ESTCP

TECHNICAL MANUAL

Rotary Waste to Energy Converter for Overseas Contingency Operations

Inclined Rotary Gasifier Technical Manual

James Hardin
Paul Amodeo
Dave Waage
SUNY Cobleskill & SUNY Research Foundation

Ken Wickiser
USMA West Point

Stephen Cosper
US Army Corps of Engineers

Jared Koelling
US Army 84th Training Command

November 2023

ESTCP Project WP18-5127

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
27/11/2023	ESTCP Technical Manual	9/21/2018 - 9/18/2023

4. TITLE AND SUBTITLE

Rotary Waste to Energy Converter for Overseas Contingency Operations

Inclined Rotary Gasifier Technical Manual

5a. CONTRACT NUMBER
18-C-0096

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

James Hardin, Paul Amodeo and Dave Waage: SUNY Cobleskill & SUNY Research Foundation

Ken Wickiser: USMA West Point

Stephen Cosper: US Army Corps of Engineers

Jared Koelling: US Army 84th Training Command

5d. PROJECT NUMBER
WP18-5127

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
State University of New York at Cobleskill - Research Foundation
Dept of Agricultural Engineering
SUNY Cobleskill, Curtis Mott 130
Cobleskill, NY 12043

8. PERFORMING ORGANIZATION REPORT NUMBER
WP18-5127

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 16F16
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
WP18-5127

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This is a Technical Manual developed under ESTCP project, “Rotary Waste to Energy Converter for Overseas Contingency Operations".

15. SUBJECT TERMS
waste heat recovery, waste to energy, emissions and waste reduction, forward operating base, Rotary Waste, Energy Converter, Overseas Contingency Operations

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			James Hardin
UNCLASS	UNCLASS	UNCLASS	UNCLASS	26	**19b. TELEPHONE NUMBER** *(Include area code)* (518) 727-2364

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1.0 IMPORTANT SAFETY INFORMATION

1.1 CAUTION WARNINGS

Read and follow all safety instructions carefully before operating the Inclined Rotary Gasifier. Hazards are identified throughout the manual by the safety alert shown below, with brief descriptions of hazards following.

Hazards include:

- Hot surfaces
- Harmful emissions
- Flammable gas
- Possible pinch points
- Electric shock risk

Failure to follow safety precautions and warnings can result in injury to the operator. The above hazard symbol can refer to more than one safety hazard at a time. Read all warnings following the symbol to ensure safe operation.

1.2 SAFETY INFORMATION

All precautions should be taken to prevent operator injury. Use of standard personal protection equipment is recommended during operation, including, but not limited to:

- Long-sleeve protective clothing
- Gloves
- Hearing protection
- Eye/face protection
- Suitable safety footwear

2.0 SYSTEM SETUP

2.1 INITIAL EQUIPMENT PLACEMENT

1) The IRG system is housed in two shipping containers. Containers must be situated in an L-shaped formation as shown below:

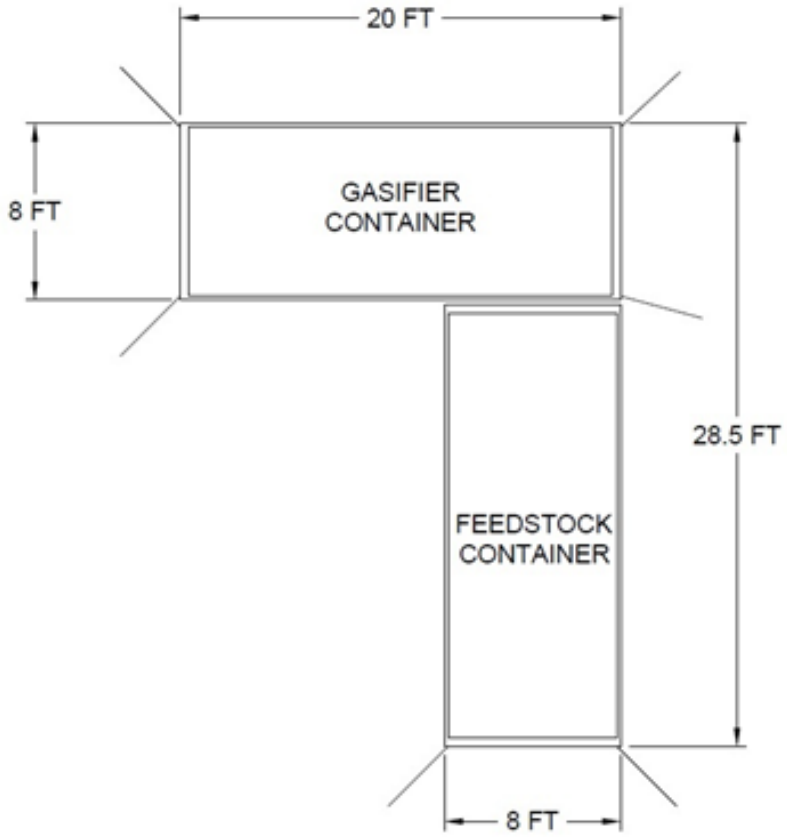


Figure 2.1. Container Configuration

2) The feed system conveyor must be pushed into place with the end aligned to the feed hopper using the rail mounting system. Secure the conveyor in place to prevent movement.

Figure 2.2. Rolling Conveyor

3) Connect all four hydraulic lines from the feedstock container to the gasifier container using the quick-connections. Hoses are arranged by size and connection configuration to prevent improper hookup.
4) All electrical connections are to be made between containers. Electrical connections must be made by and tested by a capable electrician.
5) An approved auxiliary fuel tank must be located close to the generator container, in accordance to accepted practice for spill prevention and containment. The tank should be placed away from all hot areas on the system for safety purposes.
6) Ensure all safety guards are properly installed and secure.
7) Earth ground the generator and all system equipment using local grounding rod(s).
8) Close and secure all electrical cabinets before starting the generator.

Warning: Risk of electric shock is possible if connections are improperly made.

Warning: Never open any electrical enclosure or junction box when energized. All wiring and electrical diagnosis must be completed by a qualified electrician.

Warning: The generator and system equipment must be properly grounded using approved local grounding rod and accepted practice.

3.0 WASTE PREPARATION

3.1 WASTE MIX OPTIMIZATION

To optimize IRG performance and increase system safety, certain waste handling practices are required. The following guidelines should be followed to produce the cleanest and most energy-rich syngas:

- Waste should be covered and protected from exposure to weather elements (rain, snow, etc.).
- Store waste in approved containers to prevent fire risk and exposure to wildlife.
- Waste should be as well mixed as possible, avoid separating waste into single categories.
- Avoid large amounts of plastic (keep < 30% concentration by mass).

The following waste elements must be separated from operational waste for safety reasons unless approved by command:

- Fabrics (or any item) treated with fire retardants
- Pressure treated lumber (copper arsenate and copper sulfate)
- Styrene (packing foam, utensils, cups, etc)
- Organic chlorides e.g., polyvinyl chloride (PVC)
- Items known to contain heavy metal (mercury, cadmium, arsenic, chromium, thallium, and lead)
- Rounds/ordinance
- Batteries, wire, and electronic circuit boards
- Motor pool fluids (consumed by system in other methods)
- Blood soaked items and other pathogen risks
- Large metal items
- Excessive amounts of non-flammable items such as gypsum wallboard, plaster, insulation, glass, stone, etc.

4.0 PREVENTATIVE MAINTENANCE CHECKS AND SERVICES

4.1 IRG DAILY CHECK

The system itself should be thoroughly checked daily for any potential mechanical/electrical issues that could cause issues or shutdowns during operation. A daily checklist for operator use can be found in Appendix A. Following the daily checklist, equipment should be checked in the following order:

1) Fuel hoses/connections: located at auxiliary tank plumbed to generator, all hoses should be examined for any cracks or leaks that could cause potential leakage or spills.
2) Hydraulic hoses/connections: located in both containers, all hoses should be checked for any leaks or potential problems.
3) Hydraulic tank: located in the feedstock container, the tank should be checked for any leaks. Check hydraulic fluid level using the sight glass.
4) Fuel level: auxiliary tank should be filled to sufficient level for daily operation.
5) Electrical cables: all electrical cables between containers should be checked for any cuts or breaks that would impede with operation or cause a potential safety issue.
6) Ash disposal: located under the gasifier, the ash disposal can should be emptied daily, when the system is cold, prior to runtime. Use caution as contents may be hot from the previous run.

Figure 4.1. Ash Disposal Can

7) Vessel leaks/spills: Polisher and Quencher vessels should be checked for any leaks or spills from equipment and plumbing.

If any issues are found during inspection, perform all maintenance before operating the system. Failure to do so can result in a shutdown alarm scenario and/or major equipment damage.

4.2 AAMPS DAIY CHECK

Standard PMCS should be completed for the AMMPS generator unit according to:

- ARMY TM 9-6115-753-10
- AIR FORCE TO 35C2-3-535-1
- MARINE CORPS TM 09244C/09245C-OI
- NAVY TM 7610-LL-L1A-0030

OPERATOR'S/TECHNICAL MANUAL
FOR GENERATOR SET, SKID MOUNTED
60KW ADVANCED MEDIUM MOBILE POWER SOURCES (AMMPS)
MEP-1070 50/60 Hz (NSN: 6115-01-561-7788) (EIC: N/A)

5.0 PRE-CHARGE PROCEDURE

5.1 HEADING 2

After all PMCS are completed, the system must be pre-charged with feedstock before full operation can begin. The following start-up procedure must be followed:

1) Open and secure all container doors and openings to provide adequate ventilation and to prevent injury in windy conditions.
2) Properly connect auxiliary fuel tank to generator.
3) In the feedstock container, open the 24-volt DC circuit box (Figure 5.1). Turn on circuit breakers 1, 2, 3, 4, and 5 to provide battery power to the automation system.

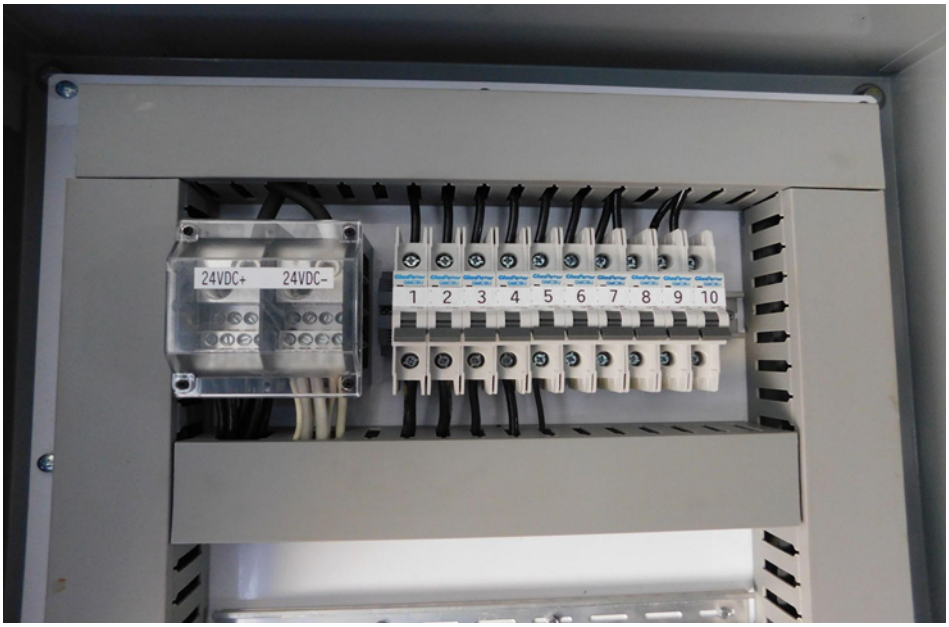


Figure 5.1. 24 Volt DC Circuit Box

Automation equipment of the system is powered via 24 volt-DC batteries connected to the circuit box in the feedstock container. The batteries are charged from the generator's alternator whenever the generator is running. If any downtime of more than two hours is expected, all circuit breakers in step 3 must be switched off to avoid excessive draining of automation batteries.

4) Start generator following AAPMPS generator instructions and allow it to stabilize and warm-up. Close electrical contactor (within the AAMPS generator) to energize the power distribution network.
5) Using the system operator station, navigate to and toggle the "Pre-Start" button. The system will begin an automated sequence starting by energizing the hydraulic oil heaters. The heaters will de-energize and the hydraulic pump will start when the hydraulic oil reaches the minimum operating temperature. Gasifier rotation will begin. The feed system will begin cycling and will feed waste into the system with 30 pounds of waste pre-feed.

During the automated procedure, adequate amounts of waste must be fed into the shredder manually. Once pre-feed is completed the system will pause all systems and wait for user input to continue.

Note: During pre-feed process, it is desired for feedstock to be wood-rich. If no lumber/wood is available, waste containing paper and cardboard is sufficient.

Warning: Generator operation produces harmful carbon monoxide emissions. Non-ventilated spaces should be avoided. Never open any enclosure or remove any safety guard when the generator is running or when the automation system is energized.

Moving parts are an injury risk, energized circuits are an electrocution risk, and moving components may start and stop automatically. All maintenance must be done by qualified individuals with approvals from command.

6.0 SYSTEM OPERATION

6.1 SYSTEM START

After all system checks are completed and the gasifier is pre-fed, the system is ready for operation. With the generator on and the power distribution circuits energized, the operator must navigate to and toggle the "System Start" button. At this time an automated process will begin in the following order:

1) Hydraulic pumps will start and stop as required to support operation. The hydraulic cooler fan will start and stop automatically to maintain proper oil temperatures.
2) Gasifier rotation will begin.
3) Gas blower rotation starts and increases in speed automatically, until the syngas flow set by the automation system is reached.
4) Polisher pumps start.
5) The swirl burner combustion air fan and satellite ignition starts.
6) Gasifier starting burner ignites.

The starting burner will automatically stop when flammable gas is measured at the swirl burner (indicated by increasing temperature) and the gasifier reaches standard operating temperatures. The "normal operation" light will illuminate on the user controls. At this time the system will automatically control feed rate to achieve optimal syngas production. The only user input required at this time will be waste loading to ensure the system has sufficient waste to keep operating.

The automation system automatically adjusts the flow of syngas to the swirl burner to maintain a minimum exhaust temperature of 800°F supplied to the gasifier. Additional syngas is fed to the generator based on the measured electrical power production to optimize liquid fuel savings between 60 and 75%.

6.2 SYSTEM STOP

At the end of desired runtime, the user must navigate to and toggle the "System Stop" button. The system will automatically reduce feed rate to the minimum level. The system will continue to run until gas reaches a desired low or non-flammability range, as indicated by the combustion temperature within the swirl burner. All systems power down in reverse order of startup. It is essential that feedstock is still provided to the system in order to maintain a material seal to prevent air leakage into the gasifier.

After the automated process has stopped all system equipment, the system is ready to complete end of operation tasks. See section 6.4.

6.3 EMERGENCY STOP

If at any point the system needs to be crash-stopped for operational reasons or due to suspected malfunction, the user must press any one of the "Emergency Stop" (Figure 6.1) mushroom head push buttons located on the system, or the digital button on the user control interface.

At this point all systems and the generator will stop at once. The gasification process may continue producing syngas by thermal capacitance for a short time. Excess syngas will leak at the point of air entry within the ash hood. Therefore, the user must locate the starting burner control (Figure 6.1) and set the starting burner HAND-OFF-AUTO switch to "HAND". This will light the starting burner, igniting any remaining syngas within the ash hood. Once the gasifier cools or residual waste is consumed, syngas flow will become non-flammable and will stop. The starting burner can be turned off by setting the HAND-OFF-AUTO starting burner switch back to "AUTO". All emergency stop buttons must be pulled out to the normal run position and the alarm reset button must be pushed on the operator screen. The operator can either restart the system as normal or allow the system to remain shut down.

Note: Never use the emergency stop buttons as standard practice to stop the system in a non-emergency situation. Continued practice will damage equipment.

Figure 6.1. Emergency Stop and Burner Control

Warning: Generator operation produces harmful carbon monoxide emissions. Non-ventilated spaces should be avoided. Caution should be used around all moving parts due to pinch-point areas. Certain equipment surfaces will get hot during operation and should be approached with caution. Flammable gas will be produced during operation, avoid activities that could cause unintended ignition.

6.4 END OF OPERATION TASKS

After each operational run day, certain tasks should be completed for safety purposes, ease of startup for the next run, and general caretaking.

1) Shut off all breakers in automation cabinet from section 5.1.
2) Clean any loose debris around the operating containers from operation.
3) Disconnect fuel lines from auxiliary tank to prevent spills.
4) Check all process equipment for any leaks or general issues.
5) Close and lock all container doors to protect the system from inclement weather and wildlife access.

7.0 OPERATIONAL TESTING

Certain operational testing can be completed during operation to monitor operational efficiency. These tests are not required for operation and should only be done if desired or considered necessary by command.

7.1 AIR EMISSIONS TESTING

Air emissions testing can be completed to monitor certain emission components such as O_2, CO, CO_2, No, NO_2, SO_2, and NOx. These components provide a better understanding of gasifier operation and can be used by qualified individuals to optimize performance. If tests are desired or required, samples can be taken using a handheld emissions tester such as a Seitron S6000-6DSC, at the single combined-emissions testing port shown in Figure 7.1.

Figure 7.1. Combined Emissions Testing Port

Warning: Generator operation produces harmful carbon monoxide emissions. Non-ventilated spaces should be avoided. Certain equipment surfaces will get hot during operation and should be approached with caution.

APPENDIX A PMCS CHECKLIST

PMCS DAILY CHECKLIST

The following checklist is to be completed before every operational run day. Any items considered not fully mission capable should be properly corrected before operation.

Item No.	Interval	Item to Be Inspected	Procedure	Not Fully Mission Capable If:
1	Daily	Fuel Hoses/ Connections	Located at auxiliary tank plumbed to generator, all hoses should be examined for any cracks or leaks that could cause potential leakage or spills.	Excessive fuel leakage from hoses or connections, visible splits in hoses
2	Daily	Hydraulic Hoses/ Connections	Located in both containers, all hoses should be checked for any leaks or potential problems.	Excessive leaking of hydraulic lines
3	Daily	Hydraulic Tank	Located in the feedstock container, the tank should be checked for any leaks. Check hydraulic fluid level using the sight glass.	Excessive leaking of hydraulic tank or low hydraulic fluid
4	Daily	Fuel Level	Auxiliary tank should be filled to sufficient level for daily operation.	Insufficient fuel level for daily operation
5	Daily	Electrical Cables	All electrical cables between containers should be checked for any cuts or breaks that would impede with operation or cause a potential safety issue.	Frayed or exposed wires, visible splits in any cables
6	Daily	Ash Disposal	Located under the gasifier, the ash disposal can should be emptied daily, when the system is cold, prior to runtime. Use caution as contents may be hot from the previous run.	Ash bucket full
7	Daily	Vessel Leaks/ Spills	Polisher and Quencher vessels should be checked for any leaks or spills from equipment and plumbing.	Vessels or hoses visibly leaking

APPENDIX B SCADA OVERVIEW

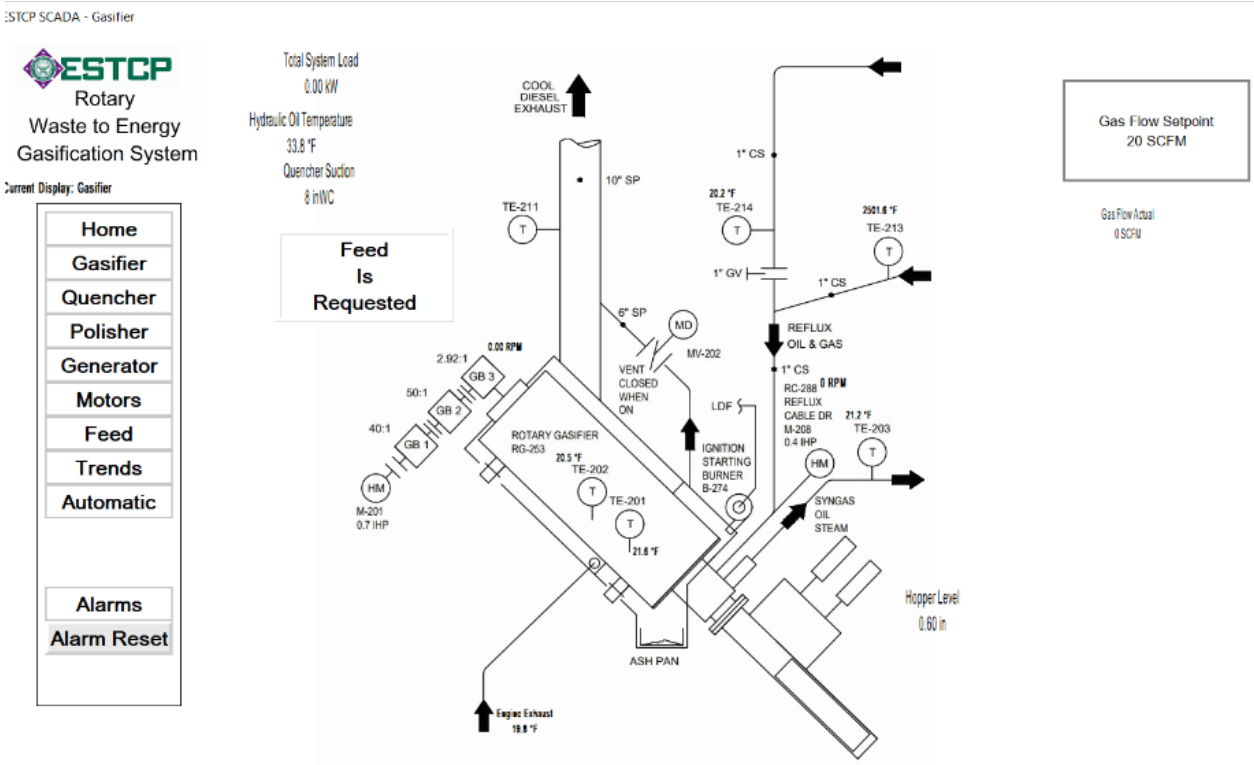
USER INTERFACE OVERVIEW

The SCADA interface allows for the control of equipment in the Waste to Energy Gasification system. The interface is broken down into a number of different tabs corresponding to different parts of the system. There are tabs for the Gasifier, Quencher, Polisher, Generator, Motors, Feed, Trends, Automatic, and for Alarms and Alarm Reset. At the center of the screen are the three automation sequence buttons: Pre-Start, System Start, and System Stop.

Figure B.1. System Main Screen

GASIFIER

In the Gasifier Tab, only one controllable button is found. The “Gas Flow Setpoint Button” is in the top right corner of the screen. This button allows the user to control the flow rate of the gas as it flows through the system. This will automatically change the blower motor speed until the setpoint gas flow equals the actual gas flow of the system.



FigureB.2. Gasifier Screen

QUENCHER

In the Quencher tab, only one controllable button is found. The Open Blowdown Valve button opens or closes the blowdown valve, which either allows for the flow of liquid from the polisher to the quencher or prevents it.

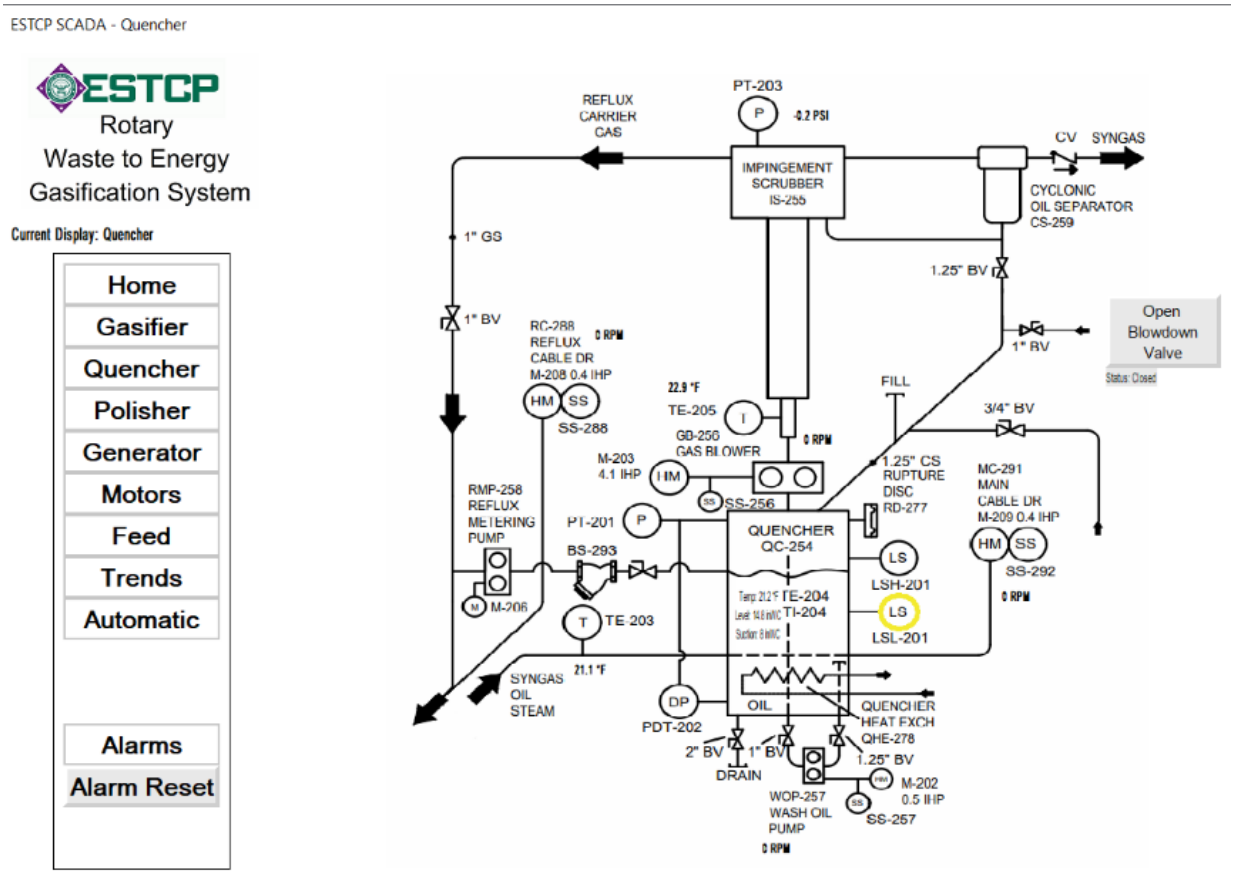


Figure B.3. Quencher Screen

POLISHER

In the Polisher tab, there are multiple buttons which provide similar functions: regulating the temperature of the polisher separator (PS-261). There is a button to enable automatic temperature control for the polisher which maintains the temperature of the polisher separator in the range of 140-145°F by automatically opening the heating/cooling values as needed.

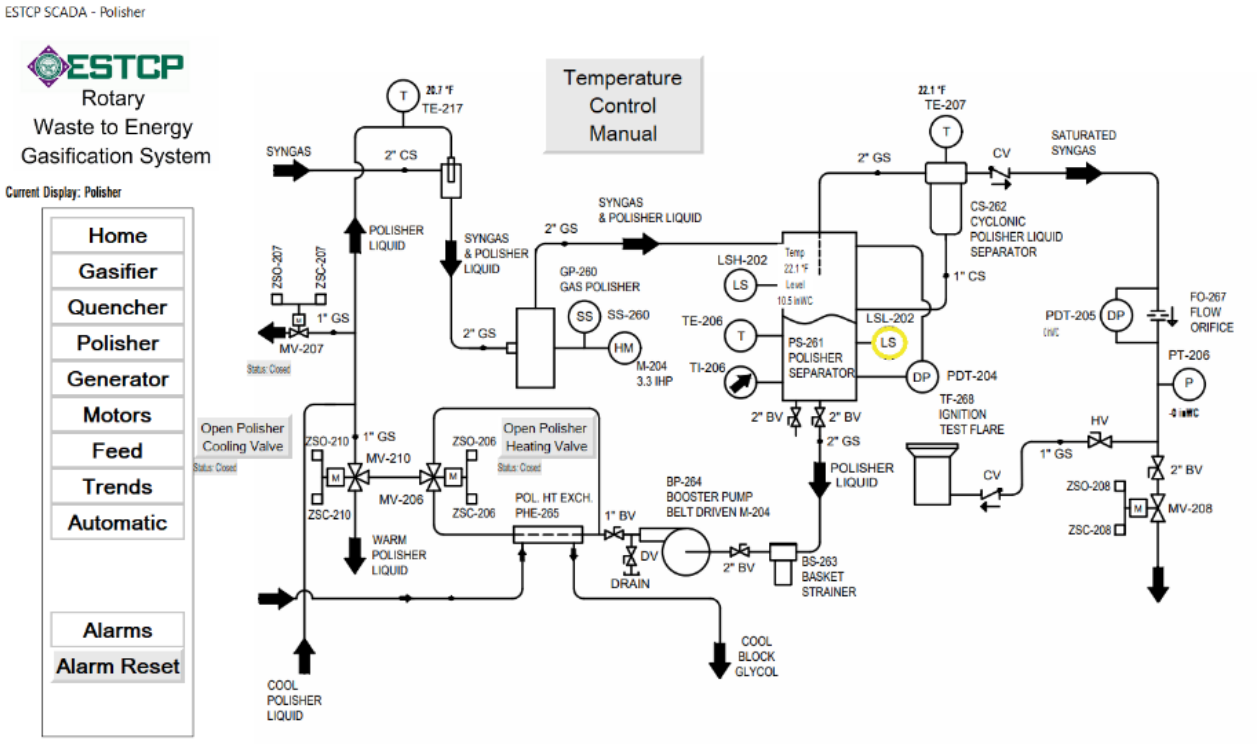


Figure B.4. Polisher Screen

GENERATOR

The generator tab displays both the total system load and the total auxiliary load. There are two buttons to enable separate dump loads of 15kW each, and button to enable a variable dump load of 0-15kW.

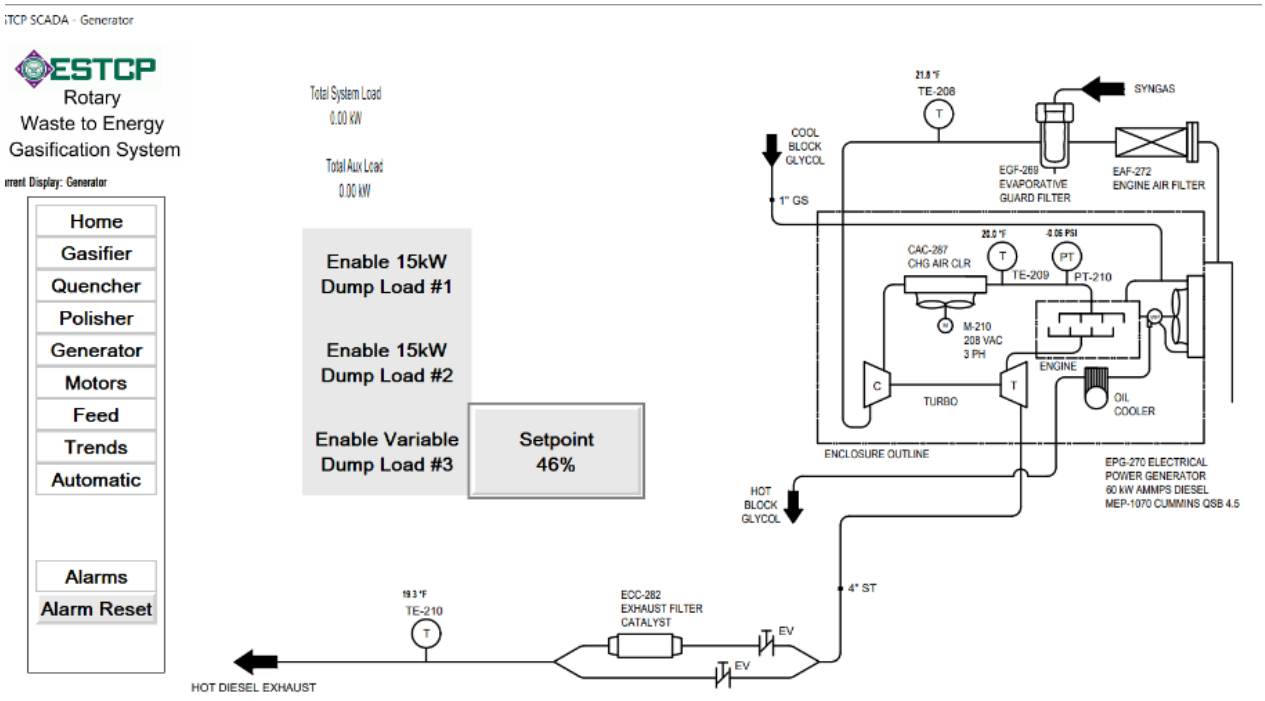


Figure B.5. Generator Screen

APPENDIX C EQUIPMENT DESCRIPTION

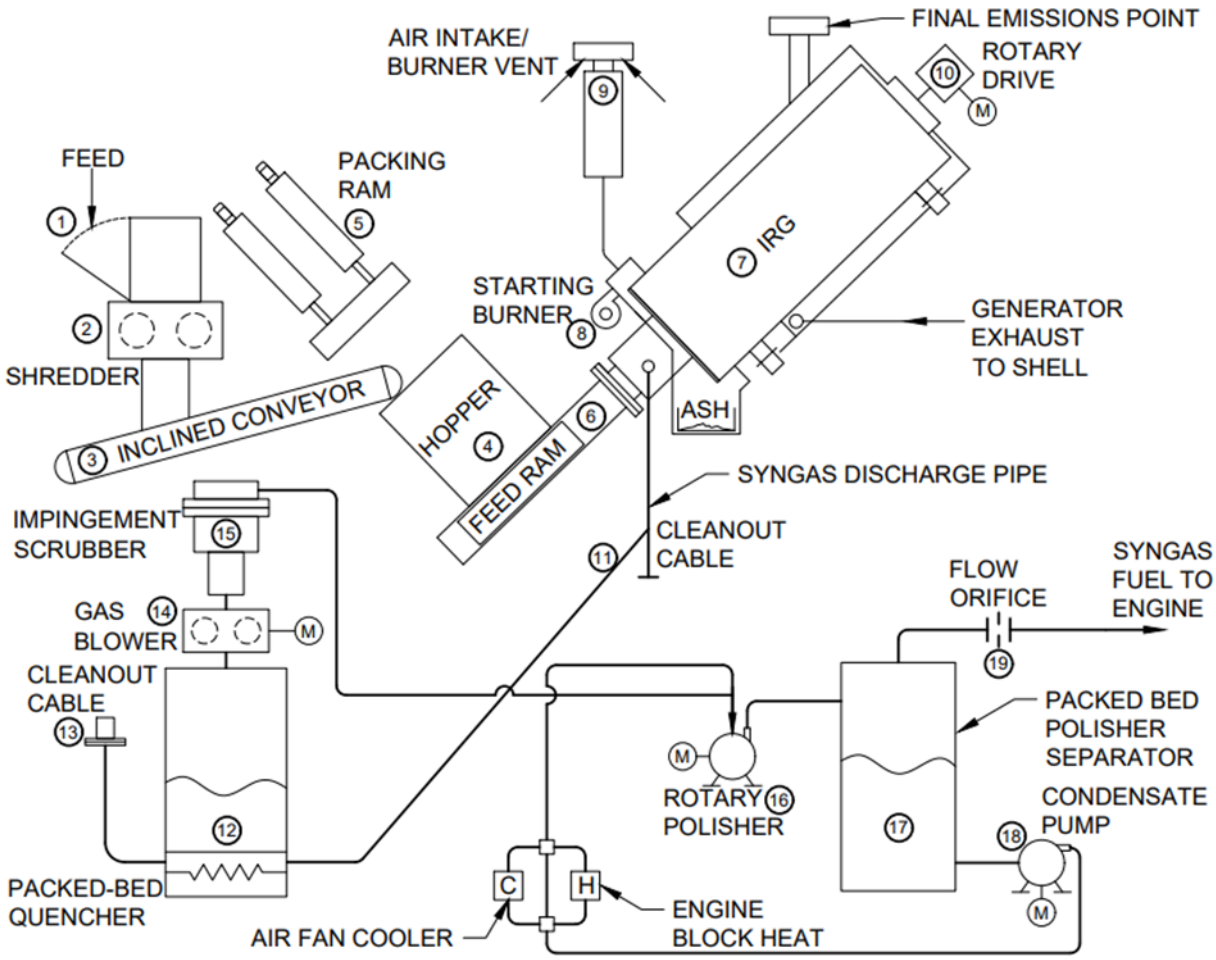


Figure C.1. Inclined Rotary Gasifier Process Flow Diagram

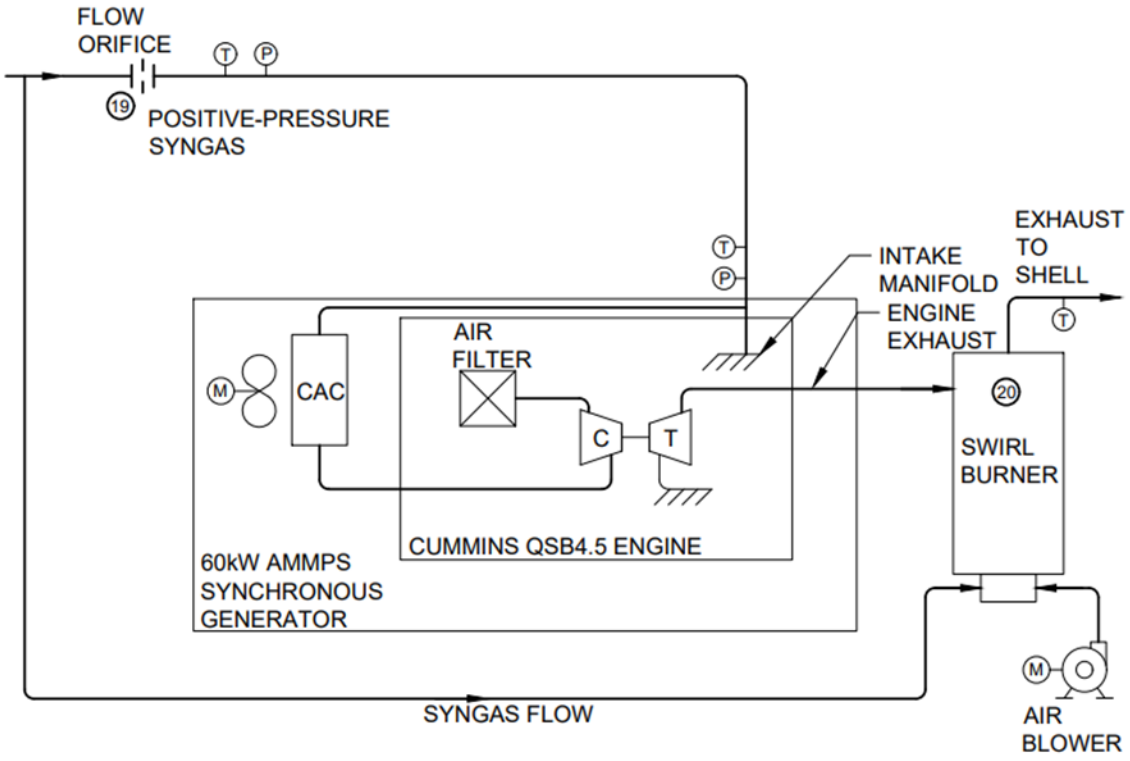


Figure C.2. Gas Distribution Diagram

Figure C.1 is the process flow diagram for the inclined rotary gasifier system. Figure C.2 is the gas distribution diagram. The function of each piece of equipment in both diagrams is described as follows:

1) Waste feed point – Waste must be fed into the feed hopper located above the shredder. The mailbox style entry prevents hand contact with the shredder knives and contains any hard items that may become airborne when pinched between the shredder cutting knives.
2) Shredder – Shreds waste into 3-inch or smaller pieces using cutting knives. Waste drops onto inclined conveyor.
3) Inclined Conveyor – Transports shredded waste from shredder outlet into hopper. Shredder is indexed automatically based upon feedstock level in hopper.
4) Hopper – Stores waste that is to be fed into the IRG. Waste feedstock level is monitored via sensors which are transmitted back to the automation system.
5) Packing Ram – Packs waste stored in hopper into feed ram during automated feed process.
6) Feed Ram – Pushes waste up into IRG during automated feed process.
7) IRG – Rotating gasifier composed of one internal rotating cylinder. One heated shell with an air gap surrounds the internal cylinder.
8) Starting Burner – Provides a pilot light to the system using fuel from the generator auxiliary tank to initiate the gasification process.
9) Air Intake/Burner Vent – Allows a limited amount of air into the system for the gasification process. Flow is determined by the gas blower speed.

10) Rotary Drive – Rotates the IRG using an electric motor and gear reduction boxes.
11) Syngas Discharge Pipe – Outlet piping for produced syngas which is plumbed from the IRG to the packed-bed quencher.
12) Packed-Bed Quencher – Rapidly cools the hot gas down to adequate operating temperature. Gas is bubbled through cooling liquid where tars and heavy oils are separated.
13) Cleanout Cable – Cable designed to rotate and clean out any particle accumulation within syngas pipe.
14) Gas Blower – Provides aspiration to the entire system by pulling negative pressure on the gasifier and positive pressure through the remaining process equipment. Powered by an electric motor.
15) Impingement Scrubber – Continually cleans syngas exiting from the packed-bed quencher, allowing for tar and heavy condensable material to flow back.
16) Rotary Polisher – Used in conjunction with the condensate pump to clean syngas and condense volatile liquids. Powered by an electric motor.
17) Packed-Bed Polisher Separator – Uses a packed bed to further clean the syngas, separating fine particulate from the gas stream before it continues on in the process.
18) Condensate Pump – Pumps fluids from the packed-bed polisher to the rotary polisher where it is used as a jet to clean gas further. Powered by an electric motor.
19) Flow Orifice – Measures syngas flow exiting the packed-bed polisher separator. This measurement is used to control the gas blower speed.
20) Swirl Burner – Burns a limited amount of syngas to produce heat of exhaust which is disbursed around the IRG shell to increase efficiency of the process. Uses a satellite burner to initiate combustion and an air blower to provide combustion air.