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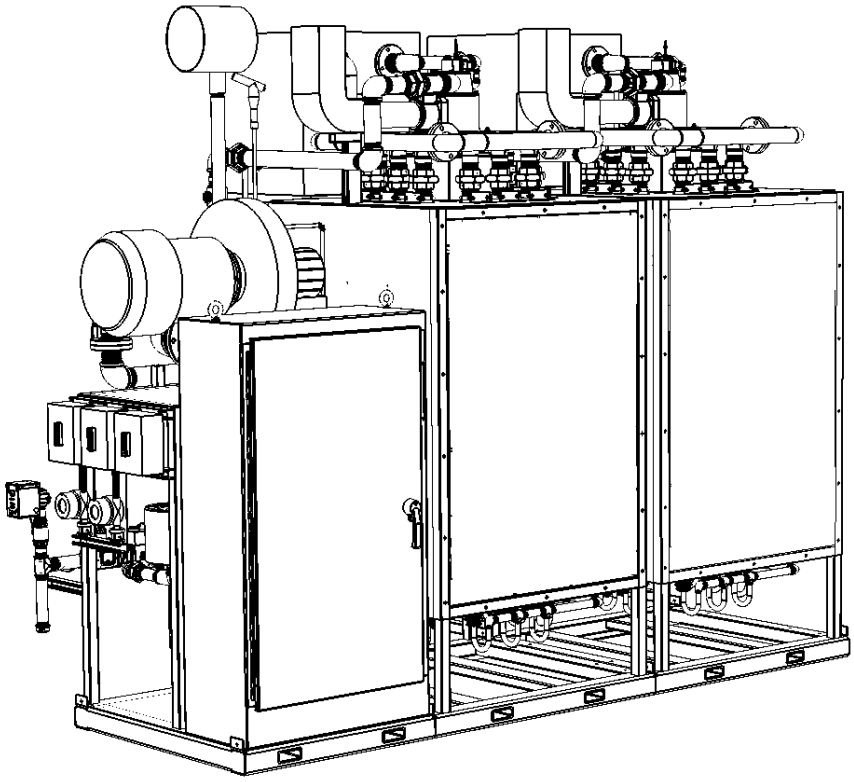
6K-ENDOFLEX™
ENDOTHERMIC GAS GENERATOR
WITH ENDOINJECTOR™ AND REACTIONCORE™ TECHNOLOGY

INSTALLATION AND OPERATION MANUAL



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1.1 NOTICE, CAUTIONS, AND WARNINGS

NOTICE
This Bulletin contains important safety information and should be read and understood by all individuals who install, operate, or service this equipment.

Failure to follow the precautions and recommendations of this manual may subject personnel and property to dangerous conditions.

WARNING
Endothermic Gas contains high concentrations of Carbon Monoxide as well as other dangerous and flammable gasses that can cause fire, asphyxia, or possible brain damage at elevated levels. It is strongly recommended that generator operators and maintenance personnel ventilate the area surrounding the generator and use carbon monoxide monitors to ensure a safe environment when working around any endothermic gas generator.

CAUTION
The EndoFlex™ generator is fitted with the EndoInjector™ for flow control. The EndoInjector™ is designed to accurately mix air and gas together and precisely control the mixture ratio to produce high quality endothermic gas. However, setting the air gas ratio set points outside the recommended values described in this manual could subject personnel and property to dangerous conditions. Only properly trained and experienced personnel shall operate and maintain the EndoInjector™ generator control system.

TECHNICAL ASSISTANCE

Contact Atmosphere Engineering with all questions or concerns regarding the installation, operation, and setup of the EndoFlex™ generator or the EndoInjector™ mixing system.

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1.2 EXPRESS WARRANTY ON ATMOSPHERE ENGINEERING EQUIPMENT

ATMOSPHERE ENGINEERING COMPANY (AEC) warrants products for a period of one (1) year from the date of shipment from AEC to the original purchaser to be free from defects in material and workmanship under normal recommended use, service, inspection, and maintenance. Normal recommended use, service, inspection, and maintenance, mean:

1. Not to be used in excess of nor below the rated capacity, pressure, and temperature ranges specified in the applicable quotation, purchase order, acknowledgment, marketing literature, nameplate, specification sheet, or the Installation, Operation, Inspection, and Maintenance Manual (THE MANUAL); and

2. Using only clean gases free of solids and other contaminants not considered constituents of the gas; and

3. Installation, operation, inspection, and maintenance in compliance with THE MANUAL; and

4. The AEC products being used only in:

    a. Ambient environments lower than 132 °Fahrenheit (54 °Celsius) unless specifically designed and so labeled by AEC for higher temperatures; and
    b. Non-corrosive environments; and
    c. Completely protected from moisture, rain, snow, or other outside environments; and
    d. Not to be used below 32 °Fahrenheit (0 °Celsius) unless precautions are taken for low temperature conditions as shown in THE MANUAL.

5. Being used only for applications permitted by THE MANUAL or other AEC literature or special applications approved in a separate written authorization by AEC.

WARRANTY EXCEPTIONS

This Warranty does not apply to damage caused by any or all of the following circumstances or conditions:

1. Freight damage;

2. Parts, accessories, materials, or components not obtained from nor approved in writing by AEC;

3. Any consequential or incidental damages including but not limited to loss of use, loss of profits, loss of sales, increased costs, arising from the use of any product system or other goods or services manufactured, sold, or provided by AEC;

4. Misapplication, misuse, and failure to follow THE MANUAL or other literature, instructions, or bulletins (including drawings) published or distributed prior to THE MANUAL.

The exclusive remedy under this Warranty or any other express warranty is the repair or replacement without charge for labor and materials of any AEC parts found upon examination by AEC to have been defective. Since certain AEC equipment is heavy, bulky and not deliverable by U.S. mail or other parcel service, AEC equipment may be returned only upon written consent of AEC and then only to the location designated by AEC. Generally such consent will be given only upon the condition that the customer assume and prepay all carrier charges and responsibility for damage in transit.

Purchasers of AEC products, equipment, goods, or services waive subrogation on all items covered under their own or any other insurance.

(CONTINUED ON NEXT PAGE)

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EXPRESS WARRANTY ON ATMOSPHERE ENGINEERING EQUIPMENT
(CONTINUED FROM PREVIOUS PAGE)

DISCLAIMER

THIS WARRANTY IS EXCLUSIVE. AEC EXPRESSLY DISCLAIMS ANY AND ALL OTHER WARRANTIES WHETHER EXPRESS OR IMPLIED INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY PURPOSE.

No person, including dealer, seller, or other representative of AEC is authorized to make, on behalf of AEC, any representations beyond those contained in AEC literature and documents or to assume for AEC any obligations or duties not contained in this Warranty and Warranty Policy.

AEC reserves the right to make design and other changes, modifications or improvements to products, services, literature, or systems, without any obligation, to furnish or install same on any previously sold or delivered products or systems.

LIMITATION OF LIABILITY

It is expressly agreed that the liability of AEC is limited and AEC does not function as an insurer. The purchaser and/or user agree that AEC is not liable for loss, harm, or damage due directly or indirectly to any occurrence or consequences there from. If AEC should be found liable to anyone on any theory (except any express warranty where the remedy is set forth in Section 2 of this Warranty and Warranty Policy) for loss harm or damage, the liability of AEC shall be limited to the lesser of the actual loss, harm or damage or the purchase price of the involved AEC equipment or service when sold (or when service performed) by AEC to customer. This liability is exclusive and regardless of cause or origin resulting directly or indirectly to any person or property from:

1. The performance or nonperformance of any obligations set forth in this Warranty and Warranty Policy;
2. Any agreement including specifications between AEC and the customer;
3. Negligence, active, passive or otherwise of AEC or any of agents or employees;
4. Breach of any judicially imposed warranty or covenant of workmanship, durability or performance; and
5. Misrepresentation (under the Restatement, common law or otherwise) and/or strict liability involvement;
6. Liability for fraud-in-the-inducement.

WARRANTY FIELD SERVICE

If Warranty Field Service is rendered at the request of the purchaser or user and the difficulty is found not to be with AEC's product, the purchaser shall pay the time and expense (at the prevailing rate at the time of the service) of AEC's field representative(s). Charges for service, labor, and other expenses that have been incurred by the purchaser, customer, or agent without written approval of AEC will not be accepted. The OEM or other reseller is responsible for transmitting installation and operating instructions, THE MANUAL or other service literature supplied by AEC with the equipment.

(END OF WARRANTY TEXT)

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1.3 GENERATOR DESCRIPTION

EndoFlex™ Endothermic Gas Generator
The EndoFlex™ is designed to produce endothermic gas by cracking natural gas in the presence of a catalyst at elevated temperatures for use in atmosphere heat treatment furnaces. The EndoFlex™ generator utilizes ReactionCore™ technology to greatly improve the efficiency if the reaction and therefore uses significantly less heating energy to produce the chemical reaction. The heating chambers utilize high efficiency open burners with pre-heat air "recoup" to improve the combustion efficiency. In addition the heating chambers are insulated with ceramic fiber modules to reduce heat loss and speed up heating time.

Mixing System
The EndoInjector™ is a precision gas mixing system and endothermic gas generator control system integrated into one package. The patented EndoInjector™ mixing system designed by Atmosphere Engineering utilizes electronic flow measurement and a precision gas injection valve to constantly monitor and control the ideal gas mixture required to generate high quality endothermic gas.

The EndoInjector™ incorporates the latest technology in regenerative blower design that is capable of significant turndown for single and multi-retort generators. When combined with the patented mixing system, the EndoInjector™ delivers flow on demand throughout the working range of any generator down to 20% of rated capacity. This feature eliminates endothermic gas waste during production while maintaining the precise gas mixture and ratio adjustment capability required to control gas quality throughout the turndown range.

Dew Point Control
The integrated dew point control logic of the EndoInjector™ will monitor the endothermic gas quality then precisely modify the air gas mixture to control the quality of the endothermic gas. The sensor required to monitor this gas is not included with the EndoInjector system but can be purchased separately from Atmosphere Engineering.

Temperature Control
The integrated temperature control logic of the EndoInjector™ will monitor a single temperature zone or multiple temperature zones and provides an output (relay or signal) that can be used to accurately control the temperature of any endothermic gas generator. The thermocouple required to monitor temperature and valves required to control temperature are not included with the EndoInjector™ system but can be purchased separately from Atmosphere Engineering.

Pressure Control
The outlet pressure of the generator is monitored using a pressure transducer that is linked to the controller. The operator can set a desired outlet pressure for the generator. The controller will provide automatic pressure control by modulating the speed of the mixing system to provide endothermic gas flow on demand while maintaining the desired generator outlet pressure at all times.

Paperless Chart Recorder
The EndoInjector™ integrates a full-color touch-screen paperless chart recorder to monitor all critical process variables of an endothermic gas generator. The data and backup files are stored and maintained on the touch-screen in an encrypted format for a period of 5+ years. The data can be exported to CSV format for easy review within an spreadsheet application (i.e. MS Excel or similar).

Custom Designed System
The EndoInjector™ is a precision mixing system that is assembled, calibrated, and fully tested to perform to the exact requirements of a specific endothermic gas generator. The system is not designed to be interchangeable with any other generator without written approval of the new generator application from Atmosphere Engineering.

Endo Reaction Quality Control Monitoring
The EndoFlex™ generator is fitted with additional dew point and unreacted methane (CH4) sensors with appropriate alarming to ensure the endothermic gas quality at all times.

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1.4 SYSTEM SPECIFICATIONS

Gas Supply
Required Gas Supply ..... 1600 CFH of Natural Gas @ 2 PSIG
Maximum Gas Supply Pressure Limit ..... 5 psig maximum

Electrical Power
Voltage 480VAC/60Hz
Amperage 30A

Endothermic Gas Production
Maximum Capability ..... 6000 CFH of Endothermic Gas @ 20"wcg
(Minimum Gas Production) ..... 1200 CFH of Endothermic Gas

Ambient Condition Limits
Ambient Temperature Limits ..... 50°F to 130°F
Humidity ..... Non-Water Condensing Conditions
System is designed to be installed inside a controlled industrial environment. The system is not designed to be used out outside.

Ventilation Requirements
Burner Exhaust (each burner) ..... 250,000 btu/hr (maximum)
Endothermic Gas Burnoff Vent ..... 1,200,000 btu/hr (maximum)
Ventilation systems shall be designed to meet facility, local, state, and federal codes regarding the safe ventilation of combustion products including CO2, CO, Water Vapor.

1.5 MODBUS COMMUNICATION

Standard communication between the HMI and the control system is handled via ModbusRTU (RS232 or RS485) or ModbusTCP/IP (Ethernet) as required. Additional communications ports are available but can vary by type depending on the control system specified when ordering and provided with the system. A modbus register address list and other communication details are provided as an attachment to this manual. Contact Atmosphere Engineering support team with any questions regarding communication setup of this device.

CAUTION: REMOTE CONNECTION CONSIDERATIONS
Connection of industrial equipment to a remote network opens the system to security and safety vulnerabilities. Access to any industrial equipment including the EndoInjector™ over a network must be strictly controlled so that only those trained in the operation of the equipment can modify parameter values within the system. Further, precautions should be integrated to prevent parameters from being modified accidentally and set to values outside of safe ranges.

1.6 DATA STORAGE

The HMI touchscreen includes a minimum of 7GB of unused internal hard drive space. The daily encrypted log files are contained within the AEC log directory and a backup file is located in a backup directory. The combined daily file size will consume approximately 300KB per day. Therefore, the actual capacity of the hard drive will be able to maintain over 60 years of log data. However, due to memory life considerations the process log data integrity should be considered maintained locally at the machine for a period of 5+ years. Of course, the actual data may last longer and can be backed up remotely for an indefinite period.

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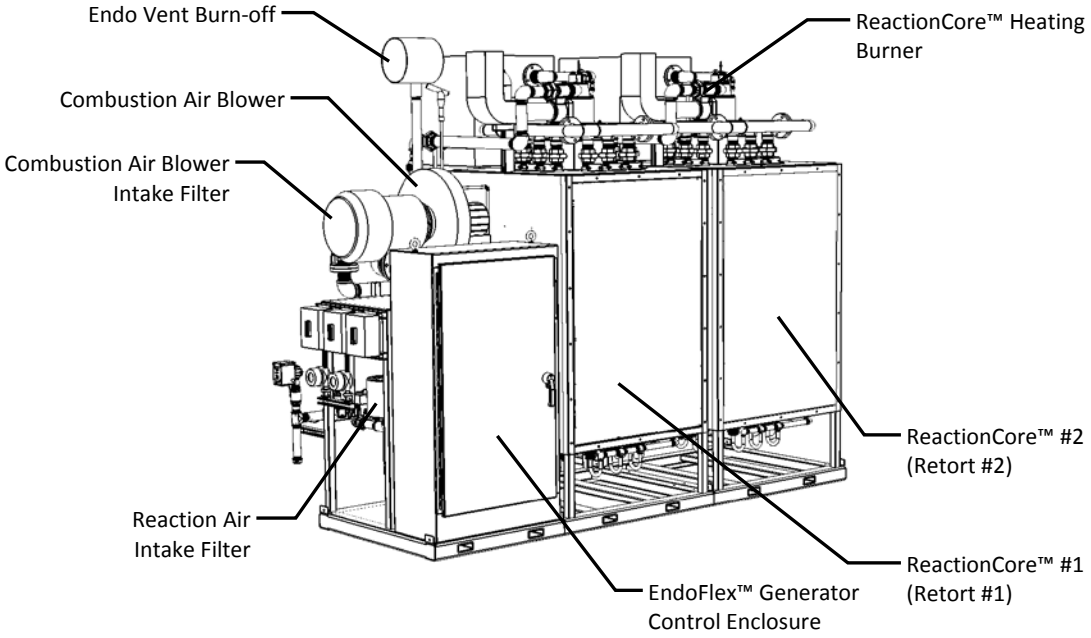
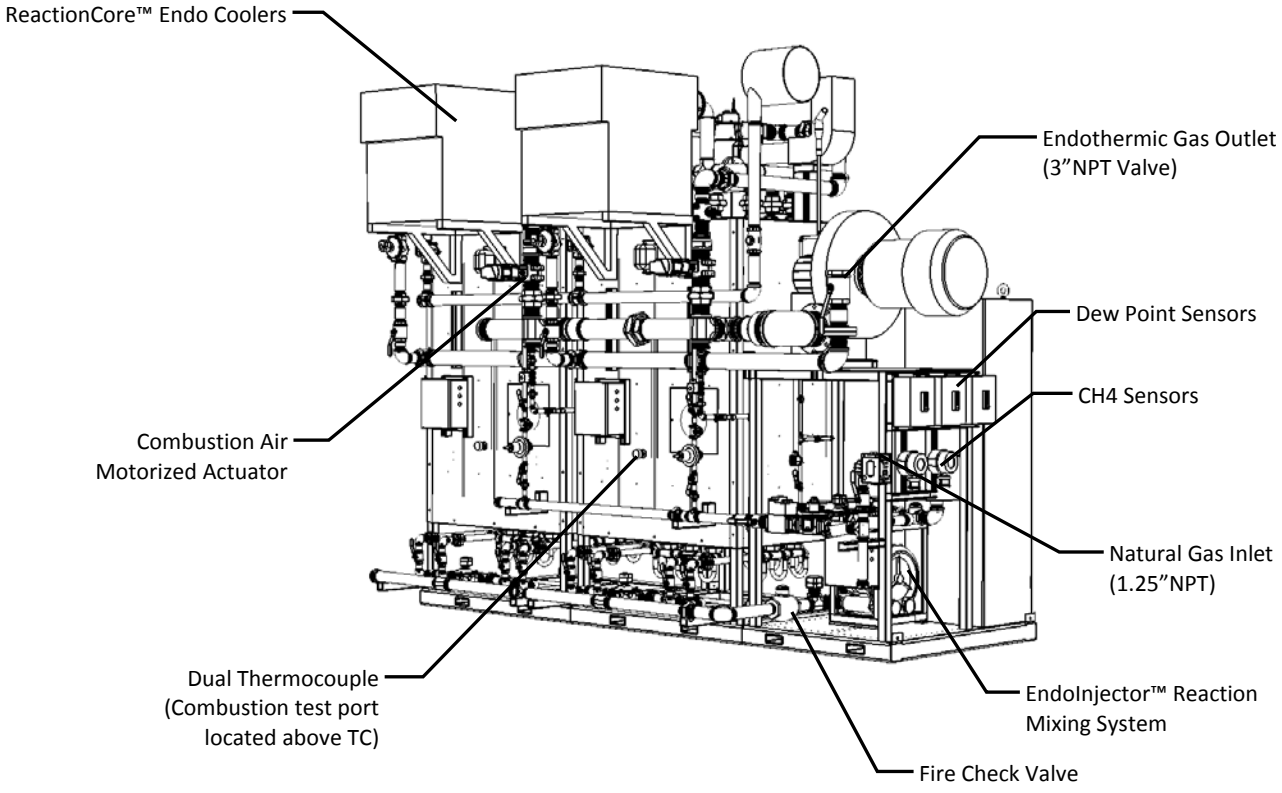
1.7 CRITICAL COMPONENT OVERVIEW

The following is a schematic detailing critical components. Refer to the electrical and mechanical assembly diagrams and material list attached to this manual and ensure that each item detailed in the attached drawing is accounted for and has not experienced physical damage during shipment prior to proceeding with the installation.





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2.0 GENERATOR INSTALLATION

2.1 INSTALLATION NOTICE

Only qualified personnel experienced with endothermic gas generator operation and safety requirements shall perform installation. It should be noted that additional mechanical components and interlocks may be required within the facility other than those supplied with the generator to ensure the generator is safe and meets NFPA 86 (or similar) guidelines.

The EndoFlex™ is a robust industrial device however; some precision measurement components may be susceptible to damage from severe shock. Care should be taken to handle the generator during the installation process. The system was not designed to safely support personnel and should not be used as a step or a support as this could damage components on the system and may cause injury.

The generator was designed as a modular system. The following modules are provided with this system and must be piped and wired together:
Module#1: Control Module (Electrical Enclosure, Reaction Mixing System, Combustion Air Blower, Sensor Array)
Module#2: ReactionCore™ #1 (Retorts, heating, and cooling system for the production of 3000cfh endothermic gas)
Module#3: ReactionCore™ #2 (Retorts, heating, and cooling system for the production of 3000cfh endothermic gas)

2.2 MECHANICAL INSTALLATION

Installation Procedure (Refer to mechanical assembly and pipeline diagram attached to manual for proper installation)

1. Inspect the generator for any damaged or missing components and confirm each component detailed in the "Critical Component Review" section of this manual is accounted for based on the configuration provided.

2. Select a location where the generator will be located in the facility. The generator should be mounted level and should be reasonably insulated from shock, vibration, and any direct radiant heat sources. Make note of the following locations on the generator and consider the best location for generator to accommodate access to and proper piping and ventilation of the following locations:
    a. Gas Supply Inlet
    b. Generator Endo Outlet Valve
    c. Endo Vent Burn-off (Exhaust Requirement)
    d. Burner Exhaust (Exhaust Requirement)
    e. Combustion and Reaction Air Intake Filters (Maintenance Access)
    f. Endothermic Gas Cooler Filters(Maintenance Access)
    g. ReactionCore™ Door Access (Maintenance Access)

3. Mechanically Assembly the generator sections (modules) together starting with the control module, then ReactionCore#1, and finally ReactionCore#2.
    a. Align sections and tighten section together using bolts thru mounting holes provided.
    b. Tighten Pipeline sections unions between each generator section (module)
    c. Electrical conduit fittings should be dry fitted at this time to ensure all connections will reach and are not missing or damaged during shipment.

4. Attach the natural gas supply pipeline to the generator main gas supply inlet valve. The gas supply must be pressure regulated to a minimum of 2 psig and a maximum of 3 psig.

5. Attach the endothermic gas outlet valve to an appropriately sized pipeline header supplying atmosphere heat treatment furnaces.

6. Install properly sized and temperature rated ventilation hoods over the combustion burner exhaust ports, and endothermic gas vent burn-off locations.

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2.3 ELECTRICAL INSTALLATION

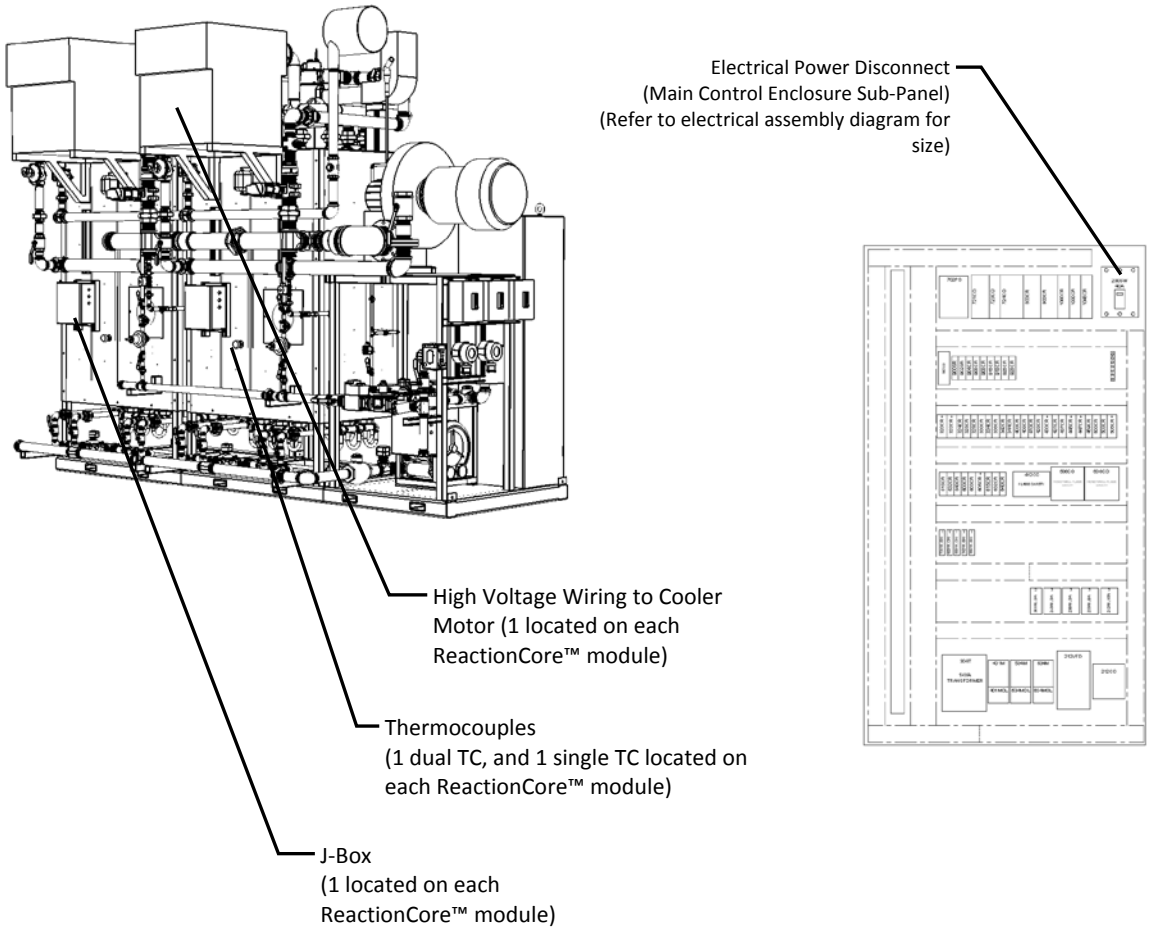
Only a qualified electrician experienced with endothermic gas generator operation and current safety requirements shall perform an EndoFlex™ generator installation. Proper safe electrical interlocks must be designed to meet safe generator operation based on NFPA86 guidelines. If necessary, installation supervision and direction of turnkey installation services are available from Atmosphere Engineering or an AEC certified installation professional. Installation Procedure (Refer to electrical assembly and pipeline diagram attached to manual for additional information):

1. After generator modules have been mechanically assembled together and secured, the interconnecting wiring should be re-run through the provided conduits to the J-Boxes located on each ReactionCore™ module. The wires have been precut, stripped, and labeled for connection to the terminal in the J-Box with the same label. Connect all wires to ReactionCore#1 module before moving to ReactionCore#2 module

2. Re-connect thermocouple wires through separate conduit (pre-mounted) directly to the thermocouples (each thermocouple wire is labeled.

3. Re-connect high voltage wires (black wires) through separate conduit (pre-mounted) from control module to the ReactionCore™ cooling system motors

4. Connect main power from a facility supplied lockable disconnect to the main disconnect located in the generator control enclosure. The facility disconnect should be clearly labeled and located reasonably close to the generator. Care should be taken to avoid heat sources and exhaust ventilation locations when mounting electrical conduit. It is important to review the electrical assembly diagram and ensure properly sized electrical wire and disconnect is provided to the generator.



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3.0 HMI OPERATION

This generator is fitted with the EndoInjector™ mixing and generator control system is designed to start and stop the same as a gas generator with a mechanical mixing system. However, the patented advanced control logic and operator interface of the EndoInjector™ mixing system are designed to provide complete monitoring and control of all critical generator variables with an integrated paperless chart recorder to log the generator performance.

The full-color touch-screen provides the main interface between an operator and the EndoInjector™ control system. The EndoInjector™ software is designed to run on any computer operating Microsoft operating system (XP or later) with the .net3.5SP1 Framework or later installed.

COMMUNICATION STATUS

The tip of the logo at the top right of the screen will blink green when communication is established between the HMI and the controller. If the tip is blinking RED then this is an indication that there is no communication link between the HMI and the controller. During startup it may take 5-10 seconds to establish communications however, a prolonged disconnect may be the sign of a communications setup problem or a wiring problem.

SYSTEM NAVIGATION BUTTONS

Generator Button

The "Generator" button is used to display a graphical representation of generator operation and component status. It should be noted that this is just a graphical summary and actual components may be in different locations from those displayed on the generator panel.

Process Button

The "Process" button is used to display the main generator process control values screen.

Chart Button

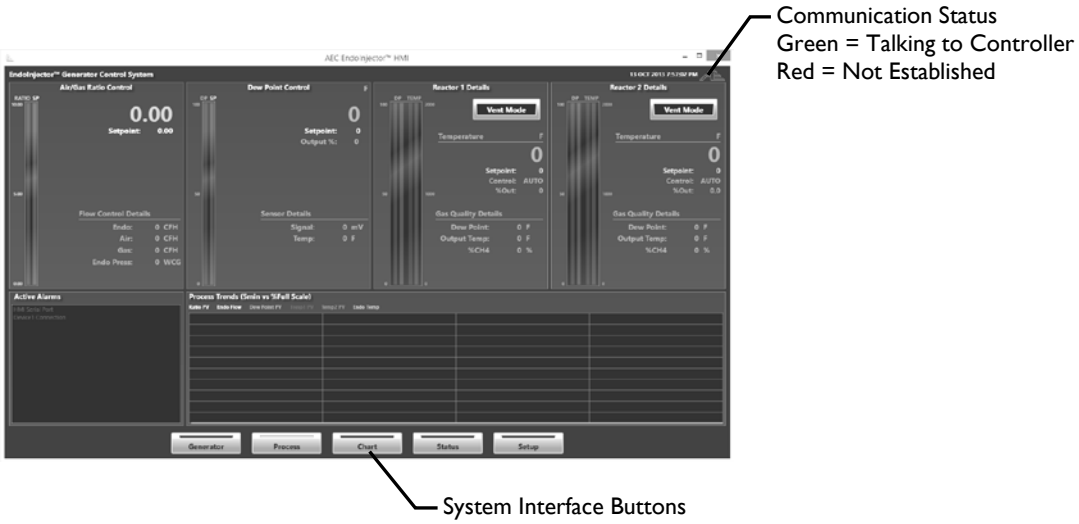
The "Chart" button is used to access the paperless chart recorder.

Status Button

The "Status" button is used to view active system alarms and communications status.

Setup Button

The "Setup" button is used to access the system setup screen. It should be noted that all system parameters are password protected with 3 levels of security to ensure accidental parameter changes cannot occur unless the user is logged in.



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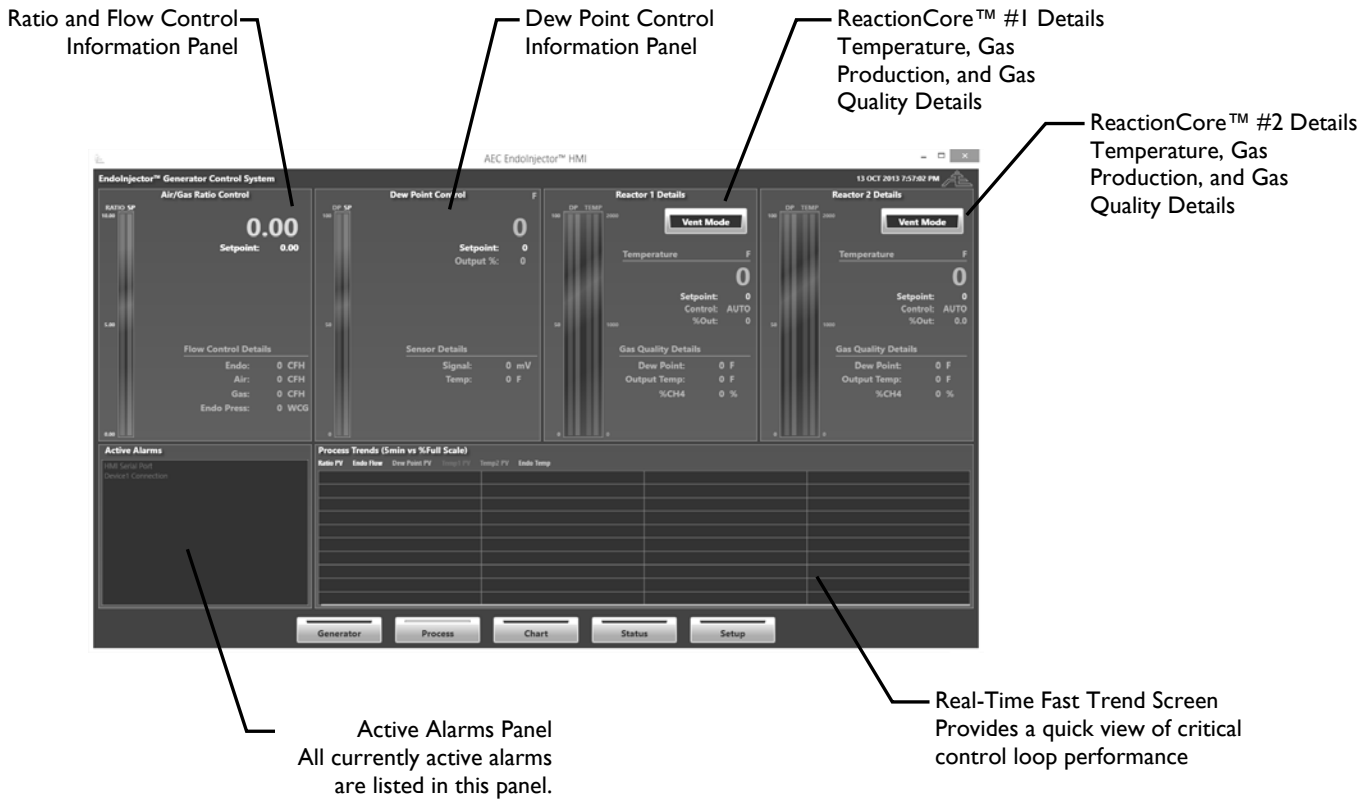
3.1 PROCESS SCREEN OVERVIEW



RATIO AND FLOW CONTROL PANEL

The ratio and flow control panel provides detailed information regarding the mixing system operation. Note: The bar graph scales are dependent on the pen scales defined within the paperless chart recorder and can be changed using the "edit pen" button on the history screen.

Air/Gas Ratio is the currently measured air flow divided by the currently measured gas flow passing through the mixing system. This value represents the actual mixture of air and gas being introduced into the gas generator and is directly correlated to the dew point of the endothermic gas produced. The actual ratio is controlled to the "Ratio Setpoint" by the fuel-injection control valve. It should be understood that a higher ratio will produce endothermic gas with a higher dew point.

Ratio Setpoint is the desired mixture of air and gas that should be introduced into the generator. This value can be entered manually or can be controlled automatically by the dew point PID loop output. When controlled automatically, the operator must provide a minimum and maximum ratio setpoint so that the dew point control loop can only change the loop by a limited range.

Endo Flow is a calculated value that represents the amount of endothermic gas being produced by the generator. It is calculated using the following equation: Endo Flow = (Air Flow + Gas Flow) x (Expansion Factor)

Air Flow is the actual calibrated measurement of air passing through the EndoInjector mixing system. This value is measured using the air flow transducer mounted to the mixing system. A calibration curve detailing the transducer performance in relation to the factory calibrated flow measurements is attached to this manual. The air flow meter has integrated test ports that can be used to certify the meter calibration while in operation.

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PROCESS SCREEN OVERVIEW *(CONTINUED)*

Gas Flow is the actual calibrated measurement of gas passing through the EndoInjector mixing system. This value is measured using the gas flow transducer mounted to the mixing system. A calibration curve detailing the transducer performance in relation to the factory calibrated flow measurements is attached to this manual. The gas flow meter has integrated test ports that can be used to certify the meter calibration while in operation.

Endothermic Gas Pressure *(Optional)* indicates the generator output endothermic gas pressure based on pressure transducer.

Premix Gas Pressure *(Optional)* indicates the premix gas pressure before the retort based on pressure transducer.

DEW POINT CONTROL PANEL

The dew point control panel provides detailed information regarding the quality of the endothermic gas being produced by the gas generator. Note: The bar graph scales are dependent on the pen scales defined within the paperless chart recorder and can be changed using the "edit pen" button on the history screen.

Dew Point is the actual dew point of the endothermic gas being produced. The dew point is typically measured by taking a sample of endothermic gas and introducing it to either a zirconia oxygen sensor (probe) or a gas analyzer.

Dew Point Setpoint is the desired dew point that should be produced by the endothermic gas generator. This value is typically entered manually by the operator. The dew point of endothermic gas is directly correlated to the resulting "%Carbon" level within a heat treating furnace. While the dew point will not exactly predict %Carbon inside a furnace, because there are many other variables that determine the %Carbon value in a heat treating furnace, but generally a higher dew point will result in a lower %Carbon value inside a heat treating furnace (all other furnace variables being equal).

%Output value represents the PID control output signal used to change the air/gas ratio setpoint. If the %Output is equal to 100% then the air/gas ratio setpoint will be equal to the maximum air/gas ratio setpoint provided by the operator. If the %Output is equal to 0% than the air/gas ratio setpoint will be equal to the minimum air/gas ratio setpoint. The corresponding values between 0-100% will result in a linear change to the air/gas ratio setpoint.

Sensor Signal is the actual measured signal from the dew point sensor. This value is used to determine the dew point of the endothermic gas sample.

Sensor Temperature *(for probe sensors only)* is the actual measured temperature of the gas sample within the dew point sensor. This value is used to determine the dew point of the endothermic gas sample. Note: The ideal temperature of a zirconia sensor during operation is 1550degF.

REACTIONCORE™ CONTROL PANEL(S)

The ReactionCore™ control panel provides detailed information regarding the temperature, production, and quality of the endothermic gas reaction occurring in each reaction module. Note: The bar graph scales are dependent on the pen scales defined within the paperless chart recorder and can be changed using the "edit pen" button on the history screen.

Temperature is the actual temperature within the hot zone of an endothermic gas generator. This value is measured by an industrial thermocouple. Note: a value of >3000 means that there is an open loop on the thermocouple input and the thermocouple is either not wired correctly or has failed.

Temperature Setpoint is the desired temperature within the hot zone of an endothermic gas generator. This value is typically set by the generator operator to a value of 1900degF or 1950degF for normal generator operation.

%Output value represents the PID control output signal used to control the temperature of the generator. The actual output can be either a time proportional (relay type) control or a 4-20mA control signal. If the temperature is lower than the temperature setpoint then the %output will increase. The increase in %output will result in the temperature control relay being energized "more often" and also result in the 4-20mA signal to increase in current.

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PROCESS SCREEN OVERVIEW *(CONTINUED)*

Production Mode (Vent, Enabled, Online, Burnout) is the indication of where the production of gas from this module is being sent.
Vent = All endothermic gas is being sent to the Endo VENT for burn-off
Enabled = The "to furnace" solenoid will be open when this module is making endothermic gas
Online = the "to furnace" solenoid is open and the amount of gas going to the furnace is enough to trigger the endo flow switch
Burnout = the chamber is currently running a catalyst burnout recipe and cannot produce endothermic gas until the burnout is complete.

Gas Quality Details the dew-point, output temperature, and residual unreacted methane (CH4) is monitored and displayed for review of gas production quality for the reaction chamber.

PROCESS CONTROL TREND PANEL

The process control trend panel is updated every second to display actual control characteristics of the mixing system that might not be seen on the one minute storage interval of the historical log found in the paperless chart recorder. The trend panel is not the same as the paperless chart recorder in that all the data is updated much more quickly (1 second intervals) and the trend data is not stored longer than 4 minutes. The primary function of the trend panel is to provide real time feedback of system operation to better tune and confirm minimal control oscillations during system operation.

Trend Panel Setup: Double tapping on the trend title will display the trend pen selection menu. Select a value to display for each pen and close the setup screen. Changes are immediate. Note: The trend pen scaling and color is dependent on the setup for those values within the paperless chart recorder and can be changed using the "edit pen" button on the chart screen.

ACTIVE ALARM PANEL

The active alarm panel displays all currently active alarms in RED. Detailed alarm status and alarm history can be found in the "Status" screen that will be displayed by pressing the "Status" button at the bottom of the screen.

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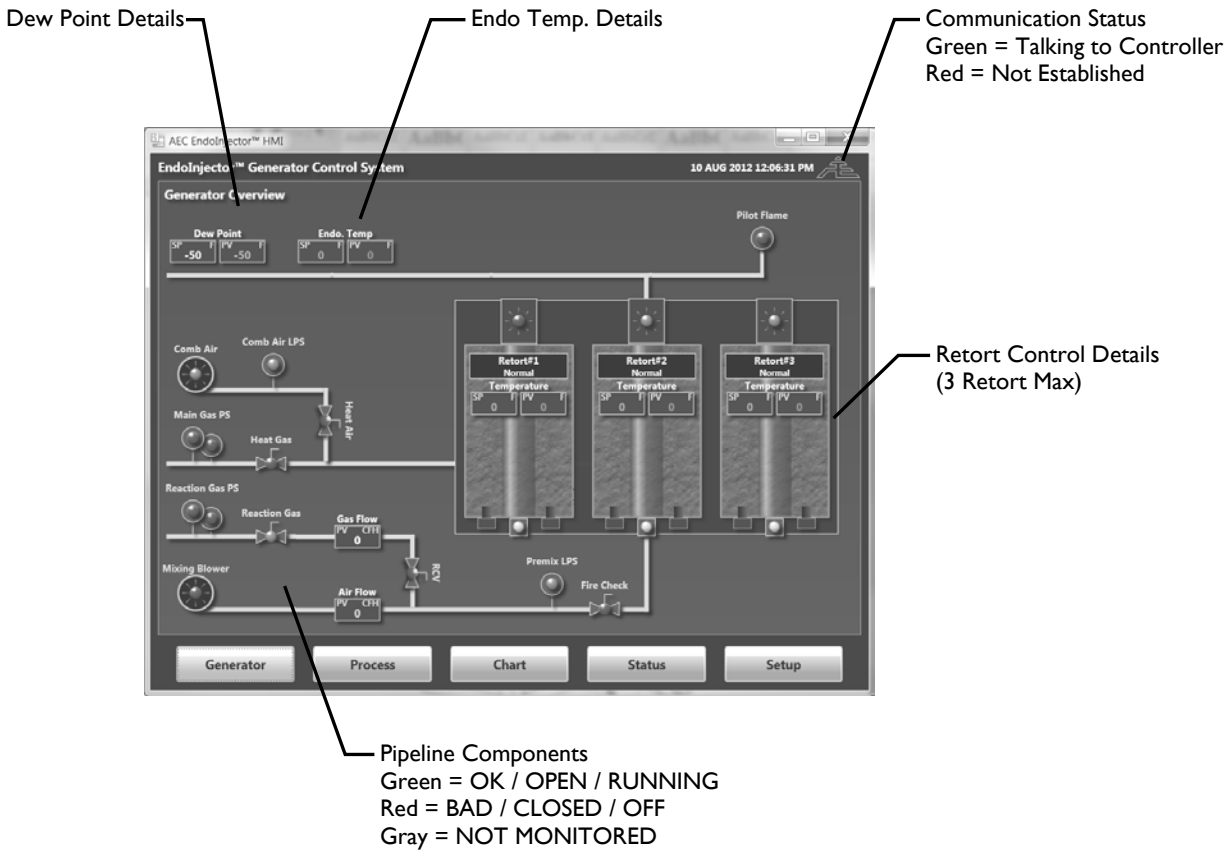
3.2 GENERATOR SCREEN OVERVIEW



Pipeline Components

The Pipeline components section is intended for status indication only and should be considered for reference and troubleshooting purposes only. Components shown on this screen indicate the standard generator components found on most generators. However, actual components may differ and/or the location of these components may be different than those pictured in the pipeline diagram. Consult the generator manufacturer drawings and diagrams for actual component locations. If the LED on the screen for a component is "GRAY" then that is an indication that the component is not being monitored by the control system.

Retort Control Details

The retort control section indicates the temperature control, flame sensor, high/low fire, retort inlet valve, and cooler status for each retort. The temperature of the retort will fade from gray thru red to yellow depending on the temperature PV measured by the thermocouple for that retort. A flame will be present when the flame sensor detects a flame and the size of the flame will change depending on the status of the temperature control relay.

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3.3 Setup Screen Overview

The setup panel organizes all setup parameters into specific groups. These groups are accessed using the "Parameter Group" buttons located at the top of the setup screen. It should be noted that all parameters are password protected to provide "READ ONLY" access to control parameters. It is not possible to change system parameter setting if not logged into the system.

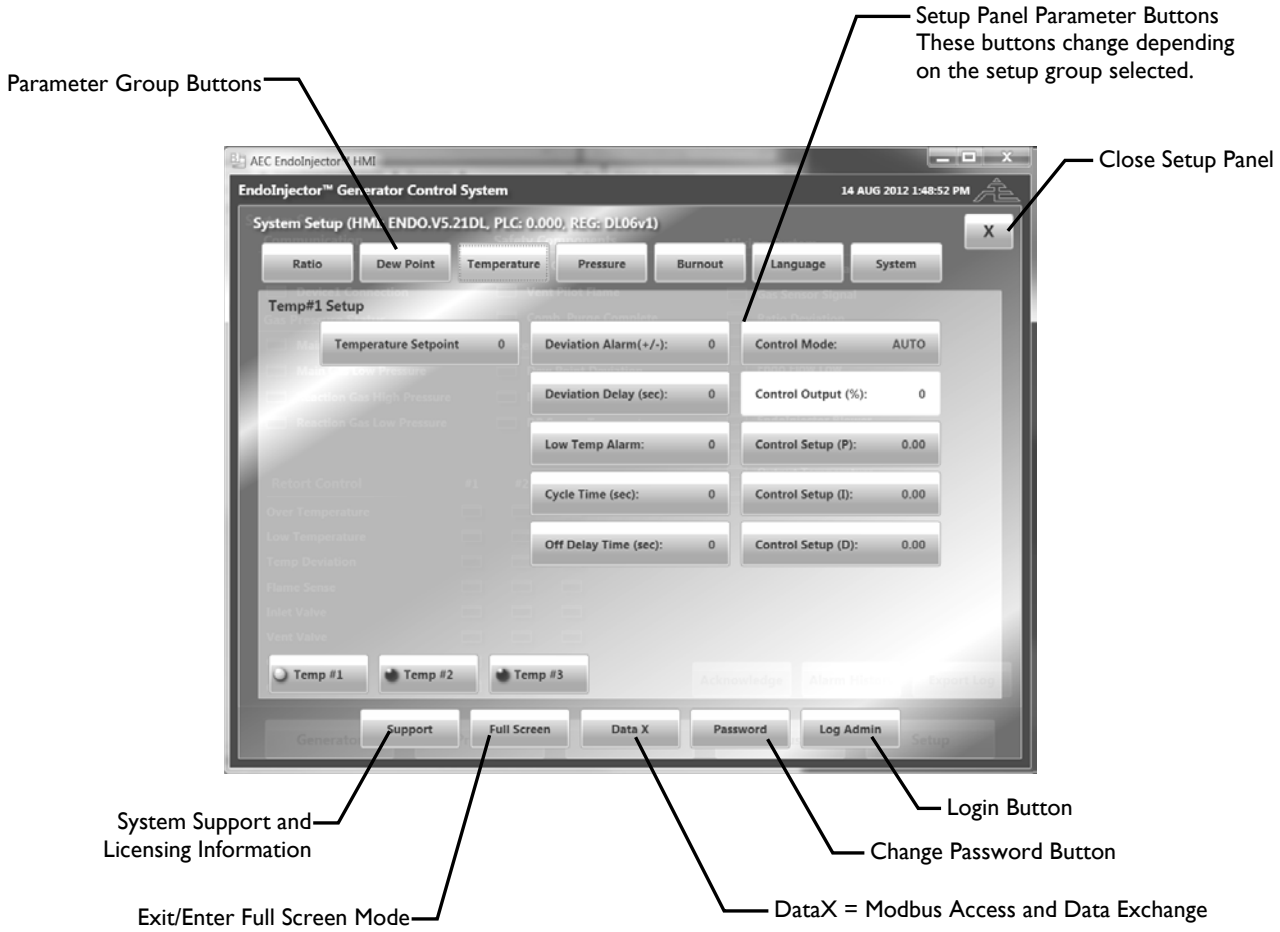
Login Permissions

The EndoInjectorV5 software provides 3 levels of access to the system configuration setup screen.

USER LEVEL (Default = 2): Provides access to standard system set points and tuning variables.

ADMINISTRATION LEVEL (Default = 22): Provides access to critical control parameters and alarm setpoint variables.

ENGINEERING LEVEL (Contact AEC): Provides access to modbus mapping and controller setup functions.



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RATIO SETUP PARAMETER GROUP *(USER, ADMIN, ENG Levels)*
These parameters define the control of the air/gas mixing function of the EndoInjector. Changes to these parameters will take effect immediately. All parameters are only editable in USER, ADMIN, and ENG levels.

Maximum Ratio Set Point *(Default = 3.00)*
Maximum Air/Gas Ratio to be introduced when dew point control output is equal to 100%. The default setting of 3.00 may differ slightly due to specific generator characteristics. If the dew point is too low and the trim signal is 100% then the Maximum Ratio Set Point should be increased to provide proper dew point control. NOTE: Do not set this value above 3.50 as excessive water vapor may be produced within the generator retorts. If the required air/gas ratio approaches 3.50 this could indicate a probe sensor failure or "sooting" of the catalyst within the retort. Consult the generator manual for troubleshooting guidelines or contact Atmosphere Engineering for further support.

Minimum Ratio Set Point *(Default = 2.50)*
Minimum Air/Gas Ratio to be introduced when dew point control output is equal to 0%. The default setting of 2.50 may differ slightly due to specific generator characteristics. If the dew point is too high and the trim signal is 0% then the Minimum Ratio Set Point can be decreased to provide proper dew point control. NOTE: Do not set this value below 2.00 as excessive "sooting" may occur within the generator retorts. If the required air/gas ratio approaches 2.00 this could indicate a probe sensor failure or water collection within the gas sample line. Consult the generator manual for troubleshooting guidelines or contact Atmosphere Engineering for further support.

Ratio Deviation Alarm / Delay *(Default = 0.10 / 30sec)*
This value defines the limit for the ratio deviation alarm and the time required outside of this range before an alarm is sounded. When the actual air/gas ratio deviates from the ratio setpoint by more than this value for mor than the delay time a Ratio Deviation Alarm will occur.

DEW POINT SETUP PARAMETER GROUP *(USER, ADMIN, ENG Levels)*
These parameters define the dew point control for the gas being produced by the gas generator. Changes to these parameters will take effect immediately. All parameters are only editable in USER, ADMIN, and ENG levels.

Dew Point Setpoint
The dew point setpoint is the desired dew point of the generated endothermic gas.

Dew Point Deviation Alarm / Delay
The deviation alarm value determines when a dew point deviation alarm should be triggered.

Control Mode *(Auto/Manual)*
The control mode defines the PID control active status for the dew point control loop. Typically this parameter is left in "AUTO" mode but can be changed to "Manual" mode during system startup to "lock" ratio control at one ratio setpoint to season catalyst or lean out generator.

Control Output (%)
The control output in the dew point setup panel is the same as the %output as detailed on the dew point detail panel on the main screen. The value is READ ONLY when dew point PID control is in AUTO mode. However, the %Output can be changed when PID is in MANUAL mode.

Control PID Values
PID settings can vary widely depending on the controller hardware incorporated with the system. If not familiar with the controller setup parameters for that hardware, contact Atmosphere Engineering for advice regarding initial settings and tuning recommendations.

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TEMPERATURE SETUP PARAMETER GROUP *(USER, ADMIN, ENG Levels)*

These parameters define the characteristics of the temperature control for the gas generator. Changes to these parameters will take effect immediately. All parameters are only editable in USER, ADMIN, and ENG levels.

Temperature Loop Selection Buttons

When more than 1 temperature control loop is activated, the buttons at the bottom of the temperature control setup screen provide a way to toggle which temperature loop is displayed and is edited from the screen. It is important to review these buttons to confirm the correct temperature loop is selected prior to making any parameters changes.

Temperature Setpoint

The temperature setpoint is the desired temperature to control the gas generator hot zone.

Temperature Deviation Alarm / Delay

The deviation alarm value determines when a temperature deviation alarm should be triggered.

Control Mode *(Auto/Manual)*

The control mode defines the PID control active status for the temperature control loop. Typically this parameter is left in "AUTO" mode but can be changed to "Manual" mode during initial system startup or for troubleshooting reasons. It should be fully understood that when the loop is in manual mode, the temperature is not under control and can go higher than desired. It is always recommended to check the over temperature controller (not included with EndoInjector™ system) prior to placing temperature PID in manual mode to ensure temperature will shut down if excessive temperature is reached.

Low Temp Alarm *(Default: 1400F)*

The low temperature alarm is a critical safety setpoint. When the actual control temperature is higher than this value the low temperature alarm relay will energize. This relay must be wired into the motor start circuit for the EndoInjector™ mixing system so that if the temperature goes below this low temperature setpoint the mixing system must stop and the reaction gas must automatically be isolated. The minimum setpoint of this value shall be 1400degF per NFPA 86 guidelines.

Control Cycle Time (sec)

The control cycle time is used to setup time proportional control of the relay output used for temperature control. This time value represents the amount of time to divide between high fire and low fire based on the %output of the temperature control PID loop. The %output represents the % of the control cycle time to remain at high fire. For example, if the Control Cycle time was set to 20 seconds and the temperature control %output was 75% then the temperature control relay would remain energized 15 seconds and de-energized 5 seconds.

Off Delay Time (sec)

Some burners and flame safety devices require that the burner be at high fire for a minimum amount of time before returning to low fire. This parameter will set the minimum amount of time in seconds that burner must remain at high fire before the burner can turn off (or return to low fire).

Control Output (%)

The control output in the temperature setup panel is the same as the %output as detailed on the temperature detail panel on the main screen. The value is READ ONLY when temperature PID control is in AUTO mode. However, the %Output can be changed when PID is in MANUAL mode.

Control PID Values

PID settings can vary widely depending on the controller hardware incorporated with the system. If not familiar with the controller setup parameters for that hardware, contact Atmosphere Engineering for advice regarding initial settings and tuning recommendations.

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PRESSURE SETUP PARAMETER GROUP *(USER, ADMIN, ENG Levels)*
(OPTIONAL FEATURE)
This parameter group is only available when pressure control is enabled from the system setup screen. The pressure control feature can only be used on "LP Configuration" systems that utilize Variable Frequency blower motor controls. Changes to these parameters will take effect immediately. All parameters are only editable in USER, ADMIN, and ENG levels.

Pressure Setpoint
The pressure setpoint is the desired generator outlet pressure the system should maintain

Pressure Deviation Alarm / Delay
The deviation alarm value determines when a pressure deviation alarm should be triggered.

Control Gain
The control gain defines how fast the system responds to deviations from setpoint. A larger gain value will force the system to respond faster, however, if the gain is too large the system may become unstable and cause pressure fluctuations.

Control Rate
The control rate defines how quickly to make changes. A larger rate will slow down the iterations of the control loop but may make the system to slow to respond to pressure changes.

BURNOUT SETUP PARAMETER GROUP *(USER, ADMIN, ENG Levels)*
This parameter group is only available when retort burnout control is enabled from the system setup screen. The retort burnout control feature can only be used on PLC control systems that have been programmed to interact with specific generator burnout air components. Changes to these parameters will take effect immediately. All parameters are only editable in USER, ADMIN, and ENG levels.

Burnout Start Buttons
The burnout start button will set the appropriate retort temperature to 1500degF and wait for the temperature to reach this setpoint before energizing the retort 1 burnout relay.

Burnout Stop Buttons
The burnout stop button will halt the retort burnout process for the retort. If the burnout relay for that retort is energized, then the burnout relay will de-energize immediately. No changes will be made to temperature setpoint for that retort.

Burnout Time (min)
The burnout time is the amount of time to energize the retort burnout relay for that retort. It should be noted that the burnout time and relay will stop if the temperature rises by more than 50deg above setpoint.

Burnout Status Messages
"Burnout Pending" – Burnout has been started but the temperature is not within 50deg of setpoint
"Burnout Active" – Burnout relay is energized and timer is counting.. remaining time is displayed with this message.
"Burnout Complete" – Indicates that the burnout timer has completed normally and that the relay has been de-energized.
"Burnout Stopped" – Indicates that the burnout was manually interrupted and that the relay is de-energized.

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LANGUAGE SETUP PARAMETER GROUP *(USER, ADMIN, ENG Levels)*

The EndoV5 HMI software is designed to be completely multi-language capable and can be changed while online. To change the language, select the flag of the country and all text and alarm messages will be in the predominant language of that country. If the language (or flag) desired is not found, contact Atmosphere Engineering support team to request a language/flag addition to the HMI program.

Editing the HMI Text Tag File

All displayed text on the HMI is locally stored as "tags" in the file "setup/ENDOV5tags" text lookup file. However, it is STRONGLY recommended not to edit this file directly using a text editor. Instead, it is recommended to use the "ENDOV5tags_Master Excel File" located in the same directory to edit any tags and use the procedure outlined here to update the ENDOV5tag file.

1. Using MS Excel, open the "ENDOV5tags_Master Excel File" located in the setup directory.
2. Edit the text as desired for the language selection desired
   Note: The first 2 columns indicate the tag number and brief usage description for the tag and each column afterwards contains the text for each specific language.
3. Save the changes to the "ENDOV5tags_Master Excel File"
4. Now, while still in the excel program, press "CTRL+A" to select all items
5. Press "CTRL+C" to copy all items in the Excel sheet.
6. Open "ENDOV5tags.txt" file located in the setup directory using notepad program or similar.
7. Press "CTRL+A" to select all items in the text file.
8. Press "CTRL+V" to paste all items from the excel file into the text file.
9. Save revised ENDOV5tags file (Note: filename cannot be changed).

Finding Which Tag to Edit

If unsure which tag number is used for a specific item on the HMI, double tap on the main title of the HMI (always located at the top left of the screen) and this will change the HMI screen so that it displays the tag number for each text item on the screen. To revert back to the language selection, double tap on the main title again.

Note: If the screen is using a language other than English, double tapping on the main title will convert the screen to English first, another double tap on the main title will convert the text to tag number assignments, and a final double tap will convert the screen back to the previously displayed language.

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SYSTEM SETUP PARAMETER GROUP *(ADMIN, ENG Levels Only)*

The EndoV5 HMI software has been designed to work with many different controllers and generator configurations. Parameters contained within the "System Setup" group are items that usually are only setup once during system installation and should not require frequent changes. It should be understood that parameters contained within the "System Setup" group can directly affect the safety of the generator. Only persons trained and experienced with generator setup and operation should attempt to change these parameters without direct support from Atmosphere Engineering.

System Signal Overview *(ADMIN, ENG Levels Only)*

The signal overview is a direct reading of the analog signals connected to the controller. It is primarily used for troubleshooting wiring and setup issues.

System Communication Setup *(ENG Level Only)*

This section contains parameters that affect how the HMI will communicate with the control device(s).

Controller Type

Select the modbus register lookup table to use with the installed controller. This parameter should only be changed with the support of Atmosphere Engineering.

HMI Comm Protocol *(Serial, TCP, or DEMO mode)*

Select the communication link type between the HMI and controller device. Demo mode will provide a demonstration mode that simulates values for training and presentation purposes.

HMI Serial Port *(Serial protocol only)*

Select the serial com port used to connect the HMI to the controller device.

HMI Baud Rate *(9600, 19200) (Serial protocol only)*

Select the serial baud rate used to communicate to the controller device.

HMI Parity *(Even, Odd, None) (Serial protocol only)*

Select the serial parity used to communicate to the controller device.

Device IP *(TCP protocol only)*

Enter the IP address of the controller device.

Enable Animation

Toggle if the screen uses animations. Turning animations off can make slow HMI screens more responsive.

Display Generator Screen

Toggle if the if the HMI should allow a visual representation of the generator. Some controller types do not provide adequate feedback from generator sensors and devices and therefore, this screen can be hidden to avoid confusion over component status.

Display Retort Number

Identify the number of retorts to display on the generator overview screen. Note: this parameter will be over written by the temperature loops active if a suitable graphic is not available to represent the temp loop and retort combination.

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System Device Setup *(ENG Level Only)*
This section contains parameters that define setup items specifically involved in how the HMI and Device are used with the generator equipment.

Device#1 Temp Unit
Informs the HMI of what temperature units are used within the controller device. This parameter MUST equal the temperature units within the control device. Note: changing this parameter does not change the units within the control device only how the HMI interacts with the controller.

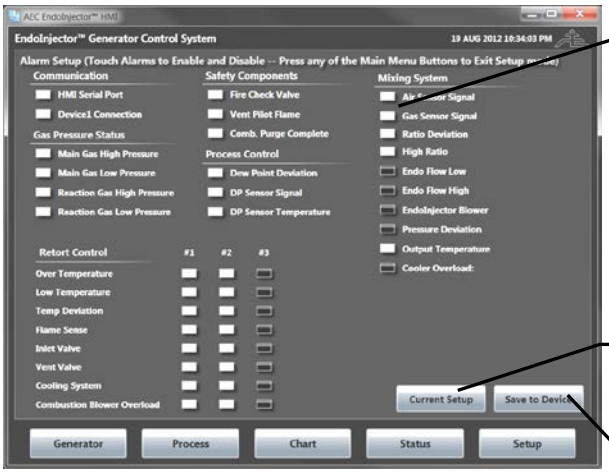
Device#1 DP Unit
Informs the HMI of what dew point units are used within the controller device. This parameter MUST equal the dewpoint units within the control device. Note: changing this parameter does not change the units within the control device only how the HMI interacts with the controller.

Device#1 Flow Unit
Informs the HMI of what flow units are used within the controller device. This parameter MUST equal the flow units within the control device. Note: changing this parameter does not change the units within the control device only how the HMI interacts with the controller.

Device#1 Press Unit
Informs the HMI of what pressure units are used within the controller device. This parameter MUST equal the pressure units within the control device. Note: changing this parameter does not change the units within the control device only how the HMI interacts with the controller.

Retort Burnout Enable
Informs the HMI if retort burnout capabilities are available within the connected controller. This parameter MUST equal the status of retort burnout capability within the controller. Note: changing this parameter enable burnout capability within the control device it only enables the burnout features on the HMI.

Device Alarm Setup (CAUTION!!!)
This is used to setup what alarms are enabled or disabled in both the HMI AND THE CONTROLLER. Note: Changing alarm enable/disable status actually changes the usage of alarms in the controller. If an alarm is "disabled" it will both be hidden on the HMI and disabled in the controller. Alarms should only be disabled when the generator does not require the alarm, the installation does not provide the necessary input signals to the controller, or alternate safeties have been installed. Exercise caution when disabling any alarms. Some alarms are critical to the safe operation of the equipment and are required to meet NFPA86 guidelines. Alarms must only be disabled if alternate safety measures are installed separate from the EndoInjector control device.



Alarm Enable Status
White = Alarm Enabled
Black = Alarm Disabled
(Press Alarm LED to Change Enable Status)
Note
Changing alarm status does not change immediately in the controller. Changes must be saved to the control device using the "Save to Device" button.

Load Current Alarm Setup from Controller

Save Alarm Setup to Controller

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System Flow Setup *(ADMIN, ENG Level Only)*
This section contains parameters that define setup items specifically involved in the flow control sensor for the EndoInjector™ and flow display on the HMI.

Flow Display Unit
Select what flow unit to display on the touchscreen. This does not change any parameters in the controller, only how the information is displayed on the HMI.

Air mA Offset
Offset the mA signal from the air flow transducer.

Gas mA Offset
Offset the mA signal from the gas flow transducer.

Endo Expansion Factor
Change the expansion factor used to calculate endothermic gas output flow rate. Endo Flow is a calculated value that represents the amount of endothermic gas being produced by the generator. It is calculated using the following equation: Endo Flow = (Air Flow + Gas Flow) x (Expansion Factor). Typical values for systems using natural gas = 1.43, and for systems using propane gas 1.52.

High Ratio Alarm Setpoint *(Default = 8.0 Nat Gas, 15.0 for Propane Systems)*
Define the maximum ratio limit that is considered safe. If the actual ratio is higher than this for longer than the high ratio alarm delay, then the critical alarm relay will be de-energized which should be interlocked to stop the mixing system. This is a test to ensure that gas supply is provided and the ratio control valve is functioning.

High Ratio Alarm Delay (sec) *(Default = 10 seconds)*
The high ratio alarm delay is the amount of time in seconds that a high ratio situation should be allowed to occur before triggering the critical alarm. Note: Depending on the reaction gas supply pipeline, there is typically a few seconds of time that the blower is started before gas is supplied to the mixing system. It may be necessary to increase this delay parameter to accommodate slower reaction gas introduction.

Valve Speed Gain *(FACTORY SET = DO NOT CHANGE THIS VALUE)*
This value defines the response characteristics of the fuel injection control valve. Typically, once this value is set at the factory, it will not require adjustment. Note: as a “rule of thumb” increasing this value will make the valve respond slower.

Low Flow Alarm
If the calculated endothermic gas flow rate is lower than this value for a time longer than the flow alarm delay time an alarm will sound.

High Flow Alarm
If the calculated endothermic gas flow rate is high than this value for a time longer than the flow alarm delay time an alarm will sound.

Flow Alarm Delay (sec)
The high/low flow alarm delay time.

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System DP Sensor Setup *(ADMIN, ENG Level Only)*
This section contains parameters that define setup items specifically involved in the setup of the dew point control for the EndoInjector™

DP Sensor Type *(Probe / Analyzer/ CO2)*
Select what sensor type will be used for measurement of the control variable. If CO2 is selected, the corresponding text will change for multiple fields.

DP Display Unit
Select what dew point unit to display on the touchscreen. This does not change any parameters in the controller, only how the information is displayed on the HMI.

Sensor TC Type *(Probe Only)*
Select what TC type is supplied with the probe.

H Factor *(Probe Only)*
The H Factor represents the presumed hydrogen amount contained in the endothermic gas. Typically, this value is set to 400 (representative of 40.0% hydrogen). The H Factor parameter is used to calibrate the dew point value calculation for zirconia oxygen sensors. Increasing the H Factor by 10 will cause approximately a 1degF offset in the dew point reading.

Sensor mV Offset
Offset the mV signal from the dew point sensor.

Sensor Temp Offset *(Probe Only)*
Offset the probe temperature signal.

CO2 Sensor Full Scale *(CO2 Only)*
Set the CO2 analyzer scale that is used to measure the control variable.

Probe Burnout Start *(Probe Only)*
Pressing this button will initiate a probe burnout immediately and will reset the probe burnout interval time.

Probe BO Interval (min) *(Probe Only)*
Time between each automatic probe burnout.

Probe BO Time (sec) *(Probe Only)*
Time to introduce burnout air to the probe.

Probe BO Delay (sec) *(Probe Only)*
Time to wait after stopping the burnout air before using the probe for automatic dew point control.

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System Temperature Setup *(ADMIN, ENG Level Only)*
This section contains parameters that define setup items specifically involved in the setup of the temperature control for the EndoInjector™

# of Temp Loops *(1, 2, or 3)*
Select how many active temperature control loops are on the generator.

Temp Display Unit
Select what temperature unit to display on the touchscreen. This does not change any parameters in the controller, only how the information is displayed on the HMI.

Temp TC Type
Select the TC type used for temperature control. All temperature loops must use the same TC type.

Temp#1 Offset
Offset the temperature signal for the first temperature control loop.

Temp#2 Offset
Offset the temperature signal for the second temperature control loop.

Temp#3 Offset
Offset the temperature signal for the third temperature control loop.

Burner Control Type (Premix, Ring, SCR)
Selection of the temperature control method used for the generator. This selection mainly affects the generator overview display regarding what pipeline diagram to display.

Purge Time (sec) *(Premix Control Type Only)*
Required amount of combustion air purge. Timer will start when the combustion air pressure switch is made. This option is only available when the combustion control type is set to “premix”.

Endo Temp Enable
Select if the output endothermic gas temperature will be monitored.

Endo Temp Offset *(Endo Temp Enable = True)*
Offset the temperature signal for the endothermic gas thermocouple.

Endo Temp Alarm *(Endo Temp Enable = True)*
When the endothermic gas output temperature is above this setpoint an alarm will be triggered.

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System Pressure Setup *(ADMIN, ENG Level Only)*
This section contains parameters that define setup items specifically involved in the setup of the pressure control for the EndoInjector™. The pressure control is only available on the "LP" configuration systems that utilize a variable speed drive to control the speed of the EndoInjector™ blower.

Endo Pressure Sensor Enable
Indicate if a pressure sensor is attached to monitor the endothermic gas generator output pressure.

Endo Pressure Sensor Scale *(Endo Pressure Sensor Enabled)*
Set the pressure transducer scale that is used to measure the generator output pressure.

Endo Pressure Sensor mA Offset *(Endo Pressure Sensor Enabled)*
Input an offset for the endo gas pressure sensor mA signal (displayed on the signal overview screen).

Premix Pressure Sensor Enable
Indicate if a pressure sensor is attached to monitor the premix gas pressure.

Premix Pressure Sensor Scale *(Premix Pressure Sensor Enabled)*
Set the pressure transducer scale that is used to measure the generator output pressure.

Premix Pressure Sensor mA Offset *(Premix Pressure Sensor Enabled)*
Input an offset for the premix pressure sensor mA signal (displayed on the signal overview screen).

Pressure Display Unit *(Pressure Control Enabled)*
Select what pressure unit to display on the touchscreen. This does not change any parameters in the controller, only how the information is displayed on the HMI.

Pressure Control Enable *(Endo Pressure Sensor Enabled)*
Select if system pressure control should be enabled. Only if the system is provided with a VFD controller to change the speed of the pump.

Blower Min Hz *(Pressure Control Enabled)*
Set the minimum speed that the blower should be allowed to run. This setting is used to set a base minimum flow rate through the generator. This value should be set at the frequency where the output flow is approximately 25-30% of rated generator capacity. Therefore, if output demand is reduced further, then the system will not allow the blower to spin slower and the output pressure will rise allowing for a relief regulator to open. The setup should provide that the flow through the EndoInjector™ mixing system is not below 20% of rated capacity.
Note: It is not recommended to run the blower motor at frequencies lower than 20Hz due to higher amperage and heat generated at these lower speeds.

Blower Max Hz *(Pressure Control Enabled)*
Set the minimum speed that the blower should be allowed to run. The setting can set to the frequency that provides the maximum flow capacity of the generator. Thus if additional demand is required, the blower will not increase in speed further than this value so that the system does not produce more endothermic gas than the system was designed.

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System Calibration Curve Setup *(ENG Level Only)*

This section contains parameters that define the calibration curves for the air and gas flow transducers attached to the mixing system. DO NOT change these parameters without specific instruction from Atmosphere Engineering.

Air Curve Data

Indicate each calibration point for the air flow transducer (mA and Flow)

Gas Curve Data

Indicate each calibration point for the gas flow transducer (mA and Flow)

Selecting any button will allow the operator to edit the calibration curve mA or Flow for each calibration point.

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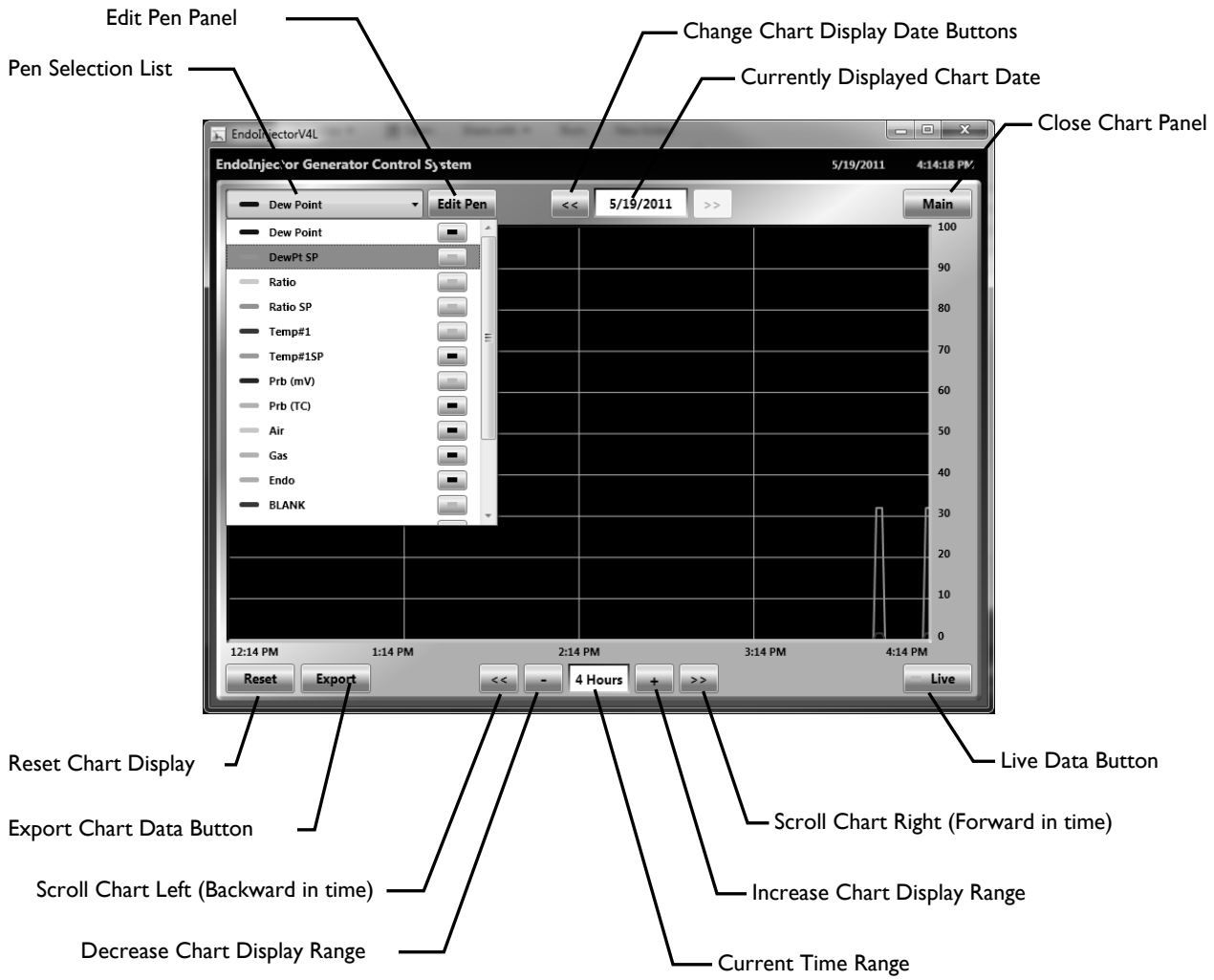
3.4 PAPERLESS CHART RECORDER

Pressing the "History" button on the main screen opens the EndoInjector paperless chart recorder. The paperless chart recorder displays the long term historical data for all generator process variables. Data is stored once every minute on the touch-screen hard drive in daily encrypted log files that can be exported to CSV files that can be opened in any spreadsheet program (i.e. MS Excel) for detailed investigation and reporting if required. The generator performance data will never overwrite old data since the hard drive space provides 50+ years worth of daily storage space. However, for tacking purposes, the data should only be considered archived for 5+ years on the touch screen unless backed up to a remotely maintained data storage center.

PAPERLESS CHART RECORDER OVERVIEW



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3.4 PAPERLESS CHART RECORDER

(CONTINUED FROM PREVIOUS PAGE)

PEN SELECTION LIST

The pen selection list provides a list of all pens available to display, the current pen color for each variable, and a button to display or hide the pen on the chart. Also, selecting a pen will update the scale values on the right of the chart to display the selected pen's scale settings. Each pen is drawn based on their own minimum and maximum scale range. The scale range for each pen can be changed by first selecting that pen in the Pen Selection List and then pressing the "Edit Pen" button. Note: The actual data values are stored regardless of pen scale or display settings.

Edit Pen Button

The edit pen button opens a panel that provides a way to edit the minimum display scale range, maximum display scale range, and pen color selection. Note that each pen is drawn based to it's own scale however, actual data stored is not affected by these settings.

Currently Displayed Chart Date

The log data is separated into daily log files. The log file that is currently being displayed is shown in the currently displayed chart date at the top of the chart.

Change Chart Display Date Buttons

The change chart display date buttons are located on either side of the current chart date at the top of the chart screen. Pressing these buttons will increase or decrease the current display date by one day.

Current Time Range

The current time range is found at the bottom of the chart display and represents the amount of time currently displayed from the left to the right on the chart. The default is to display 4 hours of data at a time but this can be increased to an entire day or decreased to just 15 minutes.

Increase / Decrease Chart Display Range Buttons (+ / -)

The increase and decrease chart display buttons will change the time range of data to display on the chart. Basically, these buttons provide a way to zoom in and out of the data in time. The limit is to increase the range to view an entire day of data or decrease the range to view just 15minutes of data.

Scroll Chart Right / Left (<< / >>)

The scroll chart buttons provide the means to pan the chart through time. Each press of either of these buttons will scroll the chart by 2 vertical gridlines (1/2 of the time range displayed).

Live Data Button

The live data button indicates and provides a way to turn the chart display on or off so that it automatically updates while viewing the data. When the live button is "on" then the chart will update and scroll automatically from right to left as new data is written to the log file.

Reset Chart Display

The reset chart display will reset the current display date to "today" and the current time range to 4 hours.

Export Data Button

The export data button opens a save dialog window to export the currently displayed daily data to a csv file. Attach a USB storage device to one of the USB ports on the back of the touch-screen then navigate and save the csv file to the storage device so that it can be transferred to another computer for review.

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3.5 ALARM STATUS SCREEN

Pressing the "Status" button on the main screen opens the alarm status screen that indicates current system alarm status.
The visibility of some alarms depends on what alarms are enabled on the system and available on the controller installed.
The lists of alarms will turn green, yellow, or red depending on status of the alarm being described.
Red = Active alarm that has not been acknowledged
Yellow = Active alarm that has been acknowledged
Green = Alarm is OK
Black = Alarm status is Unknown due to communication failure

Communication Alarm Status

COM alarms occur when any failure of the Modbus communication is detected. All other alarms will remain "Black" until all communication alarms are resolved as OK.

HMI Serial Port
A port open alarm occurs when the com port selected in the setup screen is not actually found on the HMI touch screen. Also, if the communication port of Ethernet is selected then a port alarm will occur when the IP address the HMI is trying to reach to communicate with the ratio controller is not found.

Device Connection
A ratio controller communication alarm occurs when the ratio controller cannot be found or a Modbus read or write operation has failed. Typically, this alarm will occur if the polarity of a serial connection is reversed or disconnected.

Gas Pressure Status

Main Gas High/Low Pressure
Indication that the high and low main gas pressure switches are ok.

Safety Components Alarm Status

Fire Check Valve
Indication that the fire check valve switch is ok.

Vent Pilot Flame
Indication that the vent pilot flame safety is OK. This flame must be present during the mixing system operation.

Process Control Alarm Status

Dew Point Deviation
Indication that dew point is outside the deviation band for more than the alarm delay period.

Dew Point Sensor Signal
Indication that the dew point signal is below 300mV or above 1249 mV.

Dew Point Sensor Temperature
Indication that the probe temperature is below 1100F or above 2000F

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Mixing System Alarm Status

Air / Gas Sensor Signal
Indication that air or gas sensor is outside normal 4-20mA range

Ratio Deviation
Indication that air/gas ratio is outside the deviation band for more than the alarm delay period.

High Ratio
Indication that air/gas ratio is above the high ratio alarm setpoint for more than the alarm delay period.

Endo Flow Low / High
Indication that calculated endo gas flow is below or above the alarm setpoint for more than the alarm delay period.

EndoInjector™ Blower
Indication that the blower is not in operation.

Pressure Deviation
Indication that pressure is outside the deviation band for more than the alarm delay period.

Combustion Blower Overload
Indication that combustion blower is not in operation due to motor amperage overload.

Retort(s) Alarm Status

Over Temperature
Indication that the over temperature controller for that retort is tripped open.

Low Temperature
Indication that temperature of the retort is below the low temperature alarm setpoint.

Temp Deviation
Indication that temperature of the retort is outside the deviation band for more than the alarm delay period.

Flame Sense
Indication that flame safety for the retort does not sense a flame or pilot flame present

Inlet Valve
Indication that inlet valve is open when the temperature is below the low temperature alarm setpoint.

Vent Valve
Indication that the outlet valve is not in the vent mode before system startup.

Cooling System
Indication that the cooling system for the retort is not operational.

Output Temperature
Indication that endothermic gas temperature is above the endo temp alarm setpoint. This is an indication that the cooler may not be in operation or requires maintenance..

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4.0 Generator Operating Procedures

The EndoFlex™ endothermic gas generator is fitted with the latest technology to provide feedback to the operator regarding all critical system variables. Review the HMI Software Overview section of this manual and navigate through the different screens to become familiar with where critical information and alarm history will be located prior to operating the generator. Refer to the pipeline diagram for additional help locating any components detailed in the procedures below.

4.1 Generator Startup Procedure

1. Heat Up the Generator to Operating Temperature (1850-1950degF)
   a. Turn on the main power disconnect and confirm the "Control Power" green light is illuminated
   b. Silence and acknowledge any alarm horn that has occurred during the power up sequence.
   c. Press the "Reset" button on the Temperature Limit Controller(s) located above the HMI
   d. Using the HMI, set the desired temperature set point for each module.
      [Note: if this is from a "cold" state, it is recommended to set the initial temperature set point to 1000degF and allow to reach and soak at this temperature for 30 minutes before raising to the desired operating temperature (1850degF)]
   e. Start the Combustion Air Blower by pressing the "Start Combustion Air Blower" button located on the control enclosure and confirm that the "Combustion Air On" green light is illuminated (2-4 second delay).
   f. Open the main gas supply manual valves (V001, V002)
   g. Confirm the incoming gas pressure is at 14"wcg on the pressure gauge (G001) and adjust the main gas supply regulator (R001) if required.
   h. Open the burner gas supply valve for the ReactionCore™ module that will be heated.
      Module#1 Valve: V100, Module#2 Valve: V200
   i. Turn the Retort Selection switch located on the front of the control enclosure for one (or both) of the ReactionCore™ modules to "HEAT"
   j. After 2.5minutes of purge time the burner will attempt to automatically ignite. A successful ignition will be indicated by the "Flame On" green light being illuminated on the front of the control enclosure. (Note: the purge timer can be seen if desired by watching the display located on the Honeywell flame safety relay inside the control enclosure. It may be necessary, if the burners are not tuned correctly, that the "reset" button on this relay may have to be manual pressed to initiate another purge sequence after a failed ignition attempt).
   k. Wait for the temperature to reach the desired operating temperature (1850-1950degF).

2. Start Making Endothermic Gas
   a. Ensure the temperature of at least one ReactionCore™ module is at operating temperature (1850-1950degF).
   b. Open the Reaction Gas Manual Valve (V004)
   c. Open the Retort inlet manifold valves for the ReactionCore™ module that is at operating temperature. [Note: if any retort tubes are missing, the retort inlet manifold valve for that retort should be locked in the closed position until the retort tubes are replaced]
      Module#1: V104, V105, V106, V107
      Module#2: V204, V205, V206, V207
   d. Ensure that the endothermic output valve for the ReactionCore™ module is open
      Module #1: V108, Module #2: V208
   e. It is recommended that the manual valve that feeds the endothermic gas from the ReactionCore™ to the furnace should be closed during initial production of endothermic gas.
      Module #1: V110, Module #2: V210
   f. Turn on the Vent Pilot burner by opening the vent pilot gas manual valve (V003) and turning the Vent Pilot switch to "Enable" on the front of the control enclosure and ensure the Vent Pilot On light is illuminated.
   g. Confirm on the HMI that the ReactionCore™ being started is in "VENT MODE"
   h. Confirm on the HMI the desired Endothermic Gas output pressure and dew point set points.
   i. Turn the Retort Selection switch located on the front of the control enclosure for any ReactionCore™ that is at operating temperature from "HEAT" to "ENDO".
   j. The "EndoInjector™ Ready" light should illuminate at this time.
   k. Press the "EndoInjector Start" button to begin making endothermic gas and watch the HMI to confirm the air and gas flow rates are contolling to the desired ratio
      [Note: the Vent Flow Control Valve (V006) should be set to provide approximately 1500-2000CFH of endothermic gas flow to the burnoff vent. This vent will automatically stop when the furnace demand is sufficient to ensure proper reaction control through the mixing system.]
   l. Allow 20-45 minutes for the dew point to achieve desired set point (2-3 initial oscillations is normal)
   m. When the furnaces are ready for endothermic gas, change the ReactionCore™ from "Vent Mode" to "Enabled" using the HMI and then open the manual valves that provides endothermic gas to furnaces (V110, V210, and V007).

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4.2 Generator Shutdown Procedure

1. Stop Making Endothermic Gas
   a. Change the ReactionCore™ from "Enabled" to "Vent Mode" using the HMI and then close the manual valves that provides endothermic gas to furnaces (V110, V210, and V007).
   b. Press the "EndoInjector Stop" button to stop producing Endothermic Gas
   c. Turn the Retort Selection switch located on the front of the control enclosure for any ReactionCore™ that was producing endothermic gas from "ENDO" to "HEAT" (or directly to "OFF" if desired).
   d. Turn off the Vent Pilot burner by turning the Vent Pilot switch to "OFF" on the front of the control enclosure and closing the vent pilot gas manual valve (V003).
   e. Close the Reaction Gas Manual Valve (V004)

2. Turn off the Heat
   a. Turn the Retort Selection switch located on the front of the control enclosure for both of the ReactionCore™ modules to "OFF"
   b. Close the burner gas supply valve for the ReactionCore™ modules
      Module#1 Valve: V100, Module#2 Valve: V200
   c. Close the main gas supply manual valves (V001, V002)
   d. Stop the Combustion Air Blower by pressing the "Stop Combustion Air Blower" button located on the control enclosure.
   e. It is now safe to turn off the main power disconnect for the generator.

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5.0 Maintenance

The EndoFlex™ endothermic gas generator is fitted with many sensors and alarm messages to help troubleshoot most generator issues and is designed to be as easy to maintain as possible.

5.1 Preventative Maintenance

The following is a list of recommended preventative maintenance that should be performed on the generator at prescribed intervals.

5.1.1 Filter Check (Frequency: Weekly)

a. Reaction Mixing System Intake Air Filter
   The intake air filter is the main item of concern that must be checked regularly and changed preemptively to ensure that the blower motor is not overheated or damaged. Atmosphere Engineering installs a filter change indicator next to the intake air filter that should be inspected weekly and when the filter change indicator reaches the "RED ZONE" then the filter element should be removed, blown off/cleaned, and then replaced. After resetting the filter change indicator, continue to watch the filter change indicator. If the filter change indicator reaches the "RED ZONE" again then the filter element should be changed. Filter change times will range between monthly to every 6 months depending on the air quality in the room where the EndoInjector is located. In some circumstances, it may be advisable to pipe the incoming air from a separate location.

b. Combustion Air Intake Filter
   The intake air filter is the main item of concern on the combustion system. The filter should be checked weekly (or at least as often as other combustion air intake filters located within the same location as this equipment and cleaned/changed as necessary.

c. Endothermic Gas Cooling Air Filter
   Each ReactionCore™ is fitted with an SBS cooler that requires a "box filter" to keep debris from building up on the exterior surfaces of the cooling tubes. This filter should be checked weekly and cleaned / changed as necessary.

5.1.2 Generator Catalyst Burnout Procedure (Frequency: Scheduled based on %CH4)

Important: There has been a "history" of burning generators out on a regular interval (weekly, monthly). However, it is strongly recommended to only burnout generator catalyst when the percentage of unreacted methane is unacceptably high (0.25 to 1.0%). The EndoFlex™ is fitted with CH4 sensors for each ReactionCore™. Performing a burn out a generator that does not require it can significantly reduce the life of the catalyst and retort.

1. Each ReactionCore™ can be "burned out" independently while the other is still producing endothermic gas. The only pre-requisite is that the burner should already be ignited for the desired module to be burned out.
   a. Open the Burnout Air manual isolation valve for the module to be burned out (Module#1: V103, Module#2 V203)
   b. Open the Burnout Air control valve (two full turns from closed)
   c. Close the ReactionCore™ to furnace manual valve (Module#1: V110, Module#2: V210)
   d. On the HMI, navigate to "Setup>>Login>>Burnout"
      i. Set the Desired Burnout Temperature to "1500degF"
      ii. Set the Desired Time to "20 minutes"
      iii. Set the Minimum Temp: 1450degF
      iv. Set the Max Temp: 1550degF
   e. Press the "Start Burnout" for the ReactionCore™ that will be burned out. (A small flame in the vent burnoff will be seen for about 5 minutes (assuming the other ReactionCore™ is either off or is online to the furnaces).

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5.1.3 Burner Tuning (Frequency: Monthly)
Each ReactionCore™ is fitted with a high efficiency combustion burner. The burner is tuned using a ratio regulator and flow limiting valves located on the back of each ReactionCore™ module. In addition, a stainless steel sample tube is provided (located 6 inches above thermocouple well) to sample the combustion products and confirm optimal air/fuel ratio. It is recommended to maintain the burners between 2-8% excess oxygen in the combustion products. This can be tuned using the following procedure:

At 100% output (course adjustment):

a. The combustion air differential pressure at the burner should be set to 2.1"wcd using the air limiting valve (V102, V202)
b. The fuel gas differential pressure at the burner should be set to 1.7"wcd using the gas limiting valve (V101, V201)
c. Fine adjustment can be made using a oxygen sensor taking a sample of the combustion products and then modulating the gas limiting valve to achieve the desired residual oxygen level. (2-8% oxygen)

At 15% output (course adjustment):

a. Using the ratio control regulator, make adjustment as required using a oxygen sensor taking a sample of the combustion products and then modulating the ratio regulator to achieve the desired residual oxygen level. (2-8% oxygen)
[Note: it is found that a richer mixture (lower oxygen level) at low output levels provides more reliable ignition at lower temperatures]

5.2 Catalyst Change (Frequency: Annually or as required based on unreacted %CH4)
Each ReactionCore™ is comprised of twelve (12) 72" long retort tubes.
Each retort tube contains 12" of allumdum balls for pre-heating at the bottom of the retort
On top of the alumdum balls, is 48" of 11/16" cube nickel/alumina catalyst.

IMPORTANT: The generator must be cold (ambient) temperature before attempting to remove or change the catalyst. Changing the catalyst while the generator is hot can result in personnel injury and/or property damage.

1. Removal of Spent Catalyst
    a. Place large container or box under retort to be emptied
    b. Loosen Union at bottom of retort using pipe wrench
    c. When union is separated, the catalyst and alumdum balls will fall out of the retort.
    (If the catalyst is stuck it may be necessary to tap on the retort with a rubber mallet, however, care should be taken not to damage the retort using excessive force. In addition, it is possible to remove the header at the top of the retort and force a steal bar down the retort to loosen any debris stuck in the retort.)

2. Filling Retort with New Catalyst (Charging the Catalyst)
    a. Replace and tighten the union located at the bottom of the retort that has been emptied
    b. Remove the header above the retort that has been emptied of catalyst.
    c. Pour 12" of alumdum balls into the retort. Use a tape measure to confirm fill level.
    d. Pour 48" of high quality nickel/alumina catalyst into the retort. Use a tape measure to confirm fill level.
    e. Replace and tighten the header above the retort and secure header to endo "ring" using flange bolts and high temperature gasket.

5.3 Retort Replacement

1. Removal of a damaged retort
    a. Empty all catalyst from the retort to be changed (refer to "removal of spent catalyst" section)
    b. Remove the header above the retort to be changed
    c. Remove the U-Bolt retainer on the retort.
    d. Lift the retort out the top of the generator. (Each retort weighs 80 lbs)
2. Installing Replacement Retort
    a. Drop the new retort down through the empty retort location
    b. Install a U-Bold to secure the retort. (Note: it may be necessary to install some wood below the generator to hold the retort in place while securing the U-Bolt. Note: the retort height should be the same as the other retorts on the header.
    c. Tighten the Union located at the bottom of the retort.
    d. Fill the retort with alumdum balls and catalyst (reer to "Filling Retort with New Catalyst" section)
    e. Replace and tighten the header above the retort and secure header to endo "ring" using flange bolts and high temperature gasket.

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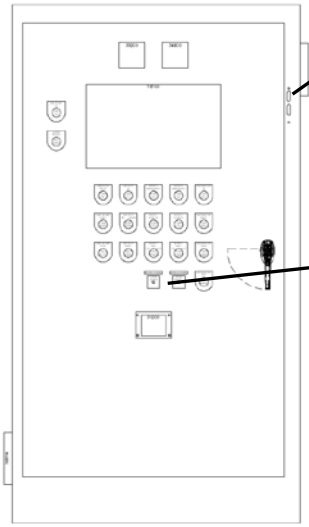
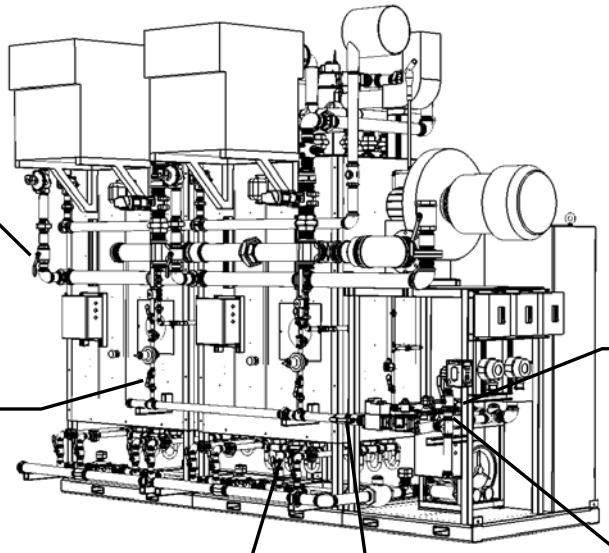
5.4 Critical Safety Lockout Locations

The EndoFlex™ is designed with lock out valves and power disconnects to provide safe "lockout / tagout" procedures. The following are some critical lockout components and their locations on the generator.



Main Power Disconnect
(Lockable)
Purpose: Disconnects all power from the main circuit breaker inside the control enclosure to all electrical components on the generator.

Retort Power Disconnects
(Lockable)
Purpose: Disconnects all electrical power from components located on the disconnected ReactionCore™ (retort) module.
Note: Heating chamber may still be hot due to residual temperature inside the chamber. DO NOT attempt to open the front door of a chamber whose temperature is not specifically known.



Endo to Furnace Isolation Manual Valve
(Lockable)
Purpose: Isolates module from endothermic gas within the pipeline going to the furnaces

Combustion Gas Manual Valves
(Lockable)
Purpose: Stops introduction of combustion gas to the burner of that module

Retort Manifold Manual Valves
(Lockable)
Stops introduction of pre-mix gas to the retorts within that module

Main Gas Supply Valve
(Lockable)
Turns off all hydrocarbon gas supply to the generator

Reaction Gas Supply Valve
(Lockable)
Turns off all hydrocarbon gas supply to the EndoInjector™ reaction mixing system

Combustion Gas Supply Valve
(Lockable)
Turns off all hydrocarbon gas supply to the combustion system

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