APPENDIX F – MAGS WASTE TREATMENT UNIT

FOR INFORMATION ONLY

TERRAGON

Technologies de l'environnement inc.
Environmental Technologies Inc.

Technical Information Package
Micro Auto Gasification System (MAGS™)
V7

Date: April 2014

2012
Globe Foundation
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Technical Innovation Award

1. TECHNOLOGY DESCRIPTION

1.1. Process Overview

Terragon has developed the Micro Auto Gasification System, or MAGS™, which is intended to be the world's most compact, efficient and environmentally safe technology for the conversion of waste into thermal energy for use by the site where the waste is generated. MAGS can be used to eliminate all combustible waste produced by a ship, community or institution, while sterilizing the inorganic portion of the waste. Waste streams that can be easily treated by MAGS, without the need for segregation, include but are not limited to paper/cardboard, plastics, food, oily rags, oils and sludges.

MAGS uses Terragon's patented technology, *Auto Gasification*, to thermally break down waste and transform it into a solid carbon material (bio-char) and a synthesis gas (syngas). The syngas becomes the main fuel source for MAGS, which eliminates the need for external energy sources and renders the appliance virtually self-sustainable. Put simply, MAGS gasifies - or "cooks" - waste, reducing it by more than 95 percent in volume to bio-char and a hot gas (syngas). The hot gas re-circulates through the appliance to maintain the elevated temperature needed to continue the gasification process, hence *Auto* Gasification.

MAGS is an energy generating device that is fuelled by waste, and as a result produces approximately 70 kW of thermal energy for use by the site where it is located. This thermal energy can be transferred to the site for a variety of applications such as hot water or space heating, consequently enabling cost savings for the end user.

Bio-char sequesters carbon thereby reducing greenhouse gas emissions when compared to alternative methods such as landfilling and incineration. Moreover, bio-char has excellent water and nutrient retention properties when combined with soil as an additive. Because of the *Auto Gasification* process and bio-char's ability to sequester carbon, MAGS can prevent the release of up to two tonnes of CO_2 for every tonne of waste that it treats.

The MAGS technology is a simple appliance whose design incorporates many beneficial features. It is extremely compact, making it small enough to be installed in any utility room, inner-city building, or small compartments within a ship. It is fully automated, uses minimal utilities because it generates its own fuel, and can be monitored remotely by Terragon technicians, thus offering immediate assistance for troubleshooting if need be. Additionally, it is exceptionally safe and can be operated by anyone with little technical background and minimal training.

1.2. Working Principles

The proprietary *Auto Gasification* process used in MAGS has three basic elements:

(i) In the Gasifier, the organic materials are heated up to a temperature of 650°C in a low-oxygen environment, where they break down to a volatile fraction and a carbonaceous residue;

(ii) The volatile fraction is combusted at about 1,100°C in the Combustion Chamber and the hot gas is used to heat both the process air used in the Gasifier, as well as the Gasifier itself; and

(iii) The hot combustion exhaust gas leaves the heat transfer zone of the Gasifier at about 700°C and is quenched with water before being introduced to a scrubber for cleaning prior to its final release into the environment.

A schematic of the overall process is shown in Figure 1.

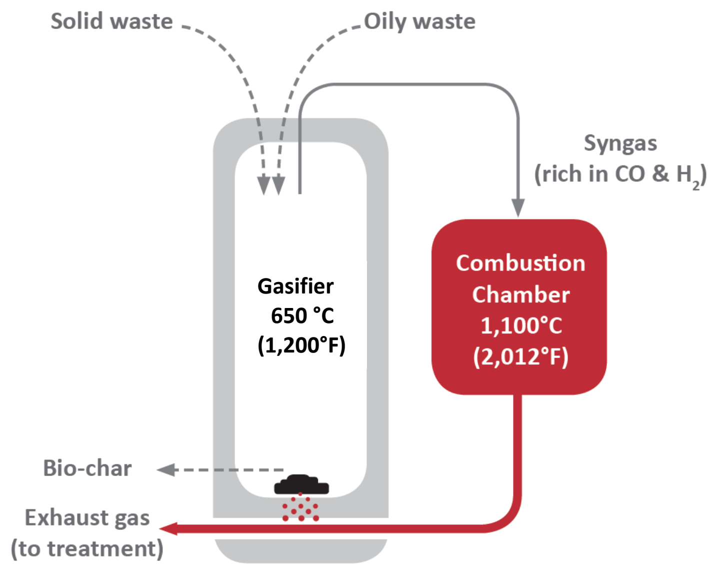

Figure 1: Simplified Schematic of the *Auto Gasification* Process

MAGS, as shown in Figure 2, consists of two Gasifiers. Each Gasifier is constructed to allow for the indirect heating of the waste inside the drum by the exhaust gases from the adjacent combustion chamber. Waste is loaded into the Gasifiers and heated up to about 650˚C (1,200 ºF). For sludge oil elimination, the sludge oil is continuously fed into the Gasifier (not shown in figure).

A controlled amount of pre-heated air is fed into the drum and brought in intimate contact with the waste. The heat and the oxygen in the air break down the hydrocarbons in the waste to form a syngas,

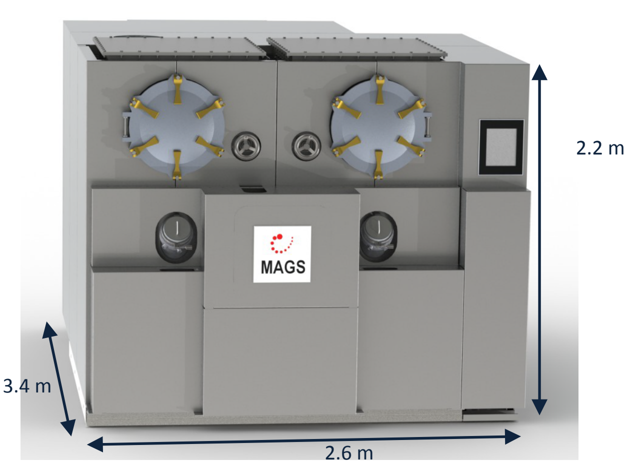

Figure 2: Schematic of MAGS™

composed primarily of CO and H_2, and bio-char. The syngas exiting the Gasifiers is fed into the Combustion Chamber where it is burned with excess air to form water and a hot combustion exhaust which is used to provide the thermal energy needed for the process. A more detailed schematic of MAGS, showing the major components, is presented in Figure 3.

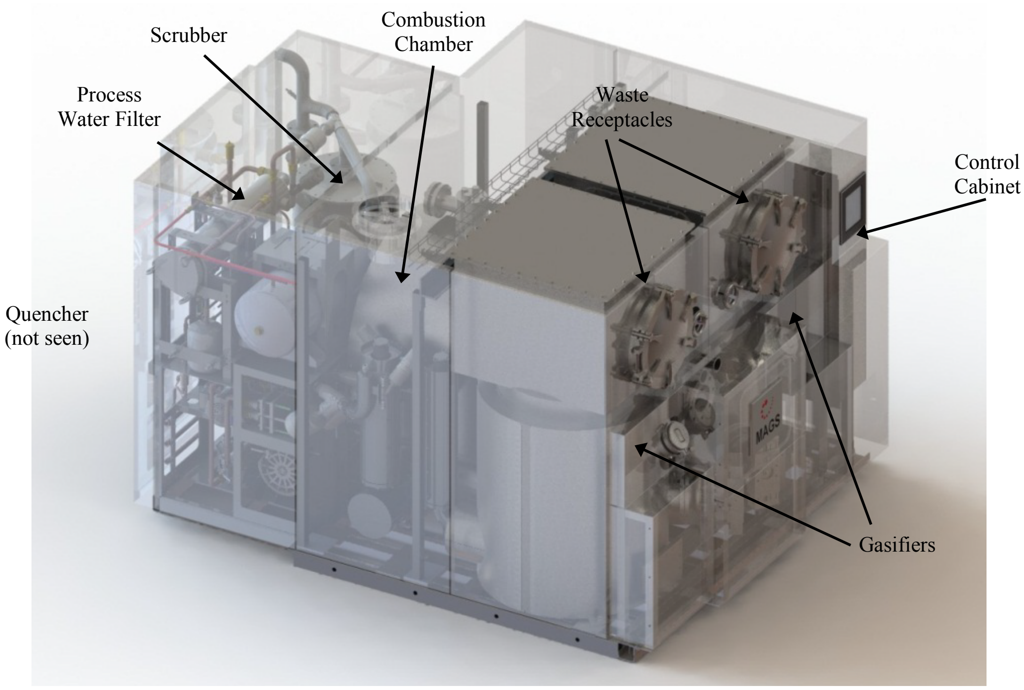

Figure 3: Overview of the Major Components of MAGS™

The Combustion Chamber is a thermally insulated reactor, maintained at 1,100°C through the combustion of diesel or syngas. A diesel burner system allows for the heat-up of the Combustion Chamber during start-up. The hot exhaust gases from the Combustion Chamber serve as the heat source for the Gasifiers and the process air.

At the start of each day, assuming that the unit is not being used around the clock, diesel is used to heat up the Combustion Chamber to 1,100°C. When the Combustion Chamber is adequately hot, its exhaust is directed towards a heat exchange zone located at the bottom of each Gasifier. The waste within the Gasifiers heats up, dries and begins gasifying, i.e. producing syngas. When the concentration of syngas is sufficient, the diesel burner switches off and the syngas serves as the main fuel for the Combustion Chamber.

Leaving the heat exchange zone below the Gasifiers at a temperature higher than 700°C, the exhaust gases are instantly quenched with water in a Venturi to a temperature of less than 80°C. The water quench serves to stop any recombination reactions that may form toxic compounds such as dioxins and furans. By bringing the hot exhaust in intimate contact with water, the Venturi also transfers most particles that may be in the exhaust to the water where they can be recovered in the water purification system.

The cold exhaust gas is fed into a packed column caustic scrubber to remove all remaining particulates and acid gases. A condenser is used to remove moisture from the exhaust gas prior to discharge.

The process comes to completion when all the organic waste is fully gasified and the production of synthesis gas stops. The residue, which is mostly inorganic carbon in the form of bio-char, may contain any incidental metal and glass found in the original waste. The bio-char residue is recovered as a sterilized inert material that can be stored or discharged safely. Because about half the amount of carbon contained in the waste is collected as bio-char, the MAGS technology offers significantly reduced emission of greenhouse gases, as compared to competing practices, such as landfilling and conventional incineration.

Figure 4: Photo of Bio-Char Produced by MAGS™

1.3. Types of Wastes

MAGS is designed to treat a variety of waste streams, specifically organic or combustible wastes. These waste streams include, but are not limited to:

- Paper/cardboard
- Plastic
- Food
- Fabrics
- Wood
- Oily wastes
- Sludges
- Biomedical waste
- Pharmaceutical waste

Terragon envisions MAGS to be part of a sustainable waste management solution, which includes waste reuse, recycling and composting. As such, whenever feasible, sites should recycle paper/cardboard and plastics, as well as compost food waste. Metals and glass should be recovered from the waste and not be introduced into MAGS since these materials will collect in large quantities at the bottom of the Gasifier.

1.4. Technical Specifications & Performance

TECHNICAL SPECIFICATIONS	
Total Weight:	**5,000 kg** (11,000 lbs.)
Overall Dimensions:	**2.6 m (L) x 3.4 m (W) x 2.2 m (H)** (8.5 ft x 11 ft x 7.2 ft)
PERFORMANCE DATA	
OPERATING CONDITIONS	
Nominal Solid Waste Throughput:	The throughput depends on the bulk density of the waste being treated. A typical waste loading containing 50% food would result in the treatment of approximately **40 kg/hr** (88 lb/hr).
Sludge Oil Throughput:	**10-15 L/hr** (2.6-4.0 gal/hr)
Operating Temperature in Gasifier:	**up to 650 °C** (1,200 °F)
Operating Temperature in Combustion Chamber:	**1,100 °C** (2,012 °F)
Types of Waste Streams:	Although MAGS can accept a variety of waste mixtures, it is ideally suited for the treatment of organic wastes, including but not limited to: paper/cardboard, plastics, food, wood, rags, oils, solvents, sludge, etc.
UTILITIES/CONSUMABLES	
Electrical Consumption:	22 kW (440VAC/60Hz)
Type of Fuel:	Light oil #1 or #2 (diesel), NATO F76 fuel, natural gas, other fuels also possible.
Fuel Consumption:	**7.5 l/hr** (2 gal/hr) for heat-up, which typically takes about 2-3 hours. Some additional fuel may be required, depending on waste composition and waste loading frequency.
Caustic (NaOH 10 wt %):	**0.1 l/hr** (3.4 fl.oz/hr)
EMISSIONS	
Gaseous	Total flow approximately **120 CFM** (204 CMH) at **50 °C** (122°F). MAGS will comply with all applicable air emission regulations for incinerators.
Water	About **5–20 l/hr** (1.3-5.3 gals/hr), depending on application and waste composition.
Bio-char	Approximately **8%** in weight of the total waste treated
Audible	Less than **75** decibel within 5 feet
System's Surface Temperatures	Less than **45 °C** (113°F)

1.5. Utility Requirements

MAGS requires a small amount of diesel fuel and electricity during the process. At the start of every day, assuming that the MAGS stopped working for a few hours and cooled down, diesel fuel is required to heat the combustion chamber to 1,100°C before the waste treatment process begins. Up to 12 liters of diesel fuel may be required to heat up the Combustion Chamber. During normal operation, no additional diesel fuel is required, as the waste produces syngas which acts as the fuel for the process. If the waste has a very high moisture content (>50%), or if the operator fails to feed waste to the system, the diesel burner will automatically turn on to keep the temperature of the Combustion Chamber at its operating temperature.

Electrical energy is required for the liquid ring pump which is used to maintain the overall system at negative pressure, the cooling water circulation pump, the valves and instrumentation and the waste water discharge pump. The electrical energy requirement for the system is approximately 22 kW.

1.6. Thermal Energy

The operation of MAGS results in a significant amount of energy generation due to the exothermic combustion reactions occurring in the combustion chamber. Most of the excess energy is transferred to the cooling water during the quench of the exhaust combustion gas. Approximately 70 kW of energy can be recovered from the process in the form of hot water (50°C). In many applications, the hot water generated by MAGS can be used as the feed to a boiler (i.e. in a hotel, apartment building) thereby reducing the energy demands of the boiler. Terragon works closely with clients to help determine the best strategy for recovering the thermal energy from MAGS.

MV7.4 Iqaluit - MAGS installation and commissioning report – Rev 4

Municipality of Iqaluit, Iqaluit, Nunavut

April 27-29, 2015

Ricardo Jordan – MAGS Service & Implementation

The purpose of this report is to summarize the installation of MAGS at the city of Iqaluit in Nunavut carried out on April 27-29, 2015. It also specifies: the damaged components found in the system that need to be replaced by Terragon, several suggestions for the City of Iqaluit to improve the current installation, and the evaluation of the existing heat recovery installation performed by the City of Iqaluit.

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1. Objectives

The main objectives of the visit to Iqaluit on April 27-29th, 2015 were the following:

- Assess the conditions of the Micro-Auto Gasification System (MAGS)
- Evaluate the heat recovery installation carried out by the City of Iqaluit
- Perform the installation, commissioning, and start-up the MAGS unit

2. Room installation

The MAGS is installed in the city's Waste Water Treatment facility, located in a remote building outside the airport. The system has been installed in the garage of the building where no existing water and electrical connections were available. The installation required the extensions of electrical and water connections to the room where MAGS is located. The garage space is not very well insulated because of leaks through the garage door, so temperatures inside the room depend heavily on a steam fired unit heater installed on the ceiling. The room is large enough for MAGS operation, and has a drain conveniently situated in from of the system.

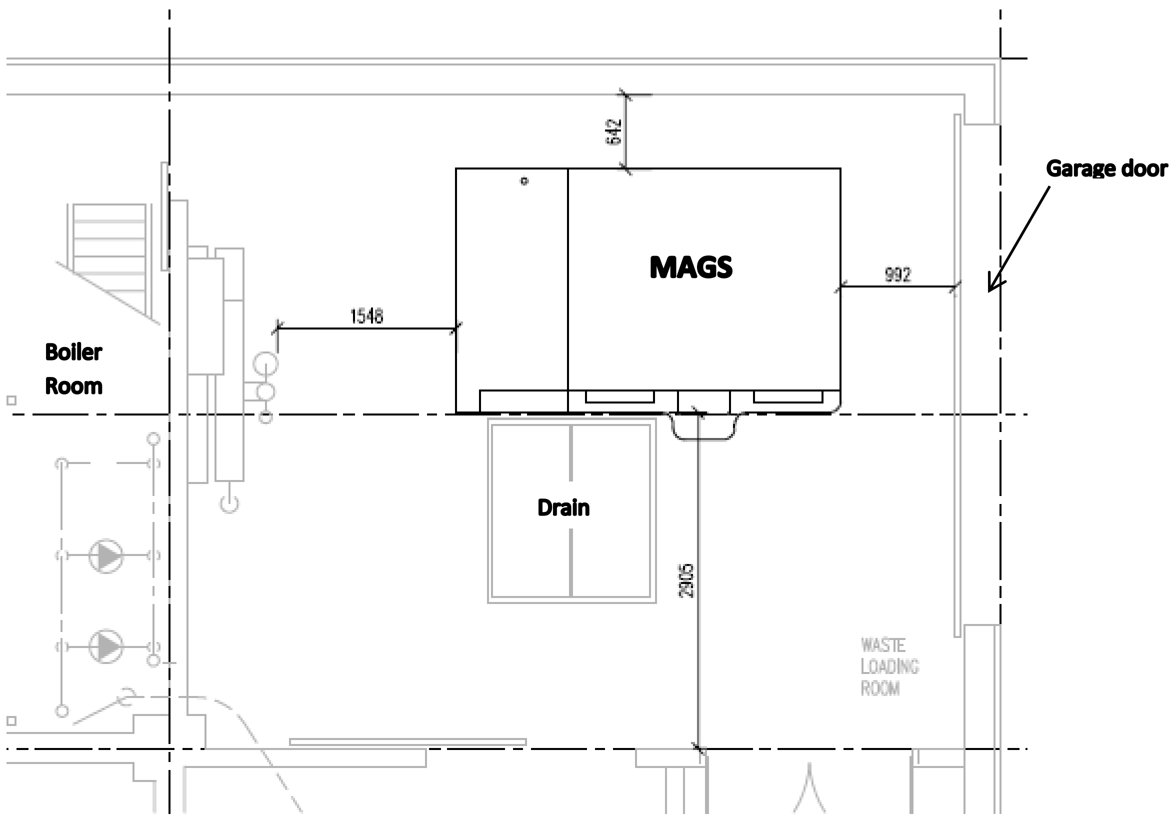


Figure 1: Room detail

Figure 2: Front view MAGS

3. Skids connections

The MAGS skids were coupled by contractors who installed only the quench pipe, the exhaust pipe, and the ventilation air duct for the fan. All other water and electrical connections were done during the installation during the visit. The installation of the system was standard and no modifications to the system were required to fit the MAGS in the room.

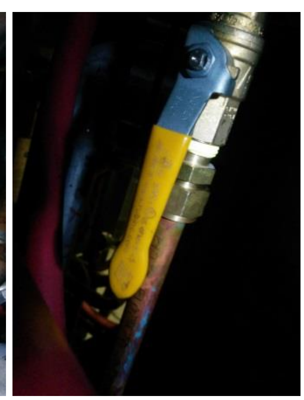



Figure 3: Skid water/electrical connection photos

4. MAGS connections and utilities testing

a. Fresh water feed line testing

Fresh water was able to flow into the MAGS from the FEW tank (main fresh water supply) at a pressure of 30-40 PSI. This pressure was adequate to fill up the cooling loop to 12-13 GPM, and to flow through the system (heat exchanger, condensers, etc.).

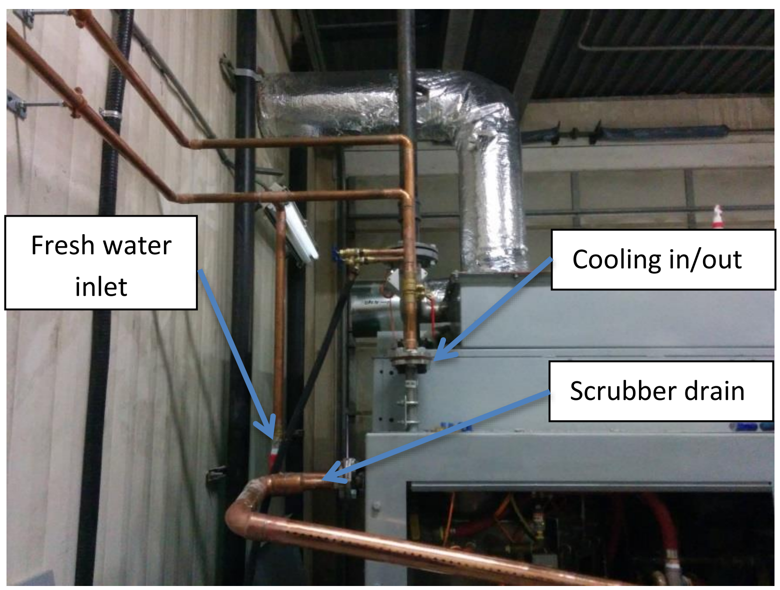


Figure 4: Fresh water & Cooling

b. Diesel Line

The diesel line runs from the main diesel tank to the MAGS and it is gravity fed into the pump. The main fuel tank is located outside the building and there is a pump that fills up an intermediate tank inside the building to warm up the fuel before using it. The fuel should be at room temperature by the time is goes into the MAGS.

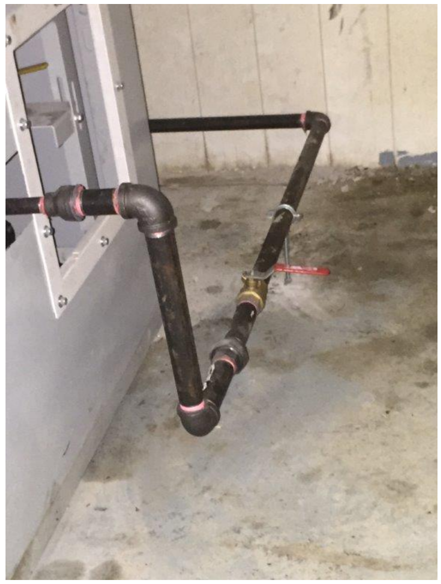


Figure 5: Gravity fed diesel line

c. Water discharge line

The scrubber drain valve goes to an HDPE buffer tank that is connected to the drain. This tank is drained manually by opening a hand valve when full. There is not pressure at the outlet of the drain so the quench flowrate should not be affected during discharge.

Figure 6: Scrubber drain set-up

d. Cooling water line testing

The heat recovery line had no flowmeter installed, so the actual flowrate through the MAGS is unknown.

<u>FOR City of Iqaluit:</u> -Install a flowmeter (mechanical flowmeter preferred) at the heat recovery water INLET of the MAGS. -See Figure 14 in Section 6 below.

e. Electrical supply

The 460V step down transformer was a custom order that was installed specifically for the MAGS. The wiring runs from the second floor of the facility to the ground floor where the MAGS is located. The installation was verified with a voltmeter to ensure 460 V supply.

Figure 7: Main power connection

f. Communication testing

There is no Ethernet cable connected to MAGS, but there is a Wi-Fi network available. Once the network is accessed, a remote connection can be set-up with Montreal for monitoring.

<u>FOR City of Iqaluit</u> -Connect an Ethernet cable to MAGS to allow remote connection with Terragon.

g. Sludge treatment

MAGS Sludge tank

The MV7.4 sludge tank must be modified so that the outlet of the sludge tank is located at the same height as the level sensors of the tank LSAL913 and LSL913. The level sensor of the tank only triggers when the level is below such sensor. The risk of operating the machine with sludge with the current setup is that the tank level will never trigger the low level alarm, risking the pump to run dry (see picture below). The solution requires welding.

External sludge transfer pump and storage tank

In order to enable the automatic sludge transfer into MAGS tank, it is required to install an external sludge tank and sludge pump. The MAGS has a 100 L sludge tank installed on the hot skid, which will be refilled from a larger reservoir when required. The MAGS can be wired to an external motor, in order to activate it whenever the tank level of the MAGS is low. The simplest and most recommended approach is to connect the MAGS to an external pump wired to the grid. The MAGS will start/stop the transfer pump when the MAGS tank level is low.

FOR TERRAGON:

-Welding a pipe to the outlet port inside the tank to enable LSL913 and LSAL913 to control the level of the sludge in the tank.

Estimated total time for welding (2 hours)

-In order to enable sludge transfer from external pump, TERRAGON needs to provide tank inlet flow valve and relay to connect MAGS automation to external pump.

FOR City of Iqaluit

-In order to treat sludge (used oils, flammables) a sludge tank needs to be installed at the facility to hold a large supply of waste oils (ideally 1000 L, but it could be smaller). To automate the transfer process the tank needs to be connected to a pump that will be wired to the MAGS automation so that it autofill the MAGS internal sludge tank whenever the system sends the signal requesting for more sludge. The pump requirements are the following:

Pump:

- Centrifugal sludge transfer pump
- 600V wired to the grid
- At least 15 GPM and 50 PSI of pressure
- MAGS sludge tank inlet located 8 ft. above ground level

Tank

- Large enough to hold at least 1000 L of used oils.
- Fixed to ground.
- Suitable tank material to resist sludge, flammable materials.
- Must be kept above freezing temperatures.

Figure 8: Sludge tank outlet above LSAL913 and LSL913

h. Room temperature control

The garage door next to the MAGS is poorly insulated and the temperature of the room depends on the diesel heater to keep the room at temperatures above freezing temperatures. At the time of the installation the heater was out of service, and needed to be repaired. Ideally the garage door should be insulated to make sure that if the unit heater breaks down, the MAGS will not freeze during the winter months.

FOR City of Iqaluit:
-Fix heater in MAGS room.
-Insulate garage door properly to avoid any damages to the system during extreme temperatures in cases when the room heater is out of service.

5. System upgrades

During the MAGS installation, several electrical components had to be installed in the electrical cabinet to upgrade the system to the latest software/electrical update.

i. Heartbeat hardware installed.
j. TLA141 thermocouple updated.
k. Automation software updated.
l. Flow control valve (FCV) head replaced.

6. Components to be fixed/replaced

Diesel pump cable

The diesel pump was not commissioned because the motor would trip the power breaker (CB4) preventing the system from operating. The CB4 breaker is the power source for P001, F008, and P105); therefore, all of these subsystems would not work when the breaker tripped.

Extensive troubleshooting procedures were carried out and it was determined that the cable was malfunctioning and has to be replaced in the next visit to Iqaluit. The pump motor, contactor, and overload are operative and are not the root of the problem.

FOR TERRAGON: -The cable consists of two extensions, either one of them can be damaged, so both lengths should be replaced. **The total length of the replacement cable must be 18 ft.,** in order to reach from the electrical cabinet to the diesel pump.

7. Heat Recovery Installation Review

Objective

The purpose of the MAGS installation at the Waste Water facility at Iqaluit, NU is to convert solid waste and used oils, to thermal energy in the form of hot water and hot air that will be integrated for use by the facility. In this particular project the energy can be used for two possible purposes:

1. For the pre-heating of the water going into the hot water heaters
2. For building space heating

Site setup (Fresh Water system)

The Waste Water facility consumes about 14,400 L of hot water per day to clean the sewage effluent screens. The building's water heating system currently consists of a steam fired water heater that takes fresh water from a storage tank (FEW Tank) to refill the heaters at a rate of 40 L/min for 15 minutes each hour. The same water piping is also connected to the plumbing faucets for use in the building. The FEW tank is an uninsulated stainless steel tank with a maximum capacity of 18,000 L. The tank is filled up with 3-5 °C water once per day when the water level in the tank drops to about 3,000 L. The water inside the tank cannot be hotter than 30 °C, because it would cause excessive temperatures in the room in which it's located.

The FEW Water system has a recirculating pump that runs 24/7, and connects to the inlet of the water heater tank, and to the plumbing faucets of the facility; a flowvalve in line opens to refill the water heater tanks every hour for 15 minutes only. The average rate of hot water consumption is 40 L/min during the 15 minutes. The facility water system is kept at a constant pressure of 60-80 PSI (tap pressure).

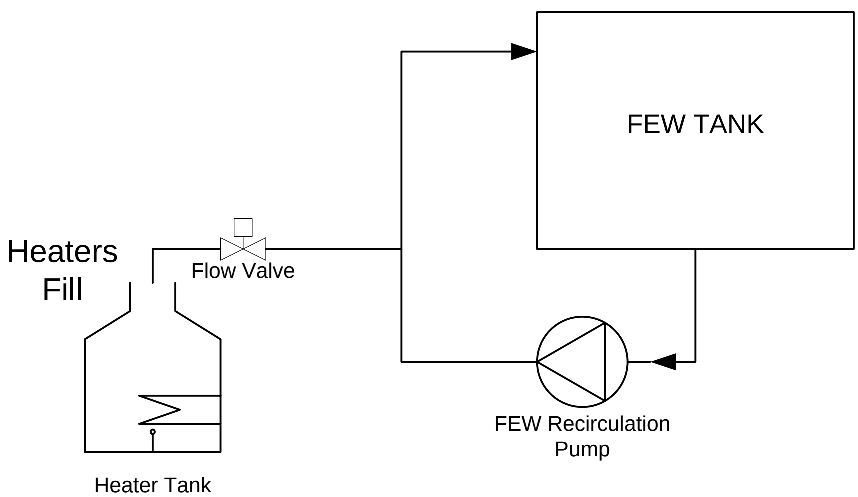


Figure 9: Recirculating system

Heat recovery closed loop

MAGS requires an independent loop of cooling water in order to prevent any kind of water contamination of the main water supply (FEW tank in this case). The closed loop for MAGS requires the following main components:

First, it requires a dedicated water pump to recirculate the cooling water through MAGS and the heat recovery components at a minimum flowrate of 15-25 GPM and 50 PSI. This way the main water supply tank has 2 degrees of separation from the MAGS process water used for gas cleaning. In the unlikely event of a leakage from one of the MAGS heat exchangers, or condensers there is absolutely not risk of contaminating the fresh water supply.

Then, in order to recover the heat from the MAGS unit, the outlet of the MAGS must flow through a heat exchanger to pre-heat the water going into the water heaters reservoir to reduce the energy demands of the boiler.

Finally, since the water flow to the heater is not continuous (15min per hour), the excess heat generated by MAGS must be removed with a unit heater, which can be used for space heating. The unit heater must be rated for at least 100 kW; large enough to take the full heat load from MAGS when the water heaters are not running.

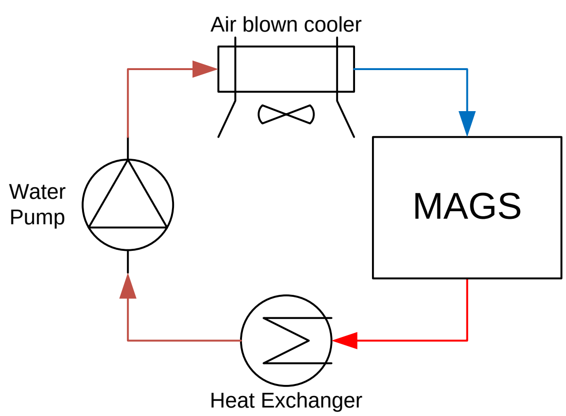


Figure 10: MAGS heat recovery loop

The current fresh water system setup has room for 3 water pumps connected in parallel used for the FEW water system. Currently there are only 2 pumps installed and there is room for a third one, which can be used for MAGS. That location is ideal because it is close to the MAGS unit and to the water heater inlet installation.

Pre-heating of water going into the water heaters

Water temperatures at the outlet of MAGS fluctuate between 50-60°C. In order to maximize the heat transfer to the water heaters, a heat exchanger should be installed where the hottest water is required: at the inlet of the water heater tank. The flow of water through this line only occurs when the water fill flowvalve opens (15min every hour). The ideal location for the heat exchanger is right before the flowvalve of the heaters (see Figure 11 below), because at this location only the water going into the water heaters is pre-heated, and no heat is transferred into the main water supply (FEW Tank) or the plumbing faucets.

The specs for the recommended heat exchanger are found below:

Thermofin PLATES AND HEAT EXCHANGERS – ITEX Model number: PWB-8-22-41H00 Duty: 88.5 kW		
	Water	Water
Inlet / Outlet temp.	74.5 / 30 °C	28 / 64.5 °C
Flow	0.5 kg/s	0.61 kg/s
Pressure drop	0.576 kPa	0.837 kPa
Fouling	0.000005 m2.K/W	0.000005 m2.K/W
Design / test pressure	150/195 PSI	150/195 PSI
Position of fluids	Circuit 1	Circuit 2

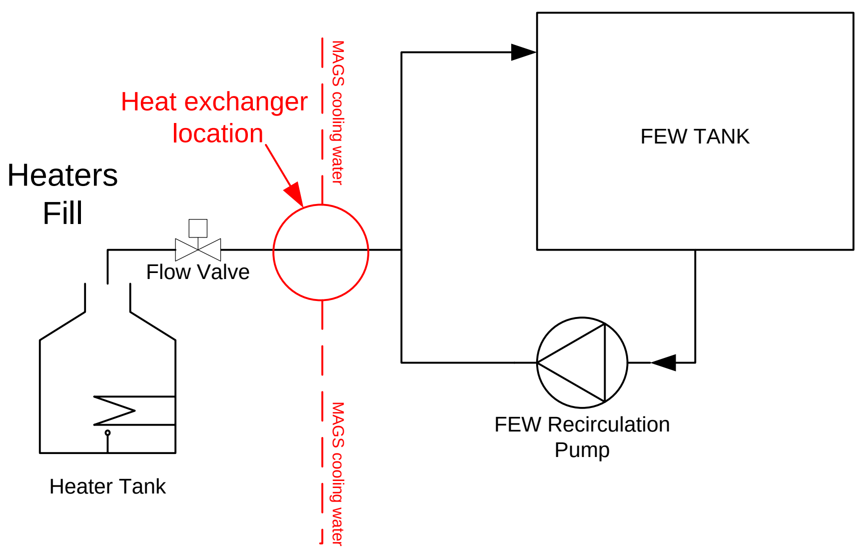


Figure 11: Location of Heat Exchanger

Building space heating

Following the heat exchanger, the excess heat from the closed loop must be removed before returning to MAGS. The simplest and most practical way to do this is by having a unit heater for space heating. A 100 kW unit heater should be installed in a room that is large enough that requires continuous heating (up to 100 kW) or 2 unit heaters of 50 kW in 2 different rooms such as the garage where MAGS is installed and the second floor of the building. Cool water should come out of the unit heater at a maximum of 25-30 °C in order to allow MAGS operation. Water temperature above 30 - 35 °C will overheat MAGS.

The unit heater must have a high output in order to take the full load of the MAGS when the water from the FEW tank is not being consumed (45 min per hour). In the spec. sheets of such unit heaters the manufacturers usually describe the capacity of unit with the hot fluid entering at 90 °C. It is very important that in the selection process the corrective factor for 60 °C entering fluid temperature (MAGS outlet), 25 °C entering air temperature (room temperature), and 20 °C temperature drop are taken into account in order to size the unit properly. The rated output specified in the spec. sheet must be multiplied by 0.5 in order to get the actual output for this application.

For example:

Brand: Trane Unit Heaters
Model: P500
Capacity specified in specs. : 333.6 BTU/hr (97.7 kW)
Temperature drop: 20 °C
Corrective factor: 0.5
Actual Output: 97.7 kW x 0.5 = **48.5 kW**
Link:http://www.trane.com/content/dam/Trane/Commercial/global/products-systems/equipment/terminal-devices/unit-heaters/s-p-unit-heaters/UH-SVX01A-EN_05012007.pdf

➔ **MAGS would need at least 2 units heaters of this model to have an output of 100 kW**

Current installation

The current installation at the Waste Water facility does not meet the requirements necessary for the heat recovery from MAGS. The current setup uses the fresh water from the FEW tank (18,000 L) as the cooling medium, and then it is recirculated back into the tank. The MAGS output is 80-100 kW, hence the uninsulated tank will increase in temperature only within a few hours of operation and the MAGS will not have enough cool water to operate. Also, the installation does not have a heat exchanger in line to pre-heat the water going into the water heaters, so the heat recovery is only being used for space heating, which is not the only objective. Then, the unit heater currently installed in line with the MAGS is undersized (actual output of 15 kW only), and it is in such a place that it is not cooling the MAGS water (hottest water), but the water from the 18,000 L tank. This makes the cooling very inefficient because the water in the tank is only ~30 °C, and the room temperature is 20-25°C. A 5°C temperature difference will achieve no cooling whatsoever and the water in the tank will reach higher temperatures that will be too hot to operate MAGS. Also, it is a safety hazard to keep such a large volume of water (18,000L) at temperatures above 30 °C.

(See draft of current installation below)

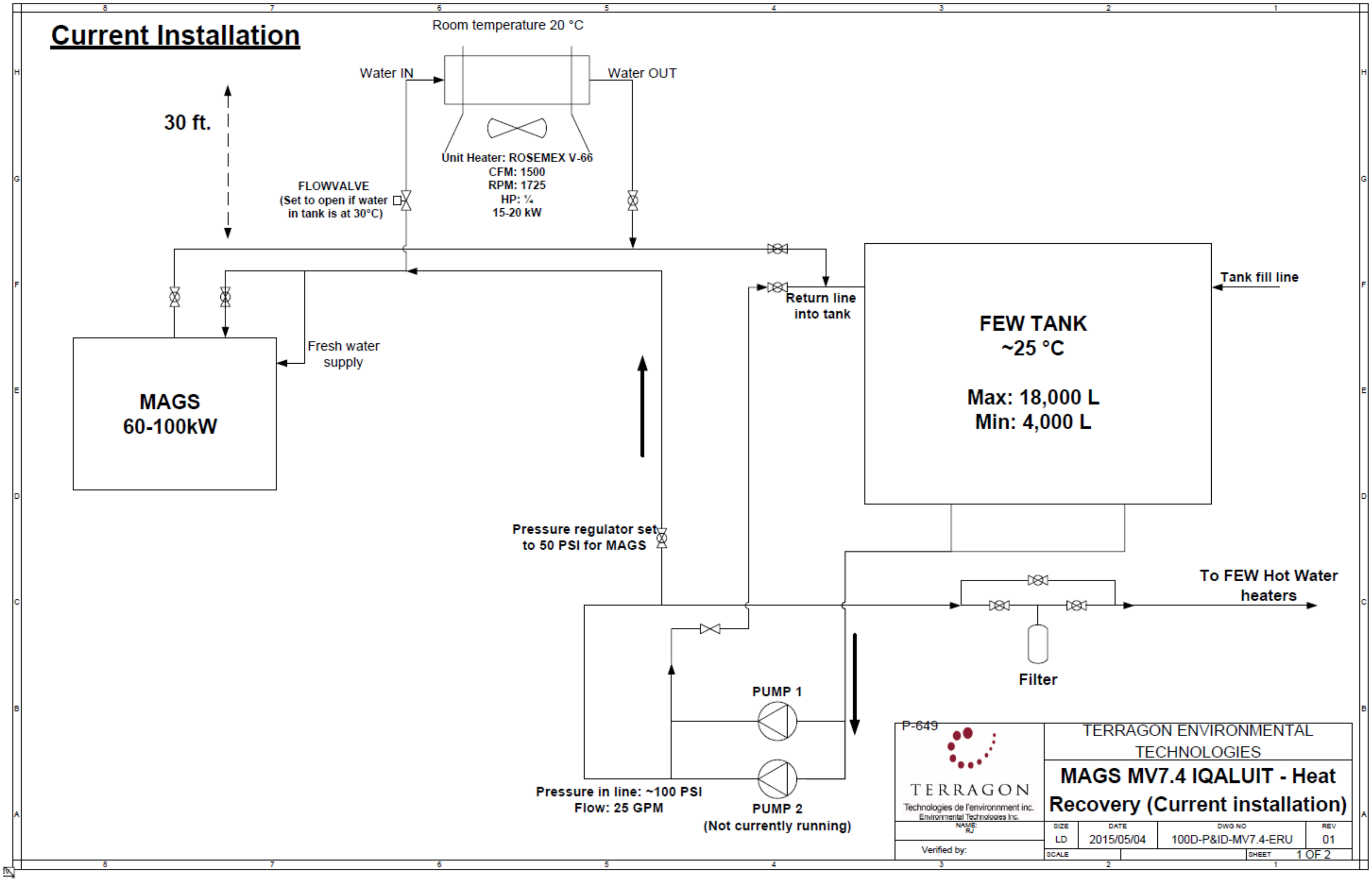


Figure 12: Current Installation layout

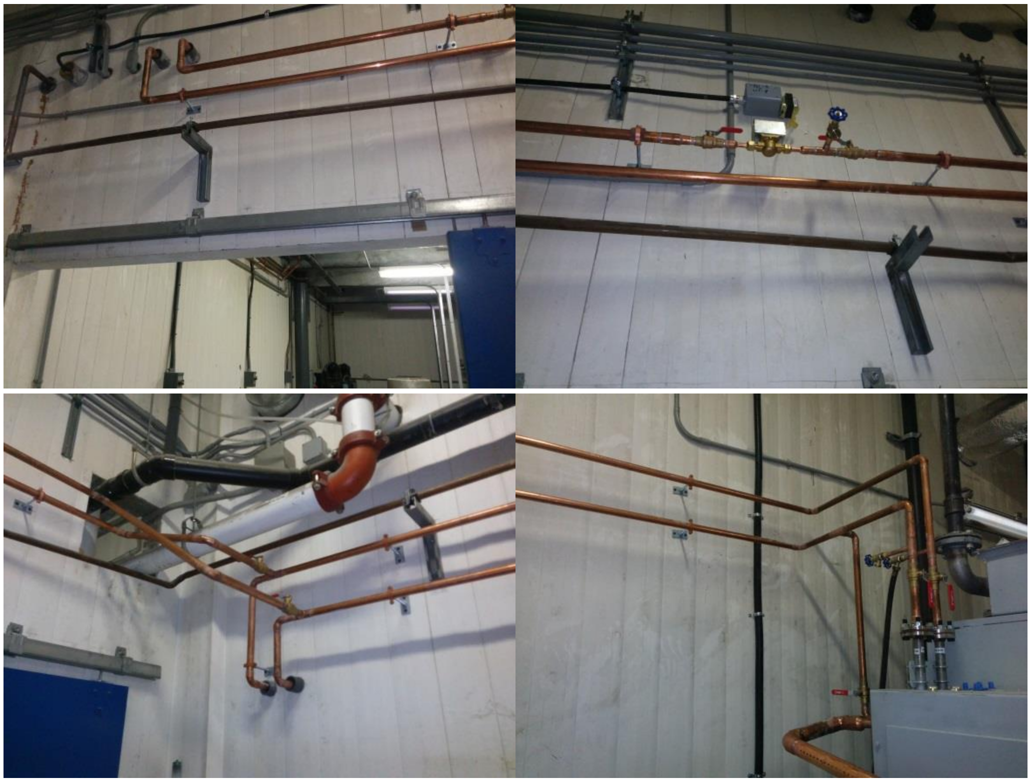


Figure 13: Current installation piping

Required modifications

The current installation can be modified to meet the requirements by reusing the piping already in place. Nonetheless, the installation and replacement of several components are necessary such as:

- Install new heat exchanger to pre-heat water going into heaters.
- Install new water pump of at least 15-25 GPM and 50 PSI (115 ft of head) for the heat recovery closed loop.
- Replace unit heater with one rated to 100 kW of duty (with temperature correction factor).
- Modify copper and cast iron piping to connect the new components in line.

(See draft of installation required below)

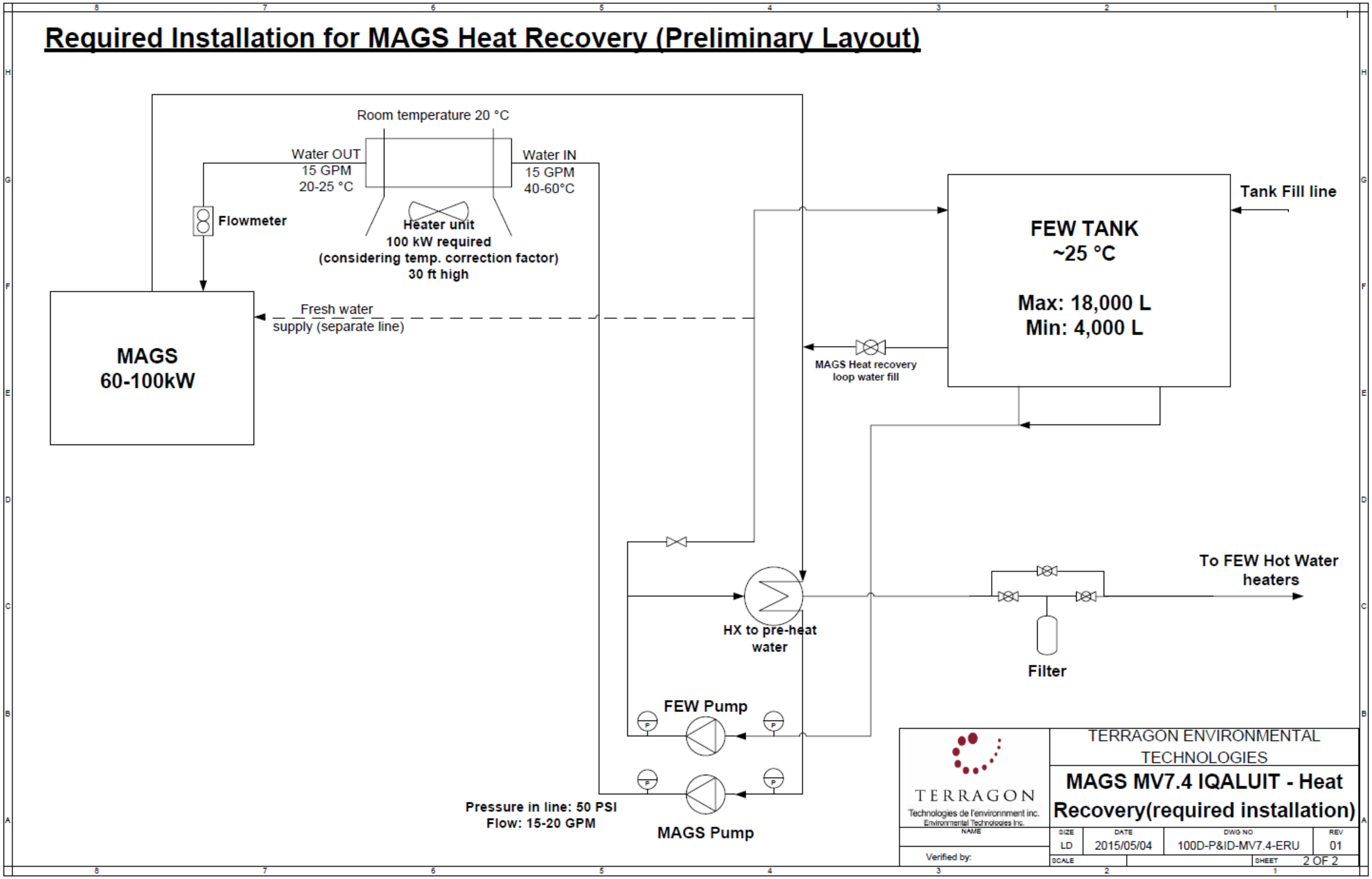


Figure 14: Required installation layout

8. Conclusion and next steps

In conclusion, MAGS was successfully commissioned and inspected. The system has no major damages from transportation and storage, the only damaged component is the diesel pump power cable that will be replaced on the next visit. Also, the sludge tank must be corrected to allow sludge treatment.

The only concern at this point is the Heat Recovery Installation for MAGS, which does not meet the requirements for the heat recovery of the system and must be modified before operation begins. These modifications require the proper water pump, heat exchanger, and unit heater sizing; as well as the selection and installation of proper measurement and control instruments for monitoring and controlling water temperatures (Thermocouples, flowmeters, pressure gauges, etc.). The layouts explained in this document are only preliminary designs with the purpose of explaining the installation requirements; proper drawings with detailed equipment description are required.

Once the heat recovery installation is modified and fully tested, the personnel from the City of Iqaluit will be trained on the operation and maintenance of MAGS.

TERRAGON
Environmental Technologies Inc.

MAGS™ 7

Waste Treatment Unit

Freezing condition protection on installation site

MAGS 7.4 – City of Iqaluit

December 2015

Introduction

With ambient temperatures getting close to freezing point it is essential that the MAGS sensitive components stay protected from freezing. This document describes the components that are susceptible to damage by freezing and the proper preventive action or measures to ensure the system's integrity.

Sensitive components:

The sensitive components are those containing water piping that is susceptible to cracking following water expansion during freezing.

- Separator water circulation
  - Ring pump casing
  - Ring pump priming lines and solenoid
  - Separator tank
- Process water circulation
  - Process water (P501) pump casing
  - pH probe
  - Process water circulation piping (copper)
  - Process water filter

Preventive freeze protection:

MAGS only produces its own heat during operation; therefore, when not in use the unit should be always kept at temperatures above freezing. If the MAGS is not operated, and it is exposed to freezing conditions, preventive action is required to avoid costly damages to the system.

The preventive measures are required to prevent water freezing in the pipes and consists on draining the water from the exposed water lines as well as removing the temperature sensitive components (pH probe). Once this procedure is completed the system can safely be stored at temperature below freezing.

Preventive freeze protection procedure

The following instructions explain how to perform these procedures:

A. Separator tank drainage
B. Ring pump casing
C. Scrubber tank
D. pH probe removal
E. Process water filter housing drainage
F. Compressed air drainage and depressurization
G. Closed cooling loop drainage
H. Isolate MAGS from energy recovery loop

System preparation for procedure:
In order to purge the water from the system the following will be required:

- ➔ Powered MAGS by turning ON transformer
- ➔ Discharge barrels available for drain water (x2) or available drain to city

Note: Wear protective glasses and gloves.

PROCEDURE

A. Separator loop draining

1. Power the system **ON** using the black handle on the electrical cabinet. [DO NOT start up the system, just power it up to be able to drain the components] To do so simply turn the black handle to the **ON** position and wait a few minutes until the touchscreen loads.
2. Enter the letter “m” as for the username and password to log into the system.
3. On the touchscreen go to **Administration→Automation→**Find the component **“Auxiliary Module”** in the Module Status list, and press the button that says **“Manual”** to override the value, and then press the button on the right to turn the **“Auxiliary Module”** ON. At this point you should hear the compressor starting.
4. Once the compressor stops, and you don’t see any alarms on the screen (if any alarm triggers the screen will display with a RED background), go to the touchscreen, and select the tab **“Device/Instruments”.**
5. Then, in the **Device/Instruments** menu at the top of the screen press on **“Device Type”**, and select **“Flowvalve”** from the drop-down menu.
6. Then, find **FV702** by scrolling up and down on the list of components, and then press the **“Manual”** button to override the valve, and then press the button on the right to open the **FV702** ON. This will drain the Separator tank completely to the scrubber tank.
7. Then, on the same page, find **FV701** by scrolling up and down on the list of components, and then press the **“Manual”** button to override the valve, and then press the button on the right to open the **FV702** ON. This will drain the remaining water to the ring pump.
8. Wait for a 5-8 minutes until all the water is drained out, and then turn **FV702**, and **FV701** OFF by turning the **“Manual”** button OFF.
9. Then, go to **Administration→Automation→**Find the component **“Auxiliary Module”** in the Module Status list, and press the button that says **“Manual”** remove the Manual override and turn the compressor OFF.
10. Then, Power **OFF** the electrical cabinet by turning the black handle to the **OFF** position. The touchscreen should go off and turn black.

Now that the separator is fully drained, proceed to drain the scrubber tank. Make sure that there are discharge barrels available or a hose available to connect to the scrubber tank to drain the tank. (This is the step where most of the water is discharged).

B. Ring Pump drainage

The ring pump should not have any water in the housing. To drain the housing open the hand valve to make sure that there is no water in the housing.

Items required:

- 1/2” barb fitting
- 1/2 “ hose

Procedure:

1. Open the ring-pump drain hand-valve to drain any water that remained in the pump casing (See **Figure 1**).
2. Close the hand-valve once no more water comes out.

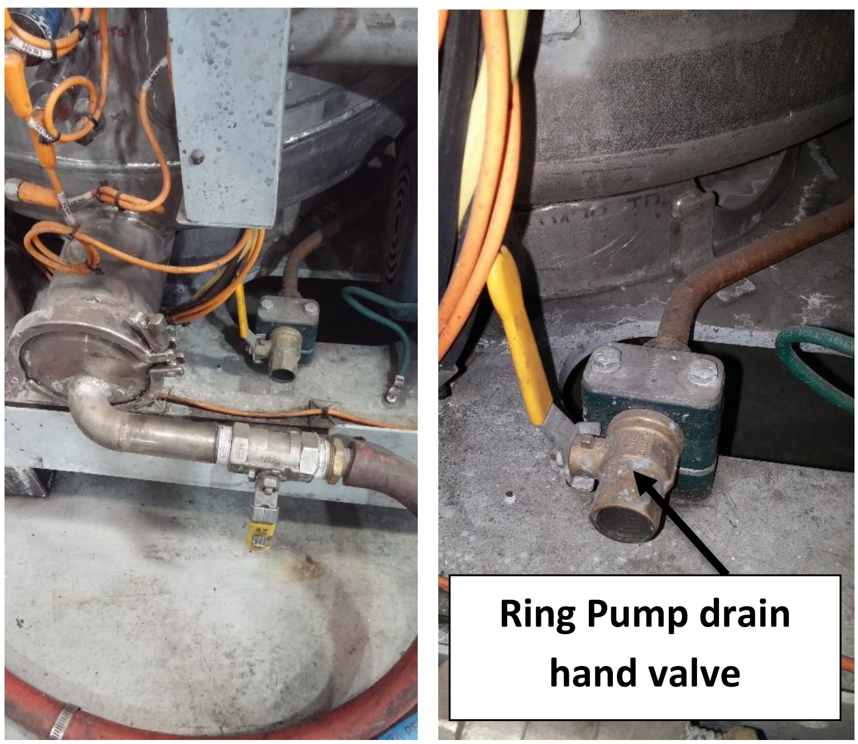


Figure 1: Ring pump drain

C. Scrubber tank drainage

Items required:

- 1” hose
- Empty buckets
- Rags to clean if water spills

Procedure:

1. Locate the Drain hand valve at the bottom of the tank as indicated in the photo below (**Figure 2 and Figure 3**).

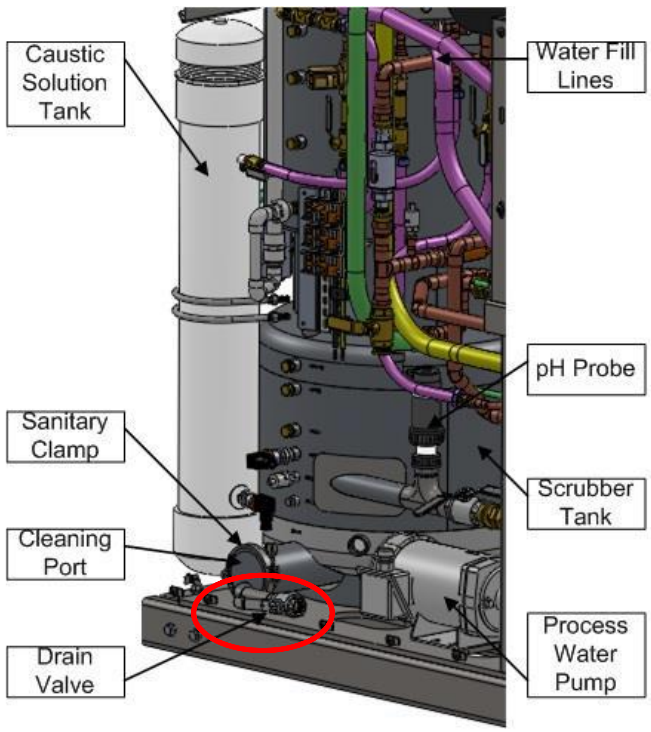


Figure 2: Scrubber tank drain location

2. Connect a hose to the hand valve before opening the valve, and make sure the other end of the hose goes to a bucket or directly to the drain.
3. Once the hose is in place, fully open the hand valve to drain the tank.
4. Then, when no more water comes out of the tank, close the hand valve and remove the hose.

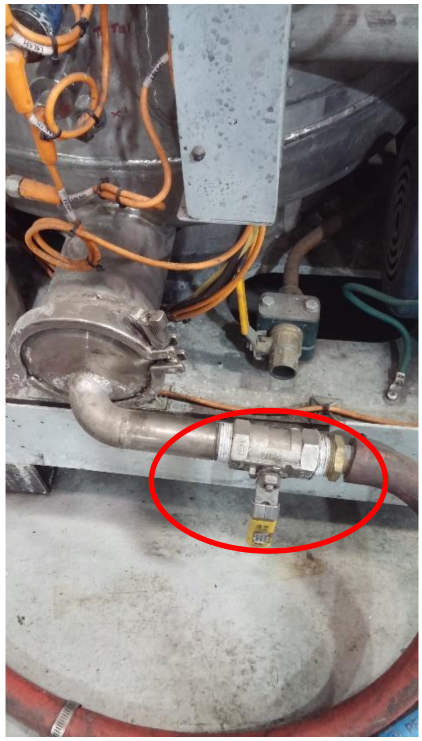


Figure 3: Scrubber drain

D. pH probe removal

Once the scrubber tank is empty, the pH probe must be removed from the transmitter and the tip of the probe must be kept in water.

<u>Procedure:</u>

1. Unscrew the top union (See **Figure 4**)
2. Disconnect the orange cable and gently pull out the transmitter from the white adapter.
3. Unscrew the pH probe from the white adaptor and **<u>place the tip of the sensor in water in a container</u>.**
4. Unscrew the bottom union (See **Figure 4**) to remove the adapter from MAGS.
5. Seal the opening of the pipe, and put the transmitter and the adapter away in a box and store properly.

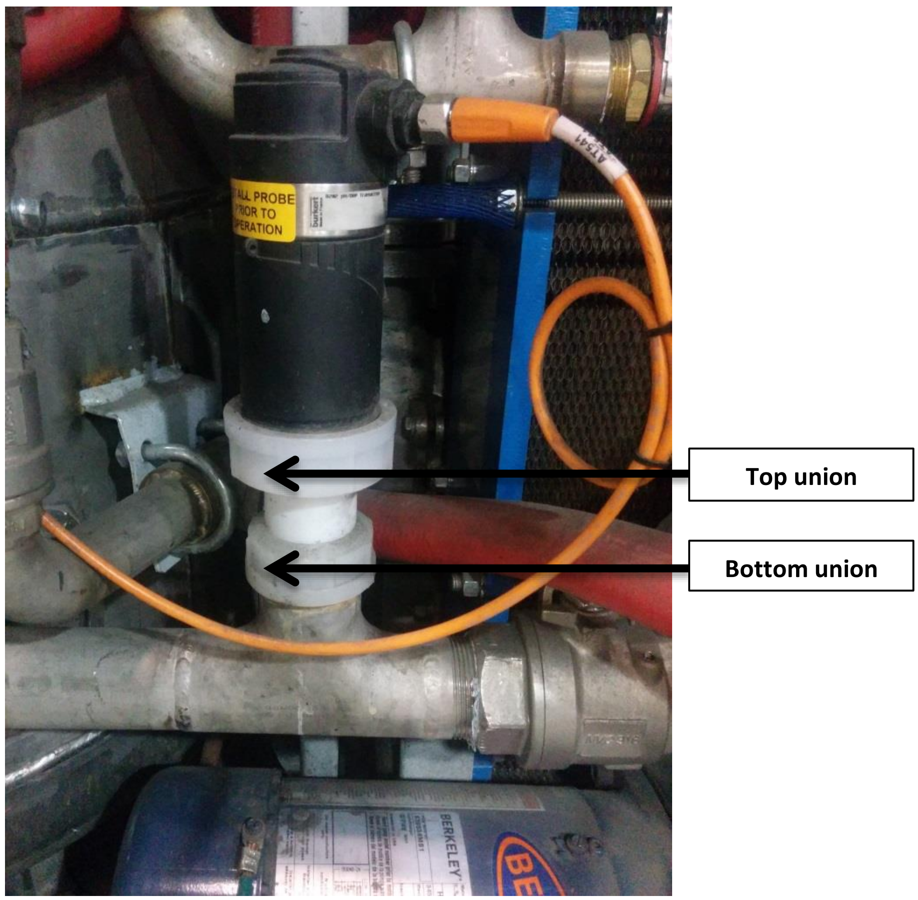


Figure 4: pH Transmitter

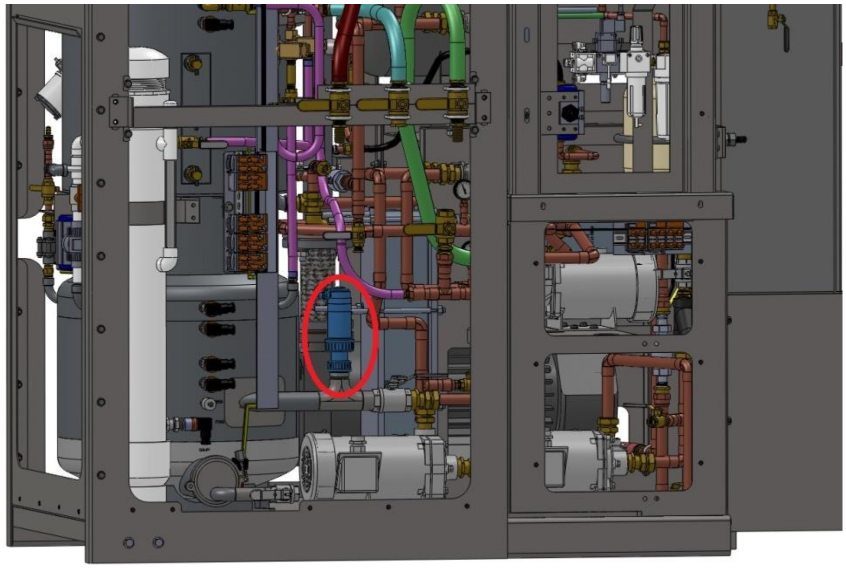


Figure 5: pH Transmitter location

E. Process water filter housing drainage

The process water filter housing must be manually drained to prevent water from freezing in the filter housing.

Items required:

- Empty bucket
- Wrench

Procedure:

1. Make sure the system is **OFF**.
2. Open the Filter housing drain hand-valve (See **Figure 6**) located at the bottom of the filter housing, and collect the water in a bucket. If flow stops, insert a small rod though the valve to push out solids that may be blocking the flow. At least 1-2 buckets of water should come out through the housing drain valve. To help with the water flow, remove the air plug located on the housing cover (See **Figure 6**).
3. Once the housing has been fully drained, tighten the air plug back and close the hand-valve.

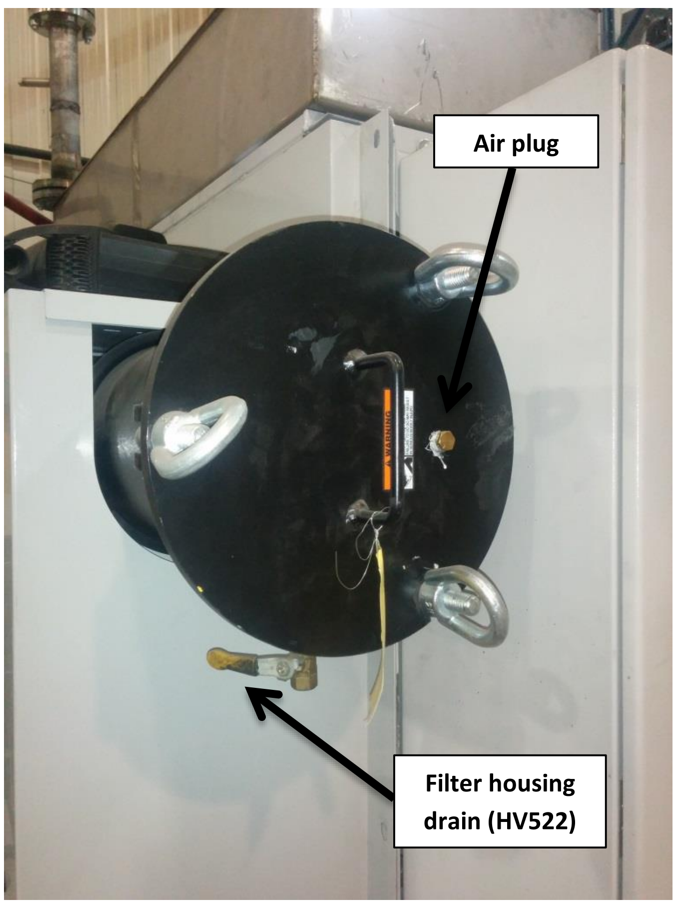


Figure 6: Filter housing draining

F. Compressed air tank draining and depressurization

The compressed air storage tank on the MAGS accumulates water contained in the air drawn in from the atmosphere before it is compressed. The tank is located on the Water Skid and is located directly behind the main electrical cabinet. It is important to drain the accumulated water and more importantly to depressurize the tank completely for storage.

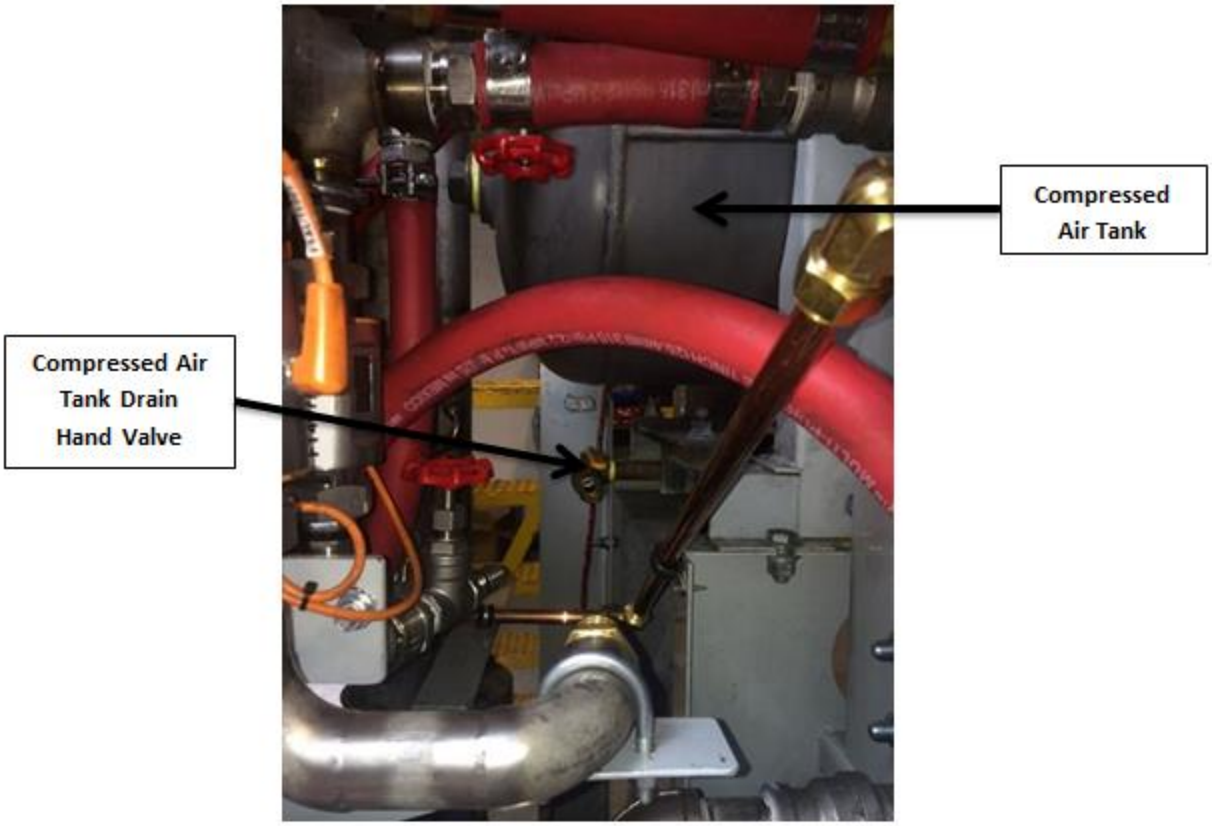


Figure 7: Compressed Air Tank

Procedure:

1. On the water skid slowly open the "**Compressed Air Tank Drain Hand Valve"** located below the tank as indicated in **Figure 7**.
2. At first, water and air will drain out simultaneously.
3. Wait until all water comes out and the tank is fully depressurized, and then close the drain hand-valve.

G. Closed cooling loop drainage

The water in the internal closed cooling loop that recirculates cold water through MAGS must be drained through one of the draining valves located on the water skids.

Procedure:

1. With the system **OFF** locate the flowmeter PSAL001/TE001 in the water skid, and follow the piping until you find a hand-valve with an outlet in the same loop (See **Figure 8**).
2. Connect a hose to the hand-valve and place the hose into a bucket.
3. Open the hand-valve to drain all the water out of the loop, leave the hand-valve open for a few more minutes until no more water comes out
4. Then close the hand valve and remove the draining hose from the draining valve.

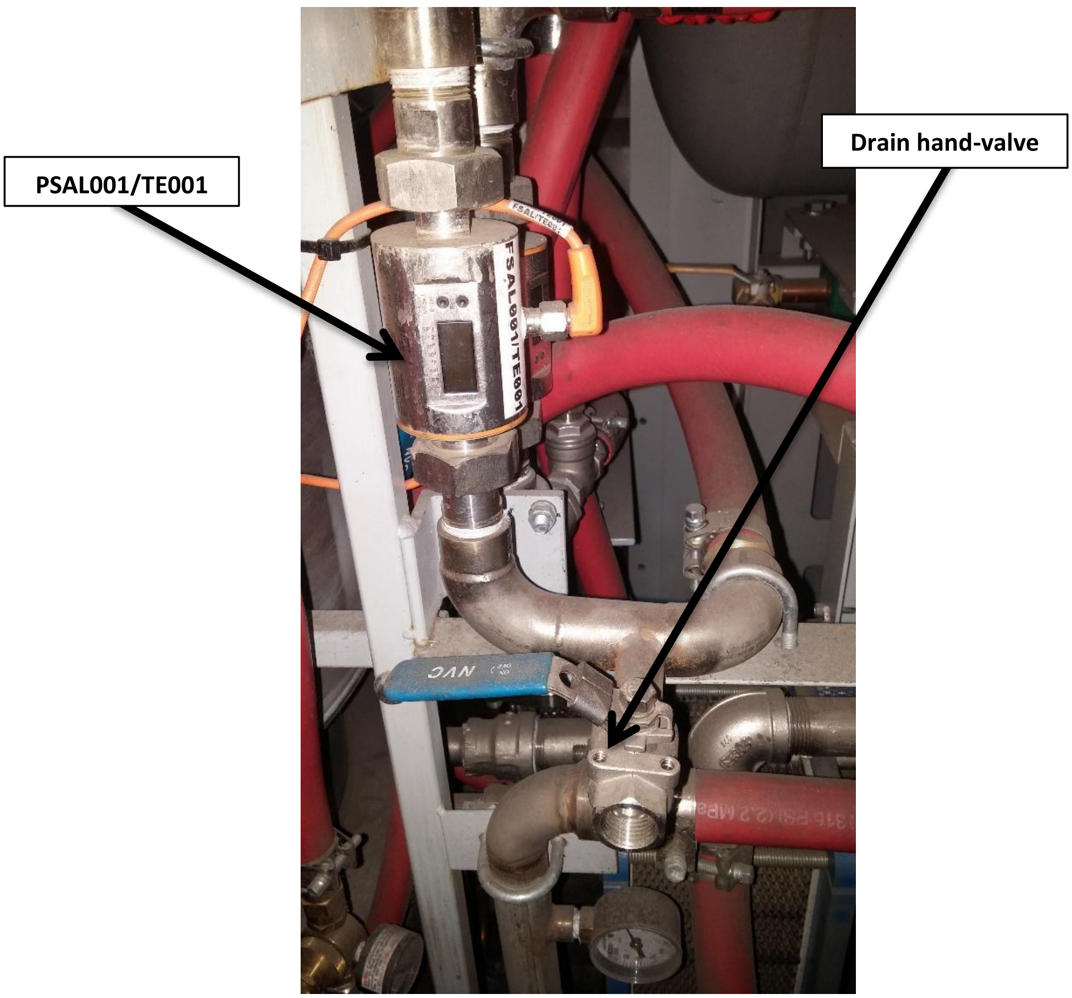


Figure 8: Closed loop cooling drain hand-valve

H. Isolate MAGS from energy recovery loop

1. In order to isolate the MAGS from the cooling water from the building, close the main water inlet by closing ‘**Hand-valve #1’** and ‘**Hand-Valve #2’** as indicated by **Figure 9** below. These are located in the boiler room in the second floor right next to the tank.

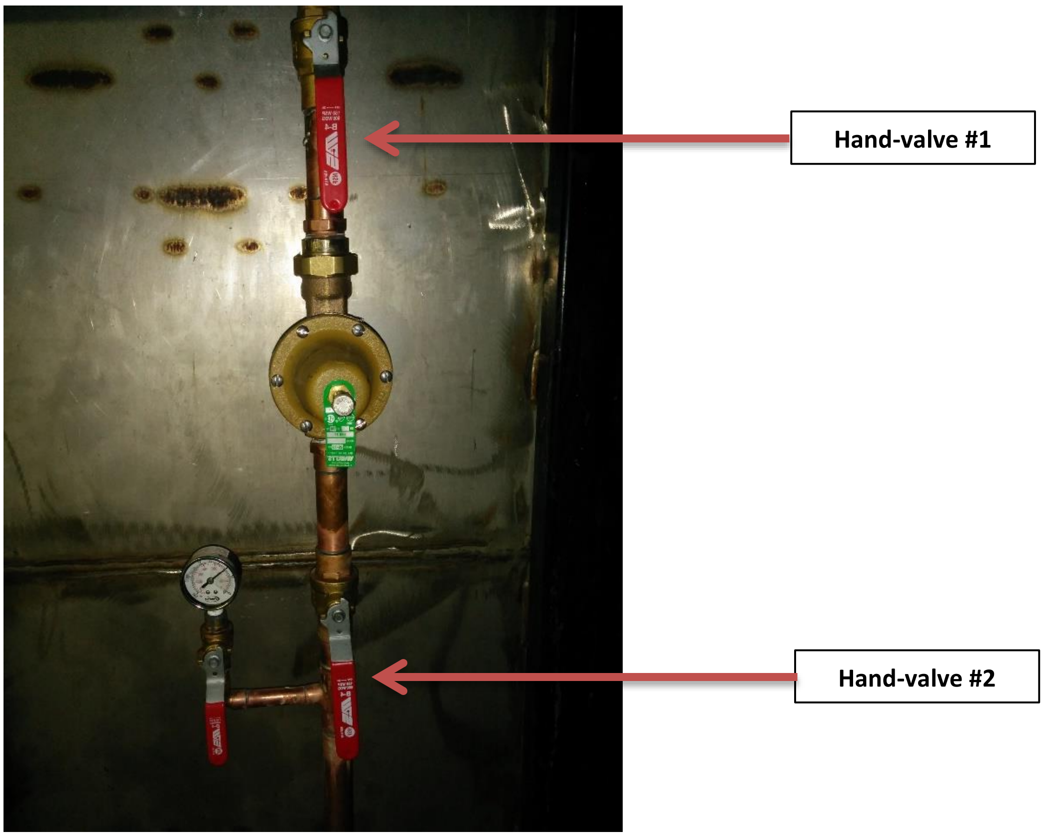


Figure 9: Main cooling water hand-valve

2. Next, close the water outlet from the cooling piping, by closing the **'RED Hand-valve'** located above the boilers by the main water tank. **<u>DO NOT TOUCH THE YELLOW HAND-VALVE.</u>**

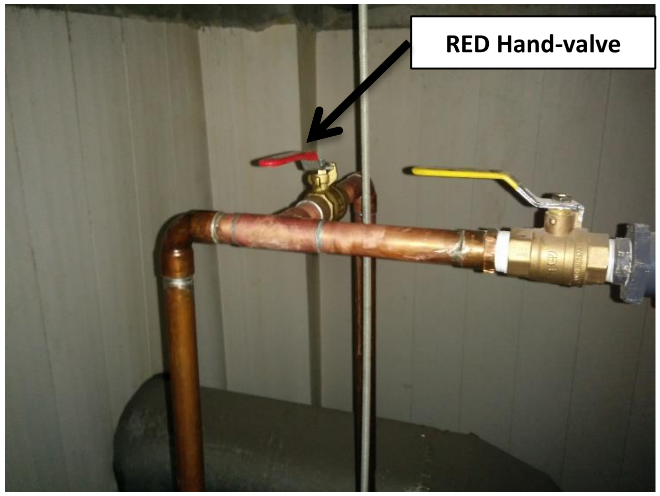


Figure 10: Return line hand-valve

3. Next, connect a hose on the ‘Drain ports’ as seen in **Figure** 11 below, and open the blue drain hand-valves in order to drain the water remaining on the pipes, and to relief the pressure in the lines.
4. When no more water comes out of the drain then, close **Hand-Valve IN** and **Hand-Valve OUT** (see **Figure 11**).

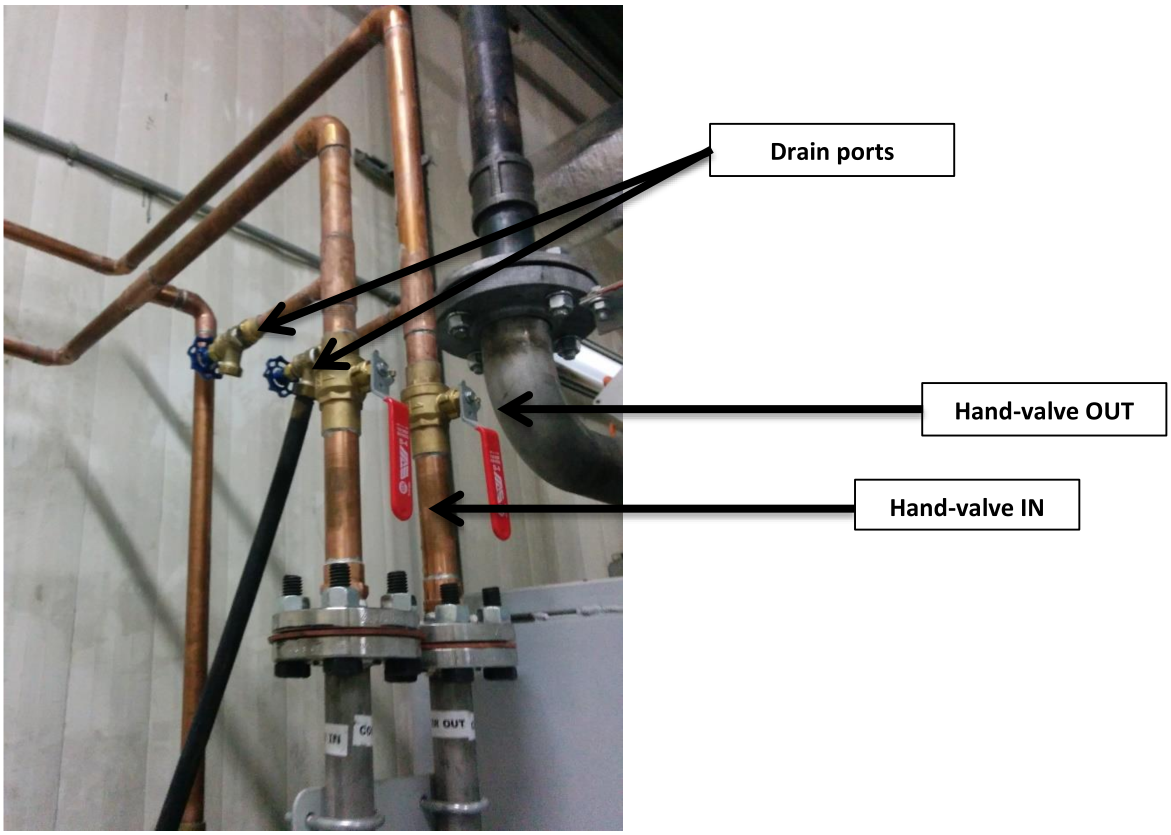


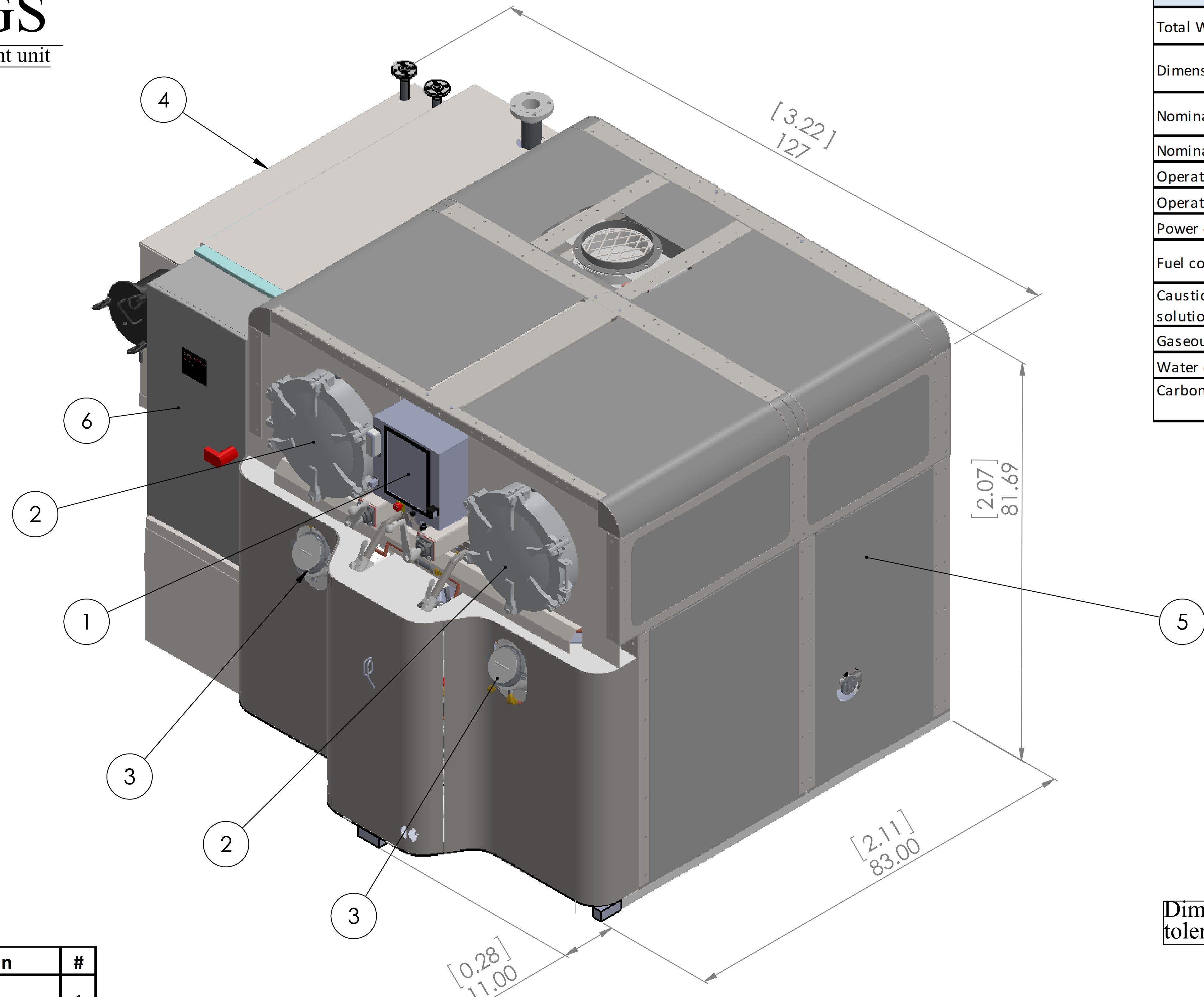
Figure 11: MAGS water connection

5. Finally close the third hand-valve as indicated in **Figure 12**

Figure 12: Hand-valve water fill

MAGS

waste treatment unit



MAGS TECHNICAL SPECIFICATIONS	
Total Weight of MAGS :	4900 kg (11 000 lbs)
Dimensions MAGS:	3.2m X 2.1m X 2.1m
Nominal Solid Waste Throughput:	Marpol waste, 35 kg – 45 kg of waste per hour.
Nominal Sludge/Oily Waste Throughput:	13 L/hour
Operating Temp. in Primary Gasifier:	600 °C
Operating Temp. in Combustion Chamber:	1100 °C
Power consumption:	25 kW
Fuel consumption:	8.3 L/hour of Diesel fuel, for two hours per day
Caustic Consumption (NaOH 10 wt % solution):	Average 2.4 L/day
Gaseous emissions:	0.09 cu. m/s (200 scfm)
Water emmissions:	Average 1 L/ hour of water
Carbonaceous char:	Average 8% in weight of the total waste treated

Dimensions in inches and [meters]
tolerance of +/- 1/8" and [3 mm]

Description	#
Control Panel (HMI)	1
Waste Loading Hatch	2
Char Removal Port	3
Service Panel (caustic tank and scrubber)	4
Service Panel (sludge system)	5
Power Cabinet	6

TERRAGON
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Fax: (514) 938-0721
www.terragon.net

DATE 20-03-2013

UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES

FRACTIONAL	± 1/16"
DECIMAL	± 0.01"
	± 0.005"
ANGULAR	± 1°

THIRD ANGLE PROJECTED

DO NOT SCALE DRAWING

TITLE

MAGS 7

general layout

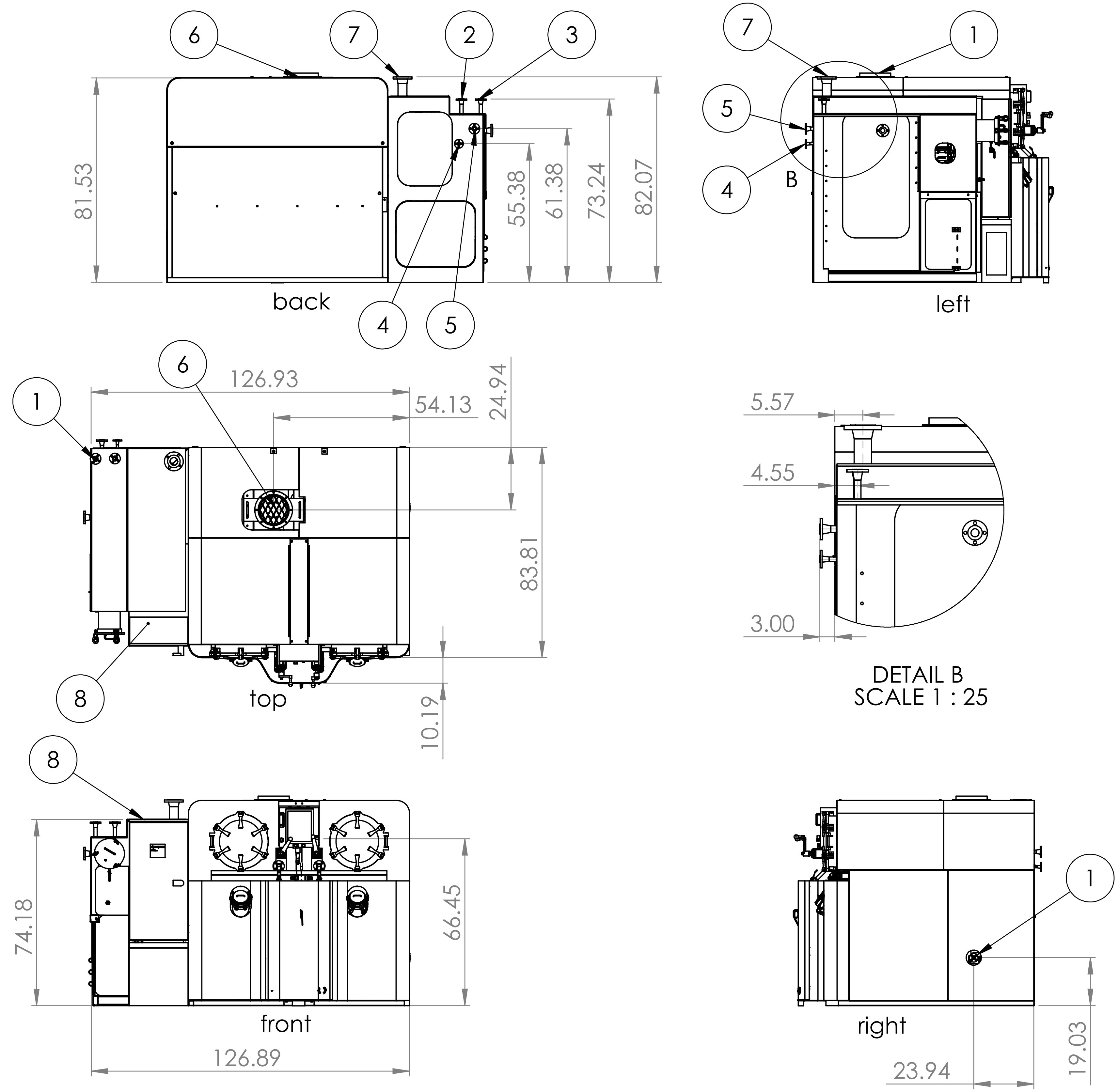
SHEET 1 OF 3

Fluid Connections

#	Name	fluid	pipe size	connection	flow rate	pressure	temperature
1	Fuel inlet	light oil #2 (diesel)	1/2" nominal (DN 15)	class 150 lbs four bolt flange	8.5 liters/hour (2.25 GPH) (operating two hours per day)	max inlet pressure: 205 kPa (30 PSIG) min inlet pressure: 10 kPa (1.5 PSIG)	N/A
2	Heat recovery water inlet	utility water	1" nominal (DN 25)	class 150 lbs four bolt flange	30 liters/ min (8 GPM)	max inlet: 400 kPa (60 PSIG) min: 150 kPa (20 PSIG)	max allowable inlet temp: 25 C (77 F)
3	Heat recovery water outlet	utility water	1" nominal (DN 25)	class 150 lbs four bolt flange	30 liters/ min (8 GPM)	outlet: 100 kPa (14.5 PSIG) below inlet pressure	30C to 45C above inlet temp (54 F to 81 F)
4	Process water inlet	fresh water	1/2" nominal (DN 15)	class 150 lbs four bolt flange	periodic use: average 4 liters per day (1.1 gal/day)	max inlet pressure: 400 kPa (60 PSIG)	max allowable inlet temp: 45 C (113 F)
5	Process water outlet (drain)	dischargeable water	2" nominal (DN 50)	class 150 lbs four bolt flange	1 litre per hour average (0.26 GPH)	max oulet pressure: 70 kPa (10 PSIG) (goes to drain should have no back pressure)	outlet temp : 55 C (131 F)
6	Ventilation exhaust	air	12" duct	12" duct socket	40 cu.meters/min (1400 SCFM)	max static: 0.125 kPa (0.01 PSIG)	10 C to 15 C (18 F to 25 F) above room temp
7	Process exhaust	air + CO2	2.5" nominal (DN 80)	class 150 lbs four bolt flange	0.09 cu.meters/sec . (200 SCFM)	N/A	max nominal: 55C (131 F) max emergency: 150 C (302 F)

Electrical Connection

#	Name	voltage	fuse size	power
8	Electrical connection	460 volts, 3 phase, 60 Hz	45 amps	nominal draw: **25 Kilowatts**



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TOLERANCES

FRACTIONAL	± 1/16"
DECIMAL	± 0.01" ± 0.005"
ANGULAR	± 1°

DATE 20-03-2013

THIRD ANGLE PROJECTED

DO NOT SCALE DRAWING

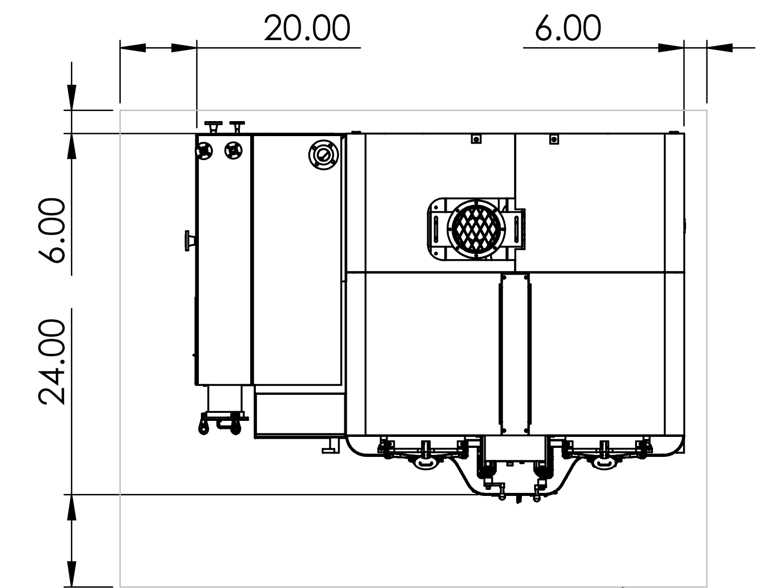
TITLE

MAGS 7

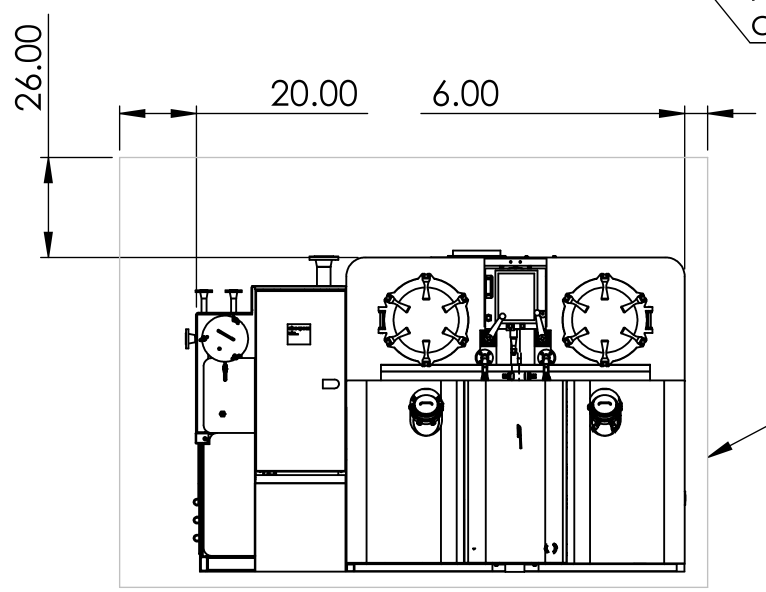
dimensions & connections

SHEET 2 OF 3

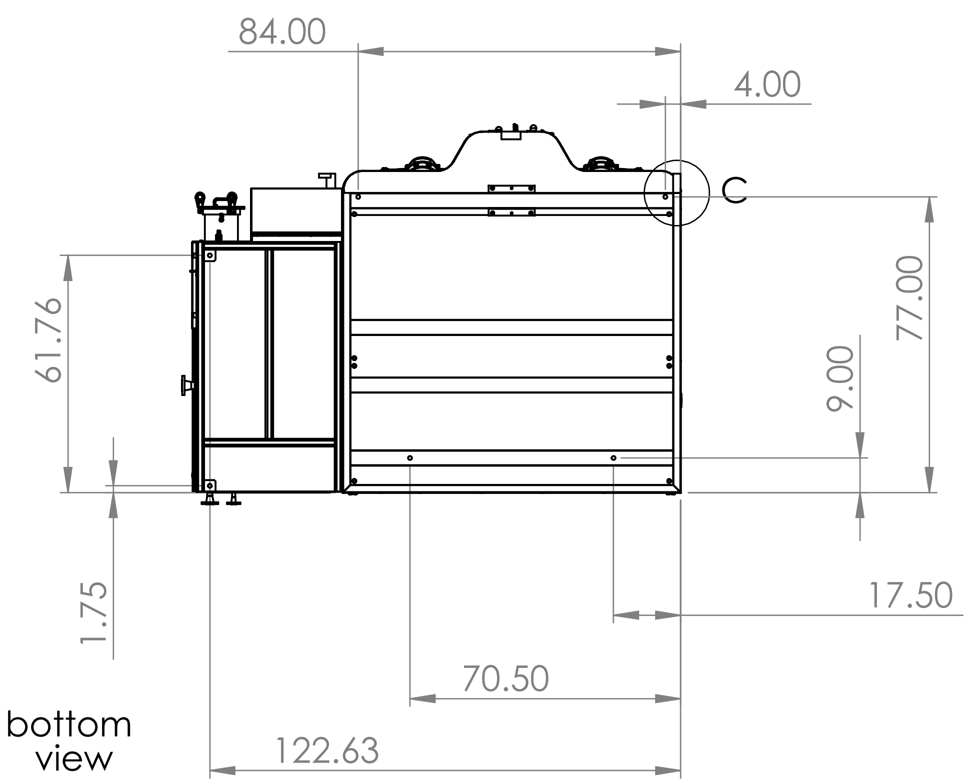
Required clearances around MAGS unit
(exceptions to the required clearances can be made
if space rerquirements are restrictive, specifically overhead clearance)



required
clearance

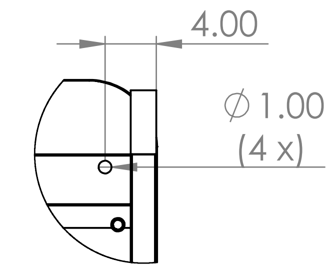


required
clearance

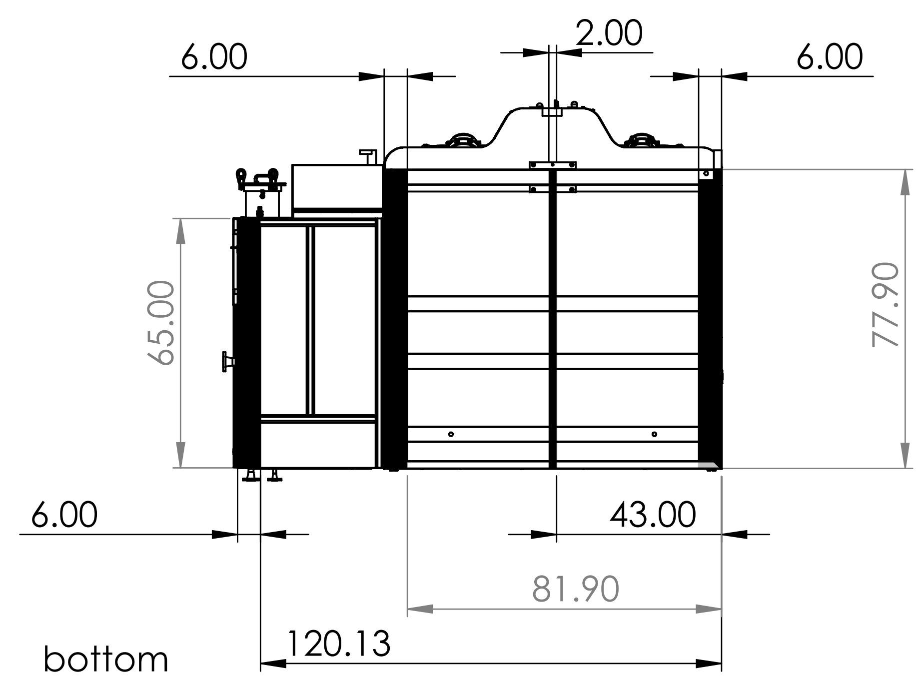


bottom
view

Anchor points for fixing
MAGS unit to concrete
floor slab



DETAIL C
SCALE 1 : 15



bottom
view

Areas in black requiring
support on MAGS unit if
not mounted onto concrete
slab.

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TOLERANCES

FRACTIONAL	± 1/16"
DECIMAL	± 0.01"
	± 0.005"
ANGULAR	± 1°

THIRD ANGLE PROJECTED

DO NOT SCALE DRAWING

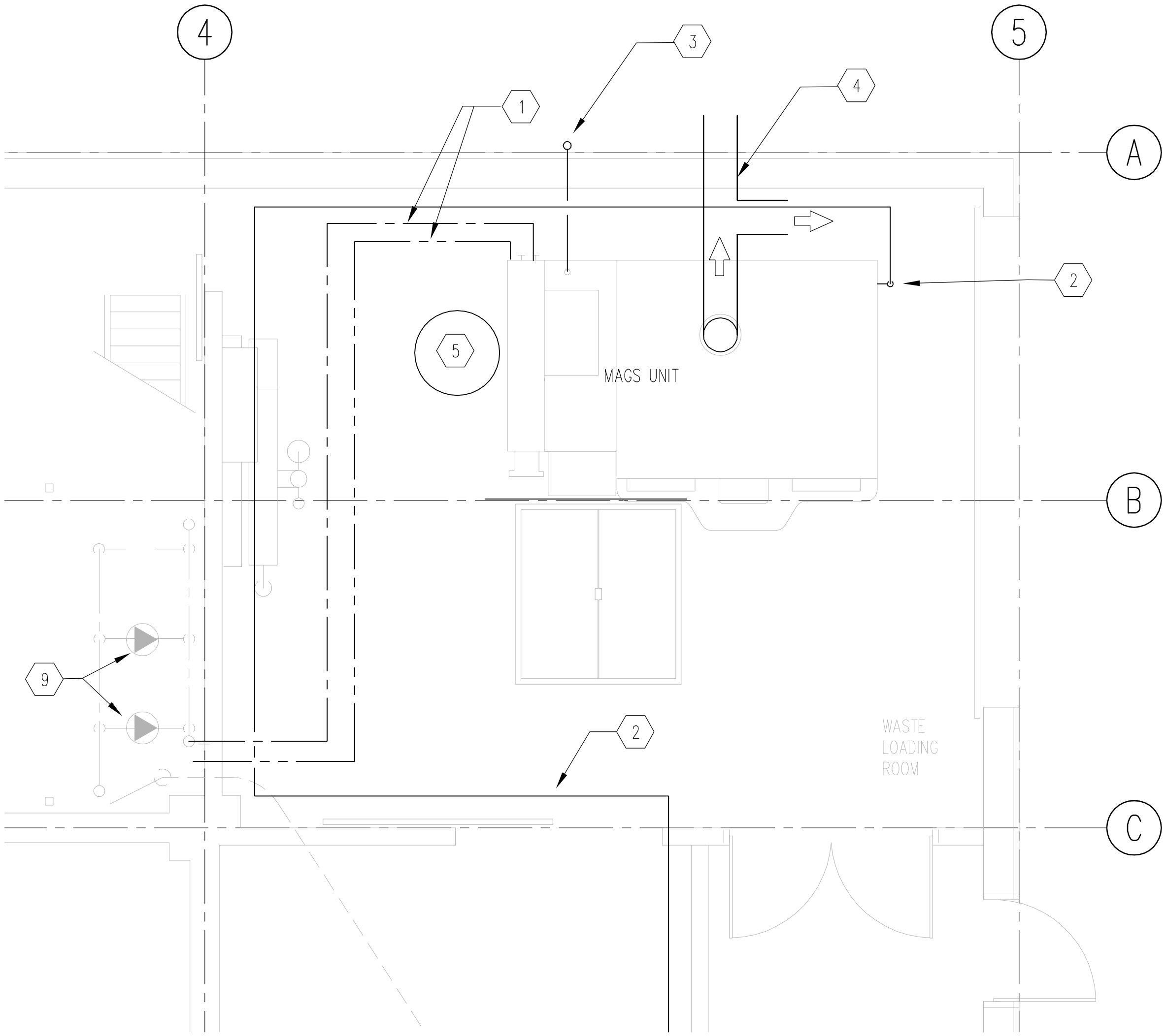
TITLE

MAGS 7

DWG. NO.

footing & clearances

SHEET 3 OF 3



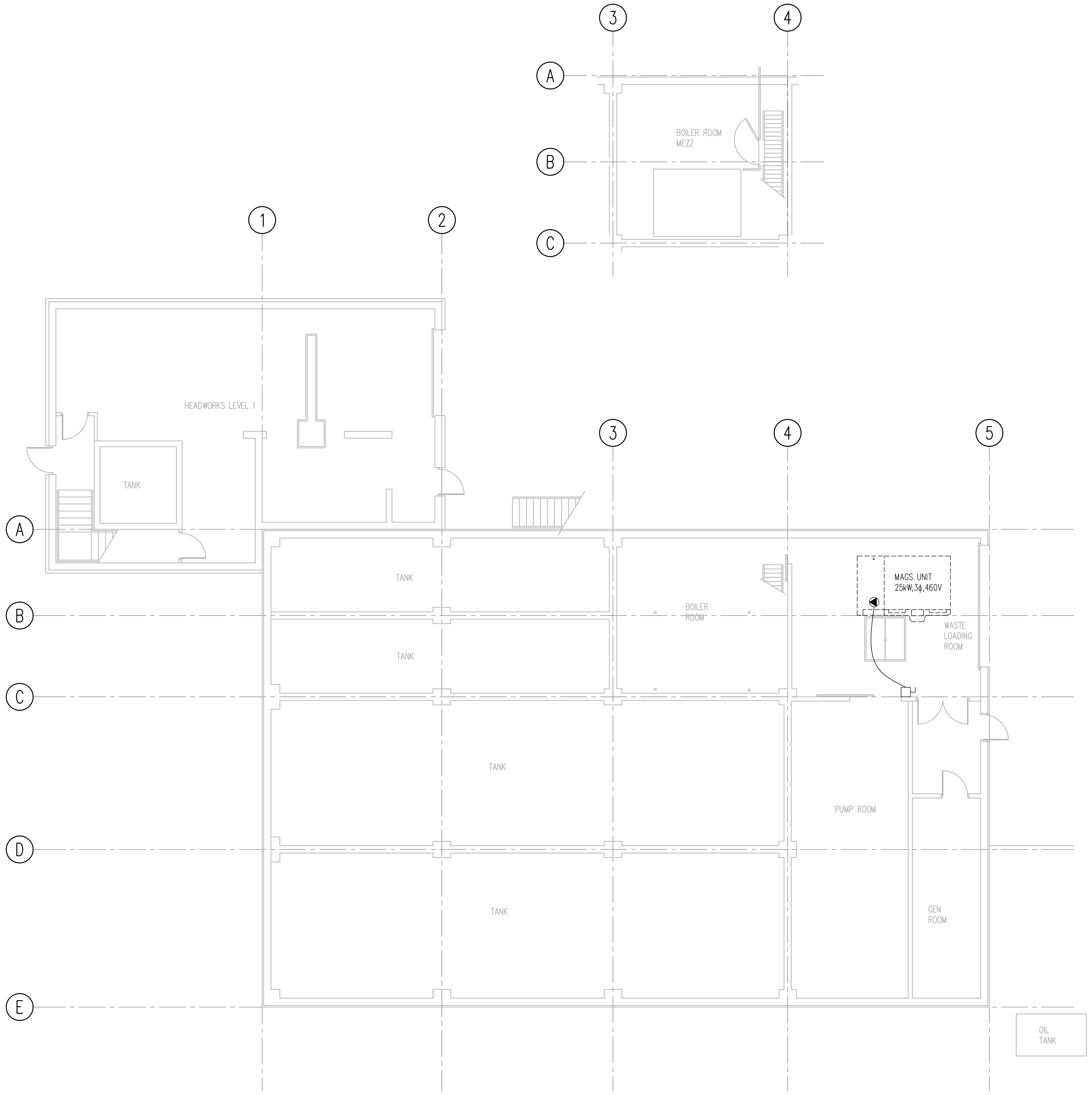
KEYNOTES:

1. NEW FEW DCW AND DHW LINES TO CONNECT TO HEAT RECOVERY WATER INLET AND OUTLET AND PROCESS WATER INLET AS SHOWN.
   8 TO 12 GPM 40mm IN SIZE
   TYPE L COPPER 95/5 SOLDER
   PROVIDE DIELECTRIC FITTING AT MAGS CONNECTIONS.
   PIPE INSULATION IS NOT REQUIRED.
2. NEW 20mm FUEL OIL LINE FROM OIL DAY TANK
3. NEW 62mm EXHAUST LINE FROM MAGS UNIT, TERMINATE 1000mm ABOVE ROOF. PROVIDE A THIMBLE THROUGH THE WALL.
   PIPE TO BE SCHEDULE 40 BLACK STEEL
4. NEW 300mm ø EXHAUST DUCT. RUN OUT THROUGH THE WALL AND ALSO PROVIDE A TERMINATION IN THE ROOM. PROVIDE A THIMBLE WHERE THE DUCT PASSES THROUGH THE WALL. PROVIDE INTERLOCKED MANUAL CONTROL DAMPERS TO CONTROL AMOUNT OF AIR RETURNED TO ROOM.
   DUCT TO BE GALVANIZED STEEL DUCT TO SMACNA LOW PRESSURE DUCT STANDARDS.
5. SAMPLE BARREL: EQUINOX MODEL E50W 227 L, 622 DIAMETER X 946 mm HIGH POLY INDOOR TANK
6. 40mm PIPING UP TO NEW UNIT HEATER IN LEVEL 22 MAIN AREA.
7. UNIT HEATER CAPACITY TO BE 60KW HEAT OUTPUT AT 30C WATER TEMPERATURE.
8. CONTROL VALVE TO OPEN IF HEAT IS REQURIED IN MAIN AREA AND IF TEMPERATURE OF WATER IN FIGS LOOP EXCEEDS 25C.
9. EXISTING FEW PUMPS P-17 AND P-18 TO REMAIN

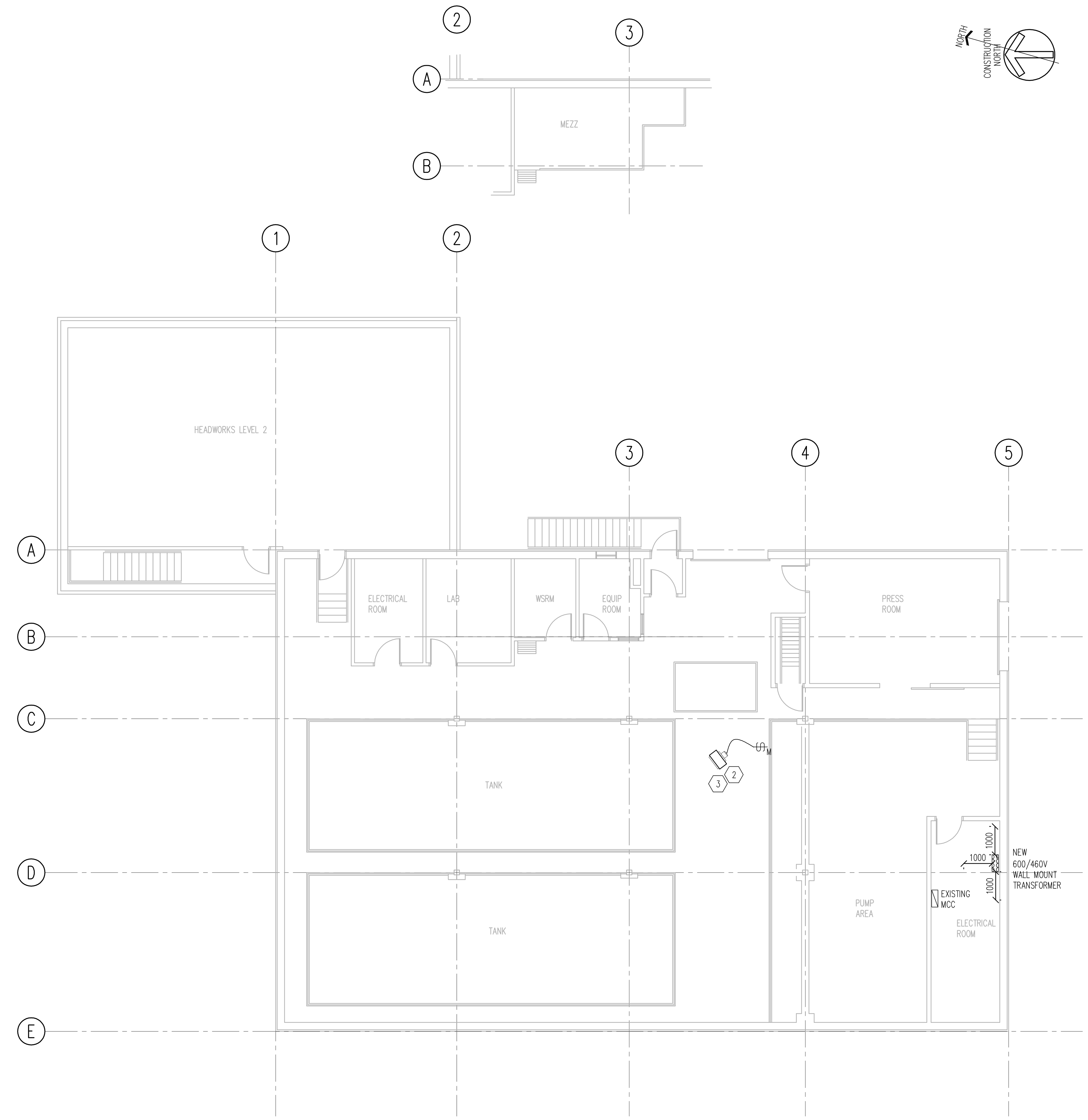
REVISED DETAIL 3 DRAWING M102 AND REVISED KEYNOTES

REVISIONS

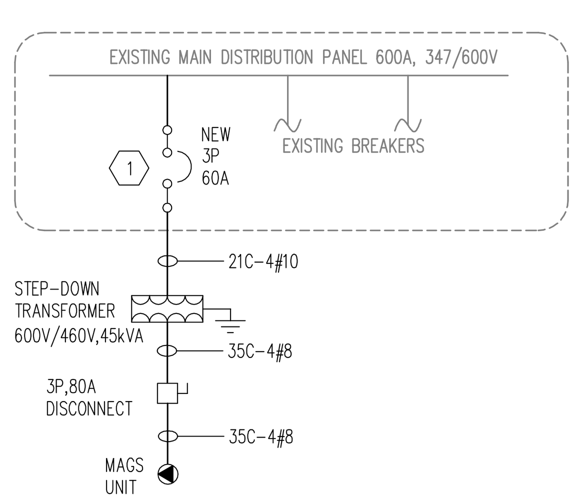
NO.	DESCRIPTION	YYYY.MM.DD	BY	APP.
A	PRELIMINARY LAYOUT	2015.02.02	UG	HR
B	ISSUED FOR PRICING	2015.02.11	UG	HR



LEVEL 1 FLOOR PLAN
1:100



LEVEL 2 FLOOR PLAN
1:100



SINGLE LINE DIAGRAM
NTS

GENERAL NOTES:

1. PROVIDE ALL NECESSARY GROUNDING AND BONDING. AS PER THE CURRENT C.E.C REQUIREMENTS.
2. PROVIDE BONDING TO ALL NON-ELECTRICAL METAL PARTS. COORDINATE WITH MECHANICAL.

KEYNOTES:

1. PROVIDE NEW 3P-60A BREAKER IN THE EXISTING MCC. CONTRACTOR TO CONFIRM EXISTING SPARE/ SPACE IN THE PANEL BOARD BEFORE INSTALLING NEW BREAKER.
2. APPROXIMATE LOCATION OF NEW UNIT HEATER. COORDINATE WITH MECHANICAL
3. FEED FROM SPARE/SPARE BREAKER FROM THE NEAREST PANEL.

ELECTRICAL SYMBOL LEGEND

	CIRCUIT BREAKER
M	UTILITY METER
	STEP-DOWN TRANSFORMER
	BRANCH CIRCUIT PANEL
	DISCONNECT
	HARD WIRED CONNECTION
$M	MANUAL DISCONNECT

DRAWING NO.	DESCRIPTOR

REFERENCE DRAWINGS

FOR BEST PLOTTING RESULTS, BE SURE TO USE WILLIAMS ENGINEERING CANADA AUTOCAD PLOT CONFIGURATION FILES AVAILABLE FROM: www.williamsengineering.com

LEGEND

A / E100 SECTION # / SOURCE / REFERENCE DWG.

1 / M200 DETAIL # / SOURCE / REFERENCE DWG.

PERMIT STAMP:

FOR INFORMATION ONLY
NOT FOR CONSTRUCTION
DATE (YYYY MM DD): 2015-02-02

ENGINEER'S SEAL:

YELLOWKNIFE OFFICE
P.O. Box 1529
2nd Floor 4902 49 Street
Yellowknife, NT X1A 2P2

Bus: (867) 873-2395
Toll Free: 1-800-263-2393
Fax: (867) 873-2547

info@williamsengineering.com
www.williamsengineering.com

WILLIAMS ENGINEERING CANADA

CLIENT:

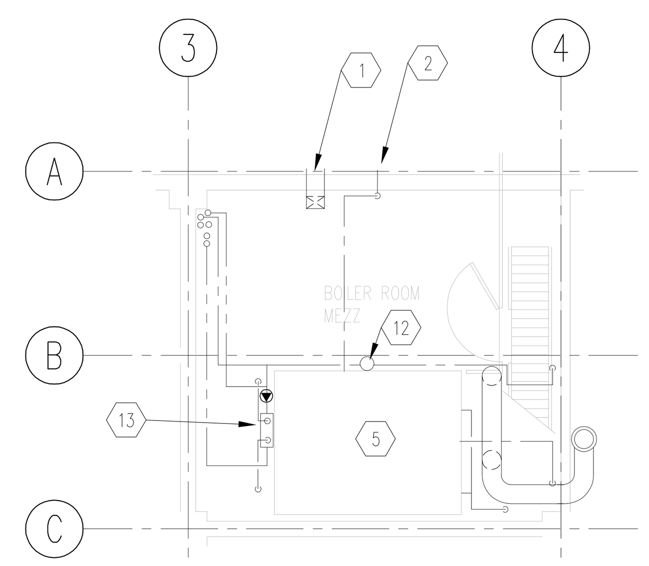
JOB. TITLE:

WASTE WATER TREATMENT PLANT
MAGS HEAT RECOVERY
IQALUIT, NU

DWG. TITLE:

ELECTRICAL FLOOR PLANS

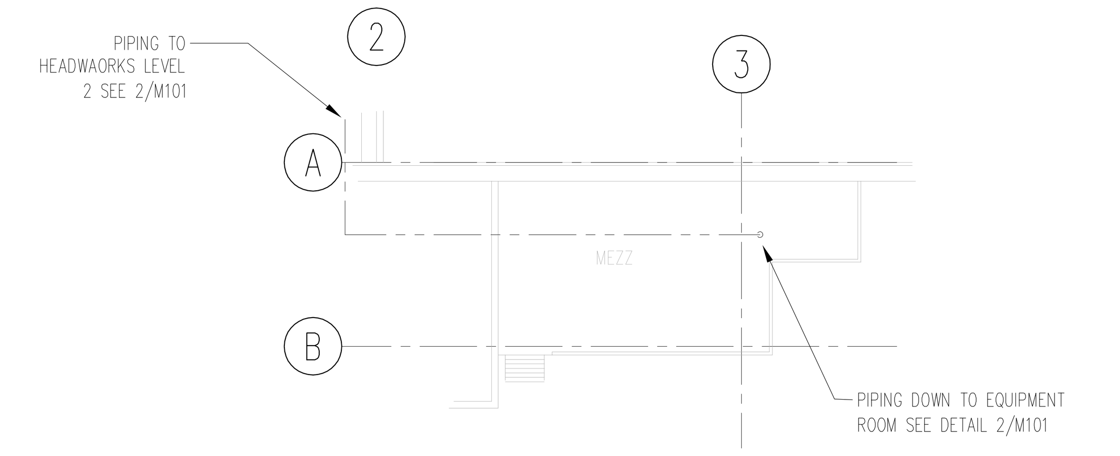
DWN. BY: UG	DES. BY: UG	PROJ. MGR.: BFG
PEER REVIEW: HR	DATE: (YY-MM-DD) 2015-02-11	SCALE: AS SHOWN
CLIENT PROJ. # --		WE PROJ. # 0032052.00
DWG # E100	OF 1	REV # B



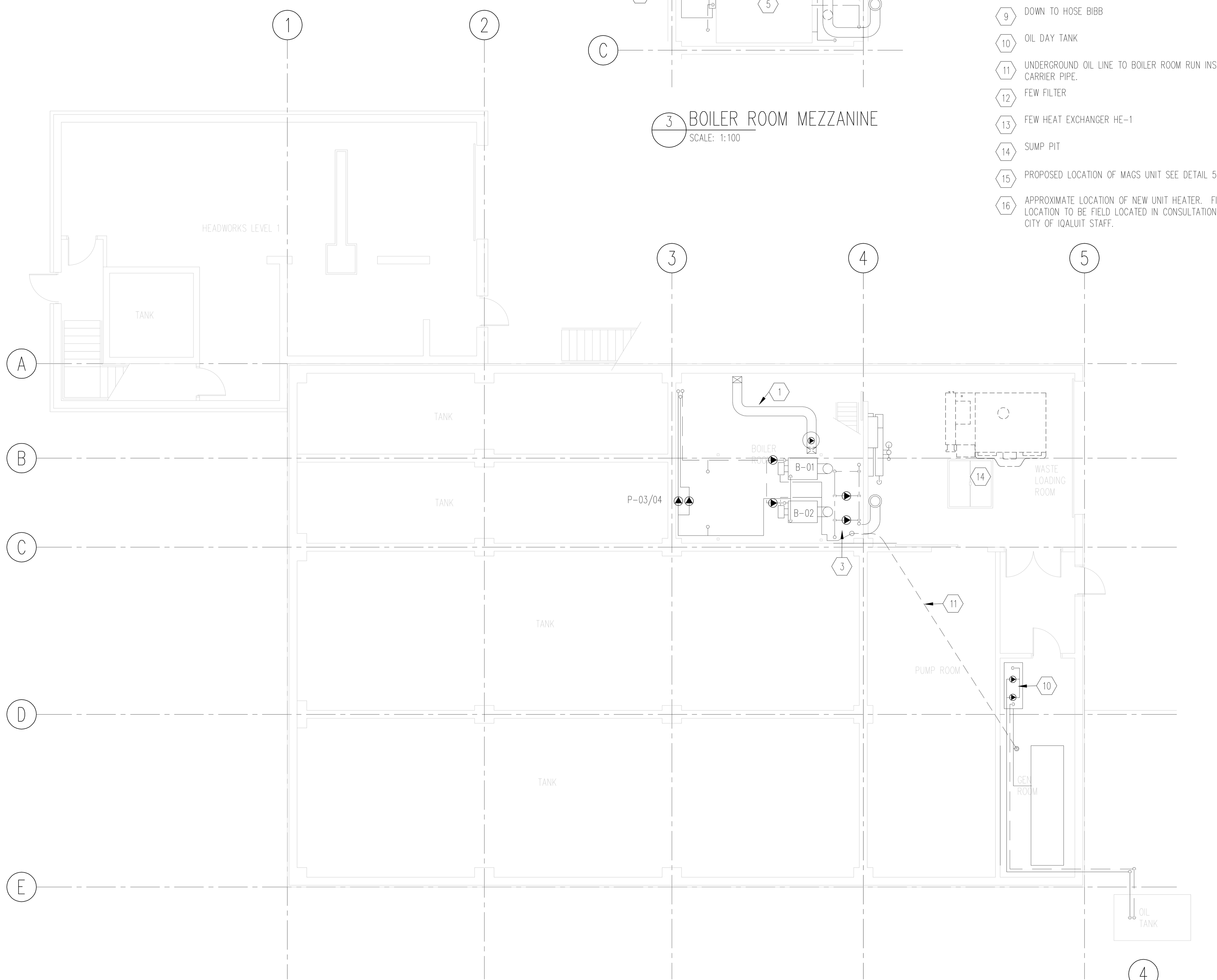
3 BOILER ROOM MEZZANINE
SCALE: 1:100

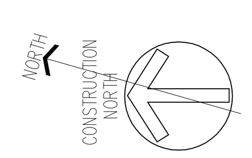
KEYNOTES:

1. COMBUSTION AIR DUCT
2. WATER FILL PIPE
3. FEW PUMPS P-17/18
4. UP TO MEZZANING SEE DETAIL 2 M101
5. FEW TANK
6. DHW TANKS TK-1A/B
7. EXPANSION TANK
8. TO FEW SYSTEM
9. DOWN TO HOSE BIBB
10. OIL DAY TANK
11. UNDERGROUND OIL LINE TO BOILER ROOM RUN INSIDE CARRIER PIPE.
12. FEW FILTER
13. FEW HEAT EXCHANGER HE-1
14. SUMP PIT
15. PROPOSED LOCATION OF MAGS UNIT SEE DETAIL 5/M101
16. APPROXIMATE LOCATION OF NEW UNIT HEATER. FINAL LOCATION TO BE FIELD LOCATED IN CONSULTATION WITH CITY OF IQALUIT STAFF.

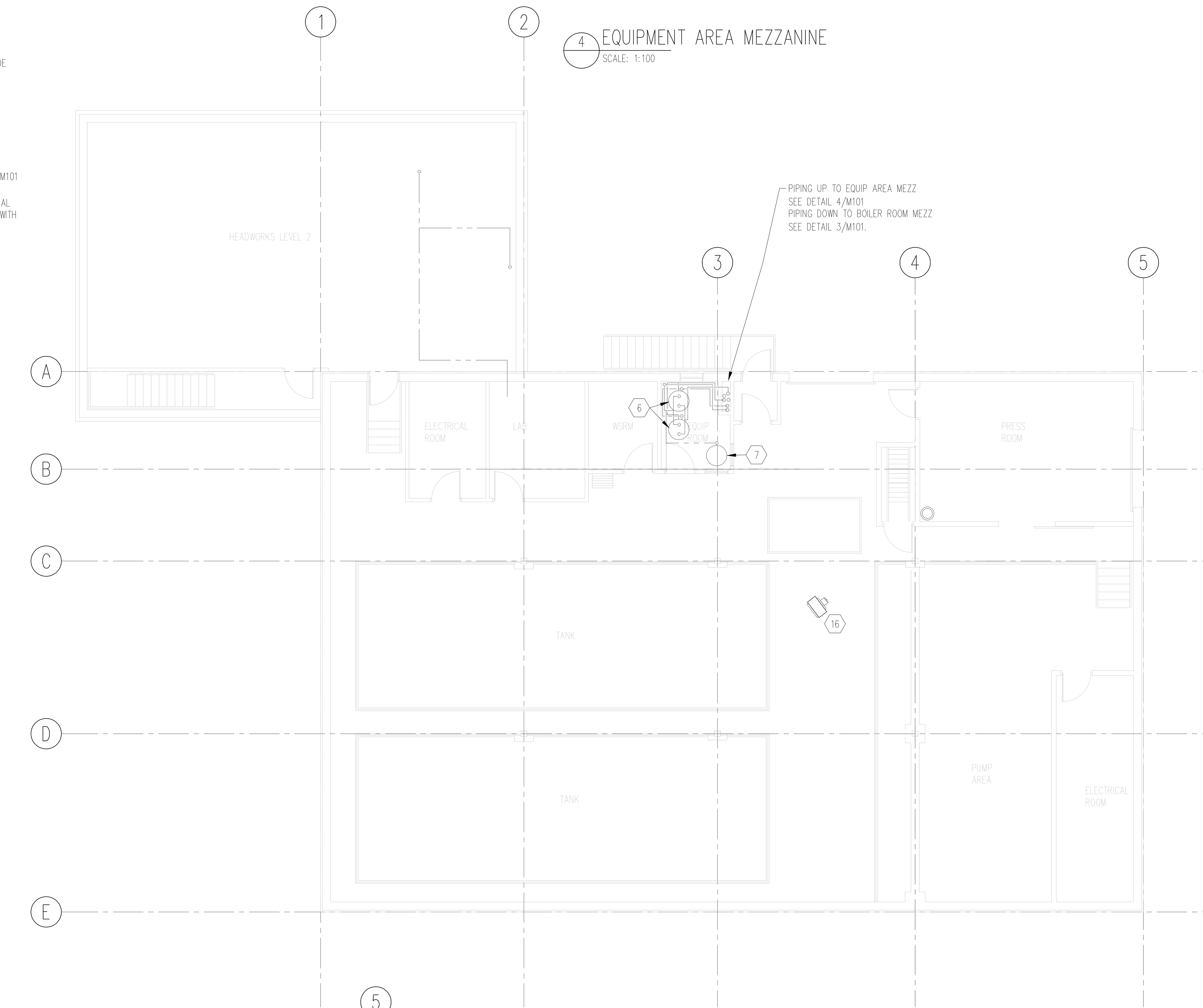


4 EQUIPMENT AREA MEZZANINE
SCALE: 1:100

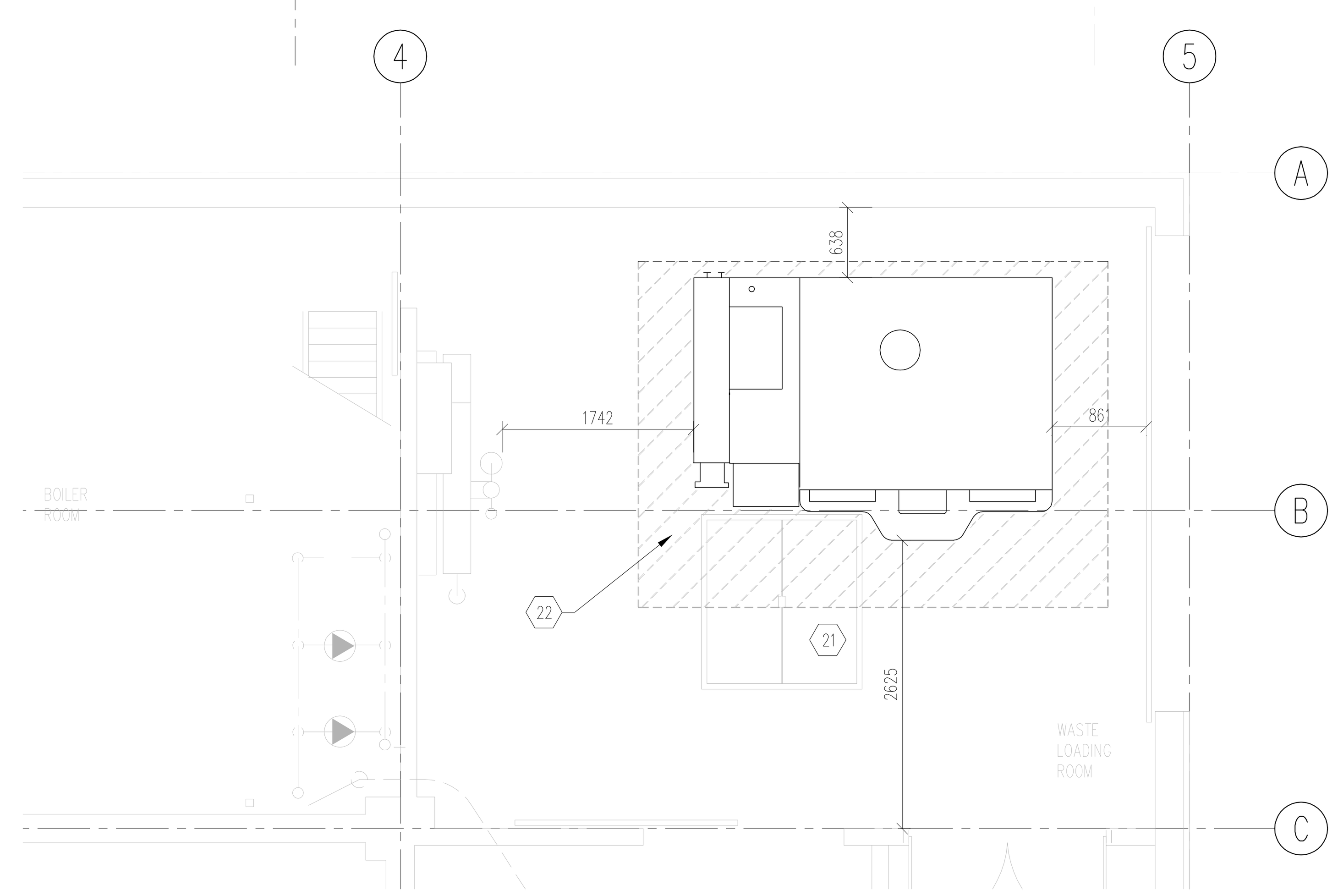




1 LEVEL 1 FLOOR PLAN
SCALE: 1:100



2 LEVEL 2 FLOOR PLAN
SCALE: 1:100



5 MAGS ROOM DETAIL
SCALE: 1:50

KEYNOTES:

21. MAGS UNIT TO BE PLACED SO THAT SUMP ACCESS CAN BE ACHIEVED
22. REQUIRED CLEARANCES AROUND MAGS UNIT.
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REVISIONS

NO.	DESCRIPTION	YYYY.MM.DD	BY	APP.
A	PRELIMINARY LAYOUT	2015.02.02	BFG	BFG
B	ISSUED FOR PRICING	2015.02.02	BFG	BFG

DRAWING NO.	DESCRIPTOR

REFERENCE DRAWINGS

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LEGEND

A E100 SECTION # SOURCE / REFERENCE DWG.
1 M200 DETAIL # SOURCE / REFERENCE DWG.

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WILLIAMS ENGINEERING
CANADA

CLIENT:

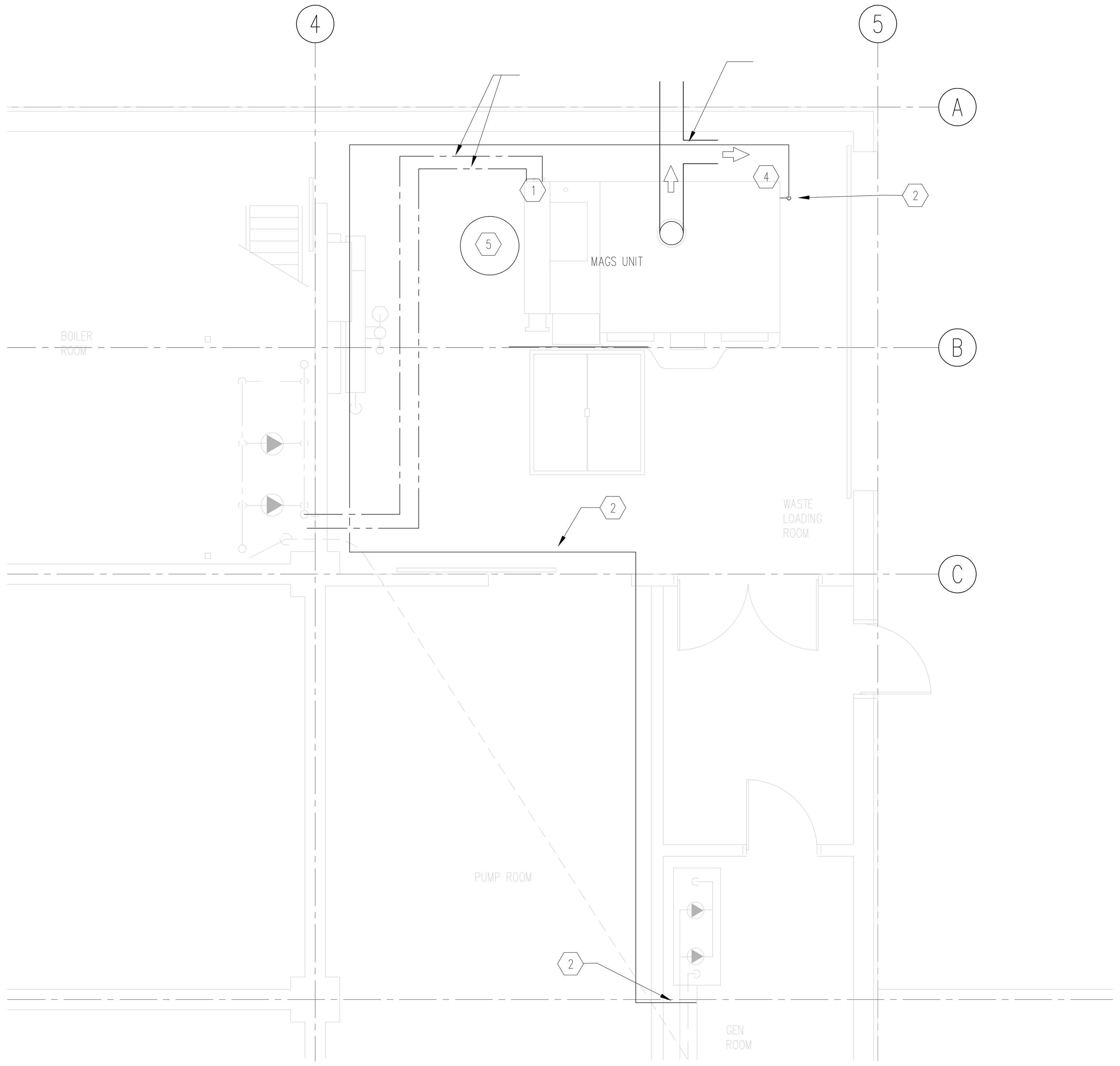
JOB. TITLE:

WASTE WATER TREATMENT PLANT
MAGS HEAT RECOVERY
IQALUIT, NU

DWG. TITLE:

MECHANICAL
FLOOR PLANS

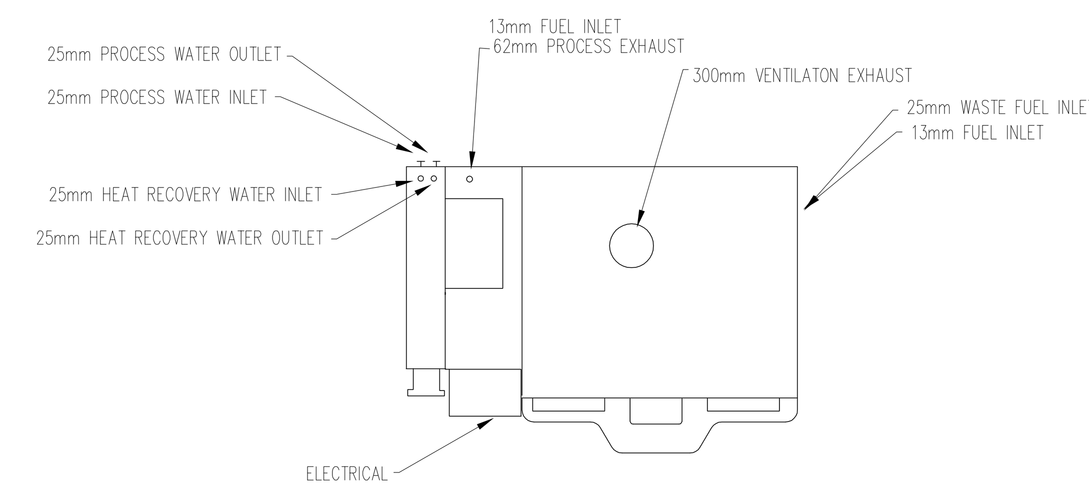
DWN. BY: ??	DES. BY: BFG	PROJ. MGR.: BFG
PEER REVIEW: ??	DATE: (YY-MM-DD) 2015-02-01	SCALE: AS SHOWN
CLIENT PROJ. # --		WE PROJ. # 0032052.00
DWG # M101	OF 2	REV # B



3 MAGS ROOM DETAIL
M102 SCALE: 1:50

KEYNOTES:

1. NEW FEW DCW AND DHW LINES TO CONNECT TO HEAT RECOVERY WATER INLET AND OUTLET AND PROCESS WATER INLET AS SHOWN.
   8 TO 12 GPM 40mm IN SIZE
2. NEW 20mm FUEL OIL LINE FROM OIL DAY TANK
3. NEW 62mm EXHAUST LINE FROM MAGS UNIT, TERMINATE 1000mm ABOVE ROOF. PROVIDE A THIMBLE THROUGH THE WALL.
4. NEW 300mm ø EXHAUST DUCT. RUN OUT THROUGH THE WALL AND ALSO PROVIDE A TERMINATION IN THE ROOM. PROVIDE A THIMBLE WHERE THE DUCT PASSES THROUGH THE WALL. PROVIDE INTERLOCKED MANUAL CONTROL DAMPERS TO CONTROL AMOUNT OF AIR RETURNED TO ROOM.
5. SAMPLE BARREL
6. 40mm PIPING UP TO NEW UNIT HEATER IN LEVEL 22 MAIN AREA.
7. UNIT HEATER CAPACITY TO BE 60KW HEAT OUTPUT AT 30C WATER TEMPERATURE.
8. CONTROL VALVE TO OPEN IF HEAT IS REQURIED IN MAIN AREA AND IF TEMPERATURE OF WATER IN FIGS LOOP EXCEEDS 25C.



6 MAGS CONNECTIONS
M102 SCALE: NTS

GENERAL NOTES:

1. ALL WORK TO BE DONE IN ACCORDANCE WITH THE NATIONAL BIULDNG CODE OF CANADA 2010, CSA B139 AND THE REQUIREMENTS OF THE AUTHORITIES HAVING JURISDICTION.
2. INSTALLATION TO BE IN ACCORDANCE WIITH THE REQUIREMENTS OF THE MAGS UNIT INSTALLATION INSTRUCTIONS.
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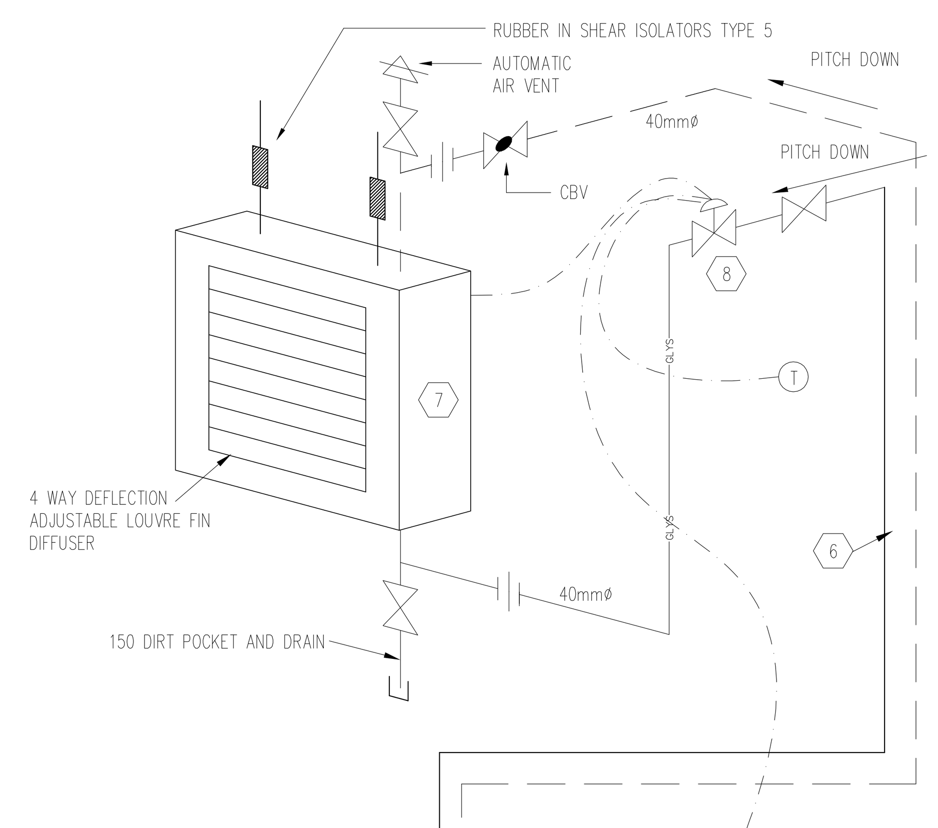
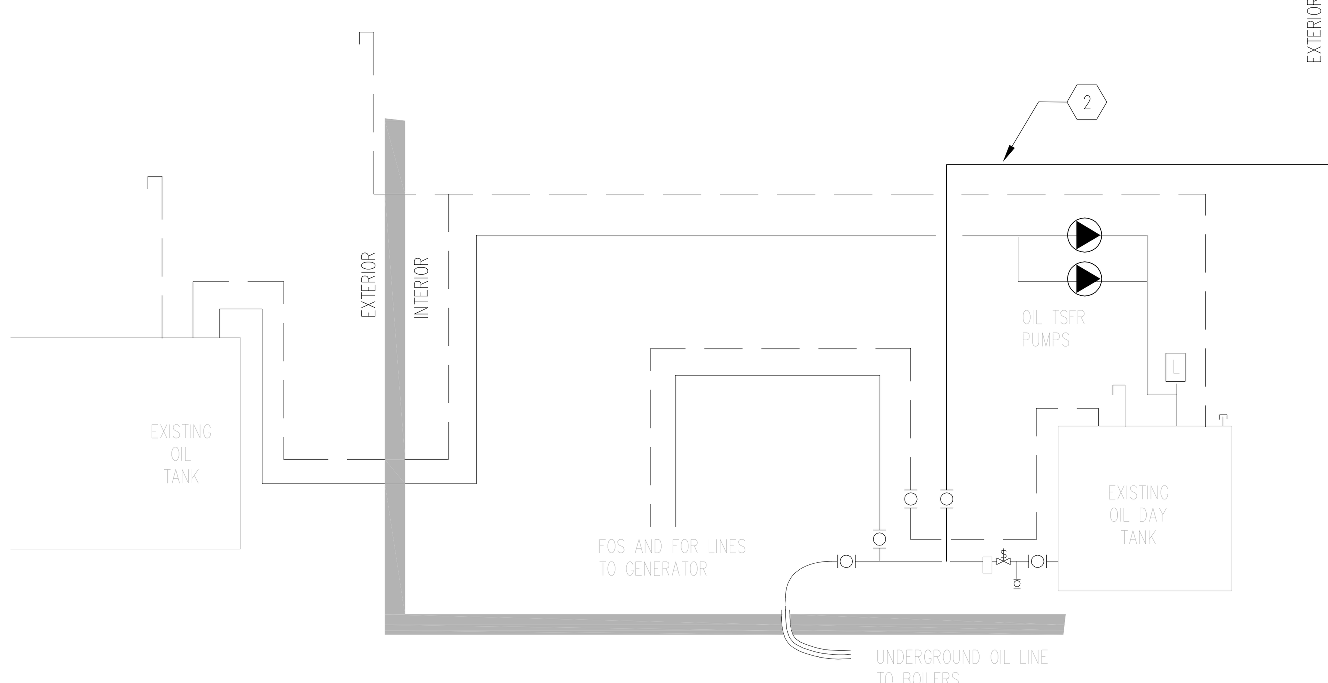
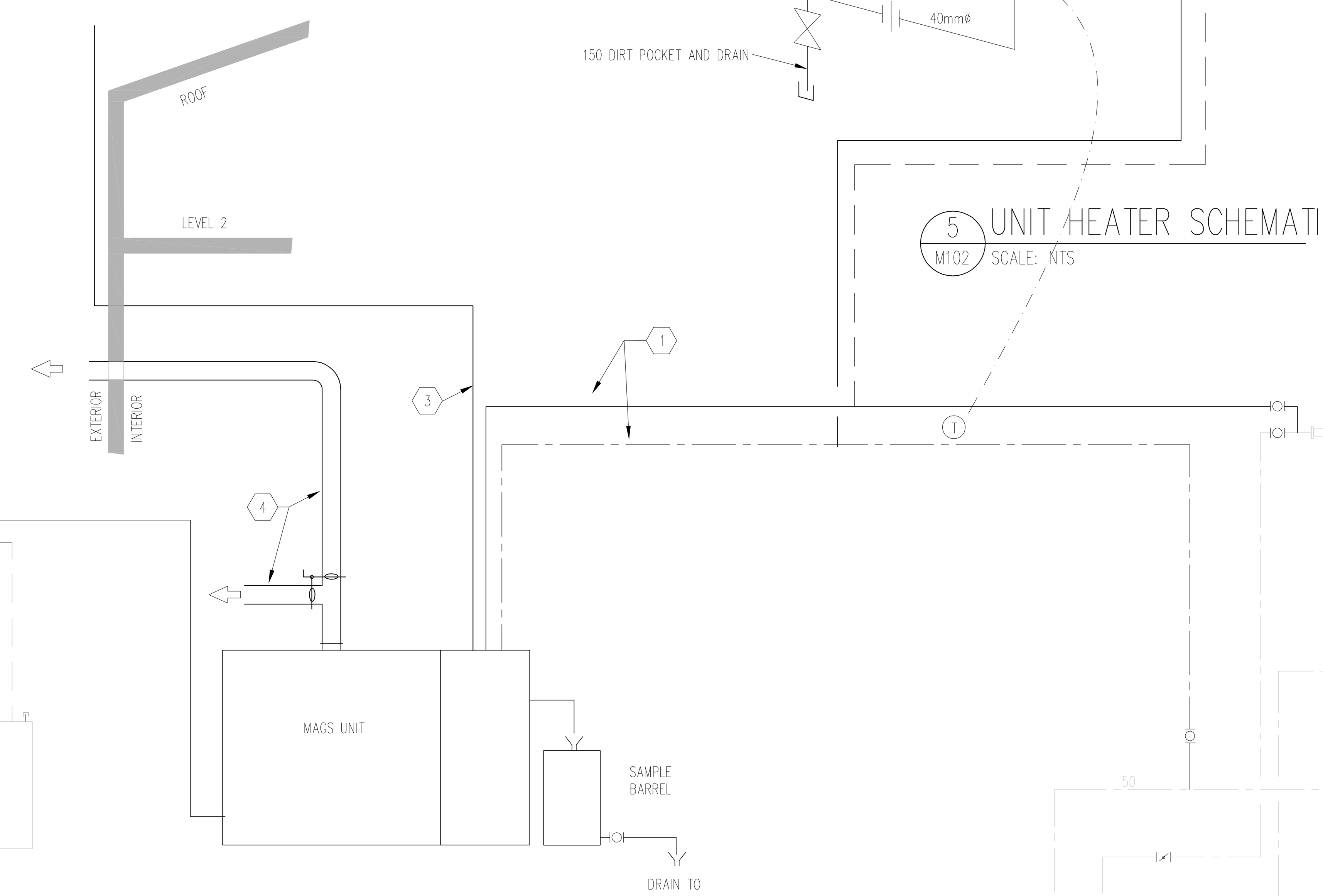


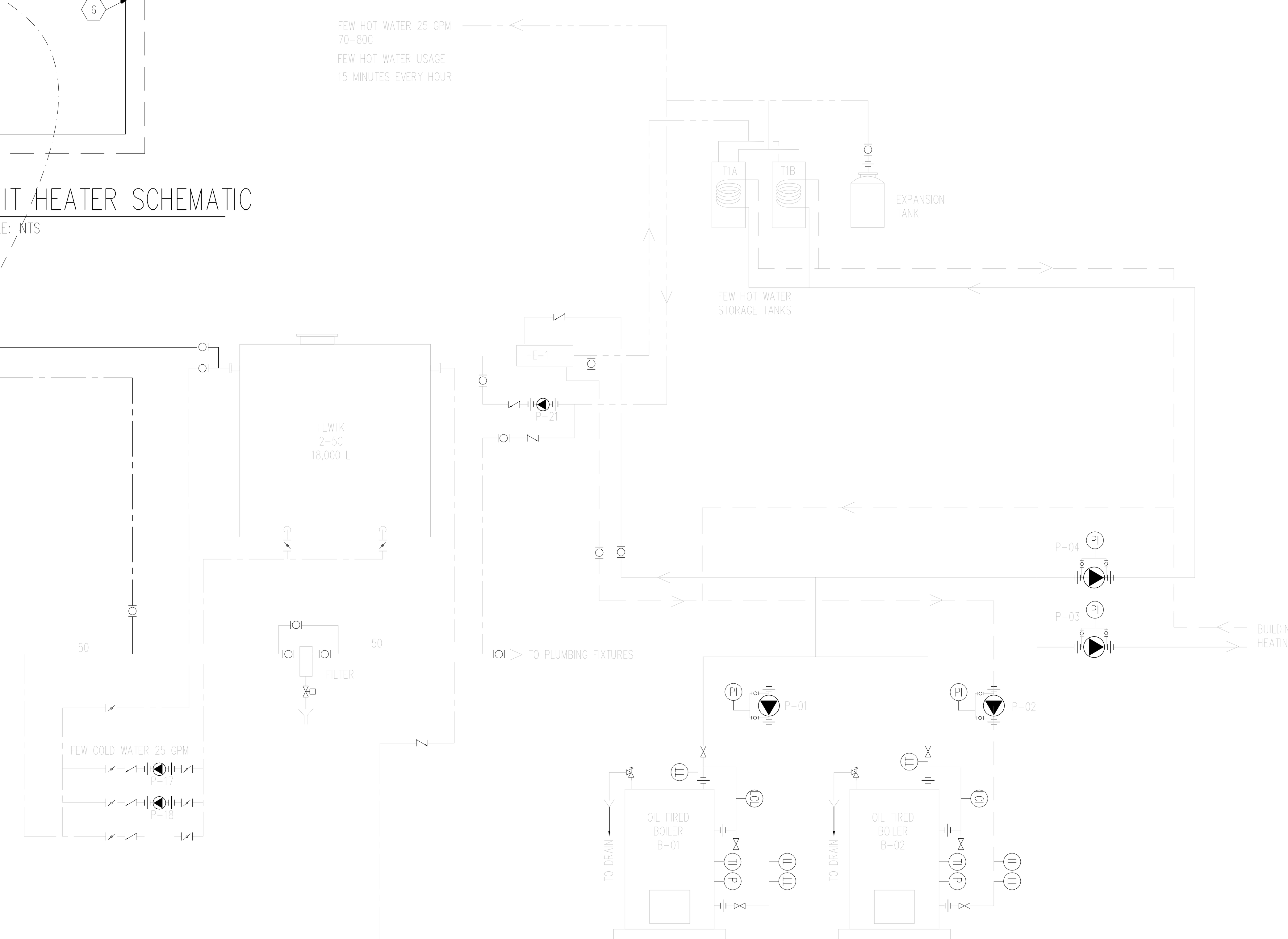
5 UNIT HEATER SCHEMATIC
M102 SCALE: NTS



1 EXISTING FUEL OIL SYSTEM
M102 SCALE: NTS



4 NEW MAGS PIPING
M102 SCALE: NTS



2 EXISTING FEW SYSTEM
M102 SCALE: NTS

REVISIONS

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WILLIAMS ENGINEERING CANADA

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WASTE WATER TREATMENT PLANT MAGS HEAT RECOVERY
IQALUIT, NU

DWG. TITLE:

MECHANICAL DETAILS & SCHEMATICS

DWN. BY:	DES. BY: BFG	PROJ. MGR.: BFG
PEER REVIEW: ??	DATE: (YY-MM-DD) 2015-02-01	SCALE: AS SHOWN
CLIENT PROJ. # --		WE PROJ. # 0032052.00
DWG # M102	OF 2	REV # A