PINNACLE
OZONE SOLUTIONS, LLC

Modular Ozone Generator

OPERATIONS & MAINTENANCE

Manual

This manual contains important information regarding your **PINNACLE Ozone Generator**. Users & Operators should have a thorough understanding of the operating parameters unique to this equipment.

WARNING: Please read, understand, and follow all installation and operational parameters of the equipment before operating the equipment. Failure to do so may result in equipment damage and/or injury to personnel. **Only authorized personnel should operate this equipment.**

Please contact **PINNACLE OZONE SOLUTIONS, LLC** for any questions at 321-205-1717.

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1. PROJECT IDENTIFICATION

1.1 Customer ID

Project Name:	
Plant Name:	
Plant Address:	
Plant Contact:	
Telephone:	
Email:	

1.2 Equipment List

1.2.1 Ozone Generator

Generator Model:		**Qty QuadBlock®:**	
		QuadBlock® GEN:	
Qty supplied:			
Serial Numbers:	#	#	#
	#	#	#
	#	#	#
Delivery Date:			
Start-Up Date			
End of Warranty Date:			

2. SAFETY

2.1 General Precautions

Pinnacle Ozone Generators are designed to ensure the best guarantees of safety and efficiency in its intended use, on the condition that it is installed, commissioned, and serviced in compliance with the instructions given in this manual.

WARNING: Please read and thoroughly understand all installation, operational, and safety parameters listed in this manual. Improper operation can result in severe bodily injury, damage to the generator, or poor performance.

WARNING: Only authorized personnel should attempt the initial start up of the ozone generator. Failure to do so could damage to the equipment. Ozone generators are tuned at factory to achieve maximum efficiency.

Call Pinnacle Ozone Solutions, LLC for any questions at 321-205-1717.

WARNING: Pinnacle Ozone generators are sold for use in **industrial applications only**. Contact Pinnacle Ozone Solutions, LLC or an authorized Pinnacle Ozone representative before you use this unit for any medical application.

WARNING: Ozone (O3) is a toxic gas. High concentrations of Ozone are dangerous and harmful to humans. Take reasonable steps to avoid exposure.

- **PERMISSIBLE EXPOSURE LIMIT (PEL):** 0.1 PPM = maximum continuous ozone concentration to which an individual can be exposed to during a normal 8-hour day/40-hour work week without adverse effects.
- **SHORT TERM EXPOSURE LIMIT (STEL):** 0.3 ppm = maximum ozone concentration to which an individual can be exposed to during a 15-minute period, not to exceed 4 times during a normal 8-hour day/40-hour work week, without adverse effects.

Install appropriate safety monitoring equipment wherever high concentrations of Ozone are used. Use protective equipment such as a charcoal filled respirator when required.

FIRST AID: Move to fresh air. Get medical attention.

WARNING: Turn the ozone generator off if an ozone odor is detected in or around the cabinet. Check the cabinet for leaks and call manufacturer for service.

WARNING: The interior of the ozone generator enclosure contains electrical parts that can produce an electrical shock hazard if not handled properly. Only certified electrician or authorized personnel should open the ozone enclosure door.

WARNING: Do not use the main disconnect to control ozone production. Power to the unit must always remain on except for service or inactive. Only use the Human Machine Interface (HMI) touchscreen to turn system application areas on or off.

WARNING: A back flow protection device must be used on all water injection applications to prevent any possibility of water entering the generator.

WARNING: Materials in contact with high concentrations of Ozone should be suitable for such use. 316L Stainless and Teflon® are recommended. Failure to provide materials suitable for ozone service may result in equipment damage and/or unsafe working conditions.

WARNING: The ozone generator must be fed with oxygen gas that is ≥ 93% pure oxygen. DO NOT attempt to feed the equipment with clean dry AIR. Refer to all Original Equipment Manufacturer (OEM) manuals for maintenance of the oxygen supply equipment.

WARNING: Oxygen vigorously accelerates the burning of combustible materials. In an oxygen-enriched atmosphere, many materials that do not burn in normal air require only a slight spark or moderate heat to set them aflame.

To reduce the risk of fire or explosion, keep gasoline, kerosene, oil, grease, cotton fibers, wood, paint, and other combustible material away from all parts of the oxygen generator.

Do not allow smoking, open flame, or usage of electronic devices that may generate sparks within 15 m (50 feet) of any part of the oxygen generator.

WARNING: On systems using a Pressure Swing Adsorption (PSA) or Vacuum Swing Adsorption (VSA) oxygen concentrator, the oxygen flow rate must exceed the ratings of the oxygen equipment. Check the ozone equipment configuration to ensure these parameters are set and that the equipment will shutdown if these flow rates are exceeded.

WARNING: All oxygen piping and fittings must be cleaned and certified for oxygen service per the requirements of CGA 4.1-1985 prior to placing the ozone generator into operation. Failure to properly clean, inspect, and certify all piping and fittings in the oxygen system will void ozone generator warranty and/or performance guarantee.

WARNING: Use only PINNACLE recommended spare parts. Substitution parts could result in damage to the equipment, may create hazardous conditions and will void the warranty.

2.2 Ozone Generator Safety Features

2.2.1 Emergency Stop Button

A System Emergency Shutdown is initiated by pressing the emergency stop button on the front of the ozone generator enclosure. Removing power by turning off the main disconnect switch on the enclosure or in the room will perform an immediate shutdown. When an emergency shutdown is initiated, all ozone production is immediately stopped, all valves will close, and injection pumps are turned off.

To recover from an emergency shutdown, verify power is applied to the generator. Verify that the emergency stop button is inactive, reset all alarms, and press the start button. The system will automatically start at the last set dose level.

2.2.2 Door Safety Interlock

Pinnacle ozone generator enclosure include a door safety interlock prohibiting personnel to access inside the enclosure while the unit is powered.

Disconnect the unit from the mains/power supply before accessing the system cabinet and ensure that it cannot be reconnected, e.g. by fitting a padlock to the master switch.

WARNING: **Bypassing the door safety interlock is prohibited.**

WARNING: The interior of the ozone generator enclosure contains electrical parts that can produce an electrical shock hazard if not handled properly. Only certified electrician or authorized personnel should open the ozone enclosure door.

2.2.3 Enclosure Ambient O3 Analyzer

Pinnacle Ozone Generators are supplied standard with an ambient O3 analyzer installed inside the generator enclosure which monitors for potential ozone leaks.

WARNING: Enclosure Ambient O3 sensor is not intended for personnel safety but for leak detection only.

2.2.4 Water Sensor

The unit features an integrated water sensor within the bottom pan for water detection.

2.3 Ozone Safety Datasheet

2.3.1 Product Identification.

Product Name:	Ozone
Common name/Synonyms:	Triatomic Oxygen, Trioxygen, O3
Physical State:	Colorless Gas with Characteristic Odor
Molecular Formula:	O3
Molecular Weight:	48.0 g/mole
Ozone Generator Manufacturer/Supplier:	Pinnacle Ozone Solutions, LLC — 2971 Oxbow Circle, Suite A — Cocoa, FL 32926
Product Use:	This SDS is limited to ozone produced in gaseous form on site by an ozone generator, in varying concentrations in either air or aqueous solution, for the purposes of odor abatement, oxidation of organic compounds, or antimicrobial intervention, in a variety of applications, from food processing to ground water remediation. Ozone occurs naturally in the environment and ambient values range from 0.01 to 0.15 ppmv. Areas near arc welders have shown levels of 10.0 ppmv. Electrical equipment such as copying machines, motors and transformers can produce levels as high as 0.5 ppmv.

2.3.2 Hazard(s) identification

GHS Classifications		
Physical Hazards	**Health Hazards**	**Environmental Hazards**
Oxidizing Gas	Skin Irritation ***CATEGORY 3*** Eye Irritation ***CATEGORY 2B*** Respiratory Systemic Toxicity ***CATEGORY 1 (ACUTE & REPEATED EXPOSURES)***	Acute Aquatic Toxicity CATEGORY I

WARNING: Severe respiratory toxicity will develop before skin or eye irritation go beyond listed categories. Anyone with chronic pulmonary problems, especially asthma should avoid exposure to ozone.

WHMIS Classifications (Workplace Hazardous Materials Information System, Canada)		
D1A	**D2A**	**D2B**
Acute Lethality ***VERY TOXIC, IMMEDIATELY***	Chronic Toxicity ***VERY TOXIC***	Mutagenicity ***TOXIC***
C	F	
Oxidizing	Dangerously Reactive	

2.3.3 First-Aid Measures

Ozone is a powerful oxidizing agent and oxidation with ozone evolves more heat and usually starts at a lower temperature than oxidation with oxygen. It reacts with non-saturated organic compounds to produce ozonides, which are unstable and may decompose with explosive violence.

Ozone is an unstable gas which, at normal temperatures, decomposes to diatomic oxygen. At elevated temperatures and in the presence of certain catalysts such as hydrogen, iron, copper and chromium, this decomposition may be explosive.

Flash Point	Nonflammable
Auto Ignition	Nonflammable
Flammability	Nonflammable but vigorously supports combustion
Extinguishing Media	Depends on Source Media

2.3.4 Fire Fighting Measures

While ozone itself is not flammable, it is a strong oxidant and may accelerate, even initiate, combustion, or cause explosions. Use whatever extinguishing agents are indicated for burning materials.

2.3.5 Accidental release Measures

Turn off the generator and ventilate the area. Evacuate the area until ozone levels subside.

2.3.6 Handling and storage

Ozone must be contained within ozone-resistant tubing and pipes from the generation to the application point. Any leaks must be repaired before further use.

2.3.7 Exposure controls/Personal Protection

Exposure Controls/Personal Protection			
OSHA Permissible Exposure Limit	**ANSI/ASTM**	**ACGIH**	**NIOSH**
8 Hour Time Weighted Average 0.1 ppmv	8 Hour Time Weighted Average 0.1 ppmv — Short Term Exposure Limit 0.3 ppmv	8 Hour Time Weighted Average 0.1 ppmv — Short Term Exposure Limit 0.3 ppmv	Exposure Limit Ceiling Value 0.1 ppmv light; 0.08 ppmv moderate; 0.05 ppmv, heavy;
For light, moderate, heavy work; Time Weighted Average less than or equal to 2 hours is 0.2 ppmv		Immediately Dangerous to Life or Health 5 ppmv	

RESPIRATORY PROTECTION: Use full face self-contained breathing apparatus for entering areas with high concentration of ozone.

Engineering controls: use ozone destruct units (thermal and/or catalytic) for destruct of ozone off gas.

2.3.8 Physical and Chemical Properties

Physical & Chemical Properties		
Physical State	Gas	**pH**
Molecular Weight	48.0 g/mole	**Flash Point**
Appearance	Clear at low concentrations, blue at higher concentrations	**Evaporate Rate**
Odor	Distinctive pungent odor	**Flammability**
Odor Threshold	0.02 to 0.05 ppm, exposure desensitizes	**Explosive Limits**
Melting Point	-193°C/-315°F	**Relative Density**
Boiling Point	-112°C/-169°F	**Partition Coefficient**
Vapor Pressure	> 1 atm	**Auto-ignition Temperature**
Vapor Density	1.6 (air = 1)	**Decomposition Temperature**
Solubility in Water	36.25 mg/L - 10%wt @ 20°C	**Viscosity**

2.3.9 Stability and Radioactivity

Ozone is highly unstable and highly reactive. Avoid contact with oxidizable substances, including alkenes, benzene and other aromatic compounds, rubber, dicyanogen, bromine diethyl ether, dintrogen tetroxide, nitrogen trichloride, hydrogen bromide, and tetrafluorohydrazine.

Ozone will readily react and spontaneously decompose under normal ambient temperatures.

2.3.10 Toxicological Information

Toxicological Information	
Like Route of Exposure	Inhalation, Eyes, Skin Exposure.
Effects of Acute Exposure	Discomfort, including headache, coughing, dry throat, shortness of breath, heavy feeling in chest (including possible pulmonary edema/fluid in the lungs); Higher levels of exposure intensify symptoms. Irritation of skin and/or eyes is also possible.
Effects of Chronic Exposure	Similar to acute exposure effects, with possible development of chronic breathing disorders, including asthma.
Inhalation LC50	Mice, 12.6 ppm for 3 hours; Hamsters, 35.5 ppm for 3 hours

2.3.11 Ecological Information

The immediate surrounding area may be adversely affected by an ozone release, particularly plant life. Discharge of ozone in water solution would also be harmful to any aquatic life. Due to natural decomposition, bioaccumulation will not occur, and the area affected would be limited.

2.3.12 Disposal Considerations

Off-gassing of ozone should be through an ozone destruct unit which uses heat and/or a catalyst to accomplish the breakdown of ozone to oxygen before release into the atmosphere.

2.3.13 Transport Information

NOT APPLICABLE, as ozone is unstable and either reacts with other substances in the environment or decomposes, and therefore must be generated at the location and time of use.

2.3.14 Regulation Information

SARA = Superfund Amendments and Renewal Act		
SARA Title III Section 302	**SARA Title III Section 304**	**SARA Title III Section 313**
Extremely Hazardous Substance TPQ: 100 lbs.	EHS RQ: 100 lbs.	Ozone is reportable if more than 10,000 lbs. are used/year.
TPQ (Threshold Planning Quantity) requires emergency planning activities if this amount is on site at any time during year.	RQ (Reportable Quantity) requires any release of this amount into the environment to be reported to the National Response Center.	
Source: EPA List of Lists		

2.3.15 Other Information

The half-life of ozone is much shorter in water than in air. Increased temperature in either solvent decreases the half-life. Published research indicates a half-life of 20 minutes for ozone dissolved in water at 20°C, and a half-life of approximately 25 hours for ozone in dry air at 24°C (McClurkin & Maier, 2010). The practical half-life time is actually less, especially in air, due to air circulation, humidity, the presence of contaminants or walls with which to react, etc. In many situations, with air movement, warmer temperatures, and normal relative humidity, the half-life of ozone in air could be 1 hour or less. Further, ventilation of a closed space to other areas will also disperse the ozone, so that concentration levels can rapidly decrease after generation ceases.

Source websites:

Canadian Centre for Occupational Health and Safety: Chemical Profiles: Ozone
http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ozone/
Haz-Map: Occupational Exposure to Hazardous Agents: Ozone
http://hazmap.nlm.nih.gov/cgi-bin/hazmap_generic?tbl=TblAgents&id=68
International Chemical Safety Cards #0068: Ozone
http://www.cdc.gov/niosh/ipcsneng/neng0068.html
NIOSH Pocket Guide to Chemical Hazards: Ozone http://www.cdc.gov/niosh/npg/npgd0476.html
United States National Library of Medicine ChemIDplus Lite: Ozone 10028-15-6
http://chem.sis.nlm.nih.gov/chemidplus/ProxyServlet?objectHandle=DBMaint&actionHandle=default&nextPage=jsp/chemidlite/ResultScreen.jsp&TXTSUPERLISTID=0010028156.

DISCLAIMER:

Pinnacle Ozone Solutions, LLC provides this information in good faith, but makes no claim as to its comprehensiveness or accuracy. It is intended solely as a guide for the safe handling of the product by properly trained personnel, and makes no representations or warranties, express or implied, of the merchantability or fitness of the product for any purpose, and Pinnacle Ozone Solutions, LLC will not be responsible for any damages resulting from the use of, or reliance upon, this information.

2.4 CGA 4.1-1985, Cleaning of Equipment for Oxygen Service

2.4.1 Scope

This document outlines the procedure to be used for cleaning components, parts, and assemblies to be used in oxygen and/or ozone in oxygen service. Cleaning procedures are presented for both equipment fabrication and cleaning of finished parts/assemblies. Equipment and materials covered under this procedure include but are not limited to piping, tubing, fittings, valves, instruments, and related components.

2.4.2 Objective

The methods established in this procedure are developed to specifically comply with and satisfy the requirements established in CGA G-4.1-2009 (6th ed.) **"Cleaning Equipment for Oxygen Service"** as published by the Compressed Gas Association.

Equipment and/or materials used for oxygen and/or ozone in oxygen service must be adequately cleaned to remove potentially harmful contamination prior to the introduction of oxygen and/or ozone. Potentially harmful contaminant may include, but are not limited to, organic and/or inorganic materials such as oils, grease, paper, fiber, rags, wood, dust, debris, solvents, weld slag, rust, oxidation, sand, or dirt that might react with, oxidize, or combust in the presence of an atmosphere enriched with or primarily composed of oxygen and/or ozone.

The cleaning and inspection methods set forth in this document are intended to result in the degree of cleanliness required for the safe operation of oxygen and/or ozone service equipment. Cleaning procedures involve the removal of contaminants including surface residue from handling, manufacturing, hot work, assembly, cleaning, and use. Cleaning procedures, methods, and materials are specifically presented based on the type or work and type of contaminants expected to be present. Cleaning methods are intended to be employed singly and in combination as may be required throughout project construction, delivery, and service.

2.4.3 Planning Requirements

2.4.3.1 Planning & Supervision

A Cleaning Plan will be developed by a qualified individual thoroughly familiar with the requirements of this procedure prior to initiating any cleaning effort. The plan will identify the methods, materials, and requirements of the work to be completed. All cleaning will be performed by and/or under the supervision of persons properly trained and qualified under this procedure.

2.4.3.2 Fabrication Cleaning Procedures

The following cleaning procedures will be used for cleaning based on the expected type(s) of contaminants; component/material types; and venue in which cleaning is to be performed. Each Cleaning Sequence consists of a series of individual steps which is the combination of a Cleaning Method together with a Cleaning Agent. Details on Cleaning Methods and Cleaning Agents are provided in Section 4 and Section 5, respectively, of this document. Each sequence will be performed in the order listed.

Shop Fabricated Component Cleaning Sequence

Shop fabricated items shall be manufactured and cleaned as follows:

- *Stainless Steel Wire Wheel or Brush*
- *Isopropyl Alcohol Rinse/Swab*
- *Argon Gas Purged Welding*
- *Glass-Bead Blast*
- *Acid Cleaning Bath*
- *Blue-Gold Cleaner Bath or Rinse/Swab*
- *Water Rinse/Flush*
- *Drying & Purging*
- *Sealing, Tagging, Bagging & Storage*

Field Fabricated Component Cleaning Sequence

Field fabricated items shall be manufactured and cleaned as follows:

- *Stainless Steel Wire Wheel or Brush*
- *Isopropyl Alcohol Rinse/Swab*
- *Argon Gas Purged Welding*
- *Acid Rinse/Swab*
- *Blue-Gold Cleaner Rinse/Swab*
- *Water Rinse*
- *Drying & Purging*
- *Sealing, Tagging, Bagging & Storage*

Component or Assembly Cleaning Sequence

Components or assemblies that are to be placed in oxygen service will be cleaned as listed below. The selection of specific cleaning techniques (immersion bath vs rinse vs swab) will be made based on the practical limitations of venue, size, and geometry of the components/assemblies to be cleaned. Such components and/or assemblies may include but are not limited to valves, non-weld fittings, instruments, manifolds, piping, etc.

- Blue-Gold Cleaner Bath/Rinse/Swab
- Water Rinse
- Elastomer Lubrication
- Drying & Purging
- Sealing, Tagging, Bagging & Storage

2.4.4 1.4Cleaning Methods

2.4.4.1 Stainless Steel Wire Wheel or Brush

The cut ends of stainless-steel tubing, piping, or fittings to be joined by welding will be thoroughly cleaned using a 304 stainless steel wire wheel or brush to remove all burrs, cuttings, sharp edges, or debris to produce a visually uniform polish across the entire joining surface. Brushed parts will be wiped free of dust using a clean dry cloth.

2.4.4.2 Cleaner Bath

The Cleaner Bath Method will be performed with the specific Cleaning Agent listed in the sequence. For parts whose size and geometry permit, cleaning is best accomplished by completely immersing the entire part (or as much of the entire part or assembly as possible) into a container of cleaning solution. Once immersed, the part will be allowed to soak with occasional agitation for a minimum of ten (10) minutes. Where component size or geometry requires successive immersion for full coverage, each successive immersion will overlap a previously immersed section. At the completion of the cleaning bath, free cleaning solution will be drained or wiped from the part or assembly prior to subsequent cleaning steps. Cleaning bath solution will be periodically checked for cleanliness and /or regularly replaced or replenished to maintain cleaning efficacy.

2.4.4.3 Cleaner Flushing

Cleaner Flushing Method will be performed with the specific Cleaning Agent listed in the sequence. Flushing will be performed by passing a continuous heavy stream of fluid across the surface of a component for a minimum of ten (10) minutes. “Circulation Loop” cleaning of some assemblies may require up to sixty (60) minutes of uninterrupted cleaning fluid flushing through the part. The required cleaning time will determine by the Cleaning Supervisor based on project conditions and periodic visual inspection of the cleaning process. The continuous cleaning stream will (typically) be produced by pumping the cleaning solution in a closed circuit (loop) across a holding tank. Pumped cleaning solution will be filtered via an in-line 25 µm (max) pleated cartridge filter in the pumping and/or return loop. Flushing solution will be periodically checked for cleanliness and/or regularly replaced or replenished to maintain cleaning efficacy.

2.4.4.4 Cleaner Rinsing

Cleaner Rinsing will be performed with the specific Cleaning Agent listed in the sequence. Rinsing will be performed by pouring a continuous stream of cleaning solution across the entire surface of the component to be cleaned. The rinse should result in a continuous sheet of fluid of approximately uniform thickness across the entire surface of the part to be cleaned. Depending on the size and geometry of the component, the rinse may be accomplished using either a squeeze bottle or by slowly pouring cleaning solution directly over the component. Rinse solution may be captured and reused as appropriate for the cleaning operation. Reused rinse solution will be periodically checked for cleanliness and/or regularly replaced or replenished to maintain cleaning efficacy.

2.4.4.5 Swabbing & Wiping

Swabbing or Wiping Methods will be performed with the specific Cleaning Agent listed in the sequence. Swabbing or wiping may be required to remove surface deposits and/or assure all areas of a part are cleaned. Swabbing or wiping will be performed by saturating a clean cloth with cleaning solution and removing excess fluids to minimize excessive dripping or running.

Swabbing will be performed by attaching the saturated cleaning cloth to a clean, rigid, non-reactive, support material such as structure such as a wood dowel, plastic rod, or stainless-steel bar stock. The swab will be passed over or through the part to be cleaned in a single direction using uniform force and speed. The used swab will be visually inspected to determine if cleaning has been achieved. Cleaning is achieved when three (3) successive swaps show no visual evidence of further contaminant removal. Swabs must be washed/rinsed and re-saturated prior to reuse.

Wiping be performed by manually passing the saturated cleaning cloth across the surface to be cleaned in a single direction using uniform application force and speed. The used wipe will be visually inspected to determine cleaning has been achieved. Cleaning is achieved when three (3) successive swaps show no visual evidence of further contaminant removal. Wipes must be washed/rinsed and re-saturated prior to reuse.

2.4.4.6 Water Rinsing

Upon completion of cleaner processing, all parts will be thoroughly rinsed with water to remove remaining cleaning solution. Water rinse will by immersing, flushing/circulating, or rinsing cleaned parts with a continuous flow of clean water for a minimum of five (5) minutes. Rinse water will be minimum potable (tap) quality, with deionized (DI) or distilled water preferred if available. Rinse water should not be reused unless two or more successive rinse bath steps are in place.

2.4.4.7 Argon Gas Purged Welding

Welding of components for oxygen service will be performed under a continuous purge of argon gas. Parts to be joined will precleaned and arranged in the final configuration before welding. One end of the assembly will be plugged and connected to a source of argon purge gas. The opposite end(s) of the assembly will remain open to atmosphere or connected to vacuum. Flow of argon gas will then be introduced into the assembly to maintain a continuous flow and pressure of purge gas. A minimum of three (3) purge volumes will be passed through the assembly prior to welding. A continuous uninterrupted flow of purge gas will be maintained through the assembly throughout all tack and finish welding operations until all completed welds have cooled to the touch.

2.4.4.8 Glass Bead Blast

All parts where surface oxidation or weld slag may be present will be glass bead blasted. Blasting will be performed using clean inert glass bead blast media suitable for the level of surface cleaning required. Blast media that has been exposed to oxidizable materials or other contaminants (carbon steel, rust, etc) will not be reused.

2.4.4.9 Drying

Cleaned parts will be thoroughly dried after all cleaning procedures. Depending on the venue and facilities available, drying may be accomplished by any one or combination of the following:

- **Wiping:** Excess cleaning fluid can be removed from cleaned surfaces by absorbing directly onto clean, dry, lint-free cloth or paper towels. Wiping is typically only used as the first step of a process that combines air, compressed air, or oxygen drying as described below.
- **Compressed Nitrogen Drying:** The preferred method of parts trying is accomplished by passing a continuous stream of clean, dry, oil-free, compressed nitrogen (N2) gas across cleaned surfaces for a minimum of five (5) minutes or until twenty-five (25) components volumes of air have been exchanged.

2.4.4.10 Oxygen Drying/Purging

All final assemblies will be purged by maintaining continuous uniform pressure and flow of clean, dry oxygen gas in a single direction through the completed assembly for a minimum of fifteen (15) minutes. Where practical, the inlet and outlet dewpoint of the oxygen purge process will be monitored throughout the purge process.

2.4.4.11 Elastomer Lubrication

All elastomers to be used in oxygen service will be lubricated per manufacturer's recommendations with an oxygen-duty compatible lubricant prior to final assembly or being placed into service.

2.4.4.12 Tagging

All parts, components, or assemblies cleaned for oxygen service will be tagged per the requirements of Section 6.4.

2.4.4.13 Sealing, Bagging & Storage

All parts, components, or assemblies cleaned for oxygen service must be properly plugged, sealed, and/or bagged to prevent recontamination. Acceptable sealing and plugging materials include clean, dry, and debris (lint) free paper, cloth, metal, or plastic, as may be required by component size and geometry. Components will be bagged in clean, dry, unused clear or colored plastic bags. Bags will be securely taped shut to prevent exposure. Double bagging is encouraged for components that will be shipped or experience a high degree of handling. Where bagging is impractical, parts will be tightly wrapped in 4 mil (or heavier) polyethylene sheeting, which is thoroughly secured with 2" waterproof cloth tape.

Bags or sealed items should only be removed immediately prior to a component being installed or placed into service. Cleaned components that will be immediately placed into service do not require sealing or bagging.

2.4.5 Cleaning Agents

2.4.5.1 Blast Media

Blast media will be manufactured from lead-free, soda-lime glass containing no free silica. Blast media will produce a clean, bright, satin finish without dimensional change to any parts.

2.4.5.2 Stainless Steel Wire Wheel or Brush

All brushing and surface cleaning of oxygen service components will use wire wheel or wire brushes of 304SS bristle and non-reactive body construction. Brass, nylon, carbon steel and/or other types of abrasives are not permitted.

2.4.5.3 Acid Cleaning Solution

Acid cleaning solution will be CitriSurf® 2050 citric acid cleaning and passivating solution, or equal. See attached MSDS. Citric acid solution should be used at ambient temperature.

2.4.5.4 Blue-Gold Cleaner

Cleaning solution will be BlueGold® Industrial Cleaner / Degreaser or equal. BlueGold cleaning solution will be diluted at a cleaner to potable water ratio of 12:1 prior to use. Wherever practical, cleaner solution should be diluted with warm water to maintain a cleaning temperature of 130 - 160 °F (55 - 70 °C).

2.4.5.5 Isopropyl Alcohol

Isopropyl alcohol cleaning solution will be 100% isopropyl alcohol.

2.4.5.6 Water

At a minimum, water will be clean ambient temperature potable (tap) water. Potable water will frequently leave "water spots" are rinsing and drying. These inert mineral deposits are the result of hardness and other minerals in the water, are typically harmless in contact with oxygen, and are acceptable in the cleaning process.

2.4.5.7 Tanks and Containers

Tanks and containers used for cleaning shall be clean, non-reactive polyethylene, polypropylene, PVC, glass, or stainless steel.

2.4.5.8 Cloths & Towels

Cloth or towels will be clean, un-dyed, lint-free cotton cloth or rags. New, clean, lint-free paper towels are also acceptable.

2.4.5.9 Oxygen Service Lubricant

Oxygen service lubricant will be DuPont™ Krytox® Performance Lubricant, or equal.

2.4.6 Inspection & Record Keeping

2.4.6.1 Checking Solvent Cleanliness

The cleanliness of cleaning fluids and solvents currently in use will be periodically checked by direct visual comparison to a reference standard of unused solvent. Used solvents exhibiting a significant deterioration in color and/or clarity should be replenished or replaced.

2.4.6.2 Cleaning Inspection

The Cleaning Supervisor will thoroughly inspect all parts before, during and after the cleaning process. Due to the variability in site conditions, component geometry, and cleaning requirements, the Supervisor has the authority to decide on which inspection methods will be used for each cleaning effort.

Direct Visual Inspection (White Light)

The most common test used to detect the cleanliness of cleaned parts is direct unmagnified visual inspection under strong, direct white (daylight balanced) light. Such inspection can detect the presence of particulate matter in excess of 50 µm, along with the presence of moisture, oils, grease, etc. Cleaning is achieved direct visual inspection shows evidence of further contaminants. Items having passed visual inspection will be deemed "Cleaned and Ready for Oxygen Service" under the requirements of this procedure. Items not passing visual inspection should be re-cleaned.

Ultraviolet Light Visual Inspection (Black Light)

Many common hydrocarbons, organic oils, grease, and inorganic contaminant fluoresce when exposed to ultraviolet light with wavelengths between 2,500-3,700 Å (angstrom), commonly called "black light". UV or Black Light inspection will occur by exposing cleaned surfaces to a stationary or handheld UV inspection lamp in a darkened room. Where UV light inspection is used, parts should be inspected both before and after cleaning to ensure visible contaminants are identified and removed. Cleaning is achieved when UV light inspection shows that all originally present contaminants have been removed. Items having passed visual inspection will be deemed "Cleaned and Ready for Oxygen Service" under the requirements of this procedure. Items not passing visual inspection should be re-cleaned.

Wipe Test Inspection

The size and geometry of many parts will limit inspection by direct or UV light. In such case a wipe test will be performed to determine the cleanliness of cleaned parts. Wipe testing will be accomplished by passing a clean, dry, lint-free cloth across the cleaned surface. Cleaning is achieved when the cloth shows no visible signs of remaining contaminants when inspected under UV and/or white light. Items having passed visual inspection will be deemed "Cleaned and Ready for Oxygen Service" under the requirements of this procedure. Items not passing visual inspection should be re-cleaned.

2.4.6.3 Record Keeping

Records of the following information, as applicable, will be prepared and kept on file for all parts, components, or assemblies cleaned for oxygen service. For large assemblies, final certification may be provided on the entire complete assembly rather than on individual components.

a. Part or PID Tag Number:
b. Part Description:
c. Serial Number:
d. Project, Invoice or Other Identification:
e. Cleaning Specification Used:
f. Cleaning Technician:
g. Cleaning Date:
h. Inspection Date:
i. Inspection Results: (Passed)
j. Inspector Name/Initials:

2.4.6.4 Tagging & Labeling

Cleaned parts and components will be tagged and labeled as described below. Tags shall be of a sturdy paper cardstock or plastic label material with text in indelible ink. Tags will be affixed using study string, wire, elastomeric band, removable adhesive (tape) in such a manner as to best prevent tag detachment during handling or contamination of the parts prior to use.

TAG CONTENT:

CLEANED FOR OXYGEN SERVICE
DO NOT OPEN UNTIL READY TO USE

Part or PID No: _____
Date Of Cleaning: _____
Inspected By: _____

2.4.7 Safety & Training

2.4.7.1 Personnel Training & Supervision

All personnel required to perform cleaning of equipment for oxygen service will be trained in and thoroughly familiar with the Scope, Objectives, Methods, Materials, and Procedures outlined in this procedure.

Cleaning operations should be overseen and supervised by an individual thoroughly familiar with and experienced in the cleaning requirements established herein. Unless otherwise required, the Cleaning Supervisor will serve as the Inspector for all cleaning operations.

All properly trained personnel may concurrently serve multiple roles in the cleaning process as may be required or appropriate for the cleaning operation, tasks, or project conditions at hand.

2.4.7.2 Personnel Safety

All personnel will be trained in the proper selection and use of Personal Protective Equipment (PPE) to be used at all times in all cleaning procedures. At a minimum, the required PPE for all cleaning activities shall be safety glasses and splash resistant clothing. Additional required PPE will be determined based on the specific MSDS requirements of any cleaning chemicals in used and/or the needs of the working environment.

Similarly, all personnel will be trained in the proper handling and disposal of all spent cleaning chemicals or materials, as listed in the MSDS. To the maximum extent practicable, all cleaning chemicals and materials shall be biodegradable, renewable, and/or recyclable to maximize safety and minimize impact to the environment.

2.4.7.3 Cleaning Conditions

All cleaning activities should be conducted in a clean, well lighted, well ventilated, and safe environment. The cleaning personnel and/or supervisor should evaluate each cleaning environment to identify and prevent potentially hazardous working conditions. Typical hazardous working conditions may include, but are not limited to spill/slip/fall hazards, electrical hazards, fire and/or explosion hazards, hot work hazards, hazardous atmospheric conditions, confined spaces, uncontrolled release of energy hazards, specialized PPE requirements, etc. Where required, additional safety procedures as may be outlined in the General Heath & Safety Plan (HASP) should be employed and are hereby incorporated by reference.

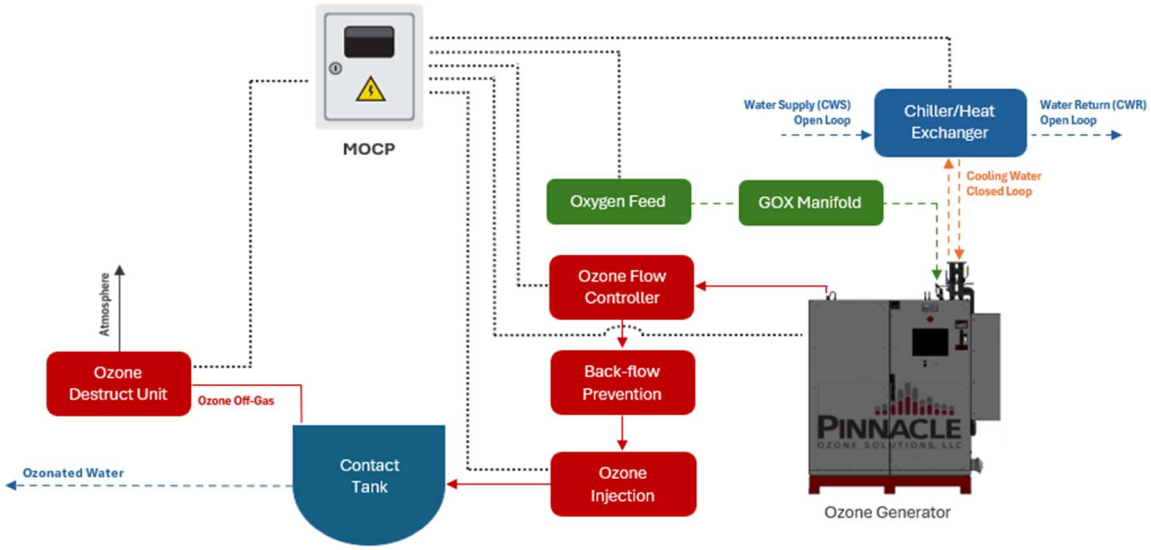
2.4.8 Reference Materials

Unless otherwise stated, the latest edition shall apply:

- Compressed Gas Association, “Cleaning Equipment for Oxygen Service”, CGA G-4.1-2009.
- Guardian Manufacturing Health & Safety Plan (HASP), 2012.

3. OZONE SYSTEM OVERVIEW

The basic elements of an ozone system include ozone generation, oxygen feed gas, ozone dissolution, and ozone off-gas destruction components. Instrumentation and controls will also ensure effective and safe operation of the system.



3.1 Ozone System - Main Components

3.1.1 Feed Gas System

Oxygen-fed ozone generators such as the Pinnacle generators convert oxygen from sources such as oxygen concentrators (PSA, VSA, VPSA) or liquid oxygen into ozone.

3.1.2 Ozone Generator

Ozone generator uses electrical discharge (Corona Discharge) to add energy to the oxygen molecules to splits O_2 into O_1 atoms. The freed oxygen atoms (O_1) then temporarily recombine with other oxygen molecules (O_2) forming ozone (O_3).

3.1.3 Cooling Water System

Ozone generators must be kept cool to efficiently produce ozone. This is generally achieved by using air or water to water chillers or heat exchanger through a closed loop cooling system.

3.1.4 Ozone Injection

- **Bubble Diffusers**: In this method, ozone gas is introduced into water through fine bubbles. The goal is to disperse ozone throughout the water, allowing it to react with impurities and pathogens.
- **Venturi Injectors:** Venturi injectors create a vacuum by forcing water through a constriction. Ozone gas is then drawn into the water stream due to the pressure difference.

3.1.5 Ozone Destruct System

Ozone is usually a small percentage of the total gas fed into the water. Therefore, the water must be degassed and the remaining ozone in the vent gas destroyed via an ozone destruct system.

3.1.6 Controls & Instrumentation:

Controls and instrumentation play a crucial role in ozone systems, ensuring their effective operation, safety, and optimal performance.

4. OZONE GENERATOR

4.1 General

The **Pinnacle Ozone Solutions, LLC** Modular Ozone Generators Series is a powerful family of ozone generators which can produce **up to 328.3 kg/d [723.7 ppd]** of ozone depending upon the selected configuration.

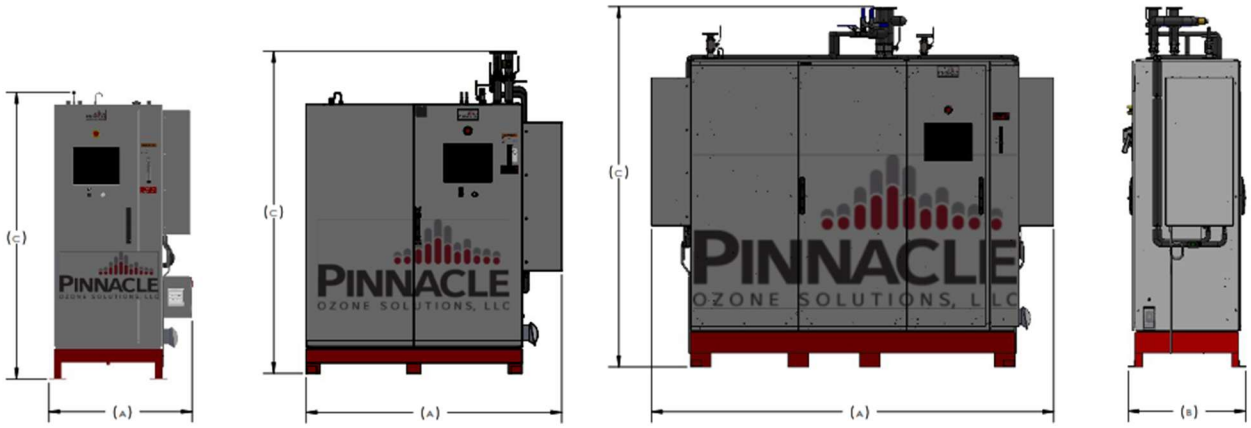
Each generator includes an internal Programmable Logic Controller (PLC) which operates the unit including startup and shutdown. Should a problem occur, the PLC software will process the issue and a fault alarm will be displayed in RED at the bottom of the HMI touchscreen.

4.2 Standard Features

- SCADA Interface: E/IP TCP (native), Hardware, all standard industrial protocols
- Enclosure: NEMA 12, Internally Cooled
- PLC Controller: Schneider Electric Modicon M251
- Operator Interface: 15" Color Touchscreen
- O2 Instrumentation: Inlet O2 Mass Flow, Pressure, and Purity (Dew Point for LOX-Fed Units)
- O3 Instrumentation: High-Range O3 Concentration
- O3 Ambient: Enclosure (Internal)
- Safety Rating UL508A Listed Electrical Panel

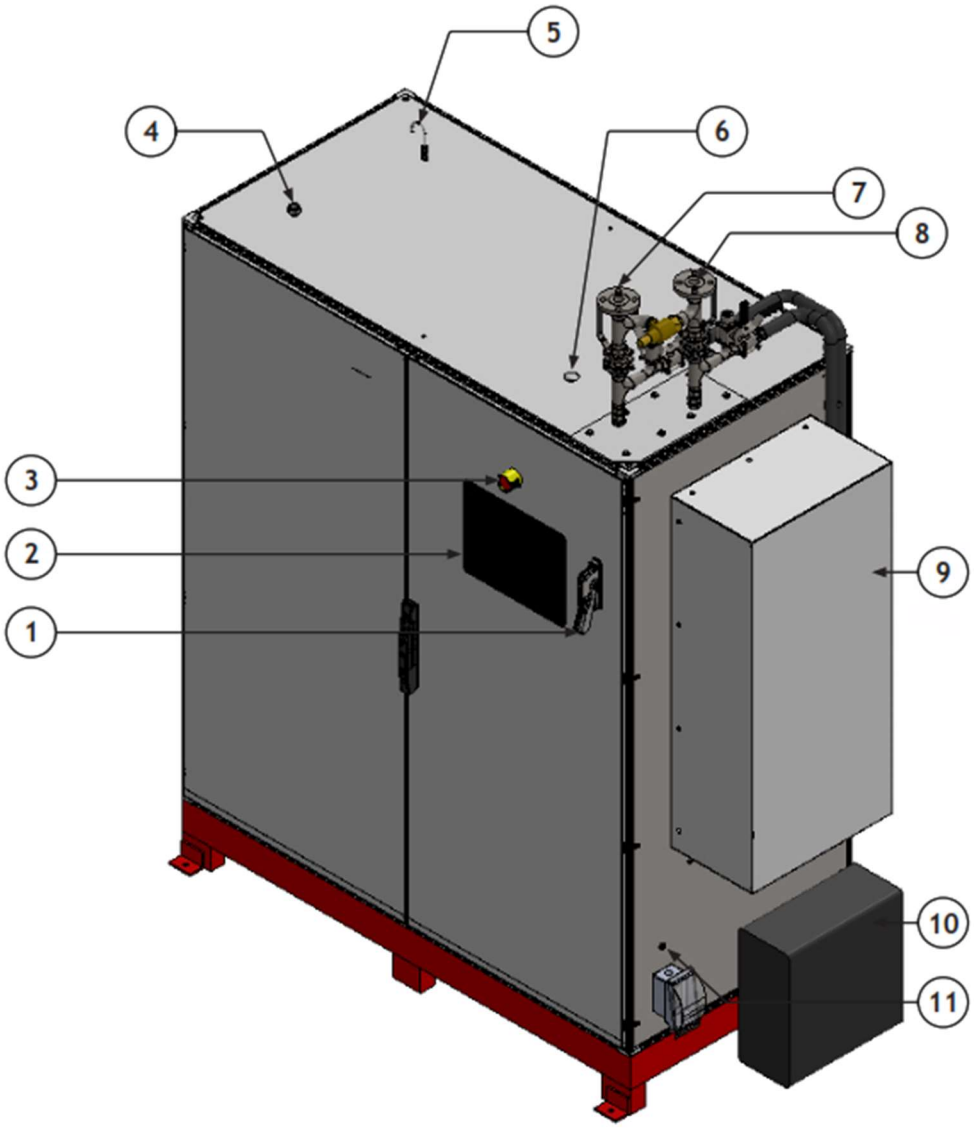
Figure 1. Front view of Ozone Generator

4.3 Specifications



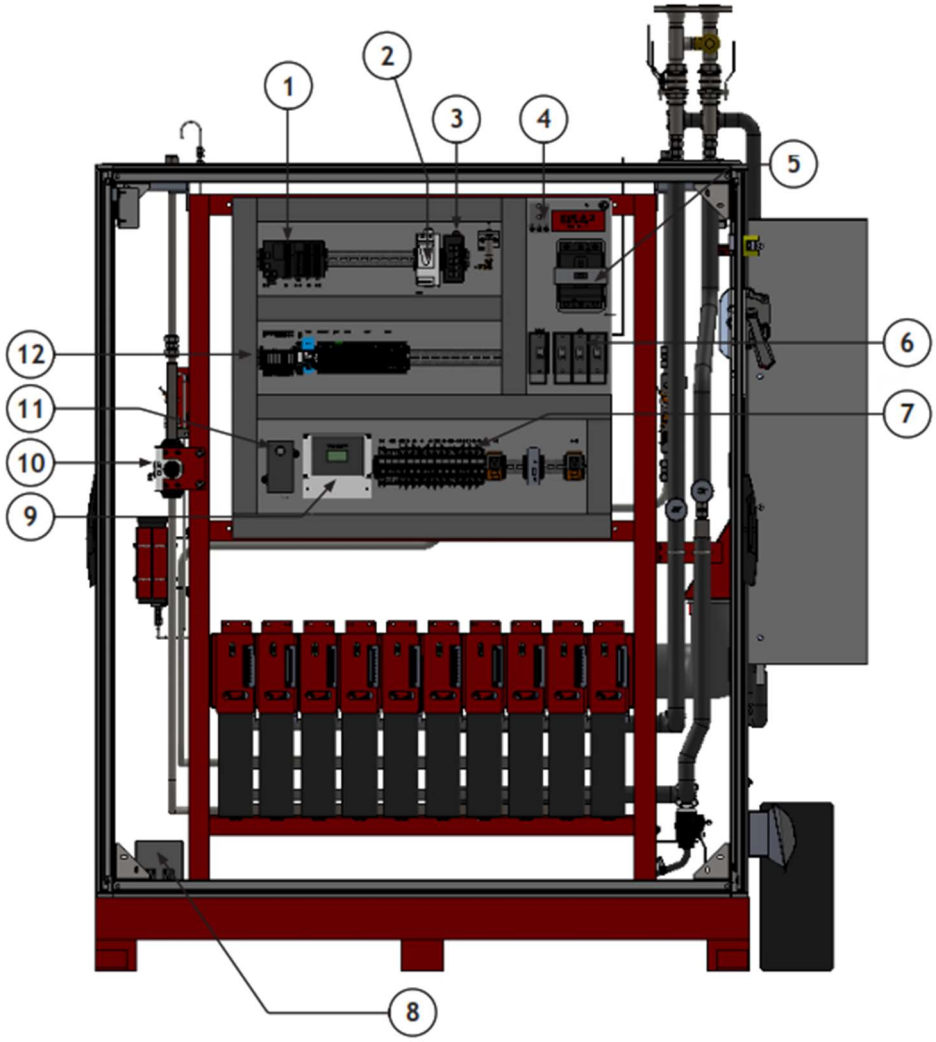
	Peak 5X	Summit 10X	Zenith 20X	Zenith 30X	Apex 36X
Concentration	6-20% BW				
Ozone output(LOX) kg/d @ 10% conc.	Up to 45.6	Up to 91.2 kg/d	Up to 182.4 kg/d	Up to 273.6 kg/d	Up to 328.3 kg/d
Ozone Output (V-PSA) kg/d @ 10% conc	Up to 38.4 kg/d	Up to 76.8 kg/d	Up to 153.6 kg/d	Up to 230.4 kg/d	Up to 276.5 kg/d
Electrical Service	208-230V/50-60hz/3ph/5W (step-down transformer included, shipped separately)				
Rated Amps	60A (35 FLA)	110A (79 FLA)	200A (156FLA)	300A (234FLA)	400A (327FLA)
Oxygen Requirements					
Oxygen Flow Rate	465 slpm	930 slpm	1860 slpm	2790 slpm	2790 slpm
LOX Oxygen Feed	Dew Point: <-35CTotal Hydrocarbons (as CH4) <15 ppm.				
V-PSA Oxygen feed	Oxygen concentration ≥ 93%				
Cooling Water Requirements					
Cooling Type	Closed-Loop Chilled Water				
Cooling Fluid	Food Grade Glycol-Water Blend (30/70 blend, not included)				
Cooling Water Flow	12 gpm (45.4 l/min)	20 gpm (75.7 l/min)	40 gpm (151.4 l/min)	55 gpm (208.1 l/min)	68 gpm (254.7 l/min)
Cooling Load	~4.25 ton	~8.5 ton	~19.7 ton	~25.0 ton	~33.0 ton
Cooling water temp.	45° - 80°F [7° - 26°C]				
Features					
Enclosure	NEMA 12, Internally Cooled (NEMA 4-4X available on request)				
Operator Interface	15" Red Lion HMI [Others available on request]				
PLC	Schneider Electric M251 PLC [Others available on request]				
Dimensions (A x B x C)					
Outline Dimensions Inches [mm]	42 x 37 x 83 [1067 x 933 x 2107]	75 x 32 x 93 [1895 x 800 x 2369]	111 x 34 x 94 [2820 x 864 x 2388]	111 x 34 x 94 [2820 x 864 x 2388]	111 x 32 x 103 [2820 x 800 x 2616]

4.4 Overall Layout



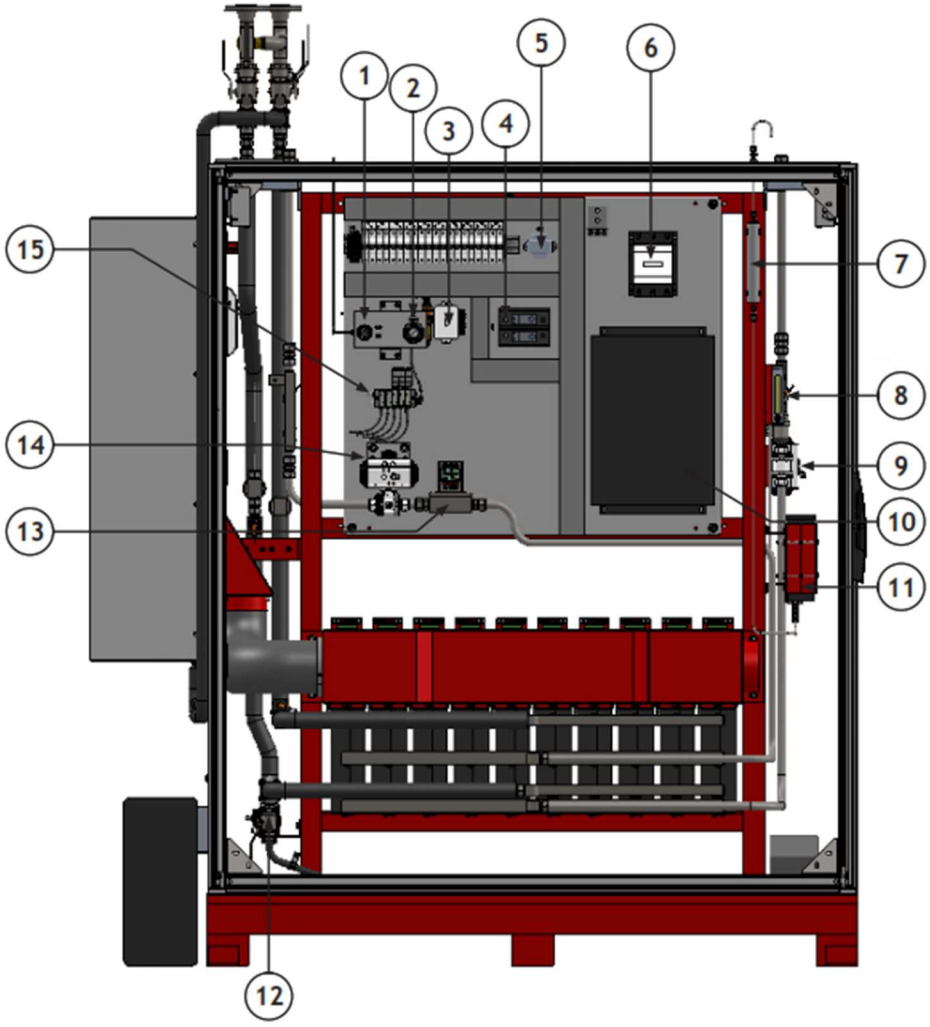
4.4.1 Ozone Generator Enclosure

NO.	DESCRIPTION	NO.	DESCRIPTION
1	Main Power Disconnect	7	Cooling Water Outlet
2	Operator Interface (HMI)	8	Cooling Water Inlet
3	Emergency Stop Button	9	Enclosure Heat Exchanger
4	Ozone Outlet	10	Compressor *(if applicable)*
5	Ambient Ozone Analyzer Destruct Outlet	11	Compressor Air Inlet
6	Electrical Service Entry		



4.4.2 Ozone Generator Enclosure – Front Interior

NO.	DESCRIPTION	NO.	DESCRIPTION
1	Programmable Logic Controller (PLC)	7	Breakers
2	24 VDC Power Supply	8	Uninterruptable Power Supply (UPS)
3	Ethernet Switch	9	Ambient Ozone Analyzer Monitor
4	Ground Power Distribution Block	10	Ozone Isolation Valve
5	Main Power Disconnect	11	Ozone Analyser Sensor
6	AC Power Distribution Block	12	Relays



4.4.3 Ozone Generator Enclosure – Back Interior

NO.	DESCRIPTION	NO.	DESCRIPTION
1	Compressed Air ON/OFF Switch	9	Ozone Isolation Valve
2	Compressed Air Pressure Regulator	10	QuadBlock® DC Converter Power Supply
3	Water Detection Controller	11	High Ozone Concentration Analyzer
4	DC Power Block	12	Drain Valve
5	Isolation Transformer	13	Oxygen Mass Flow Meter
6	HVDC Contactor	14	Oxygen Isolation Valve
7	Mini Destruct Unit (O_3 Analyzer)	15	Pneumatic Solenoid Valves
8	Ozone Flow Meter for O_3 Analyzer		

4.5 Connection Points

WARNING: Connections must be made prior to operating the ozone generator. Proceeding otherwise can result in severe bodily injury and damage to the generator.

4.5.1 Table 1: Ozone Generator Connection Points

Parameters	Nominal Operating Pressure	GENERATOR MODEL				
		Peak 5X™	Summit 10X™	Zenith 20X™	Zenith 30X™	Apex 36X™
Oxygen Inlet	**20 psig**	¾" Tube	¾" Tube	¾" Tube	1¼" Flange	1½" Flange
Ozone Outlet	**20 psig**	¾" Tube	¾" Tube	¾" Tube	1¼" Flange	1½" Flange
Cooling Water Supply	**35 psig**	¾" Tube	1" Flange	1¼" NPT	1¼" Flange	2" Flange
Cooling Water Return	**35 psig**	¾" Tube	1" Flange	1¼" NPT	1¼" Flange	2" Flange
Condensate Drain(s)	**-**	½" Hose	½" Hose	(2x) ½" Hose	(2x) ½" Hose	(2x) ½" Hose
Compressed Air Inlet	**< 1cfm 80-150 psig Intermittent**	¼" Push-Lock Hose	¼" Push-Lock Hose	¼" Push-Lock Hose	¼" Push-Lock Hose	¼" Push-Lock Hose
Maintenance Drain	**-**	½" FNPT	½" FNPT	¾" FNPT	¾" FNPT	¾" FNPT

Ozone distribution tubing or stainless-steel piping must be installed to the ozone outlet on the exterior of the enclosure. Only special ozone resistant hose made of polytetrafluoroethylene (PTFE) and stainless-steel tube should be used. Other types of tubing will break down quickly, which could result in an ozone leak.

All oxygen and ozone piping and fittings must be cleaned and certified for oxygen service per the requirements of CGA 4.11985 prior to placing the ozone generator into operation.

4.6 Cooling Water

Ozone generator efficiency is determined by many factors. Operating conditions such as feed gas quality and especially cooling conditions are of utmost importance as it will greatly influence the performance of the ozone generator.

Pinnacle Ozone Generators are liquid cooled, and we recommend either the use of **air to water/ water to water chillers or heat exchangers** with a closed loop system to ensure that clean water flows through the generator.

- **Type:** Closed-Loop Chilled Water
- **Fluid:** Food Grade Glycol-Water Blend (30/70 blend, not included)

4.6.1 Table 2: Cooling Water Data

Parameters	GENERATOR MODEL				
	Peak 5X™	Summit 10X™	Zenith 20X™	Zenith 30X™	Apex 36X™
Typical Required Cooling Water Flow:	12 gpm (45.4 l/min)	20 gpm (75.7 l/min)	40 gpm (151.4 l/min)	55 gpm (208.1 l/min)	68 gpm (254.7 l/min)
Cooling Load:	~4.25 ton	~8.5 ton	~19.7 ton	~25.0 ton	~33.0 ton
Cooling water temperature:	45° - 80°F [7° - 26°C]				

If part of the Pinnacle Ozone Solutions Scope of Supply, please refer to below Original Manufacturer O&M for more precise information on the supplied cooling water system.

4.7 Oxygen Feed

Ozone generators require the use of an oxygen concentrator to operate. All Pinnacle systems can be configured to operate with Vacuum Swing Adsorption (VSA), Pressure Swing Adsorption (PSA), Liquid Oxygen (LOX) or an oxygen concentrator provided by the customer. Oxygen concentration, oxygen pressure and fault status are monitored and sent to the ozone generator. This data is available to the operator on the operator interface (HMI) touchscreen and through a computer via optional Ethernet access.

- **PSA, VSA, VPSA or LOX O2 Acceptable**
- **Gasified Liquid Oxygen Feed (LOX):** Dew Point: <-65C, Total Hydrocarbons (as CH4) <15 ppm.
- **PSA oxygen feed:** oxygen concentration ≥ 93%
- Max 0.1 µm Filter Inlet *(not included)*
- N2 Feed NOT required.

4.7.1 Table 3: Oxygen Feed Data

Parameters	GENERATOR MODEL				
	Peak 5X™	Summit 10X™	Zenith 20X™	Zenith 30X™	Apex 36X™
Maximum Oxygen Flow Rate:	465 slpm	930 slpm	1860 slpm	2790 slpm	2790 slpm
Inlet pressure :	20 psi				

If part of the Pinnacle Ozone Solutions Scope of Supply, please refer to below Original Manufacturer O&M for more precise information on the supplied oxygen feed system.

5. OPERATION

5.1 Operation Overview

Each generator is placed in and out of service by the operator based on the facility needs.

Ozone gas discharged out of the ozone generators is routed via a set of manual valves and pipping towards the two point of delivery locations. The operator will manually configure the valves to accommodate the path of the ozone gas towards points of delivery.

It is important to note that the ozone generators are **"slaves"** to the ozone process/operation indicating that the process controls the flow rate of ozone. The ozone generator is measuring the oxygen flow rate passing through, and the ozone production is solely based **"Concentration % by Weight Set-Point"** set by the operator. The ozone generator will automatically modulate its own PDM to produce set % by weight (example: 10% by weight).

In the event the oxygen flow rate increases as the PDM reached 100%, then the ozone concentration by weight produced will decrease based on overflow condition.

5.2 Operation Modes

The ozone generator operates in either following operating modes:

- **FIXED PDM** sets the ozone generator power to a fixed level (0-100%); higher flows produce lower concentrations; lower flows produce higher concentrations. The PDM setpoint may be set by the operator via the ozone generator HMI touchscreen or remotely via an external 4-20 mA input (source specified on HMI) from either the Master Ozone Control Panel (MOCP) or Plant DCS/SCADA.
- **FIXED CONCENTRATION** adjusts the PDM as required to maintain a user-specified concentration **(6-20%).** In cases where the flow is too high to allow the specified concentration, an alarm will be displayed on the HMI touchscreen.

5.3 Start-up/Shutdown Sequence

Assumptions:

1. Oxygen and ozone are ready for service.
2. Chiller is ready for service.
3. Verify that the technology for further processing the generated ozone is ready to accept it and can process it according to its purpose.

"Ready for service" indicates that the system has power, and no alarm is present, connections and settings are checked and ready for start.

5.3.1 Start-up procedure:

1. Operator starts the system from the HMI touchscreen (with confirmation).
2. Start cooling water system and oxygen supply system.
3. Open cooling water valves of the generator, verify flow rates and incoming water temperature.
4. System starts automatically in manual mode.
5. Open oxygen and ozone gas valves with starting values and verify proper flow rates and pressures thru the injector.
6. Once gas flows and oxygen quality are verified, the high concentration ozone analyzer is zeroed.
7. After expiration of a timer (based on process), the QuadBlocks® are powered with starting PDM command. This will initiate ozone production in a fixed mode for a short time.
8. Once start-up sequence is complete, the controls system will automatically switch the concentration mode.

5.3.2 Stop procedure:

1. Operator stops the system from the HMI touchscreen (with confirmation).
2. The ozone generators are powered-Off.
3. For some time (based on process), oxygen keeps flowing to purge the ozone in the QuadBlocks® and plumbing.
4. Once timer is expired, all gas valves will close.
5. Cooling water isolation valves will close.
6. System is ready for re-start.

5.4 System Interlocks

The Pinnacle Ozone Solutions Generators utilize a series of system interlocks to automatically protect the ozone generator from fault or damage. Each ozone generator protection includes the following:

5.4.1 Mass Flowmeter:

The mass flowmeter is used to measure the **oxygen gas flow rate** to the QuadBlock® (ozone cells). Note that there is also a pressure transmitter monitoring the oxygen pressure before the mass flowmeter. If the oxygen flow rate falls below or rises above the preset levels, the ozone generator local control Panel (LCP) will initiate an alarm condition and shut down the unit.

5.4.2 Oxygen Monitor (PSA, VSA, PVSA):

An oxygen monitor is used with **oxygen concentrator (PSA, VSA or VPSA)** fed ozone generator *(instead of a dewpoint analyzer)*. The oxygen monitor measures the purity or concentration (≥ 93%) of the oxygen being fed to the ozone generator. If the oxygen purity falls below the preset levels, the ozone generator local control panel (LCP) will initiate an alarm condition and shutdown the unit.

5.4.3 Dewpoint Analyzer *(LOX):*

A dewpoint analyzer is used with **liquid oxygen (LOX)** fed units *(instead of an oxygen monitor)*. The dewpoint analyzer monitors the quality of oxygen being fed to the ozone generator. If the dewpoint values exceed the preset levels, the ozone generator local control panel (LCP) will initiate an alarm condition and shutdown the unit.

Until the Oxygen Monitor or Dewpoint Analyzer, and the Mass Flowmeter measurements are within the preset levels, the ozone generator will not start.

5.4.4 Ambient Ozone Monitor:

The ambient ozone monitor measures the ozone gas present inside the ozone generator enclosure. If the amount of ozone exceeds the preset levels, the ozone generator local control panel (LCP) will initiate an alarm condition and shutdown the unit.

5.4.5 Water Level Sensor:

The water level sensor monitors the drain pan located at the bottom of the ozone generator enclosure. If the drain pan should accumulate water, the ozone generator local control panel (LCP) will initiate an alarm condition and shutdown the unit.

5.4.6 QuadBlock® Monitoring:

Each QuadBlock® performs a continuous self-monitoring of all its operational variables *(i.e. cell temperature, heat sink temperature, output power, bus voltage, etc.)*. If an operational variable is not within the preset levels, the ozone generator local control panel (LCP) will initiate an alarm condition and shutdown the individual QuadBlock®.

Removal and replacement of a QuadBlock® module requires approximately 20-40 minutes once power is turned off and the cooling water has been drained.

Removal and replacement of a QuadBlock® requires approximately 15 - 30 minutes per QuadBlock® (1-2 person) once power is turned off and the cooling water has been drained.

Refer to ozone generator maintenance for QuadBlock® removal and replacement instruction below.

6. HMI TOUCHSCREEN OVERVIEW

The HMI touchscreen is used for accessing the ozone generator operational settings and displaying system information. The HMI has various screens for the different generator operations and settings.

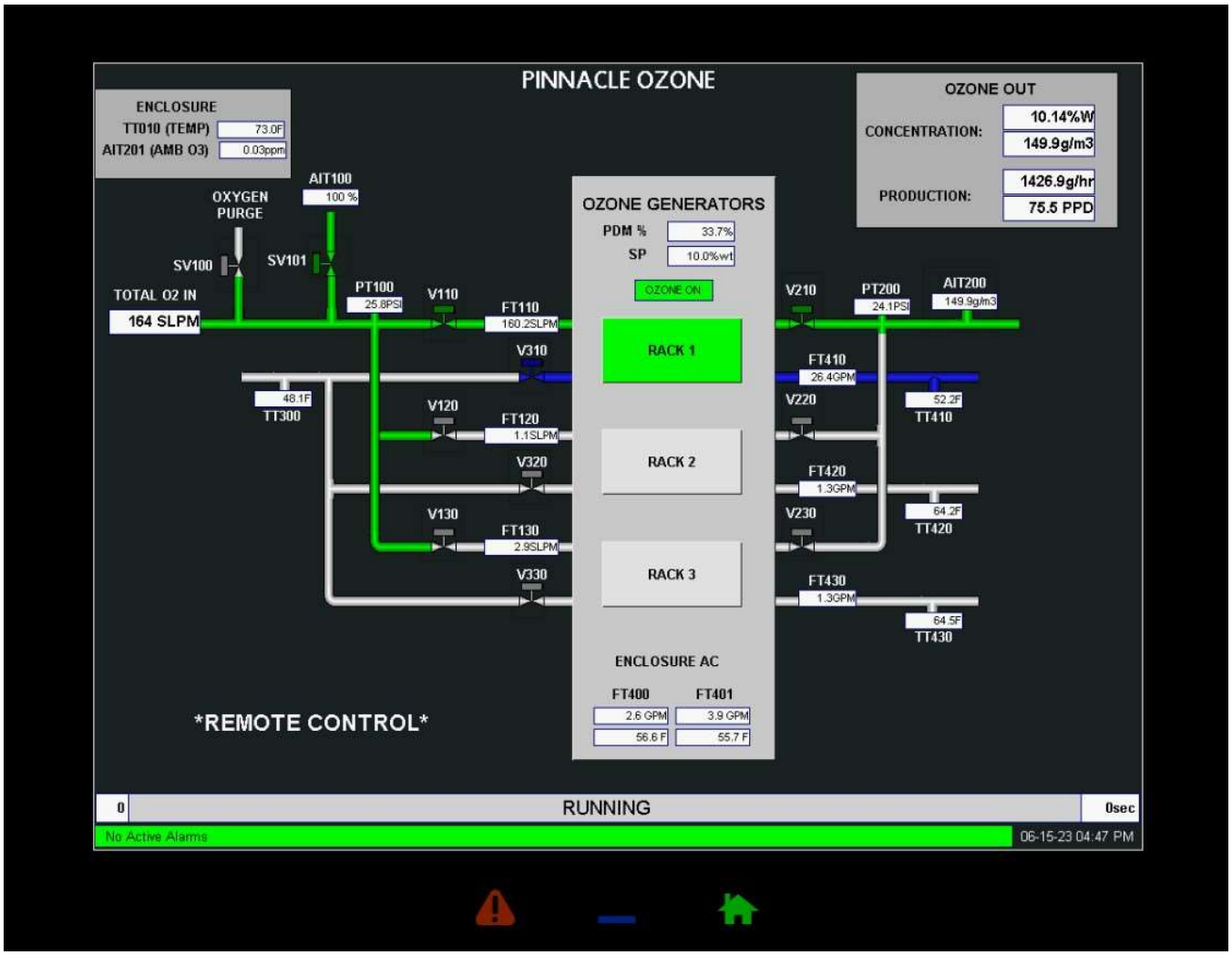
6.1 Main Menu Screen

The **Main Menu** screen is accessed by pressing the MENU button in the bottom left corner of the Red Lion Monitor. From this menu, the operator can access the Overview Screen, Alarms Screen, the Trends Screen, and the System Configuration Screen. The operator is also able to log in and out of the system.

The CLOSE button brings the operator to the previously viewed screen.

6.2 Overview Screen

The **Overview Screen** allows the operator to monitor and control the ozone generator. The Overview screen is the power-on default screen.



6.2.1 System Message Display Boxes

Located at the bottom of the Overview screen are two system message display boxes:

6.2.1.1 System Status Display

The SYSTEM STATUS DISPLAY shows the status of the generator. It will show the sequence steps while the generator starts and stops as well as the elapsed running time. In the above screen snapshot, the system status is RUNNING.

6.2.1.2 Active Alarms Banner

The ACTIVE ALARMS BANNER displays the faults or alarms that have occurred. The banner will be **GREEN** if no alarms are active and will be **RED** if there are alarms to acknowledge. Pressing the banner will bring up the Alarms screen. Refer to SYSTEM ALARMS in the Service, Troubleshooting & Maintenance section of this manual for more understanding of the Alarms screen and each alarm condition.

6.2.1.3 Ozone Generator Instrumentation

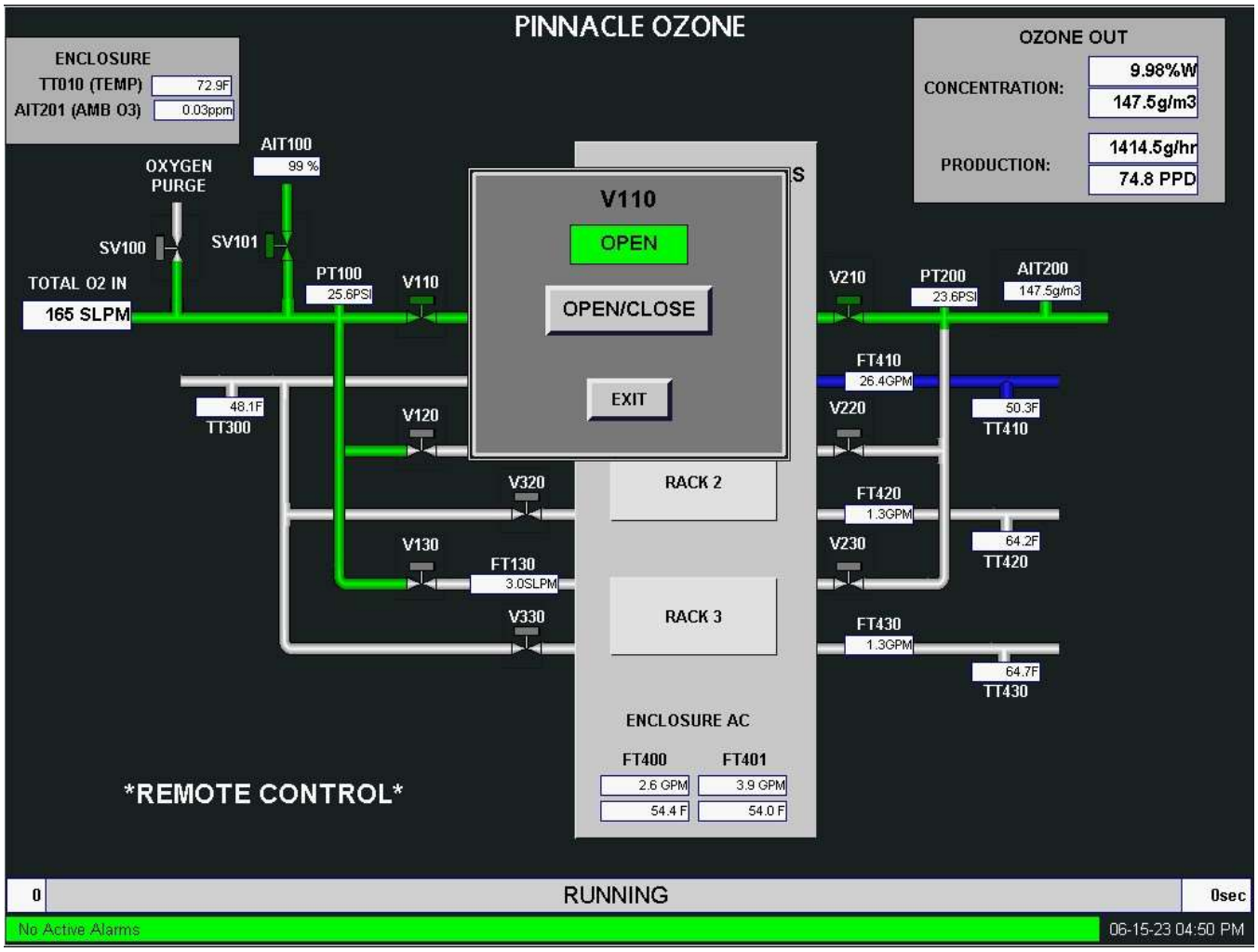
There are various Flow Transmitters (FT#), Pressure Transmitters (PT#) and Temperature Transmitters (TT#) throughout the system displaying the current values. The TRANSMITTER READINGS will appear in a GREEN box if the value is within the acceptable setpoints, or in a RED box if the value is outside of the acceptable range.

6.2.1.4 Valves

Valve V110 allows the oxygen feed into the generator:

→ Pressing the valve brings up a dialogue box which allows the operator to OPEN or CLOSE the valve.

→ Pressing EXIT returns to the Overview Screen.

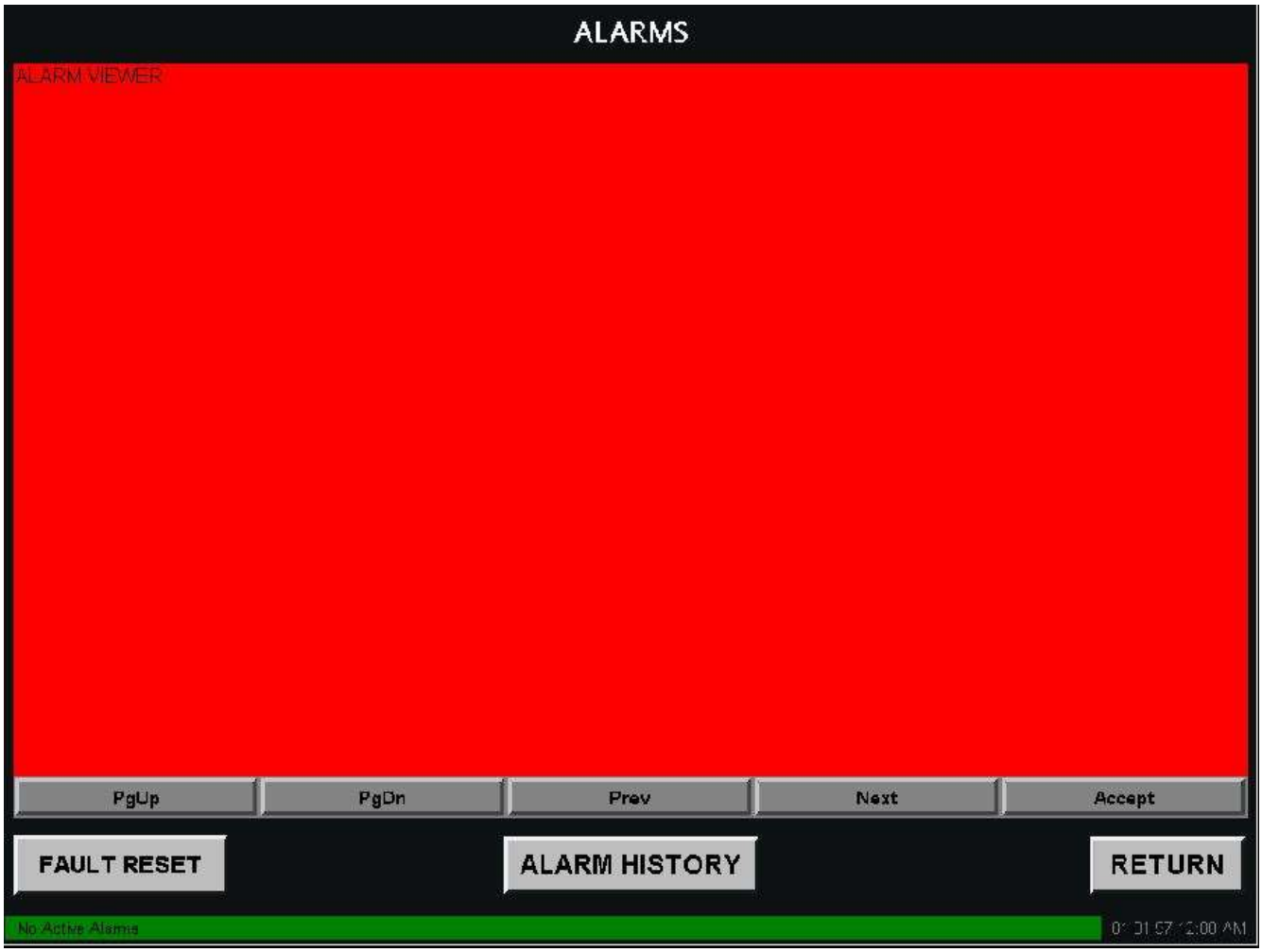


6.2.1.5


GUARDIAN OZONE
1 ON 2 ON 3 ON 4 ON 5 ON 6 ON 7 ON 8 ON 9 ON 10 ON 11 ON 12 ON
1 ON 2 ON 3 ON 4 ON 5 ON 6 ON 7 ON 8 ON 9 ON 10 ON 11 ON 12 ON
CELL TEMP (F) 60 63 61 61 60 61 61 60 61 60 63 62
HEAT SINK TEMP (F) 69 75 73 72 72 70 70 73 72 73 76 78
VOLTAGE (VDC) 315 315 313 310 313 312 315 313 318 312 318 316
CURRENT (A) 3.0 3.0 3.0 2.8 2.9 3.0 3.0 2.9 3.0 2.9 3.1 2.8
POWER (W) 944 928 955 868 892 919 959 908 969 888 984 869
PDM (%) 33 33 33 33 33 33 33 33 33 33 33 33
13 OFF 14 OFF 15 OFF 16 OFF 17 OFF 18 OFF 19 OFF 20 OFF 21 OFF 22 OFF 23 OFF 24 OFF
13 OFF 14 OFF 15 OFF 16 OFF 17 OFF 18 OFF 19 OFF 20 OFF 21 OFF 22 OFF 23 OFF 24 OFF
CELL TEMP (F) 63 62 61 60 61 62 62 63 64 66 67 68
HEAT SINK TEMP (F) 63 62 61 60 62 62 63 64 67 70 71 73
VOLTAGE (VDC) 316 312 316 319 316 316 319 321 321 319 321 318
CURRENT (A) 0.1 0.0 0.2 0.0 0.1 0.2 0.1 0.1 0.0 0.1 0.0 0.1
POWER (W) 32 0 47 0 32 63 32 32 0 32 0 16
PDM (%) 33 33 33 33 33 33 33 33 33 33 33 33
25 OFF 26 OFF 27 OFF 28 OFF 29 OFF 30 OFF 31 OFF 32 OFF 33 OFF 34 OFF 35 OFF 36 OFF
25 OFF 26 OFF 27 OFF 4 OFF 29 OFF 30 OFF 31 OFF 32 OFF 33 OFF 34 OFF 35 OFF 36 OFF
CELL TEMP (F) 65 63 61 61 61 62 61 61 62 64 65 66
HEAT SINK TEMP (F) 68 64 61 61 62 62 62 61 62 66 69 69
VOLTAGE (VDC) 319 318 321 319 319 318 319 318 319 321 318 319
CURRENT (A) 0.2 0.1 0.0 0.0 0.0 0.0 0.1 0.3 0.0 0.1 0.1 0.1
POWER (W) 64 32 0 0 0 0 32 79 0 16 32 32
PDM (%) 33 33 33 33 33 33 33 33 33 33 33 33
AIT201
GENERATORS
ALL ON
ALL OFF
PDM Control
Concentration (%W)
SP PV OUT
AUTO 10.00%W 9.97%W 33.4%
RETURN
No Active Alarms
06-15-23 04:55 PM

6.3 Alarms Screen

When the **ACTIVE ALARM BANNER** is **RED**, pressing it will bring up the Alarms Screen. The Alarms screen can also be accessed from the Main Menu screen. The Alarms Screen displays all faults that have occurred.



The Alarms screen displays all faults that have occurred.

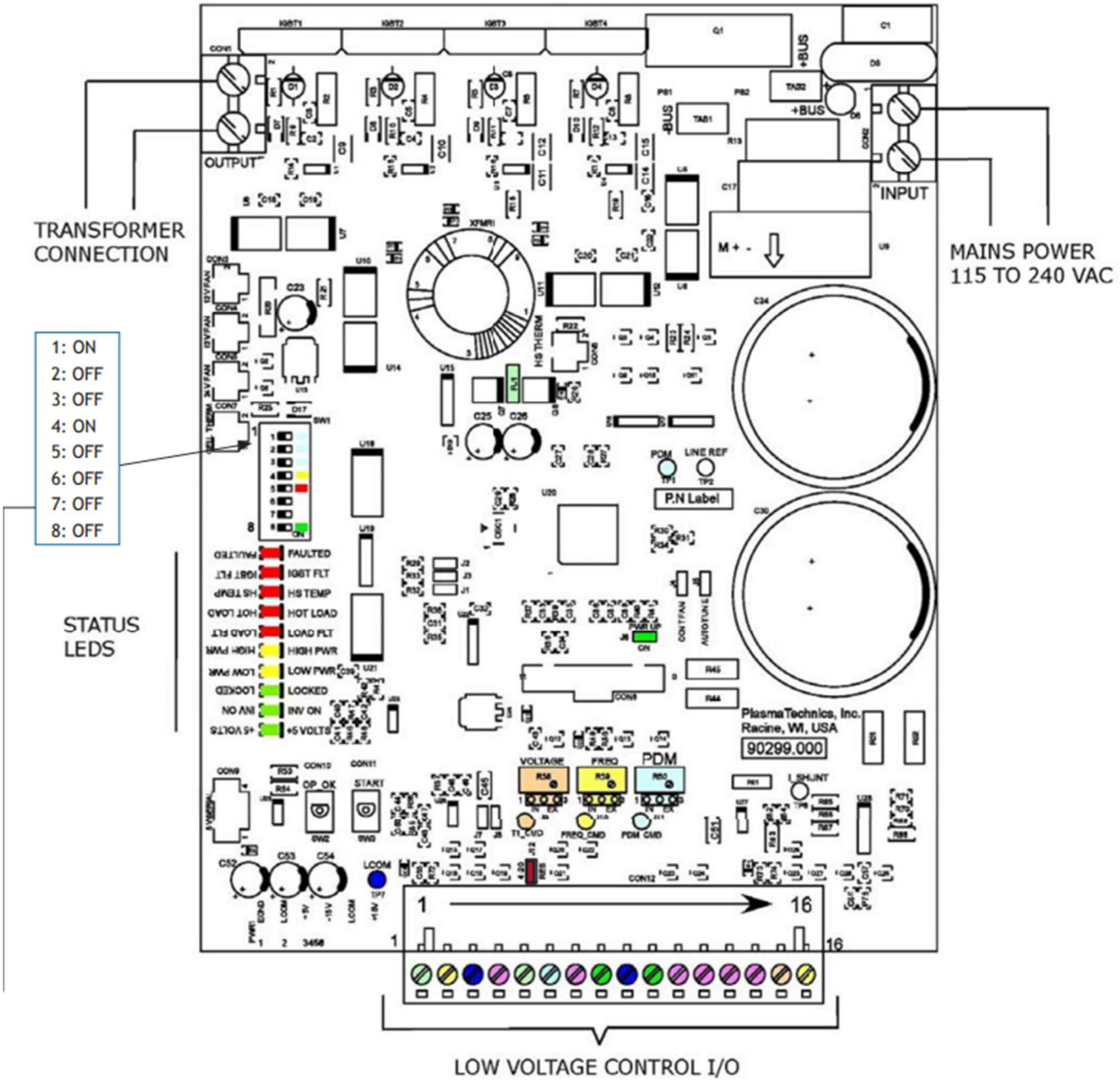
When the ACTIVE ALARM BANNER is RED at the bottom of the HMI touchscreen pressing it will bring up the Alarms screen. The Alarms screen can also be accessed from the Main Menu screen. The Alarms screen displays all the faults that have occurred. The alarm will have three columns: ALARM TIME, the time the alarm happened, ACKNOWLEDGE TIME, the time the fault was reviewed, and MESSAGE or the description of the fault alarm. At the bottom of the Alarm screen are navigational buttons, PAGE UP (PgUp), PAGE DOWN (PgDn), PREVIOUS (Prev), NEXT, or ACCEPT.

ACCEPT:	Accept acknowledges the selected/highlighted alarm, recording the date and time of review, and will clear the notification.
FAULT RESET:	Fault reset button clears latched fault indications. If the underlying fault condition still exist, the fault will remain or recur.
ALARM HISTORY:	Alarm history will bring up the Alarm History screen where the operator can see all previously acknowledged alarms.
RETURN:	Return will take the operator to the previous screen that was being viewed.

6.3.1 SYSTEM ALARMS

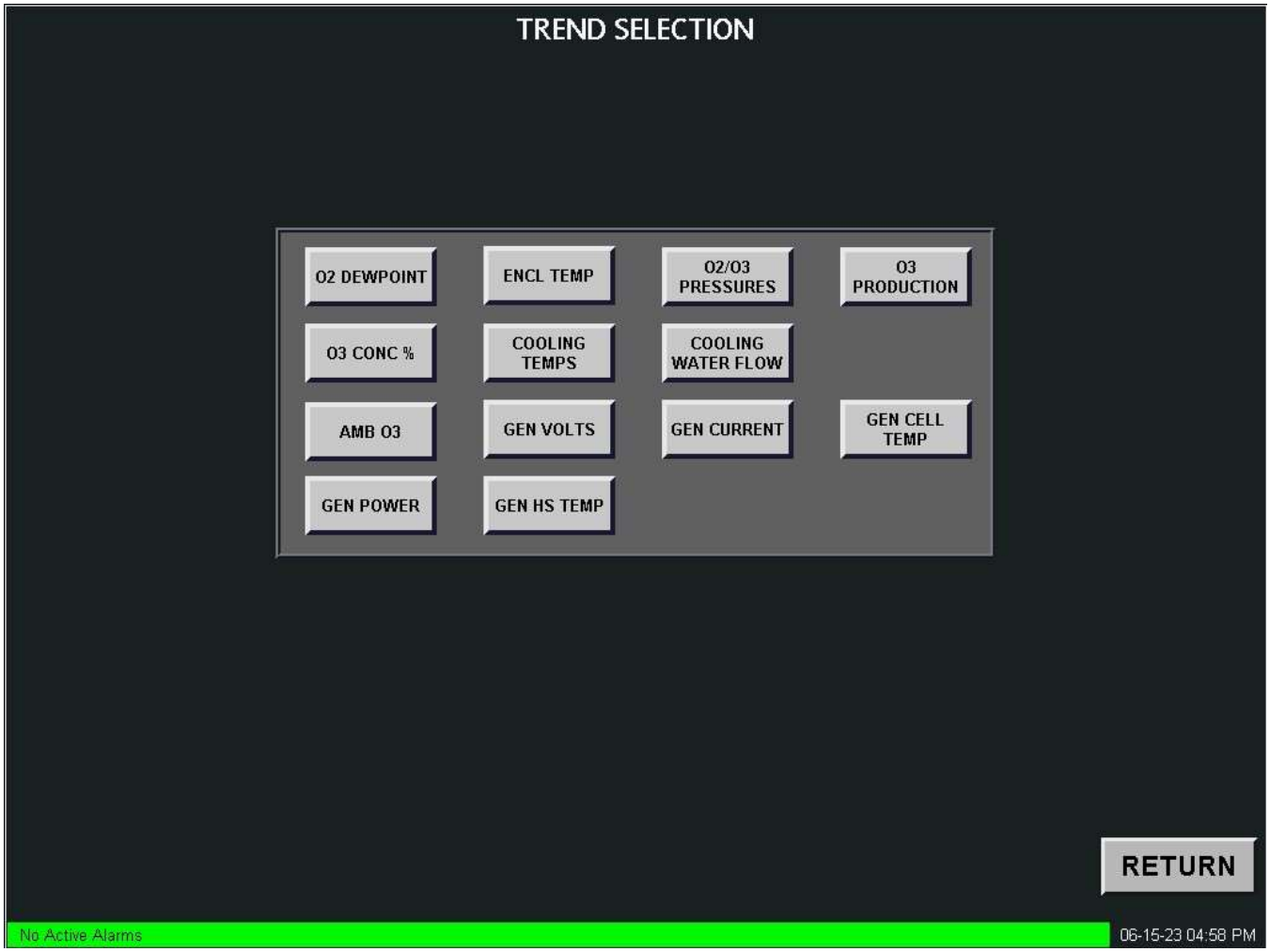
When a fault occurs, an alarm message will be displayed at the bottom of the HMI touchscreen. In addition, if the system is connected to the internet, it will send out an email alert describing the fault. Pinnacle Engineers can also use the internet connection for remote troubleshooting and adjusting special system parameters

Alarm Description	Corrective Action
Oxygen Concentration Levels Low	**THIS IS A CRITICAL FAULT, CONTACT MANUFACTURER.** Check that the oxygen source is running, and pressure gauge is above minimum setpoint. Check PSA Oxygen Setpoint on Configuration screen. Minimum PSA Oxygen Concentration is 90%.
Oxygen Pressure Levels Low	Oxygen pressure has fallen below setpoint configured on the HMI Configuration screen. Check PSA Oxygen Setpoint and Oxygen Supply for proper operation.
Gas Flow Out of Range	The total gas flow is exceeding or below value programmed on the Configuration screen. Verify proper operation of the Oxygen System. Throttle Ozone outlet valve if necessary.
Control Air Pressure Low	Check Control air regulator in the rear of the enclosure. Verify minimum of 80 psi is present on gauge. Check isolation valve is open.
Ozone Outlet Pressure Alarm	The Ozone Outlet pressure has fallen below or exceeded the set points configured on the Configuration screen. Check set points for validity. Check downstream Ozone piping for leaks, closed valves or obstructions.
Emergency Stop Active	Emergency Stop ACTIVE.
Cooling Water Supply Temperature High	Check Cooling Water source for proper operation. Check Position of Cooling Water inlet valve. If not open, check control air pressure. Check Cooling Water inlet hose connection.
Sov Circuit Breaker Trip	Reset tripped circuit breaker. If it trips again, do not reset. In either case contact Manufacturer.
Ambient O3	Shut the system down and check the ozone outlet gas fittings for proper tightness. In Diagnostics Mode, flow Oxygen by energizing the Oxygen Inlet and Ozone Outlet valves and check for leaks.
Cooling Water Return Temperature High	Check Cooling Water source for proper operation. Check position of Cooling Water inlet valve; if not open, check control air pressure. Check Cooling Water flow rate. Check Cooling Water inlet hose connection.
Drip Pan Water Level High	Water has been detected in the drip pan. Clean up excess water, dry the water sensor contacts and check for water leaks. Check for excessive condensation.
Rack Enclosure Temperature High	Ambient air in Ozone enclosure has exceeded Thermostat setting located in Control Section of the enclosure. Check setting and set appropriately. Check Status of Heat Exchanger fans and cooling water flow.
Ozone Concentration Out of Range	Ozone analyzer indicating lower or higher than set point Ozone concentration. Verify Set point value on Configuration screen. Check oxygen quality and cooling water flow temperature set points are within recommended ranges.


TRANSFORMER CONNECTION
1: ON
2: OFF
3: OFF
4: ON
5: OFF
6: OFF
7: OFF
8: OFF
STATUS LEDS
OUTPUT
INPUT
MAINS POWER 115 TO 240 VAC
P.N Label
PlasmaTechnics, Inc.
Racine, WI, USA
90299.000
PDM
1
16
LOW VOLTAGE CONTROL I/O

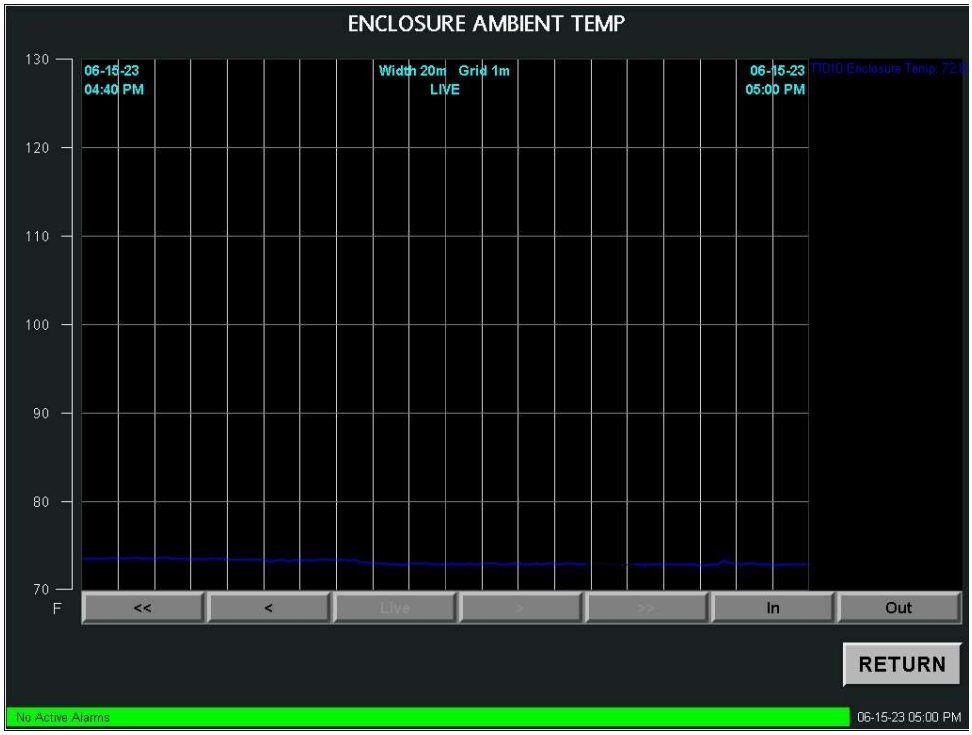
6.4 Trend Selection Screen

The Trend Selection screen is accessed from the Main Menu screen.

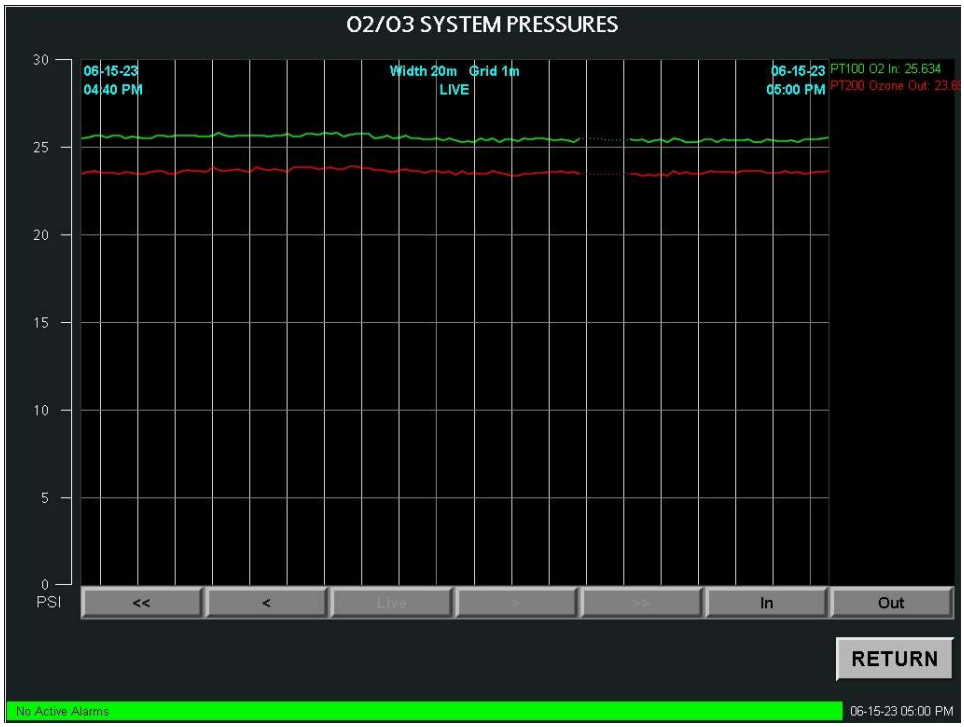


On the Trend Selection screen are Thirteen (13) DATA TREND buttons. Pressing each button will bring up the trending graph. In each of these screens, the operator can view the current trends LIVE, REWIND to previous trend points, go FORWARD to the most recent trend points, and zoom IN or OUT of the graphs.

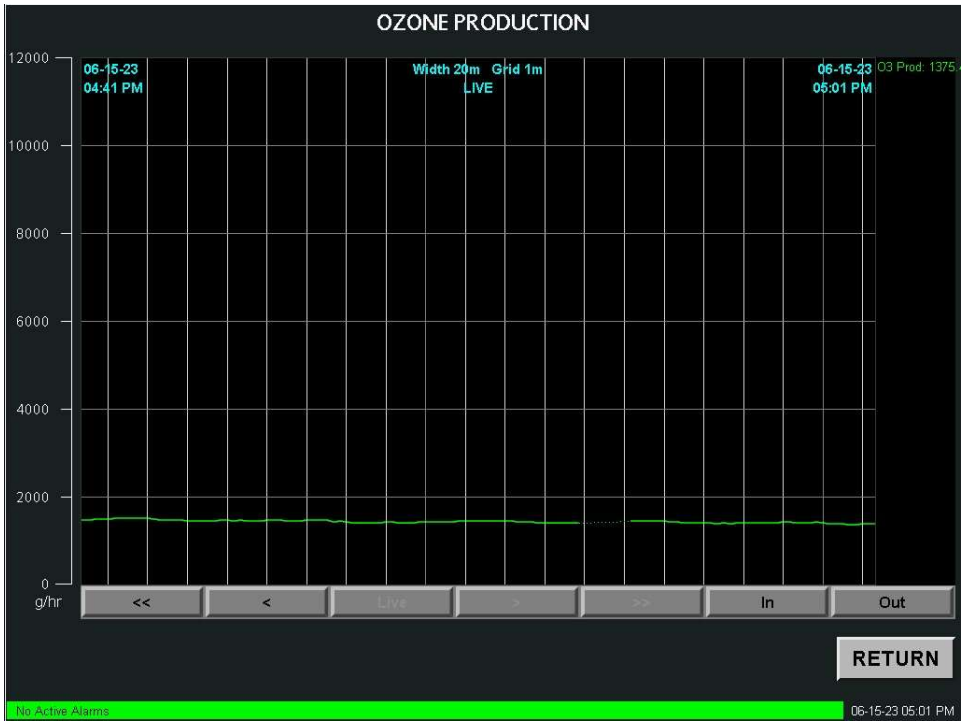
6.4.1 Enclosure Ambient Temperature



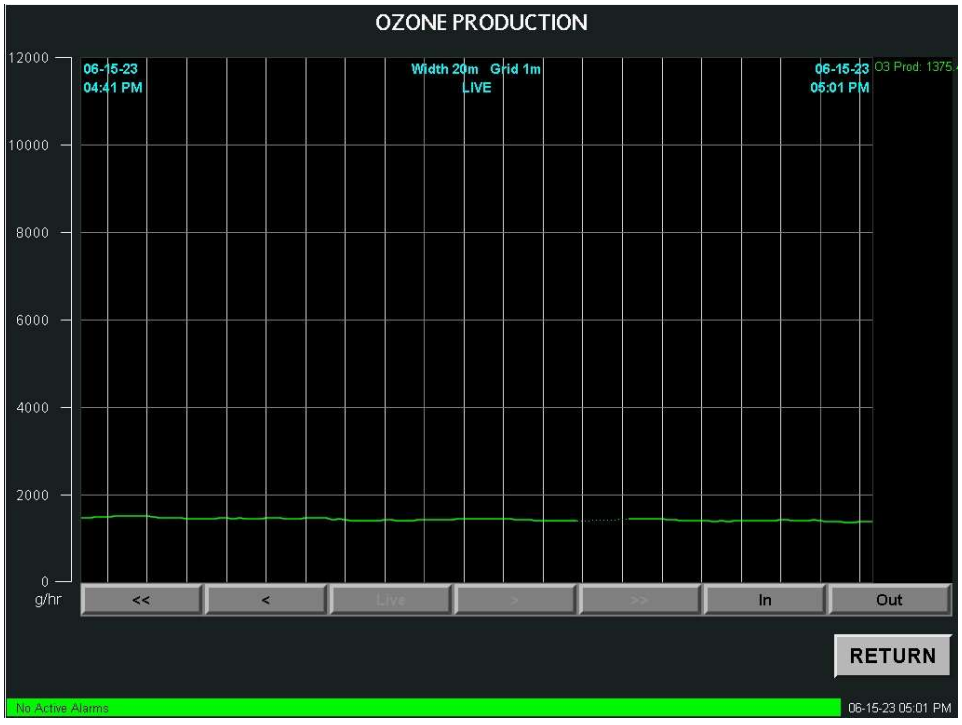
6.4.2 O2/O3 System Pressure



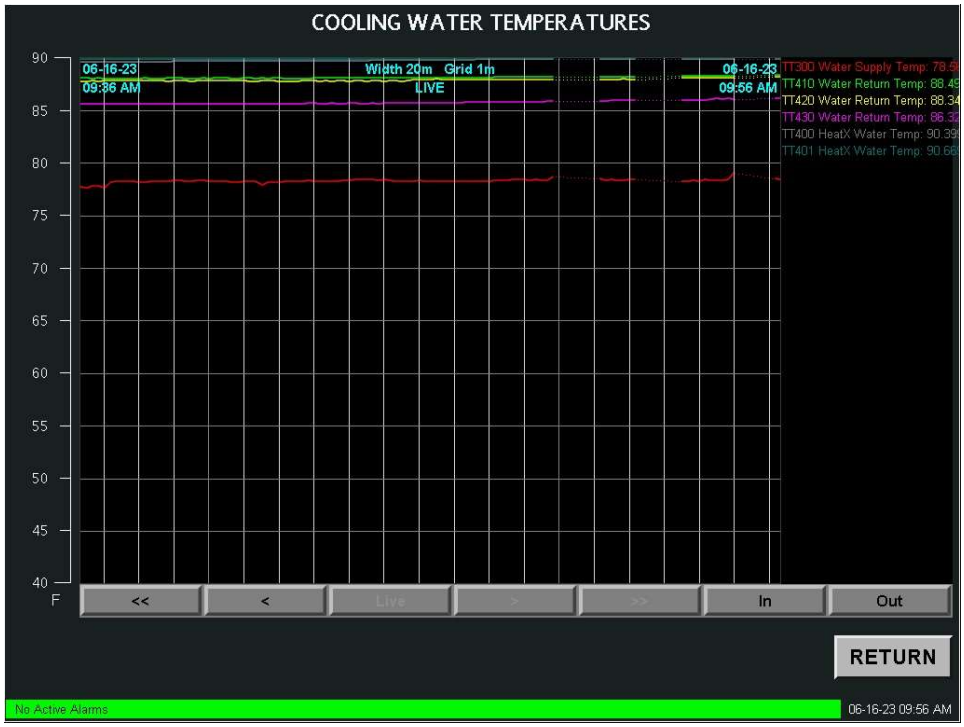
6.4.3 Ozone (O3) Production



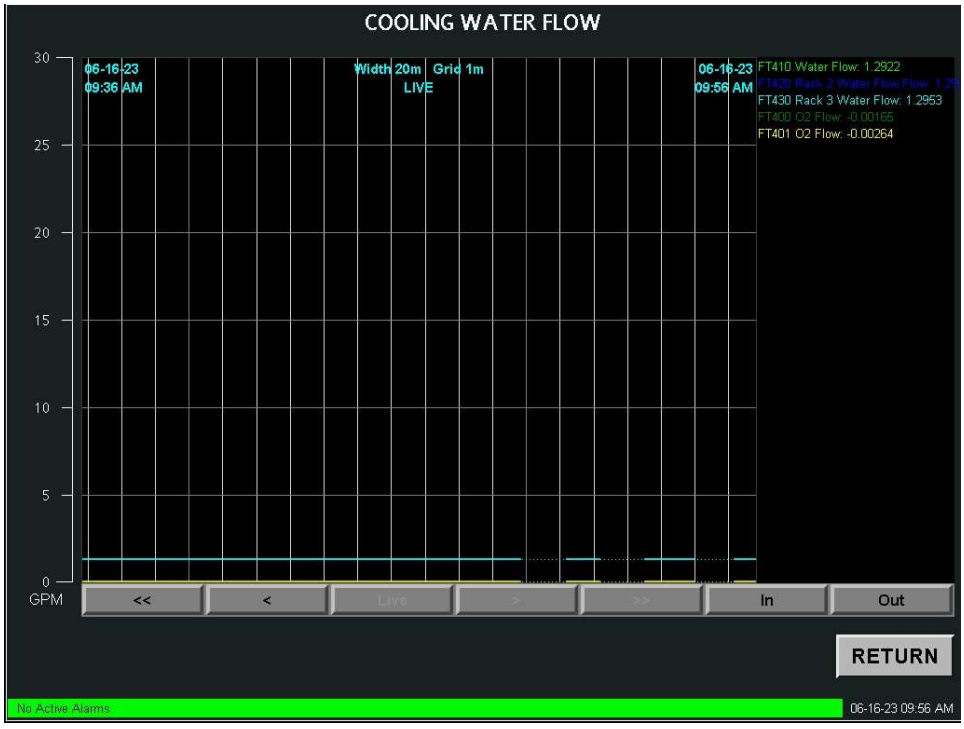
6.4.4 Ozone (O3) Concentration



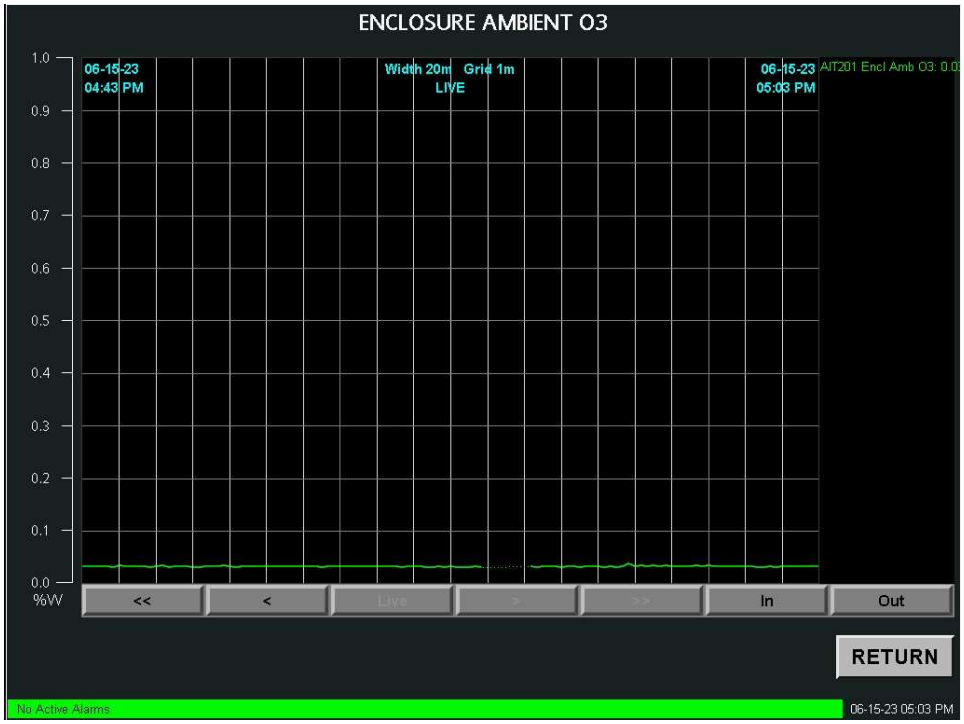
6.4.5 Cooling Temperature



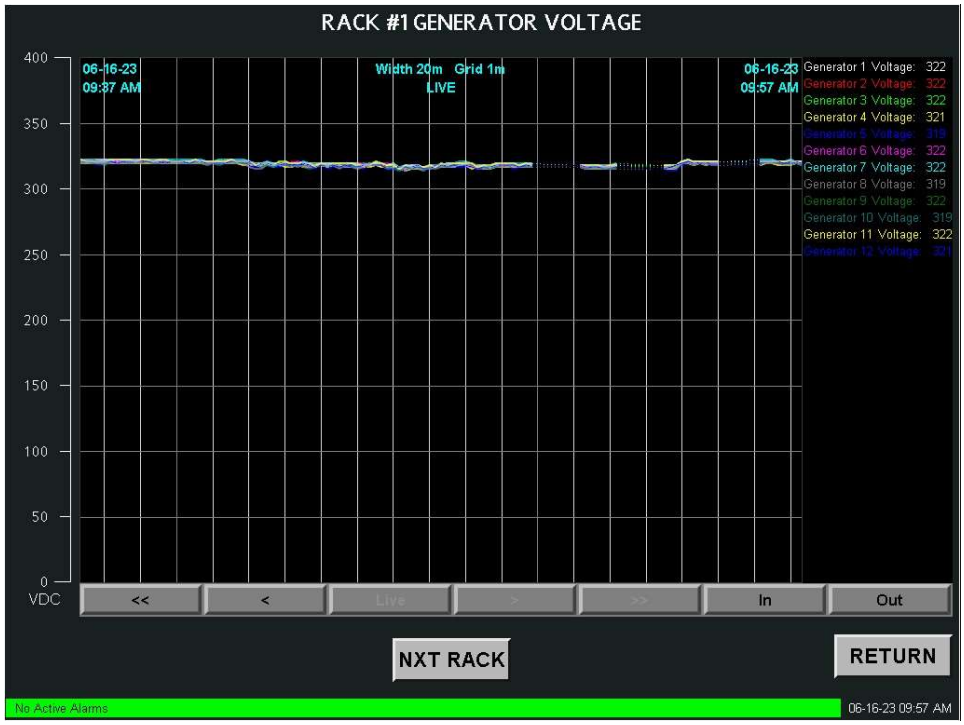
6.4.6 Cooling Water Flows



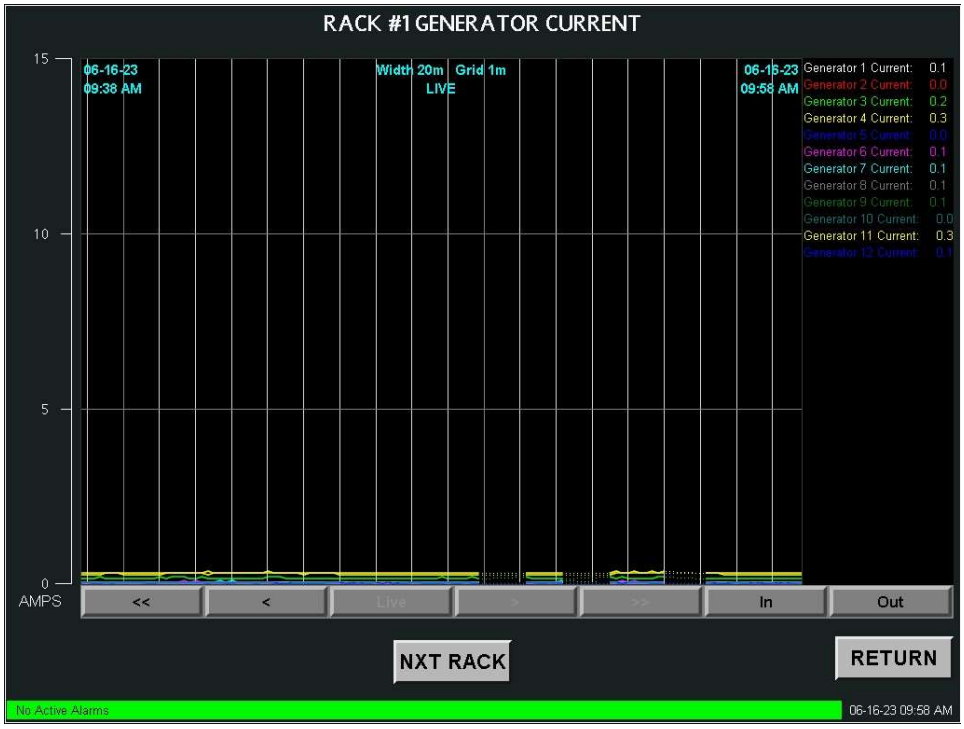
6.4.7 Ambient Ozone (Enclosure)



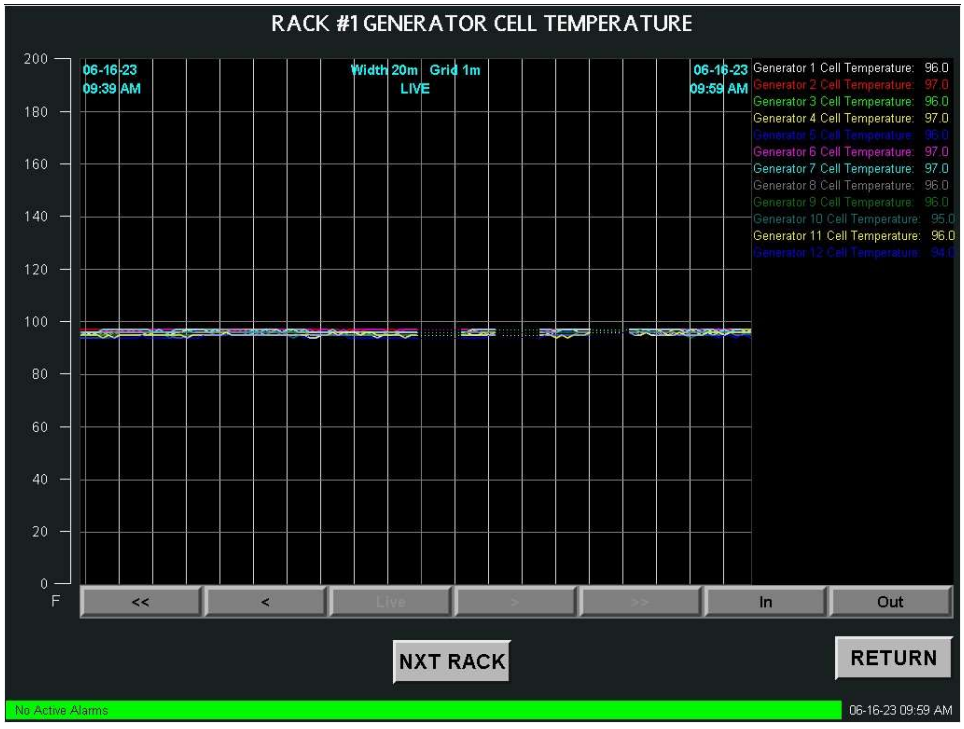
6.4.8 Generator Voltage



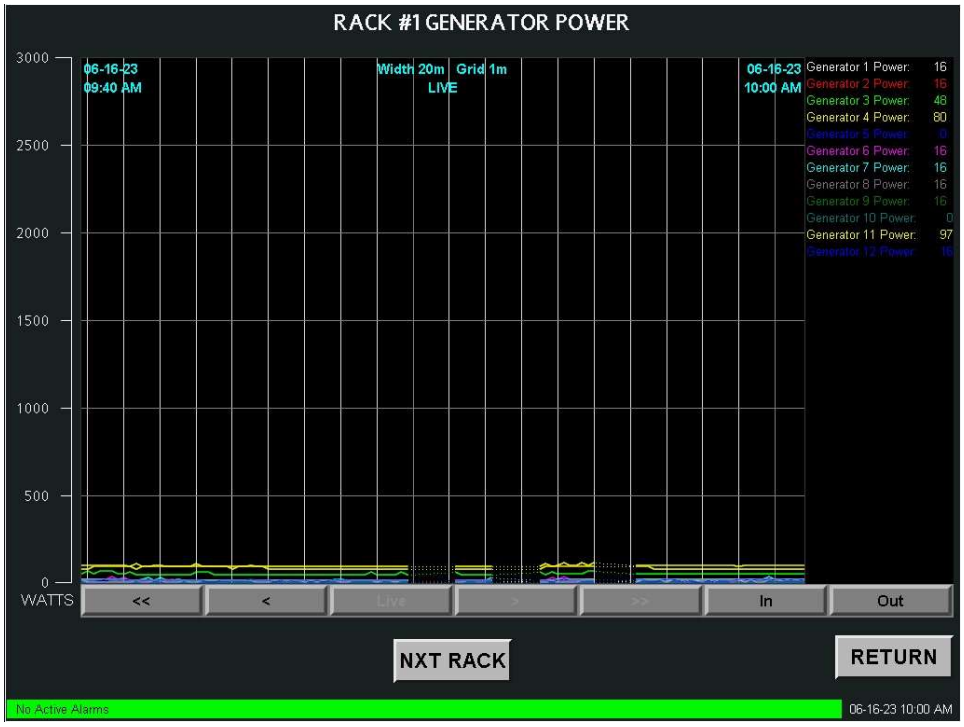
6.4.9 Generator Current



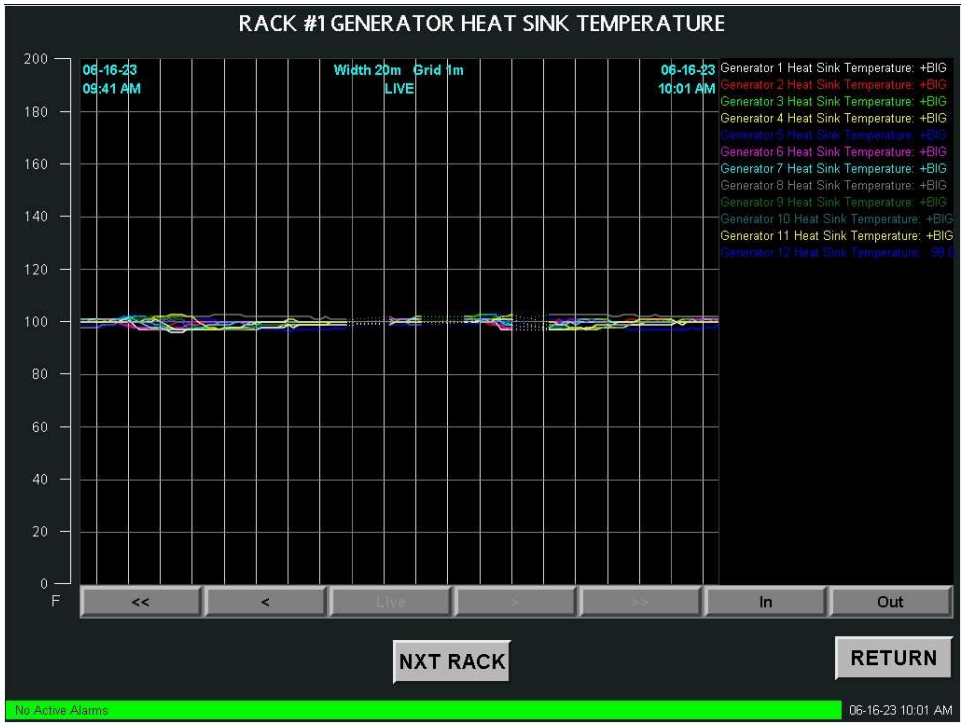
6.4.10 Generator Cell Temperature



6.4.11 Generator Power

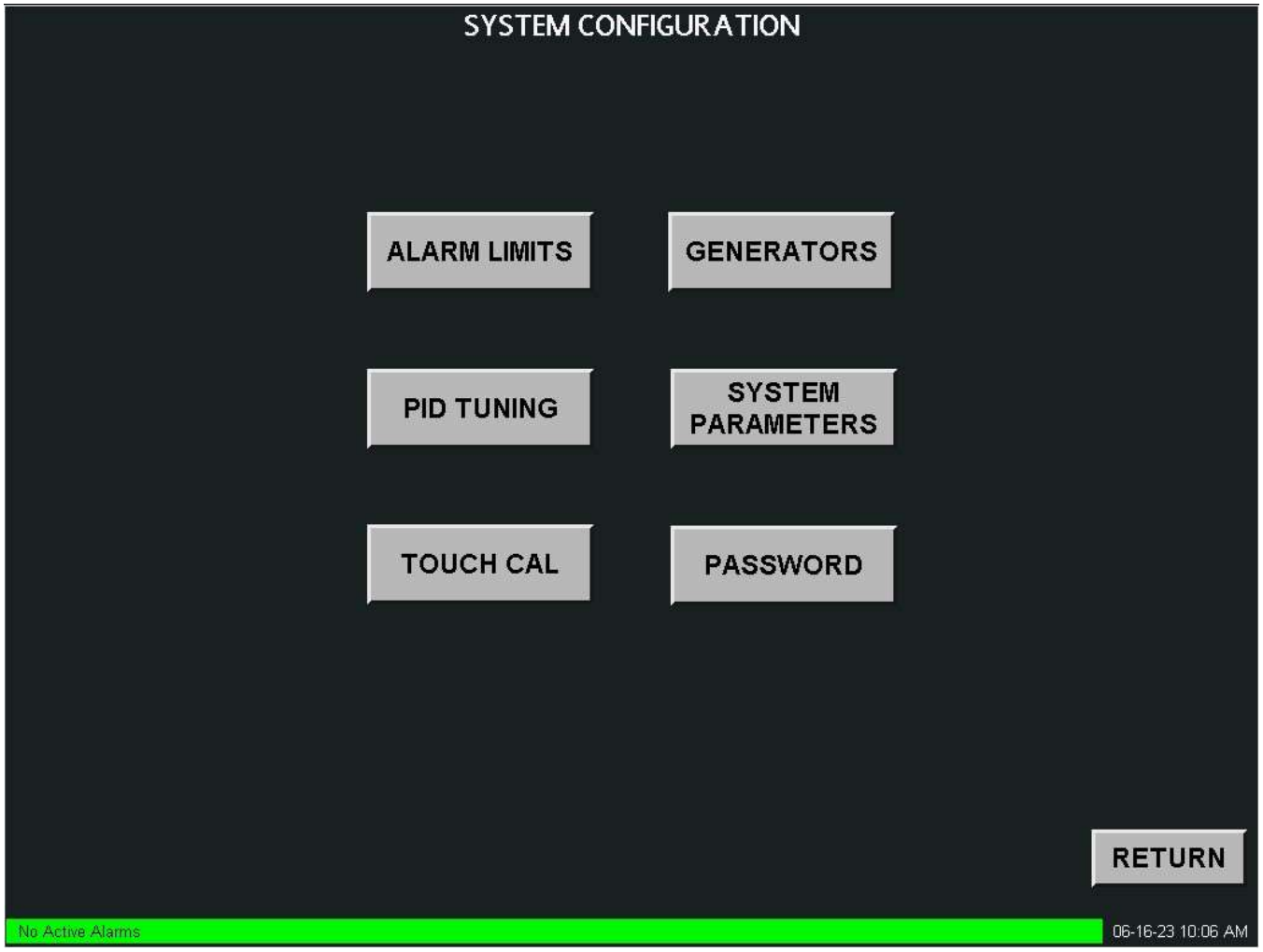


6.4.12 Generator Heat Sink Temperature

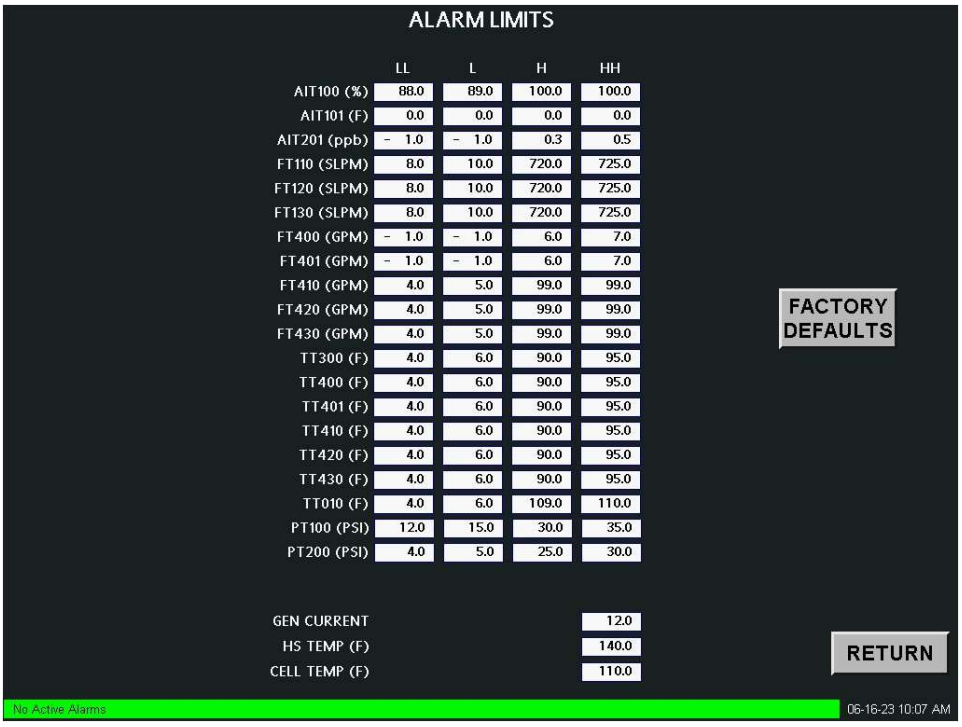


6.5 Configuration Screens

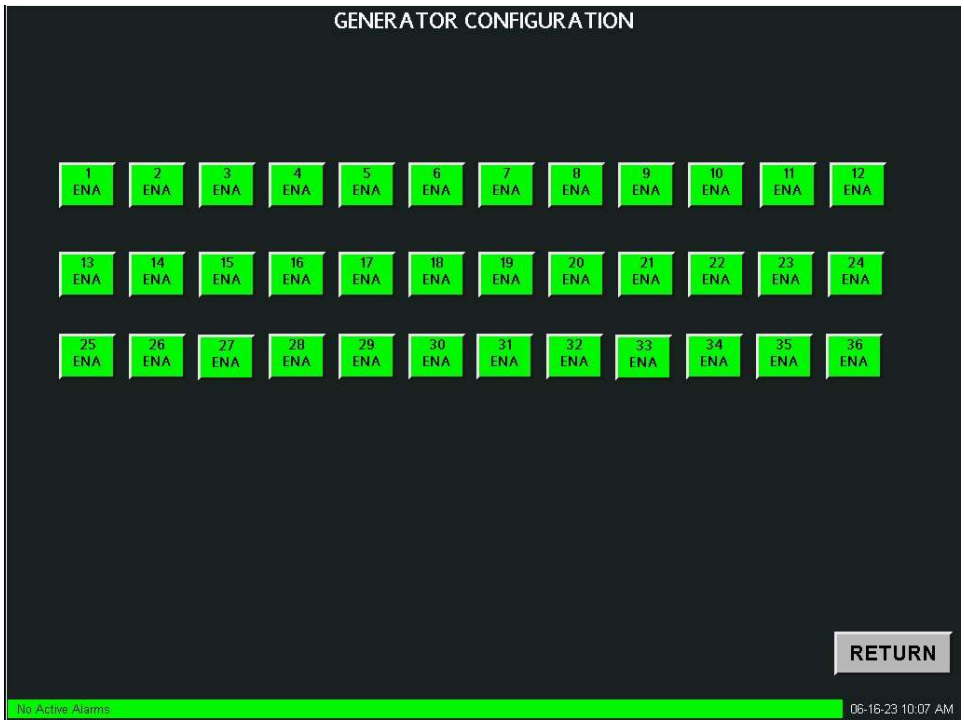
6.5.1 Main Configuration Screen



6.5.2 Alarm Limits Configuration

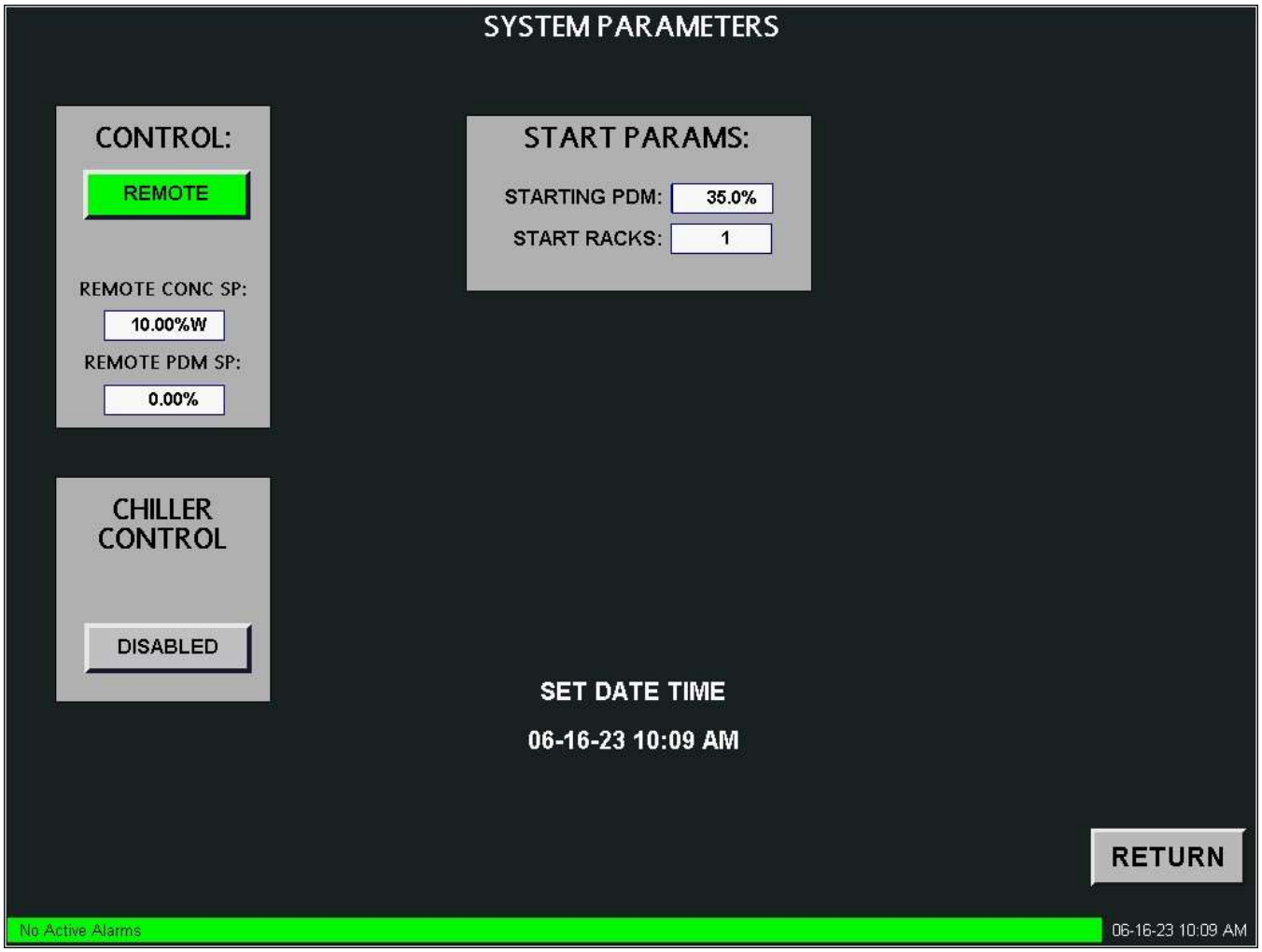


6.5.3 Generator Configuration



6.5.4 PID Configuration

6.5.5 System Parameters Configuration



7. SERVICE, TROUBLESHOOTING & MAINTENANCE

7.1 After-Sales Services & Spare Parts

Pinnacle Ozone has a service team dedicated to the maintenance and repair of all Pinnacle Systems in the field. Initial response time to a phone call is immediate during normal working hours and within a few hours during after hour support. Pinnacle Ozone has a dedicated service line to provide prompt response to all service requests.

7.1.1 Service Team Contact

Service number: +1 (321) 631-4580, Press 4 for service.
Hours: 7h00 am to 5h30 pm - 7 days week.

7.2 Recommended Spare Parts

Part No.	Description		Recommended Stock QTY
90470	QuadBlock® cooling fan	2 per Quadblock®	6
Z1028-906	QuadBlock® IN/OUT fitting seals	4 per QuadBlock®	12
SS-600-C	QuadBlock® Manifold plug (Water)	2 per QuadBlock®	6
SS-810-C	Quadblock® Manifold plug (Gas)	2 per QuadBlock®	6
TMR15	Fast Acting/Class CC Fuse, 15 AMP	-	5
A70QS400-4	Power supply Fuses	-	5
SS123203	High Conc o3 analyzer filter	-	2
MS1000SLPMDDB 15BCMGAS02	Mass Flow Meter	-	1
71215SN2ET00	Solenoid Valve	-	2
T100P3	Solenoid Valve Coil	-	2

7.3 Troubleshooting

Symptom	Corrective Action
HMI Display Blank	Is Main Disconnect on? Is the correct voltage applied? Are any circuit breakers tripped?
Low Or No Gas Flow	Is system “ON” and demanding ozone? Are the inlet and outlet gas lines connected correctly? Is the flow control “Open” to the correct flow level?
Low Or No Ozone Output	Is system “ON” and demanding ozone? Check to see that the green INV ON led on the Quadblock® power board is illuminated.
Strong Ozone Smell Is Apparent	Shut the system down and check the ozone outlet gas fittings for proper tightness. In Diagnostics Mode, flow Oxygen by energizing the Oxygen Inlet and Ozone Outlet valves and use a bubble solution on all gas fittings to check for leaks.

7.4 General Maintenance

Ozone Generator:
- Check HMI screen for Faults.
- Inspect internal drip pans for water accumulation.
- Check HMI screen for Quadblock cooling water flow, flow should be at least 1.5 GPM.

Oxygen Concentrator:
- Replacing air filters
- Rebuilding/replacing oxygen purge solenoid valves.
- Rebuilding/replacing drain valve and moisture traps.
- Refilling/replacing molecular sieve material.
- Check for proper all valves operation and purging
- Checking and recording oxygen purity and dew point

Air Dryer:
- Replacing air filters
- Rebuilding/replacing solenoid valves
- Replacing air dryer desiccant
- Checking and recording air dew point

Air Compressors:
- Replacing air filters before and after the compressor
- Rebuilding compressor heads (oil-less compressor)
- Changing compressor oil and filter (rotary screw compressor)
- Replacing belts, tubing, hoses
- Checking/replacing air relief valve as necessary.

Water Chiller:
- Checking/refilling chiller water
- Replacing/flushing chiller water
- Rebuilding check valves and relief valves
- Rebuilding circulation water pump

Ozone/Water Mixing System:
- Rebuilding injection pump
- Rebuilding/replacing check valves
- Replacing venturi
- Checking for proper air vent operation
- Verifying accuracy of pressure gauges

Ozone Destruct Device:
- Checking catalyst bed and replacing when necessary
- Checking destruct device heater and replacing when necessary
- Rebuilding destruct device blower fan

Ozone Monitors:
Ambient Safety Monitors:
- Replacing sensor with pre-calibrated sensor.
- Performing on-site calibration of sensor.
- Verifying relay operation for safety interlocks.

High Concentrator Monitor:
- Calibrating to a known reference standard.
- Replacing UV lamp.
- Cleaning/replacing filters.
- Rebuilding/replacing ozone scrubber unit.

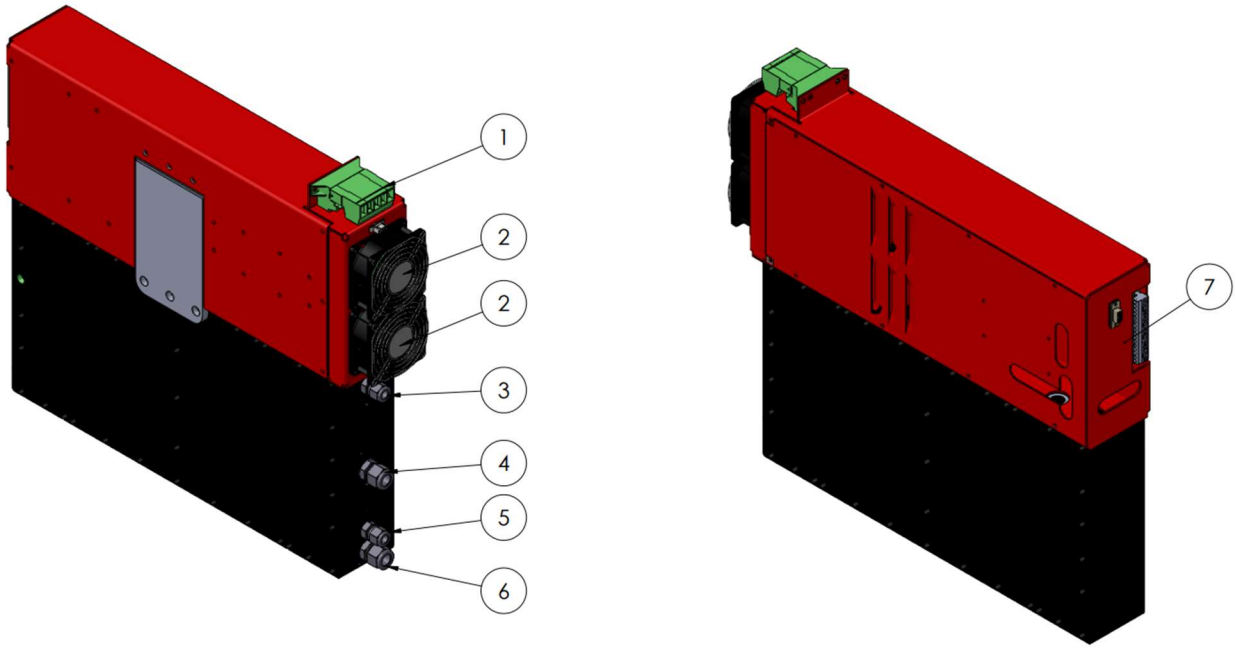
Dissolved Ozone:
- Replacing ORP or dissolved ozone probe.
- Replacing dissolved ozone probe electrolyte solution and membrane.
- Calibrating monitors.

7.5 Quadblock® Replacement

The following consists of the guidelines for the removal and replacement of a Pinnacle ozone generator - QuadBlock®

7.5.1 Tools & Safety

Tools Required:	Rachet - 1/4" and 3/8" drive Extension - 3/8"x 10" Socket- 7/16" 1/4" drive Crows Foot - 11/16" - 3/8"drive, 7/8" - 3/8" drive Wrench - 5/8" 13/16" Clean 5-gallon bucket for catching glycol Shop towels
PPE Required:	Safety Glasses Slip Resistant Work Shoes/Boots Cut Resistant Gloves
Time Required:	15 - 30 minutes per QuadBlock® (1-2 person)



7.5.2 QuadBlock®

NO.	DESCRIPTION	NO.	DESCRIPTION
1	HVDC Power Connector	5	3/8" Tube Water In
2	Cooling Fans	6	1/2" Tube O3 Out
3	3/8" Tube Water Out	7	Communication Connector
4	1/2" Tube O2 In		

7.5.3 QuadBlock® Removal and Replacement Instructions

1. Shutdown the ozone generator and purge until the high concentration ozone analyzer (AIT200) indicates less than 0.08 g/m3 gas concentration.
2. Follow standard lockout/tag-out procedures to switch off and lockout the ozone generator being serviced at the local disconnect.
3. Open ozone generator front and rear cabinet doors.
4. Isolate ozone generator from the ozone process by closing the manual valves on the oxygen and ozone lines on the top (exterior) of the generator cabinet.
5. Close manual inlet valve V300 and outlet valve V400 to isolate ozone generator cooling from common chilled glycol water loop.
6. Open vent valves V302 and V402.
7. Locate QuadBlock® drain valve at the back of the generator and, using a clean pail or carboy, direct the drain hose into the opening and open drain valve V403 to drain cooling loop. When complete, close drain valve V403.
8. Remove power connector (rear) and communication connector (front) from the QuadBlock®.
9. Remove the (4) ¼-20 mounting bolts *(two at the front and two at the back)* which secure the QuadBlock® to the frame with a 7/16" socket on a 1/4" drive rachet.
10. Loosen and then disconnect the gas and cooling water connections at the rear of the QuadBlock® using the 3/8" rachet and extension with the 7/8"crowsfoot (gas) and 11/16" crowfoot (water).
11. Return to the front of the generator enclosure and remove the QuadBlock®. The weight of the QuadBlock® is approximately 70 pounds. This step may work best with one person in front and one person in the back of the generator.
12. Remove the (4) protective caps on the New Quadblock® connections and place the protective caps on the removed QuadBlock®. Things to check before sliding the QuadBlock into the frame. You will need to check tightness of the gas and water fittings on the QuadBlock® using the 5/8" wrench (water) and 13/16" (gas. NOTE: please ensure these are tight before installing the new QuadBlock into the unoccupied position where the original QuadBlock® was located.
13. Position it so that the (4) mounting bolt holes in the frame are line up with the holes on the block, and the cooling water and gas connections to the rear are lined up as well.
14. Connect and tighten the gas and cooling water connections at the rear of the QuadBlock using 3/8" rachet, 3/8" extension and using a crows' foot 7/8" (gas) and 11/16" (water). These should be hand tight to start and then use rachet and crows' foot to tighten one (1) turn.
15. Reinstall the (4) 1/4-20 mounting bolts (two at the front and two at the back) that secure the QuadBlock to the frame with a 7/16" socket and 1/4" rachet. Recommended torque value: 57.3 in-lbs. **IMPORTANT NOTE: Do not torque until all four bolts have been started as the Quadblock® position may need to be readjusted.**
16. Reinstall the power connector (rear) and communication connector (front) to the QuadBlock®.
17. Open the ozone and oxygen manual valves on top of the generator. Close valves V302 and V402 before opening valves V300 and V400.
18. Close front and rear cabinet doors of the ozone generator.
19. Reverse standard lockout/tag-out procedures and remove tags/locks to switch the ozone generator on at the local disconnect.
20. Fill the expansion tank on the chiller with the correct Glycol mixture per the O&M manual. Use only DowFrost propylene glycol at the concentration by volume prescribed in the O&M manual for replacement coolant.
21. The removed Glycol (if clean) may be reused or disposed of properly. Do not pour the Glycol down a drain.
22. Initiate ozone system startup sequence as defined in system O&M manual.
23. If desired, package the removed QuadBlock® for return to the manufacturer for reconditioning.

8. WARRANTY

8.1 Standard Manufacturer Warranty

- Pinnacle Ozone Solution, LLC standard warranty consists of a complete one-year (12 month) parts and labor warranty.
- The warranty period begins with equipment acceptance or 60 days after delivery of equipment to the job site, whichever comes first.
- Pinnacle Ozone dielectrics are warrantied for 20 years.

8.2 Special Project Specific Warranty *(if applicable)*

This special warranty covers the installation and performance of the overall ozone system equipment supplied by Pinnacle Ozone Solutions, LLC.

Duration:	***N/A***
Coverage:	***N/A***

PINNACLE
OZONE SOLUTIONS, LLC
MODULAR • RELIABLE • EFFICIENT

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