November 26th 2016

Dr. Paul E. Labossiere P.Eng

MECH 4860 Professor

University of Manitoba

Dear Sir,

This is the final detailed design report for the “Russel Metals Inc. – HVAC and Kinetic plasma dust collection filtration system” design topic, is being submitted as part of the last section of the Engineering design class. This design has been completed while keeping in mind how to best contain the Kinetic plasma dust created through the plasma cutting process.

The purpose of this report is to deliver our team’s final detailed design on how our solution of automation will meet the customer’s needs and user requirements while improving the containment of the plasma dust during the operation of the Touch7 Kinetic 500xmc Plasma cutter combination cutting machine.

The report has been completed by team 18 which is made up of four members. The following list includes all team members and student numbers Andrew Ruday , Jonathan de Vos , Keegan Schkawritka and Kewai Qian .

If any questions arise about our teams final detailed design should be directed to me. My email address is and my phone number is .

Sincerely,

Keegan Schkawritka

Team 18

December 4th 2016

Gustavo Strange P. Eng
Manufacturing Engineering Manager
Russel Metals Inc.
1510 Clarence Ave
Winnipeg, MB R3T 1T6

Dear Mr. Strange,

We humbly submit our final report describing our solution to Russel Metals' kinetic plasma dust collection issues. The solution would be implemented in two stages, with a third optional stage that would provide excellent long term sustainability.

We would like to say it has been our pleasure to work on these issues together as a team and in coordination with yourself and Mr. Sheldon Stoess. We believe that our solution addresses all the needs and requirements of Russel Metals.

Any questions regarding this report should be addressed to Jonathan de Vos, he can be reached via email at and by phone at .

Sincerely,

Team 18

Kewei Qian

Andrew Ruday

Keegan Schkawritka

Jonathan de Vos

Automated Transfer of Plasma Cutting Dust

Russel Metals

Advisor: Meghan Guyot

Team Number: 18

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Submission Date:

December 7, 2016

Executive Summary

Russel Metals (The Client), a bulk metal sales and metal processing company, has commissioned a team of four students from the University of Manitoba Mechanical Engineering program to help find a solution for a problem they are experiencing. At its Clarence Avenue location in Winnipeg Russel Metals uses a Kinetic K5000xmc plasma cutter and combination drilling machine for metal processing. Plasma cutting creates debris, dust and fumes. These by-products are removed and contained from the cutting location by the dust collection system, however this system is not capable of containing all the plasma dust created from cutting, as a result this dust is contaminating the shop area around the machine as well exposing machine operators to this dust. The goal of this project is to contain all dust created by cutting operations in a sustainable way and to improve the disposal process. The student team identified and confirmed the clients' needs regarding the solution to this project as follows, in order of importance; that Plasma cutter downtime be kept to a minimum, that plasma dust be contained during operation of the machine, worker safety is increased, footprint of the machine is not increased, Shop cleanliness is maintained during daily operations, and the solution has long tem sustainability.

The project team identified three problem areas that are believed to cause the problem namely the top exhaust vent of the collection unit, the seal between the disposal bin and the collection unit and the disposal process. The team found a solution for all three areas, the implementation of the solution will be done in two phases with a third optional phase. Phase one involves sealing the disposal bin to the collection unit with butyl rubber and adding actuators that will create four points of contact as opposed to the existing one point of contact, as well as extending the top exhaust vent through the exterior wall. Phase two of the solution replaces the existing disposal bin with a custom made hopper to which a screw conveyor is attached, the screw conveyor is attached to a support structure just outside of the facility, within this structure the screw conveyor is connected to a sealed steel drum. Phase two solves the disposal process problem by making it a closed system, with no dust losses, that is fully automated.

The support structure and hopper will be fabricated in house by Russel Metals, the installation of the solution will be done in house by the maintenance department. As such only the cost of purchased parts was investigated, this cost is estimated to be $13,358.00 for phase one and two.

Phase three of the solution can be found in Appendix E, it involves moving the entire dust collection unit outside of the facility. This would reduce shop footprint significantly. This phase would still incorporate the solutions from phase one and two. However, the capital investment required for phase three would be significant, it is up to the client to determine whether these benefits outweigh the investment. As it stands phase one and two of the proposed solution will satisfy the clients needs related to this problem.

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1. Introduction

The client for our project is Russel Metals. The company is divided into two sections. One branch delivers large quantities of special order metals from mills to the customer. The other branch of the company processes metals from the mills into products that they then will sell to customers. This processing branch is the side which we have been working with. The metal processing done at Russel Metals includes shaping, welding and cutting processes to sheet metal and tubing. Our project deals with plasma cutting generated dust, which is formed during the process of cutting metals using a jet of hot plasma. The dust generated from the cutting process is extremely fine and red in color and so controls are put in place to contain and filter any fumes and dust generated during cutting.

The problem which Russel Metals has approached us with involves their largest plasma cutting machine and the dust which it is generating during cutting. The technical name of the machine is the Kinetic K5000xmc plasma cutter and combination drilling machine. Their problem is with the machine's air filtration unit, shown in Figure 1, which draws in the plasma cutting fumes and dust for filtration. The problem with the machine is containment of the collected dust and the methods of handling and disposing the waste dust collected.

Figure 1. Kinetic K5000xmc's air filtration unit

The current method for dust collection within the unit is using a square dust collection bin, shown in Figure 2, which is lifted into place within the machine by the lever arm. The current seal is worn to metal-on-metal, showing signs of poor sealing and dust loss. Once the bin is full it is pulled out of the filter unit. It is then lifted into the air using an overhead crane and transported to the nearest receiving door where it is lowered back to the ground. The full bin is then pushed or pulled by a worker across the shop floor and outside to a garbage bin (disposal drum). The bin has four smaller bins inside which are manually lifted and emptied into a garbage bag within a 55-gallon disposal drum. The bags are eventually removed from the drum and again transferred to the final garbage bin that is regularly collected for Russel Metals.

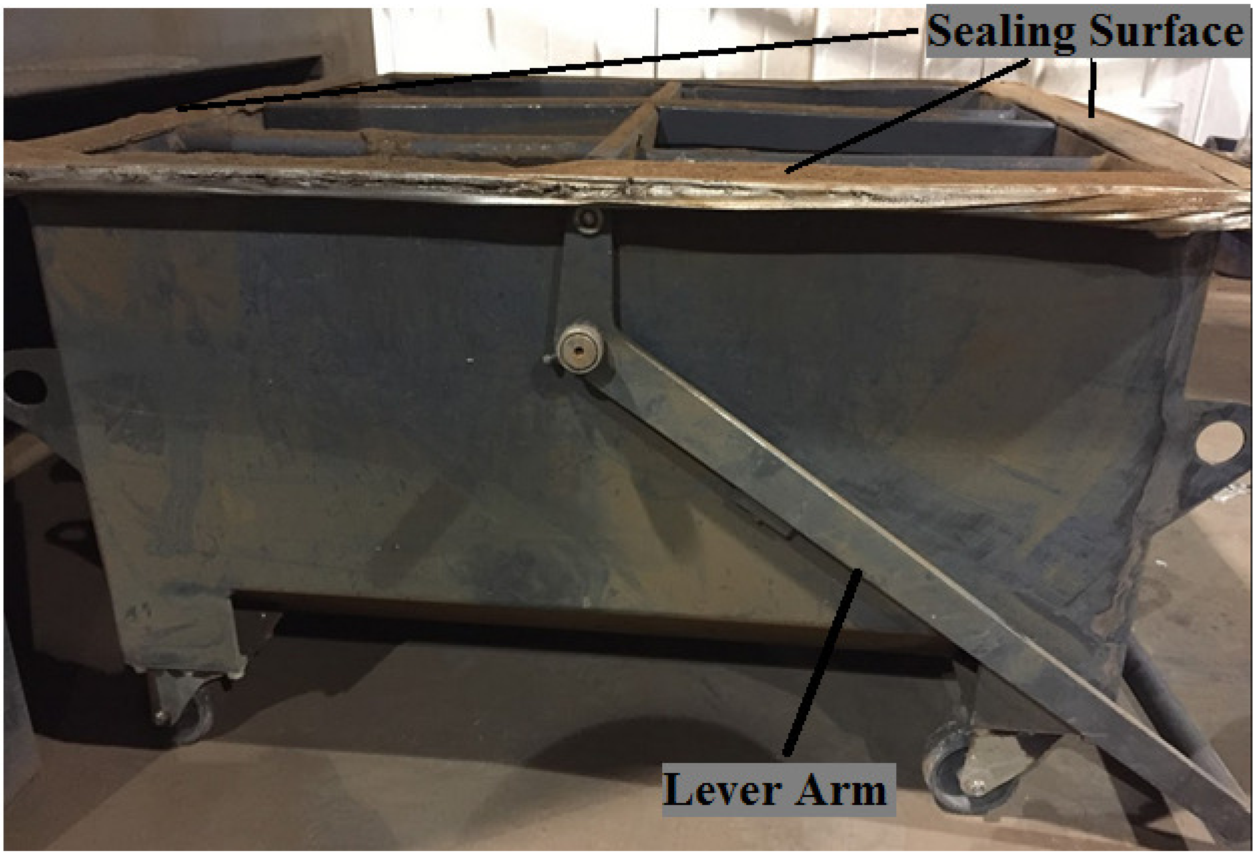

Figure 2. Filter unit's dust collection bin

1.1. Problem Breakdown

The dust containment of the plasma cutter's filter unit is not perfect; there are gaps in the performance of the system. Russel Metals stated that they wanted to fix their problem with dust escaping the filter unit. Our team was able to identify three major problem areas with the filter unit, leading to dust loss issues. The problem areas are: the dust collection bin seal, transportation and disposal of collected dust, and the filter unit's top vent.

The main concern of Russel Metals was improving how the filter unit's dust collection bin is sealed into the plasma cutter's filter unit. There were several seals and sealing methods that our team evaluated which can be found in Appendix A.

The transportation and disposal problem area deals with how the collection bin is handled and dealt with once full and in need of emptying. Any time the dust collection bin is handled or being moved dust becomes visibly airborne. This leads to contamination of shop areas which are not directly near the filter unit. The problem persists even once outdoors and emptying the collection bin into the disposal drum. Dust plumes leave the drum as the contents of the collection bin are transferred over leading to contamination and discolouring of the shop yard.

The final problem area identified is the exhaust vent, shown in Figure 3, it is on top of the plasma cutter's filter unit and vents directly out of the top and into the shop. The vent was identified as a problem area because during operation dust and smoke could be seen leaving the vent.

Figure 3. Filter unit's exhaust vent

1.2. Project Needs

For our client, Russel Metals, our team has identified and confirmed the clients' needs regarding the solution to this project as follows, in order of importance; that plasma cutter downtime be kept to a minimum, that plasma dust be contained during operation of the machine, worker safety is increased, footprint of the machine is not increased, Shop cleanliness is maintained during daily operations, and the solution has long tem sustainability.

1.3. Project Goal

The main goal of our project is to deliver a final design which will yield measurable improvements in the dust contamination problem Russel Metals is having. Beyond this goal the final design should benefit Russel Metals and its employees by meeting the other needs outlined. In doing so the needs of Russel Metals will be met, dust contamination will be significantly decreased and all worker's safety throughout the shop increased. This will be done by solving the three problem areas: the bin seal, transportation and disposal of the dust and the filter unit's top vent.

2. Final Design Concept

During phase II, a large number of concepts were generated and researched (Appendix A). Concepts for each problem area were screened and scored based off Russel Metal's defined needs and priorities. The resulting concepts were then taken to Russel Metals for review and final selection (Appendix B). During this meeting it was found that concepts which had scored highest and some concepts which had been screened out during the brainstorming process were favorable. As a result of this consultation two possible design concepts, automation and isolation, were generated.

The main concept, automation, is to reseal the filter unit's bin and automate the removal and transfer of the dust collected. This concept will address each problem area and offers many benefits to Russel Metals based on their needs. The filter unit's bin seal will be addressed and made to work reliably, preventing dust loss and shop contamination during operation. Transferring of the dust collected to the final waste and disposal bins or bags (located outside) will then be automated. This reduces downtime and the need to frequently empty the disposal bin. Lastly, the top vent will be routed outside to eliminate any dust release into the shop. These actions and changes are the basis for the final design concept, automation.

The secondary concept, isolation, is to relocate the plasma cutter's filter unit to an outdoor structure. Intended to be implemented in conjunction with the features of automation, isolation will completely eliminate the filter unit from the shop's interior clearing floor space and providing the reduced downtime of automation.

The automation concept, as discussed, comprises of three primary sections which form an automated solution to Russel Metal's plasma cutter dust problem. In this section the automation design will be presented and details of the individual components discussed. The intended phases and order installation intended discussed and final breakdown of the components required and a cost breakdown presented.

2.1. Overview of Automation Design

The automation design, shown below in Figure 4, shows the configuration of the design and highlights the solutions to the problem areas identified.

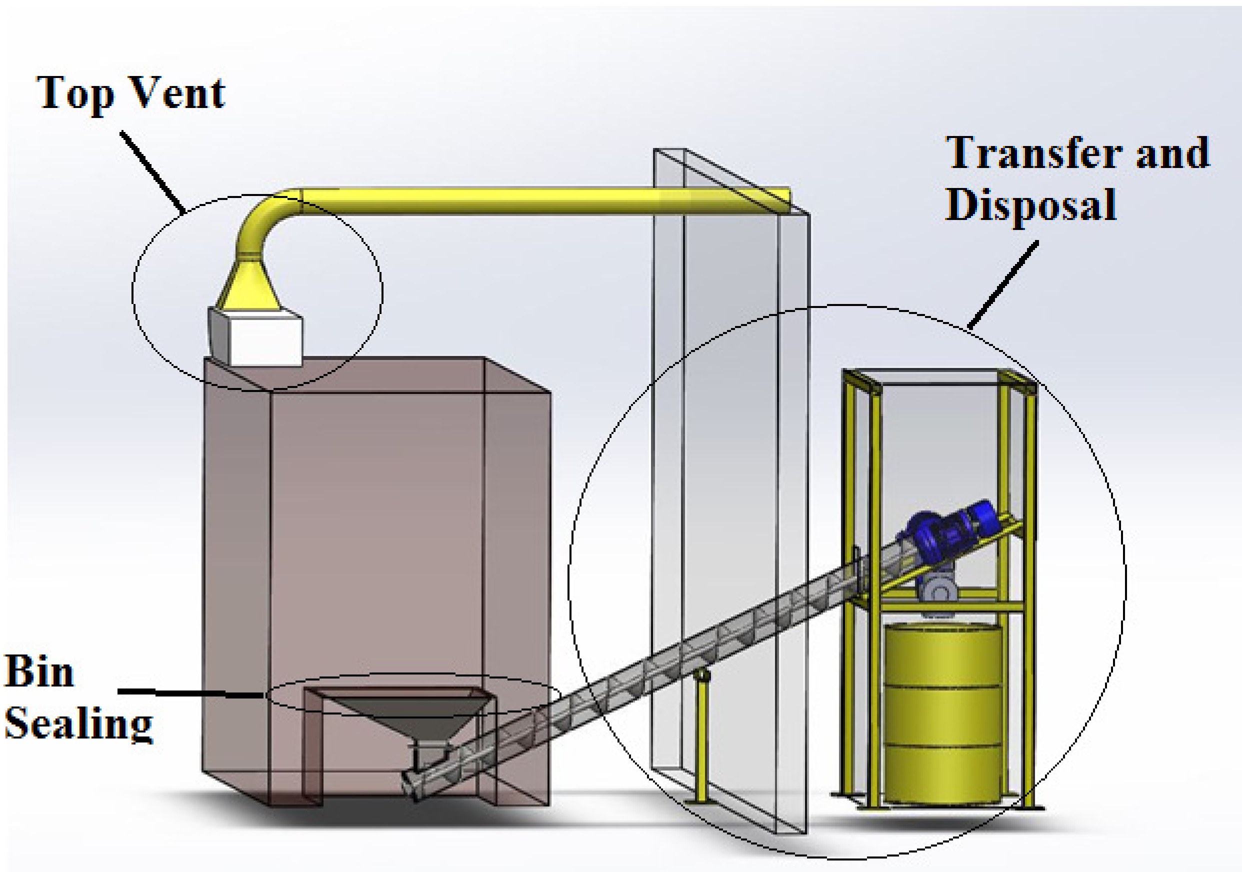

Figure 4. Automation design assembly

The new bin sealing method has three main parts: a seal, bin lifting and locking mechanism, and the lifting control. A new rubber seal material provides a consistent seal and has a long lifetime. The pneumatic lifting and locking mechanism ensures that the collection bin, with the new seal fitted, is lifted and pressed against the filter unit with adequate and evenly applied pressure around the sealing surface. The lifting control logic provides a means of controlling the lifting mechanism while ensuring that controls are not accidentally actuated.

The transfer and disposal section of our automation design, shown in Figure 5, has five main parts: the hopper, screw conveyor, rotary airlock valve, controller, and the disposal drum. The hopper is interchangeable with the current filter unit's collection bin and funnels collected dust down into the screw conveyor. The screw conveyor transports the dust outside where it is transferred through the rotary airlock valve and into the 55 gallon disposal bin. The controller automatically runs the screw conveyor and rotary airlock valve as needed to remove dust from the hopper. The controller also allows for the screw conveyor and rotary airlock valve to be stopped while the plasma cutter is running. This allows for the 55 gallon disposal bin to be emptied or replaced while production continues.

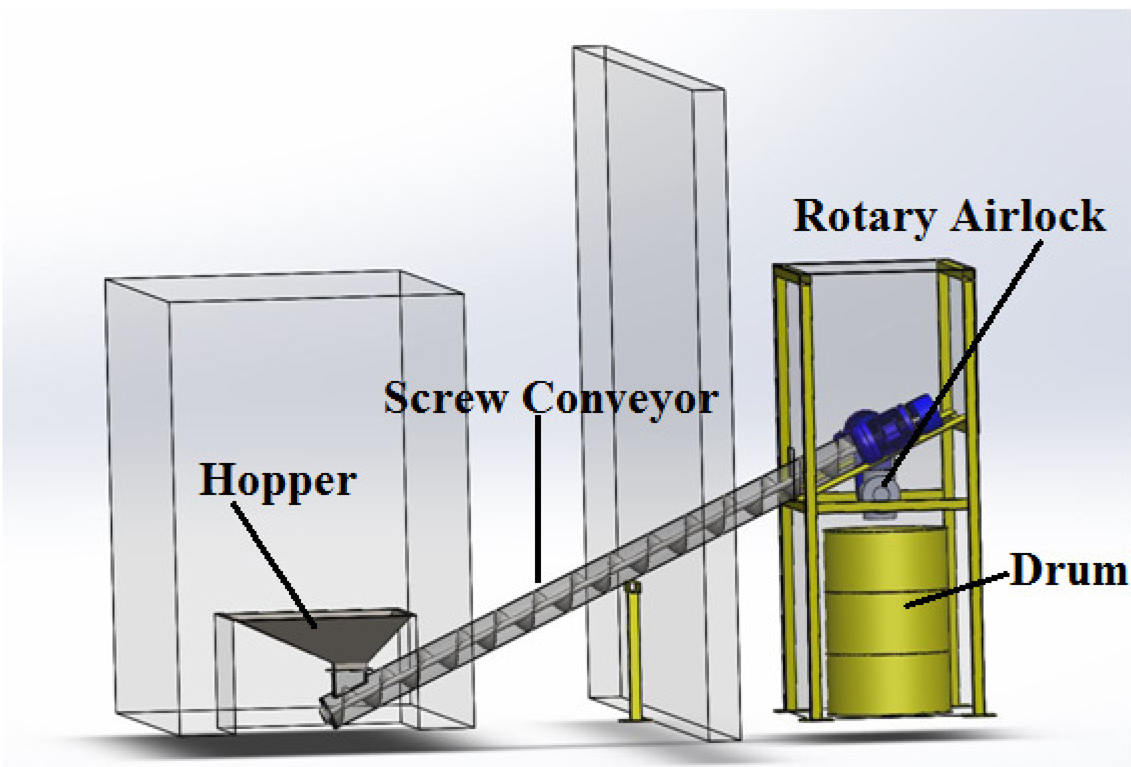

Figure 5. Transfer and disposal components

The last section of the automation design is the top vent. It comprises of one main component; an extended exhaust vent which is routed outdoors through the exterior wall. Routing the top vent outside eliminates the final source of dust contamination in the shop, prevents plasma cutting fumes not captured by the filter unit from being circulated in the shop, and prevents air streams leaving the vent from further stirring dust within the shop.

Details of the individual components of each problem area are discussed in the proceeding sections.

2.2. Filter Unit Bin Sealing

In this section three components, the bin seal, bin raising and locking mechanism and the lifting control needed to implement the new filter unit's bin seal are discussed and presented.

2.2.1 Collection Bin Seal

The first part of automation involves sealing the connection between the filter unit and filter unit bin. A lack of material able to deform and fill the voids of the mating faces (connection) has lead to Russel Metals continuing dust loss problems. To solve this problem a new seal will be implemented. The seal will be made from a rubber compound with low gas permeability, good compression set properties, durability and chemical resistance against ozone. The rubber selected for this is butyl rubber which has good tear resistance, good compression set properties, excellent chemical resistance to ozone, and extremely low gas permeability [1]. A variety of butyl rubber products from which the bin seal can be made are shown in Figure 6.

Through failure mode analysis of the bin seal (Appendix C) it was determined that the seal should be mounted to the filter unit's bin and not within the filter unit itself. This will allow for the bin seal to be easily visually inspected for wear and simplify installation or replacement. Additionally, to ensure the success and longevity of the seals effectiveness both an adhesive and mechanical means of attaching the seal to the bin should be used.

Figure 6. Butyl rubber products available [2], [3], [4], [5].

2.2.2 Collection Bin Raising and Locking Mechanism

To seal the dust collection bin against the filter unit a lifting mechanism for the dust collection bin will need to be installed. This will be accomplished by the installation of a pneumatic lifting system. The pneumatic lift system will prevent workers from being required to manually operate the original filter bin's lever arm which is located near the ground and could potentially cause back strain.

Four, pneumatic linear actuators, will instead be installed to raise the bin. The actuators will act on the underside of the outer rim of the bin lifting the bin and sealing it against the filter unit. SMC, offers a line of pneumatic actuators, the MGP series with 80mm or 100mm bore sizes, are suitable for the lifting the bin [6]. Their size and mounting method would make installation and integration straightforward. The series suggested is shown below in Figure 7.

Figure 7. SMC's MGP series of compact guided linear actuators [6].

2.2.3 Collection Bin Lifting Control Logic

To utilize any sort of powered lifting mechanism, controls should be put in place to avoid possible injuries. For the bin lifting control it is recommended that user input be used to determine if the bin is clear to be raised (or lowered) and a control system which will avoid unintended actuation of the controls integrated into the controls.

A flow chart, shown below in Figure 8, describes the logic which should be integrated into the controls in order to avoid unintended actuation of the controls.

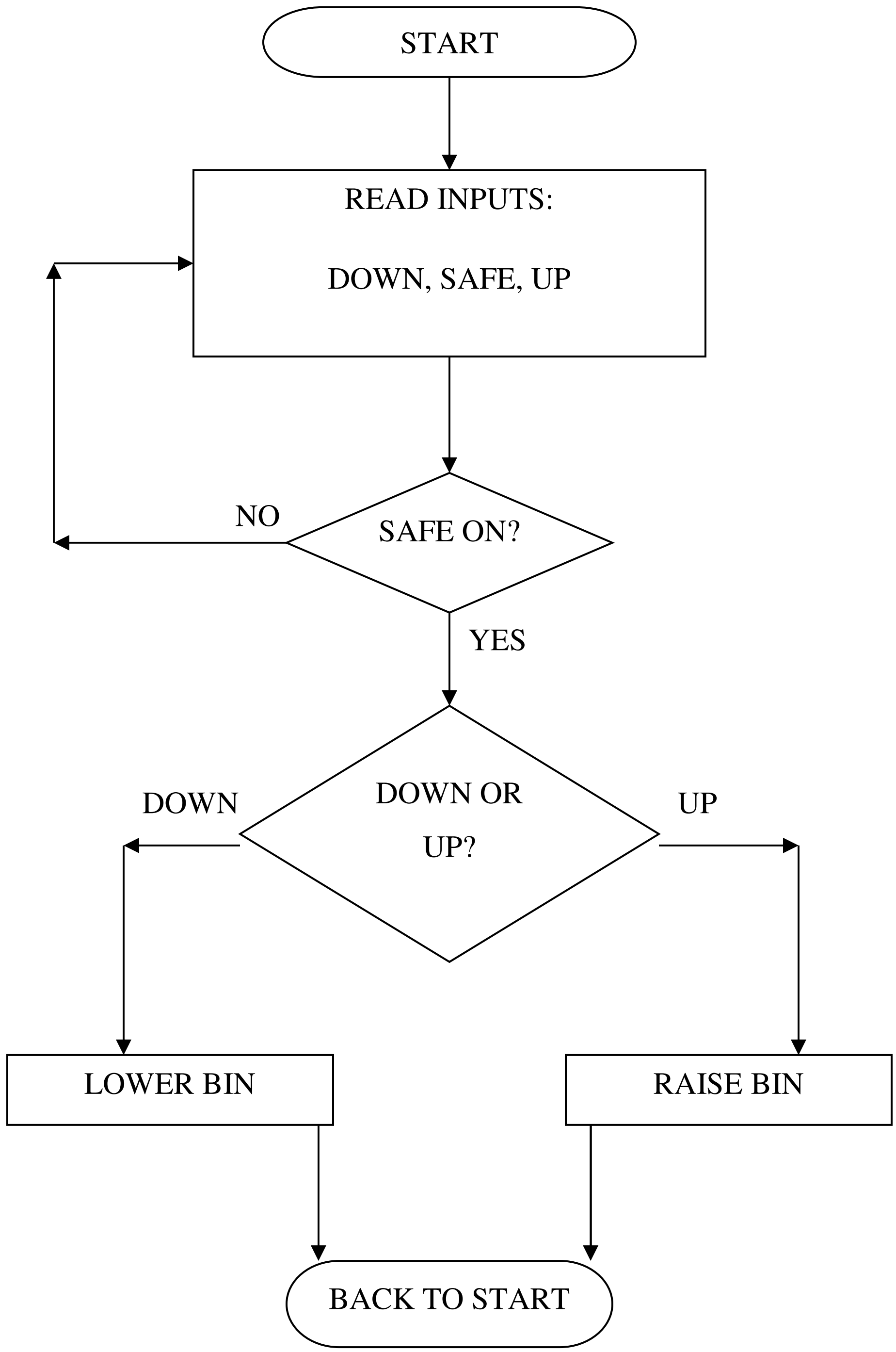

Figure 8. Bin lifting control logic flowchart

The logic is simple and shows that in order to activate either up or down motion an additional input, SAFE, must first be active. This ensures that operation of the controls will be deliberate and non accidental. For added safety additional SAFE inputs (each required to be active to enable operation) could be added to safety doors, sensors which check the collection bin's alignment, ect. to satisfy the level of safety desired.

2.3. Transfer and Disposal

In the transfer and disposal section the seven components that make up the solution to this problem are presented and discussed. These components are: the hopper, screw conveyor, support structure, rotary airlock valve, screw conveyor and rotary airlock valve controller, flexible hose and disposal bin needed to automated transfer and disposal of collected dust.

2.3.1 Hopper

A custom made hopper is required for the automation of transfer and disposal via screw conveyor of the plasma dust. There are three reasons for this. One is the space limitation of Kinetic K5000xmc's air filtration unit. With the original filter unit's dust collection bin, there is no space for installing a transportation unit. The second reason is cost saving. The cost for building a new hopper is cheaper than modifying the existing dust collection bin. the last reason is the original filter unit's dust collection bin can be used as a backup for the Kinetic K5000xmc's air filtration unit.

This hopper is meant to replace the current disposal bin; the funnel shape of the hopper is designed to create clearance for the screw conveyor to be integrated. The hopper profile guides the collected plasma cutting dust down from the large rectangular opening (the point of connection and sealing to the Kinetic K5000xmc's air filter unit) to the lower opening and connection point of the screw conveyor. The hopper profile is shown in Figure 9. The upper and larger opening is a match to the original dust bin geometry made to fit the original machine. The left and right side flanges are reinforced by using a thicker thickness of sheet metal. This will help to provide enough stability during the installation and for sealing as well as to ensure the actuators will work just the same as with the original dust bin. As Figure 10 shows, the two openings are not concentric. By using this design, the point of connection is close to the front panel of the Kinetic K5000xmc's air filtration unit which provides easy installation and maintenance.

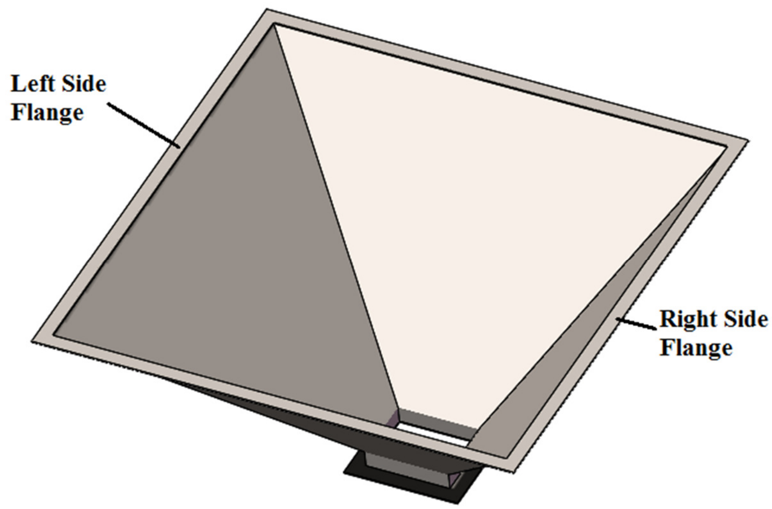

Figure 9. New hopper

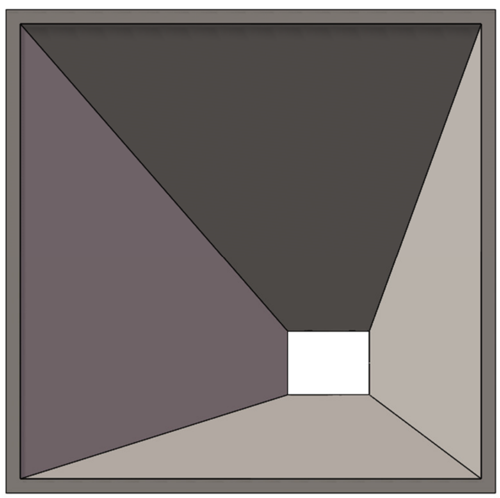

Figure 10. Top view of new hopper

2.3.2 Screw Conveyor

A screw conveyor, shown in Figure 11, is used for automated transfer and disposal of the plasma cutting dust. With adding this screw conveyor, the plasma cutting process is not necessary to be interrupted by disposal of dust from the integrated fume and dust filtration unit. Its use will significantly reduce the current plasma cutter downtime associated with transferring and disposing the dust that is collected within the filter unit's current bin.

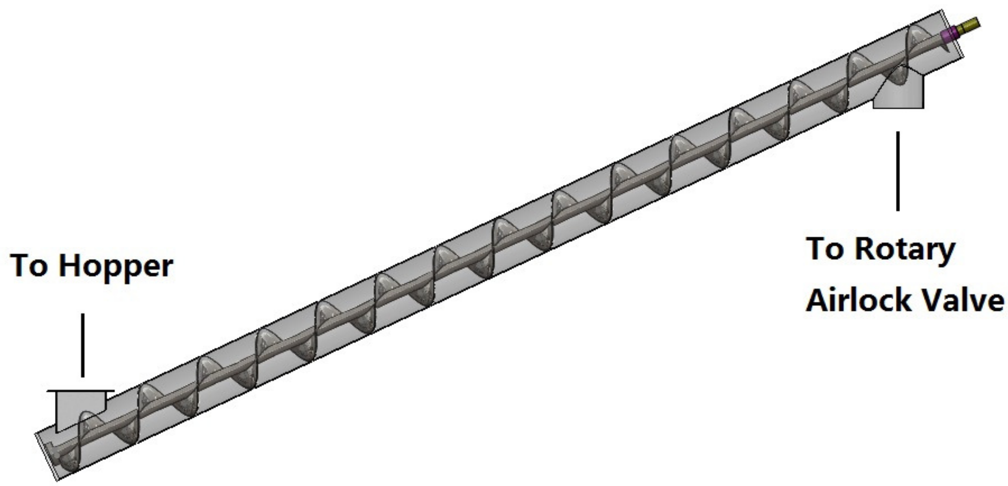

Figure 11. Screw conveyor

The screw conveyor's selection is based on the volume and weight of the dust will be transferred and the space constraints related to the current machine set up. A screw conveyor 10-feet in length is selected and sitting at a 25 degrees angle to the horizontal to achieve the low height connection point with hopper and right height connection point with rotary airlock valve to the collection drum. The 6-inches diameter is selected for the screw conveyor to provide the capacity and a two horsepower motor with the gearbox assembly is used to drive this screw conveyor.

The screw conveyor itself is a custom built sealed tube. Inside is an auger type screw which when turned will draw solid materials up from the inlet and to the outlet. It is designed to be used as a closed loop system, eliminating exposure points to any dust. The inlet of the conveyors tube is rectangle in shape and made to mate with the hopper's outlet. The outlet of this tube is a standard circular shape and designed to allow connection to the rotary airlock.

2.3.3 Support structure

Two support structures, shown in Figure 12, are designed to support the screw conveyor and motor. The inside support is a simple "T" shape structure with a horizontal tube to support the conveyor. It is should be located close to the shop wall to reduce hazards, and provides support for the conveyor shaft.

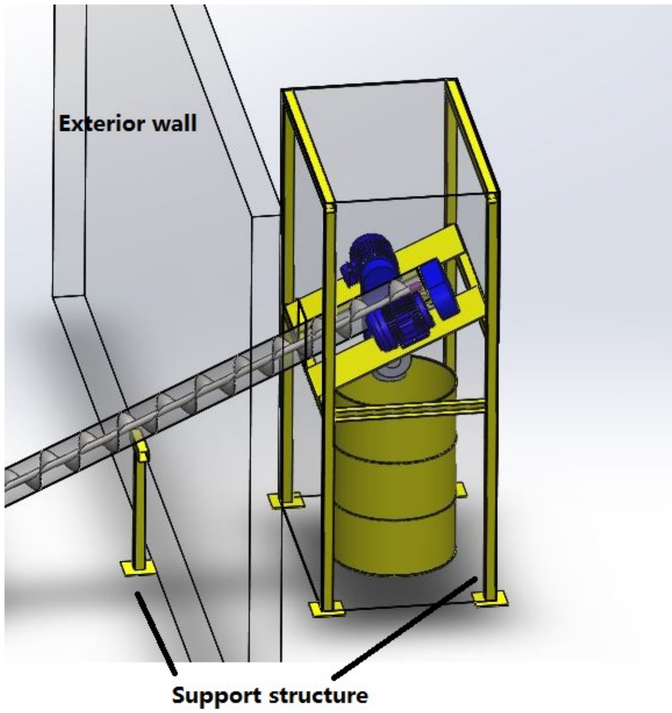

Figure 12. Support structure layout

The outside support is built just on the outside of the exterior wall. The structure provides the support needed to carry the weight of the motors, rotary airlock, and outlet of the screw conveyor. The details of the outlet end of the screw conveyor are shown Figure 13. A 55 gallon steel drum will sit inside of the structure and below the rotary airlock valve outlet. The two sheet metal plates which run along the screw conveyor (near its outlet) are used to mount the screw conveyors motor. The upper half of the structure should be shielded with a material such as clear acrylic sheets to protect the inside of the unit from extreme weather. The visibility provided by acrylic sheets will provide a clear view of inside units and easy for units visual inspection.

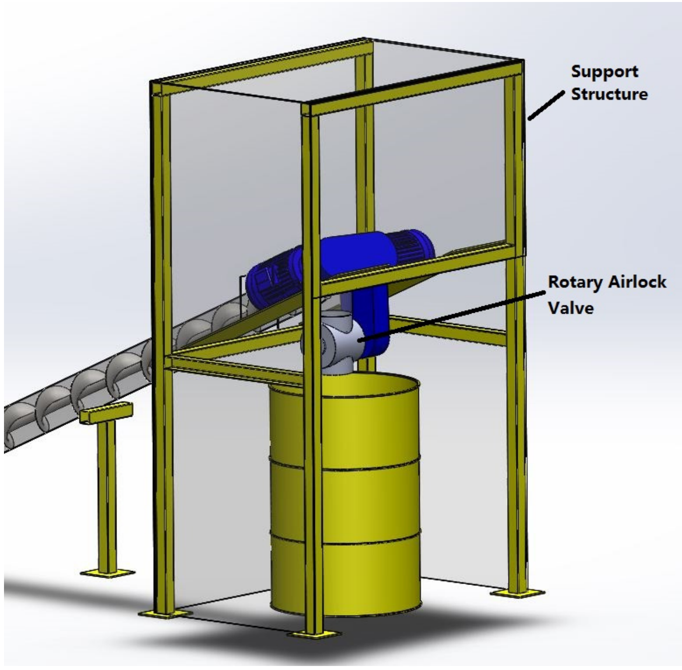

Figure 13. Outside support

2.3.4 Rotary Airlock Valve

In the automation design we have added a rotary airlock valve after the screw conveyor. The rotary valve acts as an air lock while still allowing transfer of solid materials. Our team added the rotary valve due to concerns over pressure differences between the suction side of the filter unit (where the screw conveyor inlet is connected) and the final disposal drum (the screw conveyor's outlet). A schematic depicting the pressure difference during normal operation is shown in Figure 14. If an air leak exists between the screw conveyor outlet and disposal drum air will be drawn from the outlet of the screw conveyor and back into the filter unit's collection bin. This will cause particulates being drawn through the screw conveyor to be sucked back into the filter unit while simultaneously causing a loss of suction.

The filter unit will also occasionally "pulse" air in the reverse direction of normal air flow through its filter elements. This purges dust off the filter elements allowing dust which has been filtered to descend into the collection bin. The airlock will further ensure that the pulse does not effect normal operation of the conveyor.

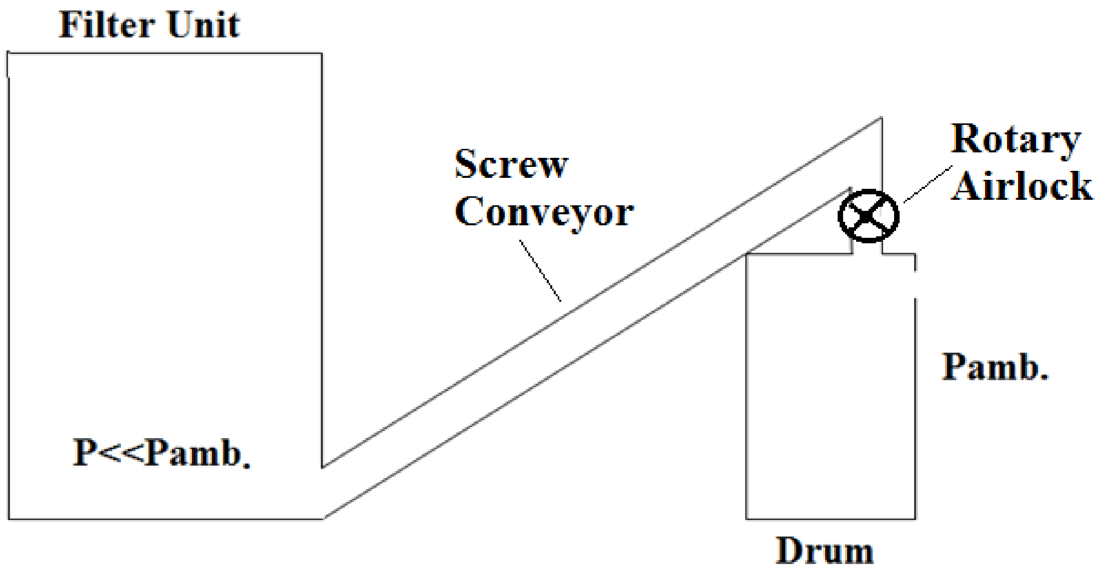

Figure 14. Schematic of pressure difference

A loss of suction would also further decrease the filter unit's ability to capture plasma cutting fumes and dust. By adding the valve directly to the screw conveyors output any air leaks between the disposal drum and airlock will not affect the systems performance. Another benefit of adding the rotary valve is during operation of the plasma cutter the valve can be turned off. This will allow for the removal and replacement of the disposal drum while still allowing production to continue. Figure 15 shows a double horn, rotary valve design, for our project we can use a simpler design for our rotary valve.

Figure 15. A Double horn rotary valve design [7].

2.3.5 Flexible Hose

The flexible hose will be installed after the rotary valve and will have a two-inch diameter. The size of the hose is due to the size of the opening on the drum which a has a two inch opening with standard threads, the hose will need to have two inch standard threads on the outside of the mounting to be properly installed on the drum. The flexible hose was chosen to allow for an easier removal process of the drum. Figure 16 shows a standard flexible two-inch hose that will need to be fixed to the rotary valve at one end and have a two-inch fastener with outer standard threads on the other side. The thread on the drum has 1A1/X1.8/300 threads. Therefore, the fastener will need to have a similar thread. Our team has found a vendor that sells the needed flexible hose from Air Handling Systems [8].

Figure 16. Two-inch flexible hose for disposal [8].

2.3.6 Drum Sizing

Through the failure mode element analysis our team has found using the larger 55-gallon drum to be the best choice as the receptacle for the waste dust. One of the reasons for choosing the large drum was that there would be less frequent handling of the dust. The larger drums also have sealed lids, helping to insure there is no dust leakage from the disposal drum. Russel Metals has access to forklifts which will make lifting the full 55 gallon drums easy. By designing for the larger 55 gallon drums to be used it is ensured that shorter and smaller disposal containers could be used in place of the larger 55 gallon drums. This will allow Russel Metals to quickly change the system if they encounter unforeseen problems. If Russel Metals did want to change drum types all they would need is an increase the length of the flexible hose, which can be easily done due to the vendor of the hose selling Russel Metals extra material. Since all standard drums have a two-inch hole in the lid the only change in our design will be the length the flexible hose used to reach the drum. Figure 17 is a standard 55-gallon drum with the two-inch opening in the top with the standard threads.

Figure 17. 55-gallon drum with a sealed lid [9].

2.3.7 Load Cell

Underneath the 55-gallon drum will be a load cell, which will be able to tell how full the drum is by weighing the amount of dust in the drum. When the drum reaches the weight which corresponds to the bin reaching its max capacity a full signal is sent to the controller. The controller will turn off the screw conveyor and the rotary airlock and prevent further operation of the conveyor until the bin is emptied. Our team has selected a model for the load cell but Russel Metals may source different models. The chosen model is the LTW 652 tank weighing load cell, it is capable of measuring weights up to 2500 lbs, highly accurate and water resistant. Water resistance is needed because this load cell will be located outside, underneath the drum. Figure 18 is an image of the chosen load cell and which can be purchased at Cooper Instruments. [10]

Figure 18. The LTW 652 tank weighing load cell [10]

2.3.8 Screw Conveyor and Rotary Airlock Controller Logic

A controller for the screw conveyor and rotary airlock will need to be implemented into the system. For Russel Metals to the gain the full benefits of installing the screw conveyor and rotary airlock the controller will need some features. The flow chart, shown in Figure 19, shows the logic which should be implemented into the controller to realize these benefits.

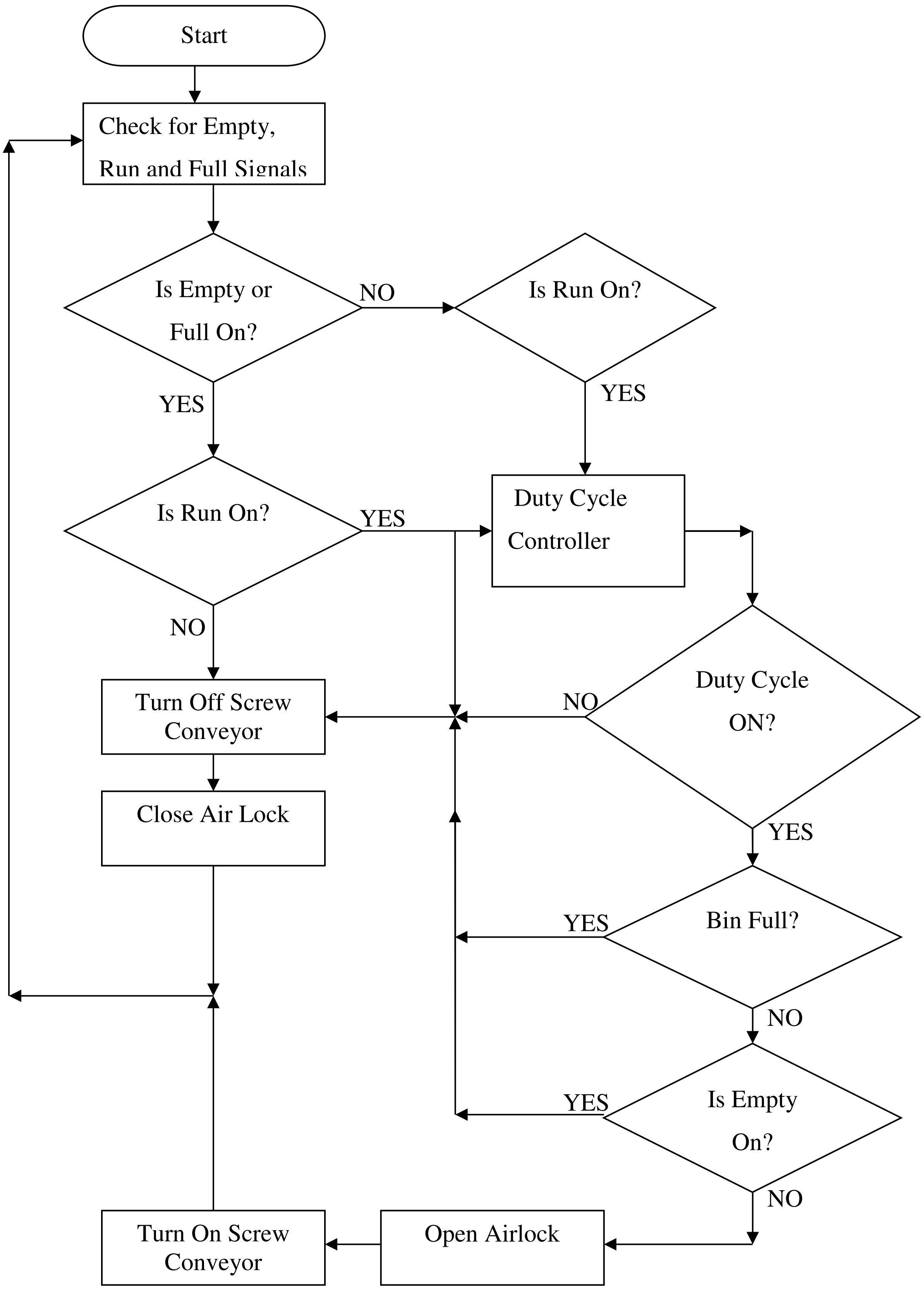

Figure 19. Screw conveyor and rotary airlock controller logic

The logic presented in Figure 19 is intended to work as follows. When the plasma cutter is running a run signal is generated and input into the controller. The run input will always start a timer programmed to monitor and control the duty cycle of the screw conveyor and airlock. When the running time has reached the time required to generate enough dust to warrant turning on the screw conveyor the timer will trigger for the screw conveyor and airlock to run. The timer output signal will then be generated for long enough for the screw conveyor to empty the contents of the hopper. There is also another input, Empty, and this input will at any time interrupt the screw conveyor and airlock drive signals turning the both off and allowing for the disposal drum to be safely removed and emptied while the plasma cutter continues to operate. The Empty signal will be generated from a load cell installed underneath the drum.

By implementing this logic, the lifespan of the screw conveyor and airlock will be increased by reducing unnecessary running time. Also the ability to interrupt the screw conveyor and airlock with the Empty input will allow for the plasma cutter to run uninterrupted, even if the disposal bin is being emptied.

2.4. Top Vent Extension

The top vent extension part of the solution is straight forward. Following building code, the vent should be extended using typical sheet metal ducting. The area between the top vent and the exterior wall is free and clear, ducting must be raised slightly to clear additional equipment up on top of the dust collection unit, and can then be directly extended through the wall. This height allows for people to walk free and clear underneath it. Figure 20 shows the concept sketch of this solution.

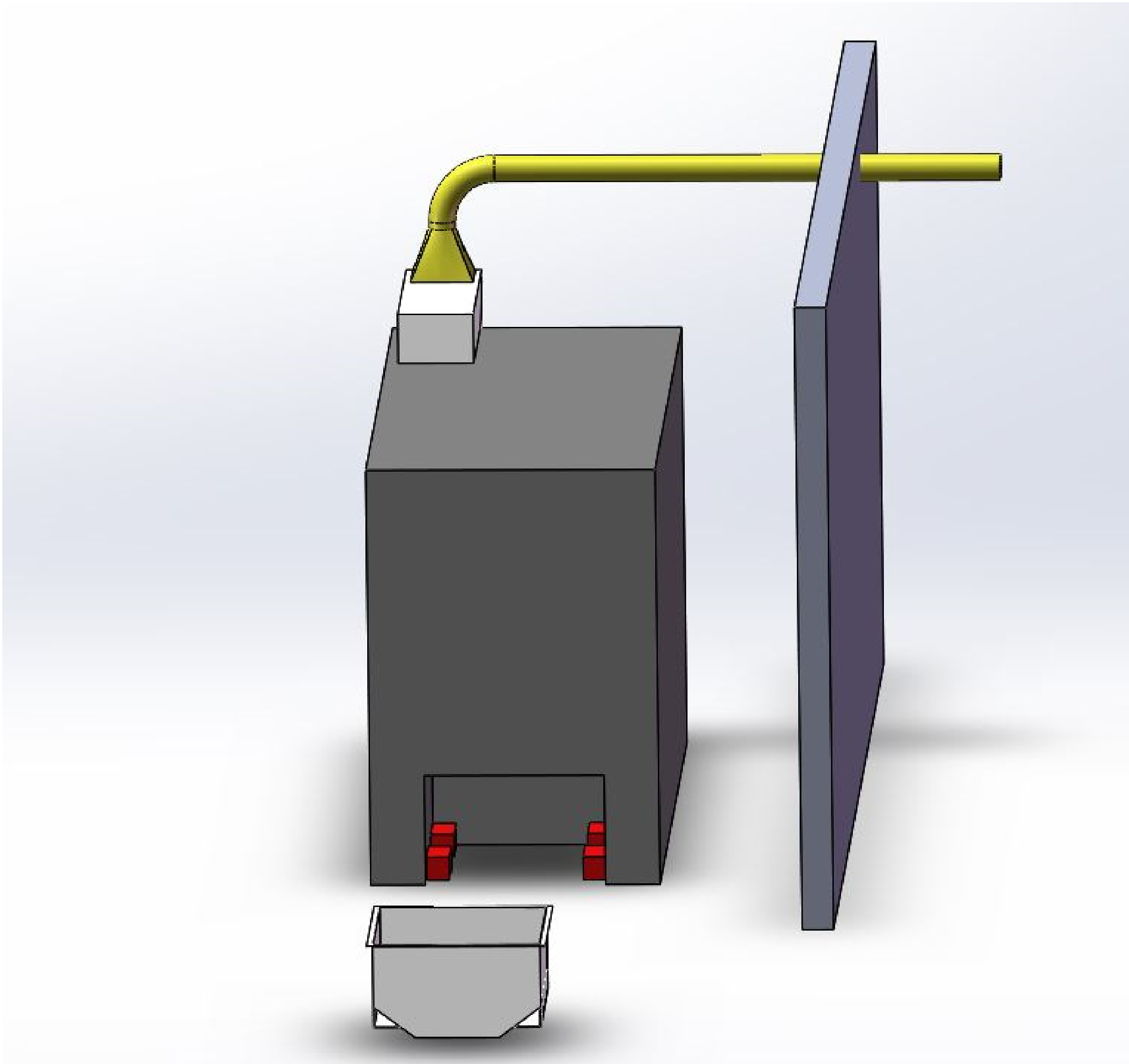

Figure 20. Upper vent duct extension.

Figure 21 is a photo of the dust collection unit as is in the current state. The vent extension path is free and clear of any obstruction, the outside of the exterior wall is also clear. The facility has an overhead crane that must be able to pass over the plasma cutting station, with this vent extension the crane will be able to do so. Ducting supports will be fastened to the collection system and to the exterior wall. Duct sizing and determining exact duct support locations was not included in the scope as Russel Metals indicated they would prefer to take care of that.

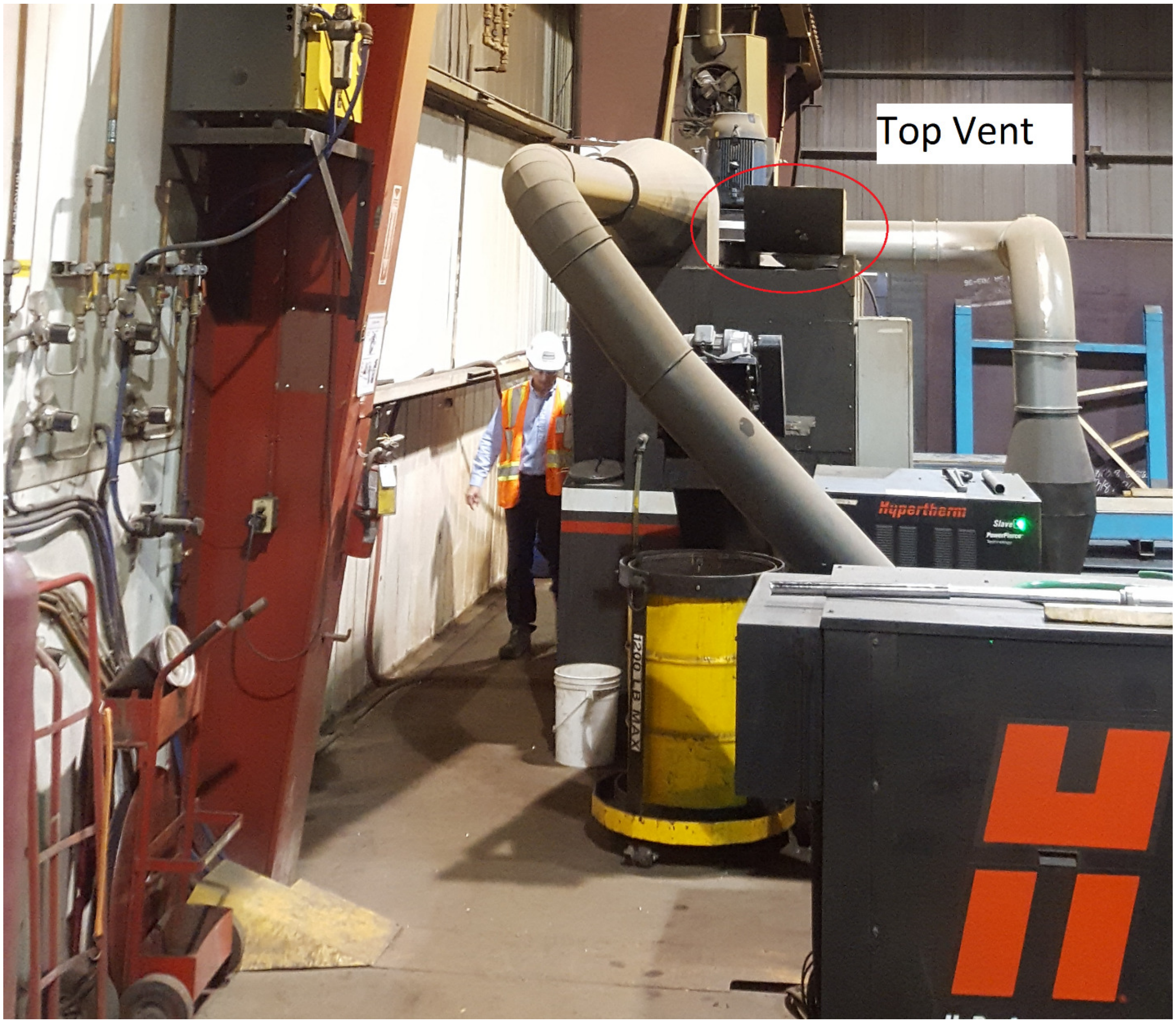

Figure 21. Photo of plasma cutter dust collection unit's top vent in its current configuration at Russel Metals.

2.5. Intended Phases of Installation

Implementation of automation is recommended to be done in two phases. Breaking the installation into two phases will allow Russel Metals to handle the installation of the automation design as two smaller, more quickly finished, and less costly projects. With each phase, benefits are attained and components installed are utilized in the next phase.

2.5.1 Phase One – Bin Sealing and Top Vent

For phase one, of automation implementation, the immanent problem of dust loss from the bin seal and fume plus dust loss from the top vent are dealt with. This is done by installing the bin sealing components of section 2.2 and the top vent modifications of section 2.4. Once installed

Russel Metals will gain improved shop cleanliness, air quality and a powered bin sealing mechanism. Thereby, increasing worker's safety and comfort while reducing strain associated the original equipment's manually actuated bin sealing mechanism. The resulting set up is shown in Figure 22

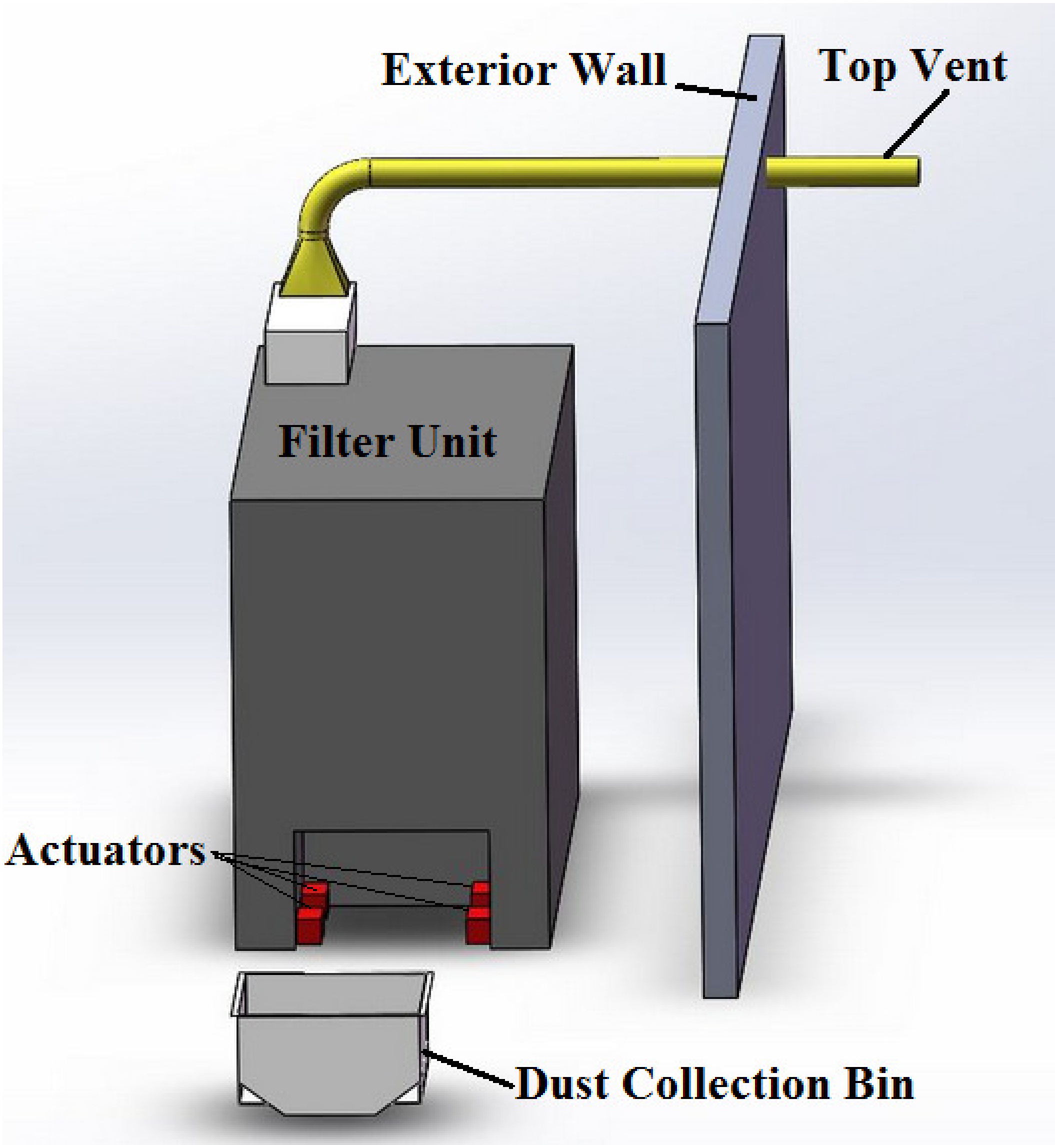

Figure 22. Phase one implementation

2.5.2 Phase Two –Transfer and Disposal

For phase two, components needed to complete automation of transferring and disposal of the collected dust are installed. This is accomplished by installing the transfer and disposal components outlined in section 2.3. Once these components are installed implementation of automation is complete and its full benefits are realized. All benefits of phase one are maintained and dust contamination associated with handling of the original equipment's dust collection bin is eliminated.

As part of phase two the original equipment collection bin (still being utilized after phase one) is placed into storage and interchanged with the hopper required to utilize the screw conveyor. In the event of a breakdown in the screw conveyor or rotary airlock valve the hopper can be removed and the original equipment's collection bin reinstalled and used. This will minimize downtime if a breakdown occurs and allow production to continue while the system is repaired.

2.6. Bill of Materials

In our final design, automation, the bill of materials (BOM) will include the all the primary parts from the three sections addressed, the filter unit's bin seal, transfer and disposal and top vent.

TABLE I
BOM FOR THE FINAL DESIGN (PURCHASED PARTS)

Item Number	Components	Quantity
1	Pleated Rubber Seal	1
2	Linear Pneumatic Actuators	4
3	Actuator Controller System	1
4	Screw conveyor and motor assembly	1
5	Rotary airlock valve and motor assembly	1
6	Screw Conveyor and Airlock Controller	1
7	Clear acrylic sheets	5
8	Flexible Hose	1
9	6" to 2" Hose Adaptor	1
10	55-gallon Drum	1
11	10' of 5" ducting	1
12	5" 90° elbow duct	1
13	5" Duct connectors	3

TABLE II
BOM FOR THE FINAL DESIGN (FABRICATED PARTS)

Item Number	Components	Raw materials	Quantity	
14	New designed hopper - body	Steel sheet metal – Gauge 13	8.69	Square feet
15	New designed hopper - flange and motor mounting plates	Steel sheet metal – Gauge 10	7.8	Square feet
16	Support structure	SQUARE H.S.S. 1 inch x1 inch	600	Inches in length
17	Support structure	Steel sheet metal – Gauge 10	1	Square feet
18	Custom adaptor connecting square vent to 5" duct	Sheet metal – Gauge 30	TBD	TBD

2.7. Cost of the Final Design

The cost estimate of our final design includes only off the shelf parts cost. The estimated costs for purchased parts are listed in TABLE III, the quote for the screw conveyor and rotary airlock can be found in appendix F.

TABLE III
PURCHASED PARTS COST

Components	Estimated cost ($)
Screw conveyor and motor assembly	7237
Rotary airlock valve and motor assembly	3226
Pneumatic Linear Actuator (x4)	2000 [11]
Ducting	200 [12]
Clear acrylic sheets	600 [13]
Flexible Hose and connections	50 [14]
55-gallon Drum	30 [15]
Butyl sealing material	15 [16]
Total:	$13,358.00

The installation cost and fabrication cost were not calculated by us as the necessary information for this could not be retrieved. Russel Metals will perform fabrication and installation of the solution components as they have an internal maintenance department capable of performing the installation and metal parts can be fabricated in house, the cost of this will be evaluated by Russel Metals. Therefore, the cost of the final design is $13,358.00, not including labour and in house fabrication.

3. Conclusion

As previously stated in the project needs section our design objectives were to: reduce the machine downtime, make sure that the plasma dust is contained during the operation of the machine, increase workers' safety, make sure the footprint of the machine is not increased, keep shop cleanliness maintained during daily operations and to make sure our solution has long tem sustainability. Our final recommended design, automation, has met these six project needs by providing solutions to the three problem areas: the bin seal, transfer and disposal and the top vent, established in the problem breakdown section.

The new bin sealing method has three main parts: the seal, bin lifting and locking mechanism and the lifting control. The new butyl rubber seal material provides a consistent seal and will have a long lifetime. The pneumatic lifting and locking mechanism ensures that the collection bin, with the new seal fitted, is lifted and pressed against the filter unit with adequate and evenly applied pressure around the sealing surface. The lifting control logic provides a means of controlling the lifting mechanism while ensuring that controls are not accidentally actuated. These three parts together form the bin sealing method and meets two of the needs of Russel Metals, dust containment and increased worker safety. Dust is contained; and shop contamination and worker exposure to dust lost from the bin seal is eliminated. The lifting and locking mechanism, combined with the logic behind its control, provides increased worker safety. Workers are no longer required to manually actuate a lever style lift (positioned near the ground) reducing the likely hood of back strain and accidental or unintended actuation of the controls are avoided.

The transfer and disposal section of our automation design has five main parts: the hopper, screw conveyor, rotary airlock valve, screw conveyor and rotary airlock controller, and the disposal drum. The hopper is interchangeable with the current filter unit's collection bin and funnels collected dust down into the screw conveyor. The screw conveyor transports the dust outside where it is transferred through the rotary airlock valve and into the 55-gallon disposal bin. The controller automatically runs the screw conveyor and rotary airlock valve as needed to remove dust from the hopper and will stop the system is the disposal drum becomes full. The controller also allows for the screw conveyor and rotary airlock valve to be stopped when the plasma cutter is running. This allows the 55-gallon disposal bin to be emptied or replaced. The system meets several of the clients needs and provides many benefits.

All of the needs of the client are met by the transfer and disposal section of the automation system. By including the rotary airlock valve and controller, the plasma cutter's downtime associated with the current method of transferring and disposing of collected dust is eliminated. This is because the rotary valve and screw conveyor can be turned off, making it possible for the 55-gallon disposal drum to be emptied or replaced while the plasma cutter and its filter unit continue to run. The controller also cycles the screw conveyor and rotary airlock on and off as needed extending its useful life. The automation solution was also designed so that all parts will be sealed, ensuring that plasma dust is contained during the operation of the plasma cutter. By fully containing the dust worker health and safety along with cleanliness is increased within the shop. The screw conveyor itself has also been arranged such that it will travel through the side of the filter unit and directly through the wall of the shop. Since the space between the filter unit and wall is not usable, the current footprint of the machine is maintained.

The last section of the automation design is the top vent. It comprises of one main component; an extended exhaust vent which is routed outdoors through the exterior wall. Routing the top vent outside eliminates the final source of dust contamination in the shop and prevents air streams leaving the vent from further stirring dust within the shop.

One need of Russel Metals was to not increase the footprint of the plasma cutters filter unit. A further benefit to Russel Metals could be gained by decreasing the footprint. During concept selection the client expressed some interest in moving the entire dust collection system outside of the Russel Metals building, this concept was called isolation. If Russel Metals should decide they would like to further reduce the footprint of the plasma cutter filter unit in the future, we recommend they precede with a final phase of relocating the filter unit outside of the shop. A rough concept for isolation can be found in Appendix E.

The final design, automation, has proven to have many benefits to Russel Metals. The main benefit to Russel Metals is the automation of the transportation and disposal of the plasma dust. Workers will no longer have to come into direct contact and handle the plasma cutter dust. Disposal of the final 55-gallon disposal drum is a one step process. Our system also utilizes a large 55-gallon drum as a waste holding receptacle for the dust which is significantly larger than the capacity of the previous system. The increased capacity of the 55-gallon drum will allow Russel Metals to dispose of and deal with the plasma dust far less frequently, therefore decreasing the overall amount of man hours put towards disposing collected dust. Our design has also increased the number of points of contact of the bin seal from two to four by using actuators to lift the bin into place which will be more reliable than manually lifting the bin into place. Using actuators will also reduce stress on the workers by reducing their work load and their ergonomic strain by decreasing repeated movements associated with disposal of the plasma dust. The type of seal was also upgraded to a butyl rubber seal, eliminating dust loss during operation of the machine and increasing the shop cleanliness. Another benefit from our design is the system will be easy to use since as stated there will be minimal human input.

The automation design meets the needs set by the client. By creating separated installation phases for the design there is an increased likely hood of a timely adaptation of components which will provide immediate benefits to Russel Metals and its employees.

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APPENDIX A

CONCEPT GENERATION AND DEVELOPMENT

Table of Contents

List of Figures

A-1. Concept Development

In this section, the steps taken to develop concepts for screening and scoring are covered. After meeting with Russel Metals, the team brainstormed ideas for three problem areas: filter unit bin, transfer and disposal, and the top vent. Ideas generated were then researched to see if any existing or competitor products already exist. Research of competitive products is covered under the Competitive Products section. Research was also done into the types of products and patents available which could be used within the design of any concepts. Results of this research are covered in the Functional Categories section. At this stage the research was complete, concepts which could be combined were combined and a full list of all concepts to be screened was generated.

A-1.1. Brainstorming

In this section the concepts that were generated internally through individual and group brainstorming sessions are presented and briefly discussed. Each section covers one the problem areas and all generated concepts related to it. The concepts generated here are then investigated by performing research on existing products and patents which are similar in nature or can perform the same function.

A-1.1.1 Filter Unit and Bin Seal

Dust losses from the filter unit's collection bin area have been identified as being caused by a poor seal between the mating surfaces of the collection bin and filter unit housing. Presented here are several concepts which are potential solutions to this problem.

Concept 1: Raising Bin Lip Seal

This concept builds on the existing equipment and set up by integrating a newly designed lip seal for the existing collection bin. The new lip seal would provide a better quality seal when the dust collection bin has been reinstalled and locked into its raised and sealed position. The sealing material would be chosen to have an extended service life or simple and cheap renewability. Shown in Figure A-1 is the sketch generated to illustrate this concept.

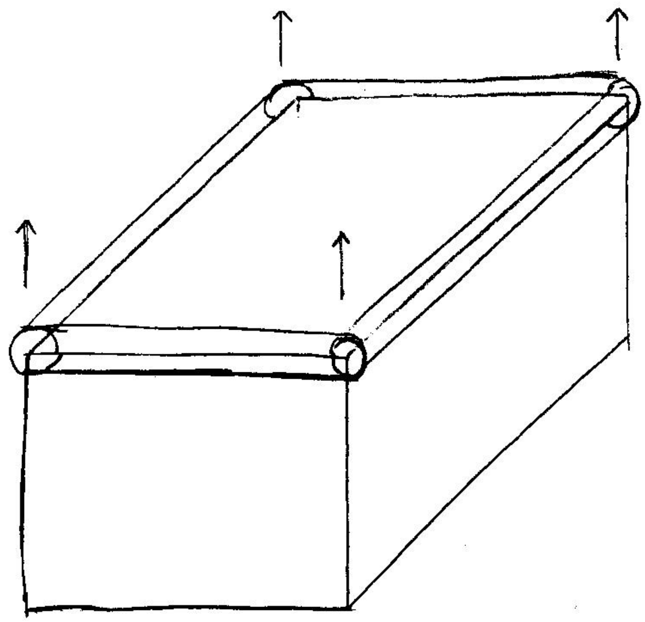

Figure A-1.Raising bin with lip seal sketch

Concept 2: Bin Lowering Cover Seal

This concept, shown in Figure A-2, illustrates a new method to seal the bin. This new design is a better design which is utilized within Russel Metal's other shop equipment. The collection bin will no longer rise to form a seal with the filter unit housing. Instead the sealing element is lowered onto the collection bin. This concept would be an improvement over the existing filter unit bin's raising mechanism which tends to park the bin in an un-level position, leading to poor sealing. Figure A-2, shows a sketch of the general concept. The lowering and sealing element could be designed to further funnel particulates into the bin, have a friction fit overlapping lip seal, have a rubberized seal or be a rubberized accordion type bellows.

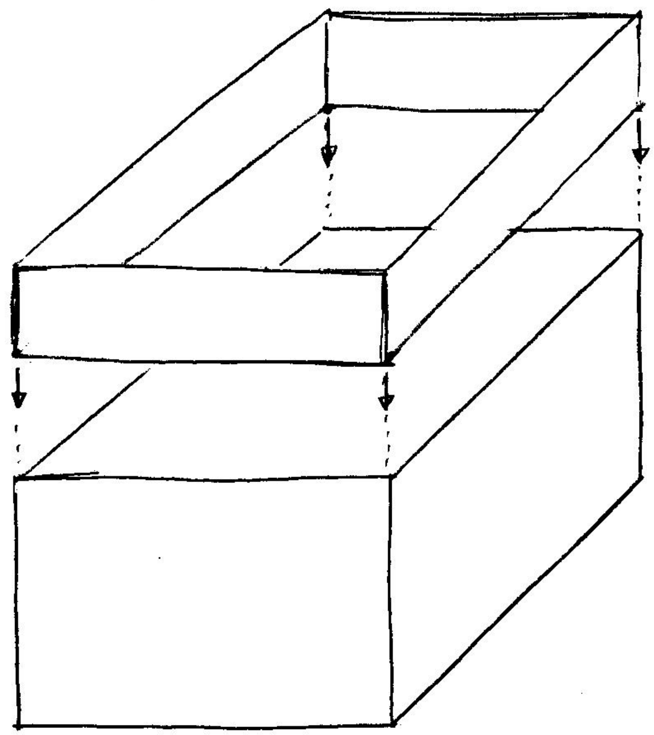

Figure A-2. Lowering seal concept sketch

Concept 3: Hopper with Extended Bracket

A modified hopper with extended bracket, shown in Figure A-3, will be installed on top of the dust collection bin. The extended bracket will slide into the dust bin until seated against the stopper. By using this type of hopper, the seal will be eliminated.

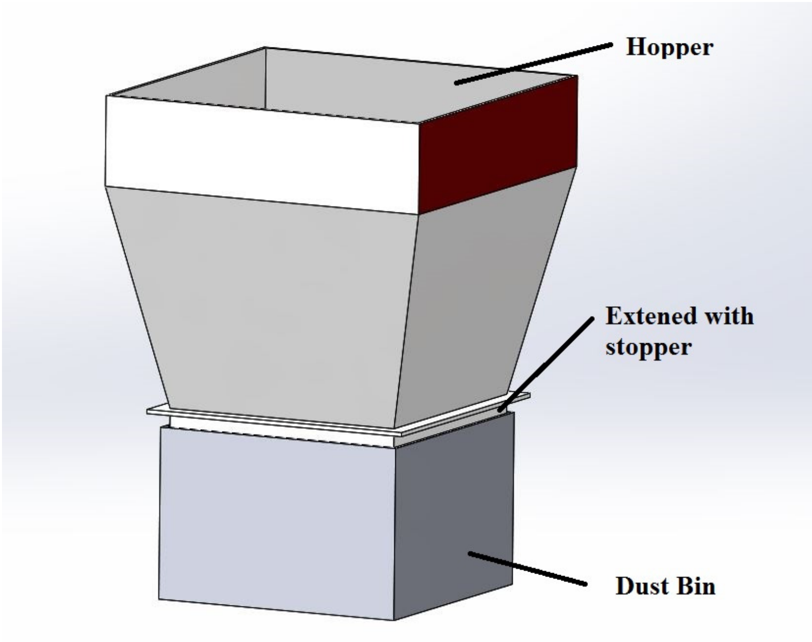

Figure A-3. Hopper with extended bracket concept

Concept 4: Twist Locking Mechanism

The twist locking mechanism will consist of two components, four pins and a cylinder bucket with four “L,” shaped cut-outs. These two components form a twist lock, as showing in Figure A-4. The seal between the hopper and bin will not be used in this concept.

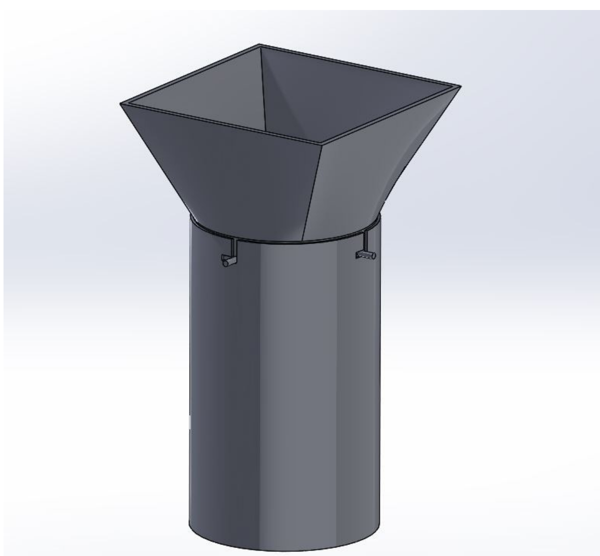

Figure A-4. Twist lock mechanism concept

Concept 5: Raised Filter Unit with Increased Capacity

The raised machine concept, shown in Figure A-5, takes the existing equipment and raises it higher in order to allow a larger dust collection container and sealing system to be installed. Drums, bins, and bags are all possible options for new collection containers. The two primary benefits to this design are: a reduction in frequency of emptying the collection bin and the possibility of having the collection bin also act as the final waste bin. This would remove the need to transfer the collected dust from the container to a secondary waste bins or bags for final disposal. In this way, this design helps to decrease downtime.

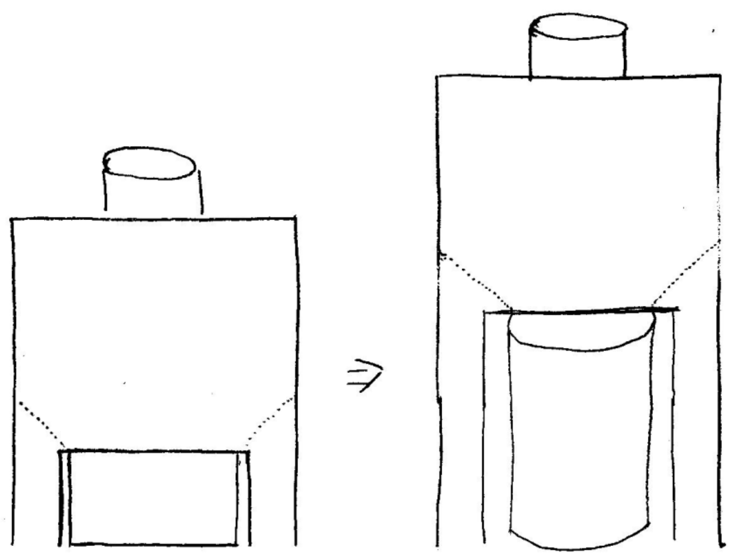

Figure A-5. Raised filter unit with increased capacity concept

Concept 6: Relocate Filter Unit to Exterior of Building (Isolation)

In this concept the filter and collection bin are relocated to be outside of the shop. This concept will provide a number of benefits including: a reduction in airborne particulates within the shop, additional workspace within the shop (decreased footprint), a quieter working environment indoors, and collected dust will no longer need to be transported outside for disposal. Figure A-6 depicts how the filter unit has been moved outside of Russel Metal’s warehouse and shop.

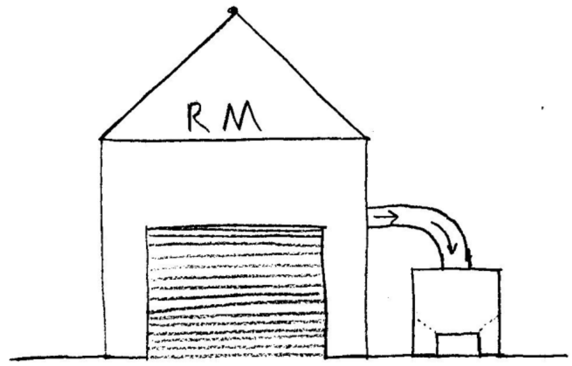

Figure A-6. Relocation of filter unit concept

A-1.1.2 Transfer and Disposal

Concept 1: Automated System

The automated system concept, shown in Figure A-7, entails installing a mechanism capable of transporting the filtered dust directly into a collection location without any human interaction with the dust. The reduction in handling steps removes potential exposure to dust, increasing worker safety. The system could implement several different types of conveyor systems or a vacuum system that could effectively transport dust into a storage location where the dust could be safely disposed. Two conveyor types that could be used for this project are the screw or belt conveyor. It is assumed that the automated system would incorporate a larger collection bin.

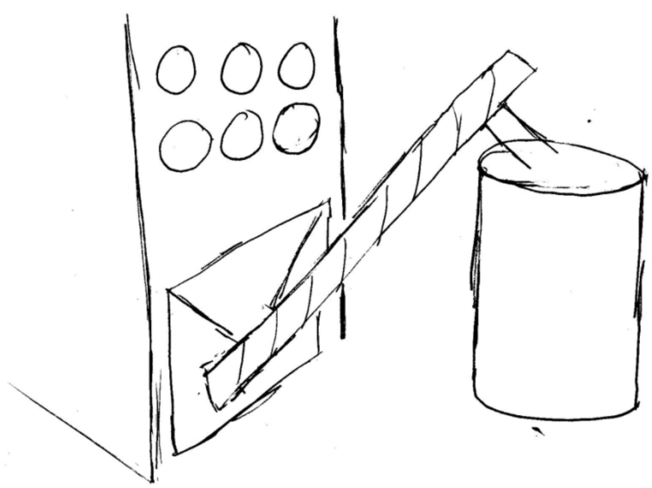

Figure A-7. Transfer automation concept

Concept 2: Hole in the Bottom of the Bin

This concept incorporates a hole in the bottom of the bin, as shown in Figure A-8. The design plans to change the disposal bin so it can be mounted onto a drum, then once mounted, a hole in the bottom of the bin could be opened and the dust will fall into the drum. The drum will have a bag placed in before the bin is mounted on top. This will allow for easy disposal of the dust. The only part of the system that will need to be changed is the disposal bin. The team will need to add a mounting system onto the drum and a hole that can be easily opened and closed for the removal of the dust. One drawback of this concept could be when the dust drops into the drum. Dust may blow back into the air and contaminate the work space; to solve this we could implement a cover for the disposal bin.

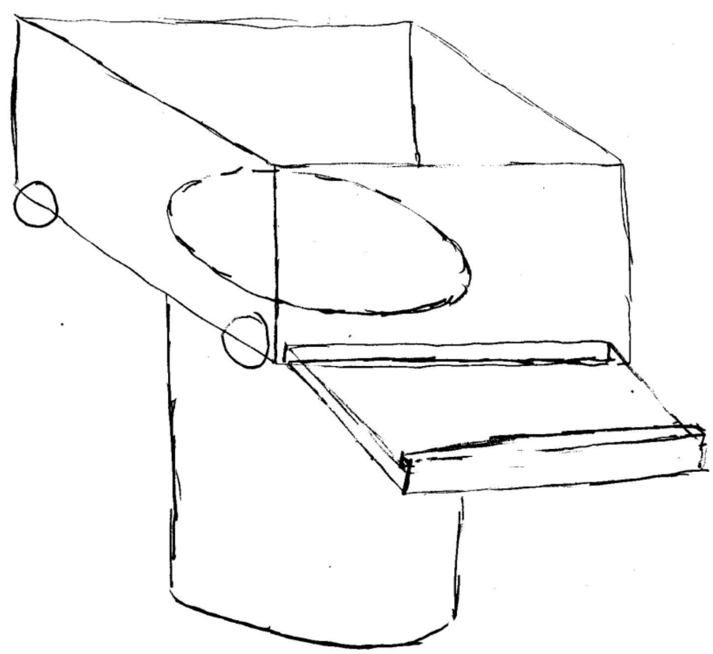

Figure A-8.Hole in the bottom of bin concept

Concept 3: Disposal Bin Lid

For the "disposal bin lid" concept we plan to add a lid to the disposal bin for transportation. This will reduce the amount of dust contamination during transport. Another added bonus of this concept is Russel Metals will no longer need to use the crane to transport the disposal bin; they can simply push the bin to the desired location.

Concept 4: Vacuum System

The vacuum system concept, shown in Figure A-9, will remove the disposal bin at the machine. The design completes this by implementing a system for sucking the dust from the machine to another storage location. This concept will not need any human interaction until the storage location is full and will only require the changing of disposal bags.

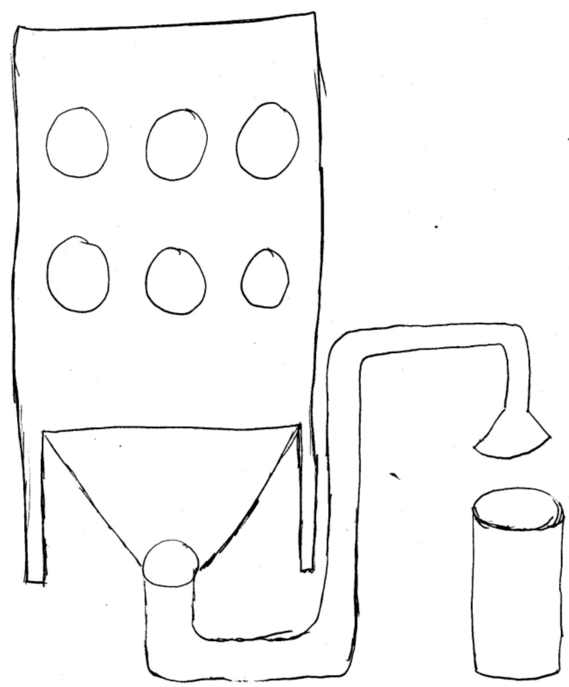

Figure A-9. Vacuum system concept

Concept 5: Disposal Room

The disposal room concept is to build a room for the dust disposal process so there will be less contamination. If the dust disposal was done in a sealed room the dust would be less likely to contaminate the working space of the other employees, but the workers disposing of the dust would still need to wear full personal protective equipment. Another advantage of this idea would be that the climate would not impede the disposal of the dust.

Concept 6: Automated Dumping/ Tipper

The automated dumping/tipper concept, shown in Figure A-10, is a device that will tip the disposal bin contents into a drum. The drum will have a bag inside so the dust can be easily thrown away. The tipper will require housing for when the bin is being tipped so dust will not contaminate the work environment. For this concept the current bin can be used or a modified bin.

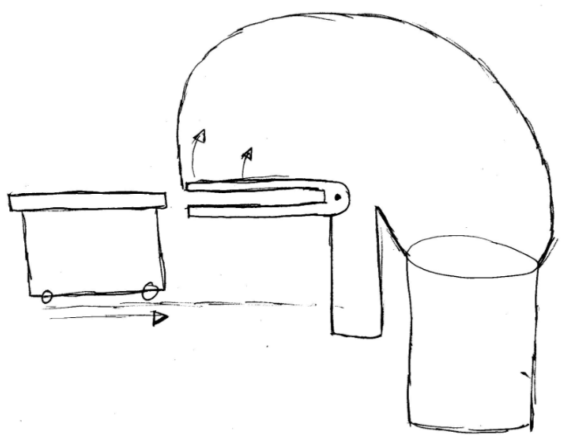

Figure A-10. Automated tipper concept

Concept 7: Crank Case

The crank case concept, shown in Figure A-11, uses the current dust collection bin's four partitioned sections. The idea is to build a mount on top of a drum so you can place the individual partitioned sections inside. A door will then be closed on the housing and a crank will be turned which will upend the smaller dust bin into the drum and bag. The process will be repeated three more times to complete the dust disposal process. This concept will only need the building and designing of the crank case to make this a viable design.

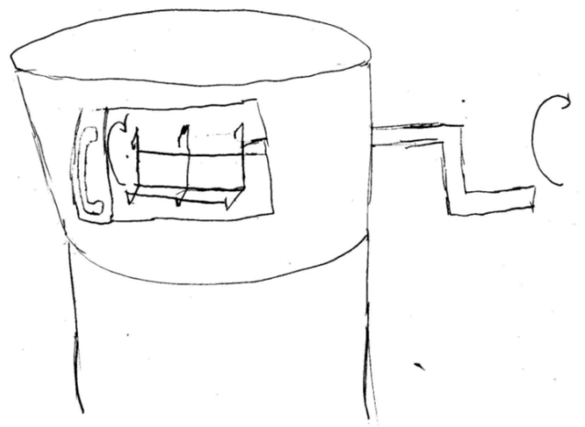

Figure A-11. Crankcase design concept

A-1.1.3 Top Vent

Concept 1: Outside venting

This idea would continue the vent from up top directly to the outside, at which point a filtration or collection system could be fitted on the exhaust if required. There is a potential problem that could block this concept; if routing a vent through the exterior wall requires an update of the entire facility to current building codes then it is no longer worth pursuing. Figure A-12 shows a sketch of this idea.

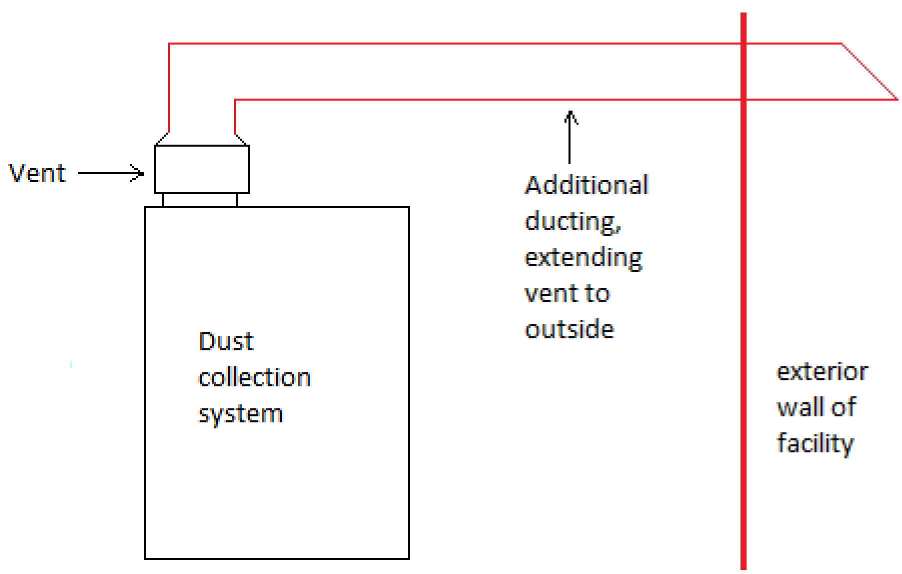

Figure A-12. Outside venting concept

Concept 2: Exhaust Vent Filter

The exhaust vent filter concept involves designing a filter system at the top vent opening to capture the dust that is escaping through this opening. The team hypothesizes that the particles shooting out the top must be miniscule meaning that a filter or collection system must be capable of handling particles of this size. Filters already exist for this purpose, developing this concept would entail choosing an off the shelf filter and designing a structure that can mount to the top vent and holds the filter. The proposed location of this concept is shown below in Figure A-13.

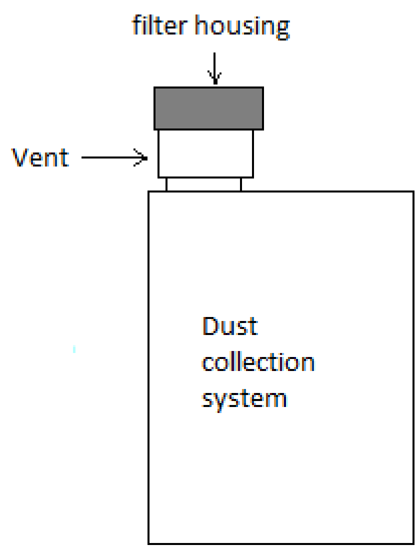

Figure A-13. Exhaust vent filter concept

Concept 3: Separation of Collection Systems

The separation of collection systems concept aims to solve the issue of dust escaping the top vent by separating the wet and dry halves of the dust collection systems. The top vent is part of the wet (drilling) particulate collection system, however the current system has both wet and dry sides connected allowing dust to escape through the wet venting. An off the shelf solution of this concept exists and is discussed in the next section.

A-1.2. Functional Categories

Research was done into the types of components and patents available which could be used within the design of any of the concepts. The results of this research are presented here.

A-1.2.1 Arrangement for Dustless Waste Bin Emptier

In the automated tipper concpet a dustless tipper would be used to prevent dust comtamination of the work space while transferring the dust from the disposal bin to waste bins and bags. This type of system will help seal the dust into the waste bags and bins reducing the amount of contamination to the area.

In patent US2696315, shown in Figure A-14, the sealing system which utilizes a spring loaded door to the waste bin will automatically close once the bin has been removed from the system. The automatic closing of the door traps all the dust inside the waste area. This patent does not describe the tipping system needed to tip the bin which our team will need to design. The patent also describes how the mounting system will work with the system but there is a drawback to this design. The lid of the bin may be caught up in the housing of the device which when undocking could lead to the destruction of either the system or the bin lid.

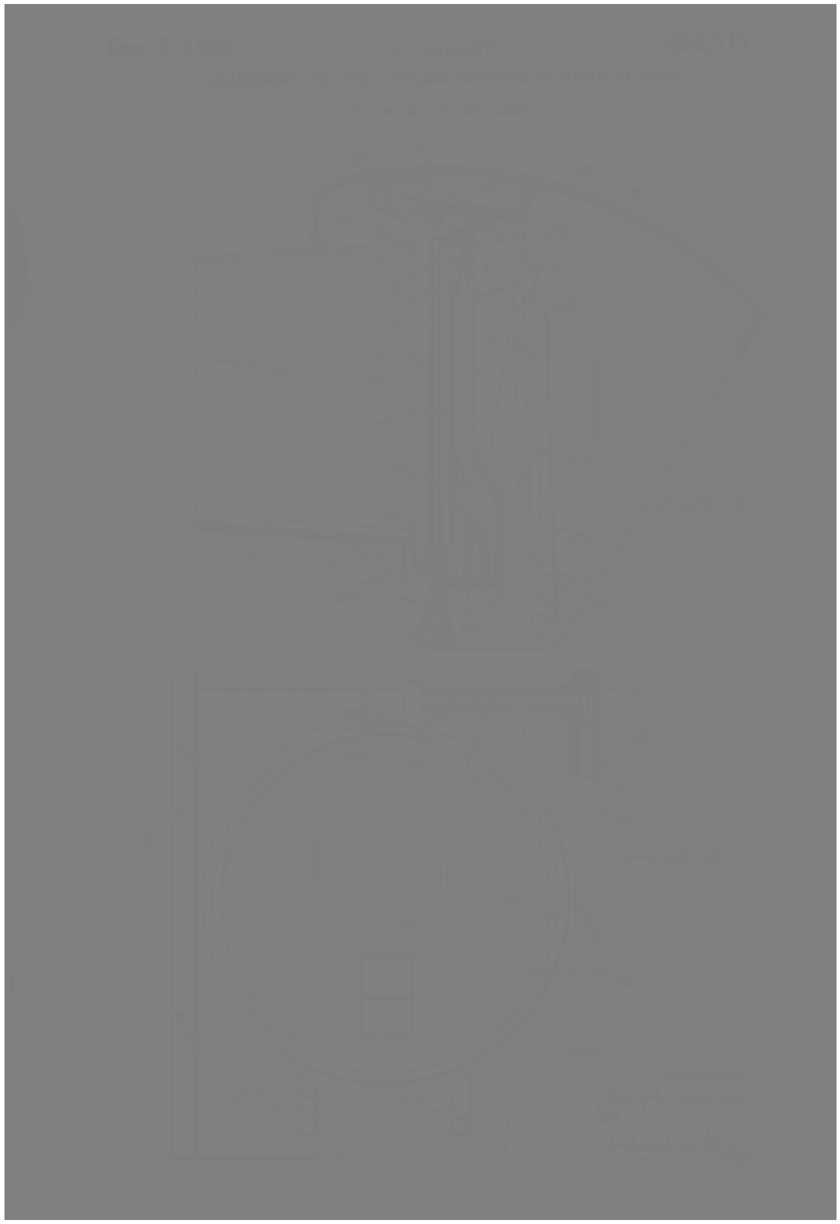

Figure A-14. Drawing for sealing of dust into the disposal drum [1].

A-1.2.2 Bin Tipper

In this concept for an automated tipper an off the shelf product is used. One such product from Simpro is shown in Figure A-15. It is a standard automated tipper. The problem with many of the automated tippers on the market is that they do not seal the disposal process which would not be viable for Russel Metals due to the dust that would contaminate the area if a similar system was used. The concept may be implemented if the filter unit is modified to use a larger bin, which would require the use of a product such as the Simpro bin tipper to ease emptying.

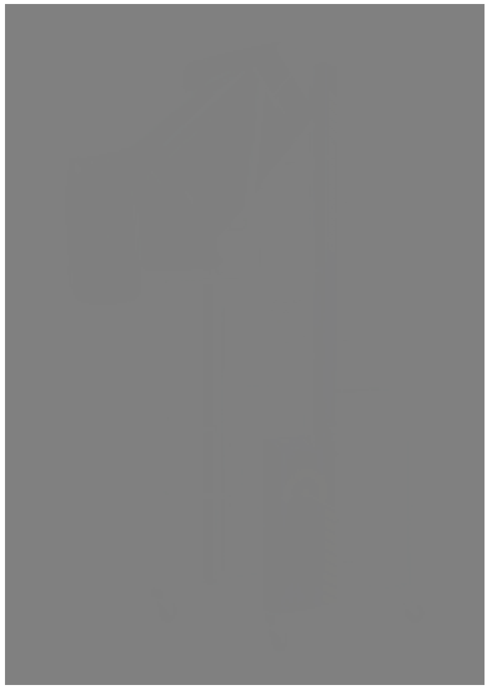

Figure A-15. Simpro bin tipper [2].

A-1.2.3 Device for Automated Dustless Waste Bin Emptying

In some concepts an automated tipper would be used to prevent human interaction with the dust while transferring from the disposal bin to waste bins and bags. This new system would eliminate the need for human interaction with the dust, but it would increase the maintenance cost due to fixes for the machine and the modification of the disposal bin.

In patent US1647829, shown in Figure A-16, the device for emptying bins into garbage collecting receptacles in a dust proof manner which utilizes a bin with a flap-cover to transport refuse into a closed off garbage receptacle with no dust escaping. The patent also has a system from mating the covers of both the bin and the garbage receptacle so they do not get in the way when the tipping occurs, both hoods are horizontal during the dumping process. The idea is there is a plate inside the hood that will keep the lids locked in location. The plate also helps with sealing the hood so there is no dust contamination.

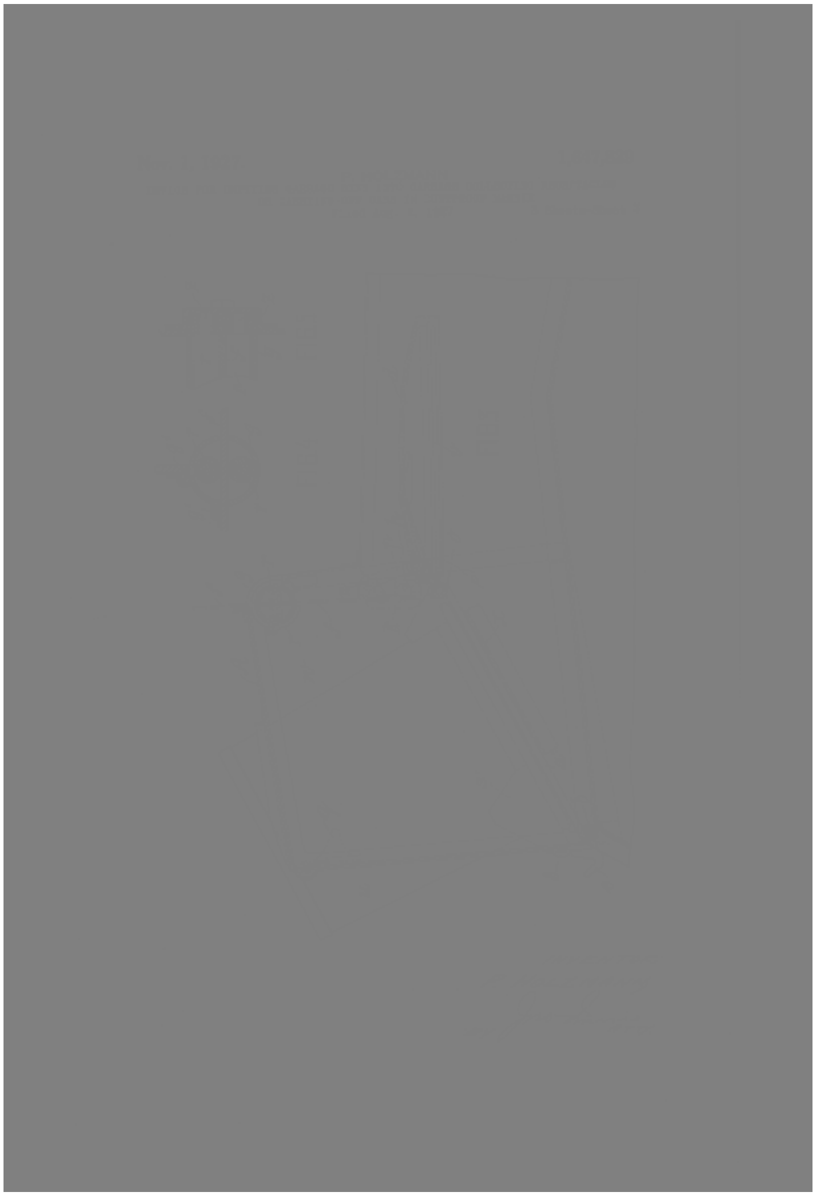

Figure A-16. Automated dustless waste bin emptying device [3].

A-1.2.4 Dust Bin Seal

One option for an improved dust bin seal for the filtration unit is a pleated accordion style seal, shown in Figure A-17. It could easily be integrated into the current filtration unit to provide a more pliant and accommodating sealing surface. The bellows could be configured to work with the raising bin or lowering seal configurations and concepts discussed in section 2.1.1.The seal can be made from multiple materials such as leather, rubber, canvas or silicone [4] to aid in sealing and durability.

Figure A-17. Accordion style bellows, for use as highly compliant seal [4].

A-1.2.5 Rotary Airlock Valve

A Rotary airlock valve, as shown in Figure A-18, will be required under the dust collectors, cyclones, and hoppers. It is designed for continuously feeding pneumatic conveying lines and holding the pressure differences between the inlet and outlet. Therefore, eliminating the metal container will be possible in our design.

Figure A-18. Dust collector series (DCS) rotary airlock valve [5].

A-1.2.6 Dust Container - Disposal bag

By using a big disposal bag instead of the metal dust bin, a larger dust holding capacity will be gained. However, a rotary airlock valve would need to be installed to maintain the pressure differences between the hoppers outlet and the big disposal bag. A wood pallet can be used to hold the disposal bag. In this case, the transportation will be more efficient.

Figure A- 19. Dust bag and rotary airlock valve [6].

A-1.2.7 Dust Disposal

A flexible screw conveyor and hopper, shown in Figure A-20, is designed to convey the bulk materials from low position to high position in horizontally. It will give the opportunity to transfer the bulk material, in our case is metal dust, from the dust bin to another dust container in consciously process.

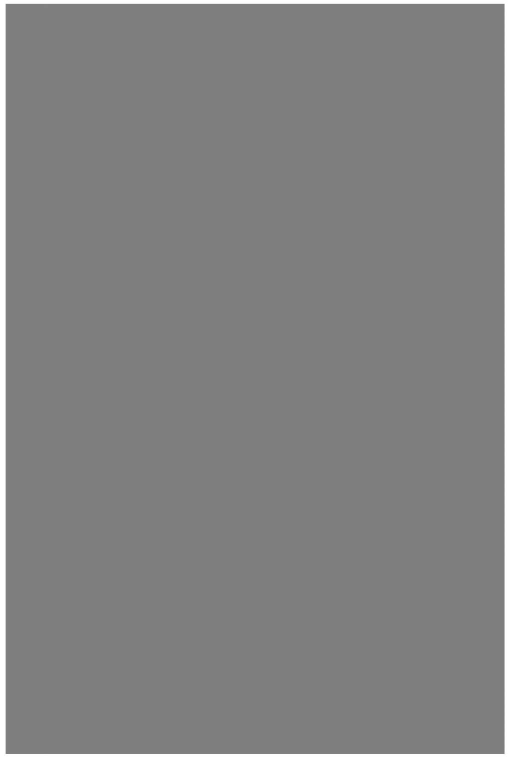

Figure A-20. Flex-screw conveyor and hopper [7].

A-1.2.8 Tubular Drag Conveyors

A tubular drag conveyor, shown in Figure A-21, is another way to convey the delicate material from one location to a different location with totally enclosed, dust-free, contamination-free handing. It can be designed to transfer materials from single in-feed points to single or multiple discharge points over long distances.

Figure A-21. Tubular drag conveyor [8].

A-1.2.9 Cyclone Particulate Separator and Vacuum System

An additional vacuum system could be helpful in developing some concepts. The vacuum system could be used to prevent dust plumes while transferring the filter unit's collected dust to waste bins and bags. Any additional vacuum system would require its own air filtration, media filters are commonly used but they require frequent cartridge maintenance or replacement depending on the design. This would add additional costs and maintenance time.

In patent US3425912, shown in Figure A-22, a multistage cyclone filter which does not utilize a filter cartridge is described. The cyclone filter works off the principals of inertia and centrifugal forces. By forcing air mixed with particulates to swirl around the inside of a cone particulates are forced against the cone walls and are carried by gravity down the cone. Air is then able to travel up a centrally located tube (within the cone), the inertia of the particulates swirling around the cone prevent particulates from taking the sharp and sudden turn to be drawn up the central tube.

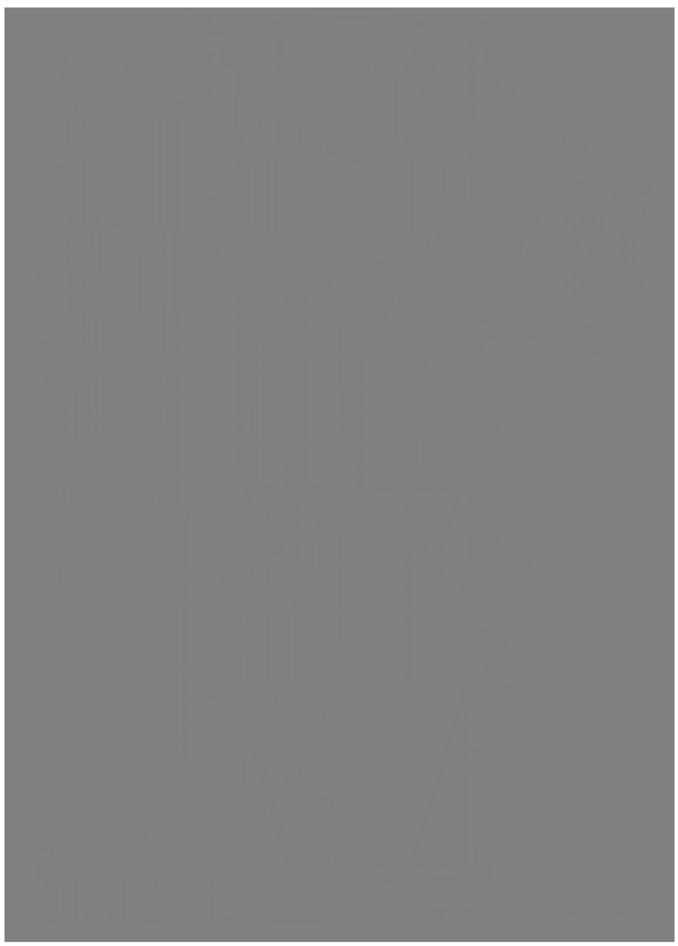

Figure A-22. Patent US3425912, vacuum cleaning system [9].

In Figure A-23, a simplified sketch of patent 3425912, is shown. Air and dust particulates enter at stage one, and are forced to swirl around the first cyclone stage, section two. Heavy particulates drop from suspension and end up in section three, the large particulate collector. Lighter particulates and air travel up the central tube to section four where multiple smaller cyclone stages are contained. The lighter particulates are able to drop from suspension in these smaller cyclones and drop into the small particulate collector, section five. Clean air is then drawn up the central tubes of each smaller cyclone to section six where the blower motor is contained. The air is then exhausted to the cap, section seven, and exits around the rim.

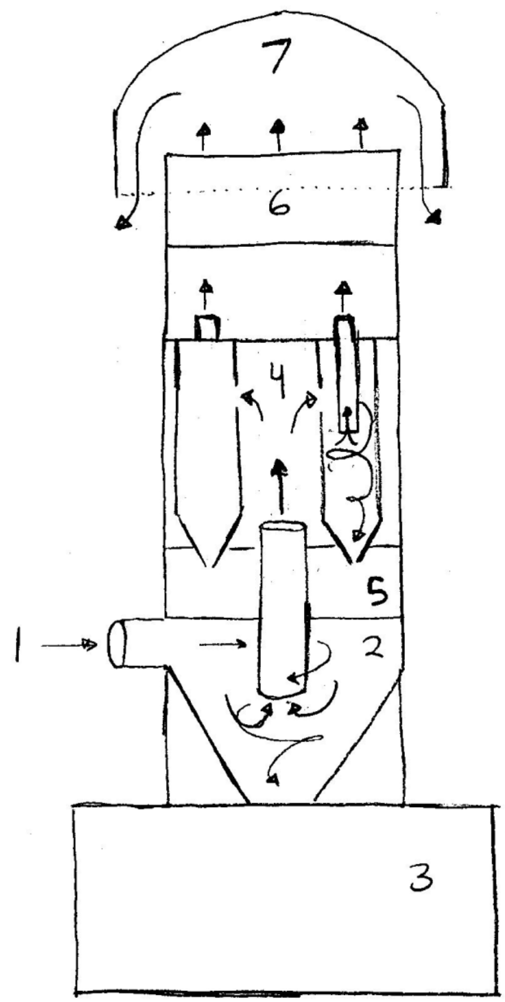

Figure A-23. Patent 3425912, simplified sketch

A-1.3. Competitive Products

In order to evaluate off the shelf solutions for our clients' problem the Conquest Equipment Corporation was contacted. Conquest Equipment is based in Winnipeg and provides filtration products for the fabrication industry. Based on their input, our client's plasma dust collector is two separate filters in one package. One side handles filtering coolant while the other side handles the dry particulates (dust and fumes). In order to radically solve the dust issue, one solution is to divide the dust collector into two separate parts. One for wet particulates (drilling process) and another for the dry (plasma cutter) dust collection. The off the shelf solution proposed by Conquest Equipment is the Donaldson Torit PowerCore TG 60 dust collector, shown in Figure A-24.

Figure A-24. Torit PowerCore TG series dust collectors [10].

This solution would meet the clients need by reducing footprint by 65% compared to the current filter and collection unit but first and foremost by completely eliminating dust contamination as the dust collection in this collector is a fully closed loop from cutting to disposal. [10]

An estimated quote for a new Donaldson Torit PowerCore TG 6 Dust Collector is $35,764. The price breakdown is shown below in Figure A-25. It is also possible to find a used Donaldson

Torit PowerCore TG 6 Dust Collector, buying used is estimated by Conquest Equipment to save about 30% of its original selling price.

Donaldson.
Torit®

Donaldson Company, Inc.
Industrial Air Filtration
PO Box 1299
Minneapolis, MN
55440-1299 U.S.A.

Company:		Quotation #	DCIQ-A34F7-079040
Address:		Date:	10/20/2016
		Project Reference:	
Attention:		Application:	
Phone:		Contaminant:	
Fax:		Temperature:	°F
Email:		Air Flow:	ACFM
		Installation Location:	
		Electrical Requirements	Power Supply: / / Control: / /

We are pleased to recommend the following Donaldson® Torit® equipment:

Description	Unit Price	Qty	Extended Price (USD)
TG6 STANDARD • EXPLOSION PROTECTION RETROFIT NOTICE : The unit configuration quoted may not support the addition of explosion protection systems commonly used when filtering combustible dusts. Before ordering any filtration equipment you must understand the nature of your dust and any fire or explosion protection strategies you intend to incorporate into your filtration equipment. • LITERATURE : Installation and Operation Manuals • LITERATURE : Replacement Parts List • INLET OPTIONS : STANDARD FRONT HIGH • OUTLET EXHAUST OPTIONS : STANDARD TOP OUTLET (INDOORS) • HOPPER OUTLET PACK : 17-GAL DUST CONTAINER • FINISH COAT : STANDARD FINISH • FILTER PACKS : POWERCORE ULTRA-WEB FR (STD) • CONTROL BOX : INTEGRATED TORIT DELTA P PLUS W/ 24VDC START/STOP, FEEDBACK & MOTOR CONTROL • INTEGRATED POWER PACK : 10 HP ALUMINUM WHEEL TEFC NEMA PREMIUM	$33,964.65	1	$33,964.65
		TOTAL:	**$33,964.65**

Lead time: weeks after approval/acceptance

FOB: Origin

Approximate weight: + 600.00 QPS

Freight: + 1,200.00 FREIGHT

$35,764.00

Figure A-25. Quotation for the Donaldson Torit PowerCore TG 6 dust collector at the Conquest Equipment Corporation

A-2. References

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APPENDIX B

ANALYSIS AND SELECTION

Table of Contents

List of Tables

B-1. Concept Analysis and Selection

For the concept analysis section, we began by screening each concept against our selection criteria, then if there were any concepts that could have similar applications or could solve a problem in another concept, the concepts were combined. We then weighted our selection criteria by using a weighting matrix that the team decided on together. The concepts where then scored using the weighted selection criteria. The top two or three concepts were then chosen to be presented to Russel Metals. We have kept the project separated into three distinct areas and the screening and scoring process will be evaluated individually for each section.

For the screening and scoring section we need to weigh our concepts against each other. For our project we came up with 11 selection criteria to evaluate our concept. The following list will explain why we have chosen our selection criteria. We found our criteria from our project needs we have laid out in the introduction section.

1) **Emptying Downtime –**The amount of time the machine will not be operational for the emptying of the dust system.
2) **Capacity or Uptime –**The amount of dust that can be stored before the system has to be changed.
3) **Ease of Operation –**How easy the system is to operate once it has been implemented.
4) **Dust Exposure Points –**The amount of points that may be a problem for dust exposure in the concepts.
5) **Workshop Safety –**The safety of the employees while working with and around the machine.
6) **Footprint –**The amount of floor space that the new design will take up on the shop floor.
7) **Ease of Integration –** How easy the concept is to introduce into the current system.
8) **Capitol Cost –**The amount of money needed upfront to implement the concepts.
9) **Maintenance Time –**The time to fix and maintain the concepts.
10) **Operational Cost –** The cost to make the concept operational, this includes the maintenance cost.
11) **Maintenance Frequency –**How often the concept will need to be fixed and maintained.

1.1. Preliminary Screening

In this section the concepts generated for each problem area, filter unit bin seal, transfer and disposal and top vent are screened. Concepts which pass the screening process were then combined and integrated where possible before continuing to the final scoring and concept selection.

1.1.1 Filter Unit and Bin Seal

For the screening process of the filter unit and bin seal, concept A, indoor lowering seal, was chosen as a reference. Concept A, was chosen to be a reference as this type of bin sealing and filter unit arrangement is used in other equipment contained at the Russel Metal's shop and performs well. The concepts to be screened were generated in section 2.4 and are labelled as follows:

A -Indoor Lowering Seal

B -Indoor Raising Bin

C -Indoor Latch

D -Indoor Lock Ring

E -Outdoor Lowering Seal

F -Outdoor Raising Bin

G -Outdoor Latch

H -Outdoor Lock Ring

I -Raised Lowering Seal

J -Raised with Raising Bin

K -Raised Latch

L -Raised Lock Ring

The results of screening these concepts are shown in Table B-I, contained on the next page.

TABLE B-I
PRELIMINARY SCREENING OF BIN SEALING CONCEPTS

	Concept Variant										
Selection Criteria	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**A Ref.**
Emptying Downtime	0	0	0	+	+	+	+	-	-	-	-	0
Capacity or Uptime	0	0	-	+	+	+	+	+	+	+	+	0
Ease of Operation	0	0	0	0	0	0	-	0	0	0	-	0
Dust Exposure Points	0	0	0	+	+	+	+	0	0	0	0	0
Workshop Safety	0	0	0	+	+	+	+	0	0	0	0	0
Footprint	0	0	0	+	+	+	+	0	0	0	0	0
Ease of Integration	+	0	0	-	-	-	-	-	-	-	-	0
Capitol Cost	+	0	0	-	-	-	-	-	-	-	-	0
Maintenance Time	0	0	0	0	0	0	0	0	0	0	0	0
Operational Cost	0	0	0	-	-	-	-	0	0	0	0	0
Maintenance Freq	-	0	0	0	0	0	0	0	0	0	0	0
Pluses	2	0	0	5	5	5	5	1	1	1	1	0
Sames	8	11	10	3	3	3	2	7	7	7	6	11
Minuses	1	0	1	3	3	3	4	3	3	3	4	0
Net	1	0	-1	2	2	2	1	-2	-2	-2	-3	0
Rank	2	3	4	1	1	1	2	5	5	5	6	0
Continue	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No	Yes

The results from Table B-1 show that multiple concepts scored similarly based on the selection criteria and the plus or minus screening system. It was decided that all concepts which ranked three or higher would proceed to the scoring stage.

1.1.2 Transfer and Disposal

The reference used for the transfer and disposal section is the current transfer and disposal method used. The system includes using the hoist to lift the disposal bin for the machine and move the bin to the door of the warehouse. Next the bin is prepped for unloading by removing steel cross pieces which hold smaller bins in place. The smaller bins are then manually dumped into a drum with a bag inside. The bag is then closed and placed in the garbage receptacle. Table

B-II is the screening process for the transfer and disposal section of our project which you will find below. There will be six concepts that will be screened they are:

M -Hole in The Bottom of the Bin

N -Disposal Bin Lid

O -Vacuum System

P -Disposal Room

Q -Automated Dumping/Tipper

R -Crankcase

TABLE B-II
PRELIMINARY SCREENING OF TRANSFER AND DISPOSAL CONCEPTS

	Concept Variant						
Selection Criteria	**M**	**N**	**O**	**P**	**Q**	**R**	**S Ref.**
Emptying Downtime	+	0	+	+	+	-	0
Collector Capacity or Uptime	0	0	0	0	0	0	0
Ease of Operation	+	+	+	-	+	+	0
Dust Exposure Points	0	+	+	0	-	+	0
Workshop Safety	-	+	+	+	0	+	0
Footprint	-	0	-	-	-	0	0
Ease of Integration	+	+	-	-	+	0	0
Capital Cost	-	-	-	-	-	-	0
Maintenance Time	0	-	+	0	-	0	0
Operational Cost	-	-	-	-	-	-	0
Maintenance Frequency	0	-	0	0	-	0	0
Pluses	3	4	5	2	3	3	0
Sames	4	3	2	4	2	5	11
Minuses	4	4	4	5	6	3	0
Net	-1	0	1	-3	-3	0	0
Rank	2	2	2	3	1	1	1
Continue	no	yes	yes	no	no	yes	no

The concepts that advanced through the screening section of the transfer and disposal concepts were Disposal Bin Lid (N), Vacuum system (O) and Crankcase (R).

1.1.3 Top Vent

The following three concepts relate to solving the top vent issues. They are assigned letters T, U and V. W is the reference concept, it stands for taking no action on the top vent. Table B-III, which follows, contains the preliminary screening results.

S -Reference for Transfer and Disposal

T -Outside Venting

U -Vent Exhaust Filter

V -Separation Of Collection Systems

TABLE B-III
PRELIMINARY SCREENING OF TOP VENT CONCEPTS

	Concept Variant			
Selection Criteria	**T**	**U**	**V**	**W Ref.**
Emptying Downtime	0	0	0	0
Collector Capacity or Uptime	0	-	0	0
Ease of Operation	0	0	0	0
Dust Exposure Points	+	+	+	0
Workshop Safety	+	+	+	0
Footprint	-	-	0	0
Ease of Integration	+	+	-	0
Capitol Cost	-	0	-	0
Maintenance Time	0	-	0	0
Operational Cost	0	-	0	0
Maintenance Frequency	0	-	0	0
Pluses	3	3	2	0
Sames	6	3	7	11
Minuses	2	5	2	0
Net	1	-2	0	0
Rank	1	3	2	2
Continue	yes	yes	yes	

The preliminary screening indicates that concept T is best followed by V. However, the net score of U is only -2 and not significantly low enough to justify cutting it out.

1.2. Weightings

After preliminary screening the selection criteria were given weightings. Each selection criteria was compared directly to another criterion and the more important criteria awarded an additional 0.1 weight. Table B-IV, contains the results of this weighting process.

TABLE B-IV

WEIGHTINGS FOR CRITERIA

		Emptying Downtime	Collector Capacity or Uptime	Ease of Operation	Dust Exposure Points	Workshop Safety	Footprint	Ease of Integration	Capitol Cost	Maint. Time	Operational Cost	Maint. Freq
	Criteria	A	B	C	D	E	F	G	H	I	J	K
A	Emptying Downtime		A	A	D	E	A	A	H	I	J	A
B	Collector Capacity or Uptime			B	D	E	F	B	H	I	J	B
C	Ease of Operation				D	E	F	G	H	I	J	K
D	Dust Exposure Points					E	D	D	H	D	J	D
E	Workshop Safety						E	E	E	E	E	E
F	Footprint							F	H	I	F	F
G	Ease of Integration								H	G	J	G
H	Capitol Cost									H	H	H
I	Maint. Time										J	I
J	Operational Cost											J
K	Maint. Freq											

Total Hits	5	3	0	7	10	5	3	9	5	7	2
Weightings	0.5	0.3	0.0	0.7	1	0.5	0.3	0.9	0.5	0.7	0.2

From Table B-IV, it is seen that the weightings favor cost and safety. Also ease of operation had a weighting of zero and was therefore excluded from scoring.

1.3. Concept Combination

Before final scoring, it was found that the concepts for transfer and disposal could be combined to create more favorable and better scoring concept designs. The results of combining these concepts are discussed below.

The hole in the bottom of the lid (M) and the bin disposal lid (N) were combined to form concept MN. We combined these concepts because the hole in the bottom of the bin had a problem where the dust would blow back when the dust pours into the drum. Adding the Lid will contain the dust inside the bin and the drum and solve the problem with the dust blowing back into the work space.

The crankcase (R) and disposal bin lid (N) concept were combined to form concept RN. These concepts were combined because the crankcase concept does not improve the transportation of the disposal bin. Adding the lid will contain the dust during the transportation of the disposal bin and reduce the contamination of the work space.

1.4. Scoring

Here the final concepts are scored from one to five (five being the best) based on each criteria. The weighting determined in section 3.2, are then applied to each ranking and totaled to give each concept a final score. Based on this analysis the concepts which are to be presented to our clients for selection were chosen.

1.4.1 Filter Unit and Bin Seal Scoring

Shown below in Table B-V, is the weighted scoring for the concepts which passed initial screening. The concepts being scored are:

A -Indoor Lowering Seal
B -Indoor Raising Bin
C -Indoor Latch
E -Outdoor Lowering Seal
F -Outdoor Raising Bin
G -Outdoor Latch
H -Outdoor Lock Ring

TABLE B-V

FILTER UNIT AND BIN SCORING

Selection Criteria	Weighting	Concept Variant													
		A		B		C		E		F		G		H	
		Rating (R)	Weighted Score (WS)	R	WS	R	WS	R	WS	R	WS	R	WS	R	WS
Emptying Downtime	**0.5**	2	1	2	1	2	1	4	2	4	2	4	2	4	2
Capacity or Uptime	**0.3**	3	0.9	3	0.9	3	0.9	4	1.2	4	1.2	4	1.2	4	1.2
Dust Exposure Points	**0.7**	1	0.7	1	0.7	1	0.7	4	2.8	4	2.8	4	2.8	4	2.8
Workshop Safety	**1**	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Footprint	**0.5**	4	2	4	2	4	2	4	2	4	2	4	2	4	2
Ease of Integration	**0.3**	4	1.2	5	1.5	3	0.9	1	0.3	1	0.3	1	0.3	1	0.3
Capitol Cost	**0.9**	4	3.6	5	4.5	4	3.6	1	0.9	1	0.9	1	0.9	1	0.9
Maintenance Time	**0.5**	4	2	5	2.5	4	2	3	1.5	3	1.5	3	1.5	3	1.5
Operational Cost	**0.7**	4	2.8	4	2.8	4	2.8	3	2.1	3	2.1	3	2.1	3	2.1
Maintenance. Freq	**0.2**	4	0.8	3	0.6	4	0.8	3	0.6	2	0.4	3	0.6	4	0.8
	Total Score	18		19.5		17.7		17.4		17.2		17.4		17.6	
	Rank	2		1		3		5		6		5		4	
	Continue ?	Develop		Develop		Develop		No		No		No		No	

From the results of scoring concepts A, B and C the indoor lowering seal, indoor bin raising seal and indoor latch (respectively) were chosen for further development and to present to the client

1.4.2 Dust Transport and Disposal

The scoring processes will use the same reference as the screening process in section 1.1.2, the current system and methods used at Russel Metals. Table B-VI, on the following page, is the scoring process for the transportation and disposal section. There are four concepts that are being scored and they are:

MN - Hole in the bottom of the bin + Disposal Bin Lid

N -Disposal Bin Lid

O -Automated Dumping/Tipper

RN - Crankcase and Disposal Bin Lid

S -Reference

TABLE B-VI
TRANSPORTATION AND DISPOSAL SCORING

		Concepts									
		MN		N		O		RN		S Ref.	
Selection Criteria	Weighting	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Emptying Downtime	0.5	4	2	2	1	5	2.5	3	1.5	3	1.5
Capacity or Uptime	0.3	3	0.9	2	0.6	2	0.6	4	1.2	3	0.9
Dust Exposure Points	0.7	4	2.8	4	2.8	5	3.5	4	2.8	1	0.7
Workshop Safety	1	5	5	3	3	4	4	5	5	2	2
Footprint	0.5	4	2	3	1.5	2	1	4	2	4	2
Ease of Integration	0.3	2	0.6	5	1.5	3	0.9	2	0.6	4	1.2
Capital Cost	0.9	3	2.7	3	2.7	1	0.9	2	1.8	4	3.6
Maintenance Time	0.5	2	1	2	1	3	1.5	2	1	3	1.5
Operational Cost	0.7	2	1.4	3	2.1	2	1.4	2	1.4	4	2.8
Maintenance Frequency	0.2	3	0.6	2	0.4	3	0.6	2	0.4	3	0.6
	Total Score		19		16.6		16.9		17.7		16.8
	Rank		1		3		4		2		4
	Continue ?		Develop		No		No		Develop		No

From the results of Table B-VI, two top rated concepts where chosen to be developed. Through the scoring section concepts MN and RN should be developed for the transportation and disposal section, when compared to the weighted selection criteria

1.4.3 Top Vent

Weighted scoring of the top vent concepts was used to help choose the optimal solution. This scoring can be found below, in Table B-VII. Ratings were determined based on the customer needs and the concepts anticipated performance. For reference the concept titles and their letter codes are shown directly below.

T -Outside Venting

U -Vent Exhaust Filter

V Separation Of Collection Systems

TABLE B-VII
TOP VENT SCORING

		Concepts					
		T		U		V	
Selection Criteria	**Weighting**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Emptying Downtime	**0.5**	3	1.5	3	1.5	3	1.5
Capacity or Uptime	**0.3**	3	0.9	1	0.3	5	1.5
Dust Exposure Points	**0.7**	5	3.5	4	2.8	5	3.5
Workshop Safety	**1**	3	3	3	3	3	3
Footprint	**0.5**	1	0.5	3	1.5	1	0.5
Ease of Integration	**0.3**	2	0.6	3	0.9	1	0.3
Capitol Cost	**0.9**	2	1.8	4	3.6	1	0.9
Maintenance Time	**0.5**	3	1.5	1	0.5	5	2.5
Operational Cost	**0.7**	4	2.8	2	1.4	4	2.8
Maintenance Freq	**0.2**	3	0.6	1	0.2	4	0.8
	Total score	16.7		15.7		17.3	
	Rank	2		3		1	
	Continue?	Develop		No		Develop	

Scoring indicates that concepts T and V are the best options for Russel Metals; therefore these two will be further developed and presented to the customer.

1.5. Concept Selection

The problem has been divided into three sections by the team; the dust bin, the transfer and disposal of dust process, and the top vent. This was done because each of these sections are causing dust contamination in their own unique way. Solution concepts where evaluated for each of these sections, the top scoring concepts are summarized in Table B-VIII.

TABLE B-VIII
SUMMARY OF TOP SCORING CONCEPTS

System Component	Highest Scoring Concept	2nd highest Scoring Concept	3rd highest Scoring Concept
Dust Bin	Raising Bin Seal	Lowering Seal	Latch
Transfer and Disposal dust process	Bin Drain Port and Lid	Drum Dumping Lid (Crankcase)	N/A
Top Vent	Separation Of Collection Systems	Outside Venting	N/A

After scoring all concepts we proceeded to contact our client's at Russel Metals and arranged to discuss which concepts they would like further developed. During this meeting it was found that some of the highest scoring concepts would be preferred while interest was also expressed in some earlier brainstormed and researched concepts.

The main final selected concept was a system that was named, Automation. The raising bin seal concept was chosen to solve the problem of dust escaping the collection bin area. While the transfer and disposal process would be carried out by a screw conveyor (as seen in Appendix A-1.2.7) system. The screw conveyor would transport the plasma cutter dust from the bin area and through the exterior wall of the Russel Metals shop where the dust would be funnelled into the final waste collection bins. For the top vent it was chosen to proceed with the outside venting concept.

There was also interest expressed in one of the very early brainstormed concepts, moving the entire filter unit outside of the Russel Metals shop. Originally screened out due the perceived high cost and downtime associated with the transition and installation it was decided to investigate considerations that should be taken into account for the concept regardless. This concept ended up being named Isolation. Along with moving the entire filter unit outside of the shop the automation concept would also likely be implemented at the same time.

APPENDIX C
FAILURE MODE ANALYSIS

List of Tables

C-1. Failure Mode Analysis

What follows is the Failure Modes and Effects Analysis (FMEA) performed by the team on the final design solutions of phase I and II. The FMEA discovered no major risk factors with the design itself and therefore once recommended changes were made no further FMEA iterations were performed.

TABLE C- I
RUSSEL METAL'S AUTOMATION FMEA ANALYSIS

Part or Function	Potential Failure Mode(S)	Effect of Failure	SEV	Potential Cause(s) of Failure	FRQ	Current Design Control (If Applicable)	DET	RPN	Recommended Action
Bin Seal	Not Sealing	Dust loss	4	Wear, Misalignment or Poor Contact Pressure	3	N/A	5	60	Mount Seal to Bin and Ensure Adequate Contact Pressure
Bin Lift Mechanism	Not Lifting, Accidental Lifting or Lowering	Dust Loss	9	User Error, Mechanism Failure (Wear)	2	Visual Inspection	1	18	Bin Position Detection Switch, Safety Style Switch
Screw Conveyor	Not Conveying Materials	Plasma Cutter Down	9	Electrical Fault, Wear, Motor Failure	3	N/A	4	108	Protect Motor From Weather Elements (Cover)
Screw Conveyor Stand	Collapse or Loss of Footing	Screw Conveyor Damage	9	Weak Structure, Structural Flaws, Soft Ground/Base	2	N/A	2	36	Ensure Structures can Handle the Load, Cement Pad for Structure Base
Top vent duct connections	imperfect seal	Dust loss	8	Incorrect installation	2	Visual inspection	2	32	Use certified installer
Exterior wall seal	imperfect seal	Heat loss from facility	5	Incorrect installation	2	Visual inspection	3	30	Use certified installer

APPENDIX D
GANTT CHART AND WORK BREAKDOWN STRUCTURE

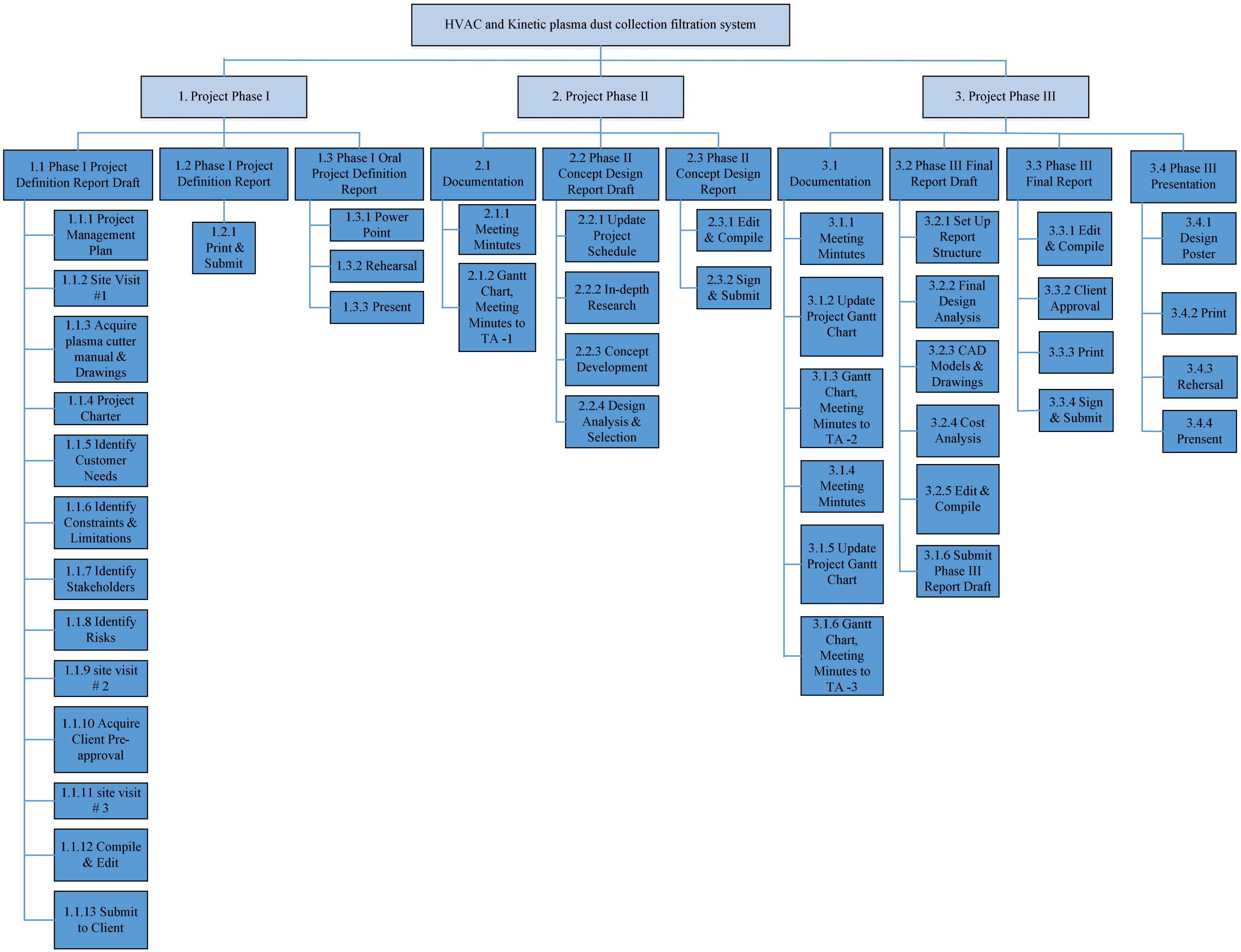
ID	Task Name	% Complete	Baseline Start	Baseline Finish	Actual Start	Actual Finish	Assigned Person	Predecessors
1	**Kinetic plasma dust collection filtration system**	**100%**	**Wed 14/09/16**	**Thu 08/12/16**	**Wed 14/09/16**	**Thu 08/12/16**	Jonathan de Vos	
2	**Project Phase I**	**100%**	**Wed 14/09/16**	**Tue 04/10/16**	**Wed 14/09/16**	**Tue 04/10/16**	Jonathan de Vos	
3	**Phase I Project Definition Report Draft**	**100%**	**Wed 14/09/16**	**Sun 02/10/16**	**Wed 14/09/16**	**Mon 03/10/16**	Jonathan de Vos	
4	Project Management Plan	100%	Wed 14/09/16	Wed 14/09/16	Wed 14/09/16	Wed 14/09/16	Jonathan de Vos	
5	Site Visit # 1	100%	Thu 15/09/16	Thu 15/09/16	Thu 15/09/16	Thu 15/09/16	Jonathan de Vos	4
6	Acquire plasma cutter manual & Drawir	100%	Thu 15/09/16	Thu 15/09/16	Thu 15/09/16	Thu 15/09/16	Jonathan de Vos	
7	Project Charter	100%	Fri 16/09/16	Thu 29/09/16	Fri 16/09/16	Thu 29/09/16	Andrew Ruday	5,6
8	Identify Customer Needs	100%	Fri 16/09/16	Mon 26/09/16	Fri 16/09/16	Mon 26/09/16	Keegan Schkawritka	7SS
9	Constraints & Limitations	100%	Fri 16/09/16	Mon 26/09/16	Fri 16/09/16	Mon 26/09/16	Keegan Schkawritka	7SS
10	Identify Stakeholders	100%	Fri 16/09/16	Mon 19/09/16	Fri 16/09/16	Mon 19/09/16	Keegan Schkawritka	7SS
11	Identify Risks	100%	Fri 16/09/16	Tue 27/09/16	Fri 16/09/16	Tue 27/09/16	Keegan Schkawritka	7SS
12	site visit # 2	100%	Tue 20/09/16	Tue 20/09/16	Tue 20/09/16	Tue 20/09/16	Jonathan de Vos	8SS
13	Acquire Client Pre-approval	100%	Tue 27/09/16	Tue 27/09/16	Tue 27/09/16	Tue 27/09/16	Jonathan de Vos	8,9
14	site visit # 3	100%	Wed 28/09/16	Wed 28/09/16	Wed 28/09/16	Wed 28/09/16	Jonathan de Vos	9
15	Compile & Edit	100%	Fri 30/09/16	Fri 30/09/16	Fri 30/09/16	Fri 30/09/16	Andrew Ruday	7,13
16	Submit Phase I Draft to Client	100%	Sun 02/10/16	Mon 03/10/16	Mon 03/10/16	Mon 03/10/16	Jonathan de Vos	15
17	**Phase I Project Definition Report**	**100%**	**Mon 03/10/16**	**Mon 03/10/16**	**Mon 03/10/16**	**Mon 03/10/16**	Andrew Ruday	
18	Print & Submit	100%	Mon 03/10/16	Mon 03/10/16	Mon 03/10/16	Mon 03/10/16	Kewei Qian	15
19	**Phase I Oral Project Definition Report**	**100%**	**Sun 02/10/16**	**Tue 04/10/16**	**Sun 02/10/16**	**Tue 04/10/16**	Keegan Schkawritka	
20	Power Point	100%	Sun 02/10/16	Mon 03/10/16	Sun 02/10/16	Mon 03/10/16	Keegan Schkawritka	15
21	Rehearsal	100%	Mon 03/10/16	Mon 03/10/16	Mon 03/10/16	Mon 03/10/16	Keegan Schkawritka	20
22	Present	100%	Tue 04/10/16	Tue 04/10/16	Tue 04/10/16	Tue 04/10/16	Keegan Schkawritka	21
23	**Project Phase II**	**100%**	**Wed 05/10/16**	**Fri 28/10/16**	**Wed 05/10/16**	**Fri 28/10/16**	Jonathan de Vos	
24	**Documentation**	**100%**	**Wed 05/10/16**	**Fri 28/10/16**	**Wed 05/10/16**	**Fri 28/10/16**	Andrew Ruday	
25	Meeting Minutes	100%	Wed 05/10/16	Fri 28/10/16	Wed 05/10/16	Fri 28/10/16	Andrew Ruday	
26	Gantt Chart, Meeting Minutes to TA -1	100%	Wed 12/10/16	Wed 12/10/16	Wed 12/10/16	Wed 12/10/16	Kewei Qian	
27	**Phase II Concept Design Report Draft**	**100%**	**Wed 05/10/16**	**Fri 21/10/16**	**Wed 05/10/16**	**Thu 27/10/16**	Kewei Qian	
28	Update Project Schedule	100%	Wed 05/10/16	Fri 07/10/16	Wed 05/10/16	Fri 07/10/16	Kewei Qian	22
29	In-depth Research	100%	Sat 08/10/16	Tue 11/10/16	Sat 08/10/16	Mon 17/10/16	Kewei Qian	28
30	Concept Development	100%	Wed 12/10/16	Sun 16/10/16	Sat 15/10/16	Thu 20/10/16	Kewei Qian	29
31	Design Analysis & Selection	100%	Mon 17/10/16	Wed 19/10/16	Fri 21/10/16	Thu 27/10/16	Kewei Qian	30
32	~~Consult with Advisor~~	~~0%~~	~~Thu 20/10/16~~	~~Thu 20/10/16~~	~~NA~~	~~NA~~	~~keegan Schkawritka~~	
33	~~Client Approval~~	~~0%~~	~~Fri 21/10/16~~	~~Fri 21/10/16~~	~~NA~~	~~NA~~	~~Jonathan de Vos~~	~~32~~
34	**Project II Concept Design Report**	**100%**	**Sat 22/10/16**	**Fri 28/10/16**	**Thu 27/10/16**	**Fri 28/10/16**	Andrew Ruday	
35	Edit & Compile	100%	Sat 22/10/16	Thu 27/10/16	Thu 27/10/16	Thu 27/10/16	Andrew Ruday	
36	Sign & Submit	100%	Fri 28/10/16	Fri 28/10/16	Fri 28/10/16	Fri 28/10/16	Andrew Ruday	35
37	**Project Phase III**	**100%**	**Sat 29/10/16**	**Thu 08/12/16**	**Sat 29/10/16**	**Thu 08/12/16**	Jonathan de Vos	
38	**Documentation**	**100%**	**Sat 29/10/16**	**Wed 30/11/16**	**Sat 29/10/16**	**Wed 30/11/16**	Andrew Ruday	
39	Meeting Minutes	100%	Sat 29/10/16	Wed 02/11/16	Sat 29/10/16	Tue 01/11/16	Andrew Ruday	25
40	Update Project Gantt Chart	100%	Sat 29/10/16	Wed 02/11/16	Sat 29/10/16	Tue 01/11/16	Kewei Qian	
41	Gantt Chart, Meeting Minutes to TA - 2	100%	Wed 02/11/16	Wed 02/11/16	Wed 02/11/16	Wed 02/11/16	Andrew Ruday	40,39
42	Meeting Minutes	100%	Wed 02/11/16	Tue 29/11/16	Thu 03/11/16	Tue 29/11/16	Andrew Ruday	41
43	Update Project Gantt Chart	100%	Wed 02/11/16	Tue 29/11/16	Thu 03/11/16	Tue 29/11/16	Kewei Qian	41
44	Gantt Chart, Meeting Minutes to TA - 3	100%	Wed 30/11/16	Wed 30/11/16	Wed 30/11/16	Wed 30/11/16	Andrew Ruday	42,43
45	**Phase III Final Report Draft**	**100%**	**Mon 31/10/16**	**Mon 28/11/16**	**Mon 31/10/16**	**Mon 28/11/16**	Andrew Ruday	
46	Set Up Report Structure	100%	Mon 31/10/16	Thu 03/11/16	Mon 31/10/16	Thu 03/11/16	Keegan Schkawritka	36
47	Final Design Analysis	100%	Fri 04/11/16	Mon 14/11/16	Fri 04/11/16	Wed 23/11/16	Jonathan de Vos	46
48	CAD Models & Drawings	100%	Fri 04/11/16	Mon 14/11/16	Fri 04/11/16	Wed 23/11/16	Kewei Qian	47SS
49	Cost Analysis	100%	Tue 15/11/16	Sun 20/11/16	Thu 24/11/16	Fri 25/11/16	Kewei Qian	48
50	~~Operating Instructions~~	~~0%~~	~~Tue 15/11/16~~	~~Sun 20/11/16~~	~~NA~~	~~NA~~	~~keegan Schkawritka~~	
51	~~Consult with Advisor~~	~~0%~~	~~Mon 21/11/16~~	~~Mon 21/11/16~~	~~NA~~	~~NA~~	~~keegan Schkawritka~~	~~49~~
52	Edit & Compile	100%	Tue 22/11/16	Sun 27/11/16	Sat 26/11/16	Mon 28/11/16	Andrew Ruday	50
53	Submit Phase III Report Draft	100%	Mon 28/11/16	Mon 28/11/16	Mon 28/11/16	Mon 28/11/16	Kewei Qian	52FF
54	**Phase III Final Report**	**100%**	**Tue 29/11/16**	**Thu 08/12/16**	**Tue 29/11/16**	**Wed 07/12/16**	Andrew Ruday	
55	~~Consult with Technical Communication Specialist~~	~~0%~~	~~Tue 29/11/16~~	~~Tue 29/11/16~~	~~NA~~	~~NA~~	~~keegan Schkawritka~~	
56	Edit & Compile	100%	Wed 30/11/16	Mon 05/12/16	Tue 29/11/16	Mon 05/12/16	Andrew Ruday	
57	Client Approval	100%	NA	NA	Thu 01/12/16	Thu 01/12/16	Jonathan de Vos	
58	Print	100%	Tue 06/12/16	Tue 06/12/16	Tue 06/12/16	Tue 06/12/16	Kewei Qian	56
59	Sign & Submit	100%	Wed 07/12/16	Wed 07/12/16	Wed 07/12/16	Wed 07/12/16	Kewei Qian	58
60	**Phase III Presentation**	**100%**	**Fri 02/12/16**	**Thu 08/12/16**	**Fri 02/12/16**	**Thu 08/12/16**	Keegan Schkawritka	
61	Design Poster	100%	Fri 02/12/16	Sun 04/12/16	Fri 02/12/16	Mon 05/12/16	Keegan Schkawritka	
62	~~Consult with Advisor~~	~~0%~~	~~Mon 05/12/16~~	~~Mon 05/12/16~~	~~NA~~	~~NA~~	~~Keegan Schkawritka~~	~~61~~
63	Print	100%	Tue 06/12/16	Tue 06/12/16	Tue 06/12/16	Tue 06/12/16	Kewei Qian	61
64	Rehearsal	100%	Wed 07/12/16	Wed 07/12/16	Wed 07/12/16	Wed 07/12/16	Kewei Qian	63
65	Present	100%	Thu 08/12/16	Thu 08/12/16	Thu 08/12/16	Thu 08/12/16	Jonathan de Vos	64

Project: Final Gantt Chart.mpp
Date: Sun 04/12/16

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 | Baseline | Baseline Milestone | Baseline Summary | Progress | Manual Progress

Work Breakdown Structure (WBS)

The work breakdown structure is shown on the next page.


HVAC and Kinetic plasma dust collection filtration system
1. Project Phase I
2. Project Phase II
3. Project Phase III
1.1 Phase I Project Definition Report Draft
1.1.1 Project Management Plan
1.1.2 Site Visit #1
1.1.3 Acquire plasma cutter manual & Drawings
1.1.4 Project Charter
1.1.5 Identify Customer Needs
1.1.6 Identify Constraints & Limitations
1.1.7 Identify Stakeholders
1.1.8 Identify Risks
1.1.9 site visit # 2
1.1.10 Acquire Client Pre-approval
1.1.11 site visit # 3
1.1.12 Compile & Edit
1.1.13 Submit to Client
1.2 Phase I Project Definition Report
1.2.1 Print & Submit
1.3 Phase I Oral Project Definition Report
1.3.1 Power Point
1.3.2 Rehearsal
1.3.3 Present
2.1 Documentation
2.1.1 Meeting Mintutes
2.1.2 Gantt Chart, Meeting Minutes to TA -1
2.2 Phase II Concept Design Report Draft
2.2.1 Update Project Schedule
2.2.2 In-depth Research
2.2.3 Concept Development
2.2.4 Design Analysis & Selection
2.3 Phase II Concept Design Report
2.3.1 Edit & Compile
2.3.2 Sign & Submit
3.1 Documentation
3.1.1 Meeting Mintutes
3.1.2 Update Project Gantt Chart
3.1.3 Gantt Chart, Meeting Minutes to TA -2
3.1.4 Meeting Mintutes
3.1.5 Update Project Gantt Chart
3.1.6 Gantt Chart, Meeting Minutes to TA -3
3.2 Phase III Final Report Draft
3.2.1 Set Up Report Structure
3.2.2 Final Design Analysis
3.2.3 CAD Models & Drawings
3.2.4 Cost Analysis
3.2.5 Edit & Compile
3.1.6 Submit Phase III Report Draft
3.3 Phase III Final Report
3.3.1 Edit & Compile
3.3.2 Client Approval
3.3.3 Print
3.3.4 Sign & Submit
3.4 Phase III Presentation
3.4.1 Design Poster
3.4.2 Print
3.4.3 Rehersal
3.4.4 Prensent

APPENDIX E
ISOLATION CONCEPT

Isolation Concept

Chips, dust and fumes are collected using two methods; a liquid conveyer for large debris and a vacuum for the dust and fumes. The conveyor and the vacuum duct run from the plasma cutting table to the collection unit behind the table. This concept would move the collection unit outside, with the vacuum duct and conveyor extending from the table, through the wall, to the collection unit outside the building within its own enclosure. This solution will satisfy the customer needs by completely removing dust exposure to the shop premises and employees, it will also free up shop space or allow for extension of the cutting table if Russel Metals so desires.

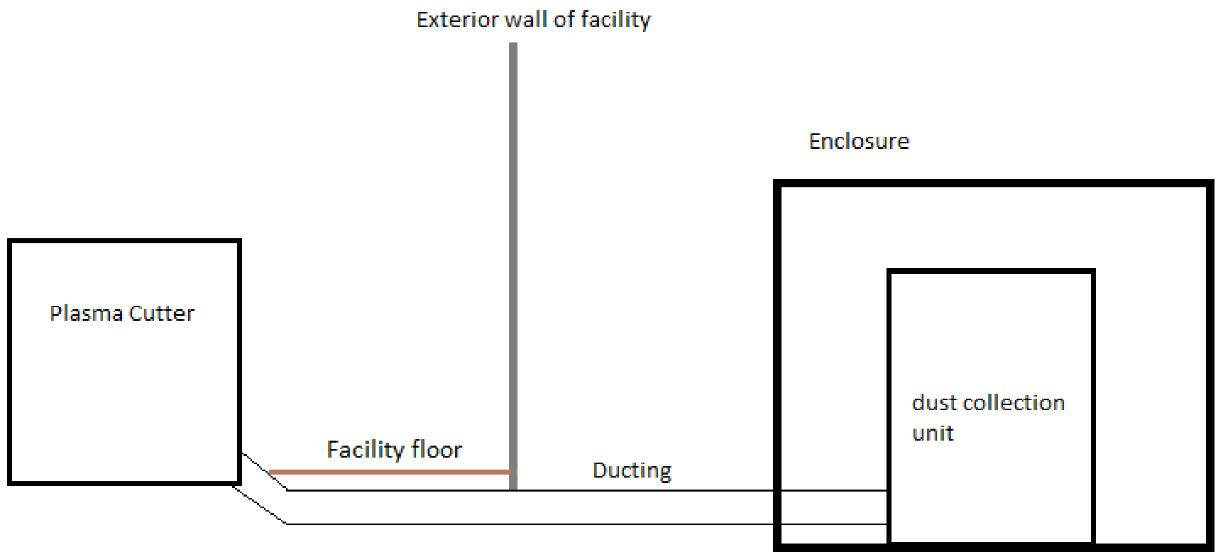


Figure 1. Concept sketch, moving collection unit outside facility

Figure 1 shows a concept sketch of what this solution would look like. The ducting and enclosure are required to be above freezing year round because of the liquid coolant that moves the large debris from the cutting table to the collection unit. The ducting and wiring will be run underground to increase shop floor space gained. The collection unit itself has the following dimensions; 3.08 m in height, 5.88 m in length and 1.38 m in width. The outside enclosure would need to accommodate this size as well as allow for extra room to run ducting and perform maintenance. Active ventilation by way of a fan will be required to remove the gasses exhausted by the collection system. Heating the enclosure may be done with a simple electric heater, target temperature for the enclosure is 4 °C or higher. Ducting heating could be achieved with a fan blowing warm air from the facility through the ducting, this would require the ducting to have significant airflow around the fluid and fume piping.

APPENDIX F
CONQUEST EQUIPMENT QUOTE

Head Office: 1-2073 Logan Ave, Winnipeg, MB, Canada, R2R 0J1
Toll Free: 1-800-786-6606
Fax: (204) 632-6613

QUOTATION

December 7, 2016

Russel Metals Inc.
1510 Clarence Avenue
Winnipeg, MB R3T 1T6

As per your RFQ we are pleased to submit the following pricing ***SUPPLY ONLY:***

(1) Only Incline Screw Conveyer with Stand.

- 6" Tube Trough design.
- 2hp 575v/3/60 VP High Efficiency TEFC Motor and Dodge® helical s/c drive.
- Approximately 10ft long.
- Standard discharge outlet c/w flex hose.
- Flanged inlet transition to mount to airlock.
- (1) Support Stand.
- Painted with Conquest Blue enamel.

$ 7,237.00*/ea CAD

(1) Only ACS Type CI 6 X 6 Rotary Airlock, 0.10 C.F.R,

- Cast iron housing and endplates
- Outboard bearings
- Square inlet/outlet flanges
- ACST-4 shaft seal assembly
- 8-vane open end mild steel rotor assembly
- Fixed edge mild steel rotor tips – beveled
- ¾ HP drive assembly including TEFC enclosure, 575 volt, 3 phase, 60 cycle, SEW gearmotor, chain drive, drive guard, and motor base, completely factory assembled. Final drive RPM is 20.

$ 3,226.00*/ea CAD

NOTE: *All field installation, electrical wiring, Motor starters and extra support stands supply by customer.*

Estimated Installation cost including Control Panel = $15,000 - $20,000

Standard Terms and Conditions

*Payment Terms: 35% Deposit with order, Balance Net 30 Days. Conquest Equipment Corporation may charge Customer interest equal to the lesser of 1.5% per month [eighteen percent (18%) per annum] or the maximum rate allowed by law on such undisputed portion.
*GST /HST and PST extra where applicable. Purchaser to provide valid exemption certificate where applicable.
*Delivery: 6 - 8 weeks.
*All amounts in CAD.
*Equipment is Supply Only FOB Winnipeg, MB
*Quote is valid for (30) days.
*Factory Warrantees apply; no additional warranties are expressed or implied.
*After Conquest Equipment Corporation has been given adequate opportunity to remedy any defect in material or workmanship Conquest Equipment Corporation retains the sole option to accept return of the goods, with freight paid by the purchaser, and to refund the purchase price for the goods after confirming the good are returned undamaged and in usable condition. Such a refund will be the full extent of Conquest Equipment Corporations's liability. Conquest Equipment Corporation shall not be liable for any other costs, expenses or damages whether direct, indirect, special, incidental, consequential or otherwise.
*Cancellation Policy: Orders cannot be cancelled without the express written consent from Conquest Equipment Corporation. Cancellation fees will apply and will be determined at the time cancellation is authorized

Thank you for the opportunity to quote on your requirements. Please feel free to call me if you have any questions.

Regards,

Paul Toupin,
Operations Manager / Sales
Conquest Equipment Corporation
Authorized Representative
Donaldson Company Industrial Air Filtration Torit® Products
Tel (204) 694-6044
Fax (204) 632-6613
Email: paul@conquestequipment.com

CUSTOMER ACCEPTANCE

By:______________________________Date:_________________________P.O.#_______________