ALL Power Labs
personal scale power

v1.09 Operation Manual

(Grid-tie model shown)

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www.allpowerlabs.com/support

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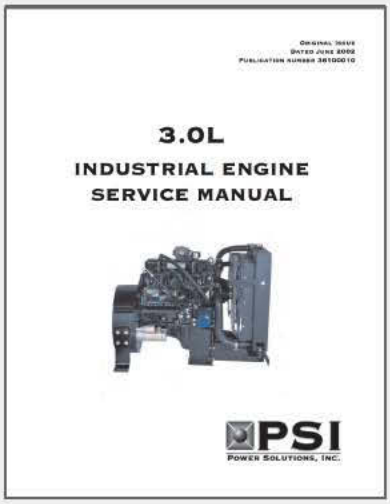
1. Specifications

	PP20 v1.09
Electrical output capacity	50 Hz, 1500 RPM: 4–25 kW
Gasifier flow rate	11-52 m^3/hr
Gas thermal output at maximum	330,000 BTU/hr 97 kW
Biomass consumption rate	50 Hz: 4.8–19.2 kg/hr
System Footprint (l×w×h)	136 cm × 178 cm ×193 cm Footprint includes ash collection vessel beside the pallet. The pallet itself is a 136cm square.
System weight	(893 kg) 1969 lbs not including packaging for shipping or feedstock.

2. Relation to other Documents

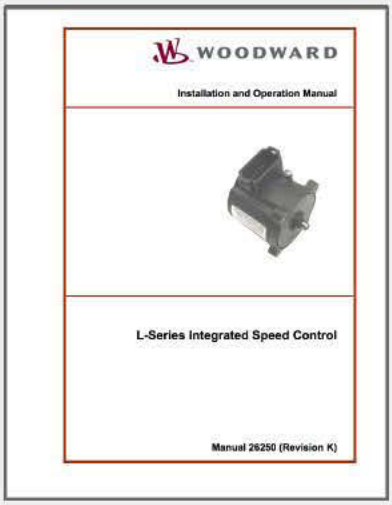
All manuals listed below are included in electronic form with the machine, or can be obtained from manufacturer's website. These are referenced in this document and in the User Manuals section of the software package of the machine. Be sure that you check in with the latest version of the manufacturers manuals.

2.1 Engine Manual



PSI 3.0L INDUSTRIAL ENGINE SERVICE MANUAL

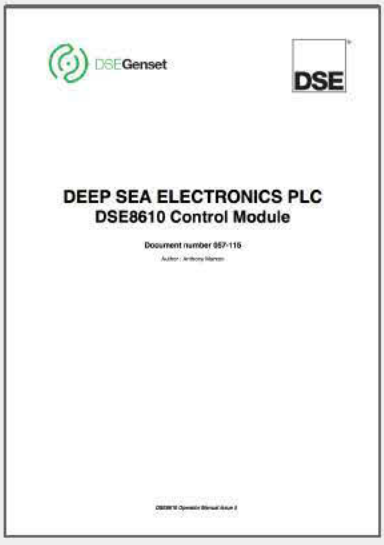
2.2 Engine governor manual



Woodward L-Series Integrated Speed Control, Manual 26250 (Revision K)

2.3 Generator manual

2.4 Grid-tie controller manual



3. List of Images and Icons

3.1 Warning icons

	**Danger** **Toxic Carbon Monoxide Gas** **Locations: front of hopper**
	**Danger** **Toxic Carbon Monoxide Gas** **Location: Laser-cut stainless handles on top of pyroreactor and ash collection port covers**
	**Danger** **Ignitable mass of combustible gas** **Location: Side of hopper, inside on side of filter**
	**Danger** **Electric Shock Hazard** **Location: Cover of grid tie**
	**Hazard** **Hot Surfaces** **Location: Housing right of PCU**

	**Warning** **Hot Surfaces** **Location: Laser cut into stainless steel heat shield**
	**Warning** **USE ONLY IN** **WELL VENTILATED AREA** **Location: Housing left of PCU**
	**Warning** **Physical injury hazard; risk of entanglement with moving parts**
	**Forbidden** **Warnings with the red circle and bar indicate forbidden procedures; doing these things will result in injury to the operator or damage to the machine.**
	**Forbidden** **Do not operate machine with open enclosure**
	**Forbidden** **Do not carry out maintenance on the machine while it is running or while it is hot**

	**Forbidden** **Do not forklift the machine from any side other than the engine side. The center of gravity is over the engine side.**
	**Requirement** **COMPULSORY TASKS AND SAFETY EQUIPMENT** **All blue circled icons indicate requirements**
	**Requirement** **Forklift from this side only**
	**Requirement** **READ THE OPERATOR'S MANUAL prior to operation** **Location: Door of PCU enclosure (see #7 pg. 12)**
	**Requirement** **WORK BOOTS REQUIRED**
	**Requirement** **HEAT RESISTANT GLOVES REQUIRED**

Requirement
EYE PROTECTION REQUIRED

4. Introduction

The *PP25 EU Grid-Tied or Off-Grid Power Pallet* biomass gasifier genset complies with the *Machinery Directive 2006/42* and its amendments, therefore it poses no danger to the operator if it is installed, used and maintained according to the instructions given by ALL Power Labs, and provided the included safety devices are kept in perfect working conditions. While the *PP20 Grid Tied or Off-Grid Power Pallet* is not currently certified under this directive, adherence to the installation, maintenance, and operation instructions given by ALL Power Labs will allow the operator to operate the machinery in a safe manner.

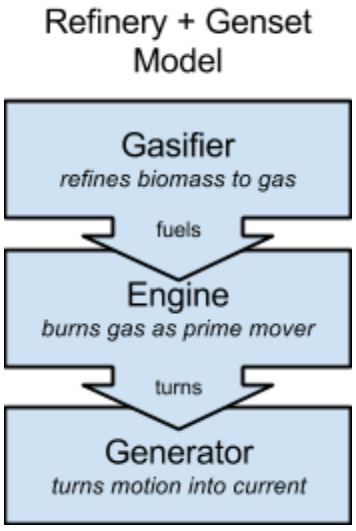
Strict observance of these instructions is required.

4.1 Purpose of this manual

This manual is intended to instruct an operator of the Grid-Tied or Off-Grid Power Pallet models on safe operation and maintenance of the machine for the purpose of generating electrical power in either a grid-tied or off-grid installation. This includes competence in assembly and installation, transport, knowledge of the name and function of the various parts of the machine, and competence with the standard operations and maintenance.

5. Description

5.1 General Use



The Grid-tied Power Pallet with Enclosure (henceforth, also referred to as simply the *Power Pallet*) is intended for generating AC electricity from locally available biomass feedstocks, and supplying this electricity onto either the electric grid or a local micro-grid.

5.2 General Description

The Power Pallet system is comprised of a gasifier integrated with automation system and an engine coupled to a generator. The purpose of the gasifier is to refine biomass feedstocks into a clean-burning gaseous fuel that is compatible with internal combustion engines. Gasification involves subjecting cellulosic biomass to the processes of *drying*, *pyrolysis*, *combustion*, *cracking*, and *reduction*. Tar cracking breaks down tar gases into carbon monoxide, hydrogen, and other light gases by exposure to high temperatures, and reduction converts charcoal into carbon monoxide and hydrogen by percolating the carbon dioxide and water vapor produced during combustion through hot charcoal. The resulting combustible mixture of combustible gases and nitrogen from combustion air is known as *producer gas*. Producer gas is made up of about 20% H_2 and 20% CO, which are both gaseous fuels that the internal combustion engine burns to generate power for grid tied applications.

6. Assembly and Installation

6.1 Packaging

The machine is packaged inside a plywood frame. Carefully remove the frame with a crowbar between the paneling and the wood frame. Be sure not to damage the equipment inside. Two sides of the wooden frame contain screens used for feedstock processing. Be sure not to damage the screens when opening the packaging.

Note: Keep the two screens for feedstock processing. DO NOT THROW OUT!

6.2 Transporting

The machine is to be transported using a forklift or pallet jack across a flat surface. **The machine is only to be lifted from the engine/generator side.** The weight of the system is biased toward the side of the engine and the generator.

DO NOT forklift the machine from any side other than the engine side.

6.3 Storage

The following must be done before storage of the Power Pallet:

- System must be entirely cooled down; drawing air through the system with embers in the reactor will cause the reactor to heat back up and restart.
-
- Purge the cooled system (near ambient temperature) with air by turning on the gas blowers for 10 minutes. If gas circuit is not purged, residual water vapor in the gas circuit increases risk of corrosion; residual carbon monoxide may slowly leak out into surrounding facility. After letting the blowers purge the gas circuit for a minute, open

the hopper lid and to let air enter the system via the hopper. This will let air percolate through the feedstock and purge the remaining gas in the hopper, drying bucket, and PyroReactor for the remaining time.

- Disconnect the on-board battery.
- Empty the cyclone ash can, the ash collection vessel, and condensate vessel.
- Store the Power Pallet in a weather protected area and keep the electronics away from moisture.

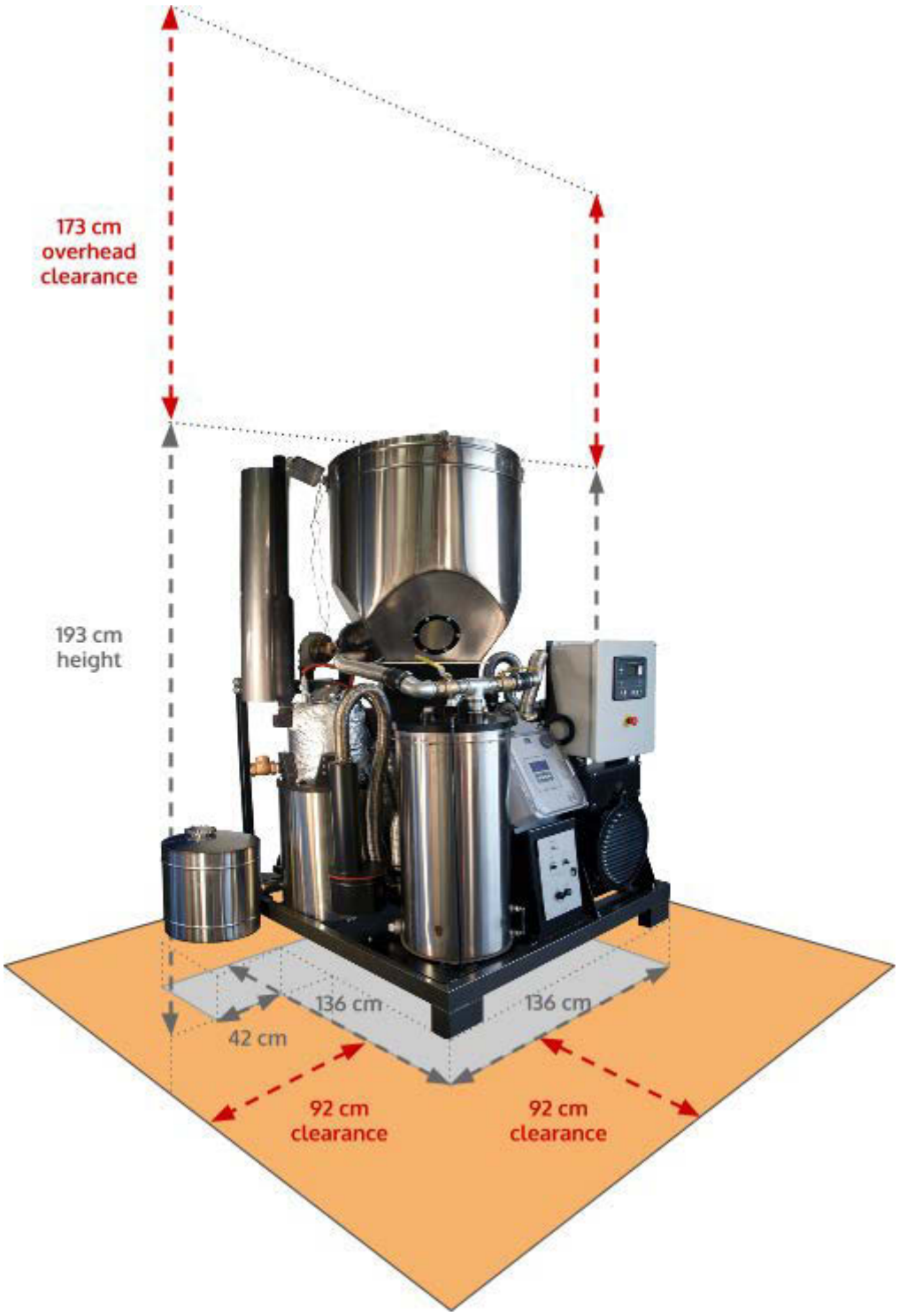
If the Power Pallet is stored for more than 6 months, all of the feedstock and charcoal must be removed. The system must be inspected for proper operation. Inspection after storage includes checking motors (grate shaker motor, ash grate motor and feedstock motor), engine coolant and oil level. The feedstock and charcoal must be taken out and refilled with new material.

6.4 Installation Requirements

6.4.1 Facility Requirements

The facility to house the Power Pallet must have the following characteristics:

- Level flooring made of nonflammable material capable of supporting the weight of the machine (listed in the Specifications section).
- The system is to be installed with a 92 cm clearance around the footprint of the machine and at least a 173 cm clearance above the machine. See illustration on the next page.
- Sufficient ventilation through an exhaust hood with air flow capacity adhering to local regulations.
- Install the CO meter provided with the Power Pallet and verify that it functions properly. Have a CO meter near the operating floor at all times even when the machine is not in operation and especially when performing maintenance.
- Operate the Power Pallet in locations having a max temperature of 40C and at an altitude of 1000m or less. In case of different conditions please consult ALL Power Labs.
- Install the Power Pallet out of direct sunlight. UV from sunlight will damage parts over time.

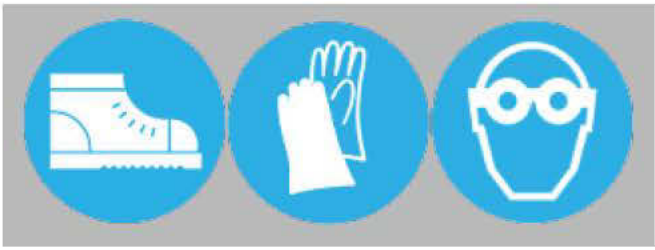


Clearance requirements around the Power Pallet.

6.4.2 Final Assembly

6.4.2.1 Safety

Assemble the final components after moving the Power Pallet to its final location for installation. During the assembly of the final components it is required to wear steel-toed boots when lifting or moving heavy equipment.



Operator must wear proper Personal Protective Equipment when operating the machine.

When filling the system with feedstock or charcoal it is required to wear a respirator appropriate to protect against fine particulates.

6.4.2.2 Tools needed for assembly

The following tools are needed for assembly.

- 9/64 inch and ⅜ inch allen wrenches
- 6' (2m) or higher ladder
- ½inch or 13mm socket wrench
- Flat head screwdriver
- Phillips-head screwdriver
- 5/16 inch socket driver
- 3/8 inch socket driver

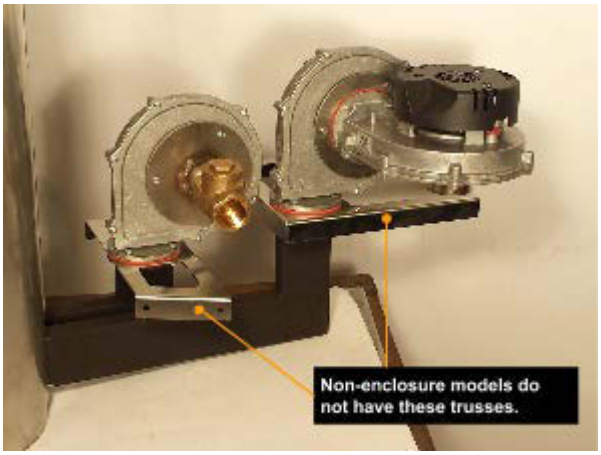
6.4.2.3 Final assembly instructions

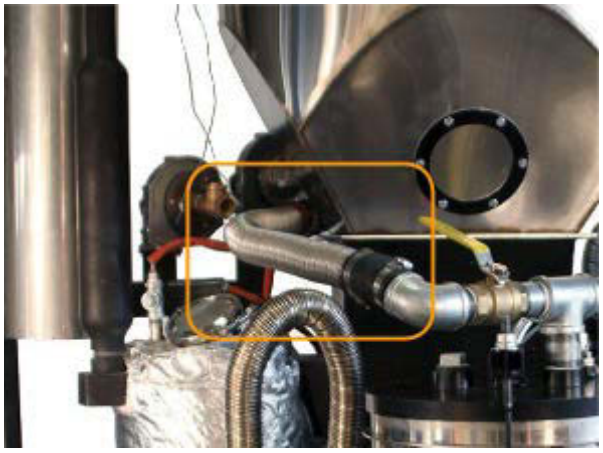
a) Hopper

Bolt the hopper onto the drying bucket with the bolts included in the user kit, with the window facing the corner of the machine with the filter

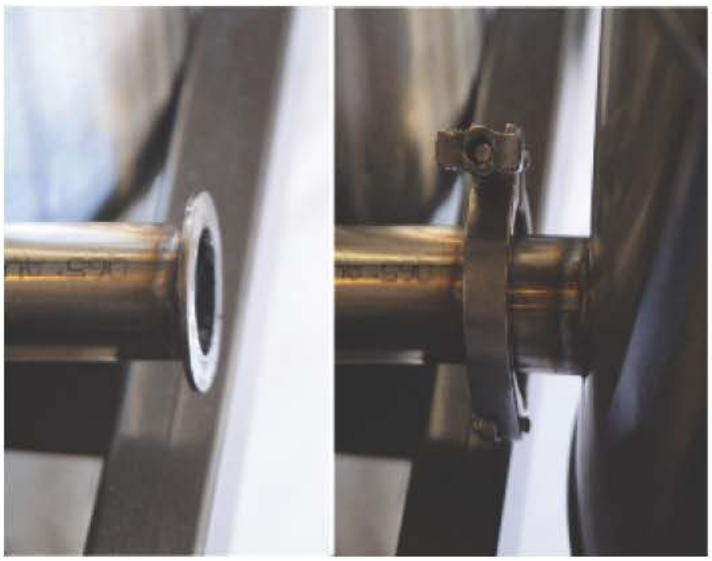
b) Flare, blowers

The flare and blower assembly comes with several parts that will need to be assembled before the Power Pallet will be functional.

	
1. Several smaller items must be attached to the flare: the blowers and the igniter	2. When properly assembled, the assembly should look as above. The single air blower should bolt through the small truss, and the double gas blowers should bolt through the larger truss.
	
3. Attach the igniter to the top of the flare with the machine screws that come with the igniter.	4. Mount the flare onto the flare stem. The flare mount can be found on the base of the flare. Attach the flare to the enclosure by sliding the flare mount to the stem on the gasifier corner of the Power Pallet, then bolt it on with the included bolts. The combustion column of the flare should be on the right side of this stem.

	
5. Attach the gas blower to the connecting pipe using the flex coupler, which is fitted to both ends with hose clamps.	6. Plug in all of the wires into their corresponding blowers.
	
Testing When all of this is done, turn on the Power Pallet, and briefly test the gas and air blowers by turning them on and listening for a sound at the blowers.	

c) Ash collection vessel



Attach the ash collection vessel to the end of the ash auger pipe using the corresponding sanitary clamp.

d) Engine

- Engine oil— 4 quarts (3.79 liters) SAE 10W30, above 0˚F (-18˚C)
- Engine coolant[1]— Recommend ethylene glycol mix 52/48, up to 60% glycol, 40% water; Fill to ¾"-1 ½" below the filler neck on the radiator. Total capacity is approximately 12 quarts (11.4 liters)
- 12 VDC Car Battery (Recommend 75 Amp-hours, 880CCA)

i. Battery

The Power Pallet will need a 12 volt DC car battery. Heavy duty batteries are recommended because of the significant loads that the battery must power during the start-up process.

ii. oil

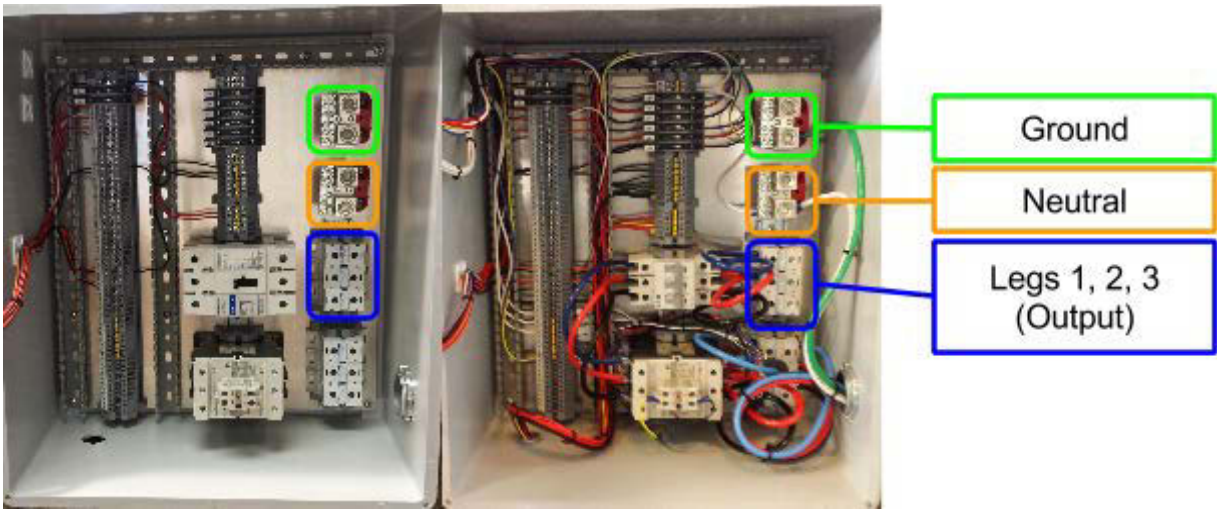
See pages 0-15 through 0-16 in the *PSI 3.0L Industrial Engine Service Manual* for details on oil requirements and maintenance.

iii. coolant

See pages 0-16 through 0-17 in the *PSI 3.0L Industrial Engine Service Manual* for details on the coolant mixture and level requirements.

e) Grid-tie controller wiring

Consult an electrician when wiring to the Power Pallet. Some regions may require the installation of a breaker box, please consult an electrician and comply with local electrical regulations.



The photograph above shows the Grid-Tie control box, without wires on the left, and with wires on the right. When consulting with an electrician to do the electrical portion of the installation of the Power Pallet, please note the important terminals highlighted above.

6.4.2.4 Torque Specifications for final assembly

The torque requirements are listed in the chart below.

Torque Requirements

Component	Bolt Size	Torque (N-m)
Drying bucket to hopper flange	5/16"-18	7
Igniter to flare stack connection	8-32	0.8
Intake Elbow to Intake Manifold	6M	10
Oil return flange to engine block	3/8"-13	35

Gasketed flanges should not be overtightened. Do not tighten enough to bulge out the gasket, as this could damage the gasket.

6.4.3 Post assembly testing

Visually check that all gaskets are seated properly and that all flanges and connections are tightened to the proper torque requirements.

To test the emergency stop button, pull the button outward and disconnect the 13-pin screw terminal connector on the bottom left most corner of the Grid-tie controller. Use a voltmeter to detect continuity between pin 3 on the 13-pin screw terminal and pin 4 on the 12 vDC power bus. The voltmeter should read 0 ohms resistance between these two terminals. When the emergency stop button is depressed, the voltmeter should show no continuity and high ohms resistance.

Before running the system, please refer to the pre-startup checklist in the operation section.

6.4.4 System Requirements

6.4.4.1 Hopper Loading (for PP25EU models only)

Facility requirements include an automated feed system. A 12 VDC powered automatic hopper lid with process control will be included with the Power Pallet. This is in the form of a twist-on

hopper lid, which receives fuel through a “funnel” flange approximately 200mm above the top of the hopper. A suitable feed duct approximately 300mm in diameter should be attached with a relatively air tight seal to this funnel on the hopper lid, and in a similarly airtight fashion on the upper end of the duct to the output of the auger or other feed system provided. This feed system must be able to deliver a minimum of 25 kg of feedstock per minute.

A process control mounted on the Power Pallet hopper has a relay that will open and close a contact connected to a command wire that can be used to synchronize. Relay connection specifications are 16 vDC 10A max at 85C.

Respect the technical specifications of the feed system.

6.5 Waste Disposal, Emissions and Dismantling

6.5.1 Waste Disposal

The tar and condensate collected from the filter and condensate vessels of the Power Pallet typically has a composition of benzene, toluene, ethylbenzene, xylenes and particulate matter. The filter media and condensate should not be poured onto the ground. The filter media and condensate (from cyclone and engine vessels) can be dried and mixed back into the feedstock at 10% tar per weight of the feedstock. If disposing of the tar and condensate, do so in compliance with local motor oil disposal regulations.

Dispose of old batteries according to local environmental regulations.

Engine oil should not be reused. Dispose of engine oil according to local environmental regulations.

6.5.2 Emissions

The Power Pallet emissions are below most emissions regulations and standards for generators in its class in most regions. Check with local regulations to make sure it is within standards of the region the Power Pallet is to be operated. The emissions of the Power Pallet are as follows:

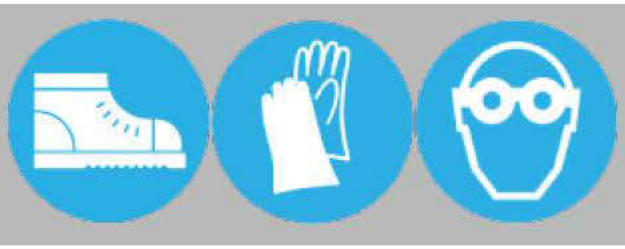
- 300 mg/m3 CO
- 650 mg/m3 NO_x at 5% of O_2

6.5.3 Dismantling

Before disassembly of the machine follow storage procedures then drain the engine oil and coolant. Respect the local waste disposal regulations.

7. Equipment Operation

7.1 Safety

	Always wear proper personal protective equipment during operation.

	Warning: Hot surfaces during and after operation. Hot components include • gasifier • gas filter • gas lines • engine and various other components. Hot surfaces can cause burns.
	Operate only in a well ventilated area
	Keep the carbon monoxide detector nearby at all times during operation and service.
	Large volumes of producer gas mixed with air can be form an ignitable gaseous mass. This machine is built is such a way to avoid dangerous masses of ignitable mixtures. But nonetheless, respect all of the indications in the manual to avoid danger in all stages of the process. including operation, normal use and maintenance.
	Do not wear loose clothing around the Power Pallet; may be caught in moving parts. Make sure all objects (including tools and stray feedstock) are clear of all moving parts.

	The wiring studs inside the electrical box on top of the generator and any outgoing wires carry high current and can cause severe burns, electric shock, and other serious injury. A trained electrician should design and make any external wiring connections. Operators should take appropriate precautions when handling or working near live wires.
	Never operate the machine with an empty or improperly packed filter. Never operate the machine with an empty hopper. Level should be above the bottom flange of the hopper. Do not attempt to light the flare without the air blower on, as this will damage the blowers.
	Enclosure doors should be closed during operation of the machine (applicable for PP25EU models only).
	Always perform the leak-down test before operation. Always make sure that the on-board 12vDC battery is fully charged before operation.

7.2 Tools

Tools required for operation

7.2.1 Provided

- Starter charcoal— necessary for first start of gasifier
- Squirt bottle— useful for adding accelerant (flammable liquid) for lighting the gasifier
- Carbon Monoxide detector— for operator safety

7.2.2 Not Provided

- Fire extinguisher
- Handheld propane torch— for lighting the gasifier
- Ladder 6 ft (2m) or higher
- Heat-resistant gloves— for handling hot components and surfaces
- Metal pan— at least 10 liter capacity; this will be useful during maintenance, especially when grate basket is being cleaned
- Metal rod or wooden stick, approximately 4 ft (1.25 m) long— for breaking feedstock jams; stick should be fire resistant
- Metal ash rake— for cleaning out grate basket
- Shop vacuum cleaner— for cleaning out the grate basket and several maintenance tasks
- Accelerant— for starting gasifier (e.g. lighter fluid, gasoline, diesel, kerosene, alcohol, any other flammable fluid)
- Car Battery Charger— in case the battery charge is exhausted before the engine can be started

7.3 Feedstock

7.3.1 Feedstock Specifications

Characteristic	Requirement
Particle size	0.5'' – 1.5''
Moisture content	less than 30% (Dry weight)
Ash content	less than 5%

Follow the feedstock specifications to avoid damage to the machine.

7.3.2 Feedstock consumption

The biomass consumption rate of the Power Pallet is approximately 1.2 kg of feedstock per 1 kWh of electrical energy. The actual consumption rate varies with load, moisture content, and quality of the feedstock.

7.4 Pre-Start Checks and Duties

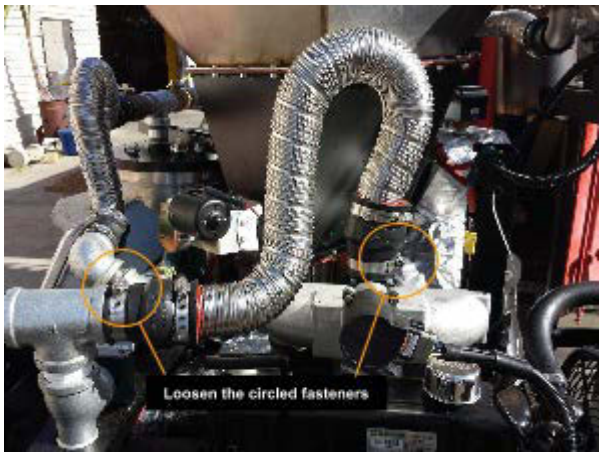
7.4.1 Checklist of Pre-Start duties

Item	Correct Operational Status
Charcoal in GEK Gasifier	Charcoal should completely fill the space above the Ash Grate and the reduction bell and about 6 inches below the PyroReactor viewport.
Hopper filled with feedstock	The hopper should be filled at least halfway before start. Please respect the feedstock requirements.
Gas filter	Filter must be packed according to the specifications in the maintenance section. If already packed, confirm that the filter is not clogged. **Pfilt** must be <300 during engine operation. A reading greater than 300 indicates time to change the filter
Condensate Vessel	Should be empty; draincock must be securely shut.
Ash Collection Vessel	Should be empty.
Cyclone can	Should be empty and attached with an airtight seal.
All seals and connections are airtight	System passes leak testing as stated in the operation section 7.4.2.5.
Air filter	Engine air filter clean enough for sufficient air flow.
Engine coolant	Filled to proper level with the appropriate coolant (see the engine manual for specifications).

12V DC Battery	Battery should be fully charged. Minimum voltage on the battery is 12V, but 14V is preferred.
Governor throttle control check (See Section 6)	Disconnect gas line to verify that governor is freely moving.
Check that blowers work	Blowers are able to pull at least 50-60 units vacuum on reactor. (**Preac**)
Oxygen sensor reading	Oxygen sensor number display should read 1.5 at startup; do not run if error condition shown.
Flare Igniter	Igniter should turn ON when **Preac** (indicated on the PCU display) is greater than 5. Check visually to make sure the Igniter turns on (glows red).
Biomass Auger feed	Runs properly (not obstructed) and fills reactor with feedstock. Alarm will sound if not working properly.
Clearance for rotational components	Make sure nothing is obstructing the rotational components of the generator, engine, or gasifier (ie: wood chips, tools, etc).
Flare or exhaust stack	Make sure nothing is obstructing the hot gas exits of the exhaust and flare stack.
Check CO meter	CO meter is working and is near the operator.
Walk Around	Double check bungs, latches, gas connections and bolts.

7.4.2 Detailed Instructions of selected Pre-start Duties

7.4.2.1 Check Governor

	
1) Disconnect the Novaflex hose between the air mixer and the engine governor to drain condensate and tars.	2) Inspect the engine governor throttle plate for tar accumulation, and clean accordingly while the tars are warm and soft. Reconnect Novaflex when finished.

Use grease cutting cleaning solvents or alcohol to dissolve excess tar as needed.

7.4.2.2 Empty Ash Vessel

The ash collection vessel of the Power Pallet can collect between 12 and 24 hours of char ash, depending on feedstock quality and load. The recommended time for emptying the ash collection vessel is right before operating the Power Pallet, while the reactor is cool, but it may also be emptied after an operating session if it is permitted to cool down until it is safe to touch. Please be aware that detaching and opening the ash collection vessel poses a carbon monoxide hazard. Make sure you are working in an area with good ventilation.

Precaution: Turn on the gas blowers to a low setting (3-4) so carbon monoxide does not vent out into the working area when the vessel is detached.

1. Detach the ash collection vessel by loosening the sanitary clamp on the inlet tube. Take the vessel to your disposal area.

2. Open the access port on top of the ash collection vessel by loosening the sanitary clamp, and dump the ash out.

3. Close the access port, and re-attach the ash collection vessel. **Be sure to establish air-tight seals. Air leaks in this location increase the risk of explosion and reactor component damage due to local combustion.**

7.4.2.3 Empty Cyclone Ash Can

The cyclone ash can collects charcoal dust and ash separated out of the gas by the cyclone. It has enough capacity to handle 14-24 hours of Power Pallet operation depending on feedstock and settings, and should be emptied before each session. However, there is no way to measure the level so check before 10 hours to make sure it does not fill and over pack. If it overpacks this could damage the ash auger. Make sure there is adequate ventilation; this step is a carbon monoxide hazard.

	**Precaution**: Turn on the gas blowers to a low setting (5) to apply a little bit of suction so carbon monoxide does not vent out into the working area when the ash can is detached.  **Inspect Gasket and fitting hardware:** the cyclone ash can holds onto the cyclone fixture using pegs on the can that pull into slots on the lid at the bottom of the cyclone. To establish an airtight seal, the gasket on the lid must not be broken or cracked. Be sure to inspect this gasket each time the cyclone ash can is emptied.
1. With the gasifier cool, take hold of the handles of the cyclone ash can and turn the can clockwise about 15°. The can should descend and come loose.	2. Dispose of the contents, and re-attach the can by aligning the pegs with the slots, lifting upwards, and tightening the can counter- clockwise. **Be sure to establish an air-tight seal; air leaks cause internal fires.**

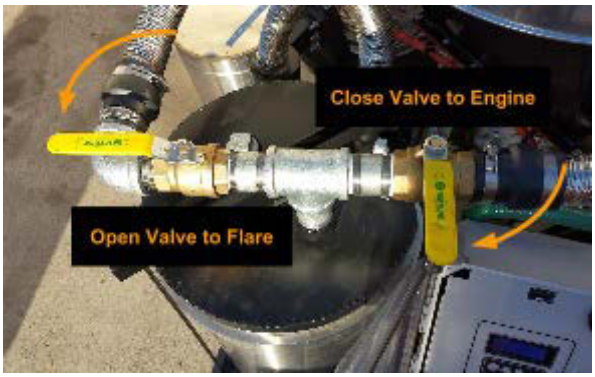
7.4.2.4 Clean Cyclone

Particulate matter and tar may gradually accumulate in the cyclone; as part of regular maintenance, it should be cleaned out by inserting a narrow bottle brush up the hole at the bottom of the cyclone to knock out any dust that has accumulated in the cyclone.

The cyclone with its ash can removed for maintenance. The hole under the cyclone can be seen. Insert a pipe brush into this hole to purge any accumulated fouling.

7.4.2.5 Leak Testing the Power Pallet

The Power Pallet operator should carry out the following leak test before running the machine. Air leaks are hazardous to the machine and to the user, risking internal fires and permanent damage to the machine. Leaks are most likely to be introduced during assembly after maintenance; thermal cycling can also potentially cause leaks. If a leak is detected, the operator should examine every seal and joint that is opened during maintenance. Advanced leak detection is explained in Section 3 of the Technician's Handbook.

	
1) Turn on the automation assembly	2) Open the valve to the flare and close the valve to the engine.

	
3) Seal off the air intake check valve; use a 1.5" pipe plug. Plastic pipe plugs usually will not require the assistance of pipe thread tape to establish a seal good enough for this test, but cast iron plugs may thread tape. If a pipe plug is not available, duct tape may be used to seal off the air intake.	4) Turn the gas blower up to 11 (the maximum setting). This will apply vacuum pressure to the entire gas circuit.
	
5) Shut the valve to the flare, then turn off the blower. The valve should lock in the vacuum pressure.	
Test criteria #1: When the numbers indicated for **Preac** and **Pcomb** stop rising, • **If the reactor pressure reading is near or >90**, the reactor passes the first leak test. • **If the pressure is <90,** it may be that the battery has insufficient charge, there	**Test criteria #2:** After closing the valve, the pressure will begin to drop. Start timing the pressure drop on the PCU right after the valve is closed. • **Takes >60s to reach 0.** This is typical for new and well sealed systems. The reactor passes the leak test.

is a significant leak, or there is a large pressure drop in the system. This needs to be solved before continuing.	• **If the pressure drops to zero <30 sec**, the reactor fails, and should not be operated until the leak is repaired.

If the graphite rope comes out, or if leak testing always seems to fail after opening the reactor access door, use a narrow pick to pull the graphite rope out. Wedge a fresh graphite rope into the groove with the end cut on a bias, and align the ends. Smear graphite paste over the rope, and try to seat the seal again. Be sure to do a leak test to verify a successful seal.

7.4.2.5 Replacing graphite gaskets (if needed)

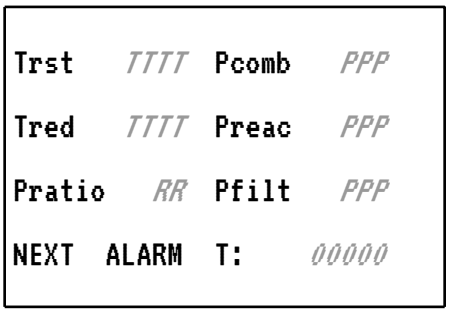
The following items on the gasifier are sealed using graphite rope and graphite paste:

- Reactor access door seal
- Interface between the air intake and the PyroReactor's flange
- Interface between the riser to the cyclone and the PyroReactor's flange
- Interface between the riser and the cyclone itself
- Interface between the underside of the PyroReactor's flange and the gas cowling

The only one of these that is regularly opened is the reactor access door, so this is likely to be the only seal that will need to be replaced in the course of maintenance. If the graphite rope comes out, or if leak testing always seems to fail after opening the reactor access door, use a narrow pick to pull the graphite rope out. Wedge a fresh graphite rope into the groove with the end cut on a bias, and align the ends. Smear graphite paste over the rope, and try to seat the seal again. Be sure to do a leak test to verify a successful seal.

7.5 PCU display

PCU display briefly shows a splash screen before displaying main screen when the Power Pallet is on:



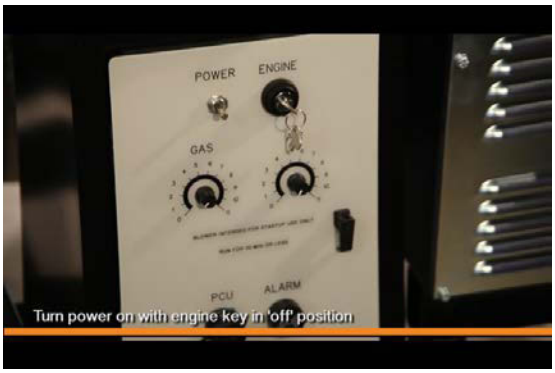
Power Pallet main screen

During normal steady-state operations, the parameters indicated above will generally meet the following conditions.

Trst	Units are degrees Celsius. Should be higher than 800˚, but less than 1020˚	Pcomb	Units are tenths of an inch of water column. Varies with load.
Tred	Units are degrees Celsius. Should be higher than 650˚C.	Preac	Units are tenths of an inch of water column. Varies with load. Should have a larger number than **Pcomb**.
Pratio	Indicates the ratio **Pcomb**/**Preac** * 100. Should be between 20 and 60.	Pfilt	Indicates pressure difference between the reactor and filter; varies with load. P_filt should be <300 during engine operation.
NEXT	Press the button below the NEXT label to advance to the next menu.	ALARM	The ALARM label will flash when there is an active alarm. Press the button below to view active alarms.
T:	This area displays the number of seconds the PCU has been powered on and can be used to correlate events with a timestamp in the data log.		

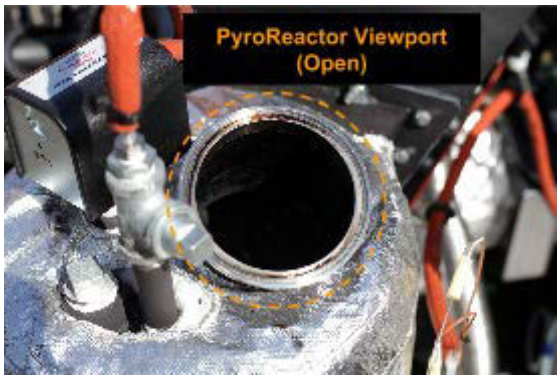
7.6 How to Operate the Power Pallet

7.6.1 Filling the Gasifier



1. Sift the dust and fines out of the bags of provided charcoal using the ½" mesh provided with the Power Pallet and pour it into the hopper.

2. Turn the main power switch 'On'' Wait a few seconds for the Power Pallet automation to come on.



Indication: The auger will activate and fill the reactor with the charcoal. This can be observed through the viewport on top of the PyroReactor if desired.

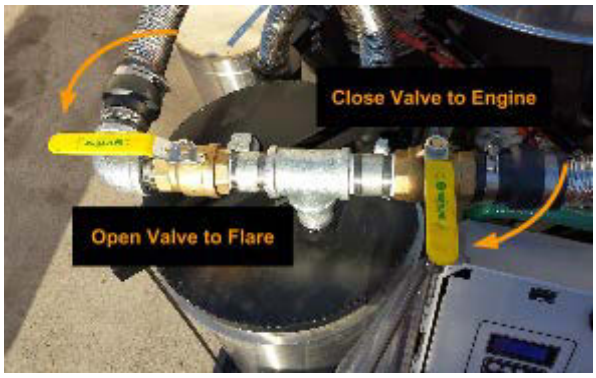
3. Fill the hopper with APL-approved feedstock and fasten the lid on the hopper, ensuring that the lid is sufficiently secure to hold a gas tight seal.

Notes: When starting the Power Pallet for the first time, fill the reactor with charcoal until it reaches the tip of the fuel switch. If there is not enough charcoal provided, use locally sourced charcoal. The ideal feedstock for the first start will have less than 15% moisture content.

The sizes of both the charcoal and feedstock pieces should be within the range of ½"-1 ½".

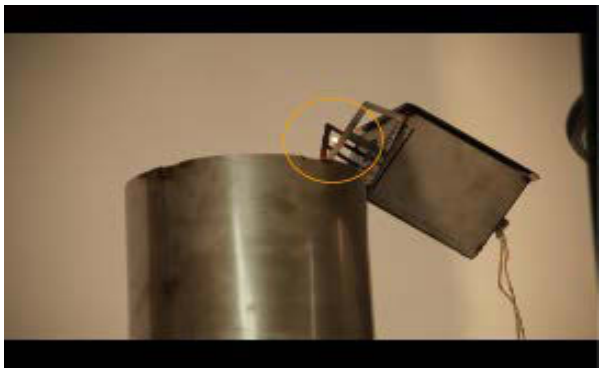
Indication: When the reactor is full, the fuel switch will automatically turn off the auger.

7.6.2 Lighting the Gasifier



1. Open the valve that leads to the flare, and close the valve that leads to the engine.

2. Turn the gas blower until **`Preac`** reading reaches 15, and adjust the air blower to just under the gas blower setting. The igniter will turn on once the **Preac** (Pressure in the reactor–indexed value) reading exceeds 5. Note: The Grid Tied Models will not have an engine key switch.



Indication: The igniter at the top of the flare stack should start glowing.

Optional: Use the squirt bottle to add approximately 15-25 mL of starting fluid (e.g. diesel, gasoline, kerosene) through the lighting port at the top of the reactor. This may help slightly moist feedstocks light faster.

	
5. Use a hand-held lighting torch to light the gasifier through the lighting port. Smoke and steam should emerge from the flare stack.	6. When **Trst** (temperature at the restriction) reaches 80˚C, cap the lighting port to stop any additional air from entering
	
7. Increase the value of the gas blower to increase **Preac** to -40 units. Once the flare is lit increase the gas blower to the maximum setting. Then increase the air setting until the combustion descends into the flare tube.	**Indication:** The flare will produce a low-pitched roaring sound when the igniter lights the gas and air mixture. If flames are visible above the flare, slowly increase the value of the air blower until the flames descend into the flare stack.

Note: startup should not take more than 20 minutes. Extended startup may deplete the battery. See Section ***7.5.4.2.*** under the heading *Bringing the gasifier up to temperature.*

7.5.3 Running the Engine and Generating Electricity

The Power Pallet off-grid and grid-tied systems have different engine startup procedures.

7.5.3.1 Off-Grid Models only

A. Starting the Engine

1. Quickly close the valve to the flare, and turn the gas and blower knobs to 0.

2. Open the gas valve to the engine.
3. Turn the key to engage the starter. You will see the servo valve close initially then slowly open as the gas line is fully purged with gas then the engine should start. Note that you may need to crank it long enough for the gas to fully purge. Do not crank for more than 5 seconds at a time before waiting 15 seconds or so for the starter to cool.

B. Shutting down the Engine

1. Turn the key switch to the off position.
2. Wait until the engine has stopped turning then close the engine valve.
3. Switch the system over to flare mode (See section 5.5.5).

7.5.3.2 Grid-Tied Models only

ning: Risk of electric shock! Do not open
id-tie controller panel or touch the bus.

A. Starting the Engine

1. Check to see that the Grid-tie controller screen says “Generator at rest”.
2. Close the valve to the flare and open the valve to the engine. Turn the Gas and Air blower knobs to 0.
3. Press the “manual mode” button and screen will note “manual mode”at the bottom of the screen.
4. Then press the green “Start” button. The Grid-tie controller will attempt to start the engine. It will try 3 times if not successful on the first try.
5. To connect to the grid once the engine is running, press the “Open/Close

Genset" button on the Grid-tie controller and it will sync the generator to the grid and close the contactor. You will now be exporting power to the grid.

Note: If the PCU sees that there is a problem then it will command the Grid-tie controller to shut down. To clear the alarm, first clear the alarm on the PCU by pressing "Reset" then press the red "Stop/Reset" button on the Grid-tie controller unit.

B. Shutting down the Grid-tie controller

1. To disconnect the generator from the grid, press the "Load Open/Close" button. This will ramp down the amount of exported power to the grid and leave the engine running.
2. To stop the engine, press the "Stop/Reset" button. The engine will run for a cool down period then stop. To stop the engine immediately, press the "Stop/ Reset button twice. To stop the engine immediately press the emergency stop button. This will shut the engine down immediately by cutting off power to the engine ignition system. The emergency stop button will cause an alarm and record an emergency stop event in the event log.
3. Switch the system over to flare mode (See section 5.5.5).

For further information please refer to the Grid-tie controller Operator's Manual.

7.5.3.2.1 Deep Sea Controller LED Status Indicator

In the Grid Tie model, the LED status indicators signify the following:

LED Number	Status
1	Bus Live
2	Generator Available
3	Generator Closed Aux
4	PLC Flag 1 (set in PLC to come on with 1 kW of Power)

7.5.4 Notes about Running the Power Pallet

7.5.4.1 *White smoke from the flare*

The first thing that comes out of the top of the flare during the lighting of the gasifier is white smoke. This smoke is a mixture of tar gases and water vapor being driven out of the system as it heats up. The heating element of the flare should eventually ignite the mixture once the concentration of combustible gases is high enough to catch fire. If there is too much water in the feedstock or the gas circuit, the flare may have difficulty lighting the smoke.

7.5.4.2. Bringing gasifier up to temperature

If you are unable to get the system up to the prescribed temperature range (Trst around 800°C) after 20 minutes with the blowers at their maximum setting, and if Tred is above 650°C, switch the valves to route the gas to the engine and try starting the engine and applying a load. The engine will draw a greater volume of gas than the blowers, and the exhaust will heat up the Pyroreactor, which should help bring the reactor up to temperature. If this procedure does not work, shut down the Power Pallet and troubleshoot.

7.5.4.3 Temperature and gas suction rate

The temperatures inside the gasifier depend on the rate of combustion. During the startup period, the combustion rate depends on the level of suction being applied to the gasifier by the gas blowers. Increasing the level of gas suction will accelerate the heating of the gasifier.

7.5.4.4 Longer starting time compared to gasoline or diesel fueled engines

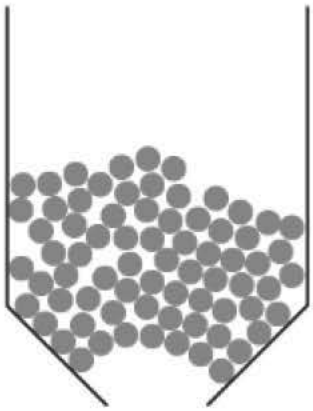
Unlike conventional gasoline or diesel engines, the engine on the Power Pallet may take up to a minute or more to start. This is because the engine must pull all the remaining air out of the gas circuit before it can start drawing in combustible gases from the gasifier. If the engine fails to start after three attempts, let the starter cool for five minutes and troubleshoot the system. For information on troubleshooting please see the Troubleshooting Section of the Technician's Handbook.

7.5.4.5 Electrical loads and Gas Quality

There must not be an electrical load on the generator when the engine is starting. Only apply the load once the engine has successfully started. The electrical load applied to the Power Pallet will have some influence on the quality of the gas. Higher loads result in greater suction on the gasifier, which result in higher temperatures. Higher temperatures result in more efficient tar cracking and more thorough reduction. Accordingly, a temperature of 750°C must be maintained at **Trst** to maintain proper engine function.

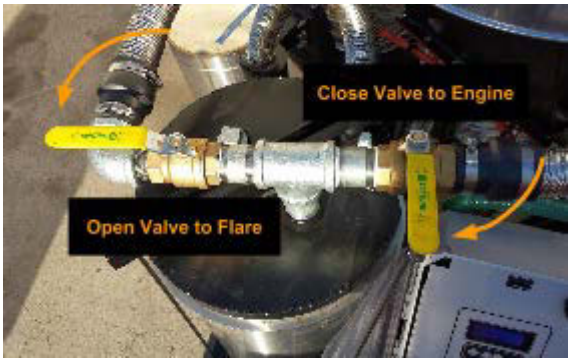
7.5.4.6 Detecting and resolving bridges

Warning: The gases that are released when opening the PyroReactor viewport are flammable and rich in carbon monoxide. Keep the carbon monoxide detector nearby at all times and ensure adequate ventilation.

Trst TTTT Pcomb PPP Tred TTTT Preac PPP Pratio RR Pfilt PPP NEXT T: 00000 *if **Pratio** > 60,* *there is probably bridging in the gasifier.*	
Indication: If the PCU display shows that the `Pratio` value is above 60, it is likely that there is bridging occurring in the gasifier.	**Definition:** Bridging is the condition of feedstock failing to flow down into an empty space because of the formation of a bridge or a dome of feedstock.
	
Recommendation: Open the pyroreactor viewport using heat resistant gloves, and use a long fire-resistant stick to poke through the charcoal inside to break bridging. Then close the pyroreactor viewport quickly.	

7.5.5 Switching Gas Output from Engine to Flare

When shutting down the gasifier, and when you need to temporarily stop the engine but want to idle the gasifier in order to keep the reactor hot and to maintain the gas quality, you may need to switch the gas output from the engine back to the flare.

	
1. After shutting down the engine in the instructions in section 7.5.3, close the valve to the engine and open the valve to the flare.	2. Adjust the gas blower knob until **Preac** indicates at least 5 units (igniter will not light at readings below this), then adjust the air blower knob until the flame descends into the flare and a low roaring noise can be heard. Higher suction rates can be used to maintain higher temperatures, as needed.
	
Indication: When the igniter lights the smoke and air mixture, the flame should descend into the flare and produce a low roaring sound. If flames are visible above the flare, increase the air blower setting until the flames descend into the flare.	

7.5.6 Gasifier Shutdown Procedure

Turn the blowers down until **Preac** is 1 and let the system run for 5 minutes (or until **Tred** is 650˚C) before completely shutting all valves off. This is because the gasifier will have enough heat in it to continue to produce gas and smoke even after the engine is stopped; all of the

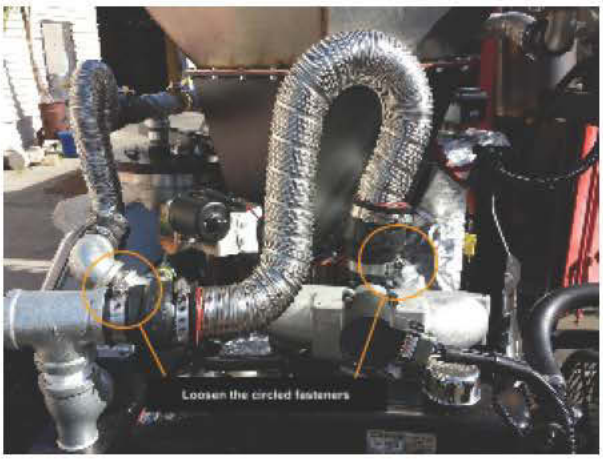
gas produced by this residual heat will result in the Power Pallet leaking smoke and carbon monoxide rich gas into its surroundings. If the gasifier is very hot and is shut down without a cool-down period, the large quantity of tar gases produced by the residual heat may even condense on the feedstock in the pyrolysis column and may increase the risk of jams when cooled down.

7.6 Power Pallet Shutdown Checklist

Warning: This procedure presents a carbon monoxide hazard to the operator. Make sure there is adequate ventilation, and keep the carbon monoxide detector nearby at all times.

Warning: There may be hot liquid tar and condensate in the hoses after shutting down the machine. These liquids are sticky, stinky, irritating, and will make a mess if spilled. Have a container nearby into which you can pour the tar and condensate from each of the following steps.

Shutdown Checklist



1) Disconnect the hose between the air mixer and the engine governor to drain condensate and tars.

2) Inspect the engine governor throttle plate for tar accumulation, and clean accordingly while the tars are warm and soft. Reconnect when finished.

	
3) Drain the condensate vessel and close the draincock securely.	The condensate vessel is located as indicated above.

7.7 Displayed Alarms and System Responses

Below is a table of the errors that are displayed and the action taken by the system.

Alarm Name on Screen	Alarm Conditions	Time until Alarm	System Shutdown Time	Advice Displayed on Screen
Auger on too long	Auger on	4 min	Auto Engine Shutdown at 6 min	Check Fuel
Auger off too long	Auger off	8 min	Auto Engine Shutdown in 10 min	Bridging?
Bad Reactor P_ratio	if P_ratio value is <p_ratio low value and >p_ratio high value (user configurable; default = 30, 60)	Variable	No action	Reactor Fuel Issue
Trst low for engine	< 700°C (default; user adjustable) for trest	3 sec	No action	Increase Load
Tred high for eng.	Engine on and reduction temperatures above 950°C	Immediate	Engine shutdown at 60 sec	Low Fuel in Reactor?
Check Oil Pressure	Oil pressure less than user setting (default = 6psi)	No alarm	Auto engine shutdown after 0.5 sec. Note: first 3 seconds during engine start up ignored	Check Oil Pressure
No O_2 Sensor Signal	Greater than 0.25 sec	30 sec	Reset oxygen sensor at 0.25 sec Auto engine shutdown after 60 sec	No O2 Sensor Signal
Auger Low Current		1 min	Auto engine shutdown after 3 min	Check Fuel

FuelSwitch/Auger Jam	10 auger fwd/rev cycles	Immediate	Auto engine shutdown at 20 forward/reverse cycles	Check Fuel & Switch
High P_comb	Combustion vacuum > 300 units	No alarm	Immediate	Check Air Intake
High Coolant Temp	Greater than 98°C default (user configurable)	0 sec	Engine shutdown 3 sec	High Coolant Temp
Reduction Temp Low	Engine on and top restriction temperatures below 790°C	3 sec	Engine shutdown 7 sec	Increase Load
Restriction Temp High	Engine on and Trst > 1050°C (user configurable)	No alarm	Engine shutdown 15 sec	Reduce Load
Reduction Temp High	Engine on and Tred > 975°C (user configurable)	No alarm	Engine shutdown 60 sec	Reduce Load
Grate Motor Fault	Electrical or mechanical issue with grate shake system	Immediate		
Ash Auger Stuck	Mechanical issue with ash removal system	Immediate		
Ash Auger Fault	Electrical issue with ash removal system	Immediate		

The display will allow for multiple alarm conditions. If multiple alarm conditions are present, menu shows the alarm count in the upper right corner. The time before shutdown is shown as a countdown on the display. Alarms that do not cause an automatic engine shutdown can be unset by resolving the alarm condition. Silencing of the alarm is allowed and will hide the alarm message from display. While hidden alarms are present the ALARM label with flash in the status view. Any new alarm conditions will turn the alarm back on and display the new alarm message.

8. Maintenance

8.1 Maintenance Safety

	Even if the system has cooled to room temperature it will still contain large amounts of CO. Do not service the system until the system has been purged according the the instructions in the Storage (section 6.3) of this manual.
	Service the machine only in a well ventilated area.
	• Do not service while system is running • Do not service machine is hot. Wait for the system to cool to room temperature.

8.2 Maintenance Schedule

Operator Level Tasks					**Time required**
Service Interval Hours:	20	62	125	500	
Service Interval Calendar (@7000hr/yr):	Daily	3 Days	Weekly	Monthly	
Pre-start Checks and Duties	✓				30 min
Grate Basket Maintenance		✓			30 min
Packed Bed Filter Maintenance (PP20 only)		✓			30 min
Cowling and Cyclone Air Cleaning			✓		45 min
Rotary Filter Maintenance (PP25 only)			✓		30 min
Unplanned Operator Attendance			✓		60 min
Sensor Calibration			✓		30 min
Engine Oil Change and Component Cleaning				✓	60 min
Manual Drying Bucket and Cyclone Cleaning				✓	120 min
Filtration System Maintenance (PP25 only)				✓	60 min
Flare Maintenance				✓	45 min

Technician Level Tasks					**Time required**
Service Interval Hours:	1750	3500	7000	14000	
Service Interval Calendar (@7000hr/yr):	3 Months	6 Mon hs	Yearly	2 Years	
Air Lock Maintenance (PP25 only)	✓				30 min
Engine General Maintenance and Tune Up	✓				120 min
Replace O_2 Sensor	✓				30 min
Overhaul Gasifier		✓			180 min
Overhaul Hopper & Air Lock (PP25 only)		✓			60 min

Turbo Maintenance (PP25 only)		✓			30 min
Replace Gasifier & Rotary Filter (PP25 only)			✓		180 min
Overhaul Hopper			✓		45 min
Overhaul Flare			✓		30 min
Overhaul Engine			✓		180 min
Replace Engine				✓	480 min

8.3 Operator Level Maintenance Instructions

Below are the instructions for operator level maintenance. The technician level maintenance instructions out of the scope of the operation manual are described in the *Technician's Handbook for the Power Pallet* and should only be conducted by a trained technician.

8.3.1 Grate Basket Maintenance

The grate basket plays a crucial role in the production of combustible gases, and must be maintained on a regular basis. Its primary role is to contain a bed of hot charcoal to support reduction reactions. The gasifier will not start to produce usable gas until the reduction reactions in the grate basket begin, but these cannot occur without charcoal filling the grate basket. Secondly, by being shaken, it separates char ash from the rest of the charcoal to maintain a good rate of gas flow. The grate basket is subjected to high temperatures and shaking; when inspecting the basket, make sure the basket is intact, and that the holes are not obstructed.

8.3.1.1 Clinkers

Clinkers are formed when the ash of the feedstock fuses together to form a hard rock-like formation instead of remaining as dusty like ash. Clinker formation can increase when using feedstocks with high ash content and high energy value. While gasifier temperatures and other operating parameters (grate shaking, engine exhaust recycling rate, etc) can directly affect clinker formation, it is important to understand that most all biomass combustion and gasification systems have the same issue of clinker formation during their normal operating parameters, ours is no different as this is a common issue among similar systems.

Check your grate basket after your first few runs to determine the clinker forming characteristics of your feedstock, and adjust the maintenance schedule according to your observations. If clinkers have accumulated in the basket, the grate basket must be cleaned out, and refilled. If clinkers are physically attached to the inner wall of the gasifier or the grate basket, try ***very very carefully*** to pry them off with a stick in a way that does not damage the equipment. If there is damage, please contact support@allpowerlabs.org.

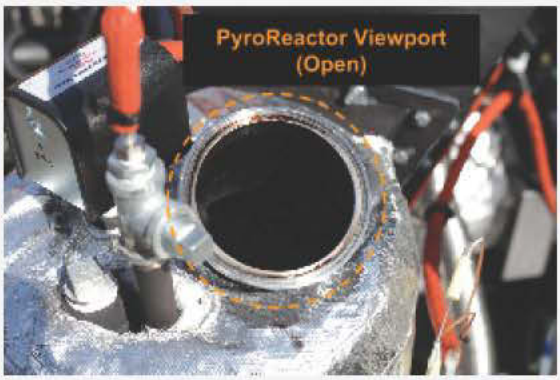
If the clinker forming risk is low, this visual inspection can be less frequent for a given feedstock. It is recommend to sift out the clinkers from the charcoal after emptying the reactor to reuse.

The grate basket shaking rate can be sped up to decrease the risk of clinkers fouling. If you observe problems with your reduction reactions or gas quality, you may need to manually remove the clinkers from the reactor. A possible indicator of clinker formation is that the operating **Pratio**, indicated on the PCU, gradually decreases over the course of operation and does not recover with grate shaking. This would be caused by a build-up of clinkers choking the flow of gases, which lowers this pressure ratio across the grate basket.

<table>
<tr><td>Warning:

Carbon Monoxide Hazard

  </td><td>  </td></tr>
<tr><td>Warning: This procedure presents a carbon monoxide hazard to the operator. Make sure there is adequate ventilation, and keep the carbon monoxide detector nearby at all times. To draw carbon monoxide away from the work area, turn the gas blowers to 5 or higher if smoke is visible. Use safety goggles and gloves for touching hot surfaces.</td><td>Recommendation:
We recommend using a small ash rake or equivalent tool for this procedure.</td></tr>
<tr><td>  </td><td>  </td></tr>
</table>

1. With the Power Pallet off, and the gasifier cooled down to ambient temperature, open the reactor access port by turning the wheel counter-clockwise until the bar is loose; rotate the bar to free it from the bar cradle, and gently pull the hatch outwards.	2. Inside the reactor, you should be able to see the gate on the grate basket. Take hold of the handle of the gate on the grate basket, and lift it up, then pull it out. This will give you access to the grate basket.
	
3. Rake the material out of the grate basket using a short metal pole or an ash rake and a metal pan to catch the charcoal. If clinkers are present, they may look like dark rocks or oysters.	4. Replace the gate on the grate basket securely, then replace the hatch and tighten it down so that it forms an air-tight seal. Do a leak test to make sure your seals are air-tight.
	← **Important:** When raking out the grate basket, all the feedstock and partially charred material in the reactor will eventually descend into the grate basket to be raked out. Be sure to fill the reactor all the way up to the fuel switch with charcoal pieces before the next run. Because the hopper may have be full, put the charcoal into the reactor through the PyroReactor viewport. The gasifier will not produce usable gas without charcoal filling the grate basket.

Technician level maintenance instructions are out of the scope of this document. For all Technician level maintenance operations, please consult a certified technician.

8.3.2 Packed Bed Filter Maintenance (PP20 Only)

8.3.2.1 Drain Condensate from Filter

The producer gas continues to cool as it passes through the gas filter, and a great deal of condensation comes out of the gas in the course of filtration. As part of daily maintenance, drain this condensation out of the filter via the sanitary fitting which serves as the gas inlet at the bottom of the filter. Be sure to reseal this fitting airtight when reconnecting the filter. Be aware

that the condensate is full of tar and smells like smoke. Capture the condensate with a basin under the drain bung.

1. Close the valve to the engine and open the valve to the flare
2. Turn on the gas blower to a low setting to pull CO gas away from the work area
3. Remove the cyclone ash can for easier access to the gas inlet
4. Slide a small basin or pan under the gas inlet to catch the condensate
5. Open the sanitary clamp to drain condensate into the collection pan
6. Empty the pan as needed and place it back under the gas inlet
7. Disconnect the filter lid assembly from the valves to enable the filter to tilt
8. Tilt the filter to drain out any additional condensate
9. Push filter back into position, and reconnect all disconnected fittings, being careful to establish airtight seals

8.3.2.2 Change Gas Filter Media

The packed bed filter is a 25 gal (94 liters) canister filled with sifted biomass as its filter media. The filter separates out any particulates, tar that survived tar cracking, or condensate that failed to be captured through the cyclone; as the producer gas ascends through the filter, it cools further and condenses residual tars onto the sifted biomass. When the filter media needs a change, it will be black and sticky, and will smell like smoke.

	
Example: this is what dirty foam filters look like. The grate will need to be wire-brushed to clear the perforations.	**Example:** the fine-grade sifted biomass at the top of the filter under the foam discs looks like this when it is due for changing.

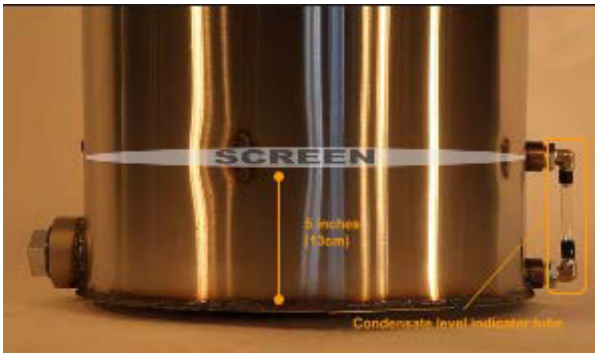
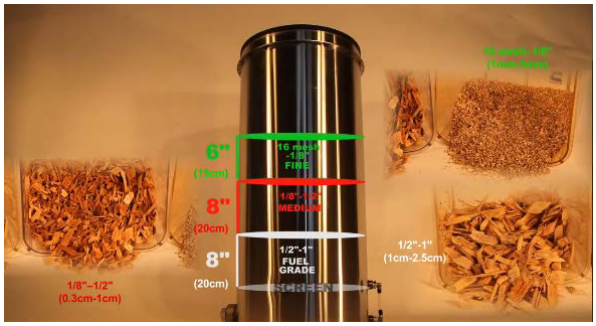
	
Example: This sample of filter media is from a filter that is over-due for changing. The biomass is stuck together from excess tar, and has begun to choke the flow of gases to the engine.	**Example**: This sample of filter media is just due for changing. It is dark from having captured tar on its surface, and is somewhat sticky, but is not badly stuck together.

The filter comes with two perforated disc screens; one to hold the filter media off the bottom of the filter canister, and one to hold down the two oiled foam discs that come with the filter, which rest on top of the filter media to trap dust particles. The top perforated disc holds the foam discs down against the suction of the engine. Without this disc, the vacuum from the engine will pull the foam into the gas outlet, causing a serious bottleneck for the gas to travel through that will ultimately choke the engine.

Perforated discs and foam filters that come with the gas filter.

The step-by-step instructions have a corresponding video at our channel on YouTube.

8.3.2.3 Changing the filter media

	
1) Set one of the screens on the tabs that are about 5 inches (13 cm) above the bottom. This space below the bottom grate is reserved for collecting condensate in the filter. Check the condensate level through the indicator tube. Drain condensate through the gas inlet at the bottom of the filter. **Important:** When changing the filter media, use a wire brush to clear blocked holes in the lower screen. Blocked holes will choke the flow of gas.	2) Add the layers of sifted biomass as shown in the image above: 8 inches of fuel grade biomass at the bottom; 8 inches of medium sifted biomass in the middle; 6 inches of fine sifted biomass on top. Use the screens provided.
	
3) Insert the black (coarse, 45 dpi) foam disc, then the green (fine, 65 dpi) foam disc, and then gently insert the perforated steel screen on top. Be careful to not damage the gasket around the upper lip of the filter drum when inserting and removing the screen.	4) Be sure not to overfill the filter. There should be a 2 inch (5cm) space at the top of the filter.

The filter is only designed for filtering gas produced from cellulosic biomass. The filter is not sufficient for filtering the gas products of coal, peat, plastics, or municipal solid waste (MSW); none of these feedstocks are suitable for use in the Power Pallet.

8.3.2.4 Cleaning Foam Filters

The foam filters that reside at the top of the gas filter will gradually accumulate tar condensates, and should be cleaned each time you replace the filter media. To clean the foam filters, you will need a basin, and plenty of alcohol. Clean the foam filters according to the following procedure:

1. Put alcohol and foam disc in basin. Cover with lid and let alcohol dissolve the tars for a few minutes.
2. Wash the foam disc by squeezing and working the alcohol through the foam.

3. Rinse the foam disc by placing the disc in a basin of hot clean water and working the remaining tar out.
4. Shake and squeeze out the excess water from the foam, and leave it to dry.

8.3.3 Cowling and Cyclone Air Cleaning

	**Warning** **USE ONLY IN** **WELL VENTILATED AREA**
	**Requirement** **EYE PROTECTION REQUIRED**
	**Warning: Dust Hazard.** **Respirator Required**

When the gasifier has cooled down to room temperature, open the ash door and remove the ½ inch bungs at the top of the gasifier near the air inlet can be taken off. This will allow access to the air lines. Empty out all feedstock and charcoal inside the gasifier. Use compressed air from the bottom and the top through the bungs to blast out any soot between the reactor and gas cowling. Remove the bottom of the cyclone and use compressed air to also purge the cyclone.

8.3.8 Rotary Filter Maintenance (PP25 only)

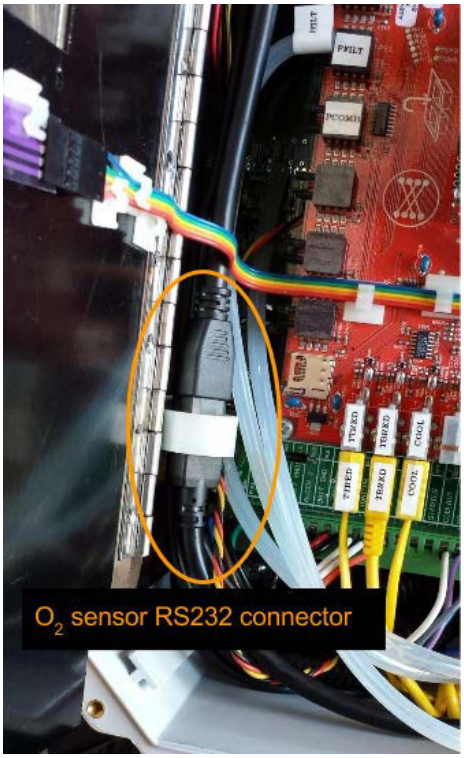
Unbolt the rotary filter to open and expose the internal housing. Use alcohol (e.g. isopropyl alcohol) to clean the inside of the filter blades to free up any soot or accumulation.

8.3.4 Sensor Calibration

8.3.4.1 Oxygen Sensor Calibration

Every oxygen sensor must be calibrated before the first use or whenever it is replaced. ALL Power Labs performs this calibration on every Power Pallet before shipping. If the oxygen sensor is exposed to water, temperatures higher than its operating temperature, or particulate buildup occurs, the sensor will not work properly without recalibration. Follow these procedures to calibrate the oxygen sensor:

1. Disconnect the gas line from the governor. Then turn the key switch for 5 seconds as if you are attempting to start the engine. This will purge the exhaust out of the exhaust manifold and expose the oxygen sensor to air.
2. Turn off the Power Pallet using the main power switch.
3. Disconnect O_2 sensor RS232 connector from inside the automation enclosure. (See graphic)



4. Power on the Power Pallet with the **sensor disconnected**. All three digits on the lambda meter will light up and the lit LED bar will sweep once through all LEDs on the display. Then the status light will turn red and the numeric display will read **"E2"**. This indicates that no sensor is detected.
5. Leave unit powered off for 30 seconds.
6. Turn on the Power Pallet.
7. The lit LED should again sweep through all the LEDs in the display, but instead of an error the display will read **"HTR"** (which stands for 'heater'). This indicates that the sensor is being heated up to operating temperature. After 30-60 seconds, the display will switch to **"CAL"**, indicating that the sensor is being calibrated. A few seconds later, the meter will begin displaying air/fuel ratio.
8. Re-attach the oxygen sensor cable.

With the calibration process above completed, the meter is now ready for use.

Important: If you power up the meter without a sensor connected, **your calibration will be reset** (see step #4 above).

8.3.4.2 Pressure Sensor Calibration

Pressure sensors should be re-calibrated if the zero-point drifts or when the PCU is first used. Calibrate the pressure sensors through the following process:

1. Remove the pressure tubing from the barbs on the PCU's pressure sensors.
2. Turn on the Power Pallet.
3. Scroll through the menus (by pressing "Next") until you reach the screen that says "Calibrate Pressure Sensors to Zero?"
4. Choose "Yes."
5. Push the pressure tubing onto the barbs on the PCU's pressure sensors.
    a. Make sure that the each tube is connected to the correct/corresponding sensor.
    b. Make sure that the pressure tube is attached to the top/front barb on each sensor and that the back/lower barb is exposed to the atmosphere.
    c. Make sure that the tubing is pushed all the way down so that it contacts the square body of the sensor.

8.3.5 Engine Component Cleaning and Oil Change

Take off the governor and clean the backside of the governoras well as anything seen in the inlet to the engine. Replace any paper gaskets between the governor and the engine as needed.

Change the engine oil and the oil filter. Refer to the *PSI 3.0L Industrial Engine Service Manual* for further instructions.

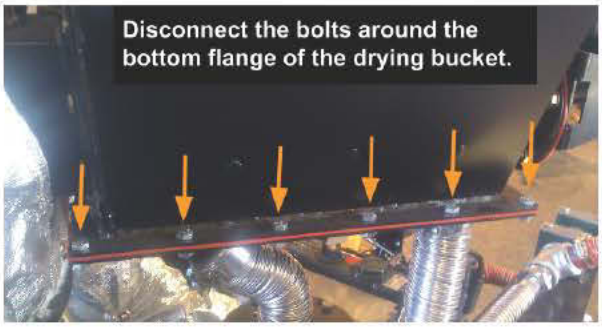
8.3.6 Filter System Maintenance (PP25 only)

Replace the static filter element with a new one. Please contact support@allpowerlabs.com for ordering information.

8.3.7 Manual Drying Bucket and Cyclone Cleaning

8.3.7.1 Drying Bucket

The drying bucket and the hoses connected to it will occasionally need to be cleaned of soot and dust. Although the cyclone onboard the Power Pallet separates out the suspended dust from the producer gas before the gas is routed to the drying bucket to recover waste heat, the cyclone cannot remove the finest soot particles that are suspended in the producer gas. This soot eventually accumulates in the drying bucket and the hose between the drying bucket and the gas filter. We recommend cleaning the drying bucket of soot once every 500 hours of operation.

Warning: **Dust and CO Hazard** 	
Warning: This procedure releases a lot of fine carbon dust. Wear a respirator and eye protection and work in a well ventilated area. Carbon monoxide may also be released.	1. Unbolt the bottom plate of the drying bucket, and set the bolts aside. Gently set the bottom plate aside without kinking any of the tubes. You may want to lay down a tarp under the drying bucket and over the engine for ease of cleaning.

Explanation: the hollow walls of the drying bucket can be accessed from underneath. The photo above shows the opening into which the producer gases flow. Soot and dust can accumulate in here and block the flow of producer gas.

Example: the photo above shows a badly fouled drying bucket. If your drying bucket is this badly fouled when you examine it after normal usage, adjust your maintenance schedule for more frequent drying bucket maintenance.

Example: the images above show some of the soot and tar from the drying bucket that came down when detaching the bottom plate. In this example, the drying bucket had not been cleaned in too long.

2. Use a long stick or a screwdriver, and dislodge any large chunks of accumulated soot and dust from the hollow walls of the drying bucket. If you have access to compressed air, use compressed air to blow any remaining soot out of the drying bucket.

Use a large pipe cleaning brush to clean out the hose. Use hot water and solvent as needed.

3. Remove the tarp, and use a vacuum cleaner to clean any soot and dust that was not caught by the tarp.

8.3.7.2 Cleaning the Cyclone

Take off the cyclone catch can and remove the cyclone from the gas cowling. Use a stick or scraping device to remove any soot accumulation in the inside of the cowling and the cyclone.

8.3.7.3 Cleaning the Gas Lines

Remove the corrugated gas lines connected to the gas filter at either end (these 3 gas lines connect from the gas filter to the blowers, engine, and drying bucket. Straighten the gas lines and use a stick or wire brush to knock off any accumulation inside.

8.3.8 Flare Maintenance

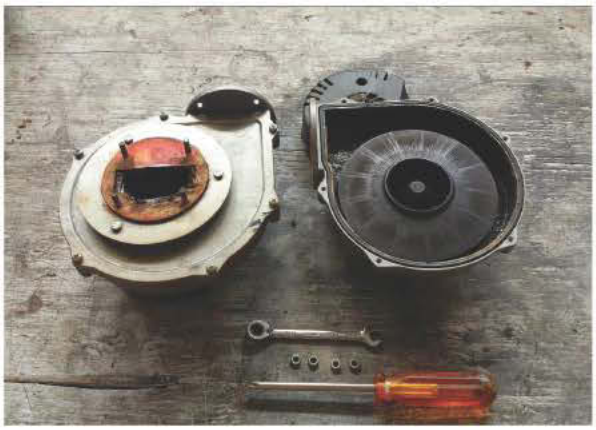
The gas blowers will gradually become fouled with tar because they draw the gas through the gasifier during startup, when these gases are rich in tar. Adjust the maintenance interval down if you do frequent start-ups, since the startup period is when these blowers accumulate the most fouling. Detach the blowers from the Power Pallet to clean the insides of the blower housings with alcohol.

The following procedure is shown on one blower; repeat for both blowers.

1. Remove the back cover and set the long screws and their corresponding nuts and washers aside. Pull the assembly with the electronics board and the stator off and set aside. This will prevent any liquid damage to these parts as you clean off the main blower housing. Blow off any dust that may be fouling the electronics, the rotor, or the stator. The rotor and the impeller do not come off.

2. Unscrew the cover of the blower. Set the screws and split lock washers aside.

Note that the impeller itself is not where the fouling accumulates; the warm tar spins off during operation. The blower housing is where the fouling may accumulate to the point of impacting performance.



3. Detach the blowers from each other using a 5/16 inch wrench. Clean any fouling from the gasket using a brush and alcohol, or other cleaning solvents as necessary.

4. Soak the housing cover and the main housing until the tars soften, then scrub the tar off with a stiff brush. Keep the main housing rotor side up, with the rotor out of the alcohol. Cover the soaking basin to prevent evaporation and to minimize the absorption of water vapor by the alcohol. The alcohol may be saved, filtered, and reused for softening tars for future cleanings.

Rinse and wipe the parts dry when clean, then re-assemble the blowers and re-attach them to the flare, being careful to correctly wire them to the automation wire terminals.

Reader’s Notes

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Reader’s Notes

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Questions?
Visit us at:
www.allpowerlabs.com/support
or by email:
support@allpowerlabs.com