# Deliverable E

Luke Beausoleil 0300244213
Nicholas Martins 0300306097
Harrison Meeds 0300306567
Michael Mekalopolos 0300239862

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# 1. Introduction

After receiving encouraging feedback from the client meeting and responses through MS Teams, group C9 has decided to continue developing our load sensor design. Collectively, there are three focused prototypes and one final wide-ranging protype. They are the vacuum and porous plate prototype, load sensor functionality, thermal resistance, and the unison (global) prototype. Dates have been tentatively set for all the above tests and will be carried out with the utmost care and attention.

# 2. Design Concept

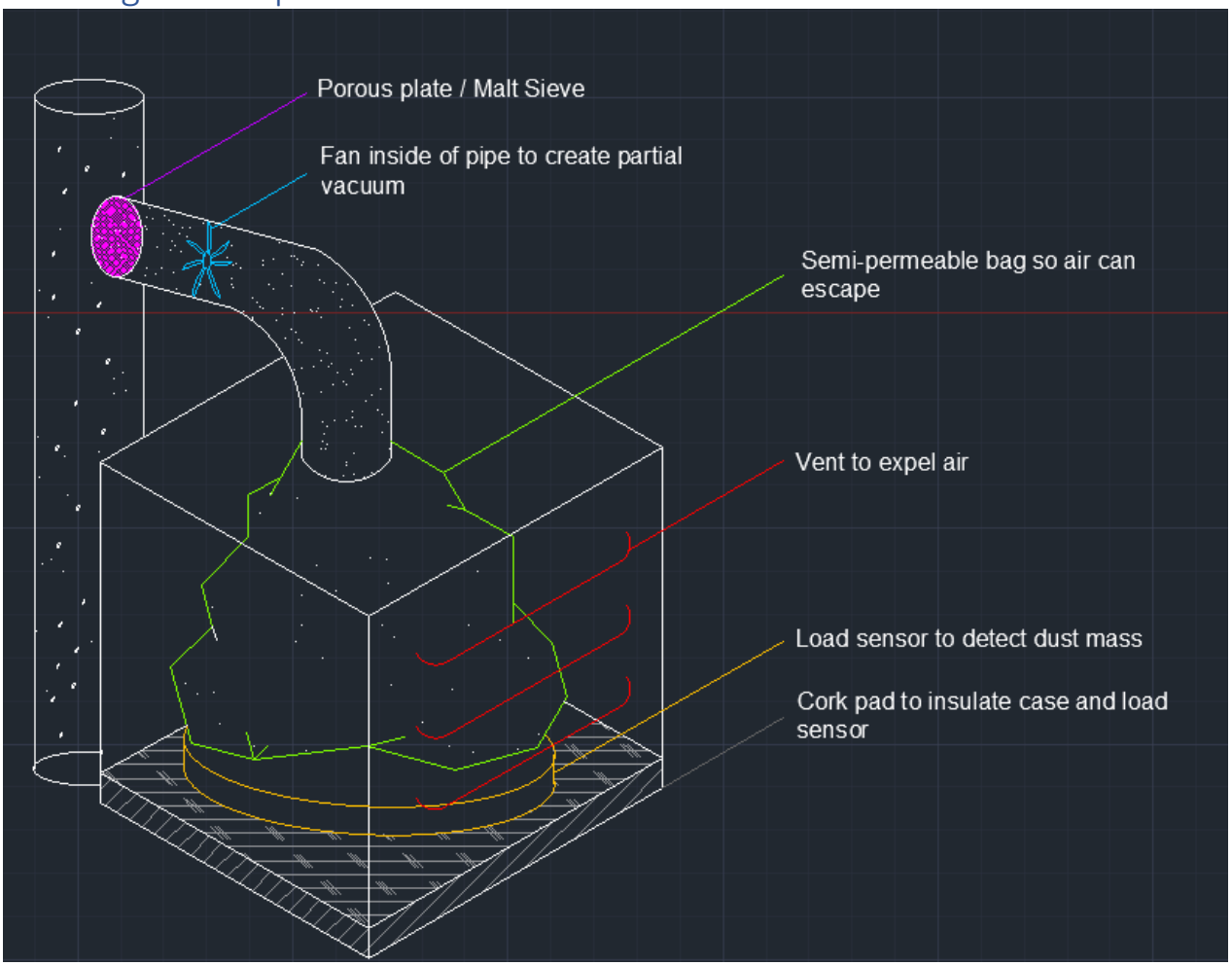


Figure 1. Entire Design Concept for Group C9's Dust Detection System.

# 3. Client Meeting Feedback

The main takeaway from the client meeting was that the current idea is that the general design concept is functional and should be continued with development.

However, the design concept was updated to accommodate the feedback received. The client indicated that the arrangement of the silo was different than the group's previous understanding. The previous understanding was that the malt was extracted from the top of a

cylindrical silo using a horizontal pipe. Currently, the understanding is that the malt is extracted from the bottom of a conical silo using a vertical pipe. This updated the product's design from being attached to the bottom of a horizontal pipe to being attached to the side of a vertical pipe.

Additionally, the meeting updated the idea of using cork for thermal insulation by supplementing it with the idea of using rubber or cork rubber. These three ideas will be tested and evaluated on their functionality with the product before a final selection is made.

Finally, the meeting provided guidance for using a Malt Sieve 60 as a porous plate. This product is relatively expensive compared to the budget of the project; however, one prototype will involve a laser cut porous plate that will mimic the qualities of the Malt Sieve 60 to test its viability.

# 4. Materials and Equipment

Sections 4.1 and 4.2 of this report outline the materials that will be used for prototyping, their purposes, their prices, and their methods of obtainment. It is important to note that any list of materials and equipment is only a tentative list, as the scope, goals, and ideas for prototyping and designing are expected to change as the project design is continued; however, the current list and bill of materials outline what is currently required for the project.

## 4.1. Materials and Equipment Needed for Prototyping

The prototyping and testing stage of the design of the final product will involve many materials that will not appear in the final solution. Table 1 outlines those materials and their purpose.

Table 1. Materials and Equipment Needed for Prototyping

| Item | Purpose(s) | Prototype(s) |
|---|---|---|
| Centrifugal Fan | To create partial vacuum in pipe. | 1 and 4 |
| Fan Motor | To run the fan. | 1 and 4 |
| Cardboard | To create a pipe that can be used for testing. | 1 and 4 |
| Duct Tape | To fasten the cardboard and other materials together. | 1, 3, and 4 |
| Mulch | To mimic malt. | 1 and 4 |
| Garbage Bag | To capture mulch and dust. | 1 and 4 |
| 18x24x1/8 in. MDF Sheet | To cut and make into a porous plate. | 1 and 4 |
| Laser Cutter | To cut holes into MDF sheet. | 1 |
| Inkscape | To design porous plate. | 1 |
| Screwdriver | a) To disassemble a vacuum cleaner.<br>b) To fasten parts together. | a) 1<br>b) 4 |
| Dirt Bag | To capture dust. | 1 and 4 |
| Arduino Uno | To run C++ code in conjunction with load sensor and motor. | 2 and 4 |
| Arduino Breadboard | To connect the sensor to the Arduino Uno. | 2 and 4 |
| Arduino Wires | To run an electrical signal through the breadboard and sensors. | 2 and 4 |
| Arduino IDE | To write code. | 2 and 4 |
| Load Sensor | To mass different substances. | 2 and 4 |
| Cork Plate | To provide thermal resistance for load sensor. | 3 and 4 |
| Rubber Sheet | To provide thermal resistance for load sensor. | 3 and 4 |

### 4.2. Bill of Materials

Every required item must be obtained from somewhere, and some of these items will have an associated cost. Therefore, the bill of materials is included as table 2 to highlight the price and method of obtaining the previously mentioned materials and equipment in table 1.

Table 2. Bill of Materials.

| Material/equipment | Quantity | Cost ($) | Purpose | Obtained From |
|---|---|---|---|---|
| *Centrifugal Fan* | 1 | | Create partial vacuum | |
| -----Vacuum Cleaner | 1 | 10 | Obtain fan | https://www.facebook.com/marketplace |
| *Fan Motor* | 1 | | To run the fan | |
| -----Vacuum Cleaner | 1 | 0 | Obtain fan motor | https://www.facebook.com/marketplace |
| *Cardboard* | | | Construct fake pipe for testing | |
| -----old cereal boxes | 10 | 0 | Obtain cardboard | Garbage |
| Duct Tape | 1 roll | 0 | Fasten Cardboard | House |
| Mulch | ~1 kg | 0 | Mimic malt for testing | Local park |
| Garbage Bag | 1 | 0 | Capture dust in testing | House |
| *MDF Porous Plate* | 1 | | Test effect of pores | |
| -----1/8" MDF Sheet | 1 | 3 | Create MDF porous plate | https://makerstore.ca/ |
| -----Laser Cutter | 1 | 0 | Cut MDF sheet | Makerspace |
| -----Inksacpe | | 0 | Design cut for MDF sheet | https://inkscape.org/ |
| *Power* | | | Power motor of fan | |
| -----Wired | | 0 | Power motor of fan | Wall outlet |
| Screwdriver | 1 case | 0 | Deconstruct vacuum cleaner | House |
| Dirt Bag | 1 | 0 | Collect dust in final product | comes with vacuum cleaner |
| Arduino Uno | 1 | 0 | Send code to load sensor for testing | Borrowed from makerspace |
| Wires | 10 | 0 | Wire Arduino | Borrowed from makerspace |
| Load Sensor | 1 | 16.9387 | Measure dust mass in final product | https://www.amazon.ca/ |
| Bathroom Scale | 1 | 0 | Measure dust mass in testing | House |
| Cork Plate | 1 | 0 | Insulate Load sensor | House |
| Arduino Uno IDE | 1 | 0 | Write code for arduino | https://wiki-content.arduino.cc/en/software |
| rubber sheet | 1 | 5.7517 | Insulate Load sensor | Home Depot |
| | | | | |
| **Total** | | 35.6904 | | |

## 5. Significant Project Risks

There are a few risks that come in hand with this prototype. One of them being is with the vacuum. The vacuum must be strong enough, so it is able to suck in the mulch allowing the dust to pass through, so we are able to calculate the dust composition. If this does not work, we would have to look for a new method or a different vacuum to be able to go through with our goal of finding the dust composition.

Another risk that can be considered making sure our code will be running properly. The load sensor is a key component so if this does not work how it should, our prototype would be at fault. Need to make sure that our code is providing us with the proper values and making sure that it will not be running into any errors. This risk be avoided by providing several tests allowing us to see if we are running into any issues, if we do, we can adapt and fix these errors that come this way.

## 6. Contingency Plans

To prevent serious setback due to these possible risks, contingency plans are put in place to be used if necessary.

In the case that the vacuum is not strong enough to suck up dust, we would have to react based on the severity of the incapability. If the vacuum is sucking up most dust, but there is clearly some dust not quite getting pulled in, the group can look for a more powerful vacuum. This would require additional spending however not nearly as much as the alternative. If the vacuum is barely sucking in any dust, then more drastic measures must be taken. In this case with the current setup being dysfunctional, the team would have to completely change the system as the problem lies withing the logistics of the current system. Ideally, based on questions from the client, a horizontal section of piping could be found in which the system could be re-tested on, seeing if gravity assisting makes the system operational. If this is not a possibility it is probable that the group would pivot to our second method which was the audio sensor and proceed with testing that.

In the case that our code doesn't function properly with the load sensor, a great amount of testing would be put in to discover the root of the problem. A probable cause of this issue would be errors in the code, several members would reread, doing research and finding if there are any issues. If the issue does not come from the code but derives from the load sensors incompatibility with our code, a different load sensor would need to be purchased, with research being done to insure its compatibility. This would be done a few times over despite the cost being thrown away as the entire system relies on the load sensor. If none of this worked a different sensing method would need to be used such as the audio sensor from our second method.

## 7. Prototype Test Plan

The tentative plan for prototyping involves four main tests, all of which involve testing the feasibilities of the current subsystem ideas, as per table 3. Each prototype test will provide feedback on the effectiveness of each subsystem. Furthermore, the results of the tests will allow the group to calculate needed values, like dust composition, by assessing the effectiveness of the fan to create a vacuum.

It should be mentioned that this list is currently tentative and will likely change as new developments and new knowledge are presented or discovered. Specifically, the current prototyping test plans may need to be altered to test for different aspects of the product or test aspects that are not yet discovered. Furthermore, the method of testing or the results from the tests may also be updated if the need presents itself. Finally, the schedule is most likely to change because it is dependent on many other aspects, such as ordering, purchasing, and/or receiving required items. Therefore, table 3 is merely an estimate of the current plan because it is not yet known what will need to change.

Table 3. Prototyping Test Plan

| Test ID | Objective | Method | Results | Tentative Schedule |
|---|---|---|---|---|
| 1 | Test the functionality of the partial vacuum with a porous plate. | A cardboard pipe with an attached porous plate will have mulch poured inside while the fan runs to create a partial vacuum and suck the mulch. | Successful if the fan and porous plate can pull the mulch and separate it from dust. These will be used to calculate dust composition. | March 1, 2023. |
| 2 | Test the functionality of load sensor in conjunction with code. | The load sensor will be connected to an Arduino which will run a C++ code from Arduino IDE. | Successful if the code can read the load sensor value correctly. Will give an approximate time it takes our product to work. | March 4, 2023. |
| 3 | Test thermal resistance of cork/rubber/cork rubber. | Measure the temperature of one face of a round cork plate and a rubber sheet when applying an external heat source to the other face. | Successful if the temperature can be maintained below a temperature (not yet determined) when applying a maximum heat of 45ºC | March 4, 2023. |
| 4 | Test the functionality of the unison of all subsystems | Determine the ability of the prototype to measure dust compositions in a realistic environment. | Successful if the prototype can return accurate dust compositions | March 15, 2023. |

## 8. Conclusion

As is evident, the first of the prototypes will be the least expensive as it is supposed to be a general guideline for moving forward in developments. The load sensor and code functionality will be carried out using existing C++ software and readily accessible dust baggage materials. The third prototype, the thermal resistance test, will be applied in order to assess the efficacy of the insulation material within the chute system. Lastly, the overall prototype will be the most vigorous process as it is an ensemble of the three former examples combining to form one system. Therefore, a prototype and project management plan has been formulated and will be the group's baseline for material relations hereafter.