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Ozone Groundwater Remediation Trailer

Installation and Operation Manual

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Cautions, Warnings and Hazards

Refer to the manual of the Ozone Generating System first, to assure proper location of all ozone equipment.

Ozone is a powerful oxidizing agent. Observe strict operating procedures when using ozone equipment.

Ensure that the Ozone Trailer is in an open area. The Ozone Groundwater Remediation System is designed to operate in outdoors but must have ample ventilation area for cooling.

Note: If the operator has asthma, he/she must not enter ozonated airspace. Ozone can induce an asthma attack.

Carefully review and familiarize yourself with the following important safety information statements concerning the use of ozone with the Groundwater Remediation System.

Warning Ozone is an extremely aggressive and powerful oxidizer. The Occupational Safety and Health Administration (OSHA) 8-hour exposure limit is 0.10-PPM. The OSHA 15-minute exposure limit for ozone is 0.3 PPM. Above 0.3 PPM, there is the risk of damage to respiratory tissues.

Warning People who have no sense of smell should not operate this equipment.

Warning Never attempt to verify ozone production by directly breathing or smelling the ozone outlet or the ozone-tubing outlet.

Warning The Ozone Groundwater Remediation System uses stainless steel or Teflon tubing to transfer the ozone to the desired locations. In the event the tubing is damaged in any way it should be replaced immediately to prevent dangerous ozone leaks**.**

Warning Make sure all ozone tubing connections between the Ozone Trailer and any external locations are secure, and in good working condition. Failure to do so could result in the discharge of ozone into an undesired space.

Introduction

The Ozone Trailer is an Ozone Groundwater Remediation System designed to work as a stand-alone unit with all necessary equipment and automation for ozone production and sparging built into one convenient mobile platform. The system consists of five major components:

- Air Compressor
- Air Drying Equipment
- Oxygen Concentrator
- Ozone Generator(s)
- Well Output Manifold(s)

Theory of Operation

The Air Compressor produces approximately 28 CFM of compressed air at 100 PSI, which is then dried to a dewpoint of 32°F and stored in a Compressed Air Storage Tank. The compressed air is utilized for the process in two ways:

- A portion of dry air (about 5 CFM) is available for Sparge Air which is combined with the ozone flow at the Air/Ozone Manifold for sparging.
- About 20 CFM of dry air is consumed by the Oxygen Concentrator for oxygen production.

The Oxygen Concentrator provides 90 SCFH (42 SLPM) of oxygen flow at 45 PSI, at approximately 93% purity. Oxygen flows through the Ozone Generators which in parallel produce 120g/hr (6.4lb/day) total ozone at full production.

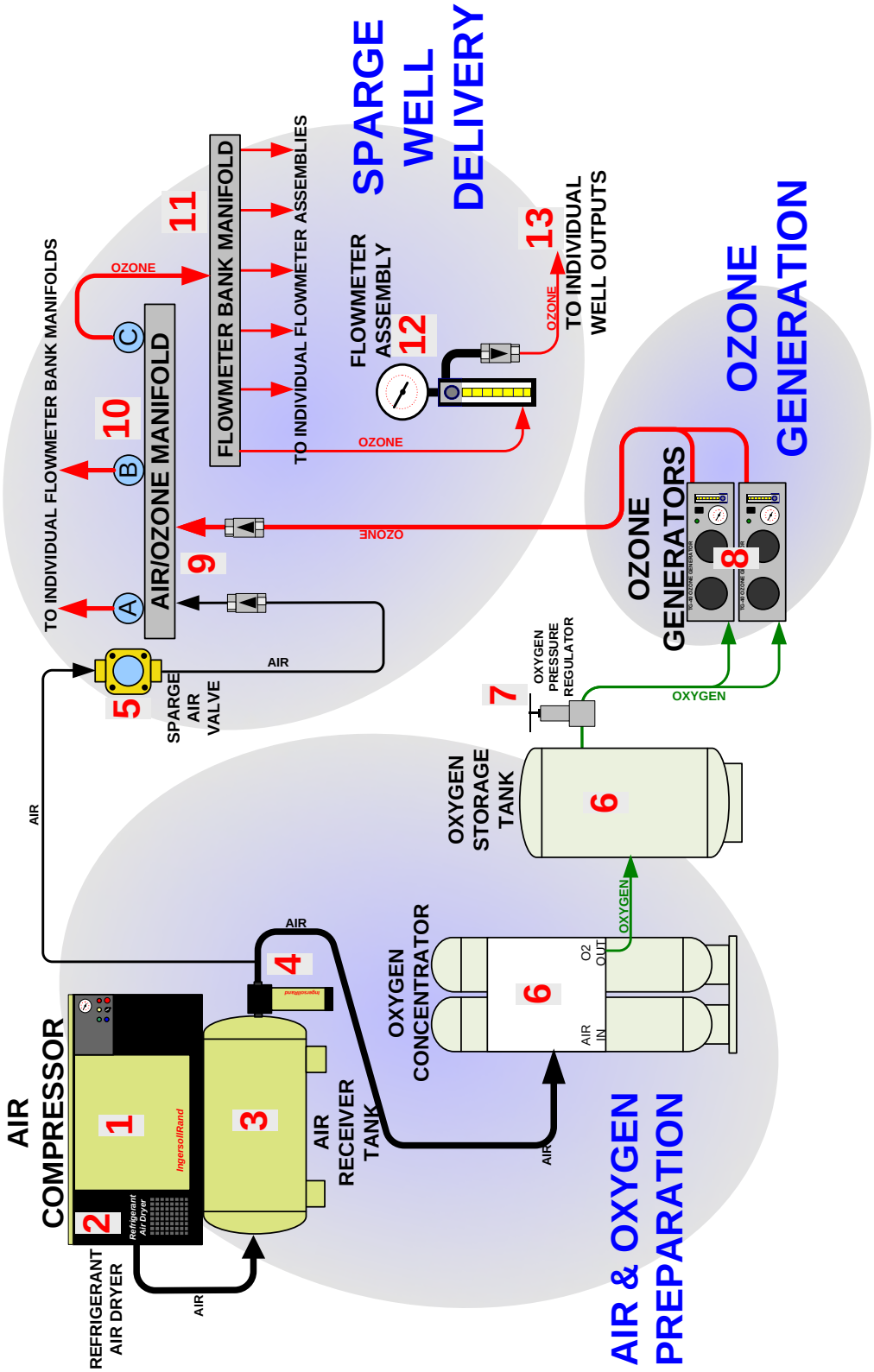
The flow of ozone from the Ozone Generators is delivered to the Air/Ozone Manifold where it combines with the Sparge Air. The mixture is then directed via timer-controlled solenoid valves to one of four Flowmeter Banks.

The Flowmeter Banks are each made up of six (6) flowmeter assemblies. Each flowmeter assembly includes a variable area flowmeter, pressure gauge, and check valve; in order to provide back-flow prevention while permitting the user to accurately monitor the individual well sparging operation. The air/ozone sparging line from each flowmeter assembly then leads to an individual well output connection on the outside of the trailer.

Monitoring devices and sensors are integrated into the control system to protect the equipment in the event of any failures or extreme environmental conditions, and to alert operators of any unexpected operation.

OZONE SYSTEM Diagrams & Information

Component Illustration (description on following pages)



Component Illustration Description

1. Air Compressor: The Air Compressor provides 28 CFM of compressed air at 100 PSI. The compressed air is utilized for oxygen production and sparging purposes.

2. Refrigerant Air Dryer: Built into the Air Compressor package, the Refrigerant Air Dryer cools the compressed air exiting the compressor, thereby causing the water to be condensed from the air and drying the air to approximately 30°F dewpoint.

3. Air Receiver Tank: Compressed air enters the 120-gallon tank at 90-125 PSI, dried to approximately 30°F dewpoint. An automatic drain, at the bottom of the tank, releases any condensate water.

4. Coalescing Filter: The filter removes any remaining moisture, oil, or contaminants that may be present in the compressed air supply.

5. Sparge Air Valve: Controlled automatically by the control system, the valve opens to allow Sparge Air flow into Air/Ozone Manifold.

6. Oxygen Concentrator & Storage Tank: The concentrator removes nitrogen and other contaminants from the compressed air using Pressure Swing Absorption (PSA), providing oxygen (at least 90% purity) to maintain 45-65 PSI oxygen pressure in the Oxygen Tank. [See Manufacturer's AS-D Manual.]

7. Oxygen Pressure Regulator: Regulates oxygen pressure feeding the Ozone Generators in order to help maintain reliable consistent ozone production.

8. Ozone Generators: The system utilizes two TG-40 Ozone Generators, which are located in the Front Trailer compartment in a clean, climate controlled environment. The Ozone Generators together are capable of producing 120g/hr of ozone, depending on oxygen flow. For Ozone Generator information and specifications, reference the TG-40 Operation Manual.

9. Air/Ozone Manifold: Both Sparge Air and Ozone enter the manifold, each at a controlled flow. Each is equipped with a Check Valve in order to prevent backflow of air into the ozone line, or ozone into the air line.

10. Bank Valves (Solenoid Valves): Exiting the manifold are three (3) Solenoid Valves which are controlled by a timer (built into the control system, user-programmable via the HMI control) which permits air/ozone flow to one Flowmeter Bank Manifold at a time.

11. Flowmeter Bank Manifolds: There are three (3) Flowmeter Bank Manifolds (Banks “A” thru “C”) each connected its respective solenoid valve. Exiting in each of the three (3) manifolds are six (6) Flowmeter Assemblies, by which the sparge air/ozone is distributed to the respective well outputs.

12. Flowmeter Assembly: There are six (6) Flowmeter Assemblies in each of the three (3) Flowmeter Banks, for a total of 18. Each Flowmeter Assembly contains three (3) main components in this order:

    a. Flowmeter – Indicates sparge flow for each individual well output.

    b. Needle Valve – Located at the top of and integral to the flowmeter housing, it allows flow adjustments for the individual well output.

    c. Pressure Gauge – Indicates sparge pressure for each individual well output.

    d. Check Valve – Prevents backflow of water or ozone back into the system from each well output.

13. Individual Well Outputs: The 18 Flowmeter Assemblies each have a respective Well Output connection on the outside of the trailer. The connection is 3/8" NPT female.

Installation

Location & Placement

The Ozone Groundwater Remediation Trailer is designed to be located outdoors and withstand most environmental conditions. The control system has built-in safety measures to prevent equipment damage in the event of extreme conditions.

The trailer should be located in such a way as to allow access to the well output connections on the outside. The location should also allow full opening of both the front and rear doors, and to allow for adequate area around the doors for exit in the event of an emergency.

The area around the trailer should allow for adequate air movement for cooling purposes, especially where air intake and exhaust vents are located.

Electrical Connections

ATTENTION: Air compressor rotation is critical. Ensure proper rotation of air compressor motor as marked on the compressor before starting the compressor or Ozone System.

POWER REQUIREMENTS:

Voltage:	115/230V single-phase
Full Load Amperage:	~75 A (maximum)
Maximum Overcurrent Protection:	200 A (provided in Power Distribution Panel)
Minimum Overcurrent Protection:	90 A
Maximum Power Consumption:	~17 kVA at full production.

MAIN SUPPLY POWER CONNECTIONS

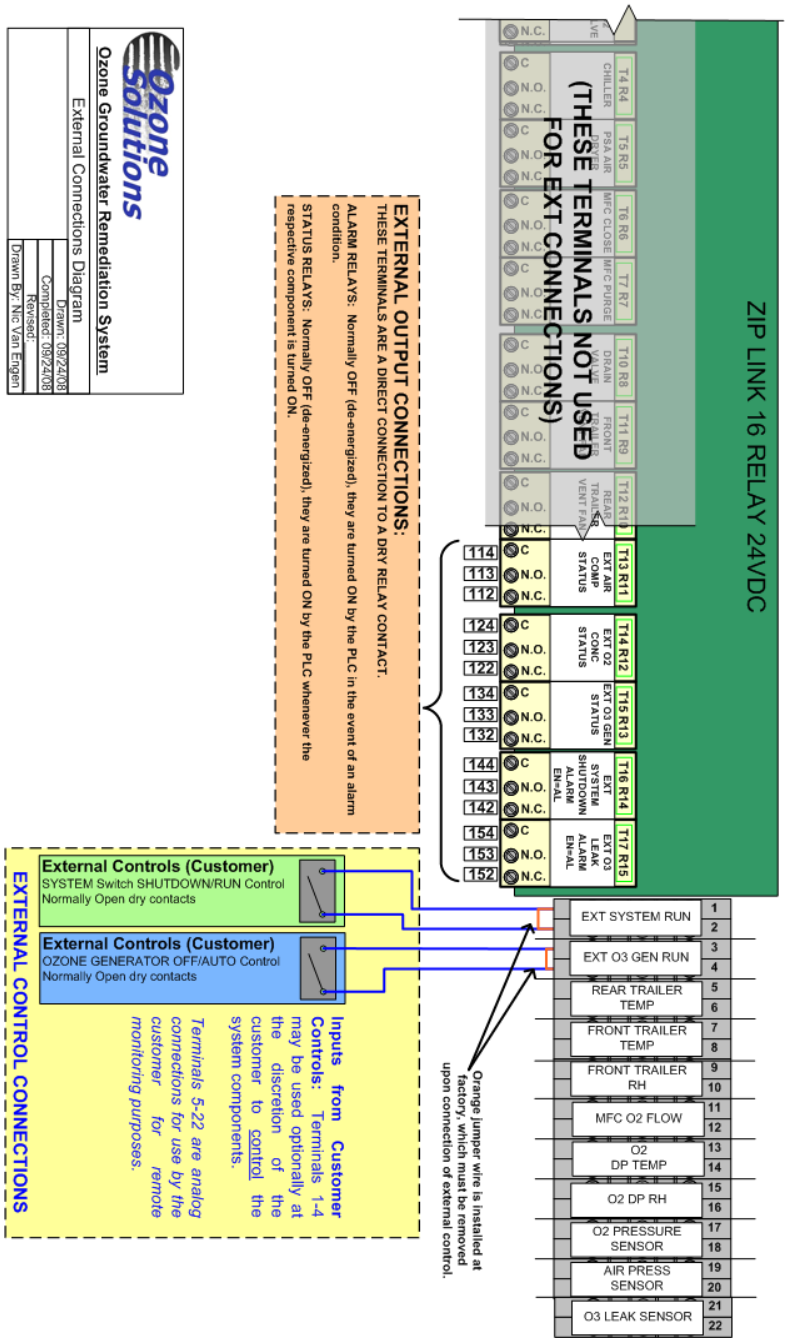
Inside the Power Distribution Panel is a MAIN DISCONNECT switch located towards the bottom of the panel.

- Connect incoming L1, L2 leads to the appropriate terminals in the panel.
- Connect Neutral Conductor to the Neutral Bar inside the panel.
- Connect equipment ground terminal in panel to earth ground.
- If local conditions deem necessary, bond the neutral and ground within the Power Distribution Panel.

EXTERNAL CONTROL WIRING

The Ozone Groundwater Remediation Trailer is equipped with input and output terminals, to be utilized for interfacing with external controls and monitoring equipment. See diagram on the following page for external connections.

NOTE: External connections are entirely optional and are not required to operate the system.



HMI Functions & Operation

Overview

The HMI panel allows access to all automatic functions of the Ozone Remediation System. All of the system components operate automatically, while the HMI panel displays the current status of each part of the system. Various setpoints (to adjust running parameters and alarm parameters) can be adjusted by the operator during shutdown or during operation. The HMI panel also allows manual operation of some of the components, to allow for a step-by-step manual start-up when necessary for troubleshooting or occasional initial startup assistance.

The MAIN SCREEN (Screen #1) provides a readout of all system operating conditions. Since most of the system functions are automatic, it is often difficult to understand what is happening as the system runs through normal start-up, shutdown, and alarm procedures. This screen allows the operator to monitor all conditions in one convenient display. Adjustment of the Oxygen Flow is available on this screen.

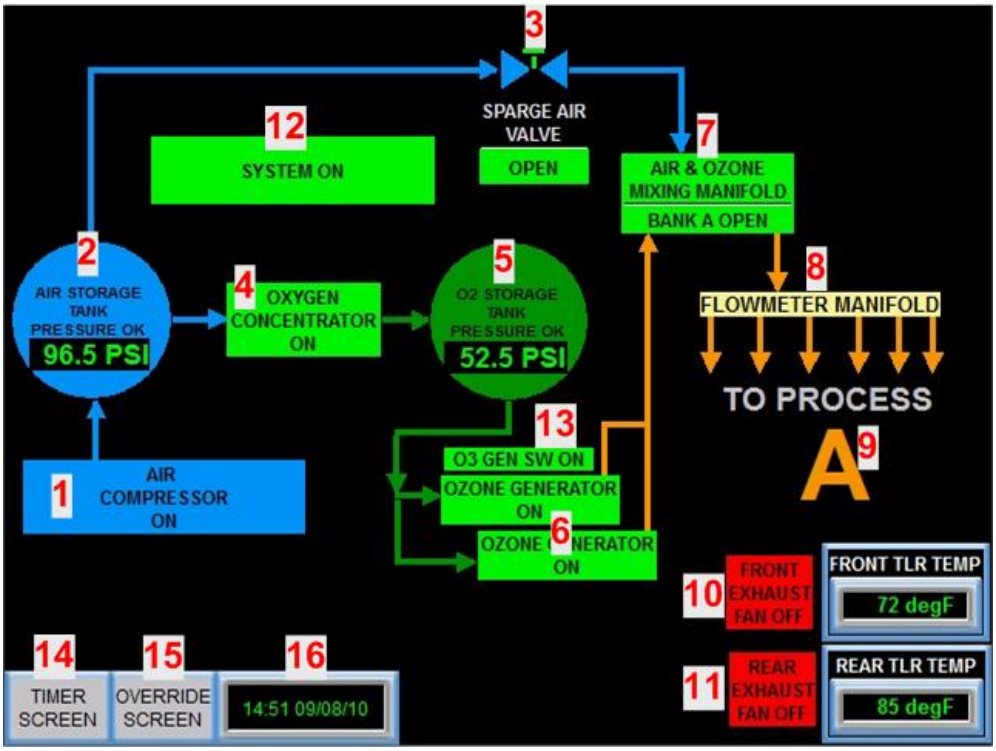
The TIMER SCREEN (Screen #2) - The timer is designed to cycle through three (3) different banks of well outputs consecutively, each according to its predetermined setpoint configured by the operator. As the timer is operating, the accumulated "open" time (time that the bank is ON) for each bank (with and without ozone) is recorded in "minutes" and displayed in on this screen. The data is logged in the form a *.csv file which is updated hourly, additionally a captured *.jpg image of the screen is updated every 15 minutes. The logged data is written to a user-installed USB memory device.

The TIMER SCREEN also displays the H2O Injection timer option, a timed relay which functions independently of ozone system controls.

The OVERRIDE SCREEN (Screen #3) provides a "MANUAL OVERRIDE" control of each system components, to allow for maintenance and troubleshooting actions not supported by the automatic operation. The screen is password protected to prevent use by unauthorized operators.

MAIN SCREEN (Screen #1)

The numbered diagram below corresponds with the numbered list



1. **AIR COMPRESSOR Status** – Indicates current status of Air Compressor (ON, OFF, or OVERRIDE).

2. **AIR STORAGE TANK Status** – Indicates air pressure in the Air Storage Tank, and displays an alarm condition.

   a. **Air Pressure OK** – Air pressure is within the parameters:

   b. **Air Pressure ALARM –** Air pressure is below the required pressure for at least 1.5 minutes.

3. **SPARGE AIR VALVE Status–** Indicates status of Sparge Air Valve (OPEN, CLOSED, or OVERRIDE).

4. **OXYGEN CONCENTRATOR Status Indicator –** Indicates status of Oxygen Concentrator (ON, OFF or OVERRIDE).

5. **O2 STORAGE TANK PRESSURE Indicator –** Indicates current Oxygen Storage Tank pressure and displays alarm condition.

   a. **O2 PRESSURE OK -** Oxygen Storage Tank pressure is within the parameters:

   b. **O2 PRESSURE LOW** – Oxygen Storage Tank pressure is below the required pressure:

6. **OZONE GENERATORS Status –** Indicates status of Ozone Generators (ON, OFF, or OVERRIDE).

7. **AIR/OZONE MIXING MANIFOLD Status –** Indicates status of valves exiting manifold – which valve is open (Bank A, Bank B, etc.), weather a manual override is enacted, or if all valves are closed.

8. **FLOWMETER MANIFOLD Status –** Graphical depiction of a Flowmeter Bank Manifold, indicators immediately above and below the graphic indicate which bank is open.

9. **FLOWMETER BANK Status –** Indicates which Flowmeter Bank Manifold is open (if multiple banks are open due to OVERRIDE status, multiple indicators will be indicated layered on top of one another).

10. **FRONT EXHAUST FAN Status –** Indicates status of Front Trailer Exhaust Fan (ON, OFF, or OVERRIDE).

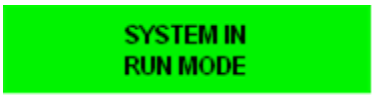
    - Normally the fan will be **OFF** whenever the system is running.

- Fan turns **ON** automatically:
  - Whenever there is excessive heat in the front trailer compartment.
  - When an ozone leak is detected in the front trailer compartment.
  - For a short time after the above conditions.

11. **REAR EXHAUST FAN Status –** Indicates status of Rear Trailer Exhaust Fan (ON, OFF, or OVERRIDE).
    - Normally the fan will be **ON** whenever:
      - The system is running.
      - There is excessive heat in *either* trailer compartment.
      - There is an ozone leak in the front trailer compartment.
      - For a short time after above conditions.
12. **SYSTEM Status –** Indicates mode of system control, which is determined by the SYSTEM switch setting (switch adjacent to the HMI control panel), EMERGENCY STOP switch settings (switches located in the front and rear trailer), and external switch connections (if connected):
    a. System is in STOP mode (or automatically shutting down) due to switch in OFF position.

    b. System is in STANDBY mode due to (air and oxygen preparation equipment is running, but Sparge Air Valve and OXYGEN FLOW CONTROLLER remain CLOSED, Ozone Generators remain OFF).

    c. System is in RUN mode.



    d. System is in EMERGENCY STOP mode.

e. System is in STOP mode, but components may be running due to manual override functions being activated.

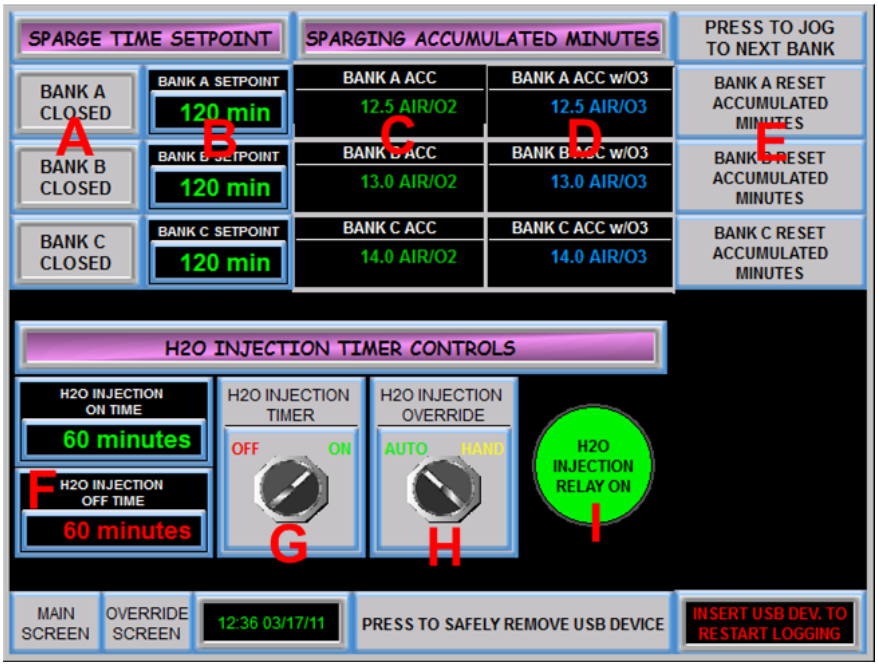
13. **O3 GEN Switch Status –** Indicates position of O3 GEN switch (OFF or ON [AUTO]). The O3 GEN switch is located adjacent to the HMI Control Panel.

14. **TIMER SCREEN Access –** Press to take user to the TIMER SCREEN (screen #2).

15. **OVERRIDE SCREEN Access –** Press to take user to the OVERRIDE SCREEN (screen #3).

16. **Current Date & Time –** Simply displays the current date and time for reference.

TIMER SCREEN (Screen #2)



A. Bank Status Indicator – Displays "CLOSED" or "SPARGING" according to bank status.

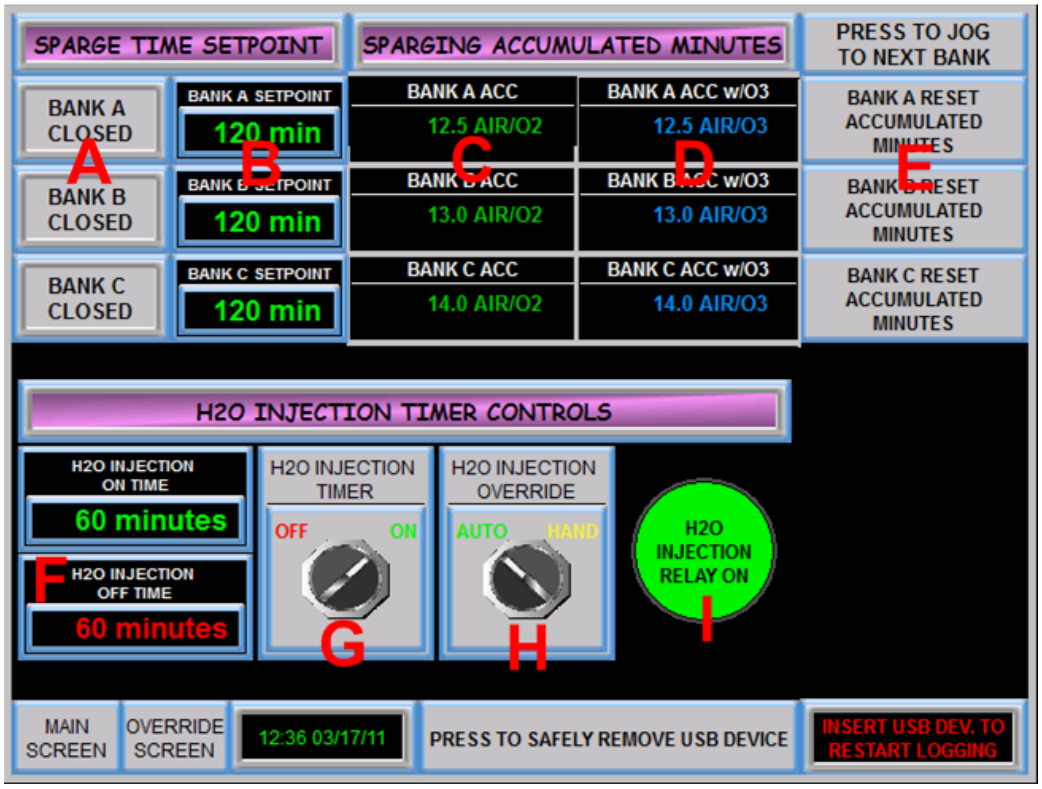
B. Bank Timer Setpoint Selector – Opens a pop-up window which contains a numerical keypad, whereby a new timer setpoint can be entered. All numerical values are entered and displayed in minutes.

C. Bank "Accumulated Open Minutes" Indicator - Displays the accumulated minutes of "open time" (amount of time "ON") for the bank, including time with and without ozone production.

D. Bank "Accumulated Open Minutes With O3" Indicator - Displays the accumulated minutes of "open time" (amount of time the bank was "ON") for the bank only during ozone production.

E. Reset Accumulated Minutes Button – Touch here to open a confirmation window, which allows the user to reset the accumulated minutes for the bank. Both accumulated times, with and without ozone, will be reset. Follow on-screen pop-up instructions. (Upon confirmation, resets accumulated minutes to "0", only for the bank indicated chosen, not all banks).

H2O Injection Timer Controls (Screen #2)



F. H2O Injection Timer Settings – Opens a pop-up window which contains a numerical keypad, whereby a new timer setpoint can be entered. All numerical values are entered and displayed in minutes. The ON time and OFF times determine the relay cycle timing. The relay will cycle continuously regardless of the Ozone System status.

G. H2O Injection Timer Switch – When ON the timer will cycle the output ON/OFF as described above. When OFF the output will turn off and the timer will stop timing.

H. H2O Injection Override – This switch, when set to HAND, will turn on the relay regardless of the timer settings. For normal operation set the switch to AUTO.

I. H2O Injection Relay indicator – Displays the current status of the injection relay.

Other H2O Injection Relay notes:

- The H2O Injection relay timer will operate regardless of the Ozone System status. It is not synchronized with the ozone bank timers, and even when the timer is set to be presumably synchronized with the ozone bank timers, it will not remain in synchronization if the Ozone System is stopped momentarily due to operator changes or alarms.
- There is a HAND/OFF/AUTO switch located in the rear of the trailer. This switch takes priority over all control system settings, and will operate the relay even without an operable control system.

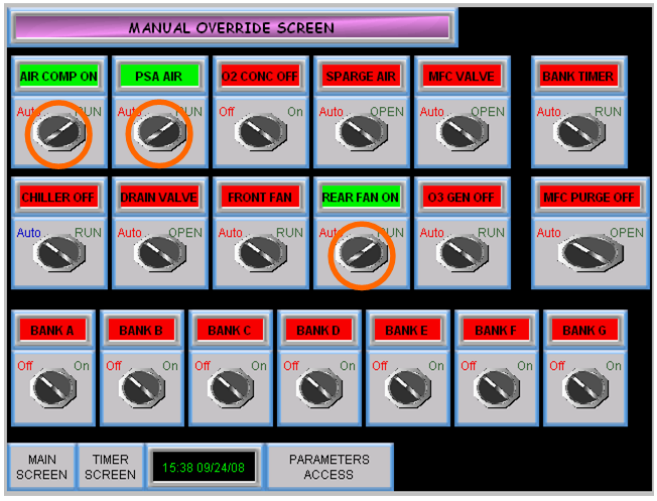
MANUAL OVERRIDE (Screen #3)

While the system is running in normal automatic operation (SYSTEM switch set to RUN, nothing is overridden), the screen will indicate each component status by showing the corresponding indicator (above the switch) in GREEN or RED color, and the switch in the AUTO position:

While the system is shut down (SYSTEM switch set to OFF), and no components are operating automatically, the screen will indicate each component as "OFF" by showing the corresponding indicator is red, and the switch is in the AUTO position:

While the system is shut down (SYSTEM switch set to OFF), and there are components which are operating in RUN or OPEN (manual override) mode the screen will indicate each component as "OFF" or "ON" by showing each corresponding indicator in red or green, and in the AUTO or RUN (or OPEN) position respectively. (The orange circle in the image highlights the switch; this circle does not exist on the screen).

In this example, the Air Compressor, Oxygen Concentrator, and Rear Trailer Fan are running in manual override mode:



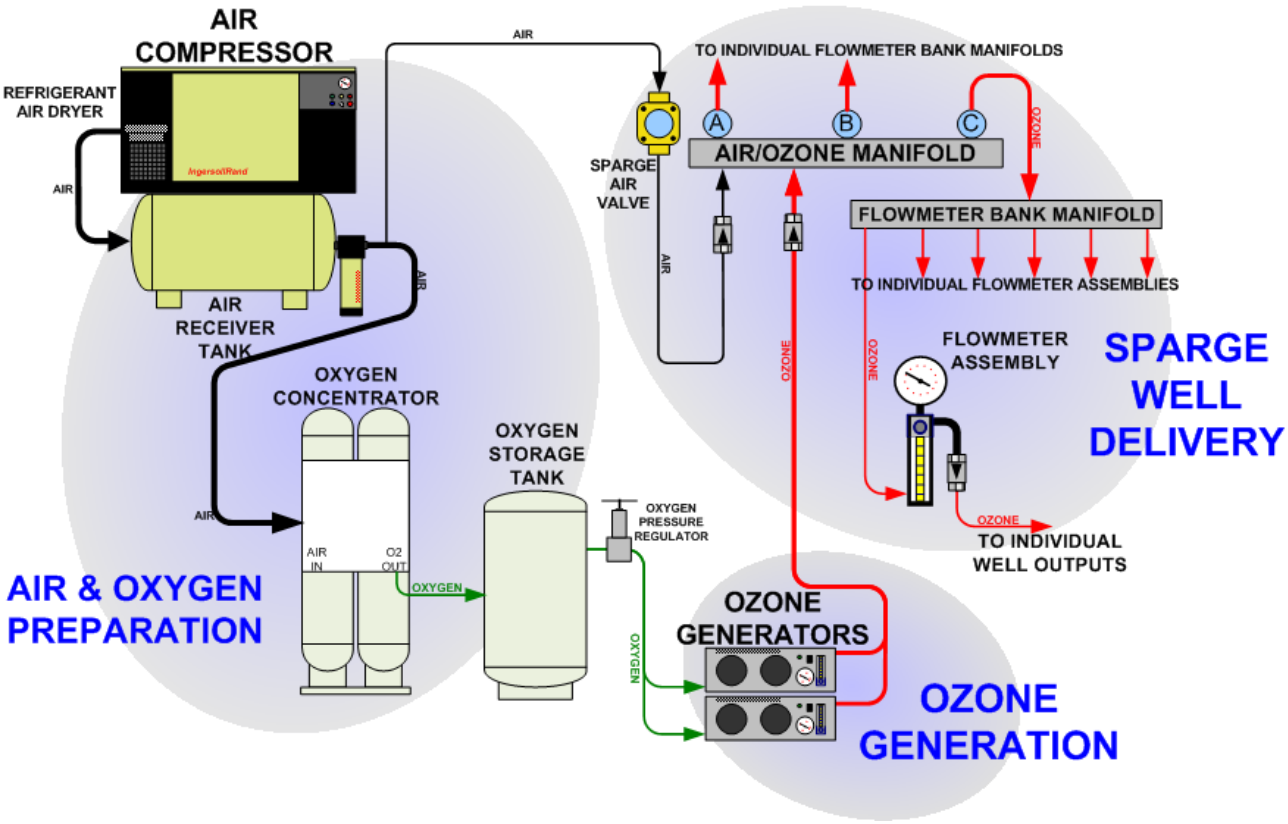
Operating Procedures

Overview

After the system is properly configured, start-up and shutdown of the system is very simple from an operator standpoint, and very little operator intervention is required. The operator turns the SYSTEM switch to RUN, and from there the operation is completely automatic.

The automated control system will function to operate the entire Ozone Groundwater Remediation Trailer and protect system components from such things as low air pressure, low oxygen pressure, high temperature, and ozone leaks. The sensors within the Ozone Trailer protect the system components and monitor the operating environment (provided that none of the components are manually overridden).

The schematic below shows how there are essentially three sections to the system. Two of the sections – "Air & Oxygen Preparation" and "Sparge Well Delivery", basically operate in sequence with each other. If the Air & Oxygen Preparation is fully operational and no alarms exist then the Sparge Well Delivery can start. The third section involves "Ozone Generation". When the first two sections are fully operational, the third can operate by beginning ozone production.



H2O Injection Timer

Reference page 17 of this manual for instructions on operating the injection timer functions.

Operator Startup

NOTE: If start-up does not occur as expected, refer to the "Configuration" or "Alarms & Troubleshooting" sections in this manual.

- Ensure all manual air, oxygen, and cooling water isolation valves are open.
- Ensure that front and rear trailer doors remain closed during operation.
    - The front door must be closed to maintain a clean and cool operating environment for the Ozone Generators.
    - The rear door must remain closed in order to attain proper airflow through the rear of the trailer to cool the equipment.
- Ensure the control switches on Oxygen Concentrator control panel are set to "ON" and "AUTO".

- Ensure that the AIR COMP CONTROL switch located on the Air Compressor Control Panel (in the rear of the trailer on the Air Compressor) is set to "REMOTE".

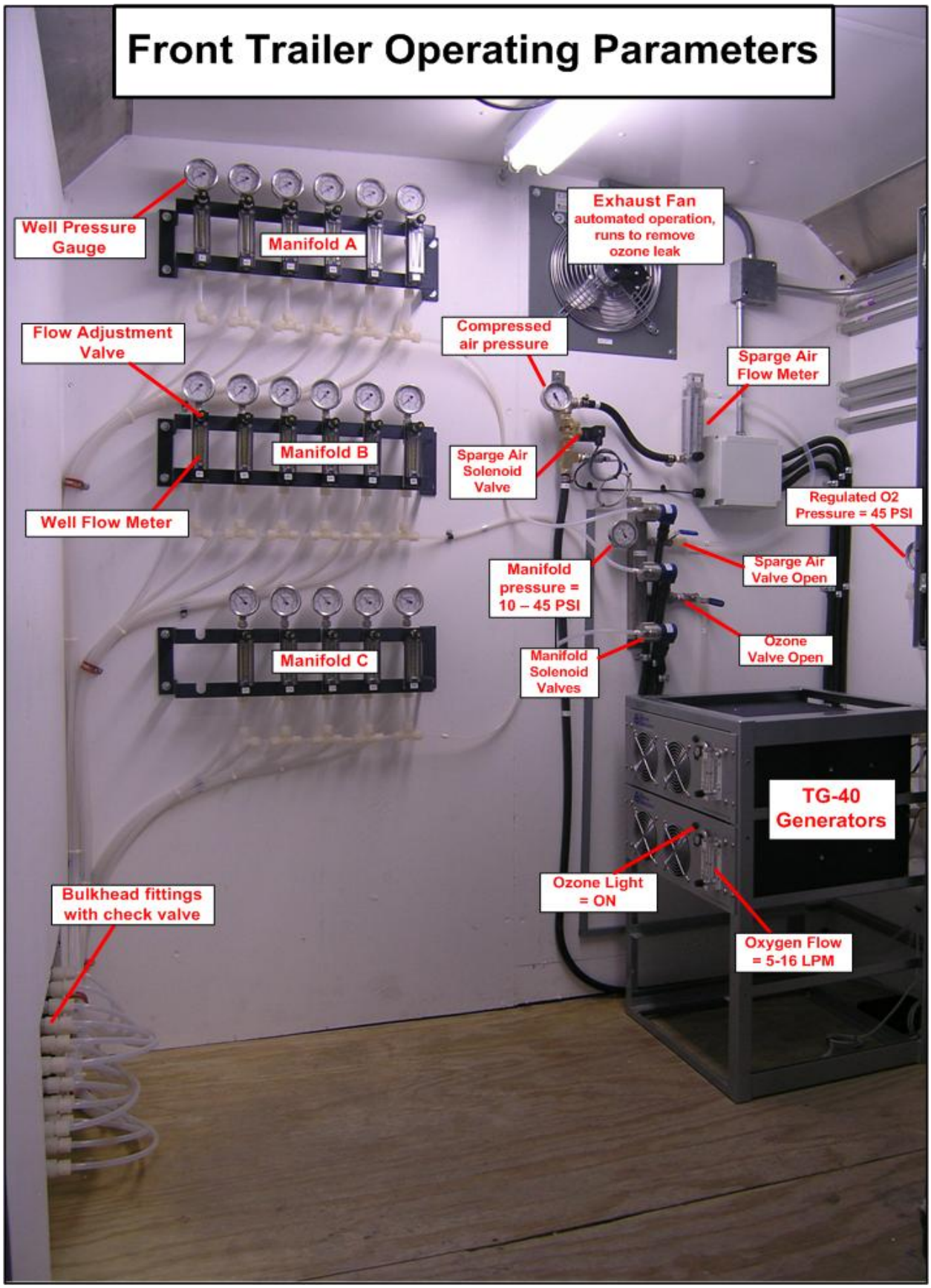
- The MAIN SCREEN should be visible on the HMI Control Panel.
- Turn SYSTEM switch (on the Main Control Panel) to RUN, and/or close external contacts.
- After a short delay, the Air Compressor should start. Observe the AIR STORAGE TANK pressure; it should quickly increase to at least 90 PSI.
- Ensure that the AIR DRYER INDICATOR moves out of the red color and remains in the GREEN or BLUE areas. The indicator should NEVER show RED after the system starts.

- Oxygen Concentrator should start. Observe the O2 STORAGE TANK pressure; it should increase to at least 12 PSI after a few minutes. It may take 15 minutes or longer for oxygen pressure to increase beyond 30 PSI (normal running pressure will be much higher, 45-60 PSI depending on usage).
- After adequate air and oxygen pressure are established, the Sparge Air Valve will open. The appropriate bank valve will also open, controlled by the bank output timer.
- "Break-through" pressure for each well will be higher than normal running pressure, as a result the flow may be lower than expected for a few minutes. The flow should increase to expected levels (as indicated by each flowmeter assembly). Ensure that flow exists for each well output on the bank of flowmeters which is currently open.
- After a delay of a few minutes (exact time delay depends on start-up conditions), the Ozone Generators will start.
- While the Ozone Generators are running, Ozone Concentration and Ozone Production are dependent on oxygen flow, oxygen pressure, and the setting of the Ozone Generators' variable output (see TG-40 Ozone Generator manual for details on flow and output adjustment). A green indicator light on each Ozone Generator indicates that the generator is producing ozone.

Operator Shutdown

- Turn the SYSTEM switch to OFF.
- Allow the system to run through the automatic shutdown sequence.
- When the panel indicates SYSTEM OFF, the shutdown sequence is complete.

Normal Operating Parameters




Normal Operating Parameters
Regulated O2 Pressure = 45 PSI
Tank O2 Pressure = 45-70 PSI
O2 Reciever Pressure = 45-70 PSI
Feed Air Pressure = 75-120 PSI
Pressure Transducer
Oxygen Pressure Regulator
Oxygen Drain Valve Closed
Oxygen Outlet Valve Open
Cycle Air Pressure = 65-90 PSI
AIRSEP
Oxygen Receiver Tank
AS-D Oxygen Concentrator
Compressed Air Inlet
Pressure Relief Valve
Oxygen Inlet Valve Open

Operating via External Control Connections

The SYSTEM switch and Ozone Generators can be operated remotely by wiring to the external electrical connection terminals in the Ozone Groundwater Remediation System Main Control Box (for more information see "Installation" section of this manual).

The external controls may be used to control the entire system (via the EXT SYSTEM switch connection) and/or Ozone Generator (via the EXT O3 GEN SWITCH connection) and turn them to OFF or AUTO at any time as necessary.

The EXT E-STOP connection may be used to immediately stop all components on the system in the event of an emergency, and should not be used for normal start-up and shutdown.

Normal delayed automatic starting and stopping of individual components will occur even when external control connections are used, so that operation is fail-safe and is not erratic.

Utilizing the external connections will not override any of the protective alarm features.

Alarms and Troubleshooting

Alarms affecting system operation

REAR TLR TEMP HIGH Alarm

Maximum Rear Trailer Temperature is 100°F, as required for safe equipment operation. The air temperature sensor, located on the rear of the trailer near the rear control box, monitors the temperature.

Setpoint: 100°F

Hysteresis: 5°F

Alarm Delay: 1 minute

Alarm Reset Delay: 0 seconds

Alarm Condition: Temperature is above the setpoint. The system will shut down until the temperature drops below 95°F.

Possible Causes for Alarm Condition:

- Rear door of trailer is open while running, resulting in inadequate airflow to the necessary areas.
- Rear trailer air intake grilles clogged.
- Outdoor temperature is excessive.

REAR TRAILER RH HIGH Alarm

Maximum (ambient) Rear Trailer Humidity is 95%, to prevent moisture damage to several system components. The humidity sensor, located on the rear of the trailer near the rear control box, monitors the humidity.

Setpoint: 95% RH

Hysteresis: 5% RH

Alarm Delay: 1 minute

Alarm Reset Delay: 0 seconds

Alarm Condition: Relative Humidity is above the setpoint. The Ozone System will shut down until the humidity drops below 90%.

Possible Causes for Alarm Condition:

- Humid weather – rainy, foggy, or misting conditions.
- Standing water in or near the trailer.

FRONT TLR TEMP HIGH Alarm

Maximum Front Trailer Temperature is 95°F, as required for safe equipment operation. The air temperature sensor, located on the wall next to the Main Control Panel, monitors the temperature.

Setpoint: 95°F

Hysteresis: 5°F

Alarm Delay: 0 minutes

Alarm Reset Delay: 0 seconds

Alarm Condition: Temperature is above the setpoint. The Ozone Generators will shut down and the Front Trailer Fan will run until the temperature drops below 90°F.

Possible Causes for Alarm Condition:

- Front door of trailer is open and the air conditioner is unable to maintain temperature.
- Recent ozone leak resulting in Front Trailer Fan running and allowing warm outside air in.
- Outdoor temperature is excessive.
- Air conditioner evaporator coil is frozen or there is an air conditioner failure.

AIR STORAGE TANK PRESSURE LOW Alarm

Minimum pressure is 90 PSI, as required for Oxygen Concentrator operation. The air pressure sensor, located on the Air Storage Tank below the Air Compressor, monitors this pressure.

Setpoint: 90 PSI

Hysteresis: 10 PSI

Alarm Delay: 99 seconds

Alarm Reset Delay: 0.01 seconds

Alarm Condition: Air Storage Tank Pressure is below the setpoint. The Oxygen Concentrator will shut down until pressure reaches 100 PSI (90 setpoint +10 hysteresis) for at least 0.01 seconds.

Possible Causes for Alarm Condition:

- Manual ball valve is closed.
- Air filter requires maintenance.
- Air leak.
- Oxygen Concentrator consuming excessive air due to oxygen flow setpoint is too high – decrease setpoint.
- Oxygen Concentrator consuming excessive air due to low oxygen pressure – allow oxygen pressure to increase by temporarily lowering oxygen flow.
- Oxygen Concentrator consuming excessive air due to Oxygen Concentrator failure.

OXYGEN PRESSURE LOW Alarm

Minimum Oxygen Pressure is 10 PSI, as required for proper Ozone Generator operation. The oxygen pressure sensor, located immediately prior to the OXYGEN FLOW CONTROLLER, monitors this pressure.

Setpoint: 10 PSI

Hysteresis: 2 PSI

Alarm Delay: 0 seconds

Alarm Reset Delay: 0 seconds

Alarm Condition: Oxygen Pressure is below the setpoint. The Ozone Generators will shut down until pressure reaches 12 PSI (10 setpoint +2 hysteresis).

Possible Causes for Alarm Condition:

- Manual ball valve closed.
- Oxygen Concentrator local switch is OFF.
- Oxygen flow is set too high, concentrator cannot maintain pressure.
- Inadequate air supply to Oxygen Concentrator – low air pressure, closed valve, or other air problem.
- Oxygen leak.

OZONE LEAK Alarm

Ozone Sensor located in the front trailer compartment indicates ozone level in the front of the trailer and alerts the Control System of excessive ozone levels.

Setpoint: 0.30 PPM Ozone

Hysteresis: 0.15 PPM Ozone

Alarm Delay: 0 seconds

Alarm Reset Delay: 5 seconds.

Alarm Condition: Excessive ozone levels exist in the front trailer compartment. The Ozone Generators will shut down and the Front and Rear Trailer Exhaust Fans will run until the ozone level is lowered to less than 0.15 PPM.

Possible Causes for Alarm Condition:

- Excessive ozone levels outside the trailer which have drifted into the front trailer compartment.
- Ozone Leak inside the front of the trailer. To diagnose, start with process of elimination. Between each test, allow the ozone level in the front of the trailer to drop below the alarm level, then:
    - To eliminate possible internal Ozone Generator leak: Turn off *one* Ozone Generator using the switch located on the Ozone Generator, and allow the system to run and determine if the ozone leak still exists. Do this with all generators.
    - Determine if the leak is limited to one particular Bank: Record current timer settings and then set each timer to 999 minutes in order to eliminate possible automatic switching. Manually cycle through one bank at a time, allowing each bank to run for at least 10 minutes *with ozone production.* (Set timers back to previous settings when finished).
    - If a leak occurs with *any* Flowmeter Bank running, the leak is in between Ozone Generators and solenoid valves (on Air/Ozone Mixing Manifold).
    - Determine if the leak is limited to one particular Flowmeter Assembly:
        - While counting number of turns to close (so that settings can be returned to normal after testing), close all flowmeter needle valves, except one.
        - Allow the system to run (ensure that the appropriate bank is open), opening one needle valve at a time every 5-10 minutes until the leaking flowmeter is found.

- If a leak occurs with numerous flowmeters, the leak precedes flowmeter needle valves.

- If the leak is related to one Flowmeter Assembly, then the leak is between needle valve and bulkhead connection at the trailer wall.

- If a particular Flowmeter Assembly is not found to be leaking, use soapy water to check all connections from the solenoid valve to the Flowmeter Bank Manifold and from the Flowmeter Bank Manifold to each Flowmeter Assembly.

- If process of elimination does not locate the leak, a **hand-held Ozone Sensor** may be useful in pinpointing the area of the leak. When using an Ozone Sensor to find a leak, bear in mind that the response time of the sensor and small amounts of air movement around the leak may affect readings. Also, ozone can be "absorbed" by clothing and other objects, which will affect readings as well.

Personal Safety and Equipment Damage Concerns

Flushing ozone from the system

Safety warnings regarding ozone gas are found at the beginning of this manual. The Ozone Groundwater Remediation System produces a large amount of ozone, which can be inadvertently "stored" within the Ozone Generators, manifolds, and ozone lines.

NOTE: In most circumstances, a very small amount of ozone will be contained within the system after shutdown and therefore exposure will be minimal.

Eventually the ozone (even while in the system) will safely revert back to oxygen, but in the right conditions the ozone can remain in the system for 24 hours or even longer. In the event that maintenance must be performed on the components in contact with ozone, the following is recommended for reducing the possibility of exposure to the ozone:

- Whenever possible it is recommended that the machine run with maximum permissible air and oxygen flow for at least 10 minutes with the Ozone Generator OFF in order to flush out most residual ozone.
- If the machine cannot be operated prior to maintenance or repair, a waiting period of 12 to 24 hours (if ozone has been produced recently) is recommended to allow the ozone to decay by reverting back into oxygen.

Isolating energy sources

The Ozone Groundwater Remediation Trailer has electrical and mechanical hazards, and maintenance or repair should not take place unless all energy sources have been turned off, disconnected, and/or drained. Energy sources include, but are not limited to:

- Electrical power
- Air Storage Tank
- Oxygen Storage Tank
- Oxygen Concentrator sieve beds
- Ozone Generator internal capacitors

Equipment Damage Concerns during normal operation.

With normal use of the system as instructed by Ozone Solutions and as outlined in this manual, the Ozone Groundwater Remediation Trailer is monitored and protected to prevent damage to equipment. Even with these protective measures, it is possible to cause equipment damage in the event of operator error or lack of maintenance:

Component	Cause/Failure	Effect
Oxygen Concentrator		
	Operating the system with malfunctioning or dirty compressed air filters	Shortened sieve bed life, lower oxygen concentration, lower oxygen flow - see also Air-Sep Oxygen Concentrator OM
	Operating the system with oxygen flow beyond the capacity of the Oxygen Concentrator (maximum capacity of the AS-D is 90SCFH/42SLPM	Shortened sieve bed life, lower oxygen concentration, lower oxygen flow - see also Air-Sep Oxygen Concentrator OM
Ozone Generators		
	Allowing water to back-up through the system and enter the Ozone Generators, by allowing check valves to become stuck open or removing check valves.	Ozone Generator failure. Solenoid valve and/or Flowmeter clogging.
	Allowing the Ozone Generators to run while the Oxygen Concentrator is damaged or not maintaining >85% purity	Ozone Generator failure.
Air Compressor		
	Low oil or lack of filter maintenance	Compressor failure
	Lack of ventilation filter maintenance, allowing the compressor to run in extreme heat conditions (normally protected by sensor)	Compressor or other rear trailer component failure due to heat. Moisture in compressed air causing O2, O3 gen., flowmeter and solenoid valve damage

Maintenance

Overview

Some of the individual components will require periodic maintenance and/or calibration, please reference the individual component manuals for information. Components requiring maintenance includes, but may not be limited to:

- Air Compressor
- Refrigerant Air Dryer & Filters
- Oxygen Concentrator
- Solenoid Valves
- Flowmeters
- Check Valves
- Ozone Leak Sensor

Maintenance Schedule

Maintenance to other components on the Ozone Groundwater Remediation Trailer are described in the following Maintenance Schedule:

Time Interval	Component	Action	Parts Required
Trailer Components			
Every Startup	Entire system	Ensure proper gas pressures and flows, ensure temperatures are not excessive after several consecutive hours of warm-up	
Monthly	Intake Air Grilles & Exhaust fans	Check and/or clean all intake air grilles in rear of trailer, run fans and check operation	
	Drain Valve(s)	Check that valve closes & opens properly	SVB-8
	Sparge air Valve	Check that valve closes & opens properly	SVB-8
	Ozone Valves	Check that valve closes & opens properly	SVSS-GC rebuild
	Ozone Manifolds/Flowmeters	Cycle through all manifolds and check for flow at all flowmeters in-use, watch for ozone leaks	FM-6-SS-123
Every 6 months, or as necessary	Compressed Air Filters	Check and/or replace all filter elements	CF-8 : Replacement Filter
	Electrical Control & Ozone Generator Enclosures	Clean ventilation air inlets, clean any dust from internal components. Clean HMI Panel.	
Annually	Ozone Leak Sensor	Replace sensor element	SEN-1.0
Every 3 years, or as needed	Check Valves	Test and/or replace	CVHP-6
Refrigerant Air Dryer - Ingersoll-Rand Package (mounted to compressor)			
Weekly	Condensate drains	Verify operation	IR-88349527
Every 3 months	Refrigerant system	Clean condensor cooling fins	
		Check dryer current draw under full load (must be producing air)	
Annually or 3000 hours	Condensate drains	Disassemble and clean, inspect, or replace	IR-88349527
Oxygen Concentrator - AirSep AS-D			
Daily	Filter drain(s)	Ensure automatic drain functions properly	AIRS-VA495-2
Monthly	Filter(s)	Inspect filters and bowls. Clean bowls, replace filters as necessary	MC-4274K53
			WILK-MTP-95-115
Every 6 months	Filter(s)	Replace particulate (primary) filter element	MC-4274K53
Annual or 8000 hours	Filter(s)	Replace coalescing (secondary) filter element	WILK-MTP-95-115
	Valves	Check performance of all valves and actuators:	
		Feed Valves (x2)	IVES-302272
		Waste Valves (x2)	
		Equalization Valves (x2)	IVES-302272N
		Product Valve	IVES-304817N
	Feed Air Regulator	Clean and lubricate feed air regulator	AIRS-PS211-1
Emergency Spare Parts	Circuit Board assy, program #2, AS-D Series		AIRS-CB039-3
	Fuse, 3.0 Amp, AS-series		AIRS-FU004-1
	Check Valve, 1/4" MPT, Oxygen, for AS-D		AIRS-VA044-1
	Valve coil		IVES-218410-001
	Valve Coil		IVES-218-410-3
	Pressure Switch		AIRS-SW003-3

Compressor - Ingersoll-Rand UP6-7.5-TAS

Time Interval	Component	Action	Parts Required
Daily	Air-end	check coolant level	CP-IR-Ultra Plus Coolant
	Entire unit	Visual check of machine for any leaks, dust build up or unusual noise or vibration	
	Package pre-filter	Visual check condition of package pre–filter, blow clean if needed	IR-38342028
	Tank	check that automatic drain is operating	IR-54579248
First 150 hours	Coolant	Change coolant filter	IR-39329602
Monthly or every 100 hours	Package pre-filter	Remove and clean package pre–filter, replace if needed Check the cooler(s) for build up of foreign matter. Clean if necessary by blowing out with air or by pressure washing.	IR-38342028
Every 3 months	Safety pressure relief valve	Operate the safety valve manually to verify that the valve mechanism is functioning correctly and that a small amount of air is released.	IR-22378665
Annually or 3000 hours	Entire unit	Check the operation of the high temperature protection switch (109 C).	IR-22275879
		Replace filter elements in IRGP64 and IRHE64 filters	IR-88343025
			IR-88342993
		Change Coolant filter	IR-39329602
		Check scavenge screen for blockage, clean if required	
		Change Separator element	IR-22388045
		Change Air Filter element	IR-88171913
		Change or clean package pre-filter	IR-38342028
		Check Drive Belt	IR-89306294
		Inspect tank for corrosion or leaks	
Two years or 9000 hours	Entire unit	Change drive belt	IR-89306294
		Replace Ultra-Plus Coolant	CP-IR-Ultra Plus Coolant
		All items on "3000 hour" service	
		Replace/Rebuild as needed:	
		Solenoid valves	
		Inlet valve kit	IR-38341723
		Minimum Pressure valve kit	IR-22245617
		Thermostatic Valve cartridge Kit	IR-22282024
Four years or 18000 hours	Entire unit	Perform all 3000 and 9000 hour maintenance	
		Replace all hoses (one each of parts listed)	IR-39172432
			IR-22418776
			IR-22418784
			IR-39580725
		Strip, clean, and re-grease motor bearings of ODP motors (if applicable)	
		Inspect or replace motor contactor points	

Specifications

Electrical Requirements:

Voltage:	115/230V single-phase
Full Load Amperage:	~75 A (maximum)
Maximum Overcurrent Protection:	200 A (provided in Power Distribution Panel)
Minimum Overcurrent Protection:	90 A
Maximum Power Consumption:	~17 kVA at full production.

Ozone Production:

120 g/hr Maximum ozone production, upgradeable to 180 g/hr

Environment:

Temperature (Operating): 32°F to 100°F (outdoors)

Temperature (Storage): 32°F to 120°F (outdoors)

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