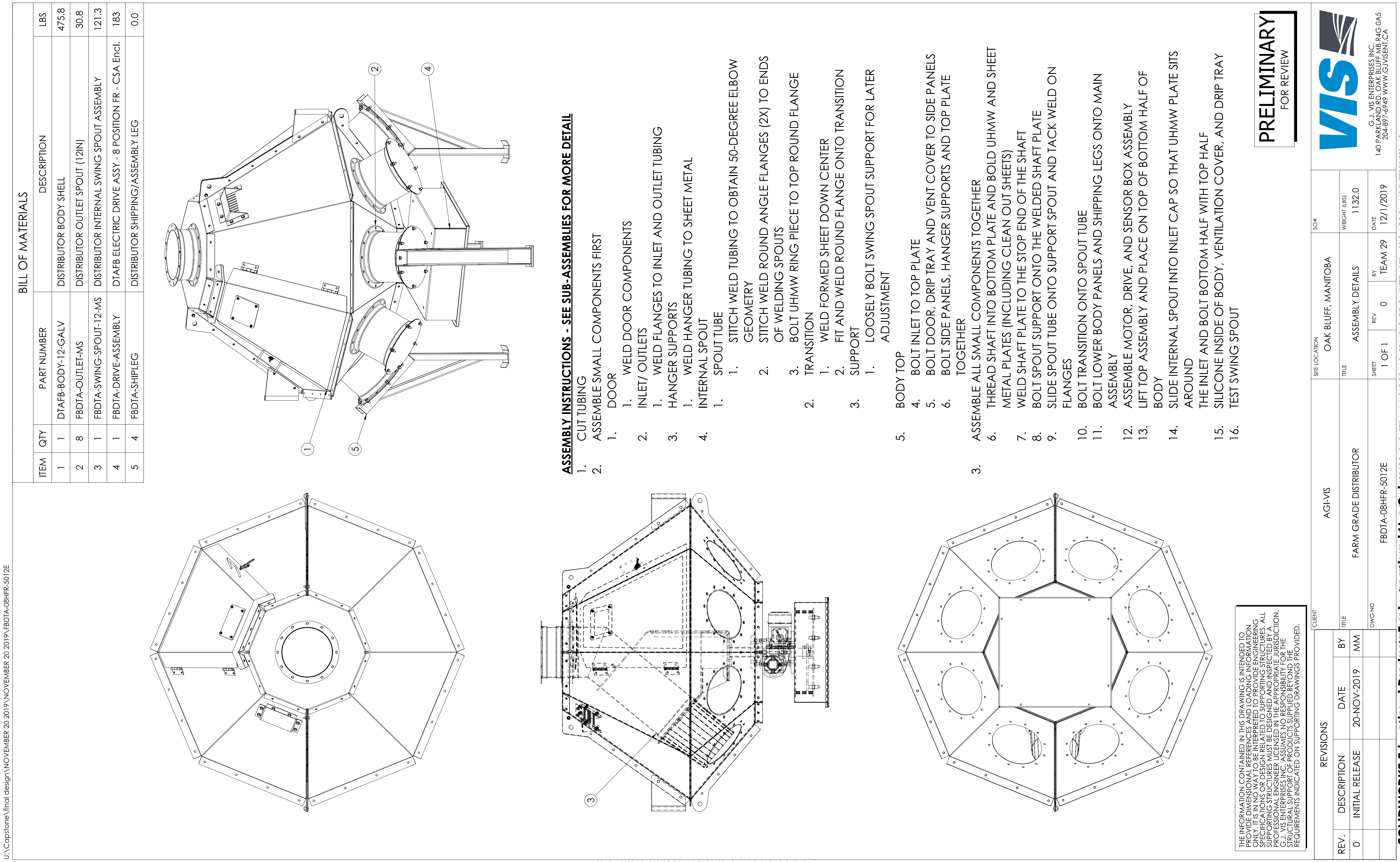
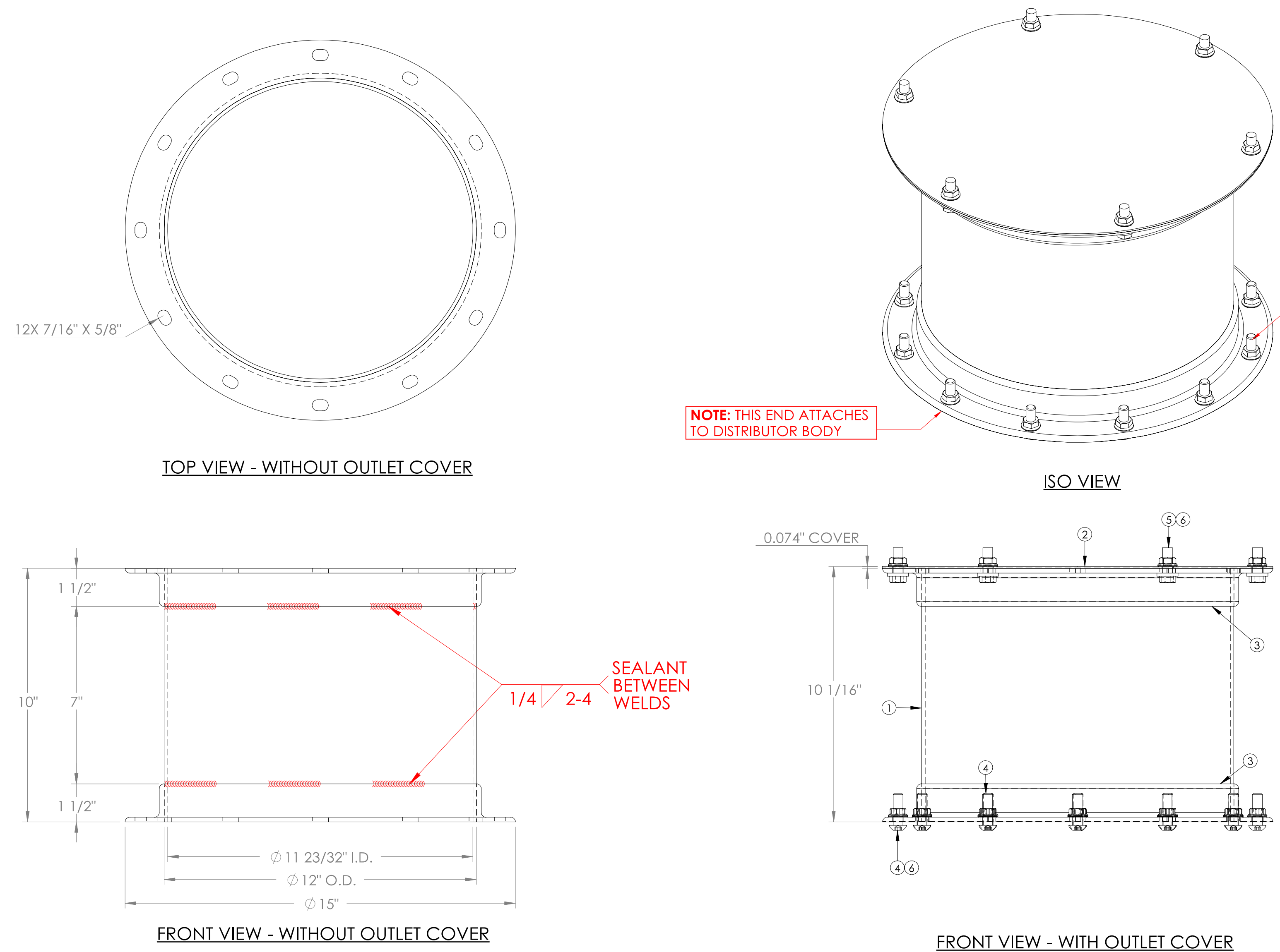


Figure H: Farm Grade Distributor

E:\CAPSTONE\NOVEMBER 20 2019\OUTLET\FBDTA-OUTLET-MS

BILL OF MATERIALS

ITEM	QTY	PART NUMBER	DESCRIPTION	MTL	LBS
1	1	FBDTA-OUTLET-TUBE-12-MS	SPOUT-12-10GAHRMS, 10in Cut Length	10ga HRMS	14.1
2	1	FBDTA-OUTLET-COV-12-MS	OUTLET SPOUT COVER	14ga HRMS	3.7
3	2	FLA-RO-ANG-12	FLANGE ROUND ROLLED ANGLE ∅12" ID L2		5.823
4	12	BOLTBH038X125	3/8 x 1 1/4 Button Head Bolt gr 5 plated	MS	0.05
5	6	BOLTFL038X100	3/8 x 1 Flanged Bolt - Grade 5 plated	MS	0.07
6	18	NUTFLANGE038	3/8 Flange Nut - Grade 5 Plated	MS	0.02



NOTE: INSTALL BOLTFL038X100 (QTY - 12) AND NUTFLANGE (QTY -12) ONLY WHEN OUTLETS ARE BEING MOUNTED TO FBDTA DISTRIBUTOR BODY. SEE FBDTA-8HFB-5012E ASSEMBLY DRAWING FOR INSTRUCTIONS.

DIMENSIONS ARE IN INCHES. TOLERANCE ±0.063" UNLESS NOTED.

MODEL SPECIFICATION	
APPLICATION	GRAIN
DENSITY (LB/CF)	48 LB/CF
FEED TYPE	METERED
DESIGN CAPACITY	10000 CF/HR
PRIMER	GREY SHOP PRIMER
PAINT	CUSTOMER TO CONFIRM

REVISIONS

REV.	DESCRIPTION	DATE	BY
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PRELIMINARY
FOR REVIEW

CLIENT: AGI-VIS	SITE LOCATION: OAK BLUFF, MANITOBA			SO#:
TITLE: DISTRIBUTOR OUTLET SPOUT (12IN) - MS	TITLE: ASSEMBLY DETAILS			WEIGHT (LBS): 30.8
DWG NO: FBDTA-OUTLET-12-MS	SHEET: 1 OF 1	REV: 0	BY: TEAM 29	DATE: 2019-11-23

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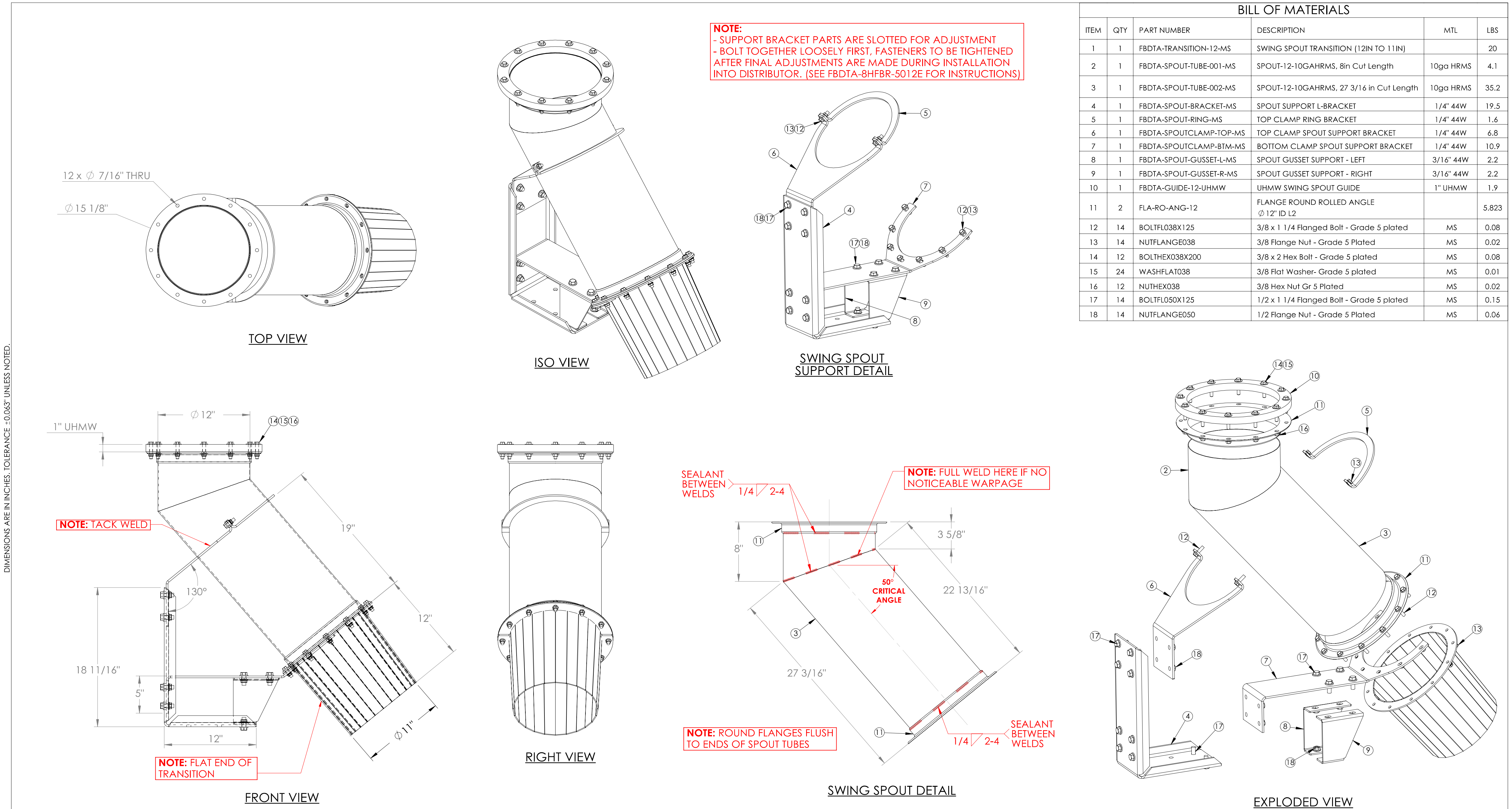
Figure I: Farm Grade Distributor Outlet Spout

E:\CAPSTONE\NOVEMBER 20 2019\SWING SPOUT\FBDTA-SWING-SPOUT-MS



BILL OF MATERIALS

ITEM	QTY	PART NUMBER	DESCRIPTION	MTL	LBS
1	1	FBDTA-TRANSITION-12-MS	SWING SPOUT TRANSITION (12IN TO 11IN)		20
2	1	FBDTA-SPOUT-TUBE-001-MS	SPOUT-12-10GAHRMS, 8in Cut Length	10ga HRMS	4.1
3	1	FBDTA-SPOUT-TUBE-002-MS	SPOUT-12-10GAHRMS, 27 3/16 in Cut Length	10ga HRMS	35.2
4	1	FBDTA-SPOUT-BRACKET-MS	SPOUT SUPPORT L-BRACKET	1/4" 44W	19.5
5	1	FBDTA-SPOUT-RING-MS	TOP CLAMP RING BRACKET	1/4" 44W	1.6
6	1	FBDTA-SPOUTCLAMP-TOP-MS	TOP CLAMP SPOUT SUPPORT BRACKET	1/4" 44W	6.8
7	1	FBDTA-SPOUTCLAMP-BTM-MS	BOTTOM CLAMP SPOUT SUPPORT BRACKET	1/4" 44W	10.9
8	1	FBDTA-SPOUT-GUSSET-L-MS	SPOUT GUSSET SUPPORT - LEFT	3/16" 44W	2.2
9	1	FBDTA-SPOUT-GUSSET-R-MS	SPOUT GUSSET SUPPORT - RIGHT	3/16" 44W	2.2
10	1	FBDTA-GUIDE-12-UHMW	UHMW SWING SPOUT GUIDE	1" UHMW	1.9
11	2	FLA-RO-ANG-12	FLANGE ROUND ROLLED ANGLE ∅ 12" ID L2		5.823
12	14	BOLTFL038X125	3/8 x 1 1/4 Flanged Bolt - Grade 5 plated	MS	0.08
13	14	NUTFLANGE038	3/8 Flange Nut - Grade 5 Plated	MS	0.02
14	12	BOLTHEX038X200	3/8 x 2 Hex Bolt - Grade 5 plated	MS	0.08
15	24	WASHFLAT038	3/8 Flat Washer- Grade 5 plated	MS	0.01
16	12	NUTHEX038	3/8 Hex Nut Gr 5 Plated	MS	0.02
17	14	BOLTFL050X125	1/2 x 1 1/4 Flanged Bolt - Grade 5 plated	MS	0.15
18	14	NUTFLANGE050	1/2 Flange Nut - Grade 5 Plated	MS	0.06

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PRELIMINARY
FOR REVIEW

CLIENT	SITE LOCATION	SO#
AGI-VIS	OAK BLUFF, MANITOBA	
TITLE: DISTRIBUTOR INTERNAL SWING SPOUT ASSEMBLY	TITLE: ASSEMBLY DETAILS	WEIGHT (LBS): 121.3
DWG NO: FBDTA-SWING-SPOUT-12-MS	SHEET: 1 OF 1 / REV: 0 / BY: TEAM 29	DATE: 2019-11-23

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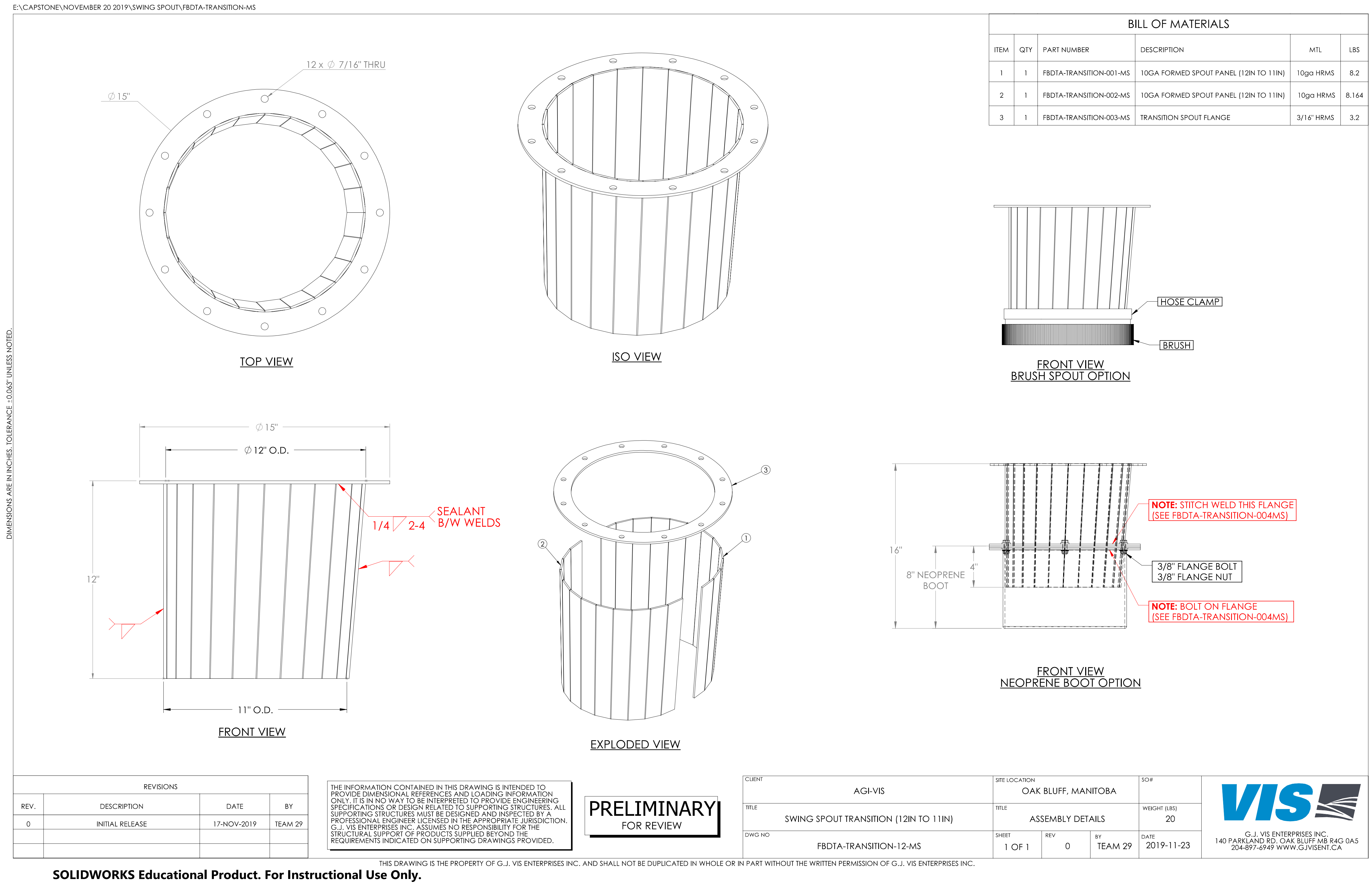
Figure J: Farm Grade Distributor Internal Swing Spout Assembly Drawing



BILL OF MATERIALS

ITEM	QTY	PART NUMBER	DESCRIPTION	MTL	LBS
1	1	FBDTA-TRANSITION-001-MS	10GA FORMED SPOUT PANEL (12IN TO 11IN)	10ga HRMS	8.2
2	1	FBDTA-TRANSITION-002-MS	10GA FORMED SPOUT PANEL (12IN TO 11IN)	10ga HRMS	8.164
3	1	FBDTA-TRANSITION-003-MS	TRANSITION SPOUT FLANGE	3/16" HRMS	3.2

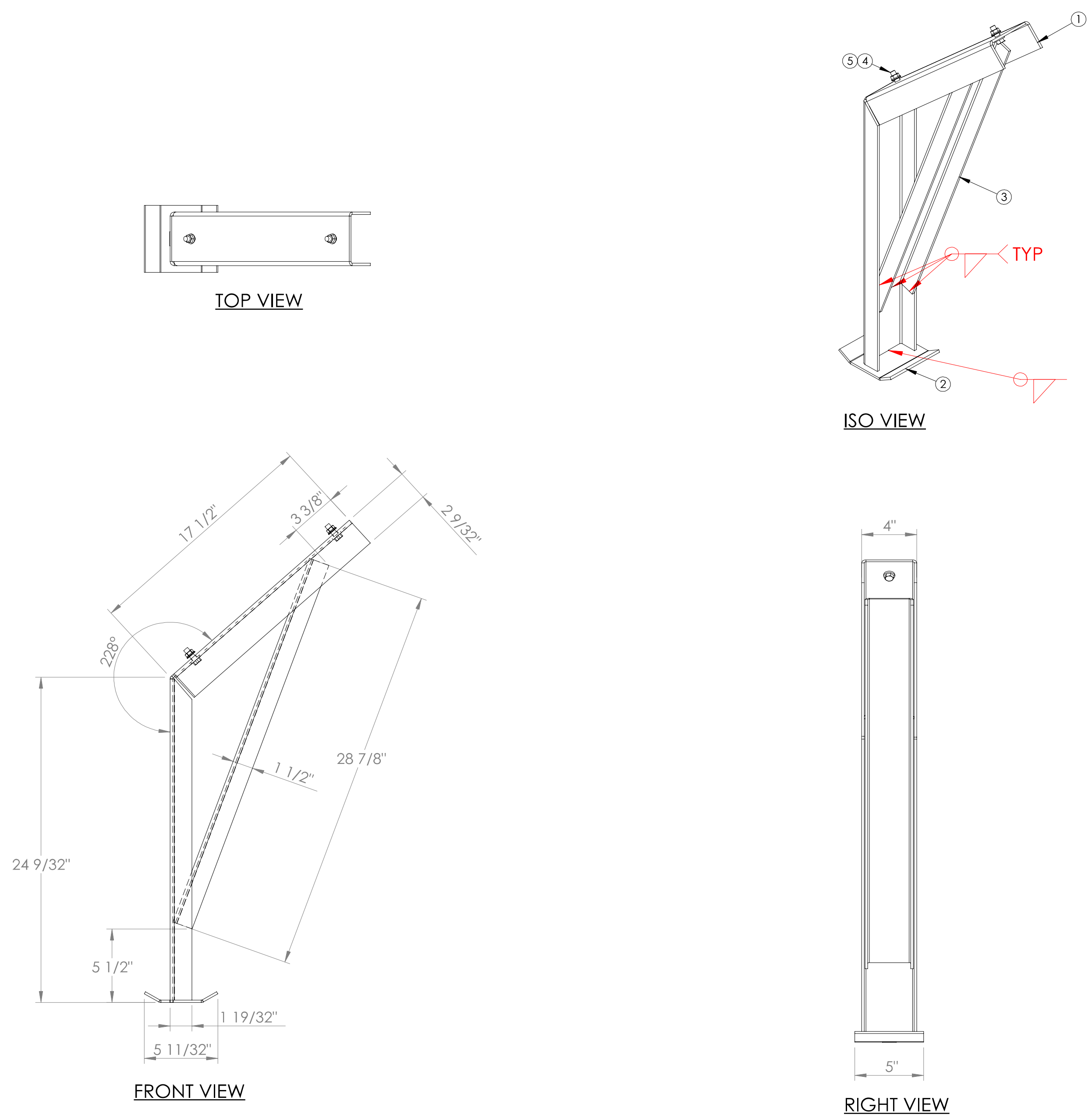
Figure K: Farm Grade Distributor Swing Spout Transition

E:\CAPSTONE\NOVEMBER 20 2019\SHIPPING LEG\FBDTA-SHIPLEG

DIMENSIONS ARE IN INCHES. TOLERANCE ±0.063" UNLESS NOTED.

BILL OF MATERIALS

ITEM	QTY	PART NUMBER	DESCRIPTION	MTL	LBS
1	1	FBDTA-SHIPPING-BRACKET	DISTRIBUTOR SHIPPING BRACKET	3/16" 44W	15.59
2	1	FBDTA-SHIPBASE	DISTRIBUTOR SHIPPING LEG BASE PLATE	3/16" 44W	1.46
3	1	FBDTA-CROSS-BRACE	SHIPPING LEG CROSS BRACE	3/16" 44W	9.07
4	2	BOLTFL038X100	3/8 x 1 Flanged Bolt - Grade 5 plated	MS	0.07
5	2	NUTFLANGE038	3/8 Flange Nut - Grade 5 Plated	MS	0.02



REVISIONS			
REV.	DESCRIPTION	DATE	BY
0	INITIAL RELEASE	23-NOV-2019	TEAM 29

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PRELIMINARY
FOR REVIEW

CLIENT	SITE LOCATION		SO#
AGI-VIS	OAK BLUFF, MANITOBA		
TITLE: FBDTA DISTRIBUTOR SHIPPING/ASSEMLY LEG	TITLE: ASSEMBLY DETAILS		WEIGHT (LBS): 26.30
DWG NO: FBDTA-SHIPLEG	SHEET: 1 OF 1	REV: 0 / BY: TEAM 29	DATE: 2019-11-23

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Figure L: Farm Grade Distributor Shipping/Assembly Leg

Farm Grade Distributor

Appendix E – Bill of Materials and Routings

Prepared for:

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Department of Mechanical Engineering

Aidan Topping, M.A.
Center of Engineering Professional Practice and Engineering Education

TABLE D: COMMERCIAL DISTRIBUTOR (DTA-08HFR5012E-MS) COSTED BOM

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To DTA-08HFR5012E-MS

Page : 1 of 1
Date : 10/30/2019
Time : 03:51:39 PM CDT

Total Weight 1,496.63

Part Number DTA-08HFR5012E-MS

Description 8 Hole Full Round 50o12 Elec -MS   Rev 000

Qty On Hand 0.00000

Qty Available 0.00000

Last Revision 03/22/2018

	Standard	Average	$ Variance	% Variance
Material Cost	5,203.10	4,364.13	838.97	19.22%
Labor Cost	5,996.25	5,996.25	0.00	0.00%
Total Cost	11,199.36	10,360.38	838.97	8.10%
Current Cost	11,199.36	10,402.89	796.46	7.66%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	DTA-DRIVE-E03-08FR	DTA DRV-8 Position FR-CSA Encl.	000010	1.00	EA	M	3,919.70	3,341.07	578.63	17.32%	650.00	no last date	
1	DTA-OUTLET-12-MS	DTA Outlet Weldment - 12 IN - MS	000020	8.00	EA	M	229.60	168.00	61.60	36.67%	1,040.00	no last date	
1	DTA-SHIPLEG	DTA Ship Leg-10-12-14-16 Outlet	000030	4.00	EA	M	41.07	32.73	8.35	25.50%	455.00	no last date	
1	DTA-SPOUT-066-12-MS	* DTA Spout for 66DI-12`DI-MS	000040	1.00	EA	M	248.90	203.93	44.97	22.05%	780.00	no last date	
1	DTA-VENT-MS	DTA Vent Assembly	000050	1.00	EA	M	14.00	10.78	3.22	29.85%	81.25	no last date	
1	HINGE-BUTT-4x3-SS	Butt Hinge-4 LGx3 Open-SS-No Holes	000060	2.00	EA	S	19.60	17.76	1.84	10.36%	0.00	09/30/2019	30
1	BOLTFL038X100	3/8 X 1 FLANGE BOLT GR 5 PLATED	000070	48.00	EA	S	6.72	5.74	0.98	16.99%	0.00	04/16/2019	197
1	CLA-JE-70558	Clamps Jergens 70558 - Pull Action	000080	2.00	EA	S	34.50	30.66	3.84	12.52%	0.00	06/29/2018	488
1	NUTFLANGE038	3/8 flanged nuts gr 5 plated	000090	48.00	EA	S	2.11	1.68	0.43	25.71%	0.00	06/25/2018	492
1	PLA-44W-188	Plate 0.188in 44W Mild Steel	000100	12.00	SQF	S	59.40	47.23	12.17	25.76%	0.00	10/24/2019	6
1	PLA-44W-250	Plate 0.25in 44W Mild Steel	000110	39.00	SQF	S	259.35	199.91	59.44	29.73%	0.00	10/23/2019	7
1	SHEHRMS12GA	Sheet HRMS Steel 12ga	000120	75.00	SQF	S	210.00	161.72	48.28	29.85%	0.00	10/16/2019	14
1	PIP-SCH40-.75D	Pipe 0.75in Diameter Sch40	000130	2.00	LF	S	3.10	2.24	0.86	38.48%	0.00	07/24/2019	98
1	FLA-RO-ANG-24	FL Rnd Angle 24 in ID L1.5 FOR DTA	000140	1.00	EA	S	55.04	50.06	4.99	9.96%	0.00	06/11/2018	506
1	FLA-RO-ANG-66	FL Rnd Angle 66 in ID L2 FOR DTA	000150	1.00	EA	S	100.00	90.62	9.38	10.35%	0.00	no last date	

TABLE E: COMMERCIAL DISTRIBUTOR (DTA-08HFR5012E-MS) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 10/30/2019
Time : 03:49:45 PM CDT

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	DTA-08HFR5012E-MS	000	8 Hole Full Round 50o12 Elec -MS	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
20	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
30	DPSPRO	DRILL,PUNCH,SAW	1.000	0.00	0.00	0.00	0.00	0.00	0.00
40	TBLPRO	TABLE PROCESSING	1.000	0.00	18.00	0.00	0.00	0.00	1,170.00
50	FRMPRO	FORM PROCESSING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
60	KIT	KITTING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
70	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
80	A03	CELL A03	1.000	0.00	24.00	0.00	0.00	0.00	1,560.00
90	PAINT	PAINTING	1.000	0.00	4.00	0.00	0.00	0.00	260.00
		Totals		0.00	46.00	0.00	0.00	0.00	Can$ 2,990.00
		Totals per Unit		0.00	46.00	0.00	0.00	0.00	Can$ 2,990.00

TABLE F: FARM BRAND DISTRIBUTOR (FBDTA-08HFR-5012E) COSTED BOM

AGI VIS

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To FBDTA-08HR-5012E

Page : 1 of 2
Date : 11/27/2019
Time : 04:07:14 PM CST

Part Number	FBDTA-08HR-5012E		
Description	*12 HOLE FULL ROUND 50O12 ELEC	Rev	000
Qty On Hand	0.00000		
Qty Available	0.00000		
Last Revision	11/26/2019		

	Standard	Average	$ Variance	% Variance
Total Weight				1,448.55
Material Cost	4,599.93	3,700.02	899.92	24.32%
Labor Cost	4,127.50	4,127.50	0.00	0.00%
Total Cost	8,727.44	7,827.52	899.92	11.50%
Current Cost	9,312.44	11,719.22	(2,406.78)	-20.54%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	PLA-44W-250	Plate 0.25in 44W Mild Steel	000005	1.50	SQF	S	9.98	7.68	2.30	29.93%	0.00	11/21/2019	6
1	SHEGALV12GA	Sheet Galvanized Steel G90 12ga	000010	75.00	SQF	S	232.50	205.70	26.80	13.03%	0.00	no last date	
1	SHEGALV10GA	Sheet Galvanized Steel G90 10ga	000020	55.00	SQF	S	264.00	238.52	25.48	10.68%	0.00	04/03/2019	238
1	SHEGALV14GA	Sheet Galvanized Steel G90 14ga	000025	1.00	SQF	S	3.07	2.50	0.58	23.12%	0.00	no last date	
1	DTA-DRIVE-E01-08FR	DTA Elec DRV -8 Position Full Round	000030	1.00	EA	M	3,124.92	2,677.73	447.18	16.70%	780.00	no last date	
1	SPOUT-12-10GAHRMS	Spout 12in OD 10 ga HRMS	000035	1.00	LF	S	24.65	12.80	11.85	92.58%	0.00	08/13/2019	106
1	FBDTA-SWING-SPOUT-MS	INTERNAL SWING SPOUT ASSEMBLY	000040	1.00	EA	M	272.21	96.52	175.69	182.03%	487.50	no last date	
1	FBDTA-OUTLET-MS	FBDTA OUTLET WELDMENT - 12 IN - MS	000050	8.00	EA	M	509.61	337.46	172.15	51.01%	780.00	no last date	
1	FLA-RO-ANG-12	FL Rnd Rolled Angle 12in ID L1.5	000060	2.00	EA	S	35.20	20.15	15.05	74.67%	0.00	no last date	
1	SHEPOLYCARB250	SHEET POLYCARBONATE 1/4IN (LEXAN)	000070	1.00	SQF	S	8.23	6.86	1.37	19.98%	0.00	11/12/2019	15
1	HINGE-BUTT-4x3-SS	Butt Hinge-4 LGx3 Open-SS-No Holes	000080	2.00	EA	S	19.60	17.76	1.84	10.36%	0.00	11/21/2019	6
1	CLA-JE-71040-SS	CLA-JE 71040 SS (equivalent 70558)	000085	1.00	EA	S	29.80	24.51	5.29	21.56%	0.00	05/27/2019	184
1	BAR-HRMS-375D	Round Bar HRMS 0.375in	000090	0.25	LF	S	0.12	0.08	0.04	47.81%	0.00	01/30/2019	301
1	DTA-SHIPLEG	DTA Ship Leg-10-12-14-16 Outlet	000100	4.00	EA	M	41.07	31.38	9.70	30.90%	455.00	no last date	
1	BOLTMACH10-24X075	10-24x3/4 Round Head Mach PLAT	000110	4.00	EA	S	0.12	0.10	0.02	25.00%	0.00	07/02/2019	148
1	NUTMACH10-24	No. 10-24 Machine Nut - Plated	000120	4.00	EA	S	0.08	0.04	0.04	81.82%	0.00	09/30/2019	58
1	BOLTBH025X075	1/4x3/4 Button Head Bolt gr 5 PLAT	000130	17.00	EA	S	2.04	1.00	1.04	103.29%	0.00	11/21/2019	6
1	NUTFLANGE025	1/4 Flange Nut gr 5 plated	000140	17.00	EA	S	0.54	0.50	0.04	8.84%	0.00	11/21/2019	6
1	BOLTFL038X100	3/8 X 1 FLANGE BOLT GR 5 PLATED	000150	110.00	EA	S	15.40	13.16	2.24	16.98%	0.00	04/16/2019	225
1	NUTFLANGE038	3/8 flanged nuts gr 5 plated	000160	110.00	EA	S	4.84	3.85	0.99	25.71%	0.00	06/25/2018	520
1	BOLTFL050X150	1/2X1-1/2 FLANGE BOLT GR 5 PLATED	000170	4.00	EA	S	1.56	1.39	0.17	12.10%	0.00	05/10/2019	201

TABLE G: FARM BRAND DISTRIBUTOR (FBDTA-08HFR-5012E) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 11/26/2019
Time : 10:54:18 AM CST

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	FBDTA-08HR-5012E	000	*12 HOLE FULL ROUND 50O12 ELEC	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
20	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
30	DPSPRO	DRILL,PUNCH,SAW	1.000	0.00	0.00	0.00	0.00	0.00	0.00
40	TBLPRO	TABLE PROCESSING	1.000	0.00	2.00	0.00	0.00	0.00	130.00
50	FRMPRO	FORM PROCESSING	1.000	0.00	4.00	0.00	0.00	0.00	260.00
60	KIT	KITTING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
70	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
80	A03	CELL A03	1.000	0.00	18.00	0.00	0.00	0.00	1,170.00
90	PAINT	PAINTING	1.000	0.00	1.00	0.00	0.00	0.00	65.00
		Totals		0.00	25.00	0.00	0.00	0.00	Can$ 1,625.00
		Totals per Unit		0.00	25.00	0.00	0.00	0.00	Can$ 1,625.00

TABLE H: FARM BRAND DISTRIBUTOR SWING SPOUT (FBDTA-SWING-SPOUT-MS) COSTED BOM

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To FBDTA-SWING-SPOUT-MS

Page : 1 of 1
Date : 11/26/2019
Time : 10:51:01 AM CST

Part Number	FBDTA-SWING-SPOUT-MS
Description	INTERNAL SWING SPOUT ASSEMBLY Rev 000
Qty On Hand	0.00000
Qty Available	0.00000
Last Revision	11/26/2019

Total Weight 185.81

	Standard	Average	$ Variance	% Variance
Material Cost	272.21	96.52	175.69	182.03%
Labor Cost	1,072.50	1,072.50	0.00	0.00%
Total Cost	1,344.71	1,169.02	175.69	15.03%
Current Cost	786.30	994.74	(208.44)	-20.95%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	FBDTA-TRANSITION-MS	* ROUND TO ROUND, Ø12 TO Ø11	000010	1.00	EA	M	21.26	16.25	5.01	30.82%	812.50	no last date	
1	SHEUHMW1000	Sheet UHMW 1in	000020	1.00	SQF	5	19.62	17.78	1.84	10.34%	0.00	06/28/2019	151
1	PLA-44W-188	Plate 0.188in 44W Mild Steel	000030	1.00	SQF	5	4.95	3.77	1.18	31.39%	0.00	11/13/2019	13
1	PLA-44W-250	Plate 0.25in 44W Mild Steel	000040	5.50	SQF	5	36.58	28.15	8.43	29.93%	0.00	11/21/2019	5
1	SPOUT-12-10GAGALV	Spout 12in OD 10 ga GALV	000050	3.00	LF	5	142.50	0.00	142.50	14250.00 %	0.00	no last date	
1	FLA-RO-ANG-12	FL Rnd Rolled Angle 12in ID L1.5	000060	2.00	EA	5	35.20	20.15	15.05	74.67%	0.00	no last date	
1	BOLTFL038X125	3/8X1-1/4 FLANGE BOLT GR 5 PLATED	000070	14.00	EA	5	2.38	2.10	0.28	13.58%	0.00	11/21/2019	5
1	NUTFLANGE038	3/8 flanged nuts gr 5 plated	000080	14.00	EA	5	0.62	0.49	0.13	25.71%	0.00	06/25/2018	519
1	BOLTHEX038X200	3/8 x 2 hex bolt gr 5 plated	000090	12.00	EA	5	1.58	1.44	0.14	10.00%	0.00	09/23/2019	64
1	WASHFLAT038	3/8 Flat Washer plated	000100	24.00	EA	5	0.72	0.48	0.24	50.00%	0.00	11/25/2019	1
1	NUTHEX038	3/8 hex nut gr 5 plated	000110	12.00	EA	5	0.36	0.29	0.07	25.00%	0.00	11/07/2019	19
1	BOLTFL050X125	1/2X1-1/4 FLANGE BOLT GR 5 PLATED	000120	14.00	EA	5	5.04	4.52	0.52	11.61%	0.00	04/16/2019	224
1	NUTFLANGE050	1/2 flanged nuts gr 5 plated	000130	14.00	EA	5	1.40	1.11	0.29	26.58%	0.00	06/25/2018	519

TABLE I: FARM BRAND DISTRIBUTOR SWING SPOUT (FBDTA-SWING-SPOUT-MS) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 11/26/2019
Time : 10:58:27 AM CST

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	FBDTA-SWING-	000	INTERNAL SWING SPOUT ASSEMBLY	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
10	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
20	TBLPRO	TABLE PROCESSING	1.000	0.00	1.00	0.00	0.00	0.00	65.00
30	FRMPRO	FORM PROCESSING	1.000	0.00	1.00	0.00	0.00	0.00	65.00
40	KIT	KITTING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
50	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
60	A03	CELL A03	1.000	0.00	2.00	0.00	0.00	0.00	130.00
		Totals		0.00	4.00	0.00	0.00	0.00	Can$ 260.00
		Totals per Unit		0.00	4.00	0.00	0.00	0.00	Can$ 260.00

TABLE J: FARM BRAND DISTRIBUTOR TRANSITION (FBDTA-TRANSITION-MS) COSTED BOM

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To FBDTA-TRANSITION-MS

Page : 1 of 1
Date : 11/27/2019
Time : 04:06:52 PM CST

Part Number	FBDTA-TRANSITION-MS
Description	* ROUND TO ROUND, Ø12 TO Ø11
Rev	000
Qty On Hand	0.00000
Qty Available	0.00000
Last Revision	11/26/2019

Total Weight 33.99

	Standard	Average	$ Variance	% Variance
Material Cost	21.26	16.25	5.01	30.82%
Labor Cost	227.50	227.50	0.00	0.00%
Total Cost	248.76	243.75	5.01	2.05%
Current Cost	833.76	252.25	581.51	230.53%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	PLA-44W-188	Plate 0.188in 44W Mild Steel	000010	1.50	SQF	5	7.43	5.65	1.77	31.39%	0.00	11/13/2019	14
1	SHEHRMS10GA	Sheet HRMS Steel 10ga	000020	4.00	SQF	5	13.83	10.60	3.23	30.52%	0.00	11/19/2019	8

TABLE K: FARM BRAND DISTRIBUTOR TRANSITION (FBDTA-TRANSITION-MS) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 11/26/2019
Time : 10:58:52 AM CST

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	FBDTA-TRANSITION-	000	* ROUND TO ROUND, Ø12 TO Ø11	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
10	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
20	TBLPRO	TABLE PROCESSING	1.000	0.00	10.00	0.00	0.00	0.00	650.00
30	FRMPRO	FORM PROCESSING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
40	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
50	A02	CELL A02	1.000	0.00	2.00	0.00	0.00	0.00	130.00
60	PAINT	PAINTING	1.000	0.00	0.50	0.00	0.00	0.00	32.50
		Totals		0.00	12.50	0.00	0.00	0.00	Can$ 812.50
		Totals per Unit		0.00	12.50	0.00	0.00	0.00	Can$ 812.50

TABLE L: FARM BRAND DISTRIBUTOR OUTLET SPOUT (FBDTA-OUTLET-MS) COSTED BOM

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To FBDTA-OUTLET-MS

Page : 1 of 1
Date : 11/26/2019
Time : 10:50:17 AM CST

Part Number FBDTA-OUTLET-MS

Description FBDTA OUTLET WELDMENT - 12 IN - MS   Rev 000
Qty On Hand 0.00000
Qty Available 0.00000
Last Revision 11/26/2019

Total Weight 37.99

	Standard	Average	$ Variance	% Variance
Material Cost	63.70	42.18	21.52	51.01%
Labor Cost	97.50	97.50	0.00	0.00%
Total Cost	161.20	139.68	21.52	15.41%
Current Cost	160.09	151.98	8.11	5.34%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	SPOUT-12-10GAHRMS	Spout 12in OD 10 ga HRMS	000010	0.83	LF	S	20.53	10.66	9.87	92.58%	0.00	08/13/2019	105
1	FLA-RO-FLAT-12	FL Rnd Flat 12 in ID - 1.5 in Wide	000020	2.00	EA	S	35.00	24.75	10.25	41.42%	0.00	no last date	
1	SHEHRMS14GA	Sheet HRMS Steel 14ga	000030	2.00	SQF	S	4.44	3.35	1.09	32.41%	0.00	11/13/2019	13
1	BOLTBH038X125	3/8x1-1/4 Button Head Bolt gr5 PLAT	000040	12.00	EA	S	2.10	2.07	0.03	1.30%	0.00	09/06/2019	81
1	BOLTFL038X100	3/8 X 1 FLANGE BOLT GR 5 PLATED	000045	6.00	EA	S	0.84	0.72	0.12	16.98%	0.00	04/16/2019	224
1	NUTFLANGE038	3/8 flanged nuts gr 5 plated	000050	18.00	EA	S	0.79	0.63	0.16	25.71%	0.00	06/25/2018	519

TABLE M: FARM BRAND DISTRIBUTOR OUTLET SPOUT (FBDTA-OUTLET-MS) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 11/26/2019
Time : 10:54:57 AM CST

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	FBDTA-OUTLET-MS	000	FBDTA OUTLET WELDMENT - 12 IN - MS	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
10	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
20	TBLPRO	TABLE PROCESSING	1.000	0.00	0.25	0.00	0.00	0.00	16.25
30	FRMPRO	FORM PROCESSING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
40	KIT	KITTING FASTENERS AND SMALL COMPONENTS	1.000	0.00	0.00	0.00	0.00	0.00	0.00
50	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
60	A03	CELL A03	1.000	0.00	0.75	0.00	0.00	0.00	48.75
70	PAINT	PAINTING PAINTING DEPARTMENT	1.000	0.00	0.50	0.00	0.00	0.00	32.50
		Totals		0.00	1.50	0.00	0.00	0.00	Can$ 97.50
		Totals per Unit		0.00	1.50	0.00	0.00	0.00	Can$ 97.50

TABLE N: DISTRIBUTOR DRIVE ASSEMBLY (DTA-DRIVE-EO1-08FR) COSTED BOM

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To DTA-DRIVE-E01-08FR

Page : 1 of 2
Date : 11/26/2019
Time : 10:52:29 AM CST

Part Number	DTA-DRIVE-E01-08FR
Description	DTA Elec DRV -8 Position Full Round (Rev 000)
Qty On Hand	0.00000
Qty Available	0.00000
Last Revision	03/22/2018

Total Weight: 182.96

	Standard	Average	$ Variance	% Variance
Material Cost	3,125.22	2,677.73	447.48	16.71%
Labor Cost	780.00	780.00	0.00	0.00%
Total Cost	3,905.22	3,457.73	447.48	12.94%
Current Cost	3,905.22	3,457.74	447.48	12.94%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	DTA-ELEC-08SWITCH	DTA ELEC TERM COMP-8 Switches	000010	1.00	EA	P	62.64	48.95	13.69	27.97%	0.00	no last date	
1	SHE304SS12GA	Sheet Stainless Steel 304 12ga	000020	23.00	SQF	S	218.50	179.46	39.04	21.75%	0.00	08/19/2019	99
1	PLA-ALUM-250	Plate 0.250 Aluminum-Utility Grade	000030	8.00	SQF	S	76.65	70.16	6.49	9.25%	0.00	09/06/2019	81
1	CEMA-INTCOL200	Internal Collar 200	000040	1.00	EA	S	32.00	23.21	8.79	37.87%	0.00	10/15/2019	42
1	INSEFECEVC001	Model EVC001 Straight Conn 2M Cord	000050	8.00	EA	S	77.60	70.40	7.20	10.23%	0.00	no last date	
1	INSEFECIG5905	INSEFEC NO/NC PN IG5905 10-36 VDC	000060	8.00	EA	S	824.00	748.80	75.20	10.04%	0.00	no last date	
1	BOLTHEX031X100SS	5/16x1 SS Hex Bolt stainless steel	000070	8.00	EA	S	1.14	1.04	0.10	10.00%	0.00	no last date	
1	BOLTHEX050X150	1/2 x 1-1/2 hex bolts gr 5 plated	000080	4.00	EA	S	1.01	0.92	0.09	10.00%	0.00	11/05/2019	21
1	BOLTHEX050X250	1/2 x 2 1/2 Hex Bolt gr 5 plated	000090	8.00	EA	S	2.38	2.16	0.22	10.00%	0.00	04/18/2019	222
1	CEMA-CB108	Coup Bolt&Nut 1/2inx3in MS GS	000100	1.00	EA	S	2.60	2.27	0.33	14.36%	0.00	10/01/2019	56
1	NUTHEX031SS	5/16 SS Hex Nut stainless steel	000110	8.00	EA	S	0.48	0.29	0.19	67.13%	0.00	11/13/2019	13
1	NUTHEX050	1/2 hex nuts gr 5 plated	000120	20.00	EA	S	1.60	1.34	0.26	19.40%	0.00	09/06/2019	81
1	THDROD050GR2	1/2 thd rod gr 2 10F length plated	000130	24.00	IN	S	4.08	1.20	2.88	240.00%	0.00	10/15/2019	42
1	WASHFLAT031SS	5/16 Flat Washer Stainless Steel	000140	16.00	EA	S	0.48	0.36	0.12	34.41%	0.00	07/18/2019	131
1	WASHFLAT050	1/2 Flat Washer plated	000150	24.00	EA	S	1.44	1.30	0.14	11.11%	0.00	11/07/2019	19
1	WASHLOCK050	1/2 Lock Washer plated	000160	20.00	EA	S	1.00	0.54	0.46	85.80%	0.00	09/06/2019	81
1	NO18MI75/40AZ-56C-115-1.9	Mini Case Size 75/40 AZ56 115 900:1	000170	1.00	EA	S	1,194.85	971.91	222.94	22.94%	0.00	08/09/2018	474
1	NO18I75-B5FL	SK18I75 B5 Flange Adapter Kit	000180	2.00	EA	S	77.00	68.48	8.52	12.44%	0.00	09/06/2019	81
1	PLA-44W-375	Plate 0.375in 44W Mild Steel	000190	0.50	SQF	S	5.38	3.88	1.50	38.62%	0.00	10/23/2019	34
1	PLA-44W-500	Plate 0.50in 44W Mild Steel	000200	0.30	SQF	S	4.10	3.06	1.04	33.86%	0.00	11/06/2019	20
1	TUBDOM0.75Dx125	Tubing DOM 0.75D x 120 wall	000210	1.25	LF	S	8.69	7.02	1.67	23.84%	0.00	08/27/2019	91

TABLE O: DISTRIBUTOR DRIVE ASSEMBLY (DTA-DRIVE-EO1-08FR) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 11/26/2019
Time : 10:59:16 AM CST

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	DTA-DRIVE-E01-08FR	000	DTA Elec DRV -8 Position Full Round	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
10	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
20	DPSPRO	DRILL,PUNCH,SAW	1.000	0.00	0.00	0.00	0.00	0.00	0.00
30	TBLPRO	TABLE PROCESSING	1.000	0.00	4.00	0.00	0.00	0.00	260.00
40	FRMPRO	FORM PROCESSING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
50	KIT	KITTING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
60	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
70	A03	CELL A03	1.000	0.00	8.00	0.00	0.00	0.00	520.00
		Totals		0.00	12.00	0.00	0.00	0.00	Can$ 780.00
		Totals per Unit		0.00	12.00	0.00	0.00	0.00	Can$ 780.00

TABLE P: DISTRIBUTOR DRIVE SHIPPING LEG (DTA-SHIPLEG) COSTED BOM

Costed BOM Report - Standard VS Average Cost Variance

SINGLE LEVEL, Ordered by PART NUMBER

Part No Equal To DTA-SHIPLEG

Page : 1 of 1
Date : 11/28/2019
Time : 10:53:13 AM CST

Part Number: DTA-SHIPLEG
Description: DTA Ship Leg-10-12-14-16 Outlet
Rev: 000
Qty On Hand: 0.00000
Qty Available: 0.00000
Last Revision: 03/22/2018

Total Weight: 15.32

	Standard	Average	$ Variance	% Variance
Material Cost	10.27	7.84	2.42	30.90%
Labor Cost	113.75	113.75	0.00	0.00%
Total Cost	124.02	121.59	2.42	1.99%
Current Cost	124.02	122.40	1.62	1.32%

Level	Part Number	Description	Item #	Qty	U/M	SRC	Std Matl	Avg Matl	$ Var	% Var	Labor	Last PO APINV Date	# days from rpt date
1	BOLTFL038X100	3/8 X 1 FLANGE BOLT GR 5 PLATED	000010	2.00	EA	S	0.28	0.24	0.04	16.98%	0.00	04/18/2019	224
1	NUTFLANGE038	3/8 flanged nuts gr 5 plated	000020	2.00	EA	S	0.09	0.07	0.02	25.71%	0.00	06/25/2018	519
1	PLA-44W-188	Plate 0.188in 44W Mild Steel	000030	2.00	SQF	S	9.90	7.53	2.37	31.39%	0.00	11/13/2019	13

TABLE Q: DISTRIBUTOR DRIVE SHIPPING LEG (DTA-SHIPLEG) ROUTING REPORT

AGI VIS

Standard Routing Summary

Page : 1 of 1
Date : 11/26/2019
Time : 11:00:46 AM CST

Facility	Part Number	Rev	Description	Unit of Measure	Standard Process Qty
Default	DTA-SHIPLEG	000	DTA Ship Leg-10-12-14-16 Outlet	EA	1.00000

Op	Work Center		Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
10	PROGR	PROGRAMMING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
20	TBLPRO	TABLE PROCESSING	1.000	0.00	0.75	0.00	0.00	0.00	48.75
30	FRMPRO	FORM PROCESSING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
40	KIT	KITTING	1.000	0.00	0.00	0.00	0.00	0.00	0.00
50	RACK	PUT ON RACK	1.000	0.00	0.00	0.00	0.00	0.00	0.00
60	A03	CELL A03	1.000	0.00	1.00	0.00	0.00	0.00	65.00
		Totals		0.00	1.75	0.00	0.00	0.00	Can$ 113.75
		Totals per Unit		0.00	1.75	0.00	0.00	0.00	Can$ 113.75

The items in the main body can be further broken down to include body shell, door, and inlet subassemblies. The labour distribution among these subsections are shown below and added together to create the main distributor standard routing summary.

Inlet

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation	
20	Table Processing	1						$ -	
30	Form Processing							$ -	
60	Painting	1		0.5				$ 32.50	
50	Cell A02	1		0.916667				$ 59.58	
40	Put on Rack							$ -	
10	Programming							$ -	
	Totals		0	1.416667	0	0	0	$ 92.08	Can $
	Totals per Unit								

Body Shell

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation	
20	Table Processing	1		2				$ 130.00	
30	Form Processing	4		4				$ 1,040.00	
60	Painting	1						$ -	
50	Cell A02	1		15.75				$ 1,023.75	
40	Put on Rack							$ -	
10	Programming							$ -	
	Totals		0	21.75	0	0	0	$ 2,193.75	Can $
	Totals per Unit								

Door

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation	
20	Table Processing	1						$ -	
30	Form Processing	1						$ -	
60	Painting	1		0.5				$ 32.50	
50	Cell A02	1		1				$ 65.00	
40	Put on Rack							$ -	
10	Programming							$ -	
	Totals		0	1.5	0	0	0	$ 97.50	Can $
	Totals per Unit								

Drip Tray & Vent Cover

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation	
20	Table Processing	1						$ -	
30	Form Processing	1						$ -	
60	Painting	1						$ -	
50	Cell A02	1		0.166667				$ 10.83	
40	Put on Rack							$ -	
10	Programming							$ -	
	Totals		0	0.166667	0	0	0	$ 10.83	Can $
	Totals per Unit								

The swing spout is a summation of the following three subsections including the internal spout and bracket support. The brush will be purchased externally and sourced in future works. The neoprene boot is not included in the total assembly cost as it is an optional item. But the potential cost is provided below.

Internal Spout

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
20	Table Processing	1						$ -
30	Form Processing							$ -
60	Painting							$ -
50	Cell A02	1		1.333333				$ 86.67
40	Put on Rack							$ -
10	Programming							$ -
	Totals		0	1.333333	0	0	0	$ 86.67
	Totals per Unit							

Support Bracket

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
20	Table Processing	1		1				$ 65.00
30	Form Processing			1				$ -
60	Painting							$ -
50	Cell A02	1		0.33				$ 21.67
40	Put on Rack							$ -
10	Programming							$ -
	Totals		0	2.33	0	0	0	$ 86.67
	Totals per Unit							

Neoprene Boot

Op	Work Center	Operation Qty	Setup Hours	Production Hours	Move Hours	Sub-Contract Costs	Other Costs	Standard Cost/Operation
20	Table Processing	1						$ -
30	Form Processing							$ -
60	Painting							$ -
50	Cell A02	1						$ -
40	Put on Rack							$ -
10	Programming							$ -
	Totals		0	0.00	0	0	0	$ -
	Totals per Unit							

Farm Grade Distributor

Appendix F – Cost Analysis

Prepared for:

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For the new farm grade distributor, the cost analysis was broken down into material and labour costs.

F.1 Material Cost Analysis

The following TABLE R, TABLE S, and TABLE T outline the selection process to determine the material for the main components of the distributor. The table compared the cost of buying the materials raw and forming vs buying pre-prepared components such as standard tubing. GS, CS, SS, and MS represent galvanized steel, carbon steel, stainless steel, and mild steel, respectively.

TABLE R: BODY MATERIAL SELECTION COST ANALYSIS

		Body		
		Per sqft	Gauge	Total for body
Materials				
GS	sqft	$ 2.74	12	$ 205.50
CS	sqft			
SS	sqft			
MS	sqft	$ 2.15	12	$ 161.24
MS+Paint	sqft	$ 75.00	12	$ 421.24

TABLE S: SWING SPOUT MATERIAL SELECTION COST ANALYSIS

		Swing Spout				
		Tubing 12" std tubing Premier	Rolling (Manufacturing in House	Brush	Clamp 12"	Rubber Boot
Materials						
GS	sqft	$ 1,468.80	TBD	~$50	$ 11.50	~50
CS	sqft					
SS	sqft					
MS	sqft	$ 828.00	TBD			
MS and Paint	sqft					

TABLE T: OUTLETS MATERIAL SELECTION COST ANALYSIS

		Outlets						
		Transitions				Standard Tubing		
		12" Premier	12" Nolan	Shipping	In house	Premier 12"	Length ft	Gauge
Materials								
GS	sqft	$ 1,468.80	$ 1,117.00	TBD	-	$ 853.20	40	10
CS	sqft					$ 686.80	40	10
SS	sqft					$ 2,888.80	40	10
MS	sqft	$ 828.00	$ 961.00	TBD	$ 2,008.00			
MS and Paint	sqft							

The table shows that using galvanized steel is cheaper than mild steel due to the additional labour time required for the painting to ensure the distributor is corrosion resistant.

F.2 Labour Cost Analysis

The following TABLE U outlines the steps allocated to each step during the manufacturing of the proposed farm grade distributor design. The table indicates the labour allocated to each std routing category as well was used to create the standard routing summary provided in Appendix F. The tables display the steps in a sequential pattern however the small components will be made in parallel with the use of two assemblers.

TABLE U: LABOUR ALLOCATED TO EACH ROUTING CATEGORY

	Std Routing Category	Instruction	Assembly/Parts	Time/unit	Total Time	Unit
1	Table Processing	Laser cutting sheet metal	Main items (body, drip tray, vent cover)	120	120	min
2	Forming	Sheet metal bending	Main items (body, drip tray, vent cover)	240	240	min
	Small Components					
	Inlet/Outlet					
3	Table Processing	Cut Tubing	11 tubes	60	60	min
			8 outlets			
			1 inlet			
			2 spouts			
4	Cell	Weld flanges to inlets/outlets	1 inlet	30	30	min
			8 outlets	30	240	min
5	Painting	painting inlet/outlets	1 inlet, 8 outlets	30	270	min
	Hanger Supports					
6	Cell	hanger support assembly	2 supports	15	30	min
	Door Assembly					
7	Cell	weld door components	1 clamp, hinges, door handle	10	30	min
8	Painting	painting	door	30	30	min
9	Cell	add gasket	door rim and window rim	10	20	min
10	Cell	tack weld bolts with glass	door	10	10	min
	Outlet Assembly					
11		Bolt outlets to bottom body panel	outlets, body bottom panel	5.625	45	min
	Internal Spout Assembly					
12	Cell	Spout tube stitch weld 50 degrees	tubing	15	15	min
13	Cell	flanges - stitches weld round angle flanges	flanges, tubing	15	30	min

14	Cell	Bolt upper UHMW	UHMW, flange	5	5	min
15	Transition					
16	Forming	bending sheet metal into form	sheet metal	60	60	min
17	Cell	wels flange to transition and loosely bolt to swing spout	swing spout, transition flanges	120	120	min
	Support Bracket					
18	Table Processing	laser cutting sheet metal piece	sheet metal	30	30	min
19	Forming	bending sheet metal into form	sheet metal	30	30	min
20	Cell	loosely bolt support pieces together	6 pieces	10	10	min
	Body Top Shell Assembly					
21	Cell	bolt inlet to top plate	inlet, top plate	15	15	min
22	Cell	bolt trip tray and vent cover to side panels	drip tray, vent cover, top side body panels	5	10	min
23	Cell	bolt door, side panels, hanger and top plate	door, upper side body panels, hangers, top plate	120	120	min
	Large Components					
	Support Bracket-->Bottom Plate					
24	Cell	thread shaft into bottom plate and the bearing sheet metal plate	shaft, bottom plate, bearing plate	1	1	min
25	Cell	sandwich pieces and bolt it down and bolt windows on	UHMW, bottom plate, bearing plate, fasteners	15	15	min
26	Cell	weld shaft to top plate of support bracket	support bracket, shaft	10	10	min
	Support Bracket-->Internal Spout					
27	Cell	Bolt-on spout support onto welded shaft plate	support bracket, shaft	5	5	min
28	Cell	bolt and welding spout tube to support spout	internal spout, support bracket	60	60	min
29	Cell	bolt transition onto spout tube	internal spout, transition	10	10	min
	Upper Assembly-->Lower Assembly					
30	Cell	bolt lower body panels and lower plate and bolt shipping legs	lower body shell, upper body shell, shipping legs	60	60	min
31	Cell	Add motor drive, sensor box assembly	motor drive, sensor box	480	480	min
32	Cell	Silicone and clean	silicone	120	120	min
33	Cell	testing/rework	all parts	600	600	min

Farm Grade Distributor

Appendix G – Project Schedule

Prepared for:

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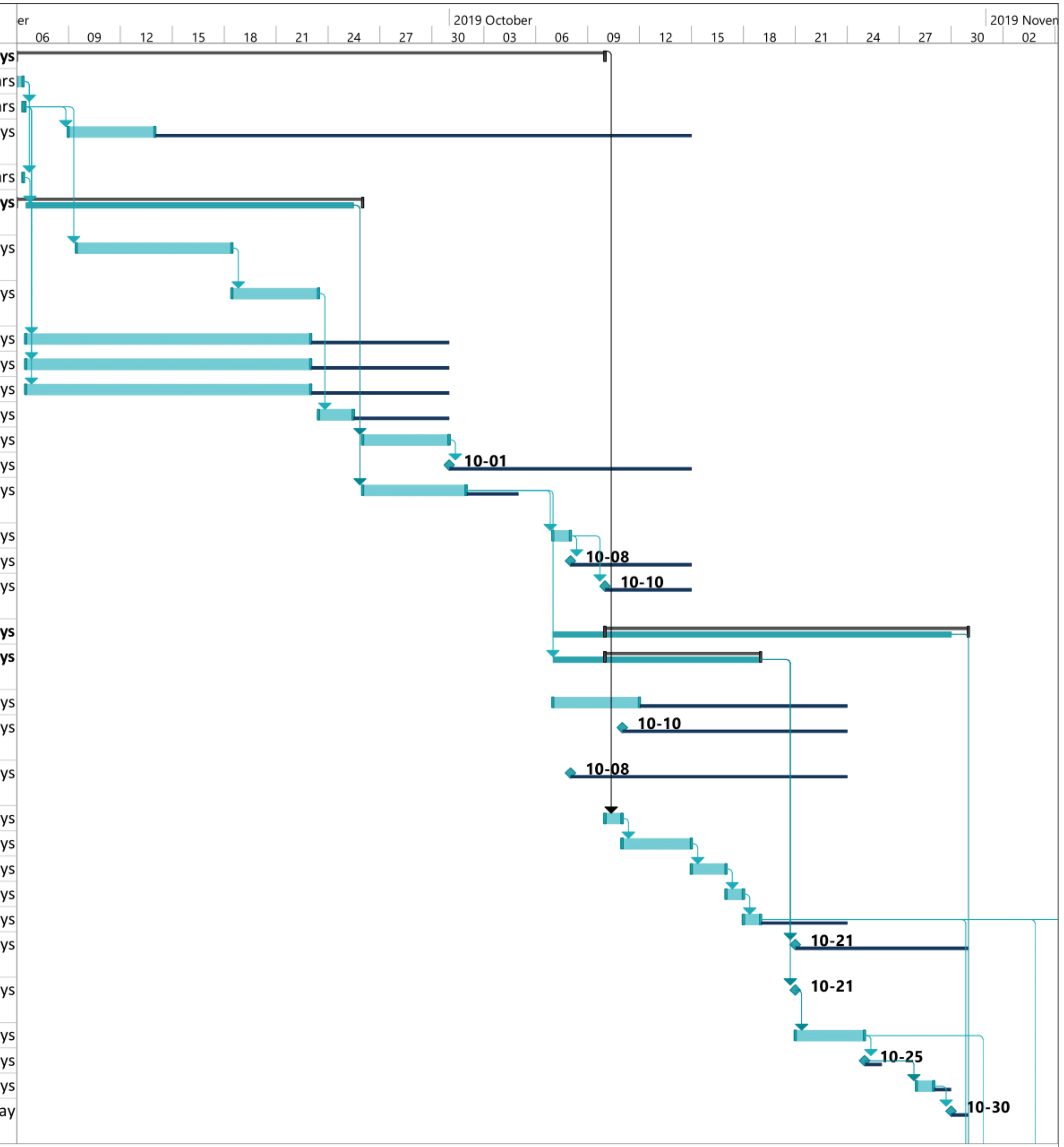
The Gantt Chart below shows the schedule to complete phases I to III. Phase I defined the customer needs and design criteria for the project. Phase II focused on the development on the concepts and Phase III detailed the final design elements. The Gantt Chart involved project management milestones and design milestones to be achieved. The team successfully completed the project within the specified timeline and only future works and recommendations remain to completed post the December 4, 2019 deadline.

ID	Task Name	Duration	Start	Finish	Predecessors	Total Slack
1	**Phase 1 Completed**	**24 days**	**Fri 19-09-06**	**Thu 19-10-10**		**0 days**
2	Initial Team Meeting	1 hr	Fri 19-09-06	Fri 19-09-06		2 hrs
3	First Site Visit	3 hrs	Fri 19-09-06	Fri 19-09-06	2	36 hrs
4	First Draft Project Charter Completed	5 days	Mon 19-09-09	Fri 19-09-13	3	21 days
5	Initial Advisor Meeting	1 hr	Fri 19-09-06	Fri 19-09-06	2	2 hrs
6	**Phase 1 Report Submitted to Advisor for Review**	**14 days**	**Fri 19-09-06**	**Wed 19-09-25**	**5**	**0 days**
7	List of Customer Needs Identified	7 days	Mon 19-09-09	Wed 19-09-18	3	3.63 days
8	Customer Needs Confirmed and Prioritized with Client	3 days	Wed 19-09-18	Mon 19-09-23	7	3.63 days
9	Gantt Chart Completed	11.5 days	Fri 19-09-06	Sun 19-09-22	3	6 days
10	WBS Completed	11.5 days	Fri 19-09-06	Sun 19-09-22	3	6 days
11	SIPOC Completed	11.5 days	Fri 19-09-06	Sun 19-09-22	3	6 days
12	House of Quality Completed	2 days	Mon 19-09-23	Wed 19-09-25	8	3.63 days
13	Phase 1 Report Completed	3 days	Thu 19-09-26	Mon 19-09-30	6	10 days
14	Phase 1 Report Due	0 days	Tue 19-10-01	Tue 19-10-01	13	10 days
15	Oral Presentation Slides Completed	4 days	Thu 19-09-26	Tue 19-10-01	6	3 days
16	Oral Presentations	1 day	Mon 19-10-07	Mon 19-10-07	15	5 days
17	Peer Evaluation 1 Due	0 days	Tue 19-10-08	Tue 19-10-08	16	5 days
18	Gantt Chart and Meeting Minutes Due	0 days	Thu 19-10-10	Thu 19-10-10	16	3 days
19	**Phase 2 Completed**	**15 days**	**Thu 19-10-10**	**Wed 19-10-30**		**0 days**
20	**Phase 2 Draft Report Completed**	**7 days**	**Thu 19-10-10**	**Fri 19-10-18**	**15**	**0 days**
21	Research Gathered	5 days	Mon 19-10-07	Fri 19-10-11		8 days
22	Client Meeting Quality Manager	0 days	Thu 19-10-10	Thu 19-10-10		9 days
23	Client Meeting Shop Assemblers	0 days	Tue 19-10-08	Tue 19-10-08		12 days
24	Brainstorming Session	1 day	Thu 19-10-10	Thu 19-10-10	1	3 days
25	List of Concepts Established	2 days	Fri 19-10-11	Mon 19-10-14	24	3 days
26	Top Two Concepts Selected	2 days	Tue 19-10-15	Wed 19-10-16	25	3 days
27	Concepts Presented to Client	1 day	Thu 19-10-17	Thu 19-10-17	26	3 days
28	Final Concept Selected	1 day	Fri 19-10-18	Fri 19-10-18	27	3 days
29	Report II Submitted for Review by Aiden Topping	0 days	Mon 19-10-21	Mon 19-10-21	20	8 days
30	Report 2 Submitted for Advisor Review (Vern Campbell)	0 days	Mon 19-10-21	Mon 19-10-21	20	3 days
31	Phase 2 Report Completed	4 days	Mon 19-10-21	Thu 19-10-24	30	3 days
32	Phase 2 Report Due	0 days	Fri 19-10-25	Fri 19-10-25	31	3 days
33	Peer Evaluation 2 Due	1 day	Mon 19-10-28	Mon 19-10-28	32	2 days
34	Gantt Chart and Meeting Minutes Due	0 days	Wed 19-10-30	Wed 19-10-30	33	1 day



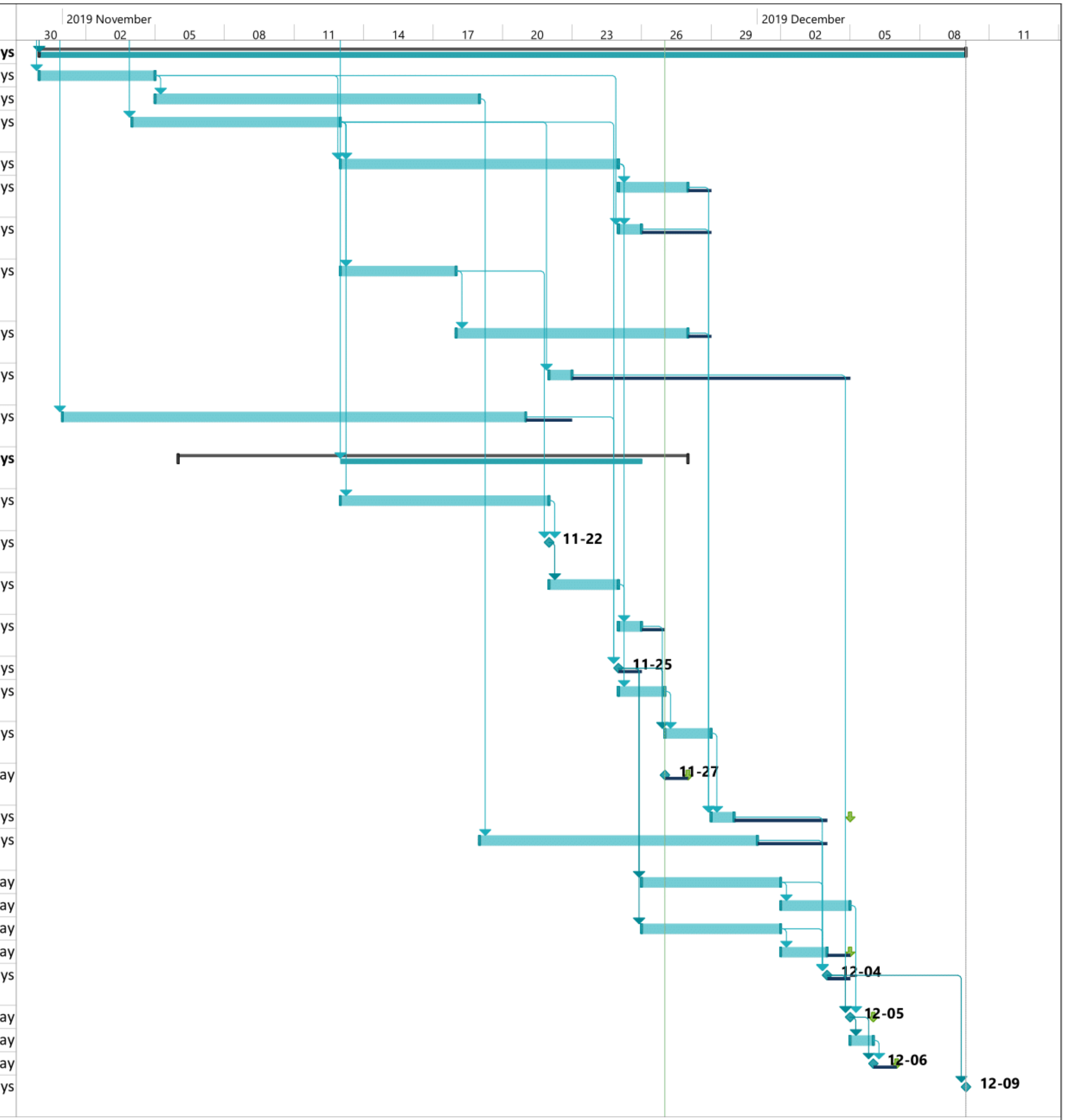
Project: Gantt Chart
Date: Wed 19-11-27

Legend: Task; Split; Milestone; Summary; Project Summary; Inactive Task; Inactive Milestone; Inactive Summary; Manual Task; Duration-only; Manual Summary Rollup; Manual Summary; Start-only; Finish-only; External Tasks; External Milestone; Deadline; Progress; Manual Progress; Slack

Page 1

Figure M: Gantt Chart Phase I and II

ID	Task Name	Duration	Start	Finish	Predecessors	Total Slack
35	**Phase 3 Completed**	**28 days**	**Thu 19-10-31**	**Mon 19-12-09**	**19**	**0 days**
36	Final Concept Modelled	3 days	Thu 19-10-31	Mon 19-11-04	28	4 days
37	Final Model Approved	10 days	Tue 19-11-05	Mon 19-11-18	36	4 days
38	Detailed Design Technical Specifications Finalized	7 days	Mon 19-11-04	Tue 19-11-12	28	3 days
39	Process Flow Chart Updated	9 days	Wed 19-11-13	Sun 19-11-24	38,36	3 days
40	Current State Process Analysis Completed	3 days	Mon 19-11-25	Wed 19-11-27	39	4 days
41	Meeting with Client to Discuss New Assembly Process	1 day	Mon 19-11-25	Mon 19-11-25	39,36	6 days
42	Analytical Analysis on Outlet, Inlet and Internal Spout Completed	4 days	Wed 19-11-13	Sun 19-11-17	38	4 days
43	FEA on Lifting Lugs and Hanger Supports Completed	8 days	Mon 19-11-18	Wed 19-11-27	42	4 days
44	Client invited to Final Presentation	1 day	Fri 19-11-22	Fri 19-11-22	38	9 days
45	Phase 3 Draft Report Completed	14 days	Fri 19-11-01	Wed 19-11-20	31	4 days
46	**CAD Assembly Drawings Completed**	**16 days**	**Wed 19-11-06**	**Wed 19-11-27**	**28**	**0 days**
47	First Draft of CAD Assembly Drawings Completed	7 days	Wed 19-11-13	Thu 19-11-21	38	3 days
48	CAD Drawings Submitted to Advisor (Jim Sykes)	0 days	Fri 19-11-22	Fri 19-11-22	47,42	3 days
49	Second Revision of Drawings Completed	2 days	Fri 19-11-22	Sun 19-11-24	48	4 days
50	CAD Drawing Reviewed by Client (Tristen Gitzel)	1 day	Mon 19-11-25	Mon 19-11-25	49	4 days
51	Draft Report Due	0 days	Mon 19-11-25	Mon 19-11-25	38,45	2 days
52	Costed BOMs and Standard Routing Summary Completed	2 days	Mon 19-11-25	Tue 19-11-26	39	3 days
53	Final Formatting of Report Completed	2 days	Wed 19-11-27	Thu 19-11-28	51,52,50	3 days
54	Gantt Chart and Meeting Minutes Due	0 days	Wed 19-11-27	Wed 19-11-27		1 day
55	Final Report Completed	1 day	Fri 19-11-29	Fri 19-11-29	53,40,43,41	3 days
56	Solidworks Renders and Animations Completed	10 days	Tue 19-11-19	Sat 19-11-30	37	4 days
57	Presentation Completed	5 days	Tue 19-11-26	Sun 19-12-01	51	1 day
58	Presentation Rehersal Sessions	3 days	Mon 19-12-02	Wed 19-12-04	57	1 day
59	Poster Completed	5 days	Tue 19-11-26	Sun 19-12-01	51	1 day
60	Poster Printed	2 days	Mon 19-12-02	Tue 19-12-03	59	1 day
61	Final Report, Poster and Presentation Due	0 days	Wed 19-12-04	Wed 19-12-04	57,59,56,55	2 days
62	Poster Presentation Evening	0 days	Thu 19-12-05	Thu 19-12-05	61,44,58	1 day
63	Peer Evaluations Completed	1 day	Thu 19-12-05	Thu 19-12-05	62	1 day
64	Peer Evals Due	0 days	Fri 19-12-06	Fri 19-12-06	62,63	1 day
65	Library Copy and Copy Write Agreement Form Due	0 days	Mon 19-12-09	Mon 19-12-09	61	0 days



Project: Gantt Chart
Date: Wed 19-11-27

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	Slack

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Figure N: Gantt Chart Phase